Agenda Date: 3/19/25
Agenda Item: 8G

STATE OF NEW JERSEY
Board of Public Utilities
44 South Clinton Avenue, 1st Floor
Trenton, New Jersey 08625-0350
www.nj.gov/bpu/

CLEAN ENERGY

IN THE MATTER OF THE IMPLEMENTATION OF P.L. 2018, C. 17, THE NEW JERSEY CLEAN ENERGY ACT OF 2018, REGARDING THE SECOND TRIENNIUM OF ENERGY EFFICIENCY AND PEAK DEMAND REDUCTION PROGRAMS	)	ORDER ADOPTING THE PROGRAM YEAR 4 TECHNICAL REFERENCE MANUAL FOR THE ENERGY EFFICIENCY PROGRAMS
	)	DOCKET NO. QO23030150

Parties of Record:

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Margaret Comes, Esq., Associate Counsel, Rockland Electric Company
Sheree Kelly, Esq., Regulatory Affairs Counsel, SJI Utilities, Inc. on behalf of Elizabethtown Gas Company and South Jersey Gas Company

BY THE BOARD:

By this Decision and Order, the New Jersey Board of Public Utilities ("Board" or "BPU") considers Board Staff's ("Staff") recommendation to approve the Technical Reference Manual ("TRM") for the fourth program year of the three (3)-year cycle of energy efficiency ("EE") programs ("PY4 TRM") established pursuant to the New Jersey Clean Energy Act of 2018, L. 2018, c. 17 ("CEA"). The TRM is a compendium of equations and guidelines used to calculate energy savings for EE measures. The PY4 TRM is used to calculate energy savings for Program Year 4, January 1, 2025 to June 30, 2025, of the second three (3)-year cycle of EE programs established pursuant to the CEA ("Triennium 2").[1]

[1] N.J.S.A. 48:3-87.8 *et seq*.

BACKGROUND AND PROCEDURAL HISTORY

On February 9, 1999, Governor Whitman signed the Electric Discount and Energy Competition Act, L. 1999, c. 23 ("EDECA"), into law, thereby creating a "societal benefits charge" ("SBC") to fund programs for the advancement of EE and renewable energy ("RE") in New Jersey.[2]

By Order dated December 22, 2004, the Board created the NJ Clean Energy Program ("NJCEP") Protocols: a compendium of engineering equations to calculate energy savings that arise from EE measures provided by the NJCEP.[3]

By Order dated June 10, 2020, the Board established the Evaluation, Measurement, and Verification ("EM&V") Working Group ("EM&V WG").[4] Facilitated by the Statewide Evaluator ("SWE"), the EM&V WG brings together Staff, the New Jersey Division of Rate Counsel, and the State's electric and gas public utilities ("Utilities") – with support from program evaluation contractors, implementation contractors, and representatives from the other EE working groups established by the Board, as appropriate – to develop a standard, transparent, and replicable approach for evaluating, measuring, and verifying the results of EE and peak demand reduction ("PDR") programs implemented pursuant to the CEA.

Following the start of the first three (3)-year cycle of programs established pursuant to the CEA ("Triennium 1") on July 1, 2021, the EM&V WG renamed the NJCEP Protocols to the "Technical Reference Manual". The EM&V WG subsequently created a TRM Committee to revise and update the TRM on a regular basis, as necessary.

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[2] N.J.S.A. 48:3-49 to -98.

[3] In re the Adoption of New Jersey's Clean Energy Program Protocols to Measure Resource Savings, BPU Docket No. EO04080894, Order dated December 22, 2004. All revisions of the Protocols and TRMs are available at: https://njcleanenergy.com/main/public-reports-and-library/market-analysis-protocols/market-analysis-baseline-studies/market-an.

[4] In re the Implementation of P.L. 2018, c. 17 Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs; In re the Clean Energy Act of 2018 – Utility Demographic Analysis; and In re Electric Public Utilities and Gas Public Utilities Offering Energy Efficiency and Conservation Programs, Investing in Class I Renewable Energy Resources and Offering Class I Renewable Energy Programs in Their Respective Service Territories on a Regulated Basis Pursuant to N.J.S.A. 48:3-98.1 – Minimum Filing Requirements, BPU Docket Nos. QO19010040, QO19060748, and QO17091004, Order dated June 10, 2020.

By Order dated October 12, 2022, and as revised via letter from the Secretary of the Board dated November 9, 2022, the Board approved Staff's recommendation that the SWE, EM&V WG, and TRM Committee support the development of a comprehensive update of the TRM, including input and feedback through a public stakeholder process, for the Board's consideration ahead of the commencement of Triennium 2 EE programs.[5] Additionally, the Board approved Staff's recommendation to permit the Utilities to report energy savings resulting from implementation of the Utilities' EE programs using the Joint Utility Coordinated Measures List during Triennium 1 with an addendum to address corrections and new measures ("2022 TRM Addendum"). By the October 2022 Order, the Board directed the Utilities to also report energy savings resulting from implementation of the Utilities' EE programs using the 2022 TRM Addendum, beginning with their annual reports for Program Year 1 and continuing in subsequent quarterly and annual reports throughout Triennium 1.

By Order dated May 24, 2023, the Board directed each Utility to propose, for Board approval, EE programs for Triennium 2 on or before October 2, 2023 and addressed certain aspects of the Triennium 2 framework.[6] Additionally, by the May 2023 Order, the Board approved the SWE's recommended "New Jersey Energy Efficiency Triennium 2 Evaluation Framework" ("Evaluation Framework") that described the roles and responsibilities of the entities participating in the EM&V of Triennium 2 programs and set forth the activities, products, and processes that guide the programs' EM&V. By the Evaluation Framework, the Board clarified the necessity of the TRM and directed that a triennial TRM be established prior to the start of each Triennium period and that an annual TRM update be completed in the intervening years.[7]

[5] In re the Implementation of P.L. 2018, c. 17 Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs; In re the Petition of Atlantic City Electric Company for Approval of an Energy Efficiency Program, Cost Recovery Mechanism and Other Related Relief for Plan Years One Through Three; In re the Petition of Elizabethtown Gas Company for Approval of New Energy Efficiency Programs and the Associated Cost Recovery Mechanism Pursuant to the Clean Energy Act and the Establishment of a Conservation Incentive Program; In re the Verified Petition of Jersy Central Power & Light Company for Approval of JCP&L's Energy Efficiency and Conservation Plan Including Energy Efficiency and Peak Demand Reduction Programs (JCP&L EEC); In re the Petition of New Jersey Natural Gas Company for Approval of Energy Efficiency Programs and the Associated Cost Recovery Mechanism Pursuant to the Clean Energy Act, N.J.S.A. 48:3-87.8 *et seq.* and 48:3-98.1 *et seq.*; In re the Petition of Public Service Electric and Gas Company for Approval of its Clean Energy Future – Energy Efficiency ("CEF-EE") Program on a Regulated Basis; In re the Petition of Rockland Electric Company for Approval of its Energy Efficiency Program and Peak Demand Reduction Programs; and In re the Petition of South Jersey Gas Company for Approval of New Energy Efficiency Programs and the Associated Cost Recovery Pursuant to the Clean Energy Act, BPU Docket Nos. QO19010040, EO20090621, GO20090619, EO20090620, GO20090622, GO18101112, EO18101113, EO20090623, and GO20090618, Order dated October 12, 2022 ("October 2022 Order").

[6] In re the Implementation of P.L. 2018, c. 17, the New Jersey Clean Energy Act of 2018, Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs; In re the Implementation of P.L. 2018, c. 17, the New Jersey Clean Energy Act of 2018, Regarding the Second Triennium of Energy Efficiency and Peak Demand Reduction Programs; In re Electric Public Utilities and Gas Public Utilities Offering Energy Efficiency and Conservation Programs, Investing in Class I Renewable Energy Resources and Offering Class I Renewable Energy Programs in Their Respective Service Territories on a Regulated Basis, Pursuant to N.J.S.A. 48:3-98.1 and N.J.S.A. 48:3-87.9 - Minimum Filing Requirements, BPU Docket Nos. QO19010040, QO23030150, and QO17091004, Order dated May 24, 2023 ("May 2023 Order").

[7] The "New Jersey Energy Efficiency Triennium 2 Evaluation Framework" is available at https://www.njcleanenergy.com/main/public-reports-and-library/market-analysis-protocols/market-analysis-baseline-studies/market-an.

By Order dated July 26, 2023, the Board approved the additional aspects of the Triennium 2 framework.[8]

By Order dated October 25, 2023, the Board updated the energy savings targets for the Triennium 2 EE programs and extended the Triennium 1 period through December 31, 2024.[9] By the October 2023 Order, the Board also delayed the start of Triennium 2 by six (6) months, from July 1, 2024 to January 1, 2025, and ordered that Triennium 2 would be a thirty (30)-month period from January 1, 2025 through June 30, 2027.

By Order dated December 18, 2024, the Board replaced the three (3)-year update cycle of the TRM with an annual update cycle.[10] As a result, the Triennium 2 TRM, which was originally approved to be used throughout Triennium 2, will be replaced by the PY4 TRM for PY4. Additionally, by the December 2024 Order, the Board ordered that EE program administrators would be permitted to use either the current Triennial TRM or the draft PY4 TRM until the Board approved the PY4 TRM because the PY4 TRM would not approved before January 1, 2025.

The PY4 TRM is based on the Triennium 2 TRM with updates derived from a variety of sources including the SWE, Evaluation Study Team ("EST"), independent program evaluators ("IPE"), and members of the TRM Committee.[11] Major proposed updates to the PY4 TRM include the following:

- Revisions to measure- and program-level realization rates, in-service rates, and net-to-gross ratios obtained from the PY2 program evaluation studies conducted by the IPEs.
- Parameter updates within individual measure sections obtained from PY2 program evaluation studies and research conducted by the EST, including revisions to residential cooling equivalent full load hours, residential space heating and water heating end-use fuel splits, residential clothes washer size and efficiency, boiler capacity associated with the residential boiler temperature reset control measure, heat pump saturation for residential smart thermostats, residential recycled refrigerator and freezer characteristics, hot water temperature difference used in the residential faucet aerator measure, and doorway area used in the commercial walk-in cooler strip curtain measure.

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[8] In re the Implementation of P.L. 2018, c. 17, the New Jersey Clean Energy Act of 2018, Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs; In re the Implementation of P.L. 2018, c. 17, the New Jersey Clean Energy Act of 2018, Regarding the Second Triennium of Energy Efficiency and Peak Demand Reduction Programs; In re Electric Public Utilities and Gas Public Utilities Offering Energy Efficiency and Conservation Programs, Investing in Class I Renewable Energy Resources and Offering Class I Renewable Energy Programs in Their Respective Service Territories on a Regulated Basis, Pursuant to N.J.S.A. 48:3-98.1 and N.J.S.A. 48:3-87.9 - Minimum Filing Requirements, BPU Docket Nos. QO19010040, QO23030150, and QO17091004, Order dated July 26, 2023.

[9] In re the Implementation of P.L. 2018, c. 17, the New Jersey Clean Energy Act of 2018, Regarding the Second Triennium of Energy Efficiency and Peak Demand Reduction Programs, BPU Docket No. QO23030150, Order dated October 25, 2023 ("October 2023 Order").

[10] In re the Implementation of P.L. 2018, c. 17, the New Jersey Clean Energy Act of 2018, Regarding the Second Triennium of Energy Efficiency and Peak Demand Reduction Programs, BPU Docket No. QO23030150, Order dated December 18, 2024 ("December 2024 Order").

[11] In re Energy Efficiency Evaluation Study Team, BPU Docket No. QO22040234, October 12, 2022. The EST is responsible for conducting evaluation studies under the direction of SWE.

- Error corrections and clarifications to energy savings calculations and supporting narrative within individual measure sections, including updates to measure baseline conditions and dual baseline calculations.
- Addition of new measures such as residential and commercial garden equipment, combination boilers, switched reluctance motors, gas heat pumps, and electronic fuel use economizers.
- Expansion of residential and commercial heat pump calculations to include fuel substitution and partial displacement scenarios.

Staff released the draft PY4 TRM for public comment on December 23, 2024.[12]

Comments Received and Staff Responses

Comment: The New Jersey Utilities Association ("NJUA") identified their desire to continue to be involved in the TRM update process. NJUA noted, "[i]n development of the PY4 TRM, the Utilities first identified concerns over some of the updated values using Program Year 2 ('PY2') evaluation results and their inclusion in the TRM. There was no mechanism to incorporate suggested changes when known inaccuracies were discussed. For future TRM updates, NJUA supports establishing these prospective values based on multiple sources of information and leveraging the expertise of the TRM Committee to select the right values with input from all members as appropriate."

Response: Staff appreciates the collaboration to continuously improve the TRM and acknowledges the importance of the SWE to manage the process. Staff agrees that prospective values should represent the best estimate of savings for the next program year, but notes the complexity of using prospective values. Staff has a process to determine which values will be carried forward and plans to follow the process for the PY4 and future updates.

Comment: NJUA recommended that "edits to the final PY4 TRM include default input values for certain measures to make it possible to calculate savings when certain site-specific information is not available. Many TRM measures contain multiple input parameters which are site specific."

Response: Staff agrees and notes that these values were vetted by the TRM Committee, and incorporated into the TRM for certain measures: Commercial and Industrial ("C&I") Lighting, C&I Indoor Horticulture LEDs, C&I Furnaces, Unit Heaters and Boilers, C&I Combination Boilers, C&I Dishwashers, C&I Pre-Rinse Spray Valves, C&I Air Conditioner, Mini-Split AC and PTAC, C&I Heat Pump Water Heater Residential Heat Pump Water Heater, Residential Air source Heat Pumps and Mini-Split Heat Pumps, C&I Air Source Heat Pumps and Mini-Split Heat Pumps, and Residential Smart Thermostats.

Comment: NJUA recommended "the removal of the language regarding the documentation required to establish the viability of the existing equipment for residential and C&I custom measures in sections 2.8.4 and 3.13.4 of the draft TRM."

Response: Staff disagrees with this recommendation. The current language represents a level of effort consistent with low rigor guidelines for small savings projects in other states. Staff agrees that a guidance document is needed to provide guidelines for larger and more complicated

[12] Notice of Request for Comments: Adoption of the Program Year 4 Technical Reference Manual for New Jersey's Triennium 2 Energy Efficiency Programs, BPU Docket No. QO23030150, December 20, 2024.

projects, but the current language should remain. Language regarding viability of existing equipment for residential and C&I custom measures only applies to custom projects.

Comment: Public Service Electric and Gas Company ("PSE&G") noted, "[i]n addition to the comments provided through NJUA, PSE&G requests that the net to gross ('NTG') values for its moderate income program, listed in Table 11.12 on page 793 of the draft PY4 TRM, be edited to reflect the Company's most recently evaluated Program Year 3 ('PY3') results."

Response: Staff agrees with this request. Given the timing of study results, the PY4 TRM relies on results from PY2 or combined PY1 and PY2 evaluation studies. This exception is granted given the extraordinary situation of an eighteen (18)-month long PY3, which has allowed PY3 study results to be available for the PY4 TRM update. In the future, Staff will recommend that such exceptions not be granted. A typical update cycle assumes a lag between study results and TRM updates of two (2) years. For example, PY3 study results will be used to inform the PY5 TRM.

Comment: New Jersey Natural Gas Company ("NJNG") commented, "Marketplace Smart Thermostats Realization Rates ('RR'): Since the PY2 evaluation study, NJNG has made implementation improvements that are anticipated to improve in-service rates. Such improvements include follow-up emails to customers educating them on other program offerings which include installing the thermostat. NJNG is also working with our marketplace provider to identify other opportunities to improve the in-service rates. NJNG proposes to utilize the PY3 RR of 86% in the 2024 TRM as it reflects some of the impact of these process changes and better reflects anticipated future performance."

Response: Staff agrees with this request for the reasons set forth in Staff's response to PSE&G's comment above.

Comment: NJNG commented on the Energy Products Heating Ventilation and Air Conditioning program, noting that "[i]ncreases to rebates and changes to ramp-up behavior have been made to program implementation since the evaluation study, impacting NJNG's net-to-gross values and should not be applied to NJNG's PY4 projects. For example, rebates increased at beginning of PY3 (July 2023). NJNG proposes to utilize 2023 TRM values, rather than PY2 evaluation values."

Response: Staff agrees with this request for the reasons set forth in Staff's response to PSE&G's comment above.

Comment: Sealed, Inc. recommended "that the BPU build on the existing TRM language by providing additional clarity regarding the specific types of measures and programs to which open source software such [as] OpenEEMeter can apply."

Response: Staff notes that use of an International Performance Measurement and Verification Protocol ("IPMVP") Option C pre/post billing analysis, such as OpenEEMeter, is limited to custom programs.[13] All other programs must use the methods described in the TRM. Within custom programs, IPMVP Option C is one (1) of several methods that can be used to estimate savings. The choice of methods is project-specific and up to the judgment of the program implementation staff assigned to the project.

[13] IPMVP provides a framework to 1) verify a project has the potential to perform and save energy, and 2) quantify site-level energy and cost impacts from a targeted project.

Comment: Sealed, Inc. proposed to change language on p. 262 and 705 of the TRM from "Open source software products compliant with IPMVP Option C or American Society of Heating, Refrigerating and Air-Conditioning Engineers ("ASHRAE") Guideline 14 such as OpenEEMeter are acceptable methods to evaluate energy savings under conditions where the energy consumption data can be fit to outdoor temperature or degree-day data" to "Open source software products compliant with IPMVP Option C or ASHRAE Guidelines 14 such as OpenEEMeter can be used as an energy savings calculation method for all energy efficiency and electrification measures and pay-for-performance programs."

Response: Staff respectfully disagrees with this proposed change. In certain scenarios, Option C pre/post billing analysis is not the most appropriate method to calculate savings.

Comment: Rockland Electric Company ("RECO") identified the following errors in the TRM:

- Section 12 - Appendix I: RRs (page 808): "RECO Energy Efficient Products Appliance Markdown – All Measure" RRs were incorrectly identified as 81% kWh and 88% kW. These should be corrected to 93% kWh and 101% kW as per the filed RECO PY2 Evaluation Study.
- Section 12 - Appendix I: RRs (page 809): "RECO Energy Efficient Products Marketplace – Smart Thermostat" RR is missing. This should be included as a 113% kWh RR as per the filed RECO PY2 Evaluation Study.
- Section 13 - Appendix J: In-Service Rates (page 814): "RECO EE Products Online Marketplace – Smart Thermostat" in-service rate is missing. This should be included as a 98% in-service rate as per the filed RECO PY2 Evaluation Study.

Response: Staff agrees with the proposed corrections and updated these sections in the final PY4 TRM. RRs excluding in-service rates ("ISR") were verified in the final study report for the first two (2) errors. For the third error, Staff verified the ISR of 98% in Table 3-13 of Final Report dated July 2024.

Comment: Jersey Central Power & Light Company ("JCP&L") commented regarding deferring updates from PY4 TRM to the Program Year 5 TRM. JCP&L highlighted three (3) areas:

- Realization rates for the Small Business Direct Install ("SBDI") Program were based on an older energy assessment tool, which will be replaced in PY4 by a Joint Utility model, and therefore JCP&L recommended using default values instead of PY2 study results.
- Realization rates for Hours of Use and NTG were derived from studies with insufficient sample size. "[I]n lieu of applying set RRs and applying parameter updates to those RRs, it would be more appropriate to rely on parameter updates to the TRM formula."
- "Use of the SBDI PY2 RRs and NTG Ratios Would Unduly Harm JCP&L's Ability to Meet the QPIs"

Response: Staff agrees with JCP&L's comment and will adjust the TRM to use default values for the RR for the SBDI program and to retain the prior RR values for Hours of Use and NTG.

Comment: LF Energy advocated for OpenEEMeter (now called OpenDSM).[14] LF Energy noted that they "encourage the NJBPU to expand the TRM language to clarify where open-source tools like OpenEEMeter can be applied. Specifically, OpenEEMeter should be explicitly identified as an approved method for calculating energy savings across all measures and as a tool for determining incentive payments under pay-for-performance programs. This would ensure transparency and consistency in program evaluations and incentivization." LFEnergy added, "Since OpenEEMeter is non-proprietary, the NJBPU can mandate that utilities in New Jersey adopt it by reference in all of the solicitations they release, requiring bidders to demonstrate how their solutions incorporate its methods and code base."

Response: Staff notes that the use of an IPMVP Option C pre/post billing analysis tool, such as OpenEEMeter, is limited to custom programs. All other programs must use the methods described in the TRM. Within custom programs, IPMVP Option C is one (1) of several methods that can be used to estimate savings. The choice of methods is project-specific and up to the judgment of the program implementation staff assigned to the project. Staff disagrees with a mandate to adopt OpenEEMeter because there are situations where an Option C pre/post billing analysis is not the most appropriate method to calculate savings.

STAFF'S RECOMMENDATIONS

Following consideration of public comments, Staff recommends the Board approve the draft PY4 TRM with the following revisions:

- Section 12 - Appendix I: RRs, at page 808: In the section titled "RECO Energy Efficient Products Appliance Markdown – All Measure," updating the RRs from 81% kWh and 88% kW to 93% kWh and 101% kW in accordance with RECO's PY2 Evaluation Study.
- Section 12 - Appendix I: RRs, at page 809: In the section titled "RECO Energy Efficient Products Marketplace – Smart Thermostat," inserting the RR value of 113% kWh in accordance with RECO's PY2 Evaluation Study.
- Section 13 - Appendix J: In-Service Rates, at page 814: In the section titled "RECO EE Products Online Marketplace – Smart Thermostat" inserting the in-service rate value of 98% in-service rate in accordance with RECO's PY2 Evaluation Study.

DISCUSSION AND FINDINGS

Following review of the record in this matter, including the PY4 TRM, revisions thereto, and all comments, the Board **HEREBY FINDS** that the process to revise the PY4 TRM provided stakeholders with adequate opportunity to comment and was therefore appropriate. The Board **FURTHER FINDS** that the proposed changes to the PY4 TRM are reasonable and will ensure the most reliable energy savings calculations will be put in place for PY4.

The Board **HEREBY ADOPTS** Staff recommended revisions to the draft PY4 TRM as follows:

- Section 12 - Appendix I: RRs, at page 808: In the section titled "RECO Energy Efficient Products Appliance Markdown – All Measure," updating the RRs from 81% kWh and 88% kW to 93% kWh and 101% kW in accordance with RECO's PY2 Evaluation Study.

[14] OpenDSM is "an open-source library used to measure the impacts of demand-side programs by using historical data to fit models and then create predictions (counterfactuals) to compare to post-intervention, observed energy usage." https://lfenergy.org/projects/opendsm/

- Section 12 - Appendix I: RRs, at page 809: In the section titled "RECO Energy Efficient Products Marketplace – Smart Thermostat," inserting the RR value of 113% kWh in accordance with RECO's PY2 Evaluation Study.
- Section 13 - Appendix J: In-Service Rates, at page 814: In the section titled "RECO EE Products Online Marketplace – Smart Thermostat" inserting the in-service rate value of 98% in-service rate in accordance with RECO's PY2 Evaluation Study.

The Board **HEREBY APPROVES** the PY4 TRM with these changes and **HEREBY DIRECTS** that PY4 TRM be used to calculate deemed energy savings for the duration of PY4 of Triennium 2.

This Order shall be effective on March 26, 2025.

DATED: March 19, 2025

BOARD OF PUBLIC UTILITIES
BY:

CHRISTINE GUHL-SADOVY
PRESIDENT

DR. ZENON CHRISTODOULOU
COMMISSIONER

MARIAN ABDOU
COMMISSIONER

MICHAEL BANGE
COMMISSIONER

ATTEST:

SHERRI L. LEWIS
BOARD SECRETARY

I HEREBY CERTIFY that the within document is a true copy of the original in the files of the Board of Public Utilities.

IN THE MATTER OF THE IMPLEMENTATION OF P.L. 2018, C. 17, THE NEW JERSEY CLEAN ENERGY ACT OF 2018, REGARDING THE SECOND TRIENNIUM OF ENERGY EFFICIENCY AND PEAK DEMAND REDUCTION PROGRAMS

DOCKET NO. QO23030150

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New Jersey 2024 Annual Technical Reference Manual

New Jersey Board of Utilities

New Jersey's Clean Energy Program™

2/19/2025

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1 INTRODUCTION

This technical reference manual (TRM) has been developed to calculate resource savings, including electricity, natural gas, and other resource savings from technologies and measures, and to calculate electric energy and capacity savings from renewable energy and distributed generation systems. Specific calculation methods for determination of the resource savings or generation are presented.

These calculations use deemed and customer-specific data as input values to industry-accepted energy and peak demand savings algorithms. The data and input values for the algorithms come from the program application forms or from deemed values. The deemed values are based on the recent impact evaluations or best available secondary research applicable to the New Jersey programs when impact evaluations are not available.

1.1 PURPOSE

The TRM was developed for the purpose of calculating energy and peak demand savings for technologies and measures supported by New Jersey's Clean Energy Program (NJCEP). This includes programs administered by the State of New Jersey through the Board of Public Utilities (BPU), the State's electric and natural gas utilities, or other parties who administer clean energy programs under the guidance of the BPU. The TRM will be updated to reflect the addition of new measures, modifications to existing measures, changes to codes and standards, and the results of evaluation studies. The TRM will be used consistently statewide to assess program impacts and calculate energy and peak demand savings consistent with BPU guidance. The TRM may be used to accomplish the following:

- Report to the BPU on program performance;
- Provide inputs for program planning and cost-effectiveness calculations;
- Provide information to the BPU for calculating Quantitative Performance Indicators (QPI) and applying the Performance Incentive Mechanism (PIM);

Resource savings to be measured include electric energy (kWh) and demand (kW) savings, natural gas savings (therms), peak gas savings (therms/day), and savings of other resources (oil, propane, gasoline, and water) where applicable. In turn, these resource savings will be used to determine avoided environmental emissions and other benefits as described in the New Jersey Cost Test. The TRM is also utilized to support preliminary estimates of the electric energy and capacity from renewable energy and distributed generation systems and the associated environmental benefits.

The calculations in this document focus on the determination of the per unit savings for the energy efficiency measures, and the per unit generation for the renewable energy or distributed generation measures. The BPU has adopted net savings for the purposes of evaluating energy efficiency and peak demand reduction program performance, and performing cost-effectiveness testing. For Triennium 1, the BPU adopted a net-to-gross ratio of 1.0, which should be applied to all programs, including low- income programs. For Triennium 2, net to gross ratios used to calculate net savings are shown in Appendix H: Net-to-Gross Factors and should be applied to the gross savings calculated from this TRM.

1.2 TRM ORGANIZATION

The TRM is organized by customer sector (Residential and Commercial) and by end-use. Within each end-use section, measures are grouped together by end-use subcategory. Note, sector applicability to measures installed multifamily (MF) buildings depends on whether the building is a low rise (3 stories or less) and whether the measure is located in the individual unit or common area. In-unit measures and all measures in MF low-rise buildings are covered in the Residential section. Measures in common areas of MF high-rise (more than 3 stories) buildings are covered in the Commercial section. Measures used in low-income (LI) or moderate income (MI) programs use the same TRM sections as measures applied to the general population. Any calculations unique to LI or MI programs are identified within each measure section. Measure applied to Agricultural facilities are covered within the Commercial section under the Agricultural end-use.

1.3 TYPES OF CALCULATIONS

The following table summarizes the spectrum of approaches to be used for calculating energy, demand, and resource savings. No one approach will serve all programs and measures. The TRM provides algorithms addressing measure types 1 and 2, and general guidelines for measure type 3.

Table 1-1 Summary of Calculations and Approaches

Type of Measure	Type of Calculation	General Approach	Examples
1. Deemed prescriptive measures	Standard formula and deemed input values	Number of installed units times deemed savings/unit	Residential appliances
2. Measures with important variations in one or more input values (e.g., , efficiency level, capacity, load, etc.)	Standard formula with one or more site-specific input values	Standard formula in the TRM with one or more input values coming from the application form, worksheet, or field tool (e.g., , efficiency levels, unit capacity, site-specific load)	Residential Electric HVAC (change in efficiency level times site-specific capacity times standard operating hours); Field screening tools that use site-specific input values
3. Custom or site-specific measures, or measures in complex comprehensive jobs	Site-specific analysis	Greater degree of site- specific analysis, either in the number of site-specific input values, or in the use of special engineering algorithms, including building simulation programs	Custom Industrial process Complex comprehensive jobs

Several systems work together to ensure accurate data on a given measure:

1. The application form that the customer or customer's agent submits with basic information.
2. Application worksheets and field tools with more detailed site-specific data, input values, and calculations (for some programs).
3. Program tracking systems that compile data and may do some calculations
4. The TRM that contains algorithms and relies on deemed or site-specific input values. Parts or all of the TRM may ultimately be implemented within the tracking system, the application forms and worksheets, and the field tools.

1.4 ALGORITHMS

The TRM presents a set of engineering algorithms to calculate energy and demand savings. Savings are generally driven by a change in efficiency level for the installed measure compared to a baseline level of efficiency. Energy savings are calculated from the change in efficiency and/or the change the annual operating hours of equipment. Operating hours may be expressed as run hours for constant output devices or equivalent full load hours (EFLH) for equipment that operates at varying levels of output throughout the year. Energy and demand savings may be calculated for both electricity and natural gas regardless of the targeted fuel.

1.5 BUILDING ENERGY SIMULATIONS

When building energy simulation software is used to develop savings estimates for several measures in a comprehensive project, the specific algorithms used are inherent in the software and account for interaction among measures by design. Building simulation software used for any program must be compliant with one of the following:

- A software tool addressing residential and/or commercial buildings whose performance has passed testing according to the National Renewable Energy Laboratory's BESTEST software or ASHRAE Standard 140 energy simulation testing protocol,
- Software approved the US Department of Energy's Weatherization Assistance program, or
- RESNET approved home energy rating software (HERS).

1.6 MEASURE INTERACTIVE SAVINGS

Throughout the TRM, the interactive effect of thermostatically-sensitive building components is accounted for in specific measure sections, as appropriate. In instances where there is a measurable amount of interaction between two energy consuming sources, the energy or peak demand savings are accounted for in either the algorithms or in the modeling software used to determine energy savings.

For example, in a measure section where the lighting load has a direct effect on the energy used to condition the space, the TRM provides an interactive effect value to be used in the savings algorithm for certain measures. Other measures rely on the characteristics of the modeling software that account for the effect within a building, such as a new construction protocol software that will apply the effects for a measurable difference in the baseline and efficient buildings.

Measure savings calculation based on simple engineering algorithms are not designed to account for the interactive effects of multiple measures installed in a building. When multiple measures are installed, it is acceptable to sum the individual measure savings. Energy savings calculations based on building energy simulations account for multiple measure interactions by design.

1.7 DATA AND INPUT VALUES

Some input values, including site-specific data, will come directly from the program application forms, worksheets, and field tools. Site-specific data on the application forms are used for measures with important variations in one or more input values (efficiency level, capacity, etc.).

Standard input values are based on the best available measured or industry data, including metered data, measured data from prior evaluations (applied prospectively), field data and program results, nameplate data, in situ values, and/or standards from industry associations.

For the deemed input assumptions where metered or measured data were not available, the input values (e.g., watts, efficiency, equipment capacity, operating hours, coincidence factors) are based on the best available industry data or standards. These input values were based on a review of literature from related evaluation studies and information from various industry organizations, equipment manufacturers, and suppliers. For custom projects, measurement and verification (M&V) options are presented that use pre- and/or post-retrofit measurements of energy consumption or equipment performance to estimate energy savings.

1.8 BASELINE ESTIMATES

For measures in which the existing equipment has failed, is at the end of its useful life, or the program administrator does not have knowledge of the state of the existing equipment, the resource savings values are based difference between the energy use of new products that meet code or represent industry standard practice vs. the high efficiency products promoted through the programs. For early replacement of functioning equipment, energy and demand savings values are based on the difference between high efficiency equipment versus existing equipment. A dual baseline approach must be followed, where the savings relative to the existing equipment baseline are used for the remaining useful life of the existing equipment and a code or standard practice baseline is used for the remaining life of the measure. In lieu of the dual baseline approach, lighting measures may use an adjusted measure life (AML) to account for early replacement of functioning systems and differences in the lifetimes of efficient vs. standard practice equipment. The AML is defined as the lifetime energy savings considering a dual baseline divided by first year savings.

Measures in the TRM are categorized according to the following baseline condition definitions:

Baseline Condition	Attributes
Time of Sale (TOS)	**Definition:** A program in which the customer is incented to purchase or install higher efficiency equipment than if the program had not existed. This may include retail rebate (coupon) programs, upstream buydown programs, online store programs, contractor based programs, or giveaways as examples. May include replacement of existing equipment at the end of its life (i.e., replace on burnout) or purchase of new equipment. In cases where a new construction characterization isn't explicitly provided, the TOS characterization is typically appropriate. TOS is sometimes referred to as normal replacement (NR). **Baseline:** New standard efficiency, code compliant, or industry standard practice equipment. **Efficient Case:** New, premium efficiency equipment above federal and state codes and standards and industry standard practice. **Example:** Appliance rebate
New Construction (NC)	**Definition:** A program that intervenes during building design, expansion, or gut rehabilitation to support the use of more-efficient equipment and construction practices. **Baseline:** Building code, federal standards, or industry standard practice. **Efficient Case:** The program's level of building specification **Example:** Building shell and mechanical measures

Baseline Condition	Attributes
Retrofit (RF)	**Definition:** A program that upgrades or enhances existing equipment. **Baseline:** Existing equipment or the existing condition of the building or equipment. A single baseline applies over the measure's life. When a measure is applied to existing operational equipment and the measure benefit will cease upon the end of the underlying equipment's life, the measure life is the smaller of the host equipment remaining life or the full measure life. **Efficient Case:** Post-retrofit efficiency of equipment. **Example:** Air sealing, insulation, controls
Early Replacement (EREP)	**Definition:** A program that replaces existing, operational equipment. **Baseline:** Dual. it begins as the existing equipment and shifts to projected TOS baseline equipment after the remaining life of the existing equipment is over. **Efficient Case:** New, premium efficiency equipment above federal and state codes and industry standard practice. **Example:** Refrigerators and freezers; early replacement of HVAC equipment. *Note: For lighting measures, the adjusted measure life (AML) may be used in lieu of a dual baseline approach.*
Early Retirement (ERET)	**Definition:** A program that retires inefficient, operational duplicative equipment or inefficient equipment that might otherwise be resold. No new equipment is installed in place of the old equipment, and no existing equipment use increases to compensate for the retirement. **Baseline:** The existing equipment, which is retired and not replaced. **Efficient Case:** Assumes zero consumption since the unit is retired. **Example:** Appliance recycling, delamping.
Direct Install (DI)	**Definition:** A program where measures are installed during a site visit and are assumed to replace existing, operational equipment. **Baseline:** Same as EREP. **Efficient Case:** Same as EREP. **Example:** Lighting and low-flow hot water measures *Note: For lighting measures, the adjusted measure life (AML) may be used in lieu of a dual baseline approach.*

1.9 PEAK SAVINGS

1.9.1 ELECTRIC COINCIDENT PEAK DEMAND

System peak demand refers to the highest amount of electricity consumed during a single hour across PJM. Peak coincident demand is the demand of a measure that occurs at the same time as the PJM system peak. PJM system peak is defined as follows in PJM Manual 18b:

"The EE Performance Hours are between the hour ending 15:00 Eastern Prevailing Time (EPT) and the hour ending 18:00 EPT during all days from June 1 through August 31, inclusive, of such Delivery Year, that is not a weekend or federal holiday."

Therefore peak coincident demand savings should be calculated based on the average demand reduction during the hours in that time frame.[1]

Peak demand savings for non-weather sensitive custom measures should be calculated based on the average demand reduction during the hours in that period. For weather sensitive custom measures, peak demand savings should be calculated based on the PJM's Zonal Weighted Temperature Humidity Index ("WTHI") standards for the appropriate zone.[2]

1.9.2 PEAK DAY NATURAL GAS

Calculations have been developed to determine the natural gas energy savings on an annual and peak day basis. Additional calculations done as part of the cost effectiveness calculations allocate the annual savings on a seasonal basis. Peak gas savings are calculated on a therm/day basis, using peak day heating degree-days representing the weather conditions under which the natural gas distribution system reaches peak capacity. Design day conditions from the London Economics study are used to calculate peak gas savings:

Condition	Average Heating Degree days base 65 (°F – day)	Average Daily Temperature (°F)
Winter Design Day	66.4	-1.4

1.10 OTHER RESOURCES

Measures that save electricity or natural gas may also affect the use of other fuels, water or other costs, and will affect emissions. The New Jersey Cost Test accounts for emissions reductions associated with electricity and natural gas and the net direct and indirect economic benefit of these other factors. The NJCT-required outputs from TRM use are natural gas and electric energy and electric summer peak demand gross impact.

1.11 PROSPECTIVE APPLICATION OF THE TRM

The TRM will be updated annually based on evaluation results and available data, and then applied prospectively for future program years in accordance with applicable BPU direction. Prospective application of the TRM will include calculation of gross energy and demand savings from the applicable measure section modified by evaluation-derived in-service rates as presented in Appendix J: In-Service Rates, realization rates as presented in Appendix I: Realization Rates and net to gross ratios as presented in Appendix H: Net-to-Gross Factors.

1.12 MEASURE COSTS

Measure costs for use in cost-effectiveness calculations are presented in a separate document. Projects will use incremental costs and/or full measure costs depending on the baseline condition. Consult the measure cost document for information on how to calculate measure costs.

1.13 MEASURE LIVES

[1] Coincidence factors and peak demand savings provided in the TRM measure sections are based on best available information. These coincidence factors may not conform to PJM requirements for offers into the forward capacity market.
[2] See PJM Manual 18B, section 10.2.

Measure effective useful life (EUL) is provided in each TRM measure section for the purpose of calculating lifetime energy savings. Projects utilizing a dual baseline approach will rely on a combination of the existing equipment remaining useful life (RUL) and the new equipment EUL. Calculations of lifetime savings for retrofit projects involving add-on equipment such as controls will use the smaller of the measure EUL and the host equipment RUL. Measures where values for adjusted measure life (AML) are provided will use the AML in lieu of a dual baseline approach. Projects consisting of multiple measures that submit a single project wide savings claim should calculate a project level EUL based on the average of the EULs of the individual measures. For such projects where measure-level savings can be calculated, use the savings weighted average of the individual measure EULs. For projects where savings by end-use are available, assign an EUL to each end use based on the measures contributing to the end use savings and estimate the project level EUL as the end-use savings weighted average. For projects were savings by measure or savings by end use are not available, a project-level EUL based on the simple average of the measure EULs is acceptable.

2 RESIDENTIAL

2.1 APPLIANCES

2.1.1 CLOTHES WASHER

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Clothes Washer
Measure Last Reviewed	September 2024
Changes Since Last Version	• Updated default capacity and IMEF values

Description

This measure is for a new or replacement ENERGY STAR or ENERGY STAR Most Efficient residential clothes washer in single family or multifamily homes. Please note that common area laundry rooms in Multifamily buildings should follow the C&I methodology.

ENERGY STAR® clothes washers have a higher Integrated Modified Energy Factor (IMEF) and a lower Integrated Water Factor (IWF), saving energy and water with greater tub capacities and sophisticated wash and rinse systems. Rather than filling the tub with water, efficient wash cycles are achieved by spinning or flipping clothes through a stream of water. Efficient rinse cycles are achieved through high-pressure spraying instead of soaking clothes. Reduced dryer load represents additional energy savings associated with the thorough removal of water from the clothes in the washer.

Baseline Case

The baseline for energy savings calculations is a clothes washer meeting the federal minimum Integrated Modified Energy Factor (IMEF) and not exceeding the federal maximum Integrated Water Factor (IWF), as defined in 10 CFR 430.32(f)(2). The IMEF and IWF are determined by clothes washer configuration (top-load or front-load) and capacity. Energy usage includes the washer and dryer energy consumption and water heating energy usage.

Efficient Case

The energy consumption of the efficient equipment is calculated based on the IMEF and IWF of the ENERGY STAR version 8.1 specification or ENERGY STAR Most Efficient product and other variables as defined in the calculation methodology below.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{washer} + \Delta kWh_{DHW} + \Delta kWh_{dryer}$$

Where,

$$\Delta kWh_{washer} = Cap \times \left(\frac{F_{washer,b}}{IMEF_b} - \frac{F_{washer,q}}{IMEF_q}\right) \times N_{cycles}$$

$$\Delta kWh_{DHW} = Cap \times \left(\frac{F_{DHW,b}}{IMEF_b} - \frac{F_{DHW,q}}{IMEF_q}\right) \times N_{cycles} \times SF_{DHW,electric}$$

$$\Delta kWh_{dryer} = Cap \times \left(\frac{F_{dryer,b}}{IMEF_b} - \frac{F_{dryer,q}}{IMEF_q}\right) \times N_{cycles} \times SF_{dryer,electric}$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{DHW} + \Delta Therms_{dryer}$$

Where,

$$\Delta Therms_{DHW} = Cap \times \left(\frac{F_{DHW,b}}{IMEF_b} - \frac{F_{DHW,q}}{IMEF_q}\right) \times N_{cycles} \times R_q \times SF_{DHW,ff} \times 0.03412$$

$$\Delta Therms_{Dryer} = Cap \times \left(\frac{F_{dryer,b}}{IMEF_b} - \frac{F_{dryer,q}}{IMEF_q}\right) \times N_{cycles} \times SF_{dryer,ff} \times 0.03412$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-1 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{washer}	Annual electric energy savings attributed to clothes washer operation	Calculated	kWh/yr	
ΔkWh_{DHW}	Annual electric energy savings attributed to water heating	Calculated	kWh/yr	
ΔkWh_{dryer}	Annual electric energy savings attributed to dryer operation	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{DHW}$	Annual fuel savings attributed to water heating	Calculated	Therms/yr	
$\Delta Therms_{dryer}$	Annual fuel savings attributed to dryer operation	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔH2O	Annual water savings	Calculated	Gal/yr	
Cap	Capacity of clothes washer	Site-specific. If unknown, use 3.39 or SJG Tier 1 use 5.03, Tier 2 use 4.6. ETG Tier 1 use 5.09, Tier 2 use 4.64	ft^3	[1]
$IMEF_q$	Integrated Modified Energy Factor of efficient unit	Site-specific. If unknown, look up in Table 2-3 or SJG Tier 1 use 2.37, Tier 2 use 2.97. ETG Tier 1 use 2.43, Tier 2 use 2.98	$ft^3/(kWh \cdot cycle)$	[2][3]
IWF_q	Integrated water factor for efficient unit	Site-specific. If unknown, look up in Table 2-8	$Gal/(cycle \cdot ft^3)$	[2][3]
$IMEF_b$	Integrated Modified Energy Factor of baseline unit	Look up in Table 2-2	$ft^3/(kWh \cdot cycle)$	[2]
N_{cycles}	Number of clothes washer cycles per year	Look up in Table 2-4	cycles	
$F_{washer,b}$	Fraction of total energy consumption attributed to clothes washer operation for the baseline case	Look up in Table 2-5	N/A	[5]

Variable	Description	Value	Units	Ref
$F_{washer,q}$	Fraction of total energy consumption attributed to clothes washer operation for the efficient case	Look up in Table 2-6	N/A	[6]
$F_{DHW,b}$	Fraction of total energy consumption attributed to water heating for the baseline case	Look up in Table 2-5	N/A	[5]
$F_{DHW,q}$	Fraction of total energy consumption attributed to water heating for the efficient case	Look up in Table 2-6	N/A	[6]
$F_{dryer,b}$	Fraction of total energy consumption attributed to dryer operation for the baseline case	Look up in Table 2-5	N/A	[5]
$F_{dryer,q}$	Fraction of total energy consumption attributed to dryer operation for the efficient case	Look up in Table 2-6	N/A	[6]
$SF_{DHW,electric}$	Electric DHW savings factor	Look up in Table 2-7	N/A	[10]
$SF_{dryer,electric}$	Electric dryer savings factor	Look up in Table 2-7	N/A	[10]
$SF_{DHW,ff}$	Fossil fuel DHW savings factor	Look up in Table 2-7	N/A	[10]
$SF_{dryer,ff}$	Fossil fuel dryer savings factor	Look up in Table 2-7	N/A	[10]
Hrs	Annual operating hours	Look up in Table 2-4	Hrs/yr	
IWF_b	Integrated water factor for baseline unit	Look up in Table 2-2	Gal/(cycle·ft^3)	
CF	Electric coincidence factor	Look up inTable 2-9	N/A	
PDF	Gas peak day factor	Look up in Table 2-9	N/A	
R_q	Recovery efficiency factor	1.26	N/A	[8]
0.03412	Unit conversion, therm/kWh	0.03412	Therm/kWh	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-2 Federal Standard Minimum IMEF and Maximum IWF

Configuration	Capacity (ft^3)	IMEF	IWF
Top Load	<1.6	1.15	12.0
Top Load	≥1.6	1.57	6.5
Front Load	<1.6	1.13	8.3
Front Load	≥1.6	1.84	4.7

Table 2-3 Efficient Unit Minimum IMEF

Efficiency Level	Front Loading	Top Loading
Clothes Washers > 2.5 ft^3		
ENERGY STAR	2.76	2.06
CEE Tier 1	2.76	2.76
CEE Tier 2	2.92	
CEE Tier 3	3.10	
Clothes Washers ≤ 2.5 ft^3		
ENERGY STAR	2.07	
CEE Tier 1	2.07	
CEE Tier 2	2.20	

Table 2-4 Annual Cycles and Hours

Type	Number of Cycles	Annual Hours	Ref
Single Family	254	295	[4]

Table 2-5 Total Energy Consumption Breakdown for Baseline Case

Efficiency Level	Clothes Washer (F_{washer})	DHW (F_{DHW})	Dryer (F_{dryer})
Federal Standard	0.07	0.65	0.28

Table 2-6 Total Energy Consumption Breakdown for Efficient Case

Efficiency Level	Clothes Washer (F_{washer})	DHW (F_{DHW})	Dryer (F_{dryer})
Clothes Washers (> 2.5 ft^3)			
ENERGY STAR	0.05	0.63	0.32
CEE Tier 1	0.05	0.63	0.32
CEE Tier 2	0.10	0.87	0.03
CEE Tier 3	0.10	0.87	0.03
Clothes Washers (≤ 2.5 ft^3)			
CEE Tier 1	0.08	0.72	0.20
CEE Tier 2	0.08	0.72	0.20

Table 2-7 DHW and Dryer Savings Factors

Fuel	$SF_{DHW,electric}$	$SF_{dryer,electric}$	$SF_{DHW,ff}$	$SF_{dryer,ff}$
Electric	1.00	1.00	0	0
Fossil Fuel	0	0	1.00	1.00
Unknown	Look up in Appendix K: DHW and Space Heat Fuel Split, or default to 0.31	0.68	Look up in Appendix K: DHW and Space Heat Fuel Split, or default to 0.69	0.32

Table 2-8 Efficient Unit Maximum IWF

Efficiency Level	Front Loading	Top Loading
Standard Sized Clothes Washers (> 2.5 ft^3)		
ENERGY STAR	3.2	4.3
CEE Tier 1	3.2	3.2
CEE Tier 2	3.2	3.2
CEE Tier 3	3.0	3.0
Small Sized Clothes Washers (≤ 2.5 ft^3)		
ENERGY STAR	4.2	
CEE Tier 1	4.2	
CEE Tier 2	3.7	

Peak Factors

Table 2-9 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[7]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Non-Energy Impacts

$$\Delta H2O = \left(IWF_b - IWF_q\right) \times Cap \times N_{cycles}$$

Measure Life

The effective useful life (EUL) is 14 years. [9]

References

[1] Based on the average clothes washer volume of all units that are ENERGY STAR qualified as of 3/17/2020.

[2] 10 CFR Subpart C of Part 430. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[3] ENERGY STAR Program Requirements Product Specification for Clothes Washers, Version 8.1. 2021. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%208.1%20Clothes%20Washer%20Final%20Specificaiton%20-%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf

[4] CEE, Residential Clothes Washer Specification (2022). *https://library.cee1.org/system/files/library/12282/CEE_ClothesWasher_Specification_17May2022.pdf*

[5] 10 CFR Subpart B of Part 430. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B

[6] The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different depending on the efficiency of the unit. Values are based on a weighted average of top loading and front loading units (based on available product from the ENERGY STAR qualified product list accessed on 3/17/2020) and consumption data from Life-Cycle Cost and Payback Period Excel-based analytical tool, available online at: https://www.regulations.gov/docketBrowser?rpp=25&so=DESC&sb=commentDueDate&po=0&dct=SR&D=EERE2008-BT-STD-0019

[7] Navigant, EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs (2013).

[8] To account for the different efficiency of electric and fossil fuel water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf). Therefore, a factor of 0.98/0.78 (1.26) is applied.

[9] Regulations.gov, Residential Clothes Washers Life-Cycle Cost Analysis (LCC) Spreadsheets (2021). https://www.regulations.gov/document/EERE-2017-BT-STD-0014-0025

[10] U.S. EIA 2015 Residential Energy Consumption Survey. https://www.eia.gov/consumption/residential/data/2015/

2.1.2 CLOTHES DRYER

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Clothes Washer
Measure Last Reviewed	December 2022

Description

This measure is for a new or replacement ENERGY STAR or ENERGY STAR Most Efficient residential clothes dryer. This measure relates to the installation of a residential clothes dryer meeting the ENERGY STAR V1.1 criteria. ENERGY STAR qualified clothes dryers save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions such as air flow and/or heat input rate, improving air circulation through better drum design or booster fans, and improving efficiency of motors. Reducing the runtime of dryers through automatic termination by temperature and moisture sensors is believed to have the greatest potential for reducing energy use in clothes dryers. ENERGY STAR provides criteria for both gas and electric clothes dryers.

This measure can also be used for small commercial and industrial applications.

Baseline Case

The baseline for energy savings calculations is a clothes dryer meeting the federal minimum combined energy factor for machines manufactured after January 2015. The minimum combined energy factor varies by clothes dryer type.

Efficient Case

The energy consumption of the efficient equipment is calculated based on the combined energy factor of the ENERGY STAR or ENERGY STAR Most Efficient product and other variables defined in the calculation methodology.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Cycles_{annual} \times Load \times \left(\frac{F_{elec,b}}{CEF_b} - \frac{F_{elec,q}}{CEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = Cycles_{annual} \times Load \times \left(\frac{F_{fuel,b}}{CEF_b} - \frac{F_{fuel,q}}{CEF_q}\right) \times \frac{3{,}412}{100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-10 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Cycles_{Annual}$	Number of dryer cycles per year	Site-specific. If unknown, use 283	Cycles	[14]
Hrs	Annual run hours of clothes dryer	Site-specific. If unknown, use 290[3]	Hrs/yr	[14][16]
Load	Average total weight of clothes per drying cycle	Look up in Table 2-11	lbs	[14]
$F_{elec,b}$	Percentage of energy consumed that is derived from electricity for baseline condition	Look up in Table 2-11	N/A	[15][16]
CEF_b	Combined energy factor for baseline condition	Look up in Table 2-11	lb/kWh	[13]
$F_{elec,q}$	Percentage of energy consumed that is derived from electricity for efficient condition	Look up in Table 2-11	N/A	[15][16]

[3] Assumes average of 56 minutes per cycle based on Ecova, 'Dryer Field Study', Northwest Energy Efficiency Alliance (NEEA) 2014.

Variable	Description	Value	Units	Ref
CEF_q	Combined energy factor for efficient case	Site-specific. If unknown, look up in Table 2-11	lb/kWh	[12]
$F_{fuel,b}$	Percentage of energy consumed that is derived from fossil fuel for baseline condition	Look up in Table 2-11	N/A	[15][16]
$F_{fuel,q}$	Percentage of energy consumed that is derived from fossil fuel for efficient case	Look up in Table 2-11	N/A	[15][16]
CF	Electric coincidence factor	Look up in Table 2-12	N/A	[15]
PDF	Gas peak demand factor	Look up in Table 2-12	N/A	
3,412	Conversion factor from kWh to Btu	3,412	Btu/kWh	
100,000	Conversion factor from Btu to therms	100,000	Btu/Therm	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-11 Default Values for Various Dryer Types

Dryer Type	Load	$F_{elec,b}$	$F_{elec,q}$	$F_{fuel,b}$	$F_{fuel,q}$	CEF_b	CEF_q (Energy Star)	CEF_q (Energy Star Most Efficient)
Vented Gas Dryer	8.45	0.16[4]	0.16	0.84[5]	0.84	3.30	3.48	
Ventless or Vented Electric, Standard ≥ 4.4 ft^3	8.45	1.00	1.00	0.00	0.00	3.73	3.93	4.3
Ventless or Vented Electric, Compact (120V) < 4.4 ft^3	3.00	1.00	1.00	0.00	0.00	3.61	3.80	4.3
Vented Electric, Compact (240V) < 4.4 ft^3	3.00	1.00	1.00	0.00	0.00	3.27	3.45	4.3
Ventless Electric, Compact (240V) < 4.4 ft^3	3.00	1.00	1.00	0.00	0.00	2.55	2.68	3.7

[4] %Electric accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 16% was determined using a ratio of the electric to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.

[5] %Gas accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 84% was determined using a ratio of the gas to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.

Peak Factors

Table 2-12 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[17]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 12 years [11].

References

[11] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020.

[12] ENERGY STAR Program Requirements for Clothes Dryers. n.d. Accessed December 27, 2022. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specification%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria_0.pdf

[13] PART 430 - ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS n.d. https://federalregister.gov. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430#430.32

[14] *Savings Calculator for ENERGY STAR Qualified Appliances*, ENERGY STAR, 2012. https://www.sfwmd.gov/sites/default/files/documents/calculator_energy_star_res_appliance_savings.xlsx

[15] *Mid-Atlantic Technical Reference Manual (TRM) V10.* (2020). https://neep.org/sites/default/files/media-files/trmv10.pdf

[16] ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis, August 2013. https://www.energystar.gov/sites/default/files/specs/ENERGY%20STAR%20Draft%202%20Version%201.0%20Clothes%20Dryers%20Data%20and%20Analysis.xlsx

[17] Northwest Energy Efficiency Alliance (NEEA), *Dryer Field Study*, November 2014. https://ecotope-publications-database.ecotope.com/2014_005_1_DryerStudy.pdf

2.1.3 DISHWASHER

Market	Residential/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Kitchen
Measure Last Reviewed	December 2022

Description

This measure covers the installation of ENERGY STAR® V6.0 qualified residential dishwashers. A dishwasher is a cabinet-like appliance that, with the aid of water and detergent, washes, rinses, and dries (when a drying process is included) dishware, glassware, eating utensils, and most cooking utensils by chemical, plumbing, and/or electrical means and discharges to the plumbing drainage system. ENERGY STAR® rated machines run more efficiently while washing dishes through improved technology such as soil sensors, improved water filtration, more efficient jets, and innovative dish rack designs. Qualified dishwashers are atleast 8.6% more efficient than non-certified models.

Baseline Case

The baseline condition is a residential dishwasher as defined in the Measure Description section above with type equivalent to the efficient case meeting the minimum effective federal performance standards. The baseline water heating system is a standard efficiency storage type electric or fossil fuel system (fuel type equivalent to the actual existing condition). Current federal annual energy consumption performance standards for dishwashers are provided in the table below.

Efficient Case

The compliance condition is an ENERGY STAR® V6.0 qualified residential dishwasher as defined in the Measure Description section above. Qualifying equipment must have rated annual energy consumption at or below the ENERGY STAR® qualified specifications as indicated the table below, based on dishwasher type. The energy consumption rating of the qualified dishwasher is to be taken from the application.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (F_{machine} + F_{wh} \times ElecSF_{wh})$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times F_{wh} \times FuelSF_{wh} \times 1.307 \times \frac{3{,}412}{100{,}000}$$

Summer Peak Coincident Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-13 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
kWh_q	Annual rated electric energy use for energy efficient condition	Site-specific. If unknown, look up in Table 2-14	kWh	[24]
kWh_b	Annual rated electric energy use for baseline condition	Look up in Table 2-14	kWh	[18]
$F_{machine}$	Fraction of energy used for the dishwasher machine	0.44	N/A	[19]
F_{wh}	Fraction of energy used for the water heater	0.56	N/A	[19]
Hrs	Annual operating hours	301	Hours	[18]
$ElecSF_{wh}$	Electric Savings Factor for water heaters	Look up in Table 2-15	N/A	[21]
$FuelSF_{wh}$	Fuel Savings Factor of water heaters	Look up in Table 2-15	N/A	[21]
1.307	Ratio of recovery efficiency of electric water heater to the recovery efficiency of fossil fuel water heater	1.307	N/A	[22][18]

Variable	Description	Value	Units	Ref
3,412	Conversion factor from kWh to Btu	3,412	Btu/kWh	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 2-16	N/A	
PDF	Gas peak day factor	Look up in Table 2-16	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-14 Baseline and Efficient kWh

Dishwasher Type	kWh_b	kWh_e
Compact	222	203
Standard	307	270

Table 2-15 Savings Factors

Type	Electric	Fuel
Electric WH	1.00	0
Fossil Fuel WH	0	1.00
Other	0	0
Unknown	Look up in Appendix K: DHW and Space Heat Fuel Split, or default to 0.20	Look up in Appendix K: DHW and Space Heat Fuel Split, or default to 0.54

Peak Factors

Table 2-16 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[20]
Natural gas peak day factor (PDF)	Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 11 years [23].

References

[18] 10 CFR 430.32 (f)(1). https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430#p-430.32(f)(1) An average of 215 annual 1.4-hour dishwasher cycles is assumed in order to estimate conventional and qualifying energy ratings, for a total of 301 hours of active use per year.

[19] ENERGY STAR Residential Appliance Savings Calculator, 2012.

[20] From NY TRM v10: "Based on 8,760 end use data for Missouri, provided to VEIC by Ameren for use in the Illinois TRM. The average dishwasher load during peak hours is divided by the peak load. In the absence of a New York specific load shape, this is deemed a reasonable proxy because load shapes are not expected to vary significantly by region. Data from Ameren was adjusted to account for the difference in assumed annual operating hours (252 hours were used in the referenced study whereas 301 hours are cited in this document) and peak range was adjusted to reflect New York peak time (the hour ending in 5PM) from Illinois peak time (1PM to the hour ending 5PM)."

[21] Based on NYSERDA Residential Statewide Baseline Study of New York State – July 2015.[6] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration of delivery mechanism. ElecSF and FuelSF "unknown" factors may not sum to 100% due to the presence of other water heating fuels.

[22] Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency.*

[23] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

[24] *ENERGY STAR® Program Requirements for Residential Dishwashers Eligibility Criteria Version 6.0* (2016), Table 1. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Residential%20Dishwasher%20Version%206.0%20Final%20Program%20Requirements.pdf

[6] NYSERDA Residential statewide Baseline Study. Volume 1: Single Family Report, Table 38: Water Heating Fuel Type by Climate Zone. Overall statewide averages applied. ElecSF and FuelSF "unknown" factors may not sum to 100% due to the presence of other water heating fuels. In the condition of other water heating fuels in home, the designation "Other" shall be applied.

2.1.4 INDUCTION RANGE/COOKTOP

Market	Residential/Multifamily
Baseline Condition	RF/TOS
Baseline	Existing
End Use Subcategory	Kitchen
Measure Last Reviewed	January 2023

Description

This measure is applicable to the replacement of electric resistance and fossil fuel cooktops with electric induction cooktops in single family and multifamily in-unit kitchens. Induction cooktops heat food faster, are easier to clean, are less likely to burn those using them, and have a higher cooking efficiency than electrical resistance stoves. Conventional residential cooktops typically employ fossil fuel or resistance heating elements to transfer energy, with efficiencies of approximately 32% and 75%-80% respectively. Residential induction cooking tops instead consist of an electromagnetic coil that creates a magnetic field when supplied with an electric current. When brought into this field, compatible cookware is warmed internally, transferring energy with approximately 85% efficiency. If the replacement equipment is a range or induction cooktop, the cooktop must have either 4 or 5 burners.

Baseline Case

The baseline condition is a standalone electric resistance or fossil fuel-fired cooktop.

Efficient Case

The compliance condition is an induction cooktop with compatible cookware.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b \times F_{elec,b} - kWh_q$$

Where,

$$kWh_b = 1.135 \times kWh_q$$

Annual Fuel Savings

$$\Delta Therms = Therms_b \times F_{fuel,b}$$

Where,

$$Therms_b = 2.1 \times kWh_q \times \frac{3,412}{100,000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-17 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
kWh_b	Energy consumption by electric baseline cooktop	Site-specific, if unknown use abovementioned formulae	kWh	[25]
kWh_q	Energy consumption by induction cooktop	Site-specific, if unknown use 125 kWh	kWh	[26]
hrs	Annual operating hours	Site-specific, if unknown use 365 hours	Hours	[27]
$F_{elec,b}$	Electric factor; used to account for the presence or absence of an electric cooktop in the baseline condition	Use a value of 1.0 if the baseline cooktop is electric. Otherwise, use 0.0. If unknown, use 0.61.	N/A	[30]
$F_{fuel,b}$	Fossil fuel factor; used to account for the presence or absence of a fossil fuel-fired cooktop in the baseline condition	Use a value of 1.0 is the baseline cooktop is fossil fuel. Otherwise, use 0.0. If unknown, use 0.39.	N/A	[30]
$Therms_b$	Energy consumption by fossil fuel baseline cooktop	Site-specific, if unknown use abovementioned formulae.	Therms	[28]

Variable	Description	Value	Units	Ref
1.135	Relative efficiency of induction to resistance cooktops	1.135	N/A	[25]
2.1	Relative efficiency of induction to gas cooktops	2.1	N/A	[28]
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
CF	Electric coincidence factor	See Table 2-18	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[29]

Peak Factors

Table 2-18 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 16 years [29].

References

[25] SWAP015-01, Induction Cooking with or without Electric Range, pg 7, May 2020. Available online at http://deeresources.net/workpapers. Based on relative efficiency of induction to resistance cooktops, 0.84/0.74 = 1.135

[26] ENERGY STAR®, Emerging Technology, 2021-2022 Residential Induction Cooking Tops, January 2023 https://www.energystar.gov/about/2021_residential_induction_cooking_tops

[27] Frontier Energy, Residential Cooktop Performance and Energy Comparison Study, Frontier Energy Report # 501318071-R0, Table 9, July 2019. https://cao-94612.s3.amazonaws.com/documents/Induction-Range-Final-Report-July-2019.pdf

[28] SWAP013-01, Residential Cooking Appliances – Fuel Substitution, pg 10; based on relative efficiency of induction to gas cooktops,0.84/0.399 = 2.1, May 2020

[29] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 10, January 2023.https://dps.ny.gov/system/files/documents/2023/03/c1e1783c-c3d3-48a4-8647-a5923c39553c.pdf.

[30] Residential Energy Consumption Survey 2015, table HC3.1

2.1.5 REFRIGERATORS

Market	Residential/Multifamily
Baseline Condition	NC/TOS/EREP/DI
Baseline	Code/Existing/Dual
End Use Subcategory	Kitchen
Measure Last Reviewed	September 2024
Changes Since Last Version	• Clarified language in parameter look ups • Added baseline values per JCPL PY2 evaluation

Description

This measure relates to the purchase and installation of a new refrigerator or refrigerator/freezer meeting either ENERGY STAR® 5.1 or Consortium for Energy Efficiency (CEE) TIER 2 or TIER 3 specifications (defined as requiring ≥10%, ≥15% or ≥ 20% less energy consumption than an equivalent unit meeting federal standard requirements respectively).

Baseline Case

Early Replacement (EREP): Early replacement uses a dual baseline. The baseline is the existing unit for the remaining life of the existing unit and the baseline is a code-compliant/standard efficiency unit for the remaining life of the installed equipment. Savings are calculated between the existing unit and the new efficient unit consumption during the assumed remaining life of the existing unit, and between a hypothetical new baseline unit and the efficient unit consumption for the remainder of the measure life.

Time of Sale (TOS) and new construction (NC): The baseline condition is a new refrigerator meeting the minimum federal efficiency standard for refrigerator efficiency as presented below.

Efficient Case

The efficient condition is a high-efficiency refrigerator meeting ENERGY STAR® 5.1 or Consortium for Energy Efficiency (CEE) TIER 2 or TIER 3 specifications requirements.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (1 + HVAC_c) \times F_{occ}$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times HVAC_{ff} \times F_{occ} \times 10$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{kWh_b - kWh_q}{8{,}760}\right) \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-19 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings for	Calculated	kWh/yr	
ΔTherms	Annual fuel savings for Time of Sale	Calculated	Therms/yr	
$\Delta kW_{Peak,}$	Peak Demand Savings for Time of Sale	Calculated	kWr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
AV	Adjusted volume of refrigerator	Site-specific	ft^3	

Variable	Description	Value	Units	Ref
kWh_q	Annual energy consumption of qualifying efficiency unit	Site-specific, if unknown look up in Table 2-20 for ENERGY STAR specifications and Table 2-22 for CEE specifcationsTable 2-20	kWh/yr	[32][35]
kWh_b	Annual energy consumption of code-compliant baseline unit	NC/TOS: look up code efficiency in Table 2-20. EREP/DI: use existing unit, if unknown, look up in Table 2-21.	kWh/yr	[31]
F_{occ}	Adjustment factor to account for number of occupants	Look up in Table 2-29, if unknown use 1.0	N/A	[33]
CF	Electric coincidence factor	Look up in Table 2-24	N/A	
PDF	Gas peak day factor	Look up in Table 2-24	N/A	
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	If unconditioned space, use 0, otherwise look up in Appendix F: HVAC Interactivity Factors	N/A	
$HVAC_d$	HVAC interaction factor for peak demand at utility summer peak hour	If unconditioned space, use 0, otherwise look up in Appendix F: HVAC Interactivity Factors	N/A	
$HVAC_{ff}$	HVAC interaction factor for annual fossil fuel energy consumption	If unconditioned space, use 0, otherwise look up in Appendix F: HVAC Interactivity Factors	MMBtu/kWh	
8,760	Hours per year	8,760	Hrs/yr	
10	Unit conversion, Therm/MMBtu	10	Therms/MMBtu	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 2-20 Federal Standard and ENERGY STAR Refrigerator Maximum Annual Energy Consumption

Product Category	Federal Baseline Maximum Energy Usage, kWh_b[7]	ENERGY STAR Maximum Energy Usage, kWh_q[8]
Standard Size Models: 7.75 cubic feet or greater		
1. Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	$7.99 \times AV + 225.0$	$7.19 \times AV + 202.5$
1A. All-refrigerators—manual defrost.	$6.79 \times AV + 193.6$	$6.11 \times AV + 174.2$
2. Refrigerator-freezers—partial automatic defrost	$7.99 \times AV + 225.0$	$7.19 \times AV + 202.5$
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker.	$8.07 \times AV + 233.7$	$7.26 \times AV + 210.3$
3-BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker.	$9.15 \times AV + 264.9$	$8.24 \times AV + 238.4$
3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.07 \times AV + 317.7$	$7.26 \times AV + 294.3$
3I-BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	$9.15 \times AV + 348.9$	$8.24 \times AV + 322.4$
3A. All-refrigerators—automatic defrost.	$7.07 \times AV + 201.6$	$6.36 \times AV + 181.4$
3A-BI. Built-in All-refrigerators—automatic defrost.	$8.02 \times AV + 228.5$	$7.22 \times AV + 205.7$
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	$8.51 \times AV + 297.8$	$7.66 \times AV + 268.0$
4-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	$10.22 \times AV + 357.4$	$9.20 \times AV + 321.7$
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.51 \times AV + 381.8$	$7.66 \times AV + 352.0$
4I-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	$10.22 \times AV + 441.4$	$9.20 \times AV + 405.7$
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	$8.85 \times AV + 317.0$	$7.97 \times AV + 285.3$
5-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	$9.40 \times AV + 336.9$	$8.46 \times AV + 303.2$
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.85 \times AV + 401.0$	$7.97 \times AV + 369.3$

[7] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32
[8] ENERGY STAR Program Requirements Product Specifications for Residential Refrigerators and Freezers Version 5.1. Effective 9/15/2014. https://www.energystar.gov/sites/default/files/asset/document/Refrigerators_and_Freezers_Program_Requirements_V5.1.pdf

Product Category	Federal Baseline Maximum Energy Usage, kWh_b[7]	ENERGY STAR Maximum Energy Usage, kWh_q[8]
5I-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	$9.40 \times AV + 420.9$	$8.46 \times AV + 387.2$
5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	$9.25 \times AV + 475.4$	$8.33 \times AV + 436.3$
5A-BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	$9.83 \times AV + 499.9$	$8.85 \times AV + 458.3$
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	$8.40 \times AV + 385.4$	$7.56 \times AV + 355.3$
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	$8.54 \times AV + 432.8$	$7.69 \times AV + 397.9$
7-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	$10.25 \times AV + 502.6$	$9.23 \times AV + 460.7$
Compact Size Models: Less than 7.75 cubic feet		
11. Compact refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	$9.03 \times AV + 252.3$	$8.13 \times AV + 227.1$
11A.Compact all-refrigerators—manual defrost.	$7.84 \times AV + 219.1$	$7.06 \times AV + 197.2$
12. Compact refrigerator-freezers—partial automatic defrost	$5.91 \times AV + 335.8$	$5.32 \times AV + 302.2$
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer.	$11.80 \times AV + 339.2$	$10.62 \times AV + 305.3$
13I. Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker.	$11.80 \times AV + 423.2$	$10.62 \times AV + 389.3$
13A. Compact all-refrigerators—automatic defrost.	$9.17 \times AV + 259.3$	$8.25 \times AV + 233.4$
14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer.	$6.82 \times AV + 456.9$	$6.14 \times AV + 411.2$
14I. Compact refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker.	$6.82 \times AV + 540.9$	$6.14 \times AV + 495.2$
15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer.	$11.80 \times AV + 339.2$	$10.62 \times AV + 305.3$
15I. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker.	$11.80 \times AV + 423.2$	$10.62 \times AV + 389.3$

Where $AV = fresh\ volume + (1.63 \times freezer\ volume)$

Table 2-21 Existing Refrigerator Baseline Consumption

	Primary Refrigerator	Secondary Refrigerator	Freezer
kWh_b	1120 JCPL[9] 958 All others	581	770 JCPL 593 All others

Table 2-22 CEE Residential Refrigerator Efficiency Specification

Efficiency Level	Percent Improvement Over Measured[10] Federal Minimum Efficiency Standard
CEE Tier 1[11]	10
CEE Tier 2	15
CEE Tier 3	30

Table 2-23 Occupant Adjustment Factor

Number of Occupants	F_{occ}
0	1.00
1	1.05
2	1.10
3	1.13
4	1.15
5 or more	1.16
Unknown	1.00

Peak Factors

Table 2-24 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

[9] Values from the JCPL PY2 Evaluation of the Refrigeator and Freezer Recycling Program applied to the UMP refrigerator and freezer UEC regression models.
[10] Measure Minimum Efficiency Standard is defined as the measured energy consumption of the refrigerator according to the DOE test method, prior to the application of any adder (84 kWh/yr) for automatic icemakers. For refrigerators with automatic icemakers, the percentage improvement is calculated by dividing the difference in annual energy use by the minimum efficiency standard, less the 84 kWh/yr adder.
[11] CEE Tier 1 is aligned with the ENERGY STAR Version 5.1 specifcation for resendential refrigerators.

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-25 Measure Life

Equipment	EUL	RUL	Ref
Refrigerator	12	4	[34]

References

[31] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[32] ENERGY STAR Program Requirements Product Specifications for Residential Refrigerators and Freezers Version 5.1. Effective 9/15/2014. https://www.energystar.gov/sites/default/files/asset/document/Refrigerators_and_Freezers_Program_Requirements_V5.1.pdf

[33] The Occupant Adjustment Factor is developed from simulating audits within the Oak Ridge National Laboratory, National Energy Audit Tool (NEAT), 2012. https://weatherization.ornl.gov/obtain/

[34] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx. Accessed December 2022.

[35] CEE, 2022 CEE Home Appliances Initiative and Residential Refrigerator Specification, May 2022 https://library.cee1.org/content/cee-residential-refrigerator-specification

2.1.6 FREEZER

Market	Residential/Multifamily
Baseline Condition	NC/TOS/RF/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Kitchen
Measure Last Reviewed	December 2022
Changes Since Last Version	• Clarified language in parameter look ups • Added baseline values per JCPL PY2 evaluation

Description

This measure relates to the promotion of residential freezers meeting the ENERGY STAR 5.1 criteria through retail channels and through upstream efforts such as the ENERGY STAR Retail Products Program. In the measure, a freezer meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard (NAECA). Energy usage specifications are defined in the tables below. Freezer adjusted volume used in the specifications is calculated as follows:

$$AV = 1.76 \times (total\ freezer\ volume)$$

Baseline Case

Early Replacement (EREP): Early replacement uses a dual baseline. The baseline is the existing unit for the remaining life of the existing unit and the baseline is a code-compliant/standard efficiency unit for the remaining life of the installed equipment. Savings are calculated between the existing unit and the new efficient unit consumption during the assumed remaining life of the existing unit, and between a hypothetical new baseline unit and the efficient unit consumption for the remainder of the measure life.

Time of Sale (TOS) and new construction (NC): The baseline condition is a new freezer meeting the minimum federal efficiency standard for refrigerator efficiency as presented below.

Efficient Case

The efficient equipment is defined as a freezer meeting the freezer efficiency specifications of ENERGY STAR v 5.1, as calculated below.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (1 + HVAC_c) \times F_{occ}$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times HVAC_{ff} \times F_{occ} \times 10$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{kWh_b - kWh_q}{8{,}760}\right) \times (1 + HVAC_d)\ \times\ TAF \times LSAF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-26 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
kWh_b	kWh consumption for basline case	TOS/NC: Look up code efficiency in Table 2-27, if volume unknown use Table 2-28 EREP/DI: Use existing unit, if unknown use Table 2-28	kWh/yr	[36][44]
kWh_q	kWh consumption for energy efficient case	Site-specific, if unknown look up in Table 2-27. If volume unknown use Table 2-28.	kWh/yr	[37]
F_{occ}	Adjustment factor to account for number of occupants	Look up in Table 2-29. If unknown use 1.0	N/A	[42]
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	0.080. If unconditioned space use 0	N/A	[43]
$HVAC_d$	HVAC interaction factor for peak demand at utility summer peak hour	0.175. If unconditioned space use 0	N/A	[43]
$HVAC_{ff}$	HVAC interaction factor for annual fossil fuel energy consumption	-0.002. If unconditioned space use 0	MMBtu/kWh	
TAF	Temperature Adjustment Factor	1.23	N/A	[39]
LSAF	Load Shape Adjustment Factor	1.15	N/A	[40]
CF	Electric coincidence factor	Look up in Table 2-30	N/A	
PDF	Gas peak day factor	Look up in Table 2-30	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life	See Measure Life Section	Years	

Table 2-27 Freezer Baseline and Efficient Annual kWh Consumption

Product Class	Baseline Annual kWh Consumption (kWh_b) [36]	Energy Efficient Annual kWh Consumption (kWh_q) [37]
Full-Size Freezers, where AV is adjusted volume		
8. Upright freezers with manual defrost	$5.57 \times AV + 193.7$	$5.01 \times AV + 174.3$
9. Upright freezers with automatic defrost without an automatic icemaker	$8.62 \times AV + 228.3$	$7.76 \times AV + 205.5$
9I. Upright freezers with automatic defrost with an automatic icemaker	$8.62 \times AV + 312.3$	$7.76 \times AV + 289.5$
9-BI. Built-In upright freezers with automatic defrost without an automatic icemaker	$9.86 \times AV + 260.9$	$8.87 \times AV + 234.8$
9I-BI. Built-in upright freezers with automatic defrost with an automatic icemaker	$9.86 \times AV + 344.9$	$8.87 \times AV + 318.8$
10. Chest freezers and all other freezers except compact freezers	$7.29 \times AV + 107.8$	$6.56 \times AV + 97.0$
10A. Chest freezers with automatic defrost	$10.24 \times AV + 148.1$	$9.22 \times AV + 133.3$
Compact Freezers, where AV is adjusted volume		
16. Compact upright freezers with manual defrost	$8.65 \times AV + 225.7$	$7.79 \times AV + 203.1$
17. Compact upright freezers with automatic defrost	$10.17 \times AV + 351.9$	$9.15 \times AV + 316.7$
18. Compact chest freezers	$9.25 \times AV + 136.8$	$8.33 \times AV + 123.1$

If freezer volume is unknown, use the default consumption values in Table 2-28.

Table 2-28 Default Values

Product Category	AV (assumed)	kWh_b	kWh_q	Market Share Weighting [38]
Upright Freezer	24.4	770 JCPL 593 All others	395	36.74%
Chest Freezer	18.0	770 JCPL 593 All others	215	63.26%
Weighted Average		770 JCPL 593 All others	281	100%

Table 2-29 Occupant Adjustment Factor

Number of Occupants	F_{occ}
Unknown	1.00
1	1.05

Number of Occupants	F_{occ}
2	1.10
3	1.13
4	1.15
5 or more	1.16

Peak Factors

Table 2-30 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-31 Measure Life

Equipment	EUL	RUL	Ref
Freezer	11	3.66	[41]

References

[36] "Electronic Code of Federal Regulations (ECFR)." 2020. https://www.ecfr.gov/cgi-bin/

[37] "ENERGY STAR Program Requirements for Residential Refrigerators and Freezers Partner Commitments." https://www.energystar.gov/ia/partners/product_specs/program_reqs/Refrigerators_and_Freezers_Program_Requirements_V5.0.pdf.

[38] The weighted average unit energy savings is calculated using the market share of upright and chest freezers. The assumed market share, as presented in the table above, comes from 2011 NIA-Frz-2008 Shipments data.

[39] Temperature adjustment factor based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report 2003-2004 Metering Study", July 29, 2004 (p.47) and assuming 78% of refrigerators are in cooled space (based on BGE Energy Use Survey, Report of Findings, December 2005; Mathew Greenwalk & Associates) and 22% in un-cooled space. Although this evaluation is based upon refrigerators only it is considered a reasonable estimate of the impact of cycling on freezers and gave exactly the same result as an alternative methodology based on Freezer eShape data.

[40] Daily load shape adjustment factor also based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48), (extrapolated by taking the ratio of existing summer to existing annual profile for hours ending 15 through 18, and multiplying by new annual profile).

[41] ENERGY STAR assumes 11 years based on Appliance Magazine U.S. Appliance Industry: Market Value, Life Expectancy & Replacement Picture for 2005-2012, 2011.

[42] The Occupant Adjustment Factor is developed from simulating audits within the ORNL weatherization tool, National Energy Audit Tool (NEAT), Oak Ridge National Laboratory, 2012.
[43] From NY TRM V10, Pg 1162
[44] JCPL PY2 Evaluation

2.1.7 WATER COOLER

Market	Residential/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Kitchen
Measure Last Reviewed	December 2022

Description

This measure estimates savings for installing ENERGY STAR Water Coolers compared to standard efficiency equipment in residential applications. The measurement of energy and demand savings is based on a deemed savings value multiplied by the quantity of the measure.

Baseline Case

Residential water cooler meeting Energy Star v. 2.0 Water Cooler requirements as directed by N.J. PL 2021, c. 464.

Efficient Case

ENERGY STAR v. 3.0 compliant residential water cooler.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times 365$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hr} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-32 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hr	Annual hours of operation	Site-specific. If unknown, assume 8,760	Hrs	
kWh_b	Energy use of baseline water cooler	Look up in Table 2-33	kWh/day	[45]
kWh_q	Energy use of energy efficient water cooler	Site-specific. If unknown, look up in Table 2-33	kWh/day	[46]
CF	Electric coincidence factor	Look up in Table 2-34	N/A	
PDF	Gas peak day factor	Look up in Table 2-34	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-33 Water Cooler Energy Use

Energy Star Water Cooler Type Product Capacity Class, and Conditioning Method	Baseline kWh_b (kWh/day)	Default Efficient kWh_q (kWh/day)
Cold Only	0.16	0.16
Hot & Cold – Low Capacity[12]	0.87	0.68
Hot & Cold – High Capacity[13]	0.87	0.80
Hot & Cold On-Demand	0.18	0.18

[12] A water cooler with a cold-water dispenser capacity of 0.50 gallons per hour or less, as measured per ANSI/ASHRAE Standard 18. For units that also provide hot water, the unit must have a hot-water dispenser capacity that is equal to or less than 41 exact 6 oz. cups per hour, as rated per ANSI/ASHRAE Standard 18.

[13] A water cooler with a cold-water dispenser capacity that is greater than 0.50 gallons per hour, as measured per ANSI/ASHRAE Standard 18. For units that also provide hot water, the unit must have a hot-water dispenser capacity greater than 41 exact 6 oz. cups per hour, as rated per ANSI/ASHRAE Standard 18.

Peak Factors

Table 2-34 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	[47]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years. [45]

References

[45] ENERGY STAR Product Specification for Water Coolers Version 2.0. https://www.energystar.gov/sites/default/files/specs//ES%20WC%20V2%200%20Spec.pdf

[46] ENERGY STAR Product Specifications for Water Coolers Version 3.0. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Verison%203.0%20Water%20Coolers%20Final%20Specification_0.pdf

[47] Assumes 24/7 operation. Site-specific load shape information should be used if known.

2.1.8 AIR PURIFIER

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	ISP
End Use Subcategory	Indoor Environment
Measure Last Reviewed	September 2024
Changes Since Last Version	• Clarified baseline CADR definition, use same cfm in baseline and efficient cases

Description

An air purifier (cleaner) meeting the efficiency specifications of ENERGY STAR is purchased and installed in place of a model meeting the New Jersey P.L. 2021, c. 464 minimum standards. Compliance with this standard will start on January 1, 2023. The Coincidence factor (CF) assumes that the purifier usage is evenly spread throughout the year and the annual active operating hours assume that the air purifier operates 16 hours a day for 365 days[51].

Baseline Case

The baseline equipment is assumed to be a conventional non-ENERGY STAR unit, meeting the New Jersey P.L. 2021, c. 464 minimum standards.

Efficient Case

The efficient equipment is defined as an air purifier meeting the efficiency specifications of ENERGY STAR Version 2.0. Certified air cleaner models shall produce a minimum 30 CADR for Smoke to be considered under this specification.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = Hrs \times \left(\frac{CADR_b}{CADR\_per\_watt_b \times 1{,}000}\right) + (8{,}760 - Hrs) \times \frac{PartialPower_b}{1{,}000}$$

$$kWh_q = Hrs \times \left(\frac{CADR_q}{CADR\_per\_watt_q \times 1{,}000}\right) + (8{,}760 - Hrs) \times \frac{PartialPower_q}{1{,}000}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-35 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Annual electric consumption of the baseline case	Calculated	kWh/yr	
kWh_q	Annual electric consumption of the efficient case	Calculated	kWh/yr	
$CADR_b$	Clean Air Delivery Rate (CADR) for baseline air purifier	Use same value as $CARD_q$	cfm	[48]
$CADR\_per\_watt_b$	Clean Air Delivery Rate (CADR) per watt for baseline air purifier	Look up in Table 2-36	cfm/Watt	[48]
$PartialPower_b$	Partial On Mode Power for baseline air purifier by category	Look up in Table 2-36	Watts	[48]
$CADR_q$	Clean Air Delivery Rate (CADR) for efficient air purifier	Site-specific. If unknown, look up in Table 2-37	cfm	[49]
$CADR\_per\_watt_q$	Clean Air Delivery Rate (CADR) per watt for efficient air purifier	Site-specific. If unknown, look up in Table 2-37	cfm/watt	[49]
$PartialPower_q$	Partial On Mode Power for efficient air purifier by category	Site-specific. If unknown, look up in Table 2-37	Watts	[49]

Variable	Description	Value	Units	Ref
Hrs	Annual active operating hours	5,840	Hrs	[51]
CF	Electric coincidence factor	Look up in Table 2-40	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
1,000	Conversion from Watts to kW	1,000	Watts/kW	
8,760	Hours per year	8,760	Hours	

Table 2-36 Baseline Air Purifier Specifications

Clean Air Delivery Rate (CADR) Range	CADR used indeemed savings calculation	CADR per Watt	Partial On Mode Power with WiFi connection (Watts)	Partial On Mode Power without WiFi connection (Watts)
30 ≤ CADR < 100	75	1.7	2	1
100 ≤ CADR < 150	125	1.9	2	1
150 ≤ CADR < 200	175	2.0	2	1
200 ≤ CADR < 250	225	2.0	2	1
CADR ≥ 250	275	2.0	2	1

Table 2-37 Efficient Air Purifier Specifications

Clean Air Delivery Rate (CADR) Range	CADR used in deemed savings calculation	Minimum Smoke CADR per Watt	Maximum Partial On Mode Power with WiFi connection (watts)	Maximum Partial On Mode Power without WiFi connection (watts)
51 ≤ CADR < 100	75	1.9	2	1
101 ≤ CADR < 150	125	2.4	2	1
151 ≤ CADR < 200	175	2.9	2	1
201 ≤ CADR < 250	225	2.9	2	1
CADR ≥ 250	275	2.9	2	1

Table 2-38 Deemed kWh Savings

Clean Air Delivery Rate (CADR) Range	CADR used in deemed savings calculation	kWh Savings	
		Maximum Partial On Mode Power with WiFi connection	Maximum Partial On Mode Power without WiFi connection
51 ≤ CADR < 100	75	27	27
101 ≤ CADR < 150	125	80	80
151 ≤ CADR < 200	175	159	159
201 ≤ CADR < 250	225	204	204
CADR ≥ 250	275	249	249

Table 2-39 Deemed kW Savings

Clean Air Delivery Rate (CADR) Range	CADR used in deemed savings calculation	kW Savings	
		Maximum Partial On Mode Power with WiFi connection	Maximum Partial On Mode Power without WiFi connection
51 ≤ CADR < 100	75	0.0031	0.0031
101 ≤ CADR < 150	125	0.0091	0.0091
151 ≤ CADR < 200	175	0.0181	0.0181
201 ≤ CADR < 250	225	0.0233	0.0233
CADR ≥ 250	275	0.0285	0.0285

Peak Factors

Table 2-40 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.667[14]	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 9 years [50].

[14] Assumes equal likelihood of usage at any time of day (16/24 hours)

References

[48] "New Jersey A5160 | 2020-2021 | Regular Session." n.d. LegiScan. Accessed December 21, 2022. https://legiscan.com/NJ/text/A5160/2020

[49] "ENERGY STAR Program Requirements for Room Air Cleaners -Partner Commitments ENERGY STAR ® Program Requirements for Room Air Cleaners Partner Commitments, Version 2.0 Rev. May 2002." n.d. Accessed December 21, 2022. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%202.0%20Room%20Air%20Cleaners%20Specification%20%28Rev.%20May%202022%29.pdf

[50] EPA, Consumer Messaging Guide for Energy Star Certified Appliances. August 2018. https://www.energystar.gov/sites/default/files/asset/document/ES_Consumer_Messaging_Guide_2018_508-c.pdf

[51] "ENERGY STAR Appliance Calculator". https://www.energy.gov/energysaver/maps/appliance-energy-calculator. n.d. Accessed December 21, 2022.

2.1.9 DEHUMIDIFIER

Market	Residential/Multifamily
Baseline Condition	TOS/NC
Baseline	Code /ISP
End Use Subcategory	Indoor Environment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of residential stand-alone or whole-house dehumidifiers meeting the minimum qualifying efficiency standards established under the ENERGY STAR® Program, Version 5.0, effective October 31, 2019. This measure is restricted to dehumidifiers with a product moisture removal capacity of less than or equal to 185 pints/day.

Baseline Case

The baseline condition is a stand-alone or whole-house dehumidifier meeting the minimum effective federal standard for performance.

Dehumidifiers manufactured and distributed in commerce on or after June 13, 2019, must meet the energy conservation standards, rated in Integrated Energy Factor as specified in the Code of Federal Regulations.

Efficient Case

The compliance condition is an ENERGY STAR® v. 5 qualified stand-alone or whole-house dehumidifier.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{pints/day \times 0.473 \times hrs}{24} \times \left(\frac{1}{IEF_b} - \frac{1}{IEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-41 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Pints/day	Product capacity to remove moisture	Site-specific	(pints/day)	
hrs	Annual run hours of dehumidifier	2,160	Hrs	[52]
IEF_b	Baseline Integrated Energy Factor	Look up in Table 2-42, Table 2-43	liters/kWh	[53]
IEF_q	Energy Efficient Integrated Energy Factor	Site-specific. If unknown, look up in Table 2-44, Table 2-45	liters/kWh	[54]
0.473	Conversion factor from liters to pint	0.473	liters/pint	
24	Hours in one day	24	N/A	
CF	Electric coincidence factor	Look up in Table 2-46	N/A	[55]
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-42 Stand-Alone Dehumidifiers Baseline Integrated Energy Factor

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
≤ 25.00	1.30
25.01 to 50.00	1.60
≥50.01	2.80

Table 2-43 Whole-House Dehumidifiers Baseline Integrated Energy Factor

Product Case Volume (ft^3)	Integrated Energy Factor (liters/kWh)
≤ 8.0	≥1.77
> 8.0	≥2.41

Table 2-44 Stand-Alone Dehumidifiers Energy Efficient Integrated Energy Factor

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
≤ 25.00	≥1.57
25.01 to 50.00	≥1.80
≥50.01	≥3.30

Table 2-45 Whole-House Dehumidifiers Energy Efficient Integrated Energy Factor

Product Case Volume (ft^3)	Integrated Energy Factor (liters/kWh)
≤ 8.0	≥2.09
> 8.0	≥3.30

Peak Factors

Table 2-46 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.405	[55]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years[56].

References

[52] ACEEE, Lauren Mattison and Dave Korn, The Cadmus Group, Inc.,"Dehumidifiers: A Major Consumer of Residential Electricity", 2012, https://www.aceee.org/files/proceedings/2012/data/papers/0193-000291.pdf

[53] 10 CFR 430.32(v)(2), January 2023 https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32#p-430.32(v)(2)

[54] ENERGY STAR® Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 5.0, October 2019

[55] Dehumidifier Metering in PA and Ohio by ADM from 7/17/2013 to 9/22/2013. 31 Units metered. Assumes all non-coincident peaks occur within window and that the average load during this window is representative of the June PJM days as well.
[56] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 10, January 2023.

2.1.10 ROOM AIR CONDITIONER

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Indoor Environment
Measure Last Reviewed	December 2022

Description

This measure relates to the purchase and installation of a room air conditioner that meets or exceeds the current ENERGY STAR 4.2 efficiency standards. A room air conditioner is powered by a single phase electric current and is an encased assembly designed as a unit for mounting in a window or through the wall. Qualifying units may be cooling only (non-reverse cycle) or provide cooling, heating, and ventilation. Only cooling energy savings are calculated in this measure.

Note that if the AC unit is connected to a network in a way so as to enable it to respond to energy related commands, there is a 5% extra CEER allowance. In these instances, the default baseline CEER would be 0.95 multiplied by the appropriate CEER from Table 2-48.

Baseline Case

The baseline condition is a room AC unit that meets the minimum federal efficiency standards [57] of the combined energy efficiency ratio based on the installed unit size and type.

Efficient Case

The efficient condition is a room air conditioner that meets or exceeds current ENERGY STAR specifications (version 4.2) [58]. The CEER for the efficient case should use site-specific information. If site-specific information is unknown, then default values may be used.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Cap}{1{,}000} \times \left(\frac{1}{CEER_b} - \frac{1}{CEER_q}\right) \times EFLH_c$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{Cap}{1,000} \times \left(\frac{1}{CEER_b} - \frac{1}{CEER_q}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-47 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Cap	Capacity of energy efficient equipment	Site-specific	Btu/hr	
$CEER_q$	Combined Energy Efficiency Ratio of ENERGY STAR unit in Btus per Watt-hour	Site-specific. If unknown, look up in Table 2-48	Btu/Wh	[61]
$CEER_b$	Combined Energy Efficiency Ratio of baseline unit in Btus per Watt-hour	Look up in Table 2-48, if unknown use 11.0[15]	Btu/Wh	[57]
$EFLH_c$	Cooling equivalent full-load hours	600	Hours	[63]
1,000	Conversion from W to kW	1,000	W/kW	
CF	Electric coincidence factor	Look up in Table 2-49	N/A	[62]
EUL	Effective useful life	See Measure Life Section	Years	

[15] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides [60]

Table 2-48 Standard and ENERGY STAR CEER Values for Room Air Conditioner

Product Type and Class (Btu/hour)		Federal standard with louvered sides ($CEER_b$)	Federal standard without louvered sides ($CEER_b$)	ENERGY STAR with louvered sides ($CEER_q$)	ENERGY STAR without louvered sides ($CEER_q$)
Without reverse cycle	<6,000	11.0	10.0	12.1	11.0
	6,000 to 7,999	11.0	10.0	12.1	11.0
	8,000 to 10,999	10.9	9.6	12.0	10.6
	11,000 to 13,999	10.9	9.5	12.0	10.5
	14,000 to 19,999	10.7	9.3	11.8	10.2
	20,000 to 27,999	9.4	9.4	10.3	10.3
	≥28,000	9.0	9.4	9.9	10.3
With reverse cycle	<14,000		9.3		10.2
	≥14,000		8.7		9.6
	<20,000	9.8		10.8	
	≥20,000	9.3		10.2	
Casement-only		9.5		10.5	
Casement slider		10.4		11.4	

Peak Factors

Table 2-49 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.31	[62]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years. [59]

References

[57] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, section 430.32 b) Room Air Conditioners. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[58] "ENERGY STAR Program Requirements for Room Air Conditioners -Eligibility Criteria ENERGY STAR ® Program Requirements Product Specification for Room Air Conditioners Eligibility Criteria Draft Version 4.2." n.d. Accessed January 9, 2023. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Draft%20Version%204.2%20Room%20Air%20Conditioners%20Specification_0_0.pdf
[59] GDS Associates, Inc. 2007. *Review of Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM)*. Https://Library.cee1.org. June 2007. https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf
[60] NEEP, Mid-Atlantic Technical Reference Manual, V10. pp 70-71., April 2020, https://neep.org/sites/default/files/media-files/trmv10.pdf
[61] "Room Air Conditioners Key Product Criteria." n.d. www.energystar.gov. Accessed January 10, 2023. https://www.energystar.gov/products/heating_cooling/air_conditioning_room/key_product_criteria.
[62] RLW Analytics. 2008. *Review of Coincidence Factor Study Residential Room Air Conditioners*. Puc.nh.gov. June 2008. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf.
[63] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

2.2 APPLIANCE RECYCLING

2.2.1 REFRIGERATOR & FREEZER RECYCLING

Market	Residential
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	N/A
Measure Last Reviewed	September 2024
Changes Since Last Version	• Added JCPL default values from PY2 evaluation

Description

In many cases, when a refrigerator or freezer is replaced by a homeowner, the existing unit is retained, sold, or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of the existing, functional equipment, thereby eliminating the consumption associated with that equipment. Refrigerator and freezer recycling programs (also called "bounty" programs) receive energy savings credit for permanently removing inefficient, functional refrigerators and freezers from the electric grid.

This measure covers the recycling of primary (i.e., installed in a kitchen) and secondary[16] (i.e., installed elsewhere) refrigerators, refrigerator-freezers and freezers. To account for the fact that secondary equipment is occasionally installed and operating for only part of the year, a part-time use adjustment factor has been developed and embedded within the gross savings estimate for secondary units to establish average annual per unit deemed electric savings.

This measure does not cover the recycling of equipment classified by the Code of Federal Regulations as "Compact refrigerator/refrigerator-freezer/freezer". This refers to any refrigerator, refrigerator-freezer or freezer with a total refrigerated volume of less than 7.75 ft3 (220 liters), where the total refrigerated volume has been determined in accordance with the procedure prescribed in Appendix A (refrigerators and refrigerator-freezers) or B (freezers) of 10 CFR 430 Subpart B.112.

[16] Secondary refrigerators are spare or backup refrigerators not installed in the kitchen.

Baseline Case

The savings calculations below apply to recycling of a functioning primary or secondary refrigerator, refrigerator-freezer, or freezer with total refrigerated volume of 7.75 ft3 (220 liters) or more.

Efficient Case

The compliance condition is the recycling of an existing room refrigerator or freezer as defined in the Measure Description section above.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{\Delta kWh}{unit}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{\Delta kW}{unit}\right)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-50 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	

Variable	Description	Value	Units	Ref
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkWh/unit	Energy Savings per unit	Look up in Table 2-51	kWh	[65]
ΔkW/unit	Demand Savings per unit	Look up in Table 2-51	kWh	[65]
CF	Electric coincidence factor	Look up in Table 2-52	N/A	
PDF	Gas peak demand factor	Look up in Table 2-52	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[64]

Table 2-51 Default Values for Annual Energy and Peak Demand Savings

	Primary Refrigerator	Secondary Refrigerator	Freezer
ΔkWh/unit	1120 JCPL[17] 958 All others	581	770 JCPL 593 All others
ΔkW/unit	0.15	0.10	0.10

Peak Factors

Table 2-52 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 5 years for a refrigerator and 4 years for a freezer [64].

References

[64] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[65] DNV, Appliance Recycling Program Impact Evaluation Study, June 2021 https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BE846898E-5EAE-4F42-9F97-385982740AC6%7D

[66] JCPL PY2 Evaluation

[17] Values from the JCPL PY2 Evaluation of the Refrigeator and Freezer Recyling Program applied to the UMP refrigerator and freezer UEC regression models.

Keeling, J.; Bruchs, D. (2017). Chapter 7: Refrigerator Recycling Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68563. http://www.nrel.gov/docs/fy17osti/68563.pdf

2.2.2 ROOM AC UNIT RECYCLING

Market	Residential
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	Recycling
Measure Last Reviewed	January 2023

Description

This measure describes the savings resulting from implementing a drop off service taking existing working inefficient Room Air Conditioner units from service, prior to their natural end of life. Like the Refrigerator Early Retirement / Recycling measure, this measure quantifies savings associated with the removal of room air conditioner units from service (rather than transferred to another location in the home or another household) and thus does not decrement savings due to retired units that are replaced in participants' homes. A room air conditioner is an appliance, other than a "packaged terminal air conditioner," which is powered by a single-phase electric current and that is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space.

Baseline Case

The baseline condition is the existing inefficient room air conditioning unit.

Efficient Case

The existing room air conditioning unit is removed from service and dismantled/recycled.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Hrs \times Btuh \times (1/EER_{exist})}{1{,}000} \times Part\ Use\ Factor$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-53 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hrs	Run hours of window AC unit	600	Hours	[63]
Btuh	Capacity of replaced unit	Site-specific, if unknown assume 7,829	Btu/hr	[69]
EER_{exist}	Efficiency of existing unit	Site-specific, if unknown assume 9.8	Btu/W/hr	[70]
Part Use Factor	Fraction of those units that are not in daily use throughout the entire cooling season as reported by the participant	Site-specific, if unknown use 0.34	N/A	[72]
CF	Electric coincidence factor	Look up in Table 2-54	N/A	
PDF	Gas peak day factor	Look up in Table 2-54	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 2-54 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.3	[71]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 3 years. [67]

References

[67] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx .

[68] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

[69] RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners (June 23, 2008 p. 22), based on population average. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf

[70] Minimum Federal Standard for most common room AC type (8000-14,999 capacity range with louvered sides) per federal standards from 10/1/2000 to 5/31/2014.

[71] RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners (June 23, 2008 p. 32), CF value for Hartford, CT. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf

[72] Source: Cadmus analysis, EmPOWER 2018 P1 & P2 ARP participant survey

2.2.3 DEHUMIDIFIER RECYCLING

Market	Residential
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	Dehumidifier
Measure Last Reviewed	January 2023
Changes Since Last Version	• Updated coincidence factor and source

Description

In many cases, when homeowner replaces a dehumidifier, the existing unit is retained, sold, or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of existing, functional, portable dehumidifiers, thereby eliminating the consumption associated with that equipment. This measure should target, but not be limited to, dehumidifiers put into service prior to June 2019. If provided data indicate the unit is replaced rather than retired, savings shall be based on the Residential Dehumidifier measure in this TRM.

Baseline Case

The baseline condition is the existing dehumidifier in working condition.

Efficient Case

The existing dehumidifier is removed from service and not replaced.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = capacity \times \frac{0.473}{24} \times hrs \times \frac{1}{L/kWh}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times RUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-55 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Capacity	Capacity of the unit	Site-specific. If unknown, use 56 pints/day	pints/day	
L/kWh	Dehumidifier Efficiency in liters (L) of water removed per kWh	Lookup in Table 2-56 based on manufacture date. If unknown, assume manufactuer date later than October 2012.[18]	L/kWh	[75][76][77]
0.473	Conversion factor	0.473	L/pint	
24	Conversion factor	24	Hr/day	
Hrs	Hours of use[19]	Site-specific. If unknown use 1,632	Hours/yr	[74]
CF	Electric coincidence factor	Lookup in Table 2-56	N/A	
PDF	Gas peak day factor	Lookup in Table 2-56	N/A	
RUL	Remaining useful life	See Measure Life Section	Years	[73]

Table 2-56 Dehumidifier Capacity and Efficiency

Capacity Range (pints/day)	ENERGY STAR Labeled (L/kWh)	Non-ENERGY STAR Labeled	
		Manufacture date before Oct. 2012 (≥L/kWh)	Manufacture date of Oct. 2012 or later (≥L/kWh)
≤ 25	1.57	1.00	1.35
>25 to ≤ 35	1.80	1.20	1.35

[18] Default manufacture date assumes that 2/3 of dehumidifier EUL (12 years) have elapsed [73]
(2/3) x (12 years) = 8 year vintage
2023 – (8 years) = 2015 manufacture date
[19] Default run hour assumption based on 68 days per year, 24 hours of use [74].

Capacity Range (pints/day)	ENERGY STAR Labeled (L/kWh)	Non-ENERGY STAR Labeled	
		Manufacture date before Oct. 2012 (≥L/kWh)	Manufacture date of Oct. 2012 or later (≥L/kWh)
>35 to ≤ 45	1.80	1.30	1.50
>45 to ≤ 50	1.80	1.30	1.60
>50 to ≤ 55	3.30	1.30	1.60
>54 to ≤ 75	3.30	1.50	1.70
>75 to ≤ 185	3.30	2.25	2.50

Peak Factors

Table 2-57 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.405	[78]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) is 4 years [73].

References

[73] CA DEER gives the following rule-of-thumb for remaining useful life: RUL = (1/3) X EUL. As the Energy Star Dehumidifier [replacement] uses an EUL of 12 years, we have a suggested RUL of (1/3) X 12 years = 4 years.

[74] Savings Calculator for ENERGY STAR® Qualified Appliances Version 3.0 Last Updated October 1, 2012.

[75] ENERGY STAR® Program Requirements for Dehumidifiers, Version 5.0, February 2019.

[76] 42 U.S.C, Title 42 Chapter 77, Subchapter III, Part A, (cc)(1) and (cc)(2). https://uscode.house.gov/view.xhtml?path=/prelim@title42/chapter77/subchapter3&edition=prelim

[77] Code of Federal Regulations Title 10, Chapter 2, Subchapter D, Part 430, Subpart C (v)(1). https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C

[78] Dehumidifier Metering in PA and Ohio by ADM from 7/17/2013 to 9/22/2013. 31 Units metered. Assumes all non-coincident peaks occur within window and that the average load during this window is representative of the June PJM days as well.

2.3 HVAC

2.3.1 AIR SOURCE HEAT PUMPS AND MINI-SPLIT HEAT PUMPS

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• Moved cooling-only equipment (central A/C, PTAC) to separate measure • Added partial displacement algorithm, updated description, and parameters

Description

This measure targets the use of air source heat pumps (ASHP) and mini split heat pumps in residential and low-rise multifamily applications. This measure may apply to early replacement of an existing system, replacement on failure, or installation of a new unit in a new or existing residential or multifamily low-rise building for HVAC applications.

In certain instances, air source heat pumps and mini-split heat pumps may only partially meet the heating load, requiring a supplementary heating system to satisfy the full heating load of the dwelling. As such, this measure addresses two displacement scenarios: partial and whole.

- **Partial displacement:** the heat pump fulfils a portion of the dwelling's heating load. Partial displacements occur in either of two scenarios: 1) the installation of a heat pump that shares the dwelling's heating load with a separate supplemental heating system or 2) the installation of a "dual fuel" heat pump that incorporates a backup fossil fuel furnace to supplement the heat pump output. Partial displacements are addressed in the equations below by a load factor parameter (F_{load}), which represents the actual heating output of the heat pump as compared to the total theoretical heating output.[20] The partial displacement scenario only applies to heating displacement; this measure assumes that the installed heat pump will serve the entire cooling load of the zone(s) affected by the installation. If the installed heat pump is not a cold-climate heat pump, assume a partial displacement scenario unless there is evidence for a whole displacement installation (such as proof that any pre-existing heating systems were removed).
- **Whole displacement:** the heat pump and any integrated supplemental resistance heat meets the dwelling's entire heating load. May assume whole displacement scenario if the installed heat pump is a cold-climate heat pump.

[20] For ductless heat pumps, F_{load} is calculated as the actual heating output of the heat pump divided by the total theoretical heating output. Total theoretical heating output is represented by the heat pump rated heating capacity multiplied by annual full load heating hours. See Table 2-64 for more information.
For ducted heat pumps, where the system is more likely to function with a temperature-based switchover from one central system to another, F_{load} is represented by the fraction of annual heating degree hours that are above the switchover temperature. See Table 2-65 for more information.

This measure does not accommodate the interactive effects of concurrent weatherization upgrades.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow the residential protocol presented in this measure.

Baseline Case

For whole building new construction, the baseline equipment is an air source, dual fuel or mini-split heat pump meeting the compliance requirements of IECC 2021 for single family and multifamily low-rise residential buildings (see Appendix E). Per Table R405.4.2(1) of IECC 2021, the standard reference design for residential buildings with a proposed air-source heat pump is the same heating and cooling system as proposed. For multifamily high-rise buildings, refer to the commercial heat pump measure (Section 3.5.1).

For replacement of failed equipment, or equipment reaching end of useful life, the baseline is a minimally code compliant version of the replaced system type and fuel. If the baseline system fuel is unknown, such as in a midstream delivery method, calculate savings using a gas baseline (fuel switching project, assume 14% boilers and 86% furnaces as baseline equipment) and electric baseline (non fuel switching project, assume ASHP as baseline equipment) and calculate the weighted average using the weights in the table below.[21]

	Fuel switch	Non fuel switch
ACE	0.130	0.870
JCPL	0.216	0.784
RECO	0.013	0.987
PSEG	0.412	0.588
Average	**0.193**	**0.807**

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline efficiency is the efficiency of the existing equipment. If the site-specific efficiency of the existing equipment is unknown, use the equipment efficiency from the IECC version in force when the equipment was new (if equipment vintage is unknown, use IECC 2012 efficiency requirements in Appendix E).
- For the duration of the measure life after the end of the RUL, the baseline is a minimally code-compliant version of the replaced equipment type and fuel.

For spaces with no existing heating: For previously unheated spaces in an existing home that has an existing central heating system, the customer may have planned to install a heat pump regardless of program intervention, or the customer may have planned to extend the existing central HVAC system to heat the new space. The baseline can therefore vary between a new equipment scenario and a retrofit scenario. For such installations, the baseline energy consumption

[21] Weights calculated by quantity of heat pump projects designated as fuel switching by measure name in the Tri 2 utility filings workbooks.

algorithm is designed to blend the baseline energy consumptions of the new equipment scenario and retrofit scenario using a baseline factor, $F_{baseline,h}$.[22]

$$\begin{pmatrix} Baseline\ heating \\ consumption \end{pmatrix} = F_{baseline,h} \times \begin{pmatrix} New\ equipment \\ scenario\ consumption \end{pmatrix} + (1 - F_{baseline,h}) \times \begin{pmatrix} Existing\ equipment \\ scneario\ consumption \end{pmatrix}$$

- New equipment scenario: absent the program, the customer would have purchased new heating equipment instead of extending the existing central heating system. The new equipment scenario baseline is a code-compliant air-source heat pump of the same size as the installed heat pump.
- Retrofit scenario: absent the program, the customer would have extended the existing central heating system instead of purchasing new heating equipment. The retrofit scenario baseline is the existing central heating equipment.

For spaces with no existing cooling: For homes without existing cooling, or spaces without cooling in an existing home that has an existing central cooling system, the customer may have planned to install a cooling regardless of program intervention, or the customer may have planned to leave the space without any cooling. The baseline can therefore vary between a new load scenario and a non-new load scenario. For such installations, the baseline energy consumption algorithm is designed to blend the baseline energy consumptions of the new equipment scenario and retrofit scenario using a baseline factor, $F_{baseline,c}$.[23]

$$\begin{pmatrix} Baseline\ cooling \\ consumption \end{pmatrix} = F_{baseline,c} \times \begin{pmatrix} New\ load \\ scenario\ consumption \end{pmatrix} + (1 - F_{baseline,c}) \times \begin{pmatrix} Non - new\ load \\ consumption \end{pmatrix}$$

- New load scenario: absent the program, the customer would not install any cooling. The new load scenario baseline is no existing cooling.
- Non-new load scenario: absent the program, the customer would have added cooling to the space. The non-new load scenario cooling baseline is the existing central cooling system if one exists, or a code-compliant air conditioner of the same cooling capacity as the installed heat pump.

Efficient Case

An air source heat pump or mini split heat pump that exceeds the program qualifying efficiency requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = kWh_{c,b} + kWh_{h,b}$$

[22] The baseline heating factors presented in Table 2-63 are based on reference [93]. $F_{baseline,h}$ is calculated as the total percent of respondents who would install new baseline equipment, averaged across heating fuel types in table 2-17 of the report.
[23] The baseline cooling factors presented in Table 2-63 are based on reference [93]. $F_{baseline,c}$ is calculated as the percent of respondents without existing cooling who would not have installed an alternative cooling system without the heat pump. The percent of respondents who installed a central heat pump with no existing cooling was assumed to be 46%, based on the known proportion of respondents who installed a minisplit with no existing cooling.

For partial displacement applications,

$$kWh_q = kWh_{c,q} + F_{load} \times kWh_{h,q} + (1 - F_{load}) \times kWh_{supplement}$$

If supplemental heat is an existing electric resistance heating system:

$$kWh_{supplement} = \frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$$

If supplemental heat is an existing fossil fuel system:

$$kWh_{supplement} = 0$$

For whole displacement applications,

$$kWh_q = kWh_{c,q} + kWh_{h,q}$$

Calculate $kWh_{c,b}$, $kWh_{h,b}$, and $kWh_{supplement}$ using the algorithms in Table 2-58 for the appropriate baseline and supplemental equipment type, if applicable.

Calculate $kWh_{c,q}$ and $kWh_{h,q}$ using the algorithms in Table 2-59 for the appropriate efficient equipment type.

Note:

- Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in Appendix E.
- The oversize derating factor (OSF) in the equations below is applicable for heat pump applications where the heat pump is sized based on heating capacity but is oversized for cooling. The appropriate OSF should be determined from site-specific conditions if possible; otherwise use the default values provided in Table 2-63.

Table 2-58 Baseline or Supplemental Electric Energy Consumption Equations

Baseline Equipment	Cooling kWh ($kWh_{c,b}$)	Heating kWh ($kWh_{h,b}$ or $kWh_{supplement}$)
No existing cooling	$(1 - F_{baseline,c}) \times \frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	N/A
No existing heating, central fossil fuel system	N/A	$F_{baseline,h} \times \frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h$
No existing heating, central electric resistance/electric furnace	N/A	$F_{baseline,h} \times \frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h + (1 - F_{baseline,h}) \times \frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
Mini-split heat pump, ASHP (Cooling Capacity < 65 kBtu/h) or whole building new construction	$OSF \times \frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h$

Baseline Equipment	Cooling kWh ($kWh_{c,b}$)	Heating kWh ($kWh_{h,b}$ or $kWh_{supplement}$)
Mini-split AC, Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	N/A
PTAC with electric resistance heat	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
PTAC with fossil fuel heat	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	N/A
PTHP	$OSF \times \frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_b \times 3.412 \times 1{,}000} \times EFLH_h$
Electric resistance/electric furnace heating	N/A	$\frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
Room Air Conditioner	$\frac{Cap_c}{CEER_b \times 1{,}000} \times EFLH_c$	N/A

Table 2-59 Energy Efficient Electric Energy Consumption Equations

Qualifying Equipment	Efficient Cooling kWh ($kWh_{c,q}$)	Efficient Heating kWh ($kWh_{h,q}$)
Mini-split heat pump, ASHP (Cooling Capacity < 65 kBtu/h)	$OSF \times \frac{Cap_c}{SEER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{HSPF2_q \times 1{,}000} \times EFLH_h$
PTHP	$OSF \times \frac{Cap_c}{EER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_q \times 3.412 \times 1{,}000} \times EFLH_h$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = see \text{ Table 2-60 } for\ appropriate\ baseline\ equipment\ type$$

For partial displacement applications in which the heat pump supplements an existing fossil fuel system,

$$Therms_q = (1 - F_{load}) \times Therms_b$$

For partial displacement applications in which a new supplemental fossil fuel heating system is installed,

$$Therms_q = (1 - F_{load}) \times Therms_{q,ff}$$

$$Therms_{q,ff} = see \text{ 2-61 } for\ appropriate\ qualifying\ equipment\ type$$

For whole displacement applications,

$$Therms_q = 0$$

Table 2-60 Baseline Fossil Fuel Consumption

Baseline Equipment	Baseline fuel consumption ($Therms_b$)
Fossil Fuel (Gas, Oil, Propane) Furnace/Boiler	$\frac{Cap_h}{Eff_{b,fuel} \times 100{,}000} \times EFLH_h$
No existing heating, central fossil fuel system	$(1 - F_{baseline,h}) \times \frac{Cap_h}{Eff_{b,fuel} \times 100{,}000} \times EFLH_h$

2-61 Energy Efficient Fossil Fuel Consumption

Qualifying Equipment	Efficient fuel consumption ($Therms_{q,ff}$)
New Supplemental Fossil Fuel (Gas, Oil, Propane) Furnace/Boiler	$\frac{Cap_h}{Eff_{q,fuel} \times 100{,}000} \times EFLH_h$

To calculate savings in gallons of delivered fuel, use Table 3-200.

Table 2-62 Fuel Savings in Gallons

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{Oil} = \frac{\Delta Therms}{1.4}$
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Peak Demand Savings

$$\Delta kW_{Peak} = OSF \times Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Use single baseline for whole displacement new construction and replace on failure.

Use dual baseline for early replacement addition to existing equipment. In both cases, the RUL is defined by the smaller of the pre-existing heating or cooling system RUL.

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline: $\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-63 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔGal_{Oil}	Oil savings	Calculated	Gallons	
$\Delta Gal_{Propane}$	Propane savings	Calculated	Gallons	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Cap_c	Cooling capacity of installed unit	Site-specific	Btu/hr	
Cap_h	Heating capacity of installed heat pump heating equipment	Site-specific	Btu/hr	
$SEER2_q$	SEER2 of installed unit	Site-specific	Btu/W-h	
$EER2_q$	EER2 of qualifying unit	Site-specific	Btu/W-h	
COP_q	Coefficient of performance of the qualifying unit at 47F	Site-specific	N/A	
$HSPF2_q$	HSPF2 of the installed unit	Site-specific	Btu/W-h	

Variable	Description	Value	Units	Ref
$SEER2_b$	SEER2 of baseline unit	Site-specific or lookup in Appendix E	Btu/W-h	[79][80][85][86]
$EER2_b$	EER2 of baseline unit	Site-specific or lookup in Appendix E	Btu/W-h	[79][80][85][86]
$HSPF2_b$	HSPF2 of the baseline unit	Site-specific or lookup in Appendix E.	Btu/W-h	[79][80][85][86]
$CEER_b$	Combined Energy Efficiency Ratio of baseline room air conditioner[24]	Use federal standard values in Appendix E, if unknown, use 11.0	Btu/W-h	
$Eff_{b,fuel}$	Efficiency of baseline boiler/furnace	Site-specific or lookup in Appendix E	N/A	[79][80][84]
$Eff_{q,fuel}$	Efficiency of newly installed supplemental boiler/furnace	Site-specific	N/A	
OSF	Oversize derating factor[25]	Site-specific, if unknown, use 0.8	N/A	
F_{load}	Partial Displacement Factor to account for the portion of heating load met by the heat pump	Lookup in Table 2-64	N/A	[88][90]
$F_{baseline,h}$	Fraction of projects where, absent the program, the customer would have purchased new heating equipment for a previously unheated space instead of extending existing central system	If installed heat pump is a ductless minisplit: 0.18 If installed heat pump is a ducted ASHP: 0.27	N/A	[93]
$F_{baseline,c}$	Fraction of projects where, absent the program, the customer would not have installed cooling in previously uncooled space, so the added cooling represented added electrical load	If installed heat pump is a ductless minisplit: 0.74 If installed heat pump is a ducted ASHP: 0.34	N/A	[93]
$kWh_{c,b}$	Baseline cooling electrical consumption, whole displacement	Calculated from Table 2-58	kWh/yr	
$kWh_{h,b}$	Baseline heating electrical consumption, whole displacement	Calculated from Table 2-58	kWh/yr	
$kWh_{c,q}$	Energy efficient cooling electrical consumption, whole displacement	Calculated from Table 2-59	kWh/yr	

[24] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides
[25] Heat pump systems may be sized to meet the peak heating load and will be oversized for cooling. The cooling EFLH assumes a nominal 20% oversizing. This derating factor has been added to account for the oversizing of heat pump cooling capacity when the unit is sized based on heating capacity. A user with a more accurate estimation of the oversizing can use a different factor than the one mentioned above to account for oversizing.

Variable	Description	Value	Units	Ref
$kWh_{h,q}$	Energy efficient heating electrical consumption, whole displacement	Calculated from Table 2-59	kWh/yr	
$kWh_{h,supplement}$	Energy efficient heating electrical consumption of supplemental heating system	Calculated	kWh/yr	
$Therms_b$	Baseline fuel consumption	Calculated from Table 2-58	Therms/yr	
$Therms_q$	Energy efficient fuel consumption	Calculated	Therms/yr	
$Therms_{q,ff}$	Fuel consumption of new efficient fuel equipment for partial displacement applications where a new supplemental fossil fuel heating system is installed	Calculated	Therms/yr	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in Appendix C	Hours	
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Appendix C	Hours	
COP_b	Coefficient of performance of the baseline PTHP at 47F	Lookup in Appendix C	N/A	[79][80][85][86]
1,000	Conversion from W to kW	1,000	W/kW	
3.412	Conversion factor from kWh to kBtu	3.412	kBtu/kWh	
1.4	Conversion from therms to gallons	1.4	Therms/gal	0
0.916	Conversion from therms to gallons	0.916	Therms/gal	0
CF	Cooling coincidence factor	Lookup in Table 2-66	N/A	[83]
PDF	Gas peak day factor	Lookup in Table 2-66	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[81]
RUL	Remaining useful life	See Measure Life Section	Years	

Table 2-64 Partial Displacement Factors for Ductless Heat Pumps[26]

NJ Climate Region	Supplemental Fuel Type			
	Delivered (Oil/Propane)	Electric	Natural Gas	Unknown
Northern	0.61	0.45	0.41	0.43
Southern	0.46	0.23	0.26	0.27
Coastal	0.46	0.23	0.26	0.27
Central	0.46	0.23	0.26	0.27
Pine Barrens	0.46	0.23	0.26	0.27
Statewide Average	**0.48**	**0.26**	**0.27**	**0.29**

Table 2-65 Partial Displacement Factors for Ducted Heat Pumps[27]

NJ Climate Region	Switchover Point					
	15°F	25°F	30°F	35°F (default)	40°F	45°F
Northern	0.95	0.78	0.68	0.43	0.29	0.17
Southern	0.99	0.82	0.71	0.43	0.29	0.19
Coastal	0.98	0.91	0.85	0.64	0.46	0.30
Central	0.99	0.83	0.74	0.47	0.31	0.19
Pine Barrens	1.00	0.86	0.76	0.46	0.31	0.19
Statewide Average	**0.98**	**0.84**	**0.75**	**0.48**	**0.33**	**0.20**

Note: For ducted heat pumps, assume a default switchover point of 35°F unless a site-specific switchover point is known and supported with documentation such as a photo of programmed controls.

[26] Partial displacement factors represent the fraction of the heating load provided by the heat pump. For ductless heat pumps, the partial displacement factors are calculated using data from a 2022 Heat Pump Impact Evaluation, prepared for NYSERDA by DNV (https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/PPSER/Program-Evaluation/Heat-Pump-Impact-Evaluation-Report-August-2022.pdf). The load fractions for ductless heat pumps are calculated as the measured annual heat output of the ductless heat pump divided by the total predicted annual heat output using rated heating capacity:

$F_{load}=((Actual\ heat\ output\ per\ metered\ data,\ Btu/yr))/((Total\ heat\ pump\ capacity, Btu/h)\times EFLH_{Heating})$

The New York load fractions for ductless heat pumps were mapped to New Jersey climate zones based on the corresponding ASHRAE climate zone. Default to statewide average if site-specific climate zone is unknown.

[27] Partial displacement factors represent the fraction of the heating load provided by the heat pump. For ducted heat pumps, the partial displacement factors are based on the percentage of heating degree hours above the "switchover point," or the point at which heating is assumed to switch from the heat pump to the supplemental system. Assume a default switchover point of 35°F unless a site-specific switchover point is known and supported with documentation such as a photo of programmed controls.

Peak Factors

Table 2-66 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[83]
Natural gas peak day factor (PDF)	See Appendix G	

Measure Life

The remaining useful life (RUL) for existing equipment is 1/3 of the effective useful life (EUL) of the equipment.

Table 2-67 Measure Life

Equipment	EUL	RUL	Ref
Central A/C	15	5	[81]
Air source heat pump	15	5	[81]
Mini split heat pump	15	5	[81]
PTAC/PTHP	15	5	[81]
Room air conditioner	12	4	[91]
Fossil fuel furnace/boiler	20	6.7	[81]
Electric resistance/electric furnace	20	6.7	[81][549]

References

[79] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[80] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[81] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[82] *ENERGY STAR® HVAC QUALITY INSTALLATION PROGRAM A new approach to residential HVAC efficiency and performance*. Pg 2, https://www.energystar.gov/ia/home_improvement/downloads/ESQI_factsheet.pdf?07d7-31fc

[83] NEEP, *Mid-Atlantic Technical Reference Manual*, V9. (October 2019). Pg 95 https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf

[84] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430 eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

[85] "2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed November 16, 2022. https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency.

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[87] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, section 430.32 b) Room Air Conditioners

[88] TMY3 data for NJ climate zone representative cities: Northern – Allentown, PA; Central – Trenton, NJ; Pine Barrens – McGuire AFB NJ; Southwest – Philadelphia, PA International Airport; Coastal – Atlantic City, NJ.

[89] Oak Ridge National Laboratory*, Fuel Conversions Needed in the Weatherization Assistant*, https://weatherization.ornl.gov/wp-content/uploads/2018/05/FuelConversions.pdf

[90] Adjusted the overall New York load fraction using the fraction of HDD above 32°F for each New Jersey climate zone. New York load fraction per 2022 *Heat Pump Impact Evaluation*, prepared for NYSERDA by DNV: https://pseg1com.sharepoint.com/sites/JointUtilityEnergyEfficiencyPrograms/EMVSERAJoint

[91] GDS Associates, Inc. 2007. *Review of Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM)*. Https://Library.cee1.org. June 2007. https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf

[92] *Energy Saver 101: Everything you need to know about Home Heating* https://www.energy.gov/sites/prod/files/2014/01/f6/homeHeating.pdf

[93] Guidehouse, *[R2246] Residential Heat Pump Metering Study*, May 2024. https://app.box.com/s/6u94k3zij1ocwmqlh7oxl5vnie1fmn7c

2.3.2 CENTRAL AIR CONDITIONER, MINI-SPLIT AC AND PTAC

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• Created new measure with cooling-equipment only (central AC, PTAC) • Included Mini-split Air Conditioner and Room Air Conditioner

Description

This measure targets the use of central air conditioners (AC) , mini-split air conditioners (MSAC) and packaged terminal air conditioners (PTAC) in residential and low-rise multifamily applications as further described below. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing residential or multifamily low-rise building for HVAC applications.

The algorithms also include the calculation of additional energy and demand savings due to the proper sizing of high efficiency units.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol in Section 4.5.1. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow the residential protocol presented in this measure as outlined in Table 2-58, Table 2-69 and Table 2-70 below.

Baseline Case

For time of sale or new construction projects, the baseline equipment is a central air conditioner, mini-split air conditioners or packaged terminal system minimally compliant with IECC 2021 (see Appendix E).

For early replacement projects or direct install projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the IECC version in force when the equipment was new (if equipment vintage is unknown, use IECC 2013 efficiency requirements from Appendix E).
- For the duration of the measure life after the end of the RUL, the baseline is a current code-compliant version of the replaced equipment.

Efficient Case

A central air conditioner, mini-split air conditioners or packaged terminal air conditioner (PTAC) that meets program eligibility requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Calculate kWh_b using the algorithms in Table 2-58 for the appropriate baseline equipment type.

Calculate kWh_q using the algorithms in Table 2-59 for the appropriate efficient equipment type.

Note: Conversions from SEER to SEER and EER to EER2 can be found in Appendix E.

Table 2-68 Baseline Energy Consumption Equations

Baseline Equipment	Baseline Cooling kWh (kWh_b)
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$
Room Air Conditioner	$\frac{Cap_c}{CEER_b \times 1{,}000} \times EFLH_c$
PTAC	$\frac{Cap_c}{EER_b \times 1{,}000} \times EFLH_c$

Table 2-69 Energy Efficient Energy Consumption Equations

Qualifying Equipment	Efficient Cooling kWh (kWh_q)
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_q \times 1{,}000} \times EFLH_c$
Room Air Conditioner	$\frac{Cap_c}{CEER_q \times 1{,}000} \times EFLH_c$
PTAC	$\frac{Cap_c}{EER_q \times 1{,}000} \times EFLH_c$

Peak Demand Savings

Table 2-70 Peak Demand Savings Equations

Qualifying Equipment	Peak Demand Savings (ΔkW_{Peak})
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$
Room Air Conditioner	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{CEER_b} - \frac{1}{CEER_q}\right) \times CF$
PTAC	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER_b} - \frac{1}{EER_q}\right) \times CF$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-71 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Cap_c	Cooling capacity of installed unit	Site-specific	Btu/hr	
$SEER2_q$	SEER2 of installed unit[28]	Site-specific	Btu/W-h	
$CEER_q$	CEER of installed unit	Site-specific	Btu/W-h	
$EER2_q$	EER2 of qualifying unit	Site-specific	Btu/W-h	
$SEER2_b$	SEER2 of baseline unit[1]	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or use 2013 if vintage is unknown	Btu/W-h	[94][95]
$CEER_b$	CEER of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or use 2013 if vintage is unknown	Btu/W-h	[94][95]
$EER2_b$	EER2 of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency	Btu/W-h	[94][95]

[28] SEER to SEER2 conversion found in Appendix E.

Variable	Description	Value	Units	Ref
		EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or use 2013 if vintage is unknown		
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Look up in Appendix C	Hours	
1,000	Conversion from W to kW	1,000	W/kW	
CF	Electric coincidence factor	0.69	N/A	[97]
EUL	Effective useful life	See Measure Life section	Years	[96]

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-72 Measure Life

Equipment	EUL	RUL	Ref
Central AC, MSAC and PTAC	15	5	[96]
Room AC	9	3	[96]

References

[94] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[95] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[96] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[97] NEEP, *Mid-Atlantic Technical Reference Manual*, V9. (October 2019). Pg 95 https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf

[98] See Appendix

2.3.3 WATER SOURCE HEAT PUMP (GROUNDWATER AND GROUND LOOP)

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	May 2024
Changes Since Last Version	• Algorithms revisions

Description

This prescriptive measure targets the use of water source heat pumps (sometimes called geothermal heat pumps) in residential and multifamily low-rise applications as further described below. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing residential or low-rise residential building for HVAC applications. The following heat pump types are included in this measure.

- Water-to-air groundwater
- Water-to-air ground loop
- Brine-to-air groundwater loop
- Brine-to-air ground loop

This measure is limited to single-zone equipment; complex built-up systems should follow custom analysis. This measure requires that:

- The heat pump system will be installed in lost opportunity projects *or* in retrofit/early retirement projects in buildings with viable existing ductwork.
- The heat pump system will be the sole source of heating and cooling in the space; it will not be installed in association with another non-electric source of auxiliary heat.

Baseline Case

For whole building new construction and time of sale applications, the baseline equipment is an air source, dual fuel or mini-split heat pump meeting the compliance requirements of IECC 2021. However, if the preexisting failed system was a ground-source heat pump, the baseline should reflect the type and efficiency of the previous system in accordance with IECC 2021 standards. For multi-family high-rise residential buildings, refer to the algorithms in Commercial and Industrial Section.

For replacement of failed equipment, or end of useful life, the baseline would be a minimally code compliant version of the replaced system type and fuel.

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site-specific efficiency of the existing equipment is unknown, use the equipment efficiency from the IECC version in force when the equipment was new (if equipment vintage is unknown, use IECC 2012).
- For the duration of the measure life after the end of the RUL, the baseline is a code-compliant version of the replaced equipment.

Efficient Case

A water-to-air groundwater loop water-to-air ground loop, brine-to-air groundwater loop, or brine-to-air ground loop heat pump that meets or exceeds code requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = kWh_{c,b} + kWh_{h,b} + kWh_{au,b}$$

$$kWh_q = kWh_{c,q} + kWh_{h,q} + kWh_{p,q}$$

Calculate $kWh_{c,b}$, $kWh_{h,b}$, and $kWh_{p,b}$ using the algorithms in **Table 2-73** for the appropriate baseline equipment type.

Calculate $kWh_{c,q}$, $kWh_{h,q}$, and $kWh_{p,q}$ using the algorithms in **Table 2-74** for the appropriate efficient equipment type.

Note:

Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in **Appendix E: Code-Compliant Efficiencies**.

The cooling output of the installed unit (Q_c) and the heating output of the installed unit (Q_h) are calculated as follows.

$$Q_c = Cap_c \times EFLH_c \times OSF$$

$$Q_h = Cap_h \times EFLH_h$$

The oversize derating factor (OSF) is applicable for heat pump applications where the heat pump is sized based on heating capacity but is oversized for cooling. The appropriate OSF should be determined from site-specific conditions if possible, otherwise use a default value of 0.8.

Table 2-73 Baseline Energy Consumption Equations

Baseline Equipment	Baseline Cooling kWh ($kWh_{c,b}$)	Baseline Heating kWh ($kWh_{h,b}$)	Auxiliary Energy Use kWh ($kWh_{au,b}$)[29]
Air Source Heat Pump (< 65 kBtu/h)	$\frac{Q_c}{SEER2_b \times 1{,}000}$	$\frac{Q_h}{HSPF2_b \times 1{,}000}$	N/A
Air Source Air Conditioner (< 65 kBtu/h)	$\frac{Q_c}{SEER2_b \times 1{,}000}$	N/A	N/A
PTAC with electric resistance heat	$\frac{Q_c}{EER2_b \times 1{,}000}$	N/A	N/A
PTHP	$\frac{Q_c}{EER2_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	N/A
GSHP (< 65 kBtu/h)	$\frac{Q_c}{EER2_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_b \times FLH_{pump}}{Eff_{motor,b}}$
Electric Resistance/electric furnace heating	N/A	$\frac{Q_h}{3.412 \times 1{,}000}$	N/A
Room Air Conditioner	$\frac{Q_c}{CEER_b \times 1{,}000}$	N/A	N/A
Furnace[30]	N/A	N/A	$4.908 \times Cap_{furnace} + 128.1$

Table 2-74 Qualifying Equipment Energy Consumption Equations

Efficient Cooling kWh ($kWh_{c,q}$)	Efficient Heating kWh ($kWh_{h,q}$)	Efficient Ground/Groundwater Loop Circulating Pump kWh ($kWh_{p,q}$)
$\frac{Q_c}{EER_{season,q} \times 1{,}000}$	$\frac{Q_h}{COP_{season,q} \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_q \times FLH_{pump}}{Eff_{motor,q}}$

Calculate seasonal efficiencies as follows:

If heat pump is part-load capable:

$$EER_{season,q} = F_{full} \times EER_{full,q} \times 1.09 \times F_{pump,full} + F_{part} \times EER_{part,q} \times F_{pump,part}$$

$$COP_{season,q} = F_{full} \times COP_{full,q} \times 1.08 \times F_{pump,full} + F_{part} \times COP_{part,q} \times F_{pump,part}$$

If heat pump is not part-load capable:

$$EER_{season,q} = rated\ EER$$

$$COP_{season,q} = rated\ COP$$

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[29] This parameter represents the additional energy consumption unrelated to cooling or heating. For ground source heat pumps, it represents the pump energy to circulate the heat exchange fluid through the ground loop. For furnaces, it represents the fan energy to distribute the heated air.

[30] This equation was derived by constructing a simple linear regression model that relates the output furnace heating capacity to the fan auxiliary usage using data downloaded from the AHRI website for all active residential furnaces.

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = see\ \textbf{Table 2-75}\ for\ appropriate\ baseline\ equipment\ type$$

$Therms_q = 0$ *(If the unit uses a furnace backup, use equation from Table 1-3)*

Table 2-75 Energy Efficient Fuel Consumption

Baseline Equipment	Baseline fuel consumption ($Therms_b$)
Electric heating (heat pump, electric resistance)	0
Fossil fuel furnace	$\frac{Q_h}{Eff_{b,fuel} \times 100{,}000}$

To calculate savings in gallons of delivered fuel, use Table 3-200.

Table 2-76 Fuel Savings in Gallons of Delivered Fuel

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{Oil} = \frac{\Delta Therms}{1.4}$
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Peak Demand Savings

$$\Delta kW_{Peak} = kW_{peak,cool} + kW_{peak,pump}$$

Where,

$$\Delta kW_{peak,cool} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER_{full,q}}\right) \times CF_c$$

$$\Delta kW_{peak,pump} = 0.746 \times \left\{\left(HP_b \times LF \times \frac{1}{Eff_{motor,b}}\right) - \left(HP_q \times LF \times \frac{1}{Eff_{motor,q}} \times DSF_{VFD}\right)\right\} \times CF_{pump}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-77 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔGal_{Oil}	Oil savings	Calculated	Gallons	
$\Delta Gal_{Propane}$	Propane savings	Calculated	Gallons	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Q_c	Cooling output of qualifying unit	Calculated	Btu	
Q_h	Heating output of qualifying unit	Calculated	Btu	
Cap_c	Cooling capacity of qualifying unit	Site-specific	Btu/hr	
Cap_h	Heating capacity of qualifying unit	Site-specific	Btu/hr	
$Cap_{furnace}$	Heating capacity of pre-existing furnace (MBH)	Site-specific	MBH	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in Appendix C	Hours	
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Appendix C	Hours	
F_{full}	Seasonal weighting factor for full load efficiency	0.25	N/A	[101]
$EER_{season,q}$	Adjusted EER of qualifying unit	Calculated	Btu/W-h	
$EER_{full,q}$	Full load EER of qualifying unit	Site-specific	Btu/W-h	
$F_{pump,full}$	Factor to adjust the full load efficiency to account for additional pumping power used by the system	0.90	N/A	[101]
F_{part}	Seasonal weighting factor for part load efficiency	0.75	N/A	[101]
$EER_{part,q}$	Part load EER of qualifying unit (if part load capable), per manufacturer literature or AHRI certification	Site-specific	Btu/W-h	
$F_{pump,part}$	Factor to adjust the part load efficiency to account for additional pumping power used by the system	0.84	N/A	[101]
$COP_{season,q}$	Adjusted coefficient of performance of the qualifying unit	Calculated	N/A	
$COP_{full,q}$	Full load coefficient of performance of the qualifying unit, per manufacturer literature or AHRI certification	Site-specific	N/A	
$COP_{part,q}$	Part load coefficient of performance of the qualifying unit (if part-load capable), per manufacturer literature or AHRI certification	Site-specific	N/A	
HP_q	Horsepower of qualifying ground/groundwater loop circulating pump motor	Site-specific	HP	

Variable	Description	Value	Units	Ref
HP_b	Horsepower of base case ground/groundwater loop circulating pump motor	Site-specific, if unknown use HP_q	HP	
$SEER2_b$	SEER of baseline unit	Site-specific or look up in Appendix	Btu/W-h	[105][106][108][109]
$IEER_b$	IEER of baseline unit	Site-specific or look up in Appendix EAppendix E: Code-Compliant Efficiencies	Btu/W-h	[105][106][108][109]
$EER2_b$	EER of baseline unit	Site-specific or look up in Appendix E	Btu/W-h	[105][106][108][109]
$HSPF2_b$	Heating seasonal performance factor of the baseline unit	Site-specific, if unknown look up in Appendix E	Btu/W-h	[105][106][108][109]
$CEER_b$	Combined Energy Efficiency Ratio of baseline room air conditioner[31]	Use federal standard values in Appendix E, if unknown, use 11.0	Btu/W-h	[101]
$Eff_{motor,b}$	Efficiency of base case ground/groundwater loop circulating pump motor	Site-specific, if unknown look up in **Table 2-78**	N/A	[107]
$Eff_{motor,q}$	Efficiency of qualifying ground/groundwater loop circulating pump motor	Site-specific	N/A	[107]
$Eff_{b,fuel}$	Efficiency of baseline furnace	Site-specific or look up in Appendix E	N/A	[105][106]
OSF	Oversize derating factor	Site-specific, if unknown use 0.8	N/A	
$kWh_{c,b}$	Baseline cooling electrical consumption	Calculated from **Table 2-73**	kWh/yr	
$kWh_{h,b}$	Baseline heating electrical consumption	Calculated from **Table 2-73**	kWh/yr	
$kWh_{au,b}$	Baseline auxiliary electrical consumption	Calculated from **Table 2-73**	kWh/yr	
$kWh_{c,q}$	Energy efficient cooling electrical consumption	Calculated from **Table 2-74**	kWh/yr	
$kWh_{h,q}$	Energy efficient heating electrical consumption	Calculated from **Table 2-74**	kWh/yr	
$kWh_{p,q}$	Energy efficient ground/groundwater loop circulating pump electrical consumption	Calculated from **Table 2-74**	kWh/yr	
$Therms_b$	Baseline fuel consumption	Lookup in **Table 2-75**	Therms/yr	

[31] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides

Variable	Description	Value	Units	Ref
$Therms_q$	Energy efficient fuel consumption	0	Therms/yr	
COP_b	Coefficient of performance of the baseline unit	Site-specific or look up in Appendix E	N/A	[105][106][108][109]
1.09	Correction for 9% increase in EER as the entering fluid temperature decreases from 77°F to 68°F	1.09	N/A	[101]
1.08	Correction for 8% increase in COP as entering fluid temperature increases from 32°F to 40°F	1.08	N/A	[101]
1,000	Conversion from W to kW	1,000	W/kW	
3.412	Conversion factor from kWh to kBtu	3.412	kBtu/kWh	
0.746	Conversion from HP to kW	0.746	kW/hp	
1.4	Conversion from therms to gallons	1.4	Therms/gal	
0.916	Conversion from therms to gallons	0.916	Therms/gal	
LF	Load factor of pump motor	0.75	N/A	[102]
DSF_{VFD}	Demand savings factor to account for variable speed pumping in qualifying unit	If variable speed pump: 0.210 If constant speed: 1.0		See section 2.3.6
FLH_{pump}	Annual full-load hours of ground/groundwater loop circulating pump motor, approximated as $EFLH_c + EFLH_h$	Look up in Appendix D: HVAC Fan and Pump Operating Hours	Hours	
CF_c	Cooling coincidence factor	Lookup in **Table 2-79**	N/A	
CF_{pump}	Pump coincidence factor	Lookup in **Table 2-79**	N/A	
PDF	Gas peak day factor	Lookup in **Table 2-79**	N/A	
EUL	Effective useful life	See Measure Life section	Years	
RUL	Remaining useful life	See Measure Life section	Years	

Table 2-78 Federal Baseline Motor Efficiencies

Motor HP	Motor Nominal Full-Load Efficiencies (percent)							
	2 Poles		4 Poles		6 Poles		8 Poles	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5

Motor HP	Motor Nominal Full-Load Efficiencies (percent)							
	2 Poles		4 Poles		6 Poles		8 Poles	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
3	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0

Peak Factors

Table 2-79 Peak Factors

Peak Factor	Value	Ref
Cooling coincidence factor (CFc)	0.69	[110]
Pump coincidence factor (CF_{pump})	If unit runs continuously all year, CF=1.0, else use 0.5	[112]
Natural gas peak day factor (PDF)	See Appendix G	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-80 Measure Life

Equipment	EUL	RUL	Ref
Water source Pump	15	5	[104]
Ground source heat pump	25	8.33	[103]
Central A/C	15	5	[104]
Air source heat pump	15	5	[104]
PTAC/PTHP	15	5	[104]
Room air conditioner	12	4	[91]
Fossil fuel furnace	20	6.7	[104]
Electric resistance/electric furnace	20	6.7	[104][551]

References

[99] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

[100] VEIC estimate. Extrapolation of manufacturer data.

[101] From NY TRM V11, pg 278-288

[102] *Determining Electric Motor Load and Efficiency*. (DOE, 2014), pg 1, https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

[103] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1

[104] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[105] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[106] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[107] *§ CFR431.25 Energy conservation standards and effective dates*, (2023) Table 1, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-B/subject-group-ECFR03b7039d87b7cc6/section-431.25

[108] "2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed November 16, 2022. https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency.

[109] "2012 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed January 23, 2023 https://codes.iccsafe.org/content/IECC2012P5/chapter-4-ce-commercial-energy-efficiency

[110] NEEP, *Mid-Atlantic Technical Reference Manual*, V9. (October 2019). Pg 95

[111] ENERGY STAR® HVAC QUALITY INSTALLATION PROGRAM A new approach to residential HVAC efficiency and performance. Pg 2, https://www.energystar.gov/ia/home_improvement/downloads/ESQI_factsheet.pdf?07d7-31fc

[112] Determining Electric Motor Load and Efficiency. (DOE, 2014), pg 1, https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

2.3.4 GAS FORCED AIR AND HYDRONIC HEATING

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP
Baseline	Code/Dual
End Use Subcategory	HVAC Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• Renamed to "Gas Forced Air/Hydronic Heating" • Added footnote to explain accommodate claiming energy savings for early replacement installations with non-EC motor baseline

Description

This section provides energy savings algorithms for qualifying furnaces and boilers installed in single family detached and low-rise multifamily buildings. The input values are based on the specifications of the actual equipment being installed and IECC 2021 standards which require an efficiency rating equal to or greater than the minimum required by federal law for residential units.

Baseline Case

New construction, time of sale: In the case of new construction, replacement of failed equipment, or end of useful life, the baseline furnace or boiler is a minimally code compliant unit with an efficiency as required by IECC 2021, which is the current residential code adopted by the state of New Jersey [113].

Early Replacement: In the case of early replacement of a working unit where the unit would have otherwise continued to function, use dual baselines as described below. This measure assumes the existing equipment is the same fuel type as the installed equipment.

- For the remaining useful life of existing unit: Baseline is the existing equipment of the same fuel type as the installed equipment. If unknown, use the code in force when the equipment was new. If the equipment vintage is unknown, look up the 2013 minimum efficiency from Appendix E.
- For the duration of the measure life after the RUL of the existing equipment: Baseline is a minimally code complient unit as required by IECC 2021.

Efficient Case

Furnace or boiler with an efficiency higher than code or standard practice.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$[32]

Annual Fuel Savings

$$\Delta Therms = Cap_{in} \times EFLH_h \times \frac{Eff_q/Eff_b - 1}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$[1]

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

[32] If the baseline system has a single-speed, shaded-pole (SP) or permanent-split capacitor (PSC) supply fan motor, electric energy savings should be claimed for this measure by referring to Measure 4.5.14 EC Motors. Electric energy savings cannot be claimed for new construction or time of sale baseline, or if the early replacement baseline has EC motors.

Calculation Parameters

Table 2-81 Calculation Parameters

Variable	Description	Value	Units	Ref
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_{in}	Input capacity of qualifying unit	Site-specific	kBtu/hr	
Eff_q	Furnace or Boiler Proposed Efficiency	Site-specific	N/A	
Eff_b	Furnace or Boiler Baseline Efficiency	Site-specific or unknown lookup in Table 2-82 and Table 2-83 for single family detached/multifamily low-rise units	N/A	[113]
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Look up in Appendix E	Hrs/yr	
100	Conversion factor	100	kBtu/Therms	
EUL	Effective useful life of furnace or boiler	See Measure Life section	years	[114]
RUL	Remaining useful life	See Measure Life section	years	[114]
PDF	Gas peak day factor	Lookup in Table 2-84	N/A	

Table 2-82 Baseline AFUE of Single Family and Low-Rise Multifamily Furnaces

Product Class	AFUE	Compliance Date	AFUE (Manufactured before compliance Date)
Weatherized gas furnaces	0.81	January 1, 2015.	0.78
Non-weatherized gas furnaces (not including mobile home furnaces)	0.80	November 19, 2015.	0.78
Weatherized oil-fired furnaces	0.78	January 1, 1992.	0.78
Non-weatherized oil-fired furnaces (not including mobile home furnaces)	0.83	May 1, 2013.	0.78
Mobile Home gas furnaces	0.80	November 19, 2015.	0.75
Mobile Home oil-fired furnaces	0.75	September 1, 1990.	0.75

Table 2-83 Baseline AFUE of Single Family and Low-Rise Multifamily Boilers

Product Class	AFUE Manufactured before Sep 1, 2012	AFUE (Manufactured on and after Sep 1, 2012 and before Jan 15, 2021)	AFUE (Manufactured on and after January 15, 2021)
Gas-fired hot water boiler	0.80	0.82	0.84
Gas-fired steam boiler	0.75	0.80	0.82
Oil-fired hot water boiler	0.80	0.84	0.86
Oil-fired steam boiler	0.80	0.82	0.85

Peak Factors

Table 2-84 Peak Factors

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	Look up in Appendix G	

Measure Life

The remaining useful life (RUL) for retrofit projects is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-85 Measure Life

Equipment	New construction EUL	Retrofit RUL	Ref
Furnace	20	6.7	[115]
Boiler	20	6.7	[115]

References

[113] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C §430.32(e). December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32#p-430.32(e)

[114] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[115] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/

2.3.5 HIGH EFFICIENCY BATHROOM EXHAUST FAN

Market	Residential/Multifamily
Baseline Condition	TOS/DI/EREP
Baseline	Existing
End Use	Ventilation Fan
Measure Last Reviewed	September 2024
Changes Since Last Version	• Updated HDD/CDD values and recalculated annual energy savings

Description

This market opportunity is defined by the need for continuous mechanical ventilation due to reduced air-infiltration from a tighter building shell. In retrofit projects, existing fans may be too loud, or insufficient in other ways, to be operated as required for proper ventilation.This measure assumes a fan capacity of 20 CFM at 0.1 inches of water column (w.c.) static pressure and a decibel level below 2 sones. Installations should be sized to meet the minimum ventilation rate as required by ASHRAE 62.2.

Baseline Case

Standard efficiency quiet bathroom ventilation fan, operating at a ventilation rate compliant with ASHRAE 62.2, with an average efficiency of 3.1 CFM/watt

Efficient Case

Energy efficient quiet bathroom ventilation fan, operating at a ventilation rate compliant with ASHRAE 62.2, with an average efficiency of 8.3 CFM/watt

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = CFM \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right)/1{,}000 \times Hrs$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = CFM \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right)/1{,}000 \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-86 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
CFM	Nominal Capacity of the exhaust fan	Site-specific, if unknown use 20 CFM	CFM	[116]
Eff_b	Average efficacy for baseline fan	Site-specific, if unknown use 3.1 CFM/watt	CFM/watt	[117]
Eff_q	Average efficacy for efficient fan	Site-specific, if unknown use 8.3 CFM/watt	CFM/watt	[118]
Hrs	Annual hours of operation	8,760	Hrs/yr	
CF	Electric coincidence factor	Lookup in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	

Peak Factors

Table 2-87 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	

Measure Life

The effective useful life (EUL) is 19 years [119].

References

[116] 20 CFM is used with continuous bathroom ventilation in ASHRAE 62.2. Note that 50CFM is the closest available fan size to ASHRAE 62.2 Section 4.1 Whole House Ventilation rates based upon typical square footage and bedrooms

[117] VEIC analysis looking at average baseline fan (i.e. non-Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM

[118] VEIC analysis looking at average efficient fan (i.e. Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM

[119] GDS Associates, *Measure Life Report: Residential and C&I Lighting and HVAC measures* (SPWG 2007), https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf

2.3.6 EC MOTOR

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Motor
Measure Last Reviewed	December 2022

Description

This measure covers the retrofit installation of an Electronically Commuted (EC) Motor to replace an HVAC supply fan motor or hydronic circulator pump motor in residential heating and cooling systems.

The deemed annual electric energy savings for fans are determined for each New Jersey location by scaling the energy savings derived from the evaluation of a 2014 Wisconsin ECM metering study using heating degree days and cooling degree days for each location.

Electric energy savings for pumps are calculated by multiplying the difference in the reciprocal of motor efficiencies with the efficient circulator motor horsepower.

Baseline Case

An existing HVAC fan or pump with a single-speed, shaded-pole (SP) or permanent-split capacitor (PSC) motor.

Efficient Case

HVAC fan or pump with an Electronically Commuted (EC) Motor.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

Pumps:

$$\Delta kWh = \Delta kWh_h + \Delta kWh_c$$

Where,

$$\Delta kWh_h = hp \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right) \times LF \times 0.746 \times hrs_h$$

$$\Delta kWh_c = hp \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right) \times LF \times 0.746 \times hrs_c$$

Fans:

$$\Delta kWh = \Delta kWh_{fan}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

Pumps:

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF_{pump}$$

Fans:

$$\Delta kW_{Peak} = \Delta kW_{fan} \times CF_{fan}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL = N/A$$

Calculation Parameters

Table 2-88 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Annual peak electric demand savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{fan}	Annual energy savings per fan motor	Look up in Table 2-90	kWh/unit	[120] [121]
ΔkW_{fan}	Electric demand savings per fan motor	Central A/C: 0.116 No Central A/C: 0	kW/unit	[121]

Variable	Description	Value	Units	Ref
		Unknown: 0.05[33]		
hp	Efficient circulator motor horsepower	Site-specific	HP	
Eff_b	Baseline motor efficiency	Site-specific, if unknown look up in Table 2-89	N/A	[123]
Eff_q	Efficient motor efficiency	Site-specific, if unknown look up in Table 2-89	N/A	[123]
LF	Motor load Factor	0.9	N/A	[122] [124]
hrs_h	Operating hours during the heating season	3,504	hrs/yr	[124]
hrs_c	Operating hours during the cooling season[34]	2,208	hrs/yr	[124]
hrs	Total operating hours	5,712	hrs/yr	
0.746	Conversion factor for HP to kWh	0.746	kW/HP	
CF_{fan}	Electric coincidence factor fan	Look up in Table 2-91	N/A	
CF_{pump}	Electric coincidence factor pump	Look up in Table 2-91	N/A	
EUL	Effective Useful Life	See Measure Life Section	Years	
RUL	Remaining Useful Life	See Measure Life Section	Years	

Table 2-89 Default Motor Efficiency by Motor Type

Motor Type	Assumed Efficiency
Shaded Pole (SP)	0.40
Permanent Split Capacitor (PSC)	0.50
ECM	0.70

Table 2-90 Annual Fan Energy Savings

Climate Region	Annual Energy Saved (ΔkWh_{fan})					HDD	CDD
	Total with Central AC	Total without Central AC	Circulation Mode	Heating Mode	Cooling Mode		
North	435	323	211	112	112	6,136	934

[33] Weighted average calculated using RECS 2020 Data -https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%207.7.pdf
[34] Cooling assumes three months (92 days) of 24 hour operation

Climate Region	Annual Energy Saved (ΔkWh_{fan})					HDD	CDD
	Total with Central AC	Total without Central AC	Circulation Mode	Heating Mode	Cooling Mode		
Coastal	404	298	211	87	106	4,795	886
Central	434	313	211	102	121	5,588	1,008
Pine barrens	425	312	211	101	113	5,529	945
Southwest	440	314	211	103	126	5,658	1,048
Statewide Average	429	312	211	101	117	5,553	973

*The percent difference in HDD is applied to the Heating Mode column kWh savings and the percent difference in the CDD is applied to the Cooling Mode column kWh savings.

Peak Factors

Table 2-91 Peak Factors

Peak Factor	Value	Ref
Fan coincidence factor (CF_{fan})	0.68	[121]
Pump coincidence factor (CF_{pump})	0.8	[125]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for retrofit projects is limited to the RUL of the host equipment. If unknown, assume 1/3 of the host equipment EUL.

References

[120] ONJSC: Monthly/Annual Temperature Normals (1991-2020). http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html

[121] Annual energy savings per fan motor were calculated for each New Jersey location by scaling the energy savings derived from the evaluation of a 2014 Wisconsin ECM metering study using heating degree days and cooling degree days for each location. Cadmus Group. *Focus on Energy Evaluated Deemed Savings Changes*. November 2014.

[122] US DOE, *Evaluation of Retrofit Variable-Speed Furnace Fan Motors*, January 2014. https://www.nrel.gov/docs/fy14osti/60760.pdf

[123] DOE Building Technologies Office. Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment. https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf. Accessed December 2022

[124] M Samotyj, *Assessment of New Energy Efficient Circulator Pump Technology*. (EPRI, 2010), Pg 4-3, https://www.epri.com/research/products/1020132

[125] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs V9*. (New York State Joint Utilities, 2021), Pg 211, technitechnical-resource-manual-version-9-filed-october-27-2021-effective-january-1-2022.pdf (ny.gov)cal-resource-manual-version-9-filed-october-27-2021-effective-january-1-2022.pdf (ny.gov)

2.3.7 DUCT SEALING AND DUCT INSULATION

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Category	HVAC
Measure Last Reviewed	September 2024
Changes Since Last Version	• Removed non-ducted equipment from look up tables • Clarified notes before algorithms • Removed references to DI Baseline Condition and dual baseline

Description

This measure describes evaluating the savings associated with performing duct sealing using mastic sealant or metal tape to the distribution system of homes with either central air conditioning or a ducted heating system. The measure also applies to insulating ductwork in unconditioned and semi-conditioned spaces of residential buildings.

If duct insulation is involved with the improvement, the first method, "Evaluation of Distribution Efficiency," must be used to estimate energy savings.

1) "Evaluation of Distribution Efficiency" – this methodology requires the evaluation of three duct characteristics below, and use of the Building Performance Institute's (BPI) "Guidance on Estimating Distribution Efficiency" [126], which are summarized in

Table 2-93 and Table 2-94 for convenience.

- Duct location, including percentage of duct work found within the conditioned space
- Duct leakage evaluation. The duct leakage assessment values are based on an assumption of 6.5% of assumed air handler flow (tight); 21% (average); or 35% (leaky).
- Duct insulation evaluation

Determine Distribution Efficiency by evaluating duct system before and after duct sealing using Building Performance Institute "Guidance on Estimating Distribution Efficiency" or the values reproduced from that document in Table 2-94 that match the duct system, and if the majority of the duct system is in conditioned space add the matching value fromTable 2-95, not to exceed 100%.

2) RESNET Test 380 4.4.2 – this method involves the pressurization of the house to 25 Pascals with reference to outside and a simultaneous pressurization of the duct system to reach equilibrium with the envelope or inside pressure of zero Pascals. A blower door is used to pressurize the building to 25 Pascals with reference to outside, when that is achieved the duct blaster is used to equalize the pressure difference between the duct system and the house. The amount of air required to bring the duct system to zero Pascals with reference to the building is the amount of air leaking through the

ductwork to the outside. This technique is described in detail in section 4.4.2 of the ANSI/RESNET/ICC 380 - 2016 Standards: http://www.resnet.us/professional/standards

Baseline Case

The baseline condition is existing leaky duct work within the unconditioned space in the home.

Efficient Case

The efficient condition is sealed duct work throughout the unconditioned space in the home.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Calculate electric savings for cooling equipment and/or electric heating equipment, if applicable.

Methodology 1: Evaluation of distribution efficiency

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where,

$$\Delta kWh_{cooling} = \frac{DE_{post,cool} - DE_{pre,cool}}{DE_{post,cool}} \times EFLH_{cool} \times \frac{Cap_{cool}}{SEER}$$

$$\Delta kWh_{heating} = \frac{DE_{post,heat} - DE_{pre,heat}}{DE_{post,heat}} \times EFLH_{heat} \times \frac{Cap_{heat}}{HSPF}$$

Methodology 2: RESNET Test 803.7

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where,

$$\Delta kWh_{cooling} = \frac{CFM_{25B} - CFM_{25Q}}{400} \times EFLH_{cool} \times \frac{12}{SEER}$$

$$\Delta kWh_{heating} = \frac{CFM_{25B} - CFM_{25Q}}{400} \times EFLH_{heat} \times \frac{12}{HSPF}$$

Annual Fuel Savings

Calculate fuel savings for fuel heating equipment, if applicable.

$$\Delta Therms = \frac{\frac{DE_{post,heat} - DE_{pre,heat}}{DE_{post,heat}} \times EFLH_{heat} \times Cap_{heat}}{AFUE \times 100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh_{cooling}}{EFLH_{cool}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-92 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{cooling}$	Annual electric energy savings, cooling	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual electric energy savings, heating	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_{cool}	Capacity of air cooling system	Site-specific	kBtu/hr	
Cap_{heat}	Capacity of air heating system	Site-specific	kBtu/hr	
CFM_{25B}	Standard duct leakage test result at 25 Pascal pressure differential of the duct system prior to sealing	Site-specific	CFM	
CFM_{25Q}	Standard duct leakage test result at 25 Pascal pressure differential of the duct system after sealing	Site-specific	CFM	
SEER	Seasonal energy efficiency ratio	Site-specific, if unknown look up in Table 2-95	Btu/W·hr	[126]
HSPF	Heating seasonal performance factor	Site-specific, if unknown look up in Table 2-95	Btu/W·hr	[126]
DE_{post}	Distribution efficiency after duct sealing and insulation	Look up in Table 2-93. For conditioned area, look up adder in Table 2-94	N/A	[127]

Variable	Description	Value	Units	Ref
DE_{pre}	Distribution efficiency before duct sealing and insulation	Look up in Table 2-93. For conditioned area, look up adder in Table 2-94	N/A	[127]
AFUE	Annual fuel utilization efficiency	Look up in Table 2-96	N/A	[126]
$EFLH_{cool}$	Cooling equivalent full load hours	Lookup in Appendix C: Heating and Cooling EFLH	Hrs	
$EFLH_{heat}$	Heating equivalent full load hours	Lookup in Appendix C: Heating and Cooling EFLH	Hrs	
400	Rule of Thumb, CFM/ton	Site-specific, if unknown use 400	CFM/ton	
12	Unit conversion, kBtu/hr·ton	12	kBtu/ hr·ton	
100	Unit conversion, kBtu/therm	100	kBtu/therm	
CF	Electric coincidence factor	Look up in Table 2-97	N/A	
PDF	Gas peak day factor	Look up in Table 2-97	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-93 Distribution Efficiencies

Duct Insulation	Location	Attic		Basement		Vented Crawl	
	Leakage Assessment / HVAC Type	Heat	Cool	Heat	Cool	Heat	Cool
R-0	Leaky	0.69	0.61	0.93	0.81	0.74	0.76
	Average	0.73	0.64	0.94	0.87	0.78	0.83
	Tight	0.77	0.73	0.95	0.94	0.82	0.91
R-2	Leaky	0.76	0.65	0.94	0.83	0.80	0.78
	Average	0.82	0.74	0.96	0.88	0.85	0.85
	Tight	0.87	0.84	0.97	0.95	0.90	0.93
R-4+	Leaky	0.79	0.67	0.95	0.83	0.82	0.79
	Average	0.84	0.77	0.96	0.89	0.87	0.86
	Tight	0.90	0.87	0.98	0.95	0.92	0.94
R-8+	Leaky	0.80	0.69	0.95	0.83	0.84	0.79
	Average	0.86	0.79	0.97	0.89	0.89	0.87
	Tight	0.92	0.90	0.98	0.95	0.94	0.94

For duct systems partly in unconditioned and conditioned space, add the values from Table 2-94 below to DE_{pre} and DE_{post} determined from

Table 2-93, with a max DE of 100%. Use the 50% adder values if 50% or more of the duct system is inside a conditioned space. Use the 80% adder values if 80% of more of the duct system is inside a conditioned space.

Table 2-94 Distribution Efficiencies Adders for Conditioned Space

Location	Attic				Basement				Vented Crawl			
HVAC Type	Heat		Cool		Heat		Cool		Heat		Cool	
Insulation/ Conditioned	50%	80%	50%	80%	50%	80%	50%	80%	50%	80%	50%	80%
R-0	0.06	0.11	0.04	0.09	0.02	0.03	0.02	0.03	0.06	0.11	0.03	0.05
R-2	0.04	0.06	0.04	0.07	0.01	0.01	0.01	0.02	0.03	0.05	0.02	0.03
R-4+	0.03	0.04	0.03	0.05	0.01	0.01	0.01	0.01	0.02	0.04	0.01	0.03
R-8+	0.02	0.03	0.02	0.03	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02

Table 2-95 SEER and HSPF Values

Product Class	SEER	HSPF
Split systems – air conditioners	13	-
Split systems – heat pumps	14	8.2
Single package units – air conditioners	14	-
Single package units – heat pumps	14	8.0

Table 2-96 AFUE Values

Product Class	Efficiency Value	Efficiency Unit
Non-weatherized gas furnaces	0.80	AFUE
Mobile home gas furnaces	0.80	AFUE
Non-weatherized oil-fired furnaces	0.83	AFUE
Mobile home oil-fired furnaces	0.75	AFUE
Weatherized gas furnaces	0.81	AFUE
Weatherized oil-fired furnaces	0.78	AFUE
Electric furnaces	3.412	HSPF

Peak Factors

Table 2-97 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[128]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-98 Measure Life

Equipment	EUL	RUL	Ref
Duct Sealing & Duct Insulation	15	5	[130]

References

[126] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[127] Building Performance Institute, Duct Efficiency Tables, http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf

[128] BG&E, Development of Residential Load Profile for Central Air Conditioners and Heat Pumps.

[129] Residential Energy Services Network, ANSI/RESNET/ICC 380-2019. http://www.resnet.us/blog/wp-content/uploads/2016/01/ANSI-RESNET-ICC_380-2016-posted-on-website-6-15-16.pdf

[130] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

2.3.8 HEAT OR ENERGY RECOVERY VENTILATOR

Market	Residential/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Heat Recovery
Measure Last Reviewed	December 2022

Description

This measure covers the installation of Energy Recovery Ventilators (ERV) and Heat Recovery Ventilators (HRV). ERVs and HRVs reduce heating and cooling loads while maintaining required ventilation rates by facilitating heat transfer between outgoing conditioned air and incoming outdoor air. ERVs and HRVs employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of pre-conditioning outdoor air prior to supplying the conditioned air to the space, either directly or as part of an air-conditioning system. This measure only applies in cases where ERV/HRV functionality is not required by federal, state, local, or municipal codes or standards. For the purposes of this measure, ERVs and HRVs are distinguished as follows:

- Energy Recovery Ventilator (ERV): Transfers both sensible (heat content) and latent (moisture content) heat between supply and exhaust airstreams.
- Heat Recovery Ventilator (HRV): Transfers sensible heat only between supply and exhaust airstreams.

Baseline Case

The baseline condition for this measure is a single- or multifamily dwelling with an IECC 2021-compliant exhaust fan system with no heat or energy recovery.

Efficient Case

The compliance condition for this measure is a single- or multifamily dwelling with an ASHRAE 62.2-compliant exhaust fan system equipped with AHRI certified ERV or HRV components.

Annual Energy Savings Algorithm

Note: Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in Appendix E: Code-Compliant Efficiencies.

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_c + \Delta kWh_h + \Delta kWh_{fan}$$

Cooling energy savings:

For ERVs:

$$\Delta kWh_c = \frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,c} - H_{indoor}\right)}{1{,}000 \times SEER2} \times hrs_c$$

For HRVs:

$$\Delta kWh_c = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{outdoor,c} - T_{indoor}\right)}{1{,}000 \times SEER2} \times hrs_c$$

Heating energy savings (both ERVs and HRVs):

$$\Delta kWh_h = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor} - T_{outdoor,h}\right)}{1{,}000 \times HSPF2} \times F_{ElecHeat} \times hrs_h$$

Fan energy savings:

$$\Delta kWh_{fan} = \Delta kW_{fan} \times (hrs_h + hrs_c)$$

$$\Delta kW_{fan} = CFM \times \left(\frac{1}{(cfm/watt)_b} - \frac{1}{(cfm/watt)_q}\right) \times \frac{1}{1{,}000}$$

Annual Fuel Savings

$$\Delta Therms = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,h} - T_{oudoor,h}\right)}{100{,}000 \times AFUE} \times F_{FuelHeat} \times hrs_h$$

Summer Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{1.08 \times CFM \times Eff_{hx,sense} \times (T_{outdoor,c,peak} - T_{indoor,c})}{1{,}000 \times EER} + \Delta kW_{fan}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-99 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_{c}	Annual electric energy savings during cooling season	Calculated	kWh	
ΔkWh_{h}	Annual electric energy savings during heating season	Calculated	kWh	
ΔkWh_{fan}	Annual electric energy savings due to fan operation	Calculated	kWh	
CFM	Flow rate of supply air passing through ERV/HRV	Site-specific	Ft^3/min	
$(cfm/watt)_{b}$	Baseline ERV/HRV fan efficacy	Look up in Table 2-103	cfm/watt	[137]
$(cfm/watt)_{q}$	Efficient ERV/HRV fan efficacy	Site-specific	cfm/watt	
$Eff_{hx,total}$	Total effectiveness of heat exchanger per rating in accordance with AHRI Standard 1060	Site-specific	N/A	[131]
Effhx,sens	Sensible effectiveness of heat exchanger per rating in accordance with AHRI Standard	Site-specific, if unknown use 0.65	N/A	[137]
SEER2	Seasonal average energy efficiency of electric cooling equipment	Site-specific, if unknown lookup in Appendix E: Code-Compliant Efficiencies for equipment type and size	Btu/watt-hour	
EER2	Energy efficiency ratio of electric cooling equipment[35]	Site-specific, if unknown lookup in Appendix E: Code-Compliant Efficiencies for equipment type and size	Btu/watt-hour	
HSPF2	Heating seasonal performance factor of electric heating equipment[36]	Site-specific, if unknown lookup in Appendix E: Code-Compliant Efficiencies for equipment type and size	Btu/watt-hour	

[35] If needed, calculate EER as follows:
$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$

[36] If needed, convert COP to HSPF as follows:
$HSPF = COP \times 3.412$. COP for electric resistance heat is 1.0

Variable	Description	Value	Units	Ref
AFUE	Efficiency of fossil fuel heating equipment (AFUE, Et or Ec)	Site-specific, if unknown lookup in Appendix E: Code-Compliant Efficiencies for equipment type and size	N/A	
$T_{indoor,h}$	Indoor heating setpoint temperature	Site-specific, if unknown use 70	°F	
$T_{indoor,c}$	Indoor cooling setpoint temperature	Site-specific, if unknown use 70	°F	
H_{indoor}	Enthalphy of indoor air	Lookup in Table 2-100 based on T_{indoor}	Btu/lb	
HP	Total fan horsepower	Site-specific	HP	
LF	Load factor	Site-specific, if unknown use 0.92	N/A	[136]
hrs_c	Operating hours in the cooling season	Look up in Table 2-100	hrs	[134]
hrs_h	Operating hours in the heating season	Look up in Table 2-100	hrs	[134]
$T_{outdoor,c}$	Temperature of outside air during cooling	Look up in Table 2-101	Btu/lb	[135]
$T_{outdoor,h}$	Temperature of outside air during heating	Look up in Table 2-101	Btu/lb	[135]
$T_{outdoor,c,peak}$	Peak outdoor temperature during cooling season	Look up in Table 2-104	°F	[138]
$H_{outdoor,c,peak}$	Peak Enthalpy of outdoor air during cooling season	Look up in Table 2-104	°F	[138]
$H_{outdoor,c}$	Enthalpy of outside air during cooling	Lookup in Table 2-101	Btu/lb	[135]
$F_{ElecHeat}$	Electric heating factor, to account for presence of electric heat	Use 1 if electric heat, otherwise use 0	N/A	
$F_{FuelHeat}$	Fuel heating factor, to account for presence of fuel heat	Use 1 if fuel heat, otherwise use 0	N/A	
1.08	Specific heat of air × density of inlet air @ 70°F × 60 min/hr	1.08	BTU/h.°F.CFM	
4.5	Density of inlet air at 70 °F x 60 min/hr	4.5	$Lb.min/ft^3.hr$	
60	Minutes per hour	60	Min/hr	
1,000	Conversion factor, one kW equals 1,000 Watts	1,000	W/kW	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
0.746	Conversion from horsepower to kW	0.746	kW/hp	
CF	Electric coincidence factor	Look up in Table 2-105	N/A	[132]
PDF	Gas peak day factor	Look up in Table 2-105	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-100 Indoor Enthalpy

Temperature, T_{indoor} (°F)	Enthalpy, H_{indoor} at 50% Relative Humidity (Btu/lb)	Temperature, T_{indoor} (°F)	Enthalpy, H_{indoor} at 50% Relative Humidity (Btu/lb)
65	22.7	72	26.4
66	23.2	73	27.0
67	23.7	74	27.5
68	24.2	75	28.1
69	24.8	76	28.7
70	25.3	77	29.3
71	25.8	78	29.9

Table 2-101 Heating and Cooling Hours[37]

NJ Climate Region	Heating Hours, hrs_h	Cooling Hours, hrs_c
Northern	4,970	1,670
Southwest	4,896	1,783
Coastal	4,981	1,954
Central	4,969	1,810
Pine Barrens	4,899	1,828
Statewide Average	4,955	1,808

Table 2-102 Outdoor Air Temperature and Enthalpy

NJ Climate Region	Avg. outdoor temperature during cooling season, $T_{outdoor,c}$ (°F)	Avg. outdoor temperature during heating season, $T_{outdoor,h}$ (°F)	Avg. enthalpy[38] of outdoor air at duing cooling season, $H_{outdoor,c}$ (Btu/lb)
Northern	74.6	42.1	13.1
Southwest	74.5	42.7	27.8
Coastal	73.0	46.2	27.0
Central	74.3	43.2	27.7
Pine Barrens	73.7	43.4	27.4

[37] Calculated from TMY3 data for representative weather stations for each NJ climate zone. Cooling hours are defined as any hour when outdoor air temperature is above 65°F for the months of June through August and heating hours are defined as any hour when outdoor air temperature is below 65°F for the months of October through April. The heating and cooling hours above represent the count of each in a typical meteorological year.
[38] Assuming 50% relative humidity

NJ Climate Region	Avg. outdoor temperature during cooling season, $T_{outdoor,c}$ (°F)	Avg. outdoor temperature during heating season, $T_{outdoor,h}$ (°F)	Avg. enthalpy[38] of outdoor air at duing cooling season, $H_{outdoor,c}$ (Btu/lb)
Statewide Average	74.1	43.5	25.1

Table 2-103 Baseline Fan Efficacy

Fan Location	Airflow Rate Minimum (CFM)	Minimum Efficacy (CFM/Watt)
HRV,ERV	Any	1.2
In-line supply or exhaust fan	Any	3.8
Other exhaust fan	<90	2.8
Other exhaust fan	>= 90	3.5
Unknown	Any	2.8

Table 2-104 Peak Outdoor Air Temperature and Enthalpy

NJ Climate Region	Peak outdoor temperature during cooling season, $T_{outdoor,c,peak}$ (°F)	Peak Enthalpy of outdoor air at duing cooling season, $H_{outdoor,c,peak}$ (Btu/lb)
Northern	89	40.24
Southwest	93	42.28
Coastal	90	41.26
Central	93	42.28
Pine Barrens	94	41.22
Statewide Average	92	41.65

Peak Factors

Table 2-105 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[132]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 14 years [133].

References

[131] Performance Rating of air-to-air exchanges for Energy Recovery Ventilation Equipment, AHRI, December 2022. http://www.ahrinet.org/ERVcertification

[132] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, and supported by research conducted by Cadmus on behalf of the RM Management Committee, September 2011.

[133] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report, August 2009 https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

[134] ONJSC: Monthly/Annual Temperature Normals (1991-2020), December 2022 http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html.

[135] NSRDB, TMY3 data, December 2022. https://nsrdb.nrel.gov/data-sets/tmy

[136] *Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors*, Cascade Energy, November 5, 2012. Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012

[137] "2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Table C403.8.5. Codes.iccsafe.org. Accessed November 16, 2022. https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency.

[138] ASHRAE Fundamentals 2021 - Chapter 14 Climactic Design Conditions - https://handbook.ashrae.org/Handbook.aspx#. Peak temperature and enthalpy taken from data from representative weather stations for each NJ climate zone.

2.3.9 MAINTENANCE

Market	Residential /Multifamily
Baseline Type	RF
Baseline	Existing
End Use Subcategory	Maintenance
Measure Last Reviewed	December 2022

Description

This section provides energy savings algorithms for existing HVAC maintenance in residential applications.

For gas applications, a tune-up of residential fossil fuel space heating boilers or furnaces results in improved seasonal heating efficiency. A tune-up typically involves inspection, cleaning the heating unit of dust and dirt, checking safety components, and/or adjustment of boiler and appurtenances per manufacturer's recommendations.

A gas savings calculation requires measurement of steady state furnace or boiler efficiency before and after maintenance using an electronic combustion analyzer. Alternatively, before and after maintenance efficiencies may be measured following the method described in ANSI/ASHRAE Standard 103-2007, Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers. Maximum post-maintenance efficiency must not exceed equipment nameplate efficiency. Technicians performing maintenance must provide documentation of before- and after-combustion analysis results.

Electric Units such as Central A/C and heat pumps also benefit greatly from tune ups. A tune up typically includes cleaning filters, inspecting bearings, verification of refrigerant charge and correct, if necessary, clean condenser, and if accessible, evaporator coil.

Note that gas savings calculations (therms) are only applicable for gas units, whereas electric saving calculations are only applicable for electric units.

Baseline Case

Gas: Residential fossil fuel space heating boiler or furnace in a single family or low-rise *Multifamily* building that has not received a tune-up in 5 years or more.

Electric: An existing central A/C, air source heat pump, ground source heat pump, ductless mini-split heat pump, mini-split AC, PTAC, or PTHP unit that has not received a tune-up in 5 years or more.

Efficient Case

Gas: Residential fossil fuel space heating boiler or furnace that has undergone a tune-up in accordance with the manufacturer's recommendations.

Electric: Electric unit after receiving tune-up.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_c + \Delta kWh_h$$

Where,

$$\Delta kWh_c = \frac{Cap_c}{SEER} \times SF \times EFLH_c$$

$$\Delta kWh_h = \frac{Cap_h}{HSPF} \times SF \times EFLH_h$$

For geothermal heat pumps:

$$SEER = EER_g \times GSHPDF \times GSER$$

$$HSPF = COP_g \times GSHPDF \times 3.412$$

For PTAC and PTHP:

$$SEER = EER$$

Annual Fuel Savings

$$\Delta Therms = Cap_{in} \times ELFH_h \times \frac{\left(\frac{1}{SSE_b} - \frac{1}{SSE_q}\right)}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{Cap_c}{EER} \times SF \times CF$$

For geothermal heat pumps:

$$EER = EER_g \times GSPK$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-106 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_c	Annual electric cooling energy savings	Calculated	kWh/yr	
ΔkWh_h	Annual electric heating energy savings	Calculated	kWh/yr	
SSE_b	Steady state efficiency of baseline gas HVAC equipment	Site-specific	N/A	
SSE_q	Steady state efficiency of repaired gas HVAC equipment	Site-specific	N/A	
Cap_c	Cooling Capacity of electrical unit receiving tune-up	Site-specific	kBtu/hr	
Cap_h	Heating Capacity of electrical unit receiving tune-up	Site-specific	kBtu/hr	
Cap_{in}	Input capacity of unit receiving tune-up	Site-specific	kBtu/hr	
EER	Energy Efficiency Ratio of unit receiving tune-up	Site-specific. If unknown, see Appendix E: Code-Compliant Efficiencies	Btu/W-h	[142]
EER_g	Full Load Energy Efficiency Ratio of ground source heat pump receiving tune up (this is measured differently than EER of an ASHP and must be converted)	Site-specific	Btu/W-h	
SEER/EER/HSPF/SEER2, EER2, HSPF2	Efficiency of unit receiving tune-up	Site-specific. If unknown, see Appendix E: Code-Compliant Efficiencies	Btu/W-h	[142]

Variable	Description	Value	Units	Ref
COP_g	Full Load coefficient of Performance of ground source heat pump receiving tune-up	Site-specific	N/A	
HSPF	Heating Seasonal Performance Factor of unit receiving tune-up	Site-specific. If unknown, see Appendix E: Code-Compliant Efficiencies	Btu/W-h	[142]
SF	Savings factor, assumed savings due completion of tune up[39]	0.05	N/A	[148]
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Appendix C: Heating and Cooling EFLH	Hours	[139]
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season[40]	Lookup in Appendix C: Heating and Cooling EFLH	Hours	[141]
GSER	Factor used to determine the SEER of a GSHP based on its EER_g	1.02	Btu/W-h	
GSPK	Factor to convert EER_g to the equivalent EER of an air conditioner to enable comparisons to the baseline unit	0.8416	N/A	
GSHPDF	Ground Source Heat Pump De-rate Factor	0.885	N/A	
3.412	Conversion from Btu to W-h	3.412	Btu/W-h	
CF	Electric coincidence factor	Look up in Table 2-107	N/A	
PDF	Gas peak day factor	Look up in Table 2-107	N/A	
EUL	Estimated useful life	Look up in Table 2-108	Years	
100	Conversion from kBtu to therms	100	kBtu/Therms	

[39] VEIC estimate. Extrapolation of manufacturer data.
[40] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

Peak Factors

Table 2-107 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[140]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

Measure life is dependent on the gas/electric equipment receiving a tune-up.

Table 2-108 Measure Life

Equipment	EUL	Ref
Air Conditioner – Room (RAC)	12	[143]
Air Conditioner – Central (CAC)	15	[144]
Air Conditioner – PTAC	15	[144]
Boiler, Hot Water – Steel Water Tube	24	[145]
Boiler, Hot Water – Steel Fire Tube	25	[145]
Boiler, Hot Water – Cast Iron	35	[145]
Boiler, Steam – Steel Water Tube	30	[145]
Boiler, Steam – Steel Fire Tube	25	[145]
Boiler, Steam – Cast Iron	30	[145]
Furnace, Gas Fired	22	[146]
Gas Heat Pump	15	[144]
Heat Pump - Air Source (ASHP)	15	[144]
Heat Pump – Ground Source (GSHP)	25	[147]
Heat Pump – PTHP	15	[144]
Ductless Mini-Split	15	[149]

References

[139] NJ utility analysis of heating customers, annual gas usage.
[140] NEEP, *Mid-Atlantic Technical Reference Manual*, *V10* (May 2020).
[141] VEIC estimate.
[142] NMR Group, Inc., *2018 Pennsylvania Statewide Act 129 Residential Baseline Study* (Feb 2018). https://www.puc.pa.gov/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf

[143] GDS Associates, Inc., *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures* (June 2007) Table 1 – Residential Measures.

[144] DEER 2014 EUL. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

[145] ASHRAE Handbook, 2015.

[146] U.S. DOE. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces* and *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces* (2016). https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0217

[147] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey. https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1

[148] *Residential HVAC Installation Practices: A Review of Research Findings* (US DOE, 2018), Pg 5. https://www.energy.gov/eere/buildings/articles/residential-hvac-installation-practices-review-research-findings

[149] Based on 2016 DOE Rulemaking Technical Support Document, as recommended in Navigant 'ComEd Effective Useful Life Research Report', May 2018. https://www.icc.illinois.gov/docket/P2017-0312/documents/287811/files/501915.pdf

2.3.10 BOILER CONTROLS

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use	HVAC
Measure Last Reviewed	September 2024
Changes Since Last Version	• Added default boiler capacity per PY2 evaluation results

Description

This measure applies to the installation of reset controls to a residential heating boiler to adjust the boiler water temperature based on the outdoor air temperature. A boiler reset control has two temperature sensors - one outside the house and one in the boiler water. As the outdoor temperature rises and falls, the control adjusts the water temperature to the lowest setting required to meet heating demand.

The input values are based on data supplied by the utilities and customer information on the application form, confirmed with manufacturer data. Unit savings are based on study results.

Baseline Case

Existing boiler without reset controls.

Efficient Case

Installation of boiler reset controls. The system’s minimum temperature setpoint must be set no more than 10 degrees above manufacturer’s recommended minimum return temperature.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = SF \times \frac{EFLH_h \times Cap_{in}}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = N/A$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-109 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
Cap_{in}	Input capacity of boiler	Site specific. If unknown, use 117	kBtu/hr	[156]
SF	Savings factor, estimated percent reduction in heating load due to controls being installed.	0.05	N/A	[150]
$EFLH_h$	Estimated full load hours for heating	Lookup in Appendix C: Heating and Cooling EFLH	hrs	[151]
EUL	Effective useful life	Lookup in Table 2-111	Years	
PDF	Peak day factor	Lookup in Table 2-110		
100	Conversion from kBtu to therm	100	kBtu	

Peak Factors

Table 2-110 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) of boiler controls is the smaller of to the remaining useful life (RUL) of the boiler or 7.33 years. If boiler RUL is unknown, assume 1/3 of the boiler EUL.

Table 2-111 Measure Life

Equipment	EUL	RUL	Ref
Boiler, Hot Water – Steel Water Tube	24	8	[152]
Boiler, Hot Water – Steel Fire Tube	25	8.33	[555]
Boiler, Hot Water – Cast Iron	35	11.67	[555]
Boiler, Steam – Steel Water Tube	30	10	[555]
Boiler, Steam – Steel Fire Tube	25	8.33	[555]
Boiler, Steam – Cast Iron	30	10	[555]

References

[150] GDS Associates, Inc. Natural Gas Energy Efficiency Potential in Massachusetts, 2009, p. 38 Table 6-4. https://ma-eeac.org/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

[151] Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

[152] ASHRAE Handbook, 2015.

[153] ETG PY2 Impact Evaluation

2.3.11 FILTER WHISTLE

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Filter Whistle
Measure Last Reviewed	December 2022
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This section provides energy savings algorithms for filter whistles on air handlers installed in residential settings. Dirty air handler filters result in increases energy consumption for the circulation fan and decreases system heating and cooling efficiency. These whistles attach to the filter of the air handler and make a sound when it is time to replace the filter.

Savings estimates are based on reduced blower fan motor power requirements for winter and summer use of the blower fan motor. This air handler filter whistle measure applies to central forced-air furnaces, central AC and heat pump systems. Where homes do not have central cooling, only the annual heating savings will apply.

Baseline Case

Air Handler Filter without Filter Whistle

Efficient Case

Air Handler Filter with Filter Whistle to promote regular replacement of filter

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{heat} + \Delta kWh_{cool}$$

Where,

$$kW_{motor} = HP \times 0.746$$

$$\Delta kWh_{heat} = kW_{motor} \times EFLH_h \times EI \times ISR$$

$$\Delta kWh_{cool} = kW_{motor} \times EFLH_c \times EI \times ISR$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh_{cool}}{EFLH_c} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-112 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkWh_h	Annual heating electric energy savings	Calculated	kWh/yr	
ΔkWh_c	Annual cooling electric energy savings	Calculated	kWh/yr	
kW_{motor}	Motor full load electric demand	Calculated, if HP is unknown use 0.377	kW	
HP	Horsepower of blower motor	Site specific, if unknown use 0.5[41]	HP	
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Appendix C: Heating and Cooling EFLH	Hours	[154]
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in Appendix C: Heating and Cooling EFLH	Hours	[155]
EI	Efficiency Improvement	15%	N/A	[156]
ISR	In-service rate	Look up by program in Appendix J: In-Service Rates, or use default values: Default for Kits = 15%, Default for Direct Install = 100%	N/A	[157]
CF	Electric coincidence factor	Look up in Table 2-113	N/A	
PDF	Gas peak demand factor	Look up in Table 2-113	N/A	

[41] Typical blower motor capacity for gas furnace is ¼ to ¾ HP, Avg of ½ HP =0.377kW.

Variable	Description	Value	Units	Ref
EUL	Effective useful life	See Measure Life Section	Years	[159]
0.746	Conversion factor for HP to kWh	0.746	kW/HP	

Peak Factors

Table 2-113 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[158]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-114 Measure Life

Equipment	EUL	RUL	Ref
Filter Whistle	5	1.67	[159]

References

[154] NJ utility analysis of heating customers, annual gas usage

[155] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

[156] Energy.gov *Maintaining Your Air Conditioner* (Accessed 12/16/2022), Says that replacing a dirty air filter with a clean one can lower total air conditioner energy consumption by 5-15%. Since the algorithms in this measure only take into account the blower fan energy use, a 15% savings seems reasonable. https://www.energy.gov/energysaver/maintaining-your-air-conditioner

[157] The In Service Rate is the average of values reported by FirstEnergy EDCs for kits including an air handler furnace whistle for PY9. http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/electric_distribution_company_act_129_reporting_requirements.aspx

[158] Per NY TRM: "Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the RM Management Committee."

[159] DEER 2020 http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

2.3.12 CEILING FAN

Market	Residential/Multifamily
Baseline Condition	TOS/DI
Baseline	Existing/Dual
End Use Subcategory	Ceiling Fan
Measure Last Reviewed	September 2024
Changes Since Last Version	• Clarified TOS and DI baseline definitions • Clarified when to calculate heating penalty • Moved HVAC interactivity factor look-ups to appendix

Description

This section provides energy savings algorithms for the installation of an ENERGY STAR v4.0 ceiling fan/light unit in residential settings. These units are known to be 60% more efficient than conventional units due to improved motors and blade design [160].

Since the savings from this measure are derived from more efficient ventilation and lighting, which have very different load shapes and measure life, the savings are split by component and claimed together.

Baseline Case

TOS: Code compliant ceiling fan/light unit with EISA qualified incandescent or halogen light bulbs.

DI: Use dual baseline. The baseline equipment for the first baseline period is the site-specific existing fan . The baseline equipment for the second baseline period is a code-compliant fan/light weith EISA qualified incandescent or halogen light bulbs.

Efficient Case

An ENERGY STAR v4.0 certified ceiling fan/lighting unit with LED bulbs.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{fan} + \Delta kWh_{light}$$

Where,

$$\Delta kWh_{fan} = \frac{\text{Days} \times Hrs_{fan} \times \left[\left(F_{low,b} \times W_{low,b}\right) + \left(F_{med,b} \times W_{med,b}\right) + \left(F_{high,b} \times W_{high,b}\right)\right]}{1{,}000} - \frac{\text{Days} \times Hrs_{fan} \times \left[\left(F_{low,q} \times W_{low,q}\right) + \left(F_{med,q} \times W_{med,q}\right) + \left(F_{high,q} \times W_{high,q}\right)\right]}{1{,}000}$$

$$\Delta kWh_{light} = \frac{W_{b,light} - W_{q,light}}{1{,}000} \times Hrs_{light} \times (1 + HVAC_e)$$

Annual Fuel Savings

If fan is located in unconditioned/exterior space:

$$\Delta Therms = 0$$

Heating penalty from improved lighting, if fan is located in heated space:

$$\Delta Therms = -\frac{W_{b,light} - W_{q,light}}{1{,}000} \times Hrs_{light} \times HF \times \frac{0.03412}{Eff_{heat}} \times F_{FH}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kW_{fan} + \Delta kW_{light}$$

Where,

$$\Delta kW_{fan} = \frac{W_{high,b} - W_{high,q}}{1{,}000} \times CF_{fan}$$

$$\Delta kW_{light} = \frac{W_{b,light} - W_{q,light}}{1{,}000} \times CF_{light} \times (1 + HVAC_d)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-115 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{fan}	Annual ceiling fan savings	Calculated	kWh/yr	
ΔkWh_{light}	Annual light savings	Calculated	kWh/yr	
ΔkW_{fan}	Annual fan peak demand savings	Calculated	kW	
ΔkW_{light}	Annual light peak demand savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Days	Days used per year	Site-specific, if unknown use 365	Days/yr	[163]
Hrs_{fan}	Daily Fan "On Hours"	Site-specific, if unknown use 3	Hrs/day	[163]
$W_{low,b}$	Fan wattage at Low speed of baseline	TOS: 15 DI: Site-specific, if unknown use 15	Watts	[163]
$W_{med,b}$	Fan wattage at Medium speed of baseline	TOS: 34 DI: Site-specific, if unknown use 34	Watts	[163]
$W_{high,b}$	Fan wattage at High speed of baseline	TOS: 67 DI: Site-specific, if unknown use 67	Watts	[163]
$W_{low,q}$	Fan wattage at Low speed of ENERGY STAR	TOS: 6 DI: Site-specific, if unknown use 6	Watts	[163]
$W_{med,q}$	Fan wattage at Medium speed of ENERGY STAR	TOS: 23 DI: Site-specific, if unknown use 23	Watts	[163]

Variable	Description	Value	Units	Ref
$W_{high,q}$	Fan wattage at High speed of ENERGY STAR	TOS: 56 DI: Site-specific, if unknown use 56	Watts	[163]
$W_{b,light}$	Total lighting wattage of baseline fixture	TOS: 129 DI: Site-specific, if unknown use 129	Watts	[163]
$W_{q,light}$	Total lighting wattage of energy efficient fixture	TOS: 42 DI: Site-specific, if unknown use 42	Watts	[163]
F_{FH}	Fraction of homes using fossil fuel heat	Look up in Appendix K: DHW and Space Heat Fuel Split	N/A	
$F_{low,b}$	Fraction of time spent at Low speed of baseline	0.4	N/A	[163]
$F_{med,b}$	Fraction of time spent at Medium speed of baseline	0.4	N/A	[163]
$F_{high,b}$	Fraction of time spent at High speed of baseline	0.2	N/A	[163]
$F_{low,q}$	Fraction of time spent at Low speed of ENERGY STAR	0.4	N/A	[163]
$F_{med,q}$	Fraction of time spent at Medium speed of ENERGY STAR	0.4	N/A	[163]
$F_{high,q}$	Fraction of time spent at High speed of ENERGY STAR	0.2	N/A	[163]
1,000	Conversion from W to kW	1,000	W/kW	
Hrs_{light}	Lighting hours of operation	Look up in Table 2-116	Hrs/yr	[161][162]
$HVAC_e$	HVAC Interactive Factor for Annual Energy Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[161]
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[161]
HF	Heating Factor	0.47	N/A	
Eff_{heat}	Efficiency of heating system	0.8	N/A	
CF	Electric coincidence factor	Look up in Table 2-117	N/A	
PDF	Gas peak demand factor	Look up in Table 2-117	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 2-116 Lighting Hours

Installation Location	Hrs
Interior	679
Exterior	1643
Unknown	808

Peak Factors

Table 2-117 Peak Factors

Peak Factor	Value	Ref
Fan coincidence factor (CF_{fan})	0.3	[164]
Light coincidence factor (CF_{light})	0.06	[161]
Natural gas peak day factor (PDF)	N/A	N/A

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-118 Measure Life

Equipment	EUL	RUL	Ref
Ceiling Fan	15	5	[161]

References

[160] "Ceiling Fans." n.d. Www.energystar.gov. https://www.energystar.gov/products/ceiling_fans.

[161] "MID-ATLANTIC TECHNICAL REFERENCE MANUAL VERSION 9." n.d. Accessed November 23, 2022. https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf .

[162] DNV KEMA Energy and Sustainability, Pacific Northwest National Laboratory, *Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates*. (US DOE, 2012), Table 4.4, https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf

[163] https://www.energystar.gov/sites/default/files/asset/document/light_fixture_ceiling_fan_calculator.xlsx

[164] Assuming that the CF for a ceiling fan is the same as Room AC; Consistent with coincidence factors found in: *RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners*, (June 23, 2008) http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf

2.3.13 SMART THERMOSTAT

Market	Residential/Multifamily
Baseline Condition	RF/TOS
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline • Corrected capacity units in parameters table • Added ISR parameter to algorithms • Added deemed savings for Midstream delivery method

Description

This measure covers the installation of Smart or Connected ENERGY STAR® V1.0[42] thermostats applied to single-family and multifamily residential HVAC systems. A "smart" thermostat that is ENERGY STAR® certified has the following properties [167].

- Automatic scheduling
- Occupancy sensing (set "on" as a default)
- For homes with a heat pump, smart thermostats must be capable of controlling heat pumps to optimize energy use and minimize the use of backup electric resistance heat.
- Ability to adjust settings remotely via a smart phone or online. In the absence of connectivity to the connected thermostat (CT) service provider, retain the ability for residents to locally:
    - View the room temperature,
    - View and adjust the set temperature, and
    - Switch between off, heating and cooling
- Have a static temperature accuracy ≤ ± 2.0 °F
- Have network standby average power consumption of ≤ 3.0 W average (Includes all equipment necessary to establish connectivity to the CT service provider's cloud, except those that can reasonably be expected to be present in the home, such as Wi-Fi routers and smart phones.)

[42] ENERGY STAR® V2.0 Connected Thermostats is under development.

- Enter network standby after ≤ 5.0 minutes from user interaction (on device, remote or occupancy detection)
- The following capabilities may be enabled through the CT device, CT service or any combination of the two. The CT product shall maintain these capabilities through subsequent firmware and software changes.
    - Ability for consumers to set and modify a schedule.
    - Provision of feedback to occupants about the energy impact of their choice of settings.
    - Ability for consumers to access information relevant to their HVAC energy consumption, e.g. HVAC run time.

Baseline Case

Mix of standard non-programmable and programmable thermostats for central heating and cooling systems

Efficient Case

Smart Thermostat meeting the measure description above.

Annual Energy Savings Algorithms

Note: Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in Appendix E: Code-Compliant Efficiencies.

Annual Electric Energy Savings

$$\Delta kWh = ISR \times (\Delta kWh_{cool} + \Delta kWh_{heat})$$

Where,

$$\Delta kWh_{cool} = \left(Cap_c \times EFLH_{cool} \times \frac{1}{SEER2} \times SF_{elec,c} \times F_{elecCool}\right)$$

$$\Delta kWh_{heat} = \left(Cap_{h,out} \times EFLH_{heat} \times \frac{1}{HSPF2} \times SF_{elec,h} \times F_{elecHeat}\right)$$

Annual Fuel Savings

$$\Delta Therms = ISR \times Cap_{h,fuel} \times EFLH_{heat} \times \frac{1}{AFUE} \times SF_{fuel} \times F_{fuelHeat} \times \frac{1}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-119 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated For Online Marketplace or Midstream delivery, look up in Table 2-119	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_{cool}	Cooling electric savings	Calculated	kWh/yr	
ΔkWh_{heat}	Heating electric savings	Calculated	kWh/yr	
Cap_c	Cooling capacity per residence	Site-specific, if unknown use 36 kBTU/hr[43]	kBtu/hr	[172]
SEER2	Seasonal energy efficiency ratio of cooling unit	Site-specific, if unknown, look up in Appendix E: Code-Compliant Efficiencies	Btu/W-h	[165]
$EFLH_{cool}$	Equivalent full load hours of operation during cooling season	Look up in Appendix C: Heating and Cooling EFLH	Hours	[166]
$SF_{elec,c}$	Cooling energy savings factor	0.07	N/A	[170]
$F_{elecCool}$	Electric cooling factor; used to account for the presence or absence of an electric cooling system	Electric Cooling: 1 No Electric Cooling: 0 Unknown: 0.39	N/A	[168]
$Cap_{h,out}$	Output heating capacity in kBTU/h per residence	Site-specific, if unknown use 72 kBtu/hr[44]	kBtu/hr	[172]

[43] Assumes a 1,800 ft^2 home with 20 BTU/h-ft2 cooling load: 1,800 ft2 x 20 BTU/h-ft2 x 1/(1,000 kBTU/h)/(BTU/h) = 36 kBTU/h
[44] Assumes a 1,800 ft^2 home with 40 Btu/h-ft^2 heating load: 1,800 ft^2 x 40 Btu/h-ft^2 x 1/(1,000 kBtu/h)/(Btu/h) = 72 kBtu/h

Variable	Description	Value	Units	Ref
$Cap_{h,fuel}$	Heating capacity in of existing fossil heat unit	Site-specific, if unknown use 90 kBtu/hr[45]	kBtu/hr	[172]
HSPF2	Heating seasonal performance factor of heating unit. If rated in COP, convert using HSPF = COP x 3.412	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	Btu/W-h	[165]
$EFLH_{heat}$	Equivalent full load hours of operation during heating season	Look up in Appendix C: Heating and Cooling EFLH	Hours	[166]
AFUE	Annual fuel utilization efficiency	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	N/A	[165]
SF_{fuel}	Fuel heating energy savings factor	0.06	N/A	[170]
$SF_{elec,h}$	Electric heating energy savings factor	0.06	N/A	[170]
$F_{elecHeat}$	Electric heating factor; used to account for the presence or absence of an electric heating system	Electric Heating: 1 No Electric Heating: 0 Unknown: look up by program in Appendix K: DHW and Space Heat Fuel Split, or default = 0.15	N/A	[169]
$F_{FuelHeat}$	Fossil fuel heating factor; used to account for the presence or absence of a fossil fuel heating system	Fossil Fuel Heating: 1 No Fossil Fuel Heating: 0 Unknown: look up by program in Appendix K: DHW and Space Heat Fuel Split, or default = 0.95	N/A	[169]
100	Conversion factor, kBTU to therms	100	kBTU/therms	
CF	Electric coincidence factor	Look up in Table 2-121	N/A	
PDF	Gas peak day factor	Look up in Table 2-121	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
ISR	In-service rate	Lookup in Appendix J. Default is 1.0	N/A	

[45] Assumes a 1,800 ft^2 home with 40 Btu/h-ft^2 heating load and 80% AFUE: 1,800 ft^2 x 40 Btu/h-ft^2 x 1/0.80 x 1/(1,000 kBtu/h)/(Btu/h) = 90 kBtu/h

Table 2-120 Deemed Savings for Online Marketplace Smart Thermostats

CEF-II Equipment Combinations	ΔkWh	ΔkW	ΔTherms
Boiler and No Cooling	0	-	62.0357
Furnace (Non-Weatherized) and No Cooling	0	-	65.1375
Electric Resistance	1,221.805	-	0
CAC, No Heating	160.603	-	0
CAC, Boiler	160.603	-	62.0357
CAC, Furnace (Non-Weatherized)	160.603	-	65.1375
CAC, Electric Resistance	1,382.408	-	0
ASHP - Split	706.3351	-	0
ASHP - Package	782.8119	-	0

Peak Factors

Table 2-121 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 5 years [171].

References

[165] "2012 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed January 23, 2023 https://codes.iccsafe.org/content/IECC2012P5/chapter-4-ce-commercial-energy-efficiency

[166] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[167] *ENERGY STAR® Program Requirements Product Specification for Connected Thermostat Products, Eligibility Criteria Version 1.0*, (January 2017), pg. 10 https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Program%20Requirements%20for%20Connected%20Thermostats%20Version%201.0.pdf

[168] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC7.7 https://www.eia.gov/consumption/residential/data/2015/hc/php/hc7.7.php ("Unknown" calculated as the number of homes with central AC divided by the total number of homes).

[169] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC6.7 https://www.eia.gov/consumption/residential/data/2015/hc/php/hc6.7.php ("Unknown" calculated as the number of homes with electric heat divided by the total number of homes).

[170] *TRM Mid-Atlantic Technical Reference Manual:Version 10* (NEEP, 2020), Pg 104, https://neep.org/mid-atlantic-technical-reference-manual-trm-v10

[171] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[172] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, Version 10, Pg 308

2.4 LIGHTING

2.4.1 LAMPS AND FIXTURES

Market	Residential/Multifamily
Baseline Condition	TOS/NC/RF/EREP/ERET/DI
Baseline	Existing/Code
End Use Subcategory	Lighting
Measure Last Reviewed	September 2024
Changes Since Last Version	• Moved HVAC interactivity factor look-ups to appendix • Corrected AML and RUL labels in measure life table • Corrected hours value in parameters table

Description

This section provides energy saving algorithms for the installation of screw-in ENERGY STAR LED general service lamps, ENERGY STAR LED fixtures, ENERGY STAR specialty LED lamps, Nightlights, and Holiday Lights.

Savings from lamps and fixtures are based on the difference between the baseline lamp/fixture wattage and new lamp/fixture wattage, and the average daily hours of usage for the lighting unit being replaced.

For ENERGY STAR Lamps, baseline lamp/fixture wattage is based on the lumen output of the ENERGY STAR lamp/fixture and a minimum lamp/fixture lumen per watt efficacy. Using the relationship in this section, the baseline lamp wattage for General Service Lamps is installed lumens divided by 45 lumens per watt, compliant with Federal regulations issued on May 8, 2022 and New Jersey P.L. 2021, c. 464 minimum standards[180]. Full compliance with this standard by retailers shall commence on August 1, 2023[179].

Baseline Case

ENERGY STAR Lamps and Fixtures: Baseline wattage assumed to equal to the installed lumens divided by 45 lumens per watt for general service bulbs in kits and retail distribution. For direct install lights exempt from or installed prior to enforcement of the EISA requirement, if the site-specific baseline wattage is unknown, use the baseline wattage assumptions in Table 2-123, Table 2-124, and Table 2-125.

Nightlights: Non LED Nightlights, assumed 6.75 watts.

Holiday Lights: Traditional incandescent holiday lights with a wattage higher than the LED wattage. For incandescent mini-bulbs, incandescent C7 bulbs, and incandescent C9 bulbs, assume baselines of 0.48, 6, and 7 watts per bulb respectively.

Efficient Case

ENERGY STAR Lamps and Fixtures: Qualifying Lamp/Fixture ENERGY STAR wattage

Nightlights: Qualifying LED Nightlight wattage.

Holiday Lights: Qualifying LED Holiday Lights wattage.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

ENERGY STAR Lamps and Fixtures:

$$\Delta kWh = N_q \times \frac{W_{b,ES} - W_{q,ES}}{1{,}000} \times Hrs_{ES} \times (1 + HVAC_c) \times ISR$$

Where,

$$W_{b,ES} = \frac{Lumen_q}{45}$$

Nightlights:

$$\Delta kWh = \frac{W_{NL} \times H_{NL,daily} \times 365}{1{,}000}$$

Holiday Lights:

$$\Delta kWh = [F_{C9} \times \Delta kWh_{C9}] + [F_{C7} \times \Delta kWh_{C7}] + [F_{mini} \times \Delta kWh_{mini}]$$

Where,

$$\Delta kWh_{C9} = \frac{\left[\left(W_{b,C9} - W_{q,C9}\right) \times N_{bulbs} \times N_{strands} \times Hrs_{HL}\right]}{1{,}000}$$

$$\Delta\, kWh_{C7} = \frac{\left[\left(W_{b,C7} - W_{q,C7}\right) \times N_{bulbs} \times N_{strands} \times Hrs_{HL}\right]}{1{,}000}$$

$$\Delta\, kWh_{mini} = \frac{\left[\left(W_{b,mini} - W_{q,mini}\right) \times N_{bulbs} \times N_{strands} \times Hrs_{HL}\right]}{1{,}000}$$

Annual Fuel Savings

ENERGY STAR Lamps and Fixtures:

$$\Delta Therms = -\, N_q \times \frac{W_{b,ES} - W_{q,ES}}{1{,}000} \times Hrs \times HVAC_{ff} \times \frac{0.03412}{Eff_{heat}} \times F_{FH}$$

No fuel savings associated with Nightlights and Holiday Lights.

Peak Demand Savings

ENERGY STAR Lamps and Fixtures:

$$\Delta kW_{Peak} = N_q \times \frac{W_{b,ES} - W_{q,ES}}{1{,}000} \times CF \times (1 + HVAC_d)$$

No Peak Demand Savings associated with Nightlights and Holiday Lights.

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-122 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
N_q	Quantity of energy efficient fixtures	Site-specifc	N/A	
$W_{b,ES}$	Wattage of baseline fixture	EISA Compliant: Calculated based on algorithm above Exempt from EISA Compliance: Site-specific, if unkown look up in Table 2-123, Table 2-124, Table 2-125	kW	[183]
$W_{q,ES}$	Wattage of energy efficient fixture	Site-specifc	kW	
$Lumens_q$	Lumens of energy efficient fixture	Site-specific	Lumens	
F_{mini}	Percentage of holiday lights that are “mini”	Site-specific, if unknown use 0.5	%	[177]

Variable	Description	Value	Units	Ref
F_{C7}	Percentage of holiday lights that are "C7"	Site-specific, if unknown use 0.25	%	[177]
F_{C9}	Percentage of holiday lights that are "C9"	Site-specific, if unknown use 0.25	%	[177]
N_{bulbs}	Number of bulbs per strand	Site-specific, if unknown use 50	Bulbs/Strand	[178]
$N_{strands}$	Number of strands of lights per package	Site-specific, if unknown use 1	Strands/package	[178]
Hrs_{ES}	Annual Hours of Operation	Site-specific, if unknown use 679	Hrs/yr	[173]
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[173]
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[173]
$HVAC_{ff}$	Heating factor, or percentage of lighting savings that must be heated	Look up in Appendix F: HVAC Interactivity Factors	N/A	[173]
ISR	In-service rate	Look up by program in Appendix J: In-Service Rates, or use default value = 0.92	N/A	[186]
Eff_{heat}	Efficiency of heating system	0.8	N/A	[182]
F_{FH}	Fraction of homes using fossil fuel heat	0.8	N/A	[181]
W_{NL}	Average watts replaced for an LED nightlight installation	6.75	W	[175]
$Hrs_{NL,daily}$	Average daily burn time for LED nightlight replacements	12	hrs	[176]
365	Days per year	365	Day/yr	
1,000	Conversion from watts to kW	1,000	W/kW	
0.03412	Conversion factor	0.03412	Therms/kWh	
$W_{q,mini}$	Wattage of LED mini bulbs	0.08	W/Bulb	[177]
$W_{b,mini}$	Wattage of incandescent mini bulbs	0.48	W/Bulb	[177]
$W_{q,C7}$	Wattage of LED C7 bulbs	0.48	W/Bulb	[177]
$W_{b,C7}$	Wattage of incandescent C7 bulbs	6	W/Bulb	[177]
$W_{q,C9}$	Wattage of LED C9 bulbs	2	W/Bulb	[177]
$W_{b,C9}$	Wattage of incandescent C9 bulbs	7	W/Bulb	[177]
45	Conversion from lumens of energy efficient fixture to wattage of baseline fixture	45	Lumens/watt	

Variable	Description	Value	Units	Ref
Hrs_{HL}	Annual hours of operation for Holiday Lights	150	Hrs/yr	[177]
CF	Electric coincidence factor	Look up in Table 2-126	N/A	
PDF	Gas peak day factor	Look up in Table 2-126	N/A	
EUL	Effective useful life (use AML for EREP/DI, use EUL for TOS/NC per Measure Life Section)	See Measure Life Section	Years	

Table 2-123 Exempt Standard Lamp Baselines

Bulb Type	Lumen Range	$W_{b,ES}$
A-Lamp (A15, A17, A19, A21)	< 310	Use ENERGY STAR Watts Equivalent
	310 – 749	40
	750 – 1,049	60
	1,050 – 1,489	75
	1,490 – 2,600	100
	> 2,600	Use ENERGY STAR Watts Equivalent

Table 2-124 Exempt Specialty Lamps Baseline

Bulb Type	Base Type	Lumen Range	$W_{b,ES}$
Globe All G (G30, G25, G16.5)	E26 and E17	< 90	Use ENERGY STAR Watts Equivalent
		90 – 179	10
		180 – 249	20
		250 – 349	25
		350 – 749	40
		750 – 1,049	43
		1,050 – 1,489	53
		1,490 – 2,600	72
		> 2,600	Use ENERGY STAR Watts Equivalent
	E12 (Candelabra)	< 90	Use ENERGY STAR Watts Equivalent
		90 – 179	10
		180 – 249	20
		250 – 349	25
		350 – 499	40
		500 – 1,049	60
		> 1,049	Use ENERGY STAR Watts Equivalent
Globe (G40)	E26 (Medium), E17, and E12	< 90	Use ENERGY STAR Watts Equivalent
		90 – 179	10
		180 – 249	20
		250 – 349	25

Bulb Type	Base Type	Lumen Range	$W_{b,ES}$
		350 – 499	40
		500 – 1,049	60
		> 1,049	Use ENERGY STAR Watts Equivalent

Bulb Type	Base Type	Lumen Range	$W_{b,ES}$
Decorative (Shapes B10, B11, B13, BA10, BA11, CA10, C7, C9, F10, F15, ST, S14)	E26 (Medium) and E17	< 70	Use ENERGY STAR Watts Equivalent
		70 – 89	10
		90 – 149	15
		150 – 299	25
		300 – 749	40
		750 – 1,049	43
		1050 – 1,489	53
		1,490 – 2,600	72
		> 2,600	Use ENERGY STAR Watts Equivalent
	Candelabra base E12	< 70	Use ENERGY STAR Watts Equivalent
		70 – 89	10
		90 – 149	15
		150 – 299	25
		300 – 449	40
		450 – 1,049	60
		> 1,049	Use ENERGY STAR Watts Equivalent

Table 2-125 Exempt Reflector/Flood Lamps Baseline

Bulb Type	Lumen Range	$W_{b,ES}$
R20	200 - 299	30
	300 – 718	45
	719 – 810	50
	811 – 1,002	55
	1,003 – 1,202	65
	1,203 – 1,516	75
	1,517 – 1,733	90
	1,734 – 2,184	100
	> 2,184	120
PAR20	200 - 299	30
	300 – 718	40
	719 – 810	50
	811 – 1,002	55
	1,003 – 1,202	65
	1,203 – 1,516	75
	1,517 – 1,733	90
	1,734 – 2,184	100

Bulb Type	Lumen Range	$W_{b,ES}$
	> 2,184	120
BR30, BR40, ER40	200 – 299	30
	300 – 399	40
	400 – 649	50
	650 – 1,419	65
	1,420 – 1,789	75
	1,790 – 2,045	90
	2,046 – 2,578	100
	> 2,578	120
ER30	200 – 299	30
	300 – 399	40
	400 – 956	50
	957 – 1183	55
	1184 – 1419	65
	1420 – 1789	75
	1790 – 2045	90
	2046 – 2578	100
	> 2578	120
PAR30, PAR38, R40	639 – 847	40
	848 – 956	50
	957 – 1,183	55
	1,184 – 1,419	65
	1,420 – 1,789	75
	1,790 – 2,045	90
	2,046 – 2,578	100
	> 2,578	120
R14, PAR16, R16	200 – 299	30
	300 – 399	40
	400 – 499	50
	500 – 599	60
	600 – 1,000	65
MR16	< 450	35

Bulb Type	Lumen Range	$W_{b,ES}$
	450 – 600	50
	> 600	75
For any lamps/bulb types for reflector lamps not captured in the criteria above	All	Use ENERGY STAR Watts Equivalent

Peak Factors

Table 2-126 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.06	[173]
Natural gas peak day factor (PDF)	N/A	

Measure Life

Table 2-127 Measure Life

Equipment	AML (for EREP/DI)	EUL (for NC/TOS)	Ref
Lamps and Fixtures	4	15	[184][185][187]

References

[173] "MID-ATLANTIC TECHNICAL REFERENCE MANUAL VERSION 9." n.d. Accessed November 23, 2022. https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf .

[174] DNV KEMA Energy and Sustainability, Pacific Northwest National Laboratory, *Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates*. (US DOE, 2012), Table 4.4, https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf

[175] Jackie Berger, *NJ Comfort Partners Energy Saving Protocols and Engineering Estimates*. (Applied Public Policy Research Institute for Study and Evaluation (APPRISE), 2014), Pg 21, https://www.njcleanenergy.com/files/file/Protocol%20and%20Engineering%20Estimate%20Summary.pdf .

[176] *Southern California Edison Company, LED,Electroluminescent & Fluorescent Night Lights: Work Paper WPSCRELG0029 Rev.1,* (February 2009), pp. 2–3

[177] The DSMore Michigan Database of Energy Efficiency Measures: Based on spreadsheet calculations using collected data

[178] Typical values of lights per strand and strands per package at Home Depot and other stores

[179] "Regulations.gov." n.d. Www.regulations.gov. Accessed December 1, 2022. https://www.regulations.gov/document/EERE-2021-BT-STD-0012-0022.

[180] "New Jersey A5160 | 2020-2021 | Regular Session." n.d. LegiScan. Accessed December 1, 2022. https://legiscan.com/NJ/bill/A5160/2020.

[181] https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430#430.32

[182] Based on RECS 2015 data for Middle Atlantic Region (Table HC6.7).

[183] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10. (New York State Joint Utilities, 2022), Pg 341-344, https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

[184] ENERGY STAR® Program Requirements Product Specification for Lamps (Light Bulbs) V2.1, June 2017, pg. 19 (Capped at 20 years). https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf

[185] ENERGY STAR® Program Requirements Product Specification for Luminaires (Light Fixtures) V2.2, August 2019, pg. 18 (Capped at 20 years). https://www.energystar.gov/sites/default/files/Luminaires%20V2.2%20Final%20Specification.pdf

[186] 2021 Pennsylvania TRM, Volume 2, Residential Measures, http://www.puc.pa.gov/pcdocs

[187] Residential AML value based on analysis conducted in Maryland. Reference: Recommended Estimated Useful Life Assumptions for the EmPOWER Upstream Lighting Programs, Joint Recommendation, PSC Staff, PSC Independent Evaluator, Office of Peoples Counsel, Maryland Energy Administration and EmPOWER Electric Utilities, Case No. 9648.

2.4.2 OCCUPANCY SENSOR

Market	Residential/Multifamily
Baseline Condition	RF/TOS
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure defines the savings associated with installing a wall-mounted occupancy sensor that switches lights off after a brief delay when it does not detect occupancy.

Baseline Case

The baseline case is lighting controlled by a manual switch.

Efficient Case

The efficient condition is lighting that is controlled with an occupancy sensor. It is assumed that the controlled load is a mix of efficient and inefficient lighting.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = (W_q/1{,}000) \times hrs \times SVG_e \times ISR \times (1 + HVAC_c)$$

Annual Fuel Savings

$$\Delta Therms = (W_q/1{,}000) \times hrs \times SVG_e \times ISR \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = (W_q/1{,}000) \times SVG_e \times ISR \times CF \times (1 + HVAC_d)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-128 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
W_q	Total wattage of the fixture(s) being controlled by the occupancy sensor	Site specific, if unknown assume 105.5	W	[199]
SVG_e	Percentage of annual lighting energy saved by lighting control	Site-specific, if unknown assume 49%	%	[192]
ISR	In service rate or percentage of units rebated that get installed	Site-specific, if unknown use default = 0.98	N/A	[193]
Hrs	Average hours of use per year	Look up in	Hours	[188][189][190][191]
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[191]
$HVAC_{ff}$	HVAC Interactive Factor for Annual Fuel Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[191]
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[191]
1000	Unit Conversion, kW/Watts	1,000	kW/W	

Variable	Description	Value	Units	Ref
CF	Electric coincidence factor	Look up in Table 2-130 Peak Factors	N/A	
PDF	Gas peak day factor	Look up in Table 2-130 Peak Factors	N/A	
EUL	Effective useful life (use AML for EREP/DI, use EUL for TOS/NC per Measure Life Section)	See Measure Life Section	Years	

Table 2-129 Hours

Installation Location	Annual Hours
Residential interior & in-unit Multi Family	679
Multi Family Common Areas	5,950
Unknown	679

Peak Factors

Table 2-130 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Lookup in Table 2-131	[195][196][197]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Table 2-131 Summer Electric Peak Coincidence Factors

Installation Location	Type	Coincidence Factor (CF)
Residential interior and in-unit Multi Family	Utility Peak CF	0.059
	PJM CF	0.058
Multi Family Common Areas	PJM CF	0.86
Exterior	PJM CF	0.018
Unknown	Utility Peak CF	0.059
	PJM CF	0.058

Measure Life

Table 2-132 Measure Life

Equipment	AML (for EREP/DI)	EUL (for NC/TOS)	Ref
Lamps and Fixtures	4	15	[200][201][202]

References

[188] Based on Navigant Consulting, “EmPOWER Residential Lighting Program: 2016 Residential Lighting Inventory and Hours of Use Study” August 31, 2017, page 13. The HOU value is for an efficient lamp.

[189] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010. This estimate is consistent with the Common Area “Non-Area Specific) assumption (16.2 hours per day or 5913 annually) from the Cadmus Group In., “Massachusetts Multifamily Program Impact Analysis”, July 2012, p 2-4.

[190] Unknown” assumes a residential interior or in-unit multifamily application.

[191] “MID-ATLANTIC TECHNICAL REFERENCE MANUAL VERSION 9.” n.d. Accessed November 23, 2022. https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf. https://neep.org/sites/default/files/resources/NEEP_CI_Lighting_LS_FINAL_Report_ver_5_7-19-11_0.pdf

[192] Average of two studies. Navigant Consulting. Department of Energy Solid-State Lighting Program. Energy Savings Estimates of Solid-State Lighting in General Illumination Lighting Applications. September 2016. This study estimates a 71% energy savings from connected lighting in residential applications. (Table F.4). Efficiency Vermont. Smart Lighting & Smart Hub. DIY Install: Does it Yield. August 2016. This study estimates reductions in hours of use of up to 27%. Additionally, the metering study saw significant amounts of dimming of lamps that were on non-dimming circuits, but did not quantify the savings associated with this consumer action.

[193] First year ISR of 0.9 (EMPOWER MD Lighting Study, EY5). Assume lifetime ISR of 0.99 (2006-2008 California Residential Lighting Evaluations, and used in the Uniform Methods Project). Assume half of bulbs not installed in year one are installed in year two, and the other half in year three. Using a discount rate of 5%, this gives 0.90 + 0.045 * 0.95 + 0.045 * 0.95^2 = 0.98

[194] The criteria that are used to determine whether equipment is “operational” vary among jurisdictions and there is no related industry standard practice. This TRM provides assumptions for estimating savings and costs for early replacement measures, but does not address this threshold question of whether a measure should be considered early replacement.

[195] Based on Navigant Consulting “EmPOWER Residential Lighting Program: 2016 Residential Lighting Inventory and Hours of Use Study” August 31, 2017, page 15

[196] Consistent with value currently used for EmPOWER Maryland Programs as of October 1, 2017. Derived from C&I common area lighting coincidence.

[197] Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York.

[198] Navigant, *ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report* Table 8.1 Page 10 https://icc.illinois.gov/docket/P2020-0486/documents/299941/files/523013.pdf.

[199] Statewide Evaluation Team (GDS Associates Inc, Nexant, Research Into Action, Apex Analytics LLC), *Energy Efficiency Potential Study for Pennsylvania* (2015), Appendix D, Pg D-1, https://www.puc.pa.gov/pcdocs/1345079.pdf

[200] ENERGY STAR® Program Requirements Product Specification for Lamps (Light Bulbs) V2.1, June 2017, pg. 19 (Capped at 20 years).

https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf

[201] ENERGY STAR® Program Requirements Product Specification for Luminaires (Light Fixtures) V2.2, August 2019, pg. 18 (Capped at 20 years). https://www.energystar.gov/sites/default/files/Luminaires%20V2.2%20Final%20Specification.pdf

[202] Residential AML value based on analysis conducted in Maryland. Reference: Recommended Estimated Useful Life Assumptions for the EmPOWER Upstream Lighting Programs, Joint Recommendation, PSC Staff, PSC Independent Evaluator, Office of Peoples Counsel, Maryland Energy Administration and EmPOWER Electric Utilities, Case No. 9648.

2.5 PLUG LOAD

2.5.1 OFFICE EQUIPMENT

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use	Plug Load
Measure Last Reviewed	December 2022

Description

This section provides deemed savings for installing ENERGY STAR office equipment compared to standard efficiency equipment in residential and multifamily applications.

Per unit savings are primarily derived from the ENERGY STAR calculator for office equipment [203].

Baseline Case

The baseline condition is assumed to be standard equipment of similar type used in a residential setting.

Efficient Case

The efficient condition is ENERGY STAR equipment meeting ENERGY STAR v8 Eligibility Criteria [204] and used in a residential setting.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Lookup\ in\ \text{Table 2-134}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Lookup\ in\ \text{Table 2-134}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 2-133 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Lookup in Table 2-134	kWh/yr	[203]
ΔkW_{Peak}	Peak Demand Savings	Lookup in Table 2-134	kW	[203]
ΔkW_{Life}	Lifetime electric energy savings	Calculated	kWh	

Table 2-134 Office Equipment Energy and Demand Savings Values per Unit

Measure		Energy Savings (kWh)	Demand Savings (kW)	Source
Computer (Desktop)		119	0.0161	[203]
Computer (Laptop)		22	0.0030	[203]
Printer (laser, monochrome)	≤ 5 images/min	37	0.0050	[203]
	5 < images/min ≤ 15	26	0.0035	
	15 < images/min ≤ 20	24	0.0031	
	20 < images/min ≤ 30	42	0.0057	
	30 < images/min ≤ 40	50	0.0068	
	40 < images/min ≤ 65	181	0.0244	
	65 < images/min ≤ 82	372	0.0502	
	82 < images/min ≤ 90	542	0.0732	
	> 90 images/min	686	0.0926	
Printer (Ink Jet)		6	0.0008	[203]
Multifunction Device (laser, monochrome)	≤ 5 images/min	57	0.0077	[203]
	5 < images/min ≤ 10	48	0.0065	
	10 < images/min ≤ 26	52	0.0070	
	26 < images/min ≤ 30	93	0.0126	
	30 < images/min ≤ 50	248	0.0335	

Measure		Energy Savings (kWh)	Demand Savings (kW)	Source
	50 < images/min ≤ 68	420	0.0567	
	68 < images/min ≤ 80	597	0.0806	
	> 80 images/min	764	0.1031	
Multifunction Device (Ink Jet)		6	0.0008	[203]
Monitor		8	0.0032	[203]

Peak Factors

Peak savings are incorporated in the demand savings values above.

Measure Life

The measure life for residential office equipment is 5 years [205].

References

[203] ENERGY STAR Office Equipment Calculator https://dnr.mo.gov/sites/dnr/files/media/file/2021/01/office-equipment-calculator.xlsx. Per PA TRM: "Using a commercial office equipment load shape, the percentage of total savings that occur during the PJM peak demand period was calculated and multiplied by the energy savings. As of December 1, 2018, the published ENERGY STAR Office Equipment Calculator does not reflect the current specification for computers (ENERGY STAR® Program Requirements Product Specification for Computers Eligibility Criteria Version 8.0). As a result, the savings values for computers presented in this measure entry reflect savings for V6-compliant models. This characterization should be updated when an updated ENERGY STAR Office Equipment Calculator becomes available."

[204] ENERGY STAR Computers Final Version 8.0 Specification Rev. July 2022

[205] Residential desktop measure life. California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/027/

2.5.2 TELEVISIONS

Market	Residential/multifamily
Baseline Type	TOS
Baseline	Code
End Use Subcategory	Electronics
Measure Last Reviewed	December 2022

s

Description

This measure relates to the upstream promotion of televisions meeting the ENERGY STAR "Most Efficient Television" Eligibility Criteria.

Baseline Case

The baseline condition is assumed to be a television meeting the Energy Star 8.0 efficiency standard and used in a residential setting.

Efficient Case

The efficient condition is an ENERGY STAR television meeting the EPA Most Efficient TV criteria and used in a residential setting.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = (kW_b - kW_q) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 2-135 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Annual electric energy savings for baseline case	Look up in Table 2-136	kWh/yr	[206][207]
kWh_q	Peak Demand Savings for efficient case	Look up in Table 2-136	kWh/yr	[206][208]
kW_b	Peak Demand Savings for baseline case	Look up in Table 2-137	kW	[206][207]
kW_q	Annual electric energy savings for efficient case	Look up in Table 2-137	kW	[206][208]
CF	Coincidence factor	Look up in Table 2-138	N/A	
PDF	Gas peak demand factor	Look up in Table 2-138	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	

Table 2-136 Conventional and ENERGY STAR kWh

Diagonal screen size	Conventional kWhb	ENERGY STAR kWhq
20	35.3	30.9
22	37.8	32.6
26	44.5	37.2
32	54.1	44.0
37	64.1	51.1
42	75.2	59.0
47	86.9	67.6
52	98.9	76.7
57	110.7	85.9

Diagonal screen size	Conventional kWhb	ENERGY STAR kWhq
62	121.9	95.1
65	128.2	100.4

Table 2-137 Conventional and ENERGY STAR kW

Diagonal screen size	Conventional kWb	ENERGY STAR kWq
20	0.018	0.016
22	0.020	0.017
26	0.024	0.020
32	0.029	0.023
37	0.034	0.027
42	0.040	0.032
47	0.047	0.036
52	0.053	0.041
57	0.060	0.046
62	0.066	0.051
65	0.069	0.054

Peak Factors

Table 2-138 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)[46]	0.21	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The estimated useful life (EUL) is 6 years. [206]

References

[206] "Consumer_Electronics_Calculator". October 2016. Energystar.gov. Accessed December 9, 2022. https://www.energystar.gov/sites/default/uploads/buildings/old/files/Consumer_Electronics_Calculator.xlsx.

[207] ENERGY STAR® Program Requirements for Televisions Eligibility Criteria Version 8.0 https://www.energystar.gov/sites/default/files/Final%20V8.0%20TVs%20Program%20Requirements.pdf

[46] The coincidence value is an estimate based on the on-mode hours per day (5 hours/day) as a percentage of all hours.

[208] ENERGY STAR® Most Efficient 2020 Recognition Criteria Televsions https://www.energystar.gov/sites/default/files/Televisions%20ENERGY%20STAR%20Most%20Efficient%202020%20Final%20Criteria.pdf

2.5.3 SMART STRIP

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

Advanced Power Strips (APS) are surge protectors that contain a number of power-saver sockets. There are two types of APS: Tier 1 and Tier 2.

Tier 1 APS have a master control socket arrangement and will shut off the items plugged into the controlled power-saver sockets when they sense that the appliance plugged into the master socket has been turned off. Conversely, the appliance plugged into the master control socket has to be turned on and left on for the devices plugged into the power-saver sockets to function.

Tier 2 APS deliver additional functionality beyond that of a Tier 1 unit, as Tier 2 units manage both standby and active power consumption. The Tier 2 APS manage standby power consumption by turning off devices from a control event; this could be a TV or other item powering off, which then powers off the controlled outlets to save energy. Active power consumption is managed by the Tier 2 unit by monitoring a user's engagement or presence in a room by either or both infrared remote signals sensing or motion sensing. After a period of user absence or inactivity, The Tier 2 unit will shut off all items plugged into the controlled outlets, thus saving energy. There are two types of Tier 2 APS available on the market. Tier 2 Infrared (IR) detect signals sent by remote controls to identify activity, while Tier 2 Infrared-Occupancy Sensing (IR-OS) use remote signals as well as an occupancy sensing component to detect activity and sense for times to shut down. Due to uncertainty surrounding the differences in savings for each technology, the Tier 2 savings are blended into a single number.

Baseline Case

The assumed baseline is a standard power strip that does not control any of the connected loads.

Efficient Case

The efficient case is the use of a Tier 1 or Tier 2 Advanced Power Strip.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Usage \times ERP \times ISR$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Load \times ERP_{Peak} \times ISR$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-139 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	N/A	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	N/A	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Usage	Annual usage of system connected to power strip	Lookup in Table 2-140	kWh	[209]
ERP	Energy reduction percentage	Lookup in Table 2-140	N/A	[209]
ISR	In-service rate	Look up by program in Appendix, or use default values in Table 2-140	N/A	[209]
Load	Demand of system connected to power strip	Lookup in Table 2-140	kW	[209]
ERP_{Peak}	Energy reduction percentage during peak period	Lookup in Table 2-140	N/A	[209]
CF	Electric coincidence factor	Look up in Table 2-141	N/A	
PDF	Gas peak demand factor	Look up in Table 2-141	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-140 Impact Factors for Advanced Power Strip Types

Strip Type	End-Use	ERP	ERP_{Peak}	ISR	Usage (kWh)	Load (kW)
Tier 1	Home Entertainment Center	0.27	0.20	0.86	471	0.057
Tier 1	Home Office	0.21	0.18	0.86	399	0.043
Tier 1	Unspecified	0.25	0.19	0.81	449	0.051
Tier 2	Unspecified	0.44	0.41	0.76	471	0.058

Peak Factors

Peak demand savings are accounted for in the percent reduction factors presented above.

Table 2-141 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

Table 2-142 Measure Life

Equipment	EUL	Ref
Smart Strip	5	[210]

References

[209] RLPNC 17-3: Advanced Power Strip Metering Study," Massachusetts Programs Administrators and EEAC, (Mar. 2019), https://ma-eeac.org/wp-content/uploads/RLPNC_173_APSMeteringReport_Revised_18March2019.pdf

[210] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life, https://www.caetrm.com/cpuc/table/effusefullife/

2.5.4 SOUNDBAR

Market	Residential/Multifamily
Baseline Type	TOS
Baseline	Code
End Use Subcategory	Soundbar
Measure Last Reviewed	December 2022

Description

This measure covers soundbars in residential applications meeting the minimum qualifying efficiency standards established under the ENERGY STAR® program, Program Requirements for Audio/Video Version 3.0, effective December 2014. A soundbar is a mains-connected product that offers audio amplification housed in a wide horizontal enclosure. ENERGY STAR® rated soundbars have a lower power draw when in sleep and idle modes and a higher amplifier efficiency than conventional models. Qualified soundbars use about 70% less energy than unqualified equipment.

Baseline Case

The baseline condition is a non-ENERGY STAR® qualified soundbar in a residential application.

Efficient Case

The compliance condition is an ENERGY STAR® qualified soundbar in a residential application with power performance specifications meeting or exceeding the requirements of ENERGY STAR® Program Requirements for Audio/Video Version 3.0, effective December 2014.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = units \times (kWh_b - kWh_q)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 2-143 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Units	Number of measures installed during program	Site-specific	N/A	
kWh_b	Energy consumption for baseline case	77	kWh/yr	[211]
kWh_q	Efficient unit energy consumption	29	kWh/yr	[211]
8,760	Hours in 1 year	8,760	Hours/yr	
CF	Electric coincidence factor	Look up in Table 2-144	N/A	[213]
PDF	Gas peak demand factor	Look up in Table 2-144	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[214]

Peak Factors

Table 2-144 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[213]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 7 years. [214]

References

[211] Pacific Gas and Electric Work Paper PGECOAPP128 Retail Products Platform Revision #2, October 2015, pg 74 http://deeresources.net/workpapers

[212] Retail Products Platform: Product Analysis, Last updated May 25, 2016 – ENERGY STAR® + 15% annual consumption increased by 15% to reflect minimum compliance with ENERGY STAR® Specification V3.0

[213] Per NY TRM: "No source specified – update pending availability and review of applicable references."

[214] EPA, Consumer Messaging Guide for Energy Star Certified Consumer Electronics. December 2016. https://www.energystar.gov/sites/default/files/asset/document/CE_Consumer_Messaging.pdf

2.5.5 ELECTRIC VEHICLE CHARGERS

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	ISP
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

The measure is for the purchase of a Level 2 electric vehicle charger consistent with the ENERGY STAR V1.1 specification for Electric Vehicle Supply Equipment (EVSE) installed for residential household use. Networked chargers enable access to online energy management tools through an EVSE network. Non-networked chargers are standalone units that are not connected to other units through an EVSE network.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

Baseline Case

A non-ENERGY STAR V1.1 networked or non-networked Level 2 electric vehicle charger.

Efficient Case

An ENERGY STAR qualified networked or non-networked Level 2 electric vehicle charger [215].

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = ((Hrs_{PS} + Hrs_{US}) \times W_b - \left(Hrs_{PS} \times W_{q,p} + Hrs_{US} \times W_{q,u}\right))/1{,}000$$

Where,

$$Hrs_{ps} = Hours_p - Hours_c$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Avg_{kW} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-145 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hrs_{ps}	Annual standby hours plugged in	Calculated	Hours	
Hrs_{c}	Annual active charging hours	Site-specific, if unknown assume 278	Hours	[219]
Hrs_{p}	Total annual hours plugged in	Site-specific, if unknown assume 3,511	Hours	[219]
Hrs_{us}	Annual standby hours unplugged	Site-specific, if unknown assume 5,249	Hours	[219]
W_{b}	Baslines average standby power	Lookup in Table 2-146	W	[216][217]
$W_{q,p}$	Efficient average standby power with vehicle plugged in	Lookup in Table 2-146	W	[218]
$W_{q,u}$	Efficient average standby power in no vehicle mode	Lookup in Table 2-146	W	[218]
Avg_{kW}	Average electric demand during standby	Lookup in Table 2-146	kW	
CF	Electric coincidence factor	Lookup in Table 2-147	N/A	
PDF	Gas peak day factor	Lookup in Table 2-147	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-146 Standby Power

Network Type	W_b	$W_{q,p}$	$W_{q,u}$	kW
Non-Networked[47]	3.7	3.5	2.1	0.00107
Networked[47]	9.9	3.2	2.5	0.00713

Peak Factors

Table 2-147 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [215].

References

[215] Energy Star Spec v1.1 effective from 3/31/2021. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20V1.1%20DC%20EVSE%20Final%20Specification_0.pdf

[216] Based on Northwest Power and Conservation Council, Regional Technical Forum updated workbook for Level 2 Electric Vehicle Charger version 3.0 https://nwcouncil.app.box.com/v/Lvl2EVChrgrsv3-0

[217] INL charger testing https://avt.inl.gov/evse-type/ac-level-2.html

[218] "ENERGY STAR Market and Industry Scoping Report: Electric Vehicle Supply Equipment ENERGY STAR Market and Industry Scoping Report Electric Vehicle Supply Equipment (EVSE)" 2013 (source data is from INL). https://www.energystar.gov/sites/default/files/asset/document/electric_vehicle_scoping_report.pdf

[219] 2021 ENERGY STAR QPL of Residential EVSE. Averaged Partial On Mode Input Power (W) and Idle Mode Input Power (W). See Northwest Power and Conservation Council, Regional Technical Forum updated workbook for Level 2 Electric Vehicle Charger version 3.0 https://nwcouncil.app.box.com/v/Lvl2EVChrgrsv3-0

[47] kW for non-networked and networked type = $(((W_b - W_{q,p}) * Hrs_{PS}/8482) + ((W_b - W_{q,u}) * Hrs_{US}/8482))/1000$

2.5.6 HEDGE TRIMMERS, LEAF BLOWER, PUSH LAWNMOWERS, CHAINSAWS AND SNOW BLOWER

Market	Residential
Baseline Condition	TOS
Baseline	Existing
End Use Subcategory	Landscaping Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• New Measure

Description

This is a time of sale measure that applies to the purchase of new residential lawn equipment, which include trimmers, leaf blower, push lawnmowers (not self propelled or ride-on, but contains an electric motor driving the blade), chainsaws, and snow blowers. This measure assumes the offset of converting use of gas lawn equipment to electrical lawn equipment, which in turn saves fossil fuels and increases electric use.

Baseline Case

The baseline equipment is an existing residential gas lawn equipment, which includes trimmers, leaf blower, push lawnmowers, chainsaws, and snow blower.

Efficient Case

The energy efficient equipment must be new residential electric lawn equipment, which includes trimmers, leaf blower, push lawnmowers, chainsaws, and snow blower.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = Look\ up\ in\ \textbf{Table 2-150}$$

Deemed annual energy savings in Table 2-150 calculated as follows:

$$\Delta kWh = \frac{Hrs}{t_{charge}} \times E_{battery} \times \frac{D}{Eff_{charger}} \times \frac{1}{1{,}000}$$

Annual Fuel Savings (Alternate Fuel)

$$\Delta Gal_{Gasoline} = Look\ up\ in\ \textbf{Table 2-150}$$

Annual Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings (Alternate Fuel)

$$\Delta Gal_{Life} = \Delta Gal \times EUL$$

Calculation Parameters

Table 2-148 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Look up in Table 2-150	kWh/yr	[220]
$\Delta Gal_{gasoline}$	Annual gallons gasoline savings	Look up in Table 2-150	Gallons	[220]
ΔkW_{Peak}	Annual peak electric demand savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔGal_{Life}	Lifetime fuel savings	Calculated	Gallons	
Hrs	Annual operating hours	Look up in Table 2-149	Hrs	[220]
t_{charge}	Run time per charge	Look up in Table 2-149	Hrs	[222]
$E_{battery}$	Rated energy of the battery	Look up in Table 2-149	Wh	[222]
D	Discharge rate	0.90	%	[222]
$Eff_{charger}$	Efficiency of the charger	0.92	%	[222]
1,000	Unit conversion, Wh/kWh	1,000	Wh/kWh	
EUL	Effective useful life	See Measure Life	Years	[220]

Table 2-149 Parameters Values

Type of Electric Equipment	Hrs	t_{charge}	$E_{battery}$
Trimmer	8.21	0.5	1HP Replacement: 100 2HP Replacement: 240
Leaf Blower	9.4	0.25	1HP Replacement: 100 2HP Replacement: 240
Push Lawnmower	15	1	300
Chainsaw	9.12	0.09	150
Snow Blower	8	0.75	280

When calculated using the assumptions above, the energy impacts are equal to the values below. These deemed impacts may be used instead of calculating site-specific savings if reliable input parameters are not available.**Table 2-150 Deemed Energy Impacts**

Type of Electric Equipment	ΔkWh_{equip}	$\Delta Gal_{gasoline}$
Trimmer	1HP Replacement: -1.61 2HP Replacement: -3.86	1HP Replacement: 1.41 2HP Replacement: 2.35
Leaf Blower	1HP Replacement: -3.68 2HP Replacement: -8.83	1HP Replacement: 1.41 2HP Replacement: 2.35
Push Lawnmower	-4.4	3.75
Chainsaw	-14.87	1.64
Snow Blower	-2.92	8

Peak Factors

Table 2-151 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[223]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is given in Table 2-152 [220].

Table 2-152 Measure Life

Type of Electric Equipment	Measure Life (yrs)
Trimmer	8

Type of Electric Equipment	Measure Life (yrs)
Leaf Blower	8
Push Lawnmower	10
Chainsaw	8
Snow Blower	10

References

[220] PSEG CEF-EE II Filing 12.1.23

[221] Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, EPA 2002

[222] PSEG-LI TRM

[223] Placeholder assumption until further research conducted.

2.5.7 ELECTRIC RIDING LAWN MOWER

Market	Residential
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Landscaping Equipment
Measure Last Reviewed	February 2024
Changes Since Last Version	• New measure

Description

This measure claims savings for the replacement of a gasoline powered ride-on lawnmower with a new all-electric ride-on lawnmower. This measure is characterized for residential applications.

Baseline Case

The baseline condition is assumed to be a gasoline powered ride-on lawnmower.

Efficient Case

The efficient condition is an all-electric ride-on lawnmower.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = -Q \times Q_{time} \times kW_{Draw} \times N_{battery}$$

Annual Fuel Savings (Another Fuel)

$$\Delta Gal_{Gasoline} = U$$

Annual Peak Demand Savings

$$\Delta kW = -kW_{Draw} \times N_{battery} \times CF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings (Another Fuel)

$$\Delta Gal_{Gasoline,\,lifetime} = Gal_{Gasoline} \times EUL$$

Calculation Parameters

Table 2-153 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings, calculated using the default values below	Calculated (From default value: -72.9)	kWh/yr	[220]
$\Delta Gal_{gasoline}$	Annual gasoline savings	Calculated (From default value: 36)	gal/yr	[220]
ΔkW_{Peak}	Annual peak demand savings	Calculated (From default value: -0.56)	kW/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Gal_{iGasoline,\ life}$	Lifetime gasoline savings	Calculated	gal	
Q	Number of full charges in a year[48]	32	N/A	[220]
Q_{time}	Time required to fully charge battery[49]	4	Hrs	[220]
kW_{draw}	Demand draw of battery while charging	0.56	kW	[220]
$N_{battery}$	No of batteries attached to lawn mower	1	N/A	[220]
U	Annual gasoline consumption	36	gallons	[220]
CF	Electric coincidence factor	Lookup in Table 2-154	N/A	
EUL	Effective useful life	See Measure Life	Years	[220]

Peak Factors

Table 2-154 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[225]

48 Annual hours of use divided by Working Time Per Charge **Error! Reference source not found.**.
49 Battery Charging Time to 100% divided by 60 minutes **Error! Reference source not found.**

Measure Life

The effective useful life (EUL) is 10 years [220].

References

[224] Department of Public Services, *2022 Tier III TRM Characterizations*. 2022, Page 56, https://publicservice.vermont.gov/document/2022-tier-iii-trm-characterizations

[225] Placeholder value until further research conducted.

2.6 SHELL

2.6.1 RESIDENTIAL/LOW-RISE MULTIFAMILY AIR SEALING

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Shell
Measure Last Reviewed	January 2023

Description

This section provides energy savings algorithms for the sealing air leakage paths to reduce the natural air infiltration rate through the installation of products and repairs to the building envelope. It is assumed that air sealing is the first priority among candidate space conditioning measures. Expected percentage savings is based on previous experiences with measured savings from similar programs.

Methods are provided below for single-family, low-rise multifamily and high-rise multifamily applications with and without blower door testing conducted before and after implementation of air sealing treatments. A blower door test is performed to measure the leakage rate by depressurizing the building to a standard pressure difference of 50 Pascals or 0.2 inches of water.

Blower door tests shall be performed whenever possible. This method provided below for single family/low-rise multifamily without blower door testing should only be used if blower door testing is not feasible due to health or safety concerns, e.g. the presence of a hazardous material like asbestos or mold, ongoing construction in the home or concerns regarding COVID-19.

Baseline Case

The baseline case is a building envelope with natural air infiltration through air leakage paths.

Efficient Case

The exterior envelope, as well as interior walls/partitions between conditioned and unconditioned spaces should be inspected and all gaps sealed. At a minimum, the following items shall be inspected, and sealing measures may be implemented based upon inspection results:

- Caulk and weather strip doors and windows that leak air
- Repair or replace doors leading from conditioned to unconditioned space
- Seal air leaks between unconditioned (including unconditioned basement and attics) and conditioned spaces to include, but not limited to, plumbing, ducting, electrical wiring, wall top plates, chimneys, flues, and dropped soffits

- Use foam sealant on larger gaps around windows, baseboards, and other places where air leakage, either infiltration or exfiltration may occur

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{\Delta CFM_{50}}{F_n \times F_h}\right) \times \left(\frac{\Delta kWh}{CFM}\right)$$

Annual Fuel Savings

$$\Delta Therms = \left(\frac{\Delta CFM_{50}}{F_n \times F_h}\right) \times \left(\frac{\Delta therms}{CFM}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{\Delta CFM_{50}}{F_n \times F_h}\right) \times \left(\frac{\Delta kW}{CFM}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-155 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	

Variable	Description	Value	Units	Ref
ΔCFM_{50}	Reduction in air leakage from blower door tests at 50 Pascals pressure difference	Site-specific, if unknown ΔCFM_{50} =0.50xSF[50]	CFM	
F_n	Infiltration-Leakage Ratio, used to convert pressurized blower door testing results to natural infiltration rates, climate zone factor	19	N/A	[226]
F_h	Infiltration-Leakage Ratio, used to convert pressurized blower door testing results to natural infiltration rates, building height factor	Look up in Table 2-156	N/A	[226]
ΔkWh/CFM	Annual electric energy savings per cubic foot per minute of reduced air leakage at 50 Pa	Look up in Table 2-157 or Table 2-158	kWh/CFM	[227]
ΔkW/CFM	Peak coincident demand electric savings per cubic foot per minute of reduced air leakage at 50 Pa	Look up in Table 2-157 or Table 2-158	kW/CFM	[227]
Δtherms/CFM	Annual fossil fuel energy savings per cubic foot per minute of reduced air leakage at 50 Pa	Look up in Table 2-157 or Table 2-158	therms/CFM	[227]
CF	Coincidence factor	Look up in Table 2-159	N/A	
PDF	Gas peak day factor	Look up in Table 2-159	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-156 Infiltration-Leakage Ratio, building height factor

Number of conditioned stories	F_h
1 story	1.00
1.5 stories	0.90
2 stories	0.81
2.5 stories	0.76
3 + stories	0.70

Table 2-157 Impact per CFM for Single-family Residential Infiltration Reduction

	ΔkWh/CFM	ΔkW/CFM	Δtherms/CFM
AC Fuel Heat	2.3	0.004	1.7
Heat Pump	21.0	0.003	N/A
AC Electric Heat	39.8	0.004	N/A

[50] For single-family and low-rise multifamily homes, if conducting a blower door test is not feasible due to health and safety concerns, multiply affected area square footage by a deemed ΔCFM_{50}/SF of 0.50 (i.e., ΔCFM_{50} = 0.50 x SF). Default ΔCFM_{50}/SF of 0.50 is the median value of single-family blower door test data provided by ConEdison, conducted 2018-2020.

	ΔkWh/CFM	ΔkW/CFM	Δtherms/CFM
Fuel Heat Only	0.8	0.000	1.7
Electric heat Only	38.4	0.000	N/A

Table 2-158 Impact per CFM for Multifamily Low-rise Infiltration Reduction

	ΔkWh/CFM	ΔkW/CFM	Δtherms/CFM
AC Fuel Heat	1.5	0.003	1.9
Heat Pump	21.2	0.003	N/A
AC Electric Heat	29.6	0.003	N/A
Fuel Heat Only	1.1	0.000	1.9
Electric heat Only	29.2	0.000	N/A

Peak Factors

Table 2-159 Peak Factors

Peak Factor	Value	Ref
Coincidence factor	0.69	[228]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 15 years [229].

References

[226] Lawrence Berkeley Laboratory, Estimation of Infiltration from Leakage and Climate Indicators, Sherman, M., December 1986, http://eta-publications.lbl.gov/sites/default/files/estimation_of_inflltration_from_leakage_and_climate_indicators.pdf

[227] New York State Joint Utilities, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, V10, January 2023, Appendix E, Pg 1221. NYC values were used due to proximity to NJ.

[228] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the RM Management Committee.

[229] GDS Associates, Inc. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures. 2007. https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf

2.6.2 INSULATION

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Shell
Measure Last Reviewed	January 2023
Changes Since Last Version	• Updated HDD/CDD values

Description

This measure applies to the installation of insulation to the attic floor, roof assembly, walls, and floors to reduce the thermal conductance of the building envelope. Energy and demand savings are realized through reductions in the building's heating and cooling loads. Existing (baseline) and installed (qualifying) shell R-values must be captured to estimate energy savings.

This measure is only applicable as a retrofit in existing single and multifamily buildings, excluding gut rehab/major renovation projects. These projects entail whole-building envelope alterations that trigger more stringent code provisions, limiting potential incremental savings.

For applications involving insulation on more than one component, evaluate each component separately via the method below and sum together to determine total estimated energy savings. If the age of the baseline equipment cannot be determined, assume two-third of the EUL has lapsed.

Baseline Case

The existing condition is a residential building envelope with insufficient insulation.

Efficient Case

The efficient condition is a residential building envelope with increased insulation meeting or exceeding applicable construction code requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Savings from reduction in Air Conditioning Load:

$$\Delta kWh_{cooling} = \frac{\left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times CDD \times 24 \times Area \times (1 - F_{framing})}{1{,}000 \times SEER}$$

Savings for homes with electric heat (Heat Pump or resistance):

$$\Delta kWh_{heating} = \frac{\left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times HDD \times 24 \times Area \times (1 - F_{framing})}{1{,}000 \times HSPF}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times HDD \times 24 \times Area \times (1 - F_{framing})}{Fuel\ Btu \times AFUE}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times Area \times (1 - F_{framing})}{1{,}000 \times EER} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-160 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta kWh_{cooling}$	Annual electric cooling energy savings	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual electric heating energy savings	Calculated	kWh/yr	
R_b	R-value of existing insulation	Site-specific, if unknown look up in Table 2-162	h.ft^2.°F/Btu	

Variable	Description	Value	Units	Ref
R_q	R-value of new insulation	Site-specific	h.ft^2.°F/Btu	
CDD	Cooling degree days: number of degrees the average daily temperature is above 65°F	Loo kup in Table 2-163	°F-day/yr	[230]
Area	Area of insulated surface	Site-specific	ft^2	
$F_{framing}$	Framing factor	Look up in Table 2-161	N/A	[232]
1,000	Conversion Factor from W to kW	N/A	W/kW	
SEER/SEER2	Efficiency in SEER of Air Conditioning equipment	Site specific, if unknown look up in Table 2-164	Btu/watt-hr	[233]
EER/EER2	Efficiency in EER of Air Conditioning equipment	Site-specific. If unknown, see Appendix E: Code-Compliant Efficiencies	Btu/watt-hr	[233]
HDD	Heating degree days: number of degrees the average daily temperature is below 65°F	Look up in Table 2-163	°F-day/yr	[230]
HSPF/HSPF2	Heating Seasonal Performance Factor	Site specific, if unknown look up in Table 2-165	Btu/watt-hr	[233]
Fuel Btu	Conversion Factor to Therms	Look up in Table 2-168		
AFUE	Annual Fuel Utilization Efficiency – Boilers & Furnaces	Site-specific, if unknown look up in Table 2-166, Table 2-167	N/A	[233]
AFUE	Annual Fuel Utilization Efficiency – Electric Resistance Heating	35%	N/A	[234]
CF	Electric coincidence factor	Look up in Table 2-169	N/A	
PDF	Gas peak day factor	Look up in Table 2-169	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-161 Framing Factor

Insulation Location	Value	Ref
Framing factor - Ceiling	7%	[232]
Framing factor - Wall	25%	[232]
Framing factor - Floor	12%	[232]

Table 2-162 Existing Insulation R-Value (R_b)

Building Envelope Component	Value
Fiberglass - Batt	3.14

Building Envelope Component	Value
Fiberglass – Blown Attic	2.2
Fiberglass – Blown Wall	3.2
Rock Wool - Batt	3.14
Rock Wool – Blown Attic	3.1
Rock Wool – Blown Wall	3.03
Cellulose – Blown Attic	3.13
Cellulose – Blown Wall	3.7
Vermiculite	2.13
Air-entrained Concrete	3.9
Urea Terpolymer Foam	4.48
Rigid Fiberglass (> 4 lb/ft^3)	4
Expanded Polystyrene (Beadboard)	4
Extruded Polystyrene	5
Polyurethane (Foamed-in-place)	6.25
Polyisocynaurate (Foil-face)	7.2

Table 2-163 Heating and Cooling Degree Days (65°F set point)

Climate Zone	HDD	CDD
Northern	6,136	934
Southwest	5,658	1,048
Coastal	4,795	886
Central	5,588	1,008
Pine Barrens	5,529	945
Statewide Average	5,553	973

Table 2-164 Cooling Equipment SEER

Cooling Equipment	SEER	SEER2
Split System (A/C)	13	13.4
Split System (HP)	14	14.3
Single Package (A/C)	14	13.4
Single Package (HP)	14	13.4

Table 2-165 Cooling Equipment HSPF

Cooling Equipment	HSPF	HSPF2
Split System (HP)	8.2	7.5
Single Package (HP)	8.0	6.7

Table 2-166 AFUE of Residential Boilers

Product Class	AFUE (Manufactured before Sep 1, 2012)	AFUE (Manufactured on and after Sep 1, 2012 and before Jan 15, 2021)	AFUE (Manufactured on and after January 15, 2021)
Gas-fired hot water boiler	0.80	0.82	0.84
Gas-fired steam boiler	0.75	0.80	0.82
Oil-fired hot water boiler	0.80	0.84	0.86
Oil-fired steam boiler	0.80	0.82	0.85

Table 2-167 AFUE of Residential Furnaces

Product Class	AFUE	Compliance Date	AFUE (Manufactured before compliance Date)
Non-weatherized gas furnaces (not including mobile home furnaces)	0.80	November 19, 2015.	0.78
Mobile Home gas furnaces	0.80	November 19, 2015.	0.75
Non-weatherized oil-fired furnaces (not including mobile home furnaces)	0.83	May 1, 2013.	0.78
Mobile Home oil-fired furnaces	0.75	September 1, 1990.	0.75
Weatherized gas furnaces	0.81	January 1, 2015.	0.78
Weatherized oil-fired furnaces	0.78	January 1, 1992.	0.78

Table 2-168 BTU Conversion Factors

Conversion Factor	Value	Units
Natural Gas - BTU to Therms	100,000	Btu/Therms
Heating Oil - BTU to Gallons to Therms	138,000 x 0.916	Btu/Therms
Propane - BTU to Gallons Therms	92,000 x 1.4	Btu/Therms

Peak Factors

Table 2-169 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[231]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 25 years [235].

References

[230] ONJSC: Monthly/Annual Temperature Normals (1991-2020). http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html.

[231] BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps, as reported in NEEP, Mid-Atlantic Technical Reference Manual, V8. 2018, p. 260

[232] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1.

[233] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430 eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

[234] Electric resistance heating calculated by determining overall fuel cycle efficiency by dividing the average PJM heat rate (9,642 btu/kWh) by the btu's per kWh (3,413 btu/kWh), resulting in 2.83 btuin per 1 btuout.

[235] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.

2.6.3 WINDOW INSULATION

Market	Residential
Baseline Condition	Retrofit
Baseline	Existing
End Use Subcategory	Window
Measure Last Reviewed	March 2024
Changes Since Last Version	• New measure

Description

This measure covers the installation of plastic window insulation film covering the interior side of a window frame. The film is sealed around the frame with adhesive tape, creating an insulating air gap between the window glass and the plastic film. This gap can only be achieved if the film is maintained without any cuts or slits. The reduced thermal conduction saves energy by decreasing heating loads on the dwelling's heating systems.

This measure claims only energy savings from heating a dwelling since it is assumed that the plastic window insulation is removed outside of the heating season to allow the windows to be opened.

Baseline Case

Existing window without insulation film.

Efficient Case

Windows with insulation film sealed with the help of adhesive tape.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{\left(\frac{1}{R_w} - \frac{1}{R_w + R_I}\right) \times A \times HDD \times 24}{COP \times 3{,}412} \times F_{ElecHeat}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\left(\frac{1}{R_w} - \frac{1}{R_w + R_I}\right) \times A \times HDD \times 24}{Eff_{FuelHeat} \times 100{,}000} \times F_{FuelHeat}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-170 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated or look up in Table 2-172	kWh/yr	
ΔTherms	Annual fuel savings	Calculated or look up in Table 2-172	Therms/yr	
$\Delta Therms_{Peak}$	Peak day gas savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
A	Glazing area of impacted windows[51] in square feet	Site-specific, if unknown use 6 square feet per window	ft^2	[236]
COP	Coefficient of performance of electric heating equipment (convert HSPF to COP by dividing by 3.412)	Site-specific, if unknown look up in Appendix E for existing efficiency of heating equipment, if heating	N/A	[236]

[51] Average Window Size - homedit.com

Variable	Description	Value	Units	Ref
		equipment unknown, assume 1.37[52]		
$Eff_{FuelHeat}$	Efficiency of fuel heating equipment	Site-specific, if unknown look up in Appendix E for existing efficiency of heating equipment, if heating equipment unknown, assume 0.79[53]	N/A	[236]
HDD	Heating degree days (basis 65°F)	Lookup in Table 2-171 HDD65 values for various NJ Location	N/A	[237]
R_w	R-value of existing windows	Site-specific, if unknown use 1.13	h.ft^2. °F/Btu	[236]
R_I	R-value added as a result of plastic window insulation[54]	1.74	h.ft^2. °F/Btu	[236]
$F_{ElecHeat}$	Electric heating factor	Electric heating: 1.0 Otherwise: 0.0 If unknown: look up in Appendix K	N/A	[236]
$F_{FuelHeat}$	Fossil fuel heating factor	Fuel heating: 1.0 Otherwise: 0.0 If unknown: look up in Appendix K	N/A	[236]
PDF	Peak Day Factor	See Appendix	N/A	
24	Hours in a day	24	Hrs	
3,412	Unit conversion, Btu/kWh	3,412	Btu/kWh	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	
EUL	Effective useful life	See Measure Life section	Years	

Table 2-171 HDD65 values for various NJ Location

Location	HDD65
Northern	6,136

[52] Based on RECS microdata weights for prevalence of heat pumps and electric resistance heating and 2013 heat pump efficiencies
[53] Average of gas-fired hot water boiler, steam boiler, and furnace 2013 minimum efficiencies
[54] Inspectapedia air gap R value of 0.87 per inch, assuming 2 inches air gap between interior glazing surface and front of interior window frame trim.

Location	HDD65
Southwest	5,658
Coastal	4,795
Central	5,588
Pine Barrens	5,529
Statewide Average	**5,553**

If the default values for all the parameters are used, the calculations result in the deemed values below.

Table 2-172 Deemed kWh and Therms Savings Value, per Window

Location	ΔkWh	ΔTherms
Northern	101.42	6.08
Southwest	93.52	5.60
Coastal	79.25	4.75
Central	92.36	5.53
Pine Barrens	91.38	5.48
Statewide Average	**91.58**	**5.49**

Peak Factors

Table 14 Peak Factors

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 1 year[55] [236].

References

[236] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, Version 11, Effective Date January 2024, https://dps.ny.gov/technical-resource-manual-trm

[237] HDD65 calculated with TMY3 weather data for representative weather stations for each NJ climate zone. See Appendix A.

[55] 1 year is assumed to be the EUL since plastic window insulation comes in the form of single-use kits that are disposed of when the heating season ends.

2.7 WATER HEATING

2.7.1 HEAT PUMP WATER HEATER

Market	Residential/Multifamily
Baseline Condition	NC/TOS/DI/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023
Changes Since Last Version	• Moved code-compliant efficiency look ups to appendix • Added unknown derating and location factors based on ResStock data

Description

Heat pump water heaters take heat from the surrounding air and transfer it to the water in the tank, unlike conventional water heaters, which use either gas (or sometimes other fuel) burners or electric resistance heating coils to heat the water.Due to the interactivity of the heat pump water heater with the building's HVAC system, there is a decrease in a home's cooling energy consumption and an increase in the heating energy consumption if the heat pump water heater is located in conditioned space.

Baseline Case

TOS/NC baseline equipment is a minimally code compliant, electric storage type water heater.[56] EREP/DI baseline equipment is a minimally code compliant system of the same type and fuel as the existing equipment.

Efficient Case

The efficient condition is an ENERGY STAR V. 5.0 qualified heat pump water heater.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{dhw} + \Delta kWh_{cooling} - \Delta kWh_{heating}$$

Where,

[56] Note that heat pump water heaters are code required for tanks greater than 55 gallons.

$$\Delta kWh_{dhw} = \frac{Load_{dhw}}{3{,}412} \times \left(\frac{F_{dhw,electric}}{UEF_b} - \frac{1}{UEF_q \times F_{derate}}\right)$$

$$\Delta kWh_{cooling} = \frac{Load_{dhw}}{1{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times \frac{F_{cool}}{SEER}$$

$$\Delta kWh_{heating} = \frac{Load_{dhw}}{1{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times F_{heat,electric} \times \frac{F_{heat}}{HSPF}$$

$$Load_{dhw} = GPD \times 365 \times 8.33 \times (T_{set} - T_{main})$$

$$GPD = 17.2 \times N_{ppl}$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{dhw} - \Delta Therms_{heating}$$

Where,

$$\Delta Therms_{dhw} = \frac{Load_{dhw}}{100000} \times \left(\frac{F_{dhw,ff}}{UEF_b} + \frac{F_{dhw,boiler}}{AFUE}\right)$$

$$\Delta Therms_{heating} = \frac{Load_{dhw}}{100000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times F_{heat,ff} \times \frac{F_{heat}}{AFUE}$$

Peak Demand Savings[57]

For water heaters with a rated storage volume of 55 gallons or less:

$$\Delta kW_{Peak} = 0.09 \times \frac{UEF_q}{3.41}$$

For water heaters with a rated storage volume greater than 55 gallons:

$$\Delta kW_{Peak} = 0.11 \times \frac{UEF_q}{3.34}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

[57] Constants in peak demand equations from Mid-Atlantic TRM v10: “Analysis of special study. Cadmus, “EmPOWER Maryland Heat Pump Water Heater Baseline and Market Analysis”, February 2020. The study leveraged HPWH load shapes from “Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters” (https://www.energy.gov/sites/prod/files/2014/01/f7/heat_pump_water_heater_testing.pdf).”

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-173 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{dhw}	Annual domestic hot water electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{cooling}$	Annual cooling electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual heating electric energy impacts	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{dhw}$	Annual domestic hot water fuel savings	Calculated	Therms/yr	
$\Delta Therms_{heat}$	Annual space heating fuel impacts	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Load_{dhw}$	Annual hot water load	Calculated	Btu	
v_t	Tank volume	Site-specific	Gal	
UEF_q	Uniform energy factor of efficient unit	Site-specific, if unknown look up in Table 2-175	N/A	[244]

Variable	Description	Value	Units	Ref
AFUE	Annual fuel utilization efficiency of existing space heating or domestic hot water boiler or furnace	Site-specific, if unknown look up in Table 2-178	N/A	[241]
GPD	Gallons per day	Calculated, if N_{ppl} unknown use 46	Gal/day	[238]
N_{ppl}	Number of people in the home	Site-specific, if unknown use default 2.65	persons	[247]
$F_{DHW,electric}$	Electric water heating factor	Look up in Table 2-174	N/A	
$F_{DHW,g}$	Gas water heating factor	Look up in Table 2-174	N/A	
$F_{DHW,boiler}$	Gas boiler water heating factor	Look up in Table 2-174	N/A	
$F_{heat,electric}$	Electric space heating factor	Look up in Table 2-174	N/A	
$F_{heat,g}$	Gas space heating factor	Look up in Table 2-174	N/A	
UEF_b	Uniform energy factor of baseline unit as a function of baseline fuel type.	Look up in Appendix E: Code-Compliant Efficiencies	N/A	[241][242]
F_{derate}	Efficiency derating factor	Look up in Table 2-176	N/A	[243][244]
$F_{location}$	Installation location factor	Look up in Table 2-176	N/A	
SEER	Seasonal energy efficiency ratio of existing air conditioning system	Look up in Table 2-177	Btu/W·hr	
HSPF	Heating seasonal performance factor of existing electric heating system	Look up in Table 2-177	Btu/W·hr	
CF	Electric coincidence factor	Look up in Table 2-179	N/A	
PDF	Gas peak day factor	Look up in Table 2-179	N/A	
T_{set}	Water heater setpoint temperature	125	°F	[239]
T_{main}	Supply water temperature in water main	60	°F	[240]
F_{cool}	Cooling factor	0.51	N/A	[242]
F_{heat}	Heating factor	0.49	N/A	[242]
365	Days per year	365	Days/yr	
8.33	Unit conversion, Btu/gal·°F	8.33	Btu/gal·°F	
3,412	Unit conversion, Btu/kWh	3,412	Btu/kWh	
3.412	Unit conversion, Btu/W·hr	3.412	Btu/W·hr	
1000	Unit conversion, Watt/kW	1000	W/kW	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-174 DHW and Heating Factors

Baseline Scenario	$F_{DHW,electric}$	$F_{DHW,g}$	$F_{DHW,boiler}$	$F_{heat,electric}$	$F_{heat,g}$
TOS/NC: use electric baseline	1.0	0	0	1.0	0
EREP/DI with existing electric water heater and space heat	1.0	0	0	1.0	0
EREP/DI with existing gas water heater and space heat	0	1.0	1.0	0	1.0

Table 2-175 Efficient UEF

Product Class	Criteria	UEF
Electric Storage Water Heater	Integrated HPWH	3.30
	Integrated HPWH, 120 Volt/15 Amp Circuit	2.20
	Split-system HPWH	2.20

Table 2-176 Derating Factors

Area	F_{derate}	$F_{location}$
Unconditioned Basement	0.86	0
Garage	0.83	0
Conditioned Space	1.00	1.00
Unknown[58]	0.95	0.62

Table 2-177 SEER and HSPF Values

Type	SEER	HSPF
Air-Source Heat Pump	14.0	8.0
Ground-Source Heat Pump	15.0	10.9
CAC	14.0	N/A
Mini Split HP	15.0	8.8

[58] Unknown derating and location factors based on ResStock data

Table 2-178 AFUE Values

Equipment Type	Size Range	AFUE
Warm Air Furnace, Gas Fired	All Capacities	0.80
Boiler, Hot Water, Gas Fired	All Capacities	0.82
Boiler, Steam, Gas Fired	All Capacities	0.80

Peak Factors

Peak coincidence is accounted for in the peak demand savings algorithm section above.

Table 2-179 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-180 Measure Life

Equipment	EUL	RUL	Ref
Heat Pump Water Heater	10	3.33	[246]

References

[238] EmPOWER heat pump water heater program participation in 2018-2019 and participant survey data; per Mid-Atlantic TRM v10, pg. 150. https://neep.org/sites/default/files/media-files/trmv10.pdf

[239] NMR Group, Inc., 2018 Pennsylvania Statewide Act 129 Residential Baseline Study (Feb 2018). https://www.puc.pa.gov/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf

[240] Using Rock Spring, PA (Site 2036) as a proxy, the mean of soil temperature at 40 inch depth is 51.861. Calculated using Daily SCAN Standard - Period of Record data from April 1999 to December 2018 from the Natural Resource Conservation Service Database. https://wcc.sc.egov.usda.gov/nwcc/rgrpt?report=daily_scan_por&state=PA. Methodology follows Missouri TRM 2017 Volume 2: Commercial and Industrial Measures. p. 78. https://energy.mo.gov/sites/energy/files/MOTRM2017Volume2.pdf

[241] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[242] 10 CFR Subpart B of Part 429, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-429/subpart-B/section-429.17

[243] Bonneville Power Administration, Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates. (November 2011), https://rpsc.energy.gov/sites/default/files/tech-resource/attachment/BPA_HPWH_Lab_Evaluation_11-9-2011.pdf

[244] Fluid Market Strategies, NEEA Heat Pump Water Heater Field Study Report. (2013), https://neea.org/img/uploads/heat-pump-water-heater-field-study-report.pdf

[245] ENERGY STAR Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria, Version 4.0. (2021), https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%204.0%20Water%20Heaters%20Final%20Specification%20and%20Partner%20Commitments_0.pdf

[246] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[247] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household, April 2016

2.7.2 INDIRECT WATER HEATER

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	December 2022

Description

This measure covers the installation of a fossil fuel indirect-fired storage water heating system in which the stored water is heated via hot water produced by a fossil fuel boiler rather than direct input from electric elements or fossil fuel burners. In such a system, a heat exchanger separates the potable water in the water heater from the boiler water. This measure applies to indirect-fired systems comprising a boiler with input heating capacity less than 300,000 Btu/h and a storage tank with a capacity of 20 to 120 gallons installed in residential applications.

This measure estimates savings associated with the delivery of potable hot water only and assumes the installation of zone priority controls to interrupt demand for space heating hot water until domestic hot water demand is met.

Baseline Case

The baseline condition is a minimally code-compliant indirect fired, fossil fuel storage type water heater with a recovery efficiency of 75%, tank volume equal to the energy efficient condition.

Efficient Case

Theefficient case is an indirect fossil fuel-fired water heating system with efficiency meeting or exceeding 0.85 AFUE.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = units \times \left(\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100,000} \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right) + \left(\frac{UA_b}{Eff_b} - \frac{UA_q}{Eff_q}\right) \times \frac{\Delta T_{amb} \times 8,760}{100,000}\right)$$

Where,

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

$$GPD = 17.2 \times N_{ppl}$$

$$UA_q = \frac{SL_q}{70} \times v_q \times 8.33$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-181 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
GPD	Gallons per day	Calculated, if N_{ppl} unknown use 46	Gal/day	[248]

Variable	Description	Value	Units	Ref
ΔT_{main}	Average temperature difference between water heater set point temperature (T_{set}) and the supply water temperature in water main (T_{main})	Calculated	°F	
ΔT_{amb}	Average temperature difference between water heater set point temperature (T_{set}) and the surrounding ambient air temperature (T_{amb})	Calculated	°F	
UA_q	Overall heat loss coefficient of the energy efficient equipment	Calculated, if SL_q unknown use 5.4	(Btu/h-°F).	[253]
Eff_q	Efficiency of energy efficient connected boiler (AFUE)	Site-specific. If unknown use 0.85[59]	N/A	
N_{ppl}	Number of people in household	Site-specific, if unknown use default 2.65	N/A	[253]
SL_q	Standby loss specification of installed equipment. Use given UAq assumption if SLq is unknown.	Site-specific	°F/hr	
v_q	Rated storage capacity of installed equipment	Site-specific	Gal	
UA_b	Overall heat loss coefficient of the baseline condition	7.85	(Btu/h-°F).	[251]
T_{set}	Water heater set point temperature	125	°F	[249]
T_{main}	Supply water temperature in water main	60	°F	[250]
T_{amb}	Surrounding ambient air temperature	70[60]	°F	
Eff_b	Efficiency of the baseline condition, deemed (AFUE)	0.75	N/A	[251]
365	Days per year	365	Days/yr	
8,760	Hours per year	8,760	Hr/yr	
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal°F	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

[59] ASHRAE 90.1 2019 Compliant AFUE values range from 82% to 84%. Assumed conservative estimate of 85%

[60] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating ambient air temperature

Peak Factors

Table 2-182 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-183 Measure Life

Equipment	EUL	RUL	Ref
Indirect Water Heater	11	3.67	[254]

References

[248] Water Research Foundation: *Residential End Uses of Water*, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household, April 2016

[249] Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 430, Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B.

[250] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature*. National Renewable Energy Laboratory, 2022.

[251] Per 10 CFR 430, typical recovery efficiency of a gas water heater, which is used for the purposes of this measure as a proxy for thermal efficiency, is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1., December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B.

[252] Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment, December 2022.

[253] Based on the average standby loss specification (in °F/hr) of AHRI-certified Indirect Water Heater storage tanks, per the AHRI Directory, Air Conditioning, Heating, and Refrigeration Institute, December 2022. https://ahridirectory.org.

[254] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

2.7.3 STORAGE WATER HEATER

Market	Residential/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of storage tank water heaters designed to heat and store water at a thermostatically controlled temperature. This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating. Additionally, qualifying equipment must be designed to heat water to a temperature no greater than 180°F.

Storage type units include residential gas storage water heaters with an input of 75,000 Btu per hour or less.

This measure applies to replacement of existing storage type water heaters using the same heating fuel as the efficient case and assumes baseline to be a minimally code compliant water heater of the same type and heating fuel as the efficient case. For new construction, this measure assumes baseline to be a minimally code compliant storage-type water heater using the same heating fuel as the efficient case.

Baseline Case

The baseline condition is a minimally code compliant water heater equivalent to the existing water heater and with tank volume, input capacity and draw pattern equivalent to the efficient water heater. For new construction, the baseline condition is a minimally code compliant storage-type water heater with tank volume, input capacity and draw pattern equivalent to the efficient water heater.

Efficient Case

The compliance condition is an ENERGY STAR® rated gas storage water heater as directed by the measure description. Efficient storage tank water heaters must be eligible under ENERGY STAR® Program Requirements for Residential Water Heaters, Eligibility Criteria Version 5.0, effective April 2023. [260] Minimum UEF qualification for ENERGY STAR® equipment is shown in Table 2-185.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{UEF_b} - \frac{1}{UEF_q}\right)$$

Where,

$$GPD = 17.2 \times N_{ppl}$$

$$\Delta T_{main} = T_{set} - T_{main}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \text{N/A}$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-184 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
GPD	Gallons per day	Calculated, if unknown use 46	Gal/day	[255]
ΔT_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main	Calculated	°F	
UEF_q	Uniform Energy Factor of the energy efficient measure	Site-specific, if unknonwn look up in Table 2-185	N/A	
N_{ppl}	Number of people served by the system	Site-specific, if unknown use default 2.65	persons	[255]

Variable	Description	Value	Units	Ref
T_{set}	Water heater set point temperature	125	°F	[256]
T_{main}	Supply water temperature in water main[61]	60	°F	[257]
UEF_b	Uniform Energy Factor of the baseline condition, based on tank volume	Look up in Appendix E: Code-Compliant Efficiencies	N/A	
8,760	Hours per year	8,760	Hours/yr	
365	Days per year	365	Days/yr	
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal°F	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
17.2	Assumed gallons of hot water used per day per person in household	17.2	Gal/day/person	[255]
CF	Electric coincidence factor	Look up in Table 2-186	N/A	
PDF	Gas peak day factor	Look up in Table 2-186	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-185 Residential Water Heaters Energy Star Criteria

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	Minimum UEF
Gas-Fired Storage Water Heater	> 20 gal and ≤ 55 gal	Medium	0.81
	> 20 gal and ≤ 55 gal	High	0.86
	> 55 gal	Medium	0.86

Peak Factors

Table 2-186 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[259]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

[61] Average value across NJ climate zones, calculated as average ambient air temperature + 6 °F.

Measure Life

The effective useful life (EUL) is 11 years for gas water heaters and 13 years for electric water heaters. [258]

References

[255] Water Research Foundation: "Residential End Uses of Water, Version 2: Executive Report", April 2016, https://www.mrwa.com/PDF/2016WaterEndUseReport.pdf

[256] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature https://www.ecfr.gov/current/title-10/chapter-II/subcharpter-D/part430/sybpart-B/appendix-E

[257] Calculated from annual NJ temperatures using methodology in Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory, 2022

[258] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

[259] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf.

[260] Energy Star Residential Water Heaters Specification Final Draft v5.0 https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%205.0%20Residential%20Water%20Heaters%20Final%20Draft%20Specification.pdf

2.7.4 TANKLESS WATER HEATER

Market	Residential/Multifamily
Baseline Condition	NC/RF/DI
Baseline	Code/Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	December 2022

Description

This measure covers the installation of instantaneous type water heaters, which heat water but contain no more than one gallon of water per 4,000 Btu per hour of input. This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating. Additionally, qualifying equipment must be designed to heat water to a temperature no greater than 180°F and, if electric power is required for operation, must use a single-phase external power supply.

Instantaneous type units include fossil fuel instantaneous water heaters with a rated input capacity of greater than or equal to 50,000 and less than 200,000 Btu per hour and a manufacturer's specified storage capacity of less than 2 gallons, residential electric instantaneous water heaters with an input of 12 kilowatts or less and a manufacturer's specified storage capacity of less than 2 gallons.

Baseline Case

The retrofit baseline condition is a minimally code compliant water heater of type (storage-type or instantaneous) equivalent to the existing water heater and with tank volume (where applicable), input capacity and draw pattern equivalent to the efficient water heater. For new construction, the baseline condition is a minimally code compliant 40-gallon storage-type with draw pattern equivalent to the efficient water heater (assume medium if unknown).

Efficient Case

The efficient case is an energy efficient fossil fuel or electric instantaneous type water heater as defined by the measure description.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412 \times UEF_b}\ (Electric\ Baseline)$$

$$kWh_b = 0\ (Fossil\ Fuel\ Baseline)$$

$$kWh_q = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412 \times UEF_q}(Electric\ Energy\ Efficient\ Case)$$

$$kWh_q = 0\ (Fossil\ Fuel\ Energy\ Efficient\ Case)$$

$$GPD = 17.2 \times N_{ppl}$$

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000 \times UEF_b}\ (Fossil\ Fuel\ Baseline)$$

$$Therms_b = 0\ (Electric\ Baseline)$$

$$Therms_q = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000 \times UEF_q}\ (Fossil\ Fuel\ Energy\ Efficient\ Case)$$

$$Therms_q = 0\ (Electric\ Energy\ Efficient\ Case)$$

$$GPD = 17.2 \times N_{ppl}$$

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\left(UA_b - UA_q\right) \times \Delta T_{amb}}{3{,}412} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms - day_{peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-187 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms\text{-}day_{Peak}$	Daily peak fuel savings	N/A	Therms/day	
ΔT_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)	Calculated	°F	
ΔT_{amb}	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)	Calculated	°F	
GPD	Gallons per day	Calculated, if N_{ppl} unknown, use 46	Gal/day	[261]
N_{ppl}	Number of people in household	Site-specific. If unknown, use 2.65	N/A	[268]
T_{set}	Water heater set point temperature	Site-specific. If unknown, use 125	°F	[262]
T_{main}	Supply water temperature in water main	60	°F	[263]
T_{amb}	Surrounding ambient air temperature	70	°F	
UEF_b	Uniform Energy Factor of the baseline condition	Retrofit: Site-specific	N/A	[266]

Variable	Description	Value	Units	Ref
		New construction: Look up in Appendix E: Code-Compliant Efficiencies		
UEF_q	Uniform Energy Factor of the energy efficient measure.	Site-specific	N/A	
UA_b	Overall heat loss coefficient of the baseline condition.	Storage water heater baseline: UA_b = 7.85 Indirect water heater baseline: UA_b = 0	(Btu/h-°F).	[264]
UA_q	Overall heat loss coefficient of the energy efficient measure.	0	(Btu/h-°F).	[265]
365	Days per year	365	Days/yr	
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal-°F	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 2-188	N/A	
PDF	Peak day factor	Look up in Table 2-188	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 2-188 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[267]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for retrofit projects is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-189 Measure Life

Equipment	New construction EUL	Retrofit RUL	Ref
Instantaneous Water Heater	20	6.66	[267]

References

[261] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household, April 2016.

[262] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[263] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory, 2022.

[264] Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment, December 2022.

[265] Based on the average standby loss specification (in °F/hr) of AHRI-certified Indirect Water Heater storage tanks, per the AHRI Directory, December 2022.

[266] 10 CFR 430.32(d), December 2022.

[267] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

[268] *Residential End Uses of Water: Version 2 Executive Report (Water Research Foundation)*, Pg 8. https://www.circleofblue.org/wp-content/uploads/2016/04/WRF_REU2016.pdf

2.7.5 COMBINATION BOILER

Market	Residential
Baseline Type	TOS/NC/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2024
Changes Since Last Version	• New measure

Description

This section provides energy savings algorithms for qualifying gas combination boilers installed in residential settings. A combination boiler is a space heating system that also has the capability to provide instantaneous domestic hot water. The input values are based on the specifications of the actual equipment being installed, federal equipment efficiency standards, and regional estimates of average baseline water heating energy usage.

For new construction, and time of sale replacement of failed equipment at the end of the boiler useful life, the baseline unit is a code compliant unit with an efficiency as required by IECC 2021, which is the current code adopted by the State of New Jersey.

For early replacement programs, the baseline efficiency is the existing boiler efficiency for the remaining life of the existing boiler and a code efficiency boiler for the remaining life of the measure.

Baseline Case

Space Heating Component:

- NC/TOS: Single baseline of boiler of the same fuel type as the installed equipment which is compliant with IECC 2021.
- EREP: Dual baseline
    - First baseline for existing equipment RUL: Existing boiler efficiency. If unknown, use minimally code-compliant efficiency from code in force at time of installation. If installation year is unknown, assume ⅔ EUL has elapsed.
    - Second baseline for remainder of measure EUL: Boiler compliant with IECC 2021.

Domestic Hot Water Component:

- NC/TOS: Single baseline of a storage water heater of the same fuel type as the installed equipment which is compliant with IECC 2021.
- EREP: Dual baseline
    - First baseline for existing equipment RUL: Existing water heater efficiency. If unknown, use minimally code-compliant efficiency for a storage water heater from code in force at time of installation. If installation year is unknown, assume ⅔ EUL has elapsed.
    - Second baseline for remainder of measure EUL: Storage water heater compliant with IECC 2021.

Efficient Case

The compliance condition is a combi-boiler unit with a heating efficiency higher than code. Qualifying systems must not have a water storage tank.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{Boiler} + \Delta Therms_{DHW}$$

Where,

$$\Delta Therms_{Boiler} = Cap_{in} \times EFLH_h \times \frac{AFUE_q/AFUE_b - 1}{100}$$

$$\Delta Therms_{DHW} = \frac{GPD \times 365 \times 8.33 \times (T_{set} - T_{main})}{100{,}000} \times \left(\frac{1}{UEF_b} - \frac{1}{UEF_q}\right)$$

$$GPD = 17.2 \times N_{people}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-190 Calculation Parameters

Variable	Description	Value	Units	Ref
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Boiler}$	Annual fuel savings from space heating	Calculated	Therms/day	
$\Delta Therms_{DHW}$	Annual fuel savings from water heating	Calculated	Therms/day	
GPD	Gallons per day of hot water use	Calculated, if unknown use 46	Gal/day	[276]
Cap_{in}	Input capacity of qualifying boiler	Site-specific	kBtu/hr	
$AFUE_q$	Boiler proposed efficiency	Site-specific	N/A	
N_{People}	Number of people served by the system	Site-specific	people	
T_{set}	Water heater setpoint temperature	Site-specific, if unknown, use 125	°F	[84]
UEF_q	Efficient case water heater Uniform Energy Factor	Site-specific, if unknown use 0.87[62]	N/A	
$EFLH_h$	Boiler equivalent full load hours of operation during heating season	Look up in Appendix CAppendix C:	Hours	[83]
$AFUE_b$	Boiler baseline efficiency	TOS/NC: Code compliant baseline values given in Table 2-191 EREP: Site-specific, if unknown use code efficiency in force when equipment was new. If vintage unknown, assume ⅔ EUL has elapsed.	N/A	[270]
UEF_b	Baseline water heater Uniform Energy Factor	TOS/NC: Code compliant baseline values if unknown use 0.657 EREP: Site-specific, if unknown use code efficiency in force when equipment was new. If vintage unknown, assume ⅔ EUL has elapsed.	N/A	[86]
T_{main}	Incoming water main temperature[63]	60	°F	[85]
100	Unit conversion from kBtu to therm	100	kBtu/therm	
365	Days per year	365	Day/yr	
8.33	Unit conversion, Btu/gal·F	8.33	Btu/gal·F	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	

[62] Minimum UEF for instantaneous (tankless) water heaters from Energy Star
[63] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6 deg F.

Variable	Description	Value	Units	Ref
8,760	Hours in one year	8760	Hours	
PDF	Peak day factor	Look up in Table 3-367	N/A	
EUL	Estimated useful life	See Measure Life Section	Years	[88]

Table 2-191 Baseline AFUE of Single Family Boilers

Product Class	AFUE Manufactured before Sep 1, 2012	AFUE (Manufactured on and after Sep 1, 2012 and before Jan 15, 2021)	AFUE (Manufactured on and after January 15, 2021)
Gas-fired hot water boiler	0.80	0.82	0.84
Gas-fired steam boiler	0.75	0.80	0.82
Oil-fired hot water boiler	0.80	0.84	0.86
Oil-fired steam boiler	0.80	0.82	0.85

Peak Factors

Table 2-192 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-193 Measure Life

Equipment	EUL	RUL	Ref
Combination Boiler	22	7.3	[88]

References

[269] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[270] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[271] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature* (National Renewable Energy Laboratory). https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/AlgorithmForMainsWaterTemperature.pdf

[272] The referenced federal standards for the baseline UEF are dependent on both draw pattern and tank size. A weighted average baseline UEF was calculated with a medium draw pattern from the referenced federal standards and water heating equipment market data from the Energy Information Association 2009 residential energy consumption survey for NJ[64] assuming tank sizes of 30 gallons for small water heaters, 40 gallons for medium water heaters, and 55 gallons for large water heaters.

[273] “Regulations.gov.” n.d. www.regulations.gov. Accessed December 13, 2022. Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters. Heat loss coefficient was calculated for a minimally code compliant fuel storage water heater found to be the most typical in terms of storage and input capacity, representing storage type water heaters of between 20 and 55 gallon capacity (40 gallon, 40,000 Btu/h assumed). Results of heat loss coefficient evaluation for this assumed baseline is used to represent the UAbaseline term.

[274] https://www.regulations.gov/document/EERE-2015-BT-TP-0007-0004

[275] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010

[276] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.

[64] Available at: https://www.eia.gov/consumption/residential/data/2009/hc/hc8.8.xls

2.7.6 WATER HEATING SETBACK

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	December 2022
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure relates to turning down an existing hot water tank thermostat setting that is at 130 degrees or higher. Savings are provided to account for the resulting reduction in standby losses. This is a retrofit measure.

Baseline Case

The baseline condition is a hot water tank with a thermostat setting that is 130 degrees or higher. Note if there are more than one DHW tanks in the home at or higher than 130 degrees and they are all turned down, then the savings per tank can be multiplied by the number of tanks.

Efficient Case

The efficient condition is a hot water tank with the thermostat reduced to no lower than 120 degrees.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{U \times A \times \left(T_b - T_q\right) \times Hrs}{3{,}412 \times RE_{electric}}\right)$$

Annual Fuel Savings

$$\Delta Therms = \left(\frac{U \times A \times \left(T_b - T_q\right) \times Hrs}{1{,}00{,}000 \times RE_{gas}}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-194 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms\text{-}day_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta kWh_{Lifetime}$	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Lifetime}$	Lifetime fuel savings	Calculated	Therms	
U	Overall heat transfer coefficient of tank	Site-specific, if unknown use 0.083[65]	(Btu/Hr-°F-ft²)	
A	Surface area of storage tank	Site-specific, if unknown look up in Table 2-195	Ft²	[277]
T_b	Hot water setpoint prior to adjustment	Site-specific, if unknown use 130	°F	[280]
T_q	New hot water setpoint	Site-specific, if unknown, use 120	°F	[279]
Hours	Number of hours in a year	8760	Hrs/yr	
$RE_{electric}$	Recovery efficiency of water heater	Electric Hot Water Heater: 0.98 Heat Pump Water Heater: 2.1	N/A	[277]
RE_{gas}	Recovery efficiency of gas water heater	0.8	N/A	[278]
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 2-196	N/A	

[65] Assumes R-12 water tank

Variable	Description	Value	Units	Ref
EUL	Effective useful life	See Measure Life	Years	
RUL	Remaining useful life of existing unit	See Measure Life	Years	

Table 2-195 Assumed Surface Area of Storage Tank by Capacity

Capacity (in gallons)	Area (in square feet)
30	19.16
40	23.18
50	24.99
80	31.84

If capacity is unknown, assume a 50 gallon tank.

Peak Factors

Table 2-196 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life for water heating setback is the smaller of 2 years or the remaining useful life of the water heater [279].

References

[277] Assumptions from Pennsylvania TRM. Area values were calculated from average dimensions of several commercially available units, with radius values measured to the center of the insulation, December 2022. https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 430, Subpart B, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency,* December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B#Appendix-E-to-Subpart-B-of-Part-430.

[278] Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 431, Section 431.110 (a) – Energy Conservation Standards and their Effective Dates. December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431#431.110.

[279] Mid-Atlantic TRM V10, December 2022. https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf.

[280] *Technical Reference Manual Volume 2: Residential Measures (2019)*; Pg 73, https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

2.7.7 FAUCET AERATORS AND SHOWERHEADS

Market	Residential/Multifamily
Baseline Condition	RF/TOS
Baseline	Existing/Code
End Use Subcategory	Water Conservation
Measure Last Reviewed	February 2024
Changes Since Last Version	• Updated baseline and efficient case description • Updated baseline and efficient flowrates • Updated default variable values in Table 2-198 • Updated non-energy impact calculations • Added calculations assumptiosn for 'unknown' location

Description

This measure presents the assumptions, analysis, and savings from adding low-flow aerators to faucets in kitchens and bathrooms, and for replacing standard showerheads with low-flow showerheads.

Savings for low-flow fixture measures are determined using the total change in flow rate (gallons per minute) per unit from the baseline (existing) fixture to the efficient low-flow fixture. This measure applies to residential and multifamily buildings.

Baseline Case

TOS: the baseline is a standard faucet or a showerhead meeting maximum flow given in the NJ A5160 [73].

RF: the baseline is the actual flow rate of the existing faucet. If unknown, default to the TOS baseline of a standard faucet or a showerhead meeting maximum flow given in the NJ A5160.

Efficient Case

The efficient condition is an energy efficient faucet aerator or showerhead with rated flow rate less than maximum flow rate given in the NJ A5160 [73]. Actual flow rates of the installed fixture are used to estimate the savings.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta H_2O \times \Delta T_{main} \times \frac{8.33}{3,412} \times \frac{1}{UEF} \times F_{elec}$$

Where,

$$\text{Aerators: } \Delta T_{main} = T_{faucet} - T_{main}$$

$$\text{Showerheads: } \Delta T_{main} = T_{shower} - T_{main}$$

Aerators:

$$\Delta H_2O = (GPM_b \times F_{Throttle,b} - GPM_q \times F_{Throttle,q}) \times \frac{1}{N_{faucet}} \times t_{use} \times N_{persons} \times 365$$

Showerhead:

$$\Delta H_2O = (GPM_b \times F_{Throttle,b} - GPM_q \times F_{Throttle,q}) \times \frac{1}{N_{shower}} \times t_{use} \times N_{persons} \times 365$$

Annual Fuel Savings

$$\Delta Therms = \Delta H_2O \times \Delta T_{main} \times \frac{8.33}{100{,}000} \times \frac{1}{UEF} \times F_{gas}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times ETDF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-197 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	

Variable	Description	Value	Units	Ref
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔH_2O	Annual water savings	Calculated	Gal/yr	
ΔT_{main}	Average temperature different between faucet operating temperature and the supply water temperature	Calculated. If unknown, use 25.	°F	
UEF	Uniform Energy Factor[66]	Site-specific. If unknown, assume 0.92 (electric) or 0.58 (gas)	N/A	[288]
N_{faucet}	Faucets per household	Site-specific. If unknown, look up in Table 2-198	N/A	[287]
N_{shower}	Showers per household	Site-specific. If unknown, look up in Table 2-198	N/A	[287]
$N_{persons}$	Average number of people per household	Site-specific. If unknown, assume 2.66	Person/ household	[281]
GPM_b	Baseline flowrate	RF: Site-specific, if unknown look up in Table 2-198 TOS: Look up in Table 2-198	Gal/min	[283], [286]
GPM_q	Efficient flowrate	Site-specific	Gal/min	[286]
T_{faucet}	Faucet existing temperature	Site-specific. If unknown, look up in Table 2-198	°F	[289]
T_{shower}	Showerhead existing temperature	Site specific, use 105 if unknown	°F	[291]
F_{elec}	Factor to account for presence or absence of electric water heater	1 if electric water heater; 0 if gas water heater; if unknown look up in Appendix KAppendix K: DHW and Space Heat Fuel Split or default[67] = 0.25	N/A	
F_{gas}	Factor to account for presence or absence of fossil fuel water heater	1 if gas water heater; 0 if electric water heater; if	N/A	

[66] Take UEF from application using the existing water heater's model number lookup. If unknown, then UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E (accessible here: https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32).
Assume medium draw pattern if unknown. If storage capacity is also unknown, use the assumptions above for a 40 gallon, medium draw, electric or gas storage water heater.

[67] From 2015 RECS microdata for Middle Atlantic Div 8. Of 228 households, fuel mix for water heating is 71% gas and 25% electric. No savings are attributed to 4% of households which use other fuel sources.

Variable	Description	Value	Units	Ref
		unknown look up in Appendix K or default [68] = 0.71		
t_{use}	Average minutes of use per person per fixture per day	Look up in Table 2-198	Minutes/ person/day	[282], [292]
$F_{throttle, b}$	Ratio of user setting to full throttle flow rate for baseline fixture	Aerator: 0.83 Showerhead: 0.9	N/A	[285], [292]
$F_{throttle, q}$	Ratio of user setting to full throttle flow rate for low flow fixture	Aerator: 0.95 Showerhead: 0.9	N/A	[285], [292]
T_{main}	Supply water temperature in water main[69]	60	°F	[284]
ETDF	Energy to Demand Factor	Aerator: 0.000134 Showerhead: 0.00008014	kW/kWh/yr	[283]
8.33	Energy required to heat one gallon of water by one degree Farenheit	8.33	Btu/gal°F	
3,412	Conversion factor from Btu/h to kW	3,412	Btu/h/kW	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
365	Number of days per year	365	Days/yr	
PDF	Peak day factor	Look up in Table 2-199	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-198 Calculation Assumptions per Fixture Type

Fixture Type	Location	Baseline gallons per minute (GPM_b)	Daily use duration (t_{use})	Operating temperature (T_{faucet}, T_{shower}) (°F)	Faucets/household (N_{faucet})
Faucet aerator	Kitchen	1.8	4.5	93	1
	Private restroom	1.5	1.6	86	1.75
	Unknown	1.6	2.5	88	1.5
Showerhead	Any	2.0	6.15	105	QHEC[70]: 1.56 HPwES[6]: 2.46

[68] From 2015 RECS microdata for Middle Atlantic Div 8. Of 228 households, fuel mix for water heating is 71% gas and 25% electric. No savings are attributed to 4% of households which use other fuel sources.
[69] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F. See Reference [284].
[70] QHEC = Quick Home Energy Check-up; HPwES = Home Performance with ENERGY STAR Program

Peak Factors

Electric coincidence is included in the ETDF factor.

Table 2-199 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G. Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) for both aerators and showerheads is 10 year [290].

Non-Energy Impacts

Aerators:

$$\Delta H_2O = (GPM_b \times F_{Throttle,b} - GPM_q \times F_{Throttle,q}) \times \frac{1}{N_{faucet}} \times t_{use} \times N_{persons} \times 365$$

Showerhead:

$$\Delta H_2O = (GPM_b \times F_{Throttle,b} - GPM_q \times F_{Throttle,q}) \times \frac{1}{N_{shower}} \times t_{use} \times N_{persons} \times 365$$

References

[281] Explore Census Data. n.d. Data.census.gov. Accessed December 1, 2022. https://data.census.gov/table?q=average+household+size&g=0400000US34&y=2020&tid=ACSDT5Y2020.B25010

[282] Cadmus and Opinion Dynamics Evaluation Team. Showerhead and Faucet Aerator Meter Study. For Michigan Evaluation Working Group. June 2013.

[283] Pennsylvania Technical Reference Manual; effective June 2016, pp. 114ff. http://www.puc.pa.gov/pcdocs/1370278.docx

[284] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature*. National Renewable Energy Laboratory. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf

[285] American Council for an Energy-Efficient Economy, *Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes*, August 2008, pg. 1-265.

[286] Baseline flow rates established by State of New Jersey, 219th Legislature, Assembly No 5610

[287] American Housing Survey Table Creator, United States Census Bureau, Housing Unit Characteristics, New York 2017 Accessed December 1, 2022 https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html?s_areas=35620&s_year=2021&s_tablename=TABLE0&s_bygroup1=1&s_bygroup2=1&s_filtergroup1=1&s_filtergroup

[288] UEF assumptions per 10 CFR Part 430, Subpart B, Appendix E. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32; assuming medium draw pattern, 40 gallon storage water heater.

[289] *Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study.* June 2013, via 2014 Demand-Side Management Evaluation Final Report, Cadmus, June 30, 2015, Table 93.

[290] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/; EUL ID: WtrHt-WH-Aertr, WtrHt-WH-Shrhd

[291] Lutz, Jim. 2011. "Water and Energy Wasted during Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems." https://eta-publications.lbl.gov/sites/default/files/water_and_energy_wasted_during_residential_shower_events_findings_from_a_pilot_field_study_of_hot_water_distribution_systems_lbnl-5115e.pdf.

[292] Biermayer, Peter, and Ernest Lawrence. 2006. "LBNL-58601-Revised Potential Water and Energy Savings from Showerheads." https://www.map-testing.com/assets/reports/LBNL%20Showerhead-final%20rpt.pdf.

2.7.8 THERMOSTATIC SHOWERHEADS

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Water Conservation
Measure Last Reviewed	December 2022
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure covers the installation of thermostatic shower restriction valves, which are valves attached to a showerhead supply for reduction of domestic hot water flow and associated energy usage in a single or multifamily household.

The device restricts hot water flow through the showerhead by activating the trickle or stop flow mode when water reaches a predetermined set temperature, as designed by the manufacturer.

The throttle factor should be used only when rated flows are used and not the actual measured flow.

Baseline Case

The baseline equipment is the residential showerhead without the restrictor valve installed.

Efficient Case

To qualify for this measure the installed equipment must be a thermostatic restrictor shower valve installed on a residential showerhead.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = GPM \times F_{Throttle} \times Min_{Waste} \times \frac{Person}{Household} \times \frac{Showers}{Person/Day} \times \frac{365}{N_{Shower}} \times 8.33 \times \frac{T_{Shower} - T_{Main}}{UEF \times 3{,}412} \times ISR \times F_{Elec}$$

Annual Fuel Savings

$$\Delta Therms = GPM \times F_{Throttle} \times Min_{Waste} \times \frac{Person}{Household} \times \frac{Showers}{Person/Day} \times \frac{365}{N_{Shower}} \times 8.33 \times \frac{T_{Shower} - T_{Main}}{UEF \times 100{,}000} \times ISR \times F_{NG}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times ETDF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-200 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{life}$	Lifetime fuel savings	Calculated	Therms	
GPM	Flow rate of the showerhead	Site-specific, if unknown look up in Table 2-201	Gal/min	[293][300]
Person/Household	Average number of people per household	Site-specific, if unknown assume 2.66	Person/ household	[295]
Showers/person/day	Showers Per Capita Per Day	Site-specific, if unknown assume 0.75	Showers/person/day	[296]
N_{Shower}	Average number of showerheads Per Household	Site-specific, if unknown assume 1.10	N/A	[297]
UEF	Uniform Energy Factor	Site-specific, if unknown assume 0.92 (electric) or 0.58 (gas)	N/A	[301]
F_{Elec}	Water heater fuel factor - electric	Look up in Table 2-202	N/A	

Variable	Description	Value	Units	Ref
F_{NG}	Water heater fuel factor - gas	Look up in Table 2-202	N/A	
$F_{Throttle}$	Ratio of actual shower gpm to showerhead rated gpm	0.9	N/A	[296]
Min_{Waste}	Hot water waste time avoided due to thermostatic restrictor valve	0.98	Minutes	[294]
T_{Shower}	Temperature at showerhead	105	°F	[298]
T_{Main}	Supply water temperature in water main[71]	60	°F	
ISR	In-Service Rate	Look up by program in Appendix J: In-Service Rates, or use default value = 1	N/A	
8.33	Energy required to heat one gallon of water by one degree Farenheit	8.33	Btu/gal°F	
3,412	Conversion factor from Btu/h to kW	3,412	Btu/h/kW	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
365	Number of days per year	365	Days/yr	
ETDF	Energy to Demand Factor	0.00008014	(kW/ kWh/yr)	[299]
CF	Electric coincidence factor	Look up in Table 2-203	N/A	
PDF	Gas peak demand factor	Look up in Table 2-203	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

[71] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F.

Table 2-201 GPM

Installation case	GPM
Existing Showerhead	2.5
New Conventional Showerhead	2.0
Low Flow Showerhead	1.5

Table 2-202 Water Heater Fuel Factors

Water Heater Fuel Type	F_{Elec}	F_{NG}
Electric	1	0
Gas	0	1
Unknown	Look up in Appendix K: DHW and Space Heat Fuel Split or default = 0.18	Look up in Appendix K: DHW and Space Heat Fuel Split or default = 0.82

Peak Factors

Table 2-203 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A[72]	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

Table 2-204 Measure Life

Equipment	EUL	RUL	Ref
Thermostatic Showerheads	10	3.3	[302]

References

[293] Cadmus and Opinion Dynamics Evaluation Team. *Showerhead and Faucet Aerator Meter Study: For Michigan Evaluation Working Group.* (June, 2013).

[294] Cadmus memo to PPL Electric. *PPL Electric 2014 ShowerStart Pilot Study*. (November 2014).

[295] Explore Census Data." n.d. Data.census.gov. Accessed December 1, 2022. https://data.census.gov/table?q=average+household+size&g=0400000US34&y=2020&tid=ACSDT5Y2020.B25010.

[72] Peak electric demand embedded in ETDF.

[296] Biermayer, Peter. 2006. "LBNL-58601-Revised Potential Water and Energy Savings from Showerheads." https://www.map-testing.com/assets/reports/LBNL%20Showerhead-final%20rpt.pdf.

[297] American Housing Survey (AHS) - AHS Table Creator." n.d. Www.census.gov. Accessed December 1, 2022. https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html?s_areas=35620&s_year=2021&s_tablename=TABLE0&s_bygroup1=1&s_bygroup2=1&s_filtergroup1=1&s_filtergroup

[298] Lutz, Jim. 2011. "Water and Energy Wasted during Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems." https://eta-publications.lbl.gov/sites/default/files/water_and_energy_wasted_during_residential_shower_events_findings_from_a_pilot_field_study_of_hot_water_distribution_systems_lbnl-5115e.pdf.

[299] Aquacraft, Inc., Water Engineering and Management. The end use of hot water in single family homes from flow trace analysis. 2001. https://www.researchgate.net/publication/252083793_THE_END_USES_OF_HOT_WATER_IN_SINGLE_FAMILY_HOMES_FROM_FLOW_TRACE_ANALYSIS The CF for showerheads is found to be 0.00371: [% showerhead use during peak × (TPerson-Day× NPerson) /(S/home)] / 240 (minutes in peak period) = [11.7% × (7.8 x 2.6 x 0.6 / 1.6)] / 240 = 0.00371. The Hours for showerheads is found to be 46.3: (TPerson-Day× NPersons× 365) /(S/home) / 60 = (7.8 x 2.6 x 0.6 x 365) / 1.6 / 60 = 46.3. The resulting FED is calculated to be 0.00008013: CF / Hours = 0.00371 / 46.3 = 0.00008013.

[300] Maximum flowrates for new showerheads taken from New Jersey P.L. 2021, c. 464 Enacted January 2022. https://legiscan.com/NJ/bill/A5160/2020

[301] Take UEF from application using the existing water heater's model number lookup. If unkown, then UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E (accessible here: https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32). Assume medium draw pattern if unknown. If storage capacity is also unknown, use the assumptions above for a 40 gallon, medium draw, electric or gas storage water heater.

[302] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

2.7.9 PIPE INSULATION

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Insulation
Measure Last Reviewed	November 2022
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure covers the installation of fiberglass, rigid foam, and cellular glass pipe insulation on exposed and uninsulated metal or steel piping with a nominal diameter between 0.50” and 4.00” for hot water and steam type space heating and/or domestic hot water (DHW) distribution systems in residential buildings. The measure is restricted to insulation of hot water distribution pipe in unconditioned spaces only. Space heating pipe insulation is limited to insulation installed in unheated spaces only. Insulation of CPVC, PEX, and HDPE piping is not eligible for savings under this measure due to low potential of savings.

In New Jersey the 2021 International Energy Conservation Code (IECC) generally defines the residential energy efficiency code requirements, but the IECC does not include residential service water heating provisions, leaving federal equipment efficiency standards to define baseline.

This measure caters for all insulation type given that they are IECC 2021 code compliant and are installed by certified professionals. The R-value of an insulation is the thermal resistance of its constituent material, which is derived by dividing the thickness of the material by the material’s thermal conductivity, or k-value. Thermal transmittance, or the material’s U-factor, is the inverse of the R-value.

Baseline Case

The baseline condition is uninsulated copper or steel domestic hot water or space heating piping located in an unconditioned space.

Efficient Case

The efficient case is insulated copper or steel domestic hot water or space heating piping located in an unconditioned space conforming to the requirements of IECC 2021 Section R403.5.2 which require hot water piping with 3/4" nominal diameter and larger to be insulated with a minimum thermal resistance of R-3.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \frac{\left[\left(\frac{UA}{L}\right)_b - \left(\frac{UA}{L}\right)_q\right] \times L \times \left(T_{pipe} - T_{amb}\right) \times hrs \times SF_{elec}}{Et_{elec} \times 3{,}412}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\left[\left(\frac{UA}{L}\right)_b - \left(\frac{UA}{L}\right)_q\right] \times L \times \left(T_{pipe} - T_{amb}\right) \times hrs \times SF_{fuel}}{Et_{fuel} \times 100{,}000}$$

Peak Demand Savings

$$\Delta kW_{peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-205 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
L	Length of installed insulation	Site-specific	ft	

Variable	Description	Value	Units	Ref
T_{pipe}	Average temperature of hot water or steam in distribution system piping	Site-specific, if unknown: DHW: 125 HW Boiler[73]: 160 Steam Boiler[74]: 212	°F	[307]
T_{amb}	Surrounding average ambient air temperature	Site-specific, if unknown: DHW: 70 Space Heat: 50	°F	[310]
Et_{fuel}	Recovery Efficiency of fuel water heaters or AFUE of boiler for space heating	Site-specific, if unknown: DHW[75]: 0.75 Space Heating Boilers: Look up in Table 2-208	N/A	[305][312]
Et_{elec}	Recovery Efficiency of electric water heaters	Site-specific, if unknown: Non- Heat Pump DHW[76]: 0.98 Heat Pump DHW: Look up in Table 2-209	N/A	[306][308]
hrs	Annual operating hours	For DHW: 8,760 Boilers: Look up heating EFLH in Appendix C: Heating and Cooling EFLH	hrs	[313]
$(UA/L)_b$	Product of Overall Heat Transfer Coefficient and Pipe Area (UA) per foot from uninsulated pipe[77]	Look up in Table 2-206	Btu/hr-°F-ft	[309]
$(UA/L)_q$	Product of Overall Heat Transfer Coefficient and Pipe Area (UA) per foot from insulated pipe[77]	Look up in Table 2-207	Btu/hr-°F-ft	[314]
SF_{elec}	Adjustment to electric water heating energy savings based on water heating fuel	Electric WH: 1.0 Fossil Fuel WH: 0 Unknown WH: Look up in Appendix K: DHW and Space Heat Fuel Split or default[78] = 0.18	N/A	[311]

[73] Average of lowest typical hot water boiler setting of (120°F) and highest typical setting of (200°F).
[74] Residential boiler's steam temperature shall be the boiling point of water at sea level (212°F).
[75] Nominal gas or oil water heater recovery efficiency taken by CFR is 75% for deriving water energy consumption of consumer products such as dishwashers, etc. [305]
[76] The CFR Uniform Test Method for the measurement of Standby Loss of Electric Storage Water Heaters, electric Storage-Type Instantaneous Water Heaters, and electric Instantaneous Water Heaters (Other Than Storage-Type Instantaneous Water Heaters) uses 98% efficiency for electric water heaters with immersed heating elements. [305]
[77] Also called Building Load Coefficient per unit length.
[78] "Unknown" calculated as the number of homes with electric water heating divided by the total number of homes with water heating in EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7.

Variable	Description	Value	Units	Ref
SF_{fuel}	Adjustment to fossil fuel water heating energy savings based on water heating fuel	Electric WH: 0 Fossil Fuel WH: 1.0 Unknown WH: Look up in Appendix K: DHW and Space Heat Fuel Split or default [79] = 0.82	N/A	[311]
CF	Electric coincidence factor	Look up in Table 2-210	N/A	
PDF	Gas peak day factor	Look up in Table 2-210	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 2-206 $(UA/L)_{baseline}$

Nominal Pipe Diameter (in)	Bare Copper Piping			Bare Steel Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat
0.50	0.44	0.48	0.53	0.53	0.59
0.75	0.54	0.58	0.64	0.65	0.72
1.00	0.65	0.70	0.78	0.79	0.88
1.25	0.80	0.86	0.96	0.97	1.09
1.50	0.90	0.97	1.09	1.10	1.23
2.00	1.10	1.19	1.33	1.34	1.51
2.50	1.31	1.42	1.58	1.60	1.80
3.00	1.57	1.70	1.90	1.92	2.16
3.50	1.77	1.92	2.15	2.18	2.45
4.00	1.98	2.14	2.40	2.43	2.73

Table 2-207 $(UA/L)_q$

Nominal Pipe Diameter (in)	Fiberglass						Rigid Foam/Cellular Glass					
	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in
0.50	0.13	0.09	0.08	0.07	0.06	0.06	0.15	0.12	0.10	0.09	0.09	0.08
0.75	0.14	0.11	0.09	0.08	0.07	0.07	0.17	0.13	0.11	0.10	0.10	0.09

[79] "Unknown" calculated as the number of homes with gas water heating divided by the total number of homes with water heating in EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7.

Nominal Pipe Diameter (in)	Fiberglass						Rigid Foam/Cellular Glass					
	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in
1.00	0.17	0.12	0.10	0.09	0.08	0.07	0.19	0.15	0.13	0.12	0.11	0.10
1.25	0.20	0.14	0.11	0.10	0.09	0.08	0.23	0.17	0.15	0.13	0.12	0.11
1.50	0.22	0.15	0.12	0.11	0.10	0.09	0.25	0.19	0.16	0.14	0.13	0.12
2.00	0.26	0.18	0.14	0.12	0.11	0.10	0.29	0.22	0.18	0.16	0.14	0.13
2.50	0.30	0.20	0.16	0.14	0.12	0.11	0.34	0.25	0.20	0.18	0.16	0.15
3.00	0.35	0.24	0.18	0.16	0.14	0.12	0.39	0.29	0.23	0.20	0.18	0.16
3.50	0.40	0.26	0.20	0.17	0.15	0.13	0.44	0.32	0.26	0.22	0.20	0.18
4.00	0.44	0.29	0.22	0.18	0.16	0.14	0.48	0.35	0.28	0.24	0.21	0.19

Table 2-208 Et_{fuel} for Space Heating Boilers

Product Class	AFUE (Manufactured before 9/1/2012)	AFUE (Manufactured on/after 9/1/2012, before 1/15/2021)	AFUE (Manufactured on/after 1/15/2021)
Gas-fired hot water boiler	0.80	0.82	0.84
Gas-fired steam boiler	0.75	0.80	0.82
Oil-fired hot water boiler	0.80	0.84	0.86
Oil-fired steam boiler	0.80	0.82	0.85

Table 2-209 Et_{elec} for Domestic Hot Water Heaters

Size (Gallons)	UEF	Et_{elec}
50	3.30	2.83
50	3.50	2.92
50	3.75	3.14
65	3.30	2.85
65	3.50	2.94
65	3.75	3.24
80	3.30	2.85
80	3.50	3.01
80	3.75	3.38

Size (Gallons)	UEF	Et_{elec}
Unknown Size[80]	-	3.016

Peak Factors

Table 2-210 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	DHW: 1.0 Space Heat: N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-211 Measure Life

Equipment	EUL	RUL	Ref
Electric Water Heaters	13	4.33	[315]
Gas Water Heaters	11	3.66	[315]

References

[303] 2022 Illinois Statewide Technical Reference Manual for Energy Efficiency. 2021, Page 88. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_3_Res_09242021.pdf

[304] Pipe Sizing Charts Tables | Energy-Models.com. 2013. Energy-Models.com. 2013. https://energy-models.com/pipe-sizing-charts-tables.

[305] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430 eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

[306] 2022 California Public Utilities Commission. n.d. Review of DEER Resources - Water Heater - DEER Water Heater Calculator. Cedars - California Energy Data and Reporting System. https://cedars.sound-data.com/deer-resources/tools/water-heaters/.

[307] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter B, Part 430, Appendix E - Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature.

[80] Unknown COP is the average of storage tank heat pump water heater's COP for medium to high draw types covering a storage capacity range of 50 gallons to 80 gallons taken from California Energy Data and Reporting System's DEER Water Heater Calculator [306].

https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B

[308] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 431. Appendix B to Subpart G of Part 431 - Uniform Test Method for the Measurement of Standby Loss of Electric Storage Water Heaters and Storage-Type Instantaneous Water Heaters, eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-G

[309] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 9 (New York State Joint Utilities, 2021), Pg 76. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

[310] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 9. (New York State Joint Utilities, 2021), Pg 74. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

[311] NREL. 2022. Review of US Residential Sector circa 2018. ResStock. September 2022. https://resstock.nrel.gov/dataviewer/building-characteristics/?datasetName=vizstock_resstock_amy2018_release_2022_1_by_state_view.

[312] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, 430.32 d) eCFR. November 28, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[313] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[314] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 9. (New York State Joint Utilities, 2021), Pg 509, https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

[315] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

2.7.10 POOL PUMPS

Market	Residential/Multifamily
Baseline Condition	TOS/NC
Baseline	Code
End Use Subcategory	Swimming Pools
Measure Last Reviewed	December 2022

Description

This measure covers the installation of ENERGY STAR® certified variable frequency drive (VFD) pool pumps in residential buildings and multifamily buildings. An ENERGY STAR® certified pool pump can run at different speeds and be programmed to match the pool operation with its appropriate pool pump speed. The measure is applicable to new construction, or time of sale baseline conditions.

Baseline Case

The baseline case is a self-priming (aboveground) or non-self-priming (inground) pool filter pump with a minimum allowable weighted energy factor defined by the Code of Federal Regulations [316]. Starting July 19, 2021, all pool pumps must be rated according to Weighted Energy Factor (WEF), i.e., kilogallons of water pumped per unit kWh [317].

Efficient Case

The efficient case is an ENERGY STAR® version 3.1 qualified variable-speed self-priming (inground) or non-self-priming (aboveground) pool filter pump. The weighted energy factor of the efficient pump must be greater than or equal to the Energy Star WEF requirement set for a given hydraulic horsepower (HHP) class of pool pumps. The HHP is the overall pumping power that is available from the motor and is different than the shaft power. The HHP can be derived from the proposed ENERGY STAR® pump's spec sheet from the ENERGY STAR® Database [318].

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = units\ x\ days\ x\ V_{pool}\ x\ N_{turnover}\ x\ \left(\frac{1}{WEFb} - \frac{1}{WEFq}\right)/1{,}000$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh\ x\ ETDF$$

Where,

$$ETDF = \frac{CF}{Hrs}$$

$$Hrs = Hrs_{daily}\ x\ days$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-212 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hrs	Annual hours of operation	Calculated	hr	
units	Number of measures installed	Site-specific	N/A	
days	Number of days of operation of the pool pump annually	Site-specific, if unknown use 122	N/A	[319]
V_{pool}	Volume of pool	Site-specific, if unknown use 22,000 gallons (inground) 7,540 (above ground)	Gallons	[320][324]
$N_{turnover}$	Number of turnovers per day, where a turnover is a full cycling of pool water by the pump through the filter or the cleaner	Site-specific, if unknown use 2	N/A	[320]
WEF_b	Minimum allowable Federal Weighted Energy Factors	Look up in Table 2-213	kgal/kWh	[317][318]
WEF_q	Energy Efficient Pool Pumps Weighted Energy factor, per Energy Star certificate	Site-specific, min qualifying in Table 2-213	kgal/kWh	[317][318]

Variable	Description	Value	Units	Ref
HHP	Hydraulic horsepower, per energy star certificate	Site-specific	hp	[318]
Hrs_{daily}	Daily hours of pump operation	Site-specific, if unknown use 5.18	hrs	[321]
CF	Coincidence factor	Look up in Table 2-214	N/A	[322]
PDF	Peak day factor	Look up in Table 2-214	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-213 Minimum Allowable WEF Rating

Dedicated-Purpose Pool Pump Type	HHP Applicability	Motor Phase	Baseline WEF Score (kgal/kWh)	Qualifying WEF Score (kgal/kWh)
Self-priming pool filter pumps	0.711 hp ≤hhp <2.5 hp	Single	−2.30 x ln(hhp) + 6.59	-2.45 x ln(hhp) + 8.4
Self-priming pool filter pumps	0.13 hp < hhp <0.711 hp	Single	−1.30 x ln(hhp) + 2.90	-2.45 x ln(hhp) + 8.4
Self-priming pool filter pumps	hhp ≤0.13 hp	Single	5.55	13.4
Non-self-priming pool filter pumps	0.13 hp < hhp < 2.5 hp	Any	−0.85 x ln(hhp) + 2.87	-1.00 x ln(hhp) + 3.85
Non-self-priming pool filter pumps	hhp ≤0.13 hp	Any	4.60	4.92

Peak Factors

Table 2-214 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.27	[322]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [323].

References

[316] Code of Federal Regulations. Review of Title 10, Chapter II, Subchapter D, Part 431, Subpart Y, 431.465 f). ECFR. September 19, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-Y.

[317] ENERGY STAR® Pool Pump ver 3.1 Final Specification Sheet. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%203.1%20Pool%20Pumps%20Final%20Specification.pdf

[318] ENERGY STAR®, ENERGY STAR® Product Finder. https://www.energystar.gov/productfinder/product/certified-pool-pumps

[319] CEE, Consortium for Energy Efficiency. 2013. Review of CEESM High Efficiency Residential Swimming Pool Initiative. Edited by Eileen Eaton. January 2013. https://library.cee1.org/system/files/library/9986/CEE_Res_SwimmingPoolInitiative_01Jan2013_Corrected.pdf

[320] "Energy Star Pool Pump Calculator | Building America Solution Center." n.d. Basc.pnnl.gov. Accessed December 1, 2022. https://basc.pnnl.gov/library/energy-star-pool-pump-calculator

[321] "Mid-Atlantic Technical Reference Manual (TRM) V10 | Northeast Energy Efficiency Partnerships." n.d. Neep.org. Accessed December 1, 2022. https://neep.org/mid-atlantic-technical-reference-manual-trm-v10

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[323] DEER 2014 EUL ID: OutD-PoolPump

[324] *Evaluation of Potential Best Management Practices – Pools, Spas, and Fountains,* (The California Urban Water Conservation Council, 2010) Pg 3. https://calwep.org/wp-content/uploads/2021/03/Pools-Spas-and-Fountains-PBMP-2010.pdf

2.8 WHOLE BUILDING

2.8.1 BEHAVIORAL CHANGE

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Category	Whole Building
Measure Last Reviewed	January 2023

Description

This measure covers enrollment in a residential behavioral program that is designed to encourage lower energy usage through behavioral messaging. These behavioral messages can be periodic normative reports or messages that present the customers with timely information on their energy usage and a call to action to reduce or save energy. Behavioral messages can be delivered through many avenues, including paper, email, and text messages.

Because the characteristics of behavioral programs make them amenable to randomized, controlled trials (RCT), and because the program design includes an annual evaluation of its behavioral energy efficiency programs, use of evaluated savings estimates is required for each program year. Evaluations should be conducted, and savings calculated in accordance with the NJ Evaluation Guidelines: Behavioral Program Process and Impact Evaluations, Prepared by NJ Statewide Evaluator (SWE). If the program design changes and an annual evaluation is not conducted, savings as a percent of annual billed consumption from the most recent approved evaluation study must be used. Results from the NJ Triennium 1 Program year 1 evaluations are shown in Table yy.

The measure life for each participating customer is 1 year. Once the customer stops participation, savings may be claimed for the last participating year plus one additional year at the discretion of the program implementer.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

ΔkWh = Savings derived from annual evaluation compliant with Behavioral Guidance Document

Annual Fuel Savings

$\Delta Therms$ = Savings derived from annual evaluation compliant with Behavioral Guidance Document

Peak Demand Savings

ΔkW_{peak} = Savings derived from annual evaluation compliant with Behavioral Guidance Document

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = 0$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-215 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated per NJ Behavioral Program Guideline	kWh	[325]
ΔTherm	Annual natural gas savings	Calculated per NJ Behavioral Program Guideline	therms	[325]
ΔkW_{Peak}	Peak Demand Savings	Calculated per NJ Behavioral Program Guideline	kW	[325]
$\Delta Therms_{Peak}$	Daily peak fuel savings	0	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Peak}$	Daily peak fuel savings	0	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
EUL	Effective useful life	See Measure Life Section	yr	[330]

Table 2-216 Annual Savings Percentage from Tri 1 PY1 Evaluations

Percent Savings [326][327][328][329]		
Utility	Electricity	Natural Gas
PSE&G	0.56%	0.41%
ETG		0.50%
SJG		1.07%
RECO	0.20%	

Measure Life

The measure life for each participating customer is 1 year. Once the customer stops participation, savings can be claimed for the last participating year plus one additional year at the discretion of the program implementer [330].

References

[325] NJ Evaluation Guidelines: Behavioral Program Process and Impact Evaluations, Prepared by NJ Statewide Evaluator (SWE). April 2023.

[326] Cadmus. Public Service Electric & Gas Clean Energy Future Program Year 2021/2022 Evaluation Report, February 3, 2023.

[327] ADM. EM&V Report, Prepared for South Jersey Industries Utility, Elizabethtown Gas, Program Year 1: July 1, 2021 – June 30, 2021. February 21, 2023.

[328] ADM. EM&V Report, Prepared for South Jersey Industries Utility, South Jersey Gas, Program Year 1: July 1, 2021 – June 30, 2021. February 21, 2023.

[329] AEG. Memorandum, PY1 Behavioral Program Evaluation, RECO, January 26, 2023.

[330] NMR "R1606 Eversource Behavior Program Persistence Evaluation." Oct. 15, 2017. https://energizect.com/sites/default/files/documents/R1606_Eversource%20Behavior%20Persistence%20Evaluation_FINAL_10.15.17%20(1).pdf

2.8.2 HOME PERFORMANCE WITH ENERGY STAR (HPWES)

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Category	Whole Building
Measure Last Reviewed	January 2023

Description

This measure addresses whole building upgrades to residential and multifamily low-rise buildings compliant with the Home Performance with Energy Star (HPwES) version 1.5 requirements [331]. In order to implement Home Performance with ENERGY STAR, there are various standards, a program implementer must adhere to . The HPwES program implemented in NJ uses software that meets national standards for savings calculations from whole-house approaches such as home performance. The difference in modeled annual energy consumption between the program and existing home is the project savings for heating, hot water, cooling, lighting, and appliance end uses.

The software the program implementer uses must adhere to at least one of the following standards:

- A software tool whose performance has passed testing according to the National Renewable Energy Laboratory's HERS BESTEST software energy simulation testing protocol [332].
- Software approved by the US Department of Energy's Weatherization Assistance Program [333].
- RESNET approved rating software [334].

There are numerous software packages that comply with these standards. Some examples of the software packages are SnuggPro[81][335], REM/Rate, EnergyGauge and TREAT.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = From\ Approved\ Software$$

Annual Fuel Savings

$$\Delta Therms = From\ Approved\ Software$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh\ x\ ETDF$$

[81] SnuggPro uses the OptiMiser energy modeling engine

Where,

$$ETDF = 0.0006033$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \ x \ PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \ x \ EUL$$

Calculation Parameters

Table 2-217 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated by Approved Software	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated by Approved Software	Therm/yr	
ΔkW_{Peak}	Peak demand savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ETDF	Energy to demand factor	0.000364	kW/kWh	
PDF	Natural gas peak day factor	See Appendix G: Natural Gas Peak Day Factors	Day/yr	

References

[331] Home Performance with Energy Star (HPwES) version 1.5 requirements Program Requirements | ENERGY STAR

[332] Information about BESTEST-EX can be found at http://www.nrel.gov/buildings/bestest-_ex.html

[333] A listing of software approved by US DOE available at https://www.energy.gov/scep/wap/weatherization-energy-audits

[334] A listing of the approved RESNET software available at https://www.resnet.us/providers/accredited-providers/hers-software-tools/

[335] SnuggPro software https://snuggpro.com/

[336] SJG PY2 Impact Evaluation

2.8.3 NEW CONSTRUCTION

Market	Residential/Multifamily
Baseline Condition	NC
Baseline	Building Code
End Use Category	Whole Building
Measure Last Reviewed	August 2024
	• Revised measure description and UDRH baseline values

Description

This measure addresses high performance residential and multifamily new building design and construction. High performance new construction projects must satisfy the requirements prescribed by the ENERGY STAR certification effective at the time the project permit is pulled, following either the Single-Family New Homes program [337] or the Multifamily New Construction program [338], US DOE Zero Energy Ready Home program [339], Passive House Institute US (PHIUS) [340] or Passive House Institute (PHI) [341].

High performance new construction projects in NJ shall estimate energy savings based on the difference in modeled annual energy consumption between the proposed new building design and a minimally code compliant building of equivalent area. Peak demand savings, if not reported by the software, should be calculated as a function of the energy savings as shown below:

$$\Delta kW = \Delta kWh \times \frac{CF}{EFLH_{cool}}$$

Where:

CF = cooling coincidence factor from Section 2.3.1

$EFLH_{cool}$= cooling equivalent full load hours from Section 2.3.1

Minimum energy performance requirements for all new construction projects are measured from baselines reflecting effective, applicable energy codes and standards (e.g., IECC and ASHRAE 90.1) at the time the project permit is pulled. Modeling software requirements shall be dictated by the selected high performance new construction compliance program (i.e., those listed above). Energy and demand savings for measures included in the program but not modeled by the software should be calculated using the appropriate TRM measure section.

For projects pursuing passive house certifications, savings shall be estimated based on a comparison of baseline and proposed/as-built OR minimally passive house compliant prototype models developed in approved program simulation software. Baseline models shall reflect input parameters relevant to climate zones 4A/5A and minimally compliant with effective, applicable energy codes and standards based on project permit date. Submitted proposed/as-built design models are compared against the corresponding baseline model to establish energy consumption savings by fuel type. For electric peak demand savings, where end use-level kWh savings are reported by simulation software, peak kW shall be established per end use and aggregated for project-level reporting. In the absence of end use-level savings, peak kW savings may be approximated per the equation shown above.

To support and provide transparency to ongoing processing of project applications under the Residential New Construction ("RNC") Program, and for applications under the New Construction Program ("NCP"), details of the approach for estimating energy savings relative to a baseline reference home are presented below.

Whole building energy savings are calculated using outputs from RESNET accredited Home Energy Rating System (HERS) modeling software [342]. All program homes are modeled using accredited software to estimate annual energy consumption for heating, cooling, hot water, and other end uses within the HERS asset rating.

The program home is then modeled to a baseline specification using a program-specific reference home (referred to in some software as a User Defined Reference Home or UDRH) feature. The program reference home specifications are set according to the lowest efficiency specified by applicable codes and standards, thereby representing a New Jersey specific baseline home against which the improved efficiency of program homes is measured.

The UDRH is designed to reflect the efficiency values of HERS Minimum Rated Features based on the following:

- The prescriptive minimum values of the IECC version applicable to the home for which savings are being calculated;
- The Federal Minimum Efficiency Standards applicable to each rated feature at the time of permitting (e.g., minimum AFUE and SEER ratings for heating and air conditioning equipment, etc.);
- An assessment of baseline practice, as available, in the event that either of the above standards reference a non-specific value (e.g., "visual inspection");
- Exclusion of specific rated features from the savings calculation in order to remove penalties for building science based best practice requirements of the program (e.g., by setting the reference and rated home to the same value for program-required mechanical ventilation); and
- Other approved adjustments as may be deemed necessary.

The difference in modeled annual energy consumption between the program and applicable baseline reference home is the projected savings for heating, hot water, cooling, lighting, appliances, and other end uses in the HERS Minimum Rated Features, as well as on-site renewable gereration, when applicable. Coincident peak demand savings are also derived from rated modeled outputs. The following table describes the baseline characteristics of Climate Zone 4 and 5 reference homes for single-family, multi-single and low-rise multifamily buildings per IECC 2021, or as otherwise specified in the "Source" column.

Table 2-218 User Defined Reference Home Definition*

Input Parameter	Climate Zone 4	Climate Zone 5	Source	Ref
Ceiling Insulation	U= 0.024	U=0.024	IECC 2021, R402.1.2 (see NOTE 1 below)	[343]
Radiant Barrier	None	None		
Rim/Band Joist	U=0.045	U=0.045	IECC 2021, R402.1.2 (see NOTE 1 below)	[343]
Exterior Walls - Wood	U=0.045	U=0.045	IECC 2021 R402.1.2 (see NOTE 1 below)	[343]
Exterior Walls - Steel	U=0.045	U=0.045	IECC 2021 R402.1.2 (see NOTE 1 below)	[343]
Foundation Walls	U=0.059	U=0.050	IECC 2021 R402.1.2 (see NOTE 1 below)	[343]
Doors	U=0.30	U=0.30	IECC 2021 R402.1.2 (see NOTE 1 below)	[343]

Input Parameter	Climate Zone 4	Climate Zone 5	Source	Ref
Windows	U=0.30 , SHGC=0.30	U=0.30 , SHGC=0.30	U-value IECC 2021 R402.1.2, SHGC changed to 0.3 to match the change the EPA made on their V3.2 and v1.2 reference home (see NOTE 1 below).	[343], [344], [345]
Glass Doors	U=0.30 , SHGC=0.30	U=0.30 , SHGC=0.30	U-value IECC 2021 R402.1.2, SHGC changed to 0.3 to match the change the EPA made on their V3.2 and v1.2 reference home (see NOTE 1 below).	[343], [344], [345]
Skylights	U=0.55 , SHGC=0.40	U=0.55 , SHGC=0.40	IECC 2021 R402.1.2 (see NOTE 1 below)	[343]
Floor	U=0.047	U=0.033	IECC 2021 R402.1.2 (see NOTE 2 below)	[343]
Unheated Slab on Grade	R-10, 4 ft	R-10, 4 ft	IECC 2021 R402.1.3	[343]
Heated Slab on Grade	R-15, 4 ft	R-15, 4 ft	IECC 2021 R402.1.3	[343]
Air Infiltration Rate	5 ACH50	5 ACH50	Based on NJ Energy code Compliance Study, June 2022, completed by DNV, ref Table 4-13	[346]
Duct Leakage	4 cfm25 per 100ft^2 CFA	4 cfm25 per 100ft^2 CFA	IECC 2021, R403.3.6	[343]
Mechanical Ventilation	Match to Proposed	Match to Proposed		
Lighting	100% High Efficacy	100% High Efficacy	IECC 2021, R404.1	[343]
Ceiling Fan (CFM/W)	70.53	70.53	eCFR: 10 CFR Part 430 Subpart C, 50" Diameter default	[347]
Clothes Dryer - CEF	3.3	3.3	eCFR: 10 CFR Part 430 Subpart C , for clothes dryers manufactured on or after 1/1/15, vented gas	[347]
Clothes Washer - IMEF	1.57	1.57	eCFR: 10 CFR Part 430 Subpart C, minimum IMEF for standard capacity top loading clothes washers manufactured on or after 1/1/2018	[347]
Clothes Washer - kWh/yr	284	284	Appliance Standard 2018+Defaults	[338]
Dishwasher - kWh/yr	307	307	ANSI/RESNET/ICC 301-2022, Page 64, Table 4.2.2.6.2.9 NAECA	[348]
Refrigerator - kWh/yr	411	411	eCFR: 10 CFR Part 430 Subpart C, top freezer, no ice maker (scenario 3) Default Size: 22 cf	[347]
Cooling Setpoint	75	75	IECC 2021, R403.1.1: 75 cooling and 70 heating	[343]
Heating Setpoint	70	70		

Input Parameter	Climate Zone 4	Climate Zone 5	Source	Ref
Thermostat	Programmable	Programmable	IECC 2021 R403.1.1	[343]
Furnace	80% AFUE	80% AFUE	eCFR: 10 CFR Part 340 Subpart C	[347]
Boiler	84% AFUE	84% AFUE	eCFR: 10 CFR Part 340 Subpart C	[347]
Combo Water Heater	N/A - default heating to Boiler and HW to Natural Gas Standalone	N/A - default heating to Boiler and HW to Natural Gas Standalone		
Air Source Heat Pump (Heating)	N/A - default to Furnace	N/A - default to Furnace		
Central Air Conditioning & Window AC units	14.1 SEER/13.4 SEER2	14.1 SEER/13.4 SEER2	eCFR: 10 CFR Part 340 Subpart C 14.1 SEER is the conversion from 13.4 SEER2 back to SEER, using the factor of 0.95	[347]
Air Source Heat Pump (Cooling)	N/A - default to CAC/Window AC	N/A - default to CAC/Window AC		
Electric Standalone Tank Water Heater	N/A - default to Natural Gas Standalone	N/A - default to Natural Gas Standalone		
Natural Gas Standalone Tank Water Heater	0.6270 UEF	0.6270 UEF	eCFR: 10 CFR Part 340 Subpart C; assumes High Draw Pattern and a 50 gallon tank (see NOTE 3 below).	[347]
Electric Instantaneous Water Heater	N/A - default to Natural Gas Standalone	N/A - default to Natural Gas Standalone		
Natural Gas Instantaneous Water Heater	N/A - default to Natural Gas Standalone	N/A - default to Natural Gas Standalone		
Water Heater Tank Insulation	None	None		
Duct Insulation, Attic	R-8	R-8	IECC 2021 R403.3.3	[343]
Duct Insulation, All Other	R-8	R-8	IECC 2021 R403.3.2; assumes ducts >=3"	[343]

* - Applicable to buildings permitted on or after March 6, 2023

1 – U-values represent total system U-value, including all components (i.e., clear wall, windows, doors).

- Type A-1 - Detached one and two family dwellings.
- Type A-2 - All other residential buildings, three stories in height or less.

2 – All frame floors shall meet this requirement. There is no requirement for floors over basements and/or unvented crawl spaces when the basement and/or unvented crawl space walls are insulated.

3 – Based on the Federal Government standard for calculating UEF (50 gallon, high-draw pattern assumed): UEF = 0.6920 - (0.0013 x Rated Storage Volume in gallons)

References

[337] Energy Star V3.1 Single Family New Homes requirements

[338] Energy Star V1.1 Multifamily New Construction requirements

[339] DOE Zero Energy Ready Home (ZERH) Program requirements.

[340] Passive House Institute US requirements

[341] Passive House Institute requirements

[342] Accredited Home Energy Rating Systems (HERS) software

[343] 2021 International Energy Conservation Code (IECC 2021)

[344] Energy Star V3.2 Single Family New Homes requirements

[345] Energy Star V1.2 Multifamily New Construction requirements

[346] New Jersey Energy Code Compliance Study

[347] Code of Federal Regulations: 10 CFR Part 430 Subpart C

[348] ANSI/RESNET/ICC 301-2022 Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index

[349] Ekotrope Appliance Default Values

2.8.4 CUSTOM

Market	Residential
Baseline Condition	TOS/NC/RF/EREP/ERET/DI
Baseline	Code/ISP/Existing/Dual
End Use Category	Custom
Measure Last Reviewed	January 2023

Description

In addition to the typical measures for which savings algorithms have been developed, it is important to identify and address additional opportunities for energy savings. Custom measures can often provide significant energy savings and can be tailored to the specific needs of a project. If necessary, the utilities may develop specific guidelines for frequent custom measures for use in reporting and contractor tracking. This will ensure that the custom measures are implemented correctly and consistently; and that the energy savings are accurately reported. Additionally, it is important to continuously monitor and evaluate the effectiveness of the custom measures implemented and make adjustments as needed.

To implement custom measures, it is necessary to develop individual calculations for each measure to determine the energy savings. These calculations should take into account factors such as the cost of implementation and the expected energy savings. Once the calculations are complete, the project should be reviewed for reasonableness. Before a full review of the project is started, the project package should first be checked for completeness and compliance with program eligibility rules. Once the project review is complete, savings can be reported based on these individual calculations.

Baseline

The project baseline depends on the baseline condition. For time of sale (TOS) and new construction (NC) measures, the baseline is the applicable equipment energy code or standard; or industry standard practice (ISP). For retrofit (RF), early replacement (EREP), early retirement (ER) and direct install (DI) measures, the baseline is the existing equipment. Early replacement and direct install projects replacing functioning equipment must use a dual baseline approach, where the existing equipment defines the first baseline and code or ISP defines the second baseline. In all cases, the baseline should be more efficient than the existing equipment; if the efficiency of the existing equipment exceeds code or ISP, the existing equipment baseline should also be used for the second baseline calculations. When existing functioning equipment is replaced and savings are based on early replacement, documentation of the existing equipment viability should be provided. Such documentation includes a customer affidavit affirming the viability of the equipment to function over its remaining useful life and a video or picture demonstrating the equipment in action.

Industry Standard Practice (ISP) shall take precedence over a code baseline when ISP can be established. Projects not subject to codes or standards shall define and document an ISP baseline as part of the project development package. ISP for specific custom projects can be established through interviews with equipment vendors or subject matter experts.

Efficient Case

The efficiency of the measure shall exceed the first (and if applicable the second) baseline efficiency, and a rationale for how the project saves energy shall be provided.

Energy Savings Algorithm

Energy and demand savings are calculated on a custom basis for each customer's specific situation. Savings are calculated as the difference between baseline energy usage/peak demand and the energy use/peak demand after implementation of the custom measure. Energy savings calculations vary according to the custom project requirements, but generally fall into the following classifications:[82]

Simple Engineering Equations

Custom engineering calculations may be developed to estimate energy savings. These may be presented as a series of simple engineering equations tailored to the custom project measure. The engineering calculations must be documented, and spreadsheets used to calculate the savings must be provided with live calculations. The engineering analysis must be sufficiently documented to allow an independent calculation of the measure savings.

Bin Methods

One method for calculating energy savings for custom energy efficiency measures is through the use of weather based bin analysis. This method involves analyzing weather data and grouping it into "bins" based on temperature, humidity, and other environmental factors. The bin analysis presents the number hours a particular weather condition exists during the year. Note, bin data to not consider time of day; hours tabulated for each weather bin are disconnected in time. Bin analysis is generally not applicable to time dependent measures.

Simulation

Another method for calculating energy savings for custom energy efficiency measures is through the use of whole building energy simulations. This approach involves creating a computer model of a building that takes into account factors such as the building's layout, construction materials, HVAC systems, lighting, and other equipment. The model is then used to simulate different scenarios and analyze the building's energy consumption under different conditions. This can be useful for identifying opportunities for energy savings and for evaluating the potential impact of different custom measures. For example, a whole building simulation can be used to analyze the impact of different insulation materials, HVAC equipment, or window treatments on energy consumption. Whole building modeling simulations can be a powerful tool for identifying and addressing opportunities for energy savings across a package of measures where significant measure interactions are expected.

Pre/Post Billing Analysis

[82] See the California Evaluation Framework [350] Chapters 6 and 7 for more information about engineering methods.

Energy savings may be calculated through an analysis of whole building or submetered energy consumption before and after measure installation. The billing analysis should use a linear or multi-variate regression approach that normalizes the savings for differences in weather conditions during the pre and post periods, and also corrects for energy consumption not related to the measures, such as the addition of photovoltaic systems or electric vehicle chargers. The pre/post billing analysis should follow the International Measurement and Verification Protocol (IPMVP) Option C and/or ASHRAE Guideline 14. Open source software products compliant with IPMVP Option C or ASHRAE Guideline 14 such as OpenEEMeter are acceptable methods to evaluate energy savings under conditions where the energy consumption data can be fit to outdoor temperature or degree-day data, and savings can be adjusted to account for changes in energy consumption not related to the project.

Pre/Post Billing Analysis approaches are best suited for EREP, ERET and DI projects where an existing equipment baseline is appropriate. Pre/Post Billing Analysis approaches are not suitable for NC and TOS projects. When calculating lifetime savings, EREP, ERET and DI projects must adjust savings from an existing equipment baseline to a code or ISP baseline during the second baseline period.

Calculation Parameters

Energy savings calculations must identify the source of each parameter used in the analysis.   Parameters that are uncertain should be identified as candidates for project specific measurement and verification (M&V).

Measurement and Verification

Projects where the input assumptions and savings estimates are uncertain may benefit from site specific measurement and verification (M&V). Project developers and reviewers should consider whether the value savings at risk is sufficient to justify the additional M&V costs. For projects that include M&V, a site specific measurement and verification plan should be developed that documents measurement activities and their use in the energy savings analysis. Depending on the level of uncertainty, M&V may be conducted before measure installation (pre installation M&V) and/or after measure installation (post installation M&V). The International Measurement and Verification Protocol (IPMVP) and/or ASHRAE Guideline 14 should be referenced when developing an M&V plan. The M&V plans may follow IPMVP Option A (partially measured retrofit isolation), Option B (fully measure retrofit isolation) Option C (Whole building billing analysis) or Option D (Calibrated simulation) approaches.

Lifetime Energy Savings Algorithms

Lifetime energy savings for Time of Sale (TOS) and New Construction (NC) projects are calculated as the product of the first year kWh and/or therm savings and the measure effective useful life (EUL). Projects with multiple measures having different EULs shall use a savings weighted average EUL across all measures in the project.

Lifetime savings for early replacement (EREP), early retirement (ERET) and direct installation (DI) measures where functioning equipment is replaced must use a dual baseline approach. The first baseline savings considers the difference between the existing equipment consumption and the measure consumption for the remaining life (RUL) of the existing equipment. The second baseline savings considers the difference between code or standard practice equipment consumption and the measure consumption for the remaining life of the measure (EUL-RUL).

Peak Factors

The summer coincident peak demand savings shall be calculated consistent with the system peak definition presented in Chapter 1.

Measure Life

Measure life will be specific to each custom measure. For custom measures using technologies that are the same or similar to those addressed in other TRM measures, refer to the TRM for measure lives. For measures not covered by the TRM, measure life assumptions shall be documented and justified in the project documentation package. The EUL for retrofit (RF) measures shall be calculated as the smaller of the measure EUL or the host equipment remaining useful life (RUL). The overall project EUL shall be the savings weighted EUL of the measures included in the project.

References

[350] California Evaluation Framework. Available at https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc_public_website/content/utilities_and_industries/energy/energy_programs/demand_side_management/ee_and_energy_savings_assist/caevaluationframework.pdf

[351] International Measurement and Verification Protocol (IPMVP) available at https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp

[352] ASHRAE Guideline 14-2014. Available at https://webstore.ansi.org/standards/ashrae/ashraeguideline142014

[353] Linux Foundation, OpenEEMeter https://lfenergy.org/projects/openeemeter/ Accessed 5/18/23.

3 COMMERCIAL & INDUSTRIAL

3.1 AGRICULTURE

3.1.1 AUTO MILKER TAKEOFF

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This section provides energy savings and demand savings algorithms for replacement of manual milker takeoffs with automatic milker takeoffs on dairy milking vacuum pump systems. Automatic milker takeoffs have flow sensors which help shut off the suction on teats once a minimum flow rate is achieved. This reduces the load on the vacuum pump.

Equipment with existing automatic milker takeoffs is not eligible. In addition, the vacuum pump system serving the impacted milking units must be equipped with a variable speed drive (VSD) to qualify for incentives. Without a VSD, little or no savings will be realized.

Baseline Case

Pre-existing manual takeoffs on constant speed dairy milking vacuum pump systems.

Efficient Case

Automatic milker takeoffs. Vacuum pump system serving the impacted milking units must be equipped with a variable speed drive (VSD).

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N_{cows} \times \Delta ESC$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times ETDF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 3-1 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
N_{cows}	Number of cows milked per day	Site specific	Cows	
ΔESC	Annual energy savings per cow	34[83]	kWh/cow	[355][356][357][358]
ETDF	Energy to demand factor	0.00017	kW/kWh	[359]
CF	Electric coincidence factor	Look up in Table 3-2	N/A	
PDF	Gas peak demand factor	Look up in Table 3-2	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

[83] Annual energy savings per cow was calculated based on the following assumptions.

- An average herd size of 102 cows [358]
- Typical dairy vacuum pump size of 10 HP per herd size [359]
- Average pump operating hours are estimated at 10 hours per day [357]
- A 12.5% Energy savings factor [358]

Peak Factors

Table 3-2 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [354].

References

[354] Idaho Power Demand Side Management Report, Supplement 1. March 15, 2022. https://docs.idahopower.com/pdfs/EnergyEfficiency/Reports/2021%20Supplement%201.pdf

[355] Chuck Nicholson, Mark Stephenson, Andrew Novakovic, *Study to Support Growth and Competitiveness of the Pennsylvania Dairy Industry*, (2017) . https://dairymarkets.org/PA/Growth_and_Competitiveness_Study_DRAFT_Final_Report_June_2018.pdf PA Values were assumed to be similar to NJ Values because of the States' close proximity.

[356] Average dairy vacuum pump size was estimated based on the Minnesota Dairy Project literature.

[357] Mark Mayer, David Kammel, *Dairy Modernization Works for Family Farms* (2008). https://archives.joe.org/joe/2010october/pdf/JOE_v48_5rb7.pdf.

[358] Public Utilities Commission of Pennsylvania, *Technical Reference Manual: Volume 3: Commercial and Industrial Measures (2019),* Pg 298, https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

[359] Regional Technical Forum (RTF) as part of the Northwest Power & Conservation Council*, Deemed Measures List. Agricultural: Variable Frequency Drives-Dairy, FY2012, V1.2*. https://rtf.nwcouncil.org/measure/dairy-milking-machines-vacuum-pump

3.1.2 DAIRY PUMP VFD

Market	Commercial
Baseline Condition	NC/RF
Baseline	Code/Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

Milking vacuum systems consume large amounts of electricity on dairy farms. A conventional system runs a vacuum pump motor at full speed and a mechanical vacuum regulator creates an intentional air leak or "bleed" to regulate the system pressure regardless of the amount of milk being pumped. When the system requires a higher level of vacuum, the regulator closes and the vacuum level increases.

This measure modifies the milking vacuum system and installs a variable speed drive (VSD) to control the vacuum pump motor. The VSD controls the speed of the vacuum pump motor, slowing it down when the milking units are attached to the udders, reducing electrical power demand and saving electricity usage. A milking vacuum system controlled with a VSD consists of three main parts: a three-phase electric motor, a VSD unit, and a differential pressure transducer. The VSD modulates the vacuum pump motor speed based on the control signal from the differential pressure transducer. The baseline for this measure reflects a standard vacuum pump motor operating at constant speed. If the motor is being replaced as part of this measure, the "New Motor" efficiency in the Standard Motor Efficiency table below shall be used. Otherwise, the "Existing Motor" efficiency shall be used.

Baseline Case

The baseline condition is a constant speed dairy vacuum pump with a motor size between 2.5-10hp that is controlled with a mechanical vacuum regulator.

Efficient Case

The compliance condition is a dairy vacuum pump with a variable speed drive installed.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left[\left(\frac{hp \times LF \times 0.746}{Eff}\right) - (0.05 \times 2 \times MU + 1.7729)\right] \times hrs$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left[\left(\frac{hp \times LF \times 0.746}{Eff}\right) - (0.05 \times 2 \times MU + 1.7729)\right] \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-3 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
hp	Rated horsepower of vacuum pump motor	Site-specific (limited to 10hp or lesser)	hp	
MU	Number of milking units equipped with a vacuum pump and controlled by VSD	Site-specific, if unknown: 5 hp motor = 3 MU 7.5hp motor = 12 MU 10 hp motor = 22 MU	N/A	
LF	Average load factor for a constant speed vacuum pump	Site-specific, if unknown use 0.76	N/A	[360]
Eff	Rated pump motor efficiency	Site-specific, if unknown look up in Table 3-4	N/A	[361][362]
hrs	Annual hours of pump operation	Site-specific, if unknown use 4,380	hours	[363]
0.746	Conversion factor from kW to hp	0.746	kW/hp	
0.05	Regression coefficient for the average speed of a VSD and processed milk units	0.05	N/A	[366]
2	Air flow rate of milking unit	2	CFM	[366]

Variable	Description	Value	Units	Ref
1.7729	Regression constant for the average speed of a VSD and processed milk units	1.7729	N/A	[366]
CF	Electric coincidence factor	Look up in Table 3-5	N/A	
PDF	Gas peak demand factor	Look up in Table 3-5	N/A	
EUL	Effective useful life	See Measure Life	Years	

Table 3-4 Standard Motor Efficiency

Motor Classification	Size (hp)	Existing Motor	New Motor
Milk: Vacuum Pump with Adjustable Speed Drive Package – 5 HP	5	87.5%	89.5%
Milk: Vacuum Pump with Adjustable Speed Drive Package – 7.5 HP	7.5	88.5%	91.7%
Milk: Vacuum Pump with Adjustable Speed Drive Package – 10 HP	10	89.5%	91.7%

Peak Factors

Table 3-5 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.4	[364]
Natural gas peak day factor (PDF)	N/A	

Measure Life

Table 3-6 Measure Life

Equipment	EUL	RUL	Ref
Dairy Pump VFD	15	5	[365]

References

[360] Cascade Energy. “Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors.” Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012. https://nwcouncil.app.box.com/s/fkxkcwm1is88dnttb8ve7eb5rhs9qhmv

[361] The Energy Independence and Security Act of 2007 (EISA), 1800 RPM, TEFC assumed as typical for Dairy vacuum pump motors, see https://www.govinfo.gov/content/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf

[362] US Department of Energy, Office of Energy Efficiency & Renewable Energy, “Premium Efficiency Motor Selection and Application Guide: A Handbook for Industry”. Table 2-1. 1800 RPM, TEFC assumed as typical for

Dairy vacuum pump motors, https://www.energy.gov/sites/prod/files/2014/04/f15/amo_motors_handbook_web.pdf

[363] Assuming 2 milking and cleaning sessions per day, 5 hours per milking session, 1 hour per cleaning session, and 365 days of milking per year.

[364] Regional Technical Forum (RTF) as part of the Northwest Power & Conservation Council, Deemed Measures List. Agricultural: Variable Frequency Drives-Dairy, FY2012, V1.2. https://rtf.nwcouncil.org/measure/dairy-milking-machines-vacuum-pump/

[365] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

[366] Sanford, Scott (University of Wisconsin–Madison). "Milking System Air Consumption When Using a Variable Speed Vacuum Pump", Figure 2. The regression coefficient of 0.0018 LPM is converted into 0.05 CFM. An air leakage rate of 2 CFM is chosen as a conservative estimate for which to perform regression analysis.

3.1.3 DAIRY REFRIGERATION TUNE UP

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Maintenance
Measure Last Reviewed	January 2023

Description

This section provides energy savings and demand savings algorithms for tune-ups on all refrigeration equipment in commercial-grade dairy settings with the intention being to reduce electrical consumption.

Baseline Case

Refrigeration equipment associated with a commercial-grade dairy farm facility that has not been inspected or tuned up in more than 12 months.

Efficient Case

The efficient condition is refrigeration equipment associated with a commercial-grade dairy farm facility that has been inspected and tuned up by a U.S. EPA 608 Certified Service Provider. The certified technician must abide by all rules and regulations related to refrigerant testing and safety protocol and must conduct the following tasks:

- Clean and inspect condenser and evaporator coils;
- Clean drain pan;
- Inspect/clean fans, screens, grills, filters, and drier cores;
- Inspect/adjust heat reclaim operation;
- Tighten all line voltage connections;
- Inspect/replace relays and capacitors as needed; and
- Add/remove refrigerant charge as needed.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{N_{cows} \times lbs_{milk} \times C_{p,milk} \times \Delta T}{AEER \times 1{,}000} \times SF$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-7 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
N_{cows}	Number of cows	Site-specific	N/A	
lbs_{milk}	Average pounds of milk produced per cow per year	Site-specific, if unknown use 19,800	Lbs/yr	[367]
$C_{p,milk}$	Specific heating capacity of milk	0.93	Btu/lb-°F	[368]
ΔT	Difference in temperature between milk entering the bulk tank and final stored temperature of cooled milk	Look up in Table 3-8	°F	[369][370]
SF	Energy savings factor	0.05	N/A	[371]
AEER	Annual energy efficiency ratio of refrigeration compressor	15.39	Btu/watt-hr	[370]
1,000	Conversion from watts to kilowatts	1,000	W/kW	
CF	Electric coincidence factor	Look up in Table 3-9	N/A	
PDF	Gas peak demand factor	Look up in Table 3-9	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-8 Milk Temperature Differential (°F)

Type of cooling	Temperature (°F)
No pre-cooler used in operation	60
Pre-cooler used	30
Pre-cooler unit and VFD Pump are used	18.3

Peak Factors

Table 3-9 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 1 year [370].

References

[367] New Jersey Dept of Agriculture, 2021 Annual Report and Agricultural Statistics. (2021), page 21. https://www.nass.usda.gov/Statistics_by_State/New_Jersey/Publications/Annual_Statistical_Bulletin/2021/2021AnnualReportFinal.pdf

[368] 2018 ASHRAE Handbook – Refrigeration, Specific heat of whole milk, Table 3: Unfrozen Composition Data, Initial Freezing Point, and Specific Heat of Foods.

[369] Scott Sanford, *Well water precoolers.* (Energy Conservation in Agriculture,2003), Pg 1, https://cdn.shopify.com/s/files/1/0145/8808/4272/files/A3784-03.pdf

[370] Sanford, Scott (University of Wisconsin–Madison). "Well Water Precoolers." Publication A3784-3. October 2003. http://learningstore.uwex.edu/Assets/pdfs/A3784-03.pdf

[371] *Best Management Practices for Dairy Farms* (Massachusetts Farm Energy Program, 2012), Pg 30, https://massfarmenergy.com/wp-content/uploads/2014/03/Dairy%20Farms%20Best%20Practices.pdf

3.1.4 DAIRY SCROLL COMPRESSOR

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the replacement of reciprocating compressors with scroll compressors in milk cooling dairy farm applications. A scroll compressor is a device used to compress refrigerant and is more efficient and reliable than traditional reciprocating compressors. Scroll compressors are now the predominant compressor type sold on the market in these applications; therefore, this measure is only applicable in retrofit scenarios. Lifecycle savings are calculated through the end of the remaining life of the existing compressor.

Baseline Case

The baseline condition for this measure is a dairy operation using a reciprocating compressor for milk cooling.

Efficient Case

The compliance condition is the replacement of a reciprocating compressor with a scroll compressor for milk cooling.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Btu/h_q}{Btu/h_{total}} \times lbs_{milk} \times cows \times \Delta T \times 0.93 \times \left[\left(\frac{1}{EER_b \times 1{,}000} \right) - \left(\frac{1}{EER_q \times 1{,}000} \right) \right]$$

Where,

$$EER_q = \frac{Btu/h_q}{W_q}$$

$$EER_b = \frac{Btu/h_b}{W_b}$$

If EER_b is unknown use

$$EER_b = 0.85 \times EER_q$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-10 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Btu/h_q	Nameplate Btu/h of installed scroll compressor	Site-specific	Btu/h	
Btu/h_{total}	Total cooling capacity of compressors on dairy farm	Site-specific	Btu/h	
Btu/h_b	Nameplate Btu/h of existing recip compressor	Site-specific	Btu/h	
lbs_{milk}	Average pounds of milk produced per cow per year	19,800	lb	[372]
cows	Number of milking cows on farm	Site-specific	N/A	
ΔT	Difference in temperature between the milk entering the bulk tank and final stored temperature of cooled milk	Look up in Table 3-11	(°F)	[373]
W_b	Nameplate wattage of existing reciprocating compressor	Site-specific	watts	

Variable	Description	Value	Units	Ref
W_q	Nameplate wattage of installed scroll compressor	Site-specific	watts	
EER_q	Energy efficiency ratio of scroll compressor based on nameplate Btu/h and wattage	Calculated	$\frac{Btu/h}{watts}$	[374]
EER_b	Energy efficiency ratio of reciprocating compressor based on nameplate Btu/h and wattage	Calculated	$\frac{Btu/h}{watts}$	[374]
0.93	Specific heat of milk	0.93	Btu/lb-°F	[375]
1,000	Conversion Factor kW to watts	1,000	Kw/watts	
8,760	Hours in one year	8,760	hours	
CF	Electric coincidence factor	Look up in Table 3-12	N/A	
PDF	Gas peak day factor	Look up in Table 3-12	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-11 Difference in temperature for various equipments

Equipment	ΔT
No Pre-Cooler	60
Standard Pre-Cooler	30
Variable Speed Pre-Cooler	18.3

Peak Factors

Table 3-12 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is limited to the Remaining Useful Life (RUL) of the existing compressor with a default value of 4 years.

References

[372] USDA, National Agricultural Statistics Service, *2021 Annual Report and Agricultural Statistics*, pg. 21. https://www.nass.usda.gov/Statistics_by_State/New_Jersey/Publications/Annual_Statistical_Bulletin/2021/2021AnnualReportFinal.pdf

[373] Sanford, Scott (University of Wisconsin–Madison). *Energy Efficiency for Dairy Enterprises*. Presentation to Agricultural and Life Sciences Program staff. It was determined that a plate cooler alone can reduce milk temperature to 68 ˚F and a plate cooler paired with a milk transfer pump VSD can reduce milk temperature to 56.3 ˚F. The additional benefits of the milk transfer pump VSD over the plate cooler is 11.7 ˚F. Milk is stored at 38°F, therefore 56.3°F-38°F=18.3°F. December 2014. https://aeeibse.wp.prod.es.cloud.vt.edu/wp-content/uploads/2018/01/EC-for-Dairy-Enterprises-Nov-2017.pdf

[374] *Massachusetts Farm Energy Best Management Practices for Dairy Farms*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), 2012. https://massfarmenergy.com/wp-content/uploads/2014/03/Dairy%20Farms%20Best%20Practices.pdf

[375] 2018 ASHRAE Handbook – Refrigeration, Specific heat of whole milk, Table 3: Unfrozen Composition Data, Initial Freezing Point, and Specific Heat of Foods.

3.1.5 LIVESTOCK WATERER

Market	Commercial
Baseline Condition	EREP/TOS/NC
Baseline	Existing/ISP/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of energy-efficient livestock waterers. A livestock waterer provides clean drinking water for livestock. Regular livestock waterers employ the use of large electric resistance heaters to prevent water from freezing. Energy efficient livestock waterers use super insulation (insulation of at least 2 inches) to maintain water temperature above freezing temperature.

Baseline Case

Early replacement (EREP) of an existing livestock waterer: First baseline, for remaining useful life of existing equipment: Electrically heated livestock waterer with no insulation. Second baseline, for remainder of measure life: Industry standard practice (ISP).

Time of sale (TOS) of an existing livestock waterer: Industry standard practice (ISP).

Addition of a new (NC) livestock waterer: Industry standard practice (ISP).

Efficient Case

Energy efficient livestock watering system that is thermostatically controlled and has factory-installed insulation with a minimum thickness of 2 inches.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W_b - W_q}{1{,}000} \times hrs \times F_{runtime}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-13 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
W_b	Rated wattage of baseline livestock waterer heating element	Site-specific. If unknown: Existing: 1,100W ISP: 500W	Watts	[376]
W_q	Rated wattage of efficient livestock waterer heating element	Site-specific	Watts	
hrs	Annual hours of operation during the winter when temperature is below 32°F	Site-specific. If unknown, look up in Table 3-14	hrs	[377]
$F_{runtime}$	Fraction of heater runtime	0.8	N/A	[378]
CF	Electric coincidence factor	Look up in Table 3-15	N/A	
PDF	Gas peak day factor	Look up in Table 3-15	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-14 Annual operating hours

Climate Zone	Hours below 32°F
Northern	1337
Southwest	1220
Coastal	583
Central	1,069
Pine Barrens	1,021
Statewide Average	1,048

Peak Factors

Table 3-15 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	[380]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [379]. For early replacement projects, if the remaining useful life (RUL) of the existing equipment is unknown, assume 1/3 of the EUL = 3.3 years.

References

[376] *New York Standard for Estimating Energy Savings from Energy Efficiency Programs Version 10*. (New York State Joint Utilities, 2021), pg 385.

[377] Based on TMY3 data for various climate zones in New Jersey.

[378] The Regional Technical Forum (RTF) analyzed metered data from three baseline livestock waterers and found the average run time of electric resistance heaters in the waterers to be approximately 80% for average monthly temperatures similar to Pennsylvania climate zones. This run time factor accounts for warmer make-up water being introduced to the tank as livestock drinking occurs. *Dairy Milking Machines Vacuum Pump Variable Frequency Drive.* n.d. Rtf.nwcouncil.org. Accessed January 13, 2023. https://rtf.nwcouncil.org/measure/dairy-milking-machines-vacuum-pump/

[379] State of Wisconsin, *Focus on Energy Evaluation, Business Program: Measure Life Study Final Report*: *Appendix B* (August 25, 2009). https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

[380] No demand savings are expected for this measure, as the energy savings occur during the winter months.

3.1.6 LOW PRESSURE IRRIGATION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

This section provides energy and demand savings algorithms for the installation of a low-pressure irrigation system, which reduces the amount of energy required to apply the same amount of water as a baseline system.

The amount of energy saved per acre is a factor of the number of nozzles, the amount of water applied, the actual reduction in operating pressure, the pumping plant efficiency, and sprinkler or micro irrigation system conversions made to the system.

This measure requires a minimum 50% decrease in irrigation pumping pressure through the installation of a low-pressure irrigation system in agriculture applications. Pressure reduction can be achieved in several ways, such as nozzle or valve replacement, sprinkler head replacement, alterations or retrofits to the pumping plant, or drip irrigation system installation. Pre and post retrofit pump pressure measurements are required.

Baseline Case

High-pressure irrigation system with a baseline pump pressure, must be measured and recorded prior to installing low-pressure irrigation equipment.

Efficient Case

Low-pressure irrigation system in agriculture applications with a minimum of 50% reduction in pumping pressure.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{\{N_{acres} \times (PSI_b - PSI_q) \times GPM\}}{1{,}714 \times Eff_{motor}} \times \left(\frac{0.746\ kW}{HP}\right) \times HRS$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times ETDF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 3-16 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
N_{acres}	Number of acres irrigated	Site-specific	Acres	
PSI_b	Baseline pump pressure, must be measured and recorded prior to installing low-pressure irrigation equipment	Site-specific	Pounds per square inch (psi)	
PSI_q	Installed pump pressure, must be measured and recorded after the installation of low-pressure irrigation equipment by the installer	Site-specific	Pounds per square inch (psi)	
GPM	Pump flow rate per acre	Site-specific	Gallons Per Minute (GPM) /acre	
HRS	Average irrigation hours per growing season	Site-specific	Hours	
Eff_{motor}	Pump motor efficiency	Site-specific, if unknown look up in Table 3-17	N/A	[381]
0.746	Conversion from kW to HP	0.746	kW/HP	
1,714	Constant used to calculate hydraulic horsepower for conversion between horsepower and pressure and flow	1,714	$PSI \times GPM/HP$	

Variable	Description	Value	Units	Ref
EDTF	Energy to Demand Factor	0.0026	kW/kWh	[383] [384]
CF	Electric coincidence factor	Look up in Table 3-18	N/A	
PDF	Gas peak demand factor	Look up in Table 3-18	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-17 Motor Baseline Efficiencies

Motor HP	Motor Nominal Full-Load Efficiencies (percent)					
	4 Pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	85.5	85.5	82.5	82.5	75.5	75.5
1.5	86.5	86.5	87.5	86.5	78.5	77.0
2	86.5	86.5	88.5	87.5	84.0	86.5
3	89.5	89.5	89.5	88.5	85.5	87.5
5	89.5	89.5	89.5	89.5	86.5	88.5
7.5	91.7	91.0	91.0	90.2	86.5	89.5
10	91.7	91.7	91.0	91.7	89.5	90.2
15	92.4	93.0	91.7	91.7	89.5	90.2
20	93.0	93.0	91.7	92.4	90.2	91.0
25	93.6	93.6	93.0	93.0	90.2	91.0
30	93.6	94.1	93.0	93.6	91.7	91.7
40	94.1	94.1	94.1	94.1	91.7	91.7
50	94.5	94.5	94.1	94.1	92.4	92.4
60	95.0	95.0	94.5	94.5	92.4	93.0
75	95.4	95.0	94.5	94.5	93.6	94.1
100	95.4	95.4	95.0	95.0	93.6	94.1
125	95.4	95.4	95.0	95.0	94.1	94.1
150	95.8	95.8	95.8	95.4	94.1	94.1
200	96.2	95.8	95.8	95.4	94.5	94.1

Peak Factors

Table 3-18 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 5 years [382].

References

[381] *Energy Conservation Program: Energy Conservation Standards for Commercial and Industrial Electric Motors; Final Rule: 79 Federal Register 103* (2014) https://www.gpo.gov/fdsys/pkg/FR-2014-05-29/html/2014-11201.htm

[382] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx Accessed January 2023.

[383] Kanagy, Pamela K., *Farm and Ranch Irrigation*. Pennsylvania Agricultural Statistics, 2009-2010. https://www.nass.usda.gov/Statistics_by_State/Pennsylvania/Publications/Annual_Statistical_Bulletin/2009_2010/fris.pdf. Accessed January 2023.

[384] Irrigation Water Withdrawals, 2015 by the U.S. Geological Society. Table 7. https://pubs.usgs.gov/circ/1441/circ1441.pdf. Accessed January 2023.

3.1.7 VENTILATION FANS

Market	Commercial
Baseline Condition	TOS/NC/EREP
Baseline	Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure is applicable to the installation of high speed, high efficiency fans and high-volume low speed (HVLS) fans installed in agricultural applications. For the purposes of this measure, a high speed fan shall consist of the blade and motor assembly. Ventilation, exhaust and circulating high speed fans improve animal comfort, control moisture and maintain indoor air quality for livestock and other agricultural applications. Variable frequency drives (VFD) may be installed along with high speed fans to increase energy savings and the associated savings are quantified by this methodology. If VFD savings are claimed via this measure, additional savings may not be claimed for VFDs utilizing a separate methodology. Qualifying fans must be rated by an Air Movement and Control Association (AMCA) accredited laboratory such as Bioenvironmental and Structural Systems (BESS) Laboratories.[84]

Baseline Case

The baseline condition for this measure is a standard efficiency exhaust, ventilation or circulating fan.

Efficient Case

The compliance condition for this measure is a high speed exhaust, ventilation, circulating, of HVLS fan that meets or exceeds the minimum efficiency requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Exhaust and Ventilation Fans:

$$\Delta kWh = \left(\frac{\frac{CFM_b}{(CFM/W)_b} - \frac{CFM_q}{(CFM/W)_q} \times F_{VFD,q}}{1{,}000} \right) \times hrs$$

Internal circulation fans and HVLS fans:

[84] BESS Laboratories is a research, product testing, and educational laboratory at the University of Illinois.

$$\Delta kWh = \left(\frac{lbf_b}{(lbf/kW)_b} - \frac{lbf_q}{(lbf/kW)_q} \times F_{VFD,q}\right) \times hrs$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-19 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	

Variable	Description	Value	Units	Ref
CFM_b	Cubic feet per minute of existing fan	Site-specific[85], if unknown use CFM_q	Ft^3/min	[388]
CFM_q	Cubic feet per minute of installed fan	Site specific	Ft^3/min	
$(CFM/W)_q$	Ventilating efficiency ratio of installed fan	Site-specific, if unknown look up in Table 3-20	CFM/W	
$(lbf/kW)_q$	Thrust efficiency ratio of installed fan	Site-specific, if unknown look up in Table 3-20	Lbf/kW	
$(CFM/W)_b$	Ventilating efficiency ratio of existing fan	Look up in Table 3-20	CFM/W	
$(lbf/kW)_b$	Thrust efficiency ratio of existing fan	Look up in Table 3-20	Lbf/kW	
lbf_b	Thrust of existing fan	Site specific[86], if unknown use lbf_q	Lbs/force	[388]
lbf_q	Thrust of installed fan	Site-specific	Lbs/force	
$F_{VFD,q}$	Reduced consumption resultant from VFD control	Look up in Table 3-21	N/A	[386]
Hrs	Operating hours	Look up in Table 3-22	Hours	
CF	Electric coincidence factor	Look up in Table 3-23	N/A	
PDF	Gas peak demand factor	Look up in Table 3-23	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-20 Baseline and Efficient Condition Efficiencies

Fan Diameter	Baseline [87]		Efficient[88]	
	Circulation, Ventilation and Exhaust Fans (CFM/W)	Circulating Fans (lbf/kW)	Circulation, Ventilation and Exhaust Fans (CFM/W)	Circulating Fans (lbf/kW)
24”-35”	9.4	10.5	14.0	15.0
36”-47”	12.2	12.9	17.0	20.0
48”-52”	15.1	19.8	19.9	24.2
53”+	16.7	20.8	22.0	24.6

[85] look up from BESS Labs database based on manufacturer and model number.

[86] look up from BESS Labs database based on manufacturer and model number.

[87] Default baseline efficiency was determined by calculating the 10th percentile of the efficiencies of all fans in the active BESS Labs database for the respective fan diameter ranges. Many low efficiency fans are often not tested by BESS Labs, therefore the average tested fan is more efficient than the average market available fan. Ventilation and exhaust fan CFM and circulating fan lbf represent the averages of each diameter range, regardless of fan efficiency. The database includes single and three phase fans at four voltages.

[88] Minimum qualifying fan efficiency is equivalent to the 75th percentile of all BESS Labs tested in the respective fan diameters. The database includes single and three phase fans at four voltages

Table 3-21 VFD Factor

Fan Application	Value
No VFD	1.00
Greenhouse	0.64
Poultry/Livestock	0.75

Table 3-22 Operating Hours

City	Circulating/HVLS Fan Hours[89]	Exhaust/Ventilation Fan Hours[90]
Northern	4,362	6,570
Southwest	4,632	6,570
Coastal	5,017	6,570
Central	4,636	6,570
Pine Barrens	4,684	6,570
Statewide Average	4,655	6,570

Peak Factors

Table 3-23 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	[387]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-24 Measure Life

Equipment	EUL	RUL	Ref
Ventialtion Fans	15	5	[385]

[89] Default hours are developed from NOAA hourly normals by summing annual hours dry bulb temperature above 50°F; NOAA National Centers for Environmental information – NCEI 2010 Hourly Normals

[90] Exhaust/Ventilation fans are assumed to operate 75% of total annual hours (8,760 x 0.75 = 6,570)

References

[385] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

[386] Teitel, M. & Levi, Asher & Zhao, Yun & Barak, Moti & Bar-lev, Eli & Shmuel, David. (2008). Energy saving in agricultural buildings through fan motor control by variable frequency drives. Energy and Buildings. 40. 953-960. 10.1016/j.enbuild.2007.07.010

[387] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential, Multifamily, and Commercial/Industrial Measures. January 1, 2023.

[388] Circulating Fans, Bioenvironmental and Structural Systems Laboratory, University of Illinois, Department of Agricultural and Biological Engineering, Accessed January 12, 2023. Available from: http://bess.illinois.edu/

3.1.8 HEAT RECLAIMERS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of a refrigeration heat recovery (RHR) system on bulk tank compressors on dairy farms. Heat recovery systems recover waste heat from bulk tank compressors used in milk cooling processes. This waste heat is used to pre-heat water before it is transferred to a water heater, thus reducing the load of the water heater. Hot water is used in various farm applications such as cleaning and livestock watering.

There are two methods of calculating savings. One is to calculate the amount of energy that can be recovered by the heat recovery system in the milk cooling process. This method is reflected in the ΔBTU_{milk} equation. The second method is to calculate the energy required to heat the water in the storage tank to the set point. This method is reflected in the ΔBTU_{hru}, equation. The smaller of the two shall be selected. If ΔBTU_{milk} is smaller than ΔBTU_{hru}, this implies that the energy recovered by the heat recovery system is not sufficient to fully heat the water to the setpoint, and therefore represents the upper limit of savings. If ΔBTU_{hru} is smaller than ΔBTU_{milk} this implies the energy required to heat the water to the setpoint is less than the energy that is recovered by the heat recovery system, and therefore represents the upper limit of savings.

Baseline Case

Baseline condition for this measure is a dairy farm without a heat recovery system to feed preheated water to the water heater.

Efficient Case

The efficient condition is a dairy farm with a heat recovery system to preheat water to the waterheater.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{MIN[\Delta \mathrm{BTU}_{\mathrm{milk}}\ or\ \Delta \mathrm{BTU}_{\mathrm{hru}}]}{3{,}412 \times E_{t,elec}}$$

Where,

$$\Delta BTU_{milk} = lbs_{milk} \times cows \times \Delta T_{milk} \times 0.93 \times ESF$$

$$\Delta BTU_{hru} = v_{hru} \times \Delta T_{water} \times 8.33 \times 365 \times cows$$

$$\Delta T_{water} = T_{set} - T_{main}$$

Annual Fuel Savings

$$\Delta Therms = \frac{MIN[\Delta BTU_{milk}\ or\ \Delta BTU_{hru}]}{100{,}000 \times E_{t,fuel}}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-25 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔBTU_{milk}	Recoverable energy from milk cooling process	Calculated	Btu	
ΔBTU_{hru}	Required energy to heat water in the storage tank unit to set temperature	Calculated	Btu	
ΔT_{water}	Change in water temperature attributable to heat recovery system	Calculated	°F	
Lbs_{milk}	Average pounds of milk produced per cow per year	19,800	Lbs/yr	[389]
Cows	Average number of cows milked per day	Site-specific	cow/day	

Variable	Description	Value	Units	Ref
ΔT_{milk}	Difference in temperature between milk entering the bulk tank and final stored temperature of cooled milk	Look up in Table 3-26	°F	[391]
ESF	Energy Savings Factor	0.4	N/A	[392]
V_{hru}	Volume of hot water for washing and cleaning per day per cow, in gallons	Site specific, if unknown use 6.3gal/cow/day	Gal/cow/day	[393]
T_{set}	Expected temperature an RHR unit can pre-heat well water up to	Site-specific, if unknown look up in Table 3-27	°F	[392]
T_{main}	Water main inlet temperature	Look up in Table 3-28	°F	[394]
$E_{t,elec}$	Thermal efficiency of electric water heater	Site-specific, if unknown use 0.98	N/A	[396]
$E_{t,fuel}$	Thermal efficiency of fossil fuel water heater	Site-specific, if unknown use 0.8	N/A	[397]
Hrs	Hours per year	Site-specific, if unknown use 2,920	Hrs/yr	[395]
0.93	Specific heat of milk	0.93	BTU/lb °F	[398]
8.33	Energy required to heat one gallon of water by one degree	8.33	BTU	
3,412	Conversion factor BTU to kWh	3,412	BTU/kWh	
100,000	Conversion factor BTUs to Therms	100,000	BTU/Therm	
CF	Electric coincidence factor	Look up in Table 3-29	N/A	
PDF	Gas peak day factor	Look up in Table 3-29	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-26 Difference in Milk Temperature (ΔT_{milk} °F)

No Pre-Cooler	Standard Pre-Cooler	Variable Speed Pre-Cooler
60 °F	30 °F	18.3 °F

Table 3-27 RHR Setpoint Temperature (T_{set})

Fully condensing RHR system	Desuperheater RHR condenser
130 °F	105 °F

Table 3-28 Cold Water Inlet Temperature (T_{main})

NJ Climate Region	Annual Average Outdoor Temperature (°F)	T_{main} (°F)
Northern	50.75	56.75
Southwest	52.37	58.37
Coastal	54.29	60.29
Central	52.45	58.45
Pine Barrens	52.44	58.44
Statewide Average	52.45	58.45

Peak Factors

Table 3-29 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	N/A
Natural gas peak day factor (PDF)	See	

Measure Life

The effective useful life (EUL) is 14 years. [389]

References

[389] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

[390] New Jersey Dept of Agriculture, *2021 Annual Report and Agricultural Statistics.* (2021), page 21. 2021AnnualReportFinal.pdf (usda.gov)

[391] Sanford, Scott (University of Wisconsin–Madison). “Well Water Precoolers.” Publication A37843. October 2003. It was determined that a plate cooler alone can reduce milk temperature to 68 ˚F and a plate cooler paired with a milk transfer pump VSD can reduce milk temperature to 56.3 ˚F. The additional benefits of the milk transfer pump VSD over the plate cooler is 11.7 ˚F. Milk is stored at 38°F, therefore 56.3°F-38°F=18.3°F.

[392] DeLaval. “Dairy Farm Energy Efficiency”. (April 20, 2011.) A heat recovery system can recover 20%-60% of the energy required in the milk cooling process.

[393] “Water Use on Dairy Farms.” 2011. MSU Extension. 2011 https://www.canr.msu.edu/news/water_use_on_dairy_farms.

[394] Burch, Jay, and Craig Christensen. n.d. “TOWARDS DEVELOPMENT of an ALGORITHM for MAINS WATER TEMPERATURE.” https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/AlgorithmForMainsWaterTemperature.pdf.

[395] “Dairy Farm Energy Management Guide: California.” n.d. Www.energy.wsu.edu. Accessed January 12, 2023. https://www.energy.wsu.edu/EnergyLibrary/AgricultureMatters/CatalogItemDetail.aspx?id=429.

[396] 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency.* https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B#p-Appendix-E-to-Subpart-B-of-Part-430(6.)(6.3)(6.3.2).

[397] 10 CFR 431.110 (a) – Energy conservation standards and their effective dates. https://www.ecfr.gov/current/title-10/chapter-II/subcharpter-D/part431/subpart-G/

[398] 2018 ASHRAE Handbook – Refrigeration, Specific heat of whole milk, Table 3: Unfrozen Composition Data, Initial Freezing Point, and Specific Heat of Foods.

3.1.9 ENGINE BLOCK HEATER TIMER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

This section provides energy savings algorithms for the installation of timers used to control engine block heaters on existing farm equipment. Engine block heaters are generally used during cold weather to warm an engine prior to use. Block heaters without automation are typicially plugged in throughout the night. Using timers allows the heater to come on at a preset time rather than being on throughout the night. There are no peak demand savings associated with this measure since it does not affect peak period usage.

Baseline Case

Engine block heater without a timer that is manually controlled.

Efficient Case

Engine block heater controlled by a timer.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W_{heater}}{1{,}000} \times (hrs_b - hrs_q) \times Days \times UF$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 3-30 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
W_{heater}	Wattage of engine block heater	Site-specific, if unknown use 1,000	W	[401]
hrs_b	Baseline hours of use per day	Site-specific, if unknown use 10	Hrs/day	[401]
hrs_q	Energy efficient hours of use per day	Site-specific, if unknown use 2	Hrs/day	[401]
Days	Days of use per year	Site-specific, if unknown use 90	Days/yr	[401]
UF	Usage Factor	Site-specific, if unknown use 0.97	N/A	[399]
CF	Electric coincidence factor	Look up in Table 3-31	N/A	
PDF	Gas peak demand factor	Look up in Table 3-31	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-31 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 15 years [400].

References

[399] Wisconsin Focus on Energy 2018 Technical Reference Manual. Public Service Commission of Wisconsin. The Cadmus Group, Inc. 2018. Pg. 590. https://www.focusonenergy.com/sites/default/files/TRM%202018%20Final%20Version%20Dec%202017_1.pdf

[400] Gutierrez, Alfredo. Circulating Block Heater. Prepared for the California Technical Forum. http://static1.squarespace.com/static/53c96e16e4b003bdba4f4fee/t/556f7c9ee4b0b65c3515c80c/1433369758093/Circulating+Block+Heater+Presentation_ver+2.pdf

[401] 2018 Wisconsin Association of FFA to Farm Engine Block Heater Timer Fundraiser Fact Sheet. https://s3.us-east-1.amazonaws.com/focusonenergy/staging/inline-files/EBHT_Trifold_2018_1.pdf

3.1.10 ELECTRIC LEAF BLOWER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	February 2024
Changes Since Last Version	• New measure

Description

This measure claims savings for the replacement of an existing commercial gasoline leaf blower with an all-electric leaf blower.

Baseline Case

The baseline condition is assumed to be a commercial gasoline powered leaf blower.

Efficient Case

The efficient condition is a commercial all-electric leaf blower.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = -kW_{battery} \times Hrs$$

When calculated with the default values in Table 3-32, ΔkWh = -163.5 kWh/yr

Annual Fuel Savings (Another Fuel)

$$\Delta Gal_{gasoline} = U \times Hrs$$

When calculated with the default values in Table 3-32, $\Delta Gal_{Gasoline}$ = 121.3 Gal/yr

Annual Peak Demand Savings

$$\Delta kW_{Peak} = -kW_{battery}\ x\ CF$$

Daily Peak Fuel Savings

$$N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings (Another Fuel)

$$\Delta Gal_{Gasoline,\,Life} = \Delta Gal_{gasoline} \times EUL$$

Calculation Parameters

Table 3-32 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated or use default - 163.5	kWh/yr	
ΔkW_{Peak}	Annual peak demand savings	Calculated	kW/yr	
$\Delta Gal_{Gasoline}$	Annual fuel savings (gasoline)	Calculated or use default 121.3	Gal/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Gal_{Gasoline,\,Life}$	Lifetime fuel savings (gasoline)	Calculated	Gal	
kW_{blower}	Electric demand of a commercial electric leaf blower[91]	0.58	kW	[405]
Hrs	Annual hours of use	282	Hrs	[404]
U	Average gallons of gasoline that a baseline leaf blower consumes in one hour[92]	0.43	Gal/hr	[405]
CF	Electric demand coincidence factor	Look up in Table 3-33	N/A	
EUL	Effective useful life	See Measure Life section	Years	[402]

Peak Factors

Table 3-33 Peak Factors

Peak Factor	Value	Ref

91 Assumes the higher range of possible electric lawn blower electric demand **Error! Reference source not found.**.

Electric coincidence factor (CF)	0.5	[406]

Measure Life

The effective useful life (EUL) is 5 years [220].

References

[402] Department of Public Services, *2022 Tier III TRM Characterizations*. 2022, Page 59, https://publicservice.vermont.gov/document/2022-tier-iii-trm-characterizations. Assumed measure life is sourced from a review of available warranties on electric leaf blowers in the market. It was found that there are many models available currently with a manufacturer 5 year warranty.

[403] Assuming the battery will be charged on a 120v outlet, 4.8a x 120v = -0.58 kW. Charger amperage assumption from STIHL manufacturer: https://www.stihlusa.com/WebContent/CMSFileLibrary/InstructionManuals/STIHL-AR-2000-L-3000-L-Owners-Instruction-Manual.pdf

[404] Quiet Communities and US Environmental Protection Agency*, National Emissions from Lawn and Garden Equipment,* 2015, Page 6, Table 3, https://www.epa.gov/sites/default/files/2015-09/documents/banks.pdf

[405] Quiet Clean PDX, *Gas Powered Leaf Blower Noise and Emissions Factsheet*, 2019

[406] Placeholder assumption until further research conducted.

3.1.11 ELECTRIC RIDING LAWN MOWER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	February 2024
Changes Since Last Version	• New measure

Description

This measure claims savings for the replacement of an existing gasoline powered ride-on lawnmower with a new all-electric ride-on lawnmower. This measure is characterized for commercial applications.

Baseline Case

The baseline condition is assumed to be a gasoline powered ride-on lawnmower.

Efficient Case

The efficient condition is an all-electric ride-on lawnmower.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = -\,Q \times Q_{time} \times kW_{Draw} \times N_{battery}$$

Annual Fuel Savings (Another Fuel)

$$\Delta Gal_{gasoline} = U$$

Annual Peak Demand Savings

$$\Delta kW_{Peak} = -kW_{draw} \times N_{battery} \times CF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings (Another Fuel)

$$\Delta Gal_{Gasoline,\,Life} = \Delta Gal_{Gasoline} \times EUL$$

Calculation Parameters

Table 3-34 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings, deemed value calculated using default variables below	Calculated (Default –3,150)	kWh/yr	[220]
ΔkW	Annual peak demand savings	Calculated (Default -0.56)	kW	
$\Delta Gal_{gasoline}$	Annual gasoline savings, deemed value calculated using default variables below	Calculated (Default 900)	gal	[220]
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Gal_{gasoline,life}$	Lifetime gasoline savings	Calculated	gal	
Q	Number of full charges in a year[93]	700	N/A	[220]
Q_{time}	Time required to fully charge battery[94]	4	Hrs	[220]
kW_{draw}	Demand draw of battery while charging	0.56	kW	[220]
$N_{battery}$	No batteries attached to lawn mower	2	N/A	[220]
U	Annual gasoline consumption	900	gallons	[220]
CF	Electric coincidence factor	Look up in Table 3-35	N/A	
EUL	Effective useful life	See Measure Life section	Years	[220]

Peak Factors

Table 3-35 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[408]

93 Annual hours of use divided by Working Time Per Charge.
94 Battery Charging Time to 100% divided by 60 minutes.

Measure Life

The effective useful life (EUL) is 6 years [220].

References

[407] Department of Public Services, *2022 Tier III TRM Characterizations*. 2022, Page 56, https://publicservice.vermont.gov/document/2022-tier-iii-trm-characterizations. Commercial Riding measure life was collected by industry data from Steve W. of Eco Equipment Supply (EES).

[408] Placeholder assumption until further research conducted.

3.1.12 HEDGE TRIMMERS, PUSH LAWNMOWERS, AND CHAINSAWS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• New Measure

Description

This measure applies to the purchase of new commercial lawn equipment, which includes hedge trimmers, push lawnmowers (not self-propelled or riding, but has an electric motor driving a blade), and chainsaws to replace gas lawn equipment.

Baseline Case

The baseline equipment gasoline-powered commercial hedge trimmers, push lawnmowers, and chainsaws.

Efficient Case

The energy efficient equipment is all-electric commercial hedge trimmers, push lawnmowers, and chainsaws.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = Look\ up\ in\ \textbf{Table 2-150}$$

Deemed annual energy savings in Table 2-150 calculated as follows:

$$\Delta kWh = -\frac{Hrs}{t_{charge}} \times E_{battery} \times \frac{D}{Eff_{charger}} \times \frac{1}{1{,}000}$$

Annual Fuel Savings (Alternate Fuel)

$$\Delta Gal_{Gasoline} = Look\ up\ in\ \textbf{Table 2-150}$$

Annual Peak Demand Saving

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Gal_{Life} = \Delta Gal_{Gasoline} \times EUL$$

Calculation Parameters

Table 3-36 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Look up in Table 2-150	kWh/yr	[220]
$\Delta Gal_{gasoline}$	Annual gallons gasoline savings	Look up in Table 2-150	Gallons	[220]
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔGal_{Life}	Lifetime fuel savings	Calculated	Gallons	
ΔkW_{Peak}	Annual peak demand savings	Calculated	kW	
Hrs	Annual operating hours	Look up in Table 2-149	Hrs	
t_{charge}	Run time per charge	Look up in Table 2-149	Hrs	[410]
$E_{battery}$	Rated energy of the battery	Look up in Table 2-149	Wh	[220]
D	Discharge rate	0.90	%	[410]
$Eff_{charger}$	Efficiency of the charger	0.92	%	[410]
1,000	Unit conversion, Wh/kWh	1,000	Wh/kWh	
CF	Electric demand coincidence factor	Look up in Table 3-39	N/A	[411]
EUL	Effective useful life	See Measure Life	Years	[220]

The table below presents the parameters used to calculate the deemed energy impacts.

Table 3-37 Parameters Values

Type of Electric Equipment	Hrs	t_{charge}	$E_{battery}$
Trimmer	125	0.5	1HP Replacement: 100 2HP Replacement: 240
Push Lawnmower	810	1	300
Chainsaw	80	0.09	150

When calculated using the assumptions above, the energy impacts are equal to the values below. These deemed impacts may be used instead of calculating site-specific savings if reliable input parameters are not available.

Table 3-38 Deemed Energy Impacts

Type of Electric Equipment	ΔkWh	$\Delta Gal_{gasoline}$
Trimmer	1HP Replacement: -24.5 2HP Replacement: -58.7	1HP Replacement: 21.5 2HP Replacement: 115
Push Lawnmower	-238	134
Chainsaw	-130	115

Peak Factors

Table 3-39 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[411]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is given in Table 2-152 [220].

Table 3-40 Measure Life

Type of Electric Equipment	Measure Life (yrs)
Trimmer	2
Push Lawnmower	6
Chainsaw	2

References

[409] PSEG CEF-EE II Filing 12.1.23
[410] PSEG-LI TRM
[411] Placeholder assumption until further research conducted.

3.2 APPLIANCES

3.2.1 CLOTHES WASHER

Market	Commercial/Multifamily
Baseline Condition	TOS/NC
Baseline	Code
End Use Subcategory	Clothes Washer
Measure Last Reviewed	January 2023

Description

This measure relates to the purchase (time of sale) and installation of a commercial clothes washer (i.e., soft-mounted front-loading or soft-mounted top-loading clothes washer that is designed for use in applications in which the occupants of more than one household will be using the clothes washer, such as multifamily housing common areas and coin laundries) exceeding the ENERGY STAR minimum qualifying efficiency standards. The Modified Energy Factor (MEF) measures energy consumption of the total laundry cycle (washing and drying). It indicates how many cubic feet of laundry can be washed and dried with one kWh of electricity; the higher the number, the greater the efficiency. The Water Factor (WF) is the number of gallons needed for each cubic foot of laundry. A lower number indicates lower consumption and more efficient use of water. Rather than filling the tub with water, efficient wash cycles are achieved by spinning or flipping clothes through a stream of water. Efficient rinse cycles are achieved through high-pressure spraying instead of soaking clothes. Reduced dryer load represents additional energy savings associated with the thorough removal of water from the clothes in the washer. Clothes washers that have earned the ENERGY STAR® label use approximately 25% less energy and 33% less water than comparable non-qualified models.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline efficiency is minimum efficiency defined in the Code of Federal Regulations at 10 CFR 431.156. Efficiency is defined by the Modified Energy Factor (MEF) that takes into account the energy and water required per clothes washer cycle, including energy required by the clothes dryer per clothes washer cycle.

Efficient Case

The efficient condition is a commercial clothes washer meeting the ENERGY STAR v. 8.1 efficiency criteria.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{washer} + \Delta kWh_{DHW} + \Delta kWh_{dryer}$$

Where,

$$\Delta kWh_{washer} = \Delta kWh_{unit} \times F_{washer}$$

$$\Delta kWh_{DHW} = \Delta kWh_{unit} \times F_{DHW} \times SF_{DHW,electric}$$

$$\Delta kWh_{dryer} = (\Delta kWh_{total} - \Delta kWh_{unit}) \times \frac{F_{loads}}{F_{dryer}} \times F_{dryer,mod} \times SF_{dryer,electric}$$

$$\Delta kWh_{unit} = \left(kWh_{unit,b} - kWh_{unit,q}\right) \times \frac{N_{cycles}}{N_{cycles,ref}}$$

$$\Delta kWh_{total} = Cap \times N_{cycles} \times \left(\frac{1}{MEF_b} - \frac{1}{MEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{DHW} + \Delta Therms_{dryer}$$

Where,

$$\Delta Therms_{DHW} = \Delta kWh_{unit} \times \frac{F_{DHW}}{Eff_{DHW}} \times SF_{DHW,ff} \times 0.03412$$

$$\Delta Therms_{Dryer} = (\Delta kWh_{total} - \Delta kWh_{unit}) \times \frac{F_{loads}}{F_{dryer}} \times F_{dyer,mod} \times F_{dryer,corr} \times SF_{dryer,ff} \times 0.03412$$

$$\Delta kWh_{unit} = \left(kWh_{unit,b} - kWh_{unit,q}\right) \times \frac{N_{cycles}}{N_{cycles,ref}}$$

$$\Delta kWh_{total} = Cap \times N_{cycles} \times \left(\frac{1}{MEF_b} - \frac{1}{MEF_q}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-41 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{washer}	Annual electric energy savings attributed to clothes washer operation	Calculated	kWh/yr	
ΔkWh_{DHW}	Annual electric energy savings attributed to water heating	Calculated	kWh/yr	
ΔkWh_{dryer}	Annual electric energy savings attributed to dryer operation	Calculated	kWh/yr	
ΔkWh_{unit}	Annual electric energy savings of a unit exclusive of dryer operation	Calculated	kWh/yr	
ΔkWh_{total}	Annual electric energy savings of a unit inclusive of dryer operation	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{DHW}$	Annual fuel savings attributed to water heating	Calculated	Therms/yr	
$\Delta Therms_{dryer}$	Annual fuel savings attributed to dryer operation	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta H2O$	Annual water savings	Calculated	Gal/yr	
Cap	Clothes washer capacity	Site-specific. If unknown, use 3.43	ft^3	[415]
N_{cycles}	Number of cycles per year	Site-specific. If unknown, look up in Table 3-44	cycles	[412]
$kWh_{unit,b}$	Baseline rated unit electricity consumption	Site-specific. If unknown, use 241	kWh/yr	[412]

Variable	Description	Value	Units	Ref
$kWh_{unit,q}$	Efficient rated unit electricity consumption	Site-specific. If unknown, use 97	kWh/yr	[412]
F_{washer}	Fraction of energy consumption attributed to clothes washer operation	Site-specific. If unknown, assume 0.20	N/A	[412]
F_{DHW}	Fraction of energy consumption attributed to water heating	Site-specific. If unknown, assume 0.80	N/A	[412]
F_{loads}	Fraction of washer loads dried in machine	Site-specific. If unknown, use 1.0	N/A	
Eff_{DHW}	Fuel water heater efficiency	Site-specific. If unknown, use 0.75	N/A	
WF_q	Water factor for efficient unit	Site-specific. If unknown, look up in Table 3-45	Gal/(cycle·ft^3)	[415][416]
MEF_b	Modified Energy Factor of baseline unit	Look up in Table 3-42	N/A	[415][416]
MEF_q	Modified Energy Factor of efficient unit	Look up in Table 3-42	N/A	[415][416]
$SF_{DHW,electric}$	Electric DHW savings factor	Look up in Table 3-43	N/A	
$SF_{dryer,electric}$	Electric dryer savings factor	Look up in Table 3-43	N/A	
$SF_{DHW,ff}$	Fossil fuel DHW savings factor	Look up in Table 3-43	N/A	
$SF_{dryer,ff}$	Fossil fuel dryer savings factor	Look up in Table 3-43	N/A	
WF_b	Water factor for baseline unit	Look up in Table 3-45	Gal/(cycle·ft^3)	[415][416]
CF	Electric coincidence factor	Look up in Table 3-46	N/A	[412]
PDF	Gas peak day factor	Look up in Table 3-46	N/A	
Hrs	Annual operating hours	265	Hrs/yr	[412]
$N_{cycles, ref}$	Reference number of cycles per year	392	cycles	[412]
F_{dryer}	Dryer usage factor	0.84	N/A	[412]
$F_{dryer,mod}$	Dryer usage factor in buildings with dryer and washer	0.95	N/A	[412]
$F_{dryer,corr}$	Fossil fuel dryer correction factor	1.12	N/A	[412]
0.03412	Unit conversion, therm/kWh	0.03412	Therm/kWh	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-42 Modified Energy Factor of Baseline and Efficienct Unit

Efficiency Level	Front Loading	Top Loading
Federal Standard	Before January 1, 2018	

Efficiency Level	Front Loading	Top Loading
	2.00	1.60
	On or After January 1, 2018	
	2.00	1.35
ENERGY STAR	2.20	

Table 3-43 DHW and Dryer Savings Factors

Fuel	$SF_{DHW,electric}$	$SF_{dryer,electric}$	$SF_{DHW,ff}$	$SF_{dryer,ff}$	Source
Electric	1.00	1.00	0	0	
Fossil Fuel	0	0	1.00	1.00	
Unknown	Look up in Appendix K: DHW and Space Heat Fuel Split	0.89	Look up in Appendix K: DHW and Space Heat Fuel Split	0.11	[417]

Table 3-44 Annual Cycles

Type	Number of Cycles
Multifamily Common Area	1,241
Laundromats	2,190

Table 3-45 Water Factor of Baseline and Efficient Unit

Efficiency Level	Front Loading	Top Loading
Federal Standard	Before January 1, 2018	
	5.5	8.5
	On or After January 1, 2018	
	4.1	8.8
ENERGY STAR	4.0	

Peak Factors

Table 3-46 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[412]

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Non-Energy Impacts

$$\Delta H2O = Cap \times \left(WF_b - WF_q\right) \times N_{cycles}$$

Measure Life

The effective useful life (EUL) for a multifamily common area is 11.3 years. The EUL for laundromats is 7.1 years. [412]

References

[412] Regulations.gov, Energy Conservation Program: Energy Conservation Standards for Commercial Clothes Washers; Final Rule (2014). https://www.regulations.gov/document/EERE-2012-BT-STD-0020-0037

[413] Metered data from Navigant Consulting, *EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Appliance Rebate Program.* March 21, 2014, page 36. This data applies to residential applications. In the absence of metered data specific to multifamily common area and commercial laundromat applications, this coincidence value is used as a proxy given consistency with the PJM peak definition; however, this value is likely conservatively low for commercial applications and is a candidate for update should more applicable data become available .

[414] Clothes Washer Calculations for the ENERGY STAR Appliance Calculator. 2022. https://www.sfwmd.gov/sites/default/files/documents/calculator_energy_star_res_appliance_savings.xlsx.

[415] Based on the average commercial clothes washer volume of all units meeting ENERGY STAR V8.1 criteria listed in the ENERGY STAR database of certified products accessed on 03/07/2016. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%208.1%20Clothes%20Washer%20Final%20Specification%20-%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf

[416] Office of Energy Efficiency and Renewable Energy, Department of Energy, Energy Conservation Program: Energy Conservation Standards for Commercial Clothes Washers. https://www.federalregister.gov/documents/2021/12/20/2021-27461/energy-conservation-program-energy-conservation-standards-for-commercial-clothes-washers

[417] Space heat and DHW factors in Appendix from program data. Dryer fuel data from EIA Residential Energy Consumption Survey 2015, Table HC3.1, buildings with 5 or more units. https://www.eia.gov/consumption/residential/data/2015/#appliances

3.2.2 CLOTHES DRYERS

Market	Commercial/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Clothes Washer
Measure Last Reviewed	January 2023

Description

This measure covers residential grade clothes dryers meeting the criteria established under the ENERGY STAR® Program, Version 1.1, effective May 5, 2017, installed in small commercial settings. ENERGY STAR® clothes dryers have a higher combined energy factor (CEF), and save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions, improving air circulation, and improved efficiency of motors. Reduced dryer runtime is achieved through automatic termination of the dryer cycles based on temperature and moisture sensors. Clothes dryers originally qualified for the ENERGY STAR® label in May 2014. Clothes dryers that have earned this label are approximately 20% more efficient than non-qualified models.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline for energy savings calculations is a clothes dryer meeting the federal minimum combined energy factor for machines manufactured after January 2015. The minimum combined energy factor varies by clothes dryer type.

Efficient Case

A clothes dryer that is an ENERGY STAR® version 1.1 qualifying model.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = Cycles_{annual} \times Load \times \left(\frac{F_{elec,b}}{CEF_b} - \frac{F_{elec,q}}{CEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = Cycles_{annual} \times Load \times \left(\frac{F_{fuel,b}}{CEF_b} - \frac{F_{fuel,q}}{CEF_q}\right) \times \frac{3{,}412}{100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-47 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Cycles_{Annual}$	Number of dryer cycles per year	Site-specific. If unknown, look up in Table 3-49	Cycles	[418]
Load	Average total weight of clothes per drying cycle	Look up in Table 3-48	lbs	[418]
$F_{elec,b}$	Percentage of energy consumed that is derived from electricity for baseline dryer	Look up in Table 3-48	%	[424][425]
$F_{elec,q}$	Percentage of energy consumed that is derived from electricity for efficient dryer	Look up in Table 3-48	%	[424][425]
$F_{fuel,b}$	Percentage of energy consumed that is derived from fossil fuel for baseline dryer	Look up in Table 3-48	%	[424][425]
$F_{fuel,q}$	Percentage of energy consumed that is derived from fossil fuel for efficient dryer	Look up in Table 3-48	%	[424][425]
CEF_b	Combined energy factor for baseline dryer	Look up in Table 3-48	lb/kWh	[420]

Variable	Description	Value	Units	Ref
CEF_q	Combined energy factor for efficient dryer	Look up in Table 3-48	lb/kWh	[419]
Hrs	Annual run hours of clothes dryer	Site-specific. If unknown look up in Table 3-49	Hrs/yr	[418][423]
CF	Electric coincidence factor	Look up in Table 3-50	N/A	[421]
PDF	Gas peak day factor	Look up in Table 3-50	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-48 Clothes Dryer Values

Variable	Vented Gas Dryer	Ventless or Vented Electric, Standard ≥ 4.4 ft³	Ventless or Vented Electric, Compact (120V) < 4.4 ft³	Vented Electric, Compact (240V) < 4.4 ft³	Ventless Electric, Compact (240V) < 4.4 ft³
Load	8.45	8.45	3.00	3.00	3.00
$F_{elec,b}$[95]	0.16	1.00	1.00	1.00	1.00
$F_{elec,q}$	0.16	1.00	1.00	1.00	1.00
$F_{fuel,b}$[96]	0.84	0.00	0.00	0.00	0.00
$F_{fuel,q}$	0.84	0.00	0.00	0.00	0.00
CEF_b	3.30	3.73	3.61	3.27	2.55
CEF_q	3.48	3.93	3.80	3.45	2.68
Energy Star Most Efficient CEF_q		4.3	4.3	4.3	3.7

Table 3-49 Annual Dryer Cycles

Facility Type	Commercial – Multifamily	Laundromat
$Cycles_{Annual}$	1,241	2,190
Hrs[97]	1,158	2,044

[95] %Electric accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 16% was determined using a ratio of the electric to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.
[96] %Gas accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 84% was determined using a ratio of the gas to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.
[97] Assumes average of 56 minutes per cycle based on Ecova, 'Dryer Field Study', Northwest Energy Efficiency Alliance (NEEA) 2014.

Peak Factors

Table 3-50 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[421]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 12 years [422].

References

[418] Savings Calculator for ENERGY STAR Qualified Appliances, ENERGY STAR, 2012. https://www.sfwmd.gov/sites/default/files/documents/calculator_energy_star_res_appliance_savings.xlsx

[419] *ENERGY STAR Program Requirements for Clothes Dryers -Partner Commitments Criteria ENERGY STAR ® Program Requirements Product Specification for Clothes Dryers Partner Commitments*. n.d. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specification%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria_0.pdf

[420] PART 430 - ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS n.d. https://federalregister.gov. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430#430.32

[421] *Mid-Atlantic Technical Reference Manual (TRM) V10.* (2020), https://neep.org/sites/default/files/media-files/trmv10.pdf

[422] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[423] Northwest Energy Efficiency Alliance (NEEA), 'Dryer Field Study', November 2014 https://ecotope-publications-database.ecotope.com/2014_005_1_DryerStudy.pdf

[424] *Mid-Atlantic Technical Reference Manual (TRM) V10* (2020). https://neep.org/sites/default/files/media-files/trmv10.pdf

[425] ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis, August 2013. https://www.energystar.gov/sites/default/files/specs/ENERGY%20STAR%20Draft%202%20Version%201.0%20Clothes%20Dryers%20Data%20and%20Analysis.xlsx

3.2.3 CLOTHES DRYER MODULATING VALVE

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Clothes Washer
Measure Last Reviewed	January 2023

Description

This measure relates to the installation of a two-stage modulating gas valve retrofit kit on a standard commercial non-modulating gas dryer. Commercial gas clothes dryers found in coin-operated laundromats or on-premise laundromats (hospitals, hotels, health clubs, etc.) traditionally have a single firing rate which is sized properly for highest heat required in initial drying stages but is oversized for later drying stages requiring lesser heat. This causes the burner to cycle on/off frequently, resulting in less efficient drying and wasted gas. Replacing the single stage gas valve with a two-stage gas valve allows the firing rate to adjust to the changing heat demand, thereby reducing overall gas consumption.

Accurately estimating dryer energy consumption is complicated and challenging due to a variety of factors that influence cycle times and characteristics and ultimately drying energy requirements. Clothing loads can vary by weight, volume, fiber composition, physical structure, and initial water content, meaning that drying energy requirements can differ for any given cycle. Additionally, dryer settings selected by the user andinteractions with the site's HVAC systems are known to influence dryer performance. As better information becomes available, this characterization can be modified to allow for a more site-specific estimation of savings.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

A 30- to 250- pound capacity commercial gas dryer with no modulating capabilities.

Efficient Case

A 30- to 250-pound capacity commercial gas dryer retrofitted with a two-stage modulating gas valve kit.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = N_{Cycles} \times SF$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \mathrm{N/A}$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-51 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
N_{Cycles}	Number of dryer cycles per year	Site-specific. If unknown, look up in Table 3-52	Cycles/yr	[426]
SF	Savings factor	0.18	Therms/cycle	[427][426]
PDF	Gas peak day factor	Look up in Table 3-53	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-52 Estimated Dryer Cycles per Year

Application	Cycles per Year
Coin-Operated Laundromats	1,483
Multifamily Dryers	1,074
On-Premise Laundromats	3,607

Peak Factors

Table 3-53 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is equal to 10 years[426].

References

[426] *IL 2022 Illinois Statewide Technical Reference Manual for Energy Efficiency : Version 10* (2022), Pg 734. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

[427] IL TRM v10, pg 734. Based on Illinois weather data, and average dryer performance for laundromat (30 to 45lb) and hotel (75 to 170 lb) dryers.

3.2.4 REFRIGERATORS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/ISP/ Dual
End Use Subcategory	Kitchen
Measure Last Reviewed	January 2023

Description

This measure includes the installation of ENERGY STAR® compliant commercial refrigerators with an integral compressor and condenser. This measure is only applicable to horizontal or vertical self-contained refrigerators with solid or transparent doors.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Early Replacement: The baseline condition for the Early Replacement measure is the existing commercial refrigerator for the remaining useful life of the unit, and then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard.

Time of Sale: The baseline condition is a standard-efficiency commercial refrigerator meeting, but not exceeding, federal energy efficiency standards.

Efficient Case

The efficient condition is a high-efficiency packaged commercial refrigerator meeting ENERGY STAR® Version 5.0 requirements.

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (1 + HVAC_c) \times Days$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times HVAC_{ff} \times 10 \times Days$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{kWh_b - kWh_q}{Daily\ Hours}\right) \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-54 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric savings	Calculated	kWh/yr	
$\Delta Therms$	Annual fue savings compared to existing unit	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings compared to existing unit	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
V	Refrigerator volume	Site-specific	ft^3	
Days	Number of days of operations in a year	Site-specific. If unknown, use 365 days	days	
Daily Hours	Hours of operation in a day	Site-specific. If unknown, use 24 hours	hours	
kWh_q	Annual energy consumption of qualifying efficient unit	Look up in Table 3-57	kWh	[429]

Variable	Description	Value	Units	Ref
kWh_b	Annual energy consumption of code-compliant baseline unit	Site-specific or look up in Table 3-56, Table 3-57	kWh	[428]
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	0.080	N/A	
$HVAC_d$	HVAC interaction factor for peak demand at utility summer peak hour	0.175	N/A	
$HVAC_{ff}$	HVAC interaction factor for annual fossil fuel energy consumption	-0.002	MMBtu/kWh	
10	Unit conversion, Therm/MMBtu	10	Therm/MMBtu	
CF	Electric coincidence factor	Look up in Table 3-58	N/A	
PDF	Gas peak day factor	Look up in Table 3-58	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-55 Daily Energy Consumption of Code-Compliant Baseline Unit

Product Class	Daily Refrigerator Energy (kWh_b)
Vertical Closed	
Solid	*VCS.SC.M**
All volumes	*0.05 x V+1.36*
Transparent	*VCT.SC.M*
All volumes	*0.1 x V+0.86*
Horizontal Closed	
Solid	*HCS.SC.M*
All volumes	*0.05 x V+0.91*
Transparent	*HCT.SC.M*
All volumes	*0.06 x V+0.37*

Where V = unit volume in cubic feet

* DOE Equipment Class designations relevant to ENERGY STAR eligible product scope

(1) Equipment family code (HCS= horizontal closed solid, HCT=horizontal closed transparent, VCS= vertical closed solid, VCT=vertical closed transparent).

(2) Operating mode (SC=self-contained).

(3) Rating Temperature (M=medium temperature (38 °F), L=low temperature (0 °F)).

Table 3-56 Daily Energy Consumption of Existing Unit

Product Class	Daily Refrigerator Energy when existing unit was manufactured before 03/26/2017 (kWh_{ex})	Daily Refrigerator Energy when existing unit was manufactured after 03/27/2017 (kWh_{ex})
Vertical Closed		
Solid	*VCS.SC.M*	*VCS.SC.M*
All volumes	*0.10 x V+2.04*	*0.05 x V+1.36*
Transparent	*VCT.SC.M*	*VCT.SC.M*
All volumes	(0.12V + 3.34) x 365	(0.1 x V+0.86) x 365
Horizontal Closed		
Solid	*HCS.SC.M*	*HCS.SC.M*
All volumes	(0.10V+2.04) x 365	(0.05 x V+0.91) x 365
Transparent	*HCT.SC.M*	*HCT.SC.M*
All volumes	(0.12V + 3.34) x 365	(0.06 x V+0.37) x 365

Where V = unit volume in cubic feet

Table 3-57 Daily Energy Consumption of Qualifying Efficient Unit

Product Class	Daily Refrigerator Energy (kWh_q)
Vertical Closed	
Solid	*VCS.SC.M*
0 < V < 15	*0.0267 x V+0.8*
15 ≤ V < 30	*0.05 x V+0.45*
30 ≤ V < 50	*0.05 x V+0.45*
50 ≤ V	*0.025 x V+1.6991*
Transparent	*VCT.SC.M*
0 < V < 15	*0.095 x V+0.445*
15 ≤ V < 30	*0.05 x V+1.12*
30 ≤ V < 50	*0.076 x V+0.34*
50 ≤ V	*0.105 x V-1.111*
Horizontal Closed	
Solid or Transparent	*HCT.SC.M, HCS.SC.M*
All volumes	*0.05 x V+0.28*

Where V = unit volume in cubic feet

Peak Factors

Table 3-58 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	Appendix G: Natural Gas Peak Day Factors	

Measure Life

Table 3-59 Measure Life

Equipment	EUL	RUL	Ref
Commercial Reach-in Refrigerator	12	Site-specific. If unknown use 4 years	[431]

References

[428] Code of Federal Regulations, Energy Efficiency Program for Certain Commercial and Industrial Equipment, title 10, sec. 431.66 (2010).

[429] ENERGY STAR Program Requirements Product Specification for Commercial Refrigerators and Freezers Eligibility Criteria Version 5.0, ENERGY STAR ®, December 2022.

[430] Code of Federal Regulations, Energy Efficiency Program for Certain Commercial and Industrial Equipment, title 10, sec. 431.66 (2013).

[431] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020. http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

3.2.5 FREEZERS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/ISP/Dual
End Use Subcategory	Kitchen
Measure Last Reviewed	January 2023

Description

This measure covers the installation of ENERGY STAR® compliant commercial freezers operating with an integral compressor and condenser. Eligible equipment includes commercial freezers and refrigerator-freezers. This measure is only applicable to horizontal or vertical self-contained equipment with solid or transparent doors.

In the case of early replacement of a working unit where the unit would have otherwise been installed until failure, remaining useful life (RUL) savings are claimed additional to the estimated useful life (EUL) savings of the new unit. Early replacement savings are calculated between existing unit and efficient unit consumption during the assumed remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life. Assume that the remaining useful life of the existing unit equals 1/3 of the measure's effective useful life.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Early Replacement (EREP) and Direct Install (DI): Early replacement and DI uses a dual baseline. The baseline is the existing unit for the remaining life of the existing unit and the baseline is a code-compliant/standard efficiency unit for the full measure life of the installed equipment.

Time of Sale (TOS) and New Construction (NC): The baseline condition is a minimally code compliant commercial freezer.

Baseline annual electric consumption shall align with federally mandated maximum energy use associated with the Product Class and the chilled or frozen compartment volume (V) of the qualifying equipment [432]. Volume specification shall be taken from ENERGY STAR® qualified products listing or specification sheet of the proposed equipment.

Efficient Case

The compliance condition is an ENERGY STAR® version 5.0 qualified commercial refrigerator-freezer or freezer. Annual electric energy consumption of the qualifying equipment shall come from application. Volume specification shall be taken from ENERGY STAR® qualified products listing or specification sheet of the proposed equipment.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (1 + HVAC_c) \times Days$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times HVAC_f \times 10 \ \times Days$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{kWh_b - kWh_q}{Daily\ Hours}\right) \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Time of Sale (compared to code baseline):

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-60 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings for Time of Sale	Calculated	Therms/yr	

Variable	Description	Value	Units	Ref
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
V	Freezer unit volume	Site-specific	ft^3	
Days	Number of days of operations in a year	Site-specific. If unknown, use 365 days	days	
Daily Hours	Hours of operation in a day	Site-specific. If unknown, use 24 hours	hours	
kWh_q	Annual energy consumption of qualifying efficiency unit	Site-specific. If unknown, look up in Table 3-62	kWh/yr	[434]
kWh_b	Annual energy consumption of code-compliant baseline unit	Site-specific or look up in Table 3-61, Table 3-62	kWh/yr	[432]
CF	Electric coincidence factor	Look up in Table 3-64	N/A	
PDF	Gas peak day factor	Look up in Table 3-64	N/A	
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	0.080	N/A	
$HVAC_d$	HVAC interaction factor for peak demand at utility summer peak hour	0.175	N/A	
$HVAC_{ff}$	HVAC interaction factor for annual fossil fuel energy consumption	-0.002	MMBtu/kWh	
8,760	Hours per year	8,760	Hrs/yr	
10	Unit conversion, Therm/MMBtu	10	Therm/MMBtu	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-61 Current Federal Standard Baseline Equipment Daily Energy Consumption

Type	Freezer	
	Solid Door	Transparent Door
Vertical	$0.22 \times V + 1.38$	$0.29 \times V + 2.95$
Horizontal	$0.06 \times V + 1.12$	$0.08 \times V + 1.23$

Table 3-62 Energy Star Equipment Daily Energy Consumption

Volume (ft^3)	Vertical Closed Freezer		Horizontal Closed Freezer
	Solid Door	Transparent Door	Solid or Transparent Door
$0 < V < 15$	$0.21 \times V + 0.9$	$0.232 \times V + 2.36$	$0.057 \times V + 0.55$
$15 \leq V < 30$	$0.12 \times V + 2.248$	$0.232 \times V + 2.36$	$0.057 \times V + 0.55$
$30 \leq V < 50$	$0.258 \times V - 2.703$	$0.232 \times V + 2.36$	$0.057 \times V + 0.55$
$50 \leq V$	$0.142 \times V + 4.445$	$0.232 \times V + 2.36$	$0.057 \times V + 0.55$

Table 3-63 Existing Equipment Daily Energy Consumption

Type	Freezer	
	Solid Door	Transparent Door
Manufactured after 03/27/2017		
Vertical	$0.22 \times V + 1.38$	$0.29 \times V + 2.95$
Horizontal	$0.06 \times V + 1.12$	$0.08 \times V + 1.23$
Manufactured before 03/27/2017		
Vertical	$0.40 \times V + 1.38$	$0.75 \times V + 4.10$
Horizontal	$0.40 \times V + 1.38$	$0.75 \times V + 4.10$

Peak Factors

Table 3-64 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	[432]
Natural gas peak day factor (PDF)	N/A	

Measure Life

Table 3-65 Measure Life

Equipment	EUL	RUL	Ref
Freezer	12	Site-specific. If unknown, use 4 years	[433]

References

[432] 10 CFR Appendix A to Subpart C of Part 431 – Uniform Test Method for the Measurement of Energy Consumption of Commercial Refrigerators, Freezers, and Refrigerator-Freezers. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-C/subject-group-ECFR8115bf7451f830f/section-431.66

[433] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, *Effective/Remaining Useful Life Values*, California Public Utilities Commission (December 16, 2008).

[434] ENERGY STAR® Program Requirements Product Specification for Commercial Refrigerators and Freezers, Eligibility Criteria Version 5.0. (2022).

3.2.6 DEHUMIDIFIER

Market	Commercial/Multifamily
Baseline Condition	TOS/NC
Baseline	Code/ISP
End Use Subcategory	Indoor Environment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of commercial stand-alone or ducted dehumidifiers meeting the minimum qualifying efficiency standards established under the ENERGY STAR® Program, Version 5.0, effective October 31, 2019. With a higher Energy Factor than comparable non-qualified models, ENERGY STAR® dehumidifiers have more efficient refrigeration coils, compressors, and fans that use less energy to remove moisture in Commercial buildings. Dehumidifiers originally qualified for the ENERGY STAR® label in January 2001. Dehumidifiers that have earned this label are approximately 15% more efficient than non-qualified models. This measure is restricted to dehumidifiers with a product moisture removal capacity of less than or equal to 185 pints/day.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is a stand-alone or ducted dehumidifier meeting the minimum effective federal standard for performance.

Dehumidifiers manufactured and distributed in commerce on or after June 13, 2019 must meet the energy conservation standards, rated in Integrated Energy Factor as specified in the Code of Federal Regulations.

Efficient Case

The compliance condition is an ENERGY STAR® v. 5 qualified stand-alone or whole-house dehumidifier.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{pints/day \times 0.473 \times hrs}{24} \times \left(\frac{1}{IEF_b} - \frac{1}{IEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Lfe} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-66 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Pints/day	Product capacity to remove moisture	Site-specific	pints/day	
hrs	Annual run hours of dehumidifier	1,632	N/A	[435]
IEF_b	Basline Integrated Energy Factor	Look up in Table 3-67 & Table 3-68	liters/kWh	[436]
IEF_q	Energy Efficient Integrated Energy Factor	Site-specific. If unknown, look up in Table 3-69 & Table 3-70	liters/kWh	[437]
0.473	Conversion factor from liters to pint	0.473	liters/pint	
24	Hours in one day	24	N/A	
CF	Electric coincidence factor	0.405	N/A	[438]
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-67 Stand-Alone Dehumidfiers Baseline Integrated Energy Factor

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
≤ 25.00	1.30
25.01 to 50.00	1.60

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
≥50.01	2.80

Table 3-68 Whole-Home (Ducted) Dehumidifiers Baseline Integrated Energy Factor

Product Case Volume (ft^3)	Integrated Energy Factor (liters/kWh)
≤ 8.0	≥1.77
> 8.0	≥2.41

Table 3-69 Stand-Alone Dehumidfiers Energy Efficient Integrated Energy Factor

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
≤ 25.00	≥1.57
25.01 to 50.00	≥1.80
≥50.01	≥3.30

Table 3-70 Whole-Home (Ducted) Dehumidifiers Energy Efficient Integrated Energy Factor

Product Case Volume (ft^3)	Integrated Energy Factor (liters/kWh)
≤ 8.0	≥2.09
> 8.0	≥3.30

Peak Factors

Table 3-71 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years [439].

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-72 Measure Life

Equipment	EUL	RUL	Ref
Dehumidifier	12	4	[439]

References

[435] "ENERGY STAR Appliance Calculator". https://www.energy.gov/energysaver/maps/appliance-energy-calculator. n.d. Accessed December 21, 2022.

[436] 10 CFR 430.32(v)(2), January 2023 https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32#p-430.32(v)(2)

[437] ENERGY STAR® Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 5.0, October 2019.

[438] Dehumidifier Metering in PA and Ohio by ADM from 7/17/2013 to 9/22/2013. 31 Units metered. Assumes all non-coincident peaks occur within window and that the average load during this window is representative of the June PJM days as well.

[439] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

3.2.7 ROOM AIR CONDITIONER

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/DI
Baseline	Code/Dual
End Use Subcategory	Indoor Environment
Measure Last Reviewed	January 2023
Changes Since Last Version	• Clarified baseline definitions in parameters table • Moved code-compliant efficiencies look up to appendix

Description

This measure relates to the purchase and installation of a room air conditioning unit that meets the ENERGY STAR minimum qualifying efficiency specifications as presented in this section. This measure is for ENERGY STAR room air conditioner units installed in small commercial spaces. All HVAC applications other than comfort cooling and heating, such as process cooling, are defined as non-standard applications and are ineligible for this measure.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Room air conditioner having energy efficiency ratio (EER) as per Code of Federal Regulation's combined energy efficiency ratio (CEER).

Efficient Case

Room air conditioner meeting the requirements of Energy Star 4.2 room air conditioner specification.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = EFLH_c \times Cap \times \left(\frac{1}{CEER_b} - \frac{1}{CEER_q}\right)/1{,}000$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{EFLH_c} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-73 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Cap	Cooling capacity of efficient equipment	Site-specific	Btu/hr	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in Appendix C: Heating and Cooling EFLH, limit to small commercial buildings	Hours	[440]
$CEER_b$	Efficiency of baseline unit	EREP/DI: Site-specific existing efficiency, if unknown look up vintage code in in Appendix E: Code-Compliant Efficiencies TOS: Look up current code in Appendix E: Code-Compliant Efficiencies	Btu/hr/watt	[441]

Variable	Description	Value	Units	Ref
$CEER_q$	Efficiency of efficient unit	Site specific or defaults in lookup in Table 3-74	Btu/hr/watt	[442]
CF	Electric coincidence factor	Look up in Table 3-75	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	
1,000	Conversion from watts to kW	1,000	Watts/kW	

Table 3-74 ENERGY STAR CEER values for room air conditioner

Product Type and Class (Btu/hour)		ENERGY STAR with louvered sides (CEER)	ENERGY STAR without louvered sides (CEER)
Without reverse cycle	<6,000	12.1	11.0
	6,000 to 7,999	12.1	11.0
	8,000 to 10,999	12.0	10.6
	11,000 to 13,999	12.0	10.5
	14,000 to 19,999	11.8	10.2
	20,000 to 27,999	10.3	10.3
	≥28,000	9.9	10.3
With reverse cycle	<14,000	N/A	10.2
	≥14,000	N/A	9.6
	<20,000	10.8	N/A
	≥20,000	10.2	N/A
Casement-only[98]		10.5	
Casement slider[99]		11.4	

[98] Casement-only refers to a RAC designed for mounting in a casement window with an encased assembly with a width of ≤ 14.8 inches and a height of ≤ 11.2 inches.

[99] Casement-slider refers to a RAC with an encased assembly designed for mounting in a sliding or casement window with a width of ≤ 15.5 inches.

Peak Factors

Table 3-75 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.31	[443]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-76 Measure Life

Equipment	EUL	RUL	Ref
Room Air Conditioner	9	3	[444]

References

[440] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

[441] Code of Federal Regulations – Title 10, Chapter II, Subchapter D, Part 430, Subpart C, §430.32., January 2023 https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[442] ENERGY STAR Program Requirements for Room Air Conditioners, Eligibility Criteria, Version 4.0, January 2023 https://www.energystar.gov/products/heating_cooling/air_conditioning_room/key_product_criteria

[443] NEEP, Mid-Atlantic Technical Reference Manual, V8. pp 77-80., May 2018 https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V8_0.pdf

[444] PA TRM Energy Efficiency and Conservation Programs (TRM), Version 9, January 2023.

3.2.8 WATER COOLER

Market	Commercial/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Kitchen
Measure Last Reviewed	January 2023

Description

This measure estimates savings for installing ENERGY STAR Water Coolers compared to standard efficiency equipment in commercial applications. The measurement of energy and demand savings is based on a deemed savings value multiplied by the quantity of the measure.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Water cooler meeting Energy Star v. 2.0 Water Cooler requirements as directed by N.J. PL 2021, c. 464.

Efficient Case

ENERGY STAR v. 3.0 compliant water cooler.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times 365$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hr} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-77 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hr	Annual hours of operation	Site-specific, if unknown assume 8,760	Hrs	
kWh_b	Energy use of baseline water cooler	Look up in Table 3-78	kWh/day	[445]
kWh_q	Energy use of energy efficient water cooler	Site-specific, if unknown look up in Table 3-78	kWh/day	[446]
CF	Electric coincidence factor	Look up in Table 3-79	N/A	
PDF	Gas peak day factor	Look up in Table 3-79	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-78 Water Cooler Energy Use

Energy Star Water Cooler Type Product Capacity Class, and Conditioning Method	Baseline kWh_b (kWh/day)	Default Efficient kWh_q (kWh/day)
Cold Only	0.16	0.16
Hot & Cold – Low Capacity[100]	0.87	0.68
Hot & Cold – High Capacity[101]	0.87	0.80
Hot & Cold On-Demand	0.18	0.18

[100] A water cooler with a cold-water dispenser capacity of 0.50 gallons per hour or less, as measured per ANSI/ASHRAE Standard 18. For units that also provide hot water, the unit must have a hot-water dispenser capacity that is equal to or less than 41 exact 6 oz. cups per hour, as rated per ANSI/ASHRAE Standard 18.

[101] A water cooler with a cold-water dispenser capacity that is greater than 0.50 gallons per hour, as measured per ANSI/ASHRAE Standard 18. For units that also provide hot water, the unit must have a hot-water dispenser capacity greater than 41 exact 6 oz. cups per hour, as rated per ANSI/ASHRAE Standard 18.

Peak Factors

Table 3-79 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	[447]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years. [445]

References

[445] ENERGY STAR Product Specifications for Water Coolers Version 2.0. https://www.energystar.gov/sites/default/files/specs//ES%20WC%20V2%200%20Spec.pdf

[446] ENERGY STAR Product Specifications for Water Coolers Version 3.0. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Verison%203.0%20Water%20Coolers%20Final%20Specification_0.pdf

[447] Assumes 24/7 operation. Site-specific load shape information should be used if known.

3.3 APPLIANCE RECYCLING

3.3.1 REFRIGERATOR & FREEZER RECYCLING

Market	Commercial
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	Recycling
Measure Last Reviewed	January 2023

Description

In many cases, when a refrigerator or freezer is replaced by a building owner, the existing unit is retained, sold, or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of the existing, functional equipment, thereby eliminating the consumption associated with that equipment. Refrigerator and freezer recycling programs (also called "bounty" programs) receive energy savings credit for permanently removing inefficient, functional refrigerators and freezers from the electric grid.

This measure covers the recycling of primary (i.e., installed in a kitchen) and secondary (i.e., installed elsewhere) refrigerators, refrigerator-freezers and freezers. To account for the fact that secondary equipment is occasionally installed and operating for only part of the year, a part-time use adjustment factor has been developed and embedded within the gross savings estimate for secondary units to establish average annual per unit deemed electric savings.

This measure does not cover the recycling of equipment classified by the Code of Federal Regulations as "Compact refrigerator/refrigerator-freezer/freezer". This refers to any refrigerator, refrigerator-freezer or freezer with a total refrigerated volume of less than 7.75 ft3 (220 liters), where the total refrigerated volume has been determined in accordance with the procedure prescribed in Appendix A (refrigerators and refrigerator-freezers) or B (freezers) of 10 CFR 430 Subpart B.112.

Note: The following values are developed for residential equipment installed in commercial buildings. There currently is no methodology for recycling of commercial scale refrigerators and freezers.

Baseline Case

The savings calculations below apply to recycling of a functioning primary or secondary refrigerator, refrigerator-freezer, or freezer with total refrigerated volume of 7.75 ft3 (220 liters) or more.

Efficient Case

The compliance condition is the recycling of an existing refrigerator or freezer as defined in the Measure Description section above.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{\Delta kWh}{unit}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{\Delta kW}{unit}\right)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 3-80 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkWh/unit	Energy Savings	Lookup in Table 3-81	kWh	[449]
ΔkW/unit	Demand Savings per unit	Lookup in Table 3-81	kWh	[449]
CF	Electric coincidence factor	Look up in Table 3-82	N/A	
PDF	Gas peak demand factor	Look up in Table 3-82	N/A	
EUL	Effective useful life	See	Years	[448]

Table 3-81 Default Values for Annual Energy and Peak Demand Savings

	Primary Refrigerator	Secondary Refrigerator	Freezer
ΔkWh/unit	958	581	593
ΔkW/unit	0.15	0.10	0.10

Peak Factors

Table 3-82 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 5 years for a refrigerator and 4 years for a freezer [448].

References

[448] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[449] DNV, Appliance Recycling Program Impact Evaluation Study, June 2021 https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BE846898E-5EAE-4F42-9F97-385982740AC6%7D

3.3.2 ROOM AC UNIT RECYCLING

Market	Commercial
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	Recycling
Measure Last Reviewed	January 2023

Description

In many cases where a business removes an appliance, the existing unit is retained, sold, or donated for use elsewhere and represents additional load on the grid. This measure covers removing the existing functional equipment before its natural end of life, thereby eliminating the consumption associated with that equipment. This measure is applicable to commercial and multifamily high-rise buildings.

A room air conditioner is an appliance, other than a "packaged terminal air conditioner," which is powered by a single-phase electric current and that is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of delivering conditioned air to an enclosed space.

Baseline Case

The baseline condition is the existing room air conditioning unit.

Efficient Case

The existing room air conditioning unit is removed from service.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Hrs \times Btu/h}{EER \times 1{,}000} \times PartUse$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{Btu/h}{EER \times 1{,}000} \times PartUse \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-83 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Btu/h	Capacity of replaced unit	Site-specific, if unknown assume 8,500	Btu/hr	[452]
EER	Efficiency of existing unit	Site-specific, if unknown assume 9.8	Btu/W/hr	[453]
Hrs	Run hours of A/C unit	Site-specific, if unknown assume 325	Hours	[451]
PartUse	Factor to account for units that are not in daily use throughout entire cooling season, as reported by applicant	Site-specific, if unknown assume 0.34	N/A	[456]
CF	Electric coincidence factor	Look up in Table 3-84	N/A	
PDF	Gas peak day factor	Look up in Table 3-84	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-84 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.3	[452]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 3 years. [450]

References

[450] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx .

[451] From MidAtlantic TRM v10: "VEIC calculated the average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008) to FLH for Central Cooling at 31%. Applying this to the FLH for Central Cooling provided for Baltimore (1050) we get 325 FLH for Room AC."

[452] RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners (June 23, 2008 p. 22). Btu/h in this measure based on maximum capacity average in report, CF in this measure consistent with factors presented in report. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf

[453] Minimum Federal Standard for most common room AC type (8000-14,999 capacity range with louvered sides) per federal standards from 10/1/2000 to 5/31/2014.

[454] Minimum Federal Standard for most common Room AC type (8000-14,999 capacity range with louvered sides). Current federal standards use CEER while previous federal standards used EER for efficiency levels.

[455] *Mid-Atlantic TRM Manual: Version 10* (NEEP, 2020), Pg 110 https://neep.org/mid-atlantic-technical-reference-manual-trm-v10.

[456] Cadmus analysis, EmPOWER 2018 P1 & P2 ARP participant survey

3.3.3 DEHUMIDIFIER RECYCLING

Market	Commercial
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

In many cases, when a dehumidifier is replaced by a building owner, the existing unit is retained, sold or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of existing, functional, portable dehumidifiers, thereby eliminating the consumption associated with that equipment. This measure should target, but not be limited to dehumidifiers put into service prior to June 2019. If provided data indicates the unit is replaced rather than retired, savings shall be based on the Commercial Dehumidifier measure in this TRM.

Baseline Case

The baseline condition is the existing inefficient dehumidifier.

Efficient Case

The existing inefficient dehumidifier is removed from service and not replaced.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = capacity \times \frac{0.473}{24} \times hrs \times \frac{1}{L/kWh}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times RUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-85 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Capacity	Capacity of the unit	Site-specific. If unknown, use 56	pints/day	[463]
L/kWh	Dehumidifier Efficiency	Look up in Table 3-86	L/kWh	[458][460][461]
0.473	Conversion factor	0.473	L/pint	
24	Conversion factor	24	Hr/day	
Hrs	Hours of use	1632	Hours	[458]
CF	Electric coincidence factor	Look up in Table 3-87	N/A	
PDF	Gas peak day factor	Look up inTable 3-87	N/A	
RUL	Remaining useful life	See Measure Life Section	Years	

Table 3-86 Dehumidifier Capacity and Efficiency

Capacity Range (pints/day)	ENERGY STAR Labeled (L/kWh)	Non-ENERGY STAR Labeled	
		Manufacture date before Oct. 2012 (≥L/kWh)	Manufacture date of Oct. 2012 or later (≥L/kWh)
≤ 25	1.57	1.00	1.35
>25 to ≤ 35	1.80	1.20	1.35
>35 to ≤ 45	1.80	1.30	1.50
>45 to ≤ 50	1.80	1.30	1.60
>50 to ≤ 55	3.30	1.30	1.60
>54 to ≤ 75	3.30	1.50	1.70

Capacity Range (pints/day)	ENERGY STAR Labeled (L/kWh)	Non-ENERGY STAR Labeled	
		Manufacture date before Oct. 2012 (≥L/kWh)	Manufacture date of Oct. 2012 or later (≥L/kWh)
>75 to ≤ 185	3.30	2.25	2.50

Peak Factors

Table 3-87 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.405	[462]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) is 4 years [457].

References

[457] CA DEER gives the following rule-of-thumb for remaining useful life: RUL = (1/3) X EUL. As the Energy Star Dehumidifier [replacement] uses an EUL of 12 years, we have a suggested RUL of (1/3) X 12 years = 4 years.

[458] Savings Calculator for ENERGY STAR® Qualified Appliances Version 3.0 Last Updated October 1, 2012.

[459] ENERGY STAR® Program Requirements for Dehumidifiers, Version 5.0, February 2019.

[460] 42 U.S.C, Title 42 Chapter 77, Subchapter III, Part A, (cc)(1) and (cc)(2). https://uscode.house.gov/view.xhtml?path=/prelim@title42/chapter77/subchapter3&edition=prelim

[461] Code of Federal Regulations Title 10, Chapter 2, Subchapter D, Part 430, Subpart C (v)(1). https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C

[462] Dehumidifier Metering in PA and Ohio by ADM from 7/17/2013 to 9/22/2013. 31 Units metered. Assumes all non-coincident peaks occur within window and that the average load during this window is representative of the June PJM days as well.

[463] *Mid-Atlantic Technical Reference Manual (TRM) V10.* (2020), https://neep.org/sites/default/files/media-files/trmv10.pdf

3.4 FOODSERVICE

3.4.1 OVENS, FRYER, STEAMER & GRIDDLE

Market	Commercial
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Cooking equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of qualified commercial kitchen equipment that exceeds the efficiency standards specified in the New Jersey P.L. 2021, c. 464 meets the descriptions below.

- Convection Ovens [465] – This measure includes gas and electric commercial convection ovens. A convection oven forces hot dry air over the surface of a food product. A full-size convection oven can accommodate standard full-size sheet pans measuring 18 x 26 x 1 inch. A half-size convection oven can accommodate half-size sheet pans measuring 18 x 13 x 1 inch. Though not subject to minimum standards specified in the New Jersey P.L. 2021, c. 464, the baseline for half-size gas convection ovens were taken from a Pacific Gas & Electric workpaper [469].
- Rack Ovens [465] – This measure includes gas commercial rack ovens. A rack oven is a high-capacity oven in which a rack is wheeled into the oven and can be rotated during the baking process. Single and double rack ovens are included in this measure.
- Steamers [466] – This measure includes gas and electric commercial steamers, also known as compartment steamers. A steamer is a device that contains one or more food steaming compartments in which the energy in the steam is transferred to the food by direct contact. To calculate the savings for this measure, the number of pans must be known. Countertop, wall-mounted, and floor models mounted on a stand, pedestal, or cabinet-style base are included. Commercial steamer microwave ovens are not included in this measure.
- Fryers [467]– This measure includes gas and electric commercial deep-fat fryers. A deep-fat fryer is an appliance in which oils are placed to such a depth that the cooking food is essentially supported by displacement of the cooking fluid rather than by the bottom of the vessel. Depending on the fryer type, heat is delivered to the cooking fluid by means of an immersed electric element or band-wrapped vessel (electric fryers), or by heat transfer from gas burners through either the walls of the fryer or through tubes passing through the cooking fluid (gas fryers). Standard fryers and large vat fryers are included in this measure.
- Griddles [468] – This measure includes single-sided gas and electric commercial griddles. A single-sided commercial griddle is a commercial appliance designed for cooking food in oil or its own juices by direct contact with either a flat, smooth, hot surface or a hot channeled cooking surface where plate temperature is thermostatically controlled. To calculate the energy savings in this measure, the griddle dimensions must be known. This measure does not include double-sided gas or electric commercial griddles.

- Gas Conveyor Ovens – Though not eligible for ENERGY STAR® qualification, this measure additionally covers the installation of energy efficient gas conveyor ovens. Conveyor ovens cook food by carrying it on a moving belt through a heated chamber. Qualifying conveyor ovens have baking efficiencies greater than or equal to 42% and idle energy rates less than or equal to 57,000 Btu/h, per assumed efficiency of qualified equipment by Pacific Gas and Electric workpaper, where 1 pizza equals 0.76 lbs [470].

Baseline Case

The baseline idle energy and cooking efficiency is compliant with the New Jersey P.L. 2021, c. 464 minimum standards, which establishes Energy Star Program Requirements for Commercial Oven Version 2.2 as the baseline for electric and gas convection ovens and gas rack ovens, Energy Star Program Requirements for Commercial Fryers Version 2.0 as the baseline for electric and gas fryers and Energy Star Program Requirements for Commercial Steam Cookers, Version 1.2 as the baseline for electric and gas steamers.[102] Preheat energy and all values for half size gas convection ovens, conveyor ovens and griddles are reported from referenced FSTC sources.

Table 3-88 Equipment Baselines Case Default Characteristics

Equipment	$Btu_{preheat,baseline}$ (Btu)	$Btu/h_{idle,baseline}$ (Btu/h)	$(lbs/hr)_{baseline}$	$Eff_{baseline}$	Ref
Convection Oven, Electric, Full Size	5,118	5,459	70	0.71	[469][465]
Convection Oven, Electric, Half Size	3,412	3,412	45	0.71	[469][465]
Convection Oven, Gas, Full Size	19,000	12,000	70	0.46	[469][465]
Convection Oven, Gas, Half Size	13,000	12,000	45	0.30	[469]
Conveyor Oven, Gas	21,270	55,000	114	0.30	[479]
Rack Oven, Gas, Double Rack	100,000	30,000	250	0.52	[471][465]
Rack Oven, Gas, Single Rack	50,000	25,000	130	0.48	[475][465]
Steamer, Electric	5,118	3-pan: 1,365 4-pan: 1,808 5-pan: 2,286 6-pan and larger: 2,730	11.7 x No. of pans	0.50	[466][472]
Steamer, Gas	20,000	3-pan: 6,250 4-pan: 8,350 5-pan: 10,400	23.3 x No. of pans	0.38	[466][472]

[102] https://legiscan.com/NJ/bill/A5160/2020.

Equipment	$Btu_{preheat,baseline}$ (Btu)	$Btu/h_{idle,baseline}$ (Btu/h)	$(lbs/hr)_{baseline}$	$Eff_{baseline}$	Ref
		6-pan and larger: 12,500			
Fryer, Electric	8,189	3,412	65	0.80	[473][480]
Fryer, Gas	18,500	9,000	60	0.50	[473][480]
Griddle, Electric	4,436 x Griddle Width (ft)	2,730 x Griddle Width (ft)	11.7 x Griddle Width (ft)	0.60	[474]
Griddle, Gas	7,000 x Griddle Width (ft)	7,000 x Griddle Width (ft)	8.4 x Griddle Width (ft)	0.30	[474]

Efficient Case

The compliance condition is food service equipment that exceeds the minimum efficiency specified in New Jersey P.L. 2021, c. 464 or, in the case of conveyor ovens, half-size gas convection ovens and griddles, equipment aligning with FSTC assumptions for energy efficient products meeting the minimum performance specifications listed in the table below. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from Table 3-89.

Table 3-89 Equipment Efficient Case Default Characteristics

Equipment	$Btu_{preheat,ee}$ (Btu)	$Btu/h_{idle,ee}$ (Btu/h)	$(lbs/hr)_{ee}$	Eff_{ee}	Ref
Convection Oven, Electric, Full Size	3,412	4,606	82	0.76	[469][481]
Convection Oven, Electric, Half Size	3,071	2,593	53	0.76	[469][481]
Convection Oven, Gas, Full Size	11,000	9,349	82	0.51	[469][481]
Convection Oven, Gas, Half Size	7,500	4,293	53	0.53	[469][481]
Conveyor Oven, Gas	15,000	40,000	158	0.46	[470][479]
Rack Oven, Gas, Double Rack	85,000	24,600	280	0.56	[471][482]
Rack Oven, Gas, Single Rack	44,000	19,733	140	0.51	[475][482]
Steamer, Electric	5,118	990	14.7 x No. of pans	0.70	[472][483]
Steamer, Gas	9,000	1,221	20.8 x No. of pans	0.47	[472][483]
Fryer, Electric, Standard	6,483	2,327	71	0.86	[473][484]

Equipment	$Btu_{preheat,ee}$ (Btu)	$Btu/h_{idle,ee}$ (Btu/h)	$(lbs/hr)_{ee}$	Eff_{ee}	Ref
Fryer, Gas, Standard	16,000	7,571	67	0.52	[473][484]
Griddle, Electric	2,389 x Griddle Width (ft)	1,000 x Griddle Area (ft^2)	16.3 x Griddle Width (ft)	0.75	[474]
Griddle, Gas	5,000 x Griddle Width (ft)	2,068 x Griddle Area (ft^2)	16.4 x Griddle Width (ft)	0.46	[474]

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = days \times \frac{(\Delta Btu_{preheat} + \Delta Btu_{idle} + \Delta Btu_{cooking})}{3412}$$

Annual Fuel Savings

$$\Delta Therms = days \times \frac{(\Delta Btu_{preheat} + \Delta Btu_{idle} + \Delta Btu_{cooking})}{100{,}000}$$

Where:

$$\Delta Btu_{preheat} = N_{preheat} \times (Btu_{preheat,baseline} - Btu_{preheat,ee})$$

$$\Delta BTU_{idle} = Btu/h_{idle,baseline} \times [hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{baseline}}] - Btu/h_{idle,ee} \times [hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{ee}}]$$

$$\Delta Btu_{cooking} = lbs \times Q_{food} \times (\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}})$$

NOTE: $\Delta Btu_{preheat}$, ΔBtu_{idle} and $\Delta Btu_{cooking}$ terms can be calculated per the equations above using either actual qualifying equipment specs or default values as defined in the Common Variables, Baseline Efficiencies, Compliance Efficiency, and Operating Hours sections below, or looked up from Table 3-92.

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{(days \times hrs)} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-90 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Btu_{preheat}$	Daily preheat energy savings	Calculate based on calculations above or look up in Table 3-92	Btu	
ΔBtu_{idle}	Daily idle energy savings	Calculate based on calculations above or look up in Table 3-92	Btu	
$\Delta Btu_{cooking}$	Daily cooking energy savings	Calculate based on calculations above or look up in Table 3-92	Btu	
days	Operating days per year	Site-specific, if unknown look up based on facility type in Table 3-91	Btu	
hrs	Daily operating hours	Site-specific, if unknown look up based on facility type in Table 3-91	hours	
$Btu_{preheat,baseline}$	Basline Equipment preheat energy	Look up based on qualifying equipment type in Table 3-88	Btu	
$Btu_{preheat,ee}$	Energy Efficient Equipment preheat energy	Site-specific, if unknown look up based on qualifying equipment type in Table 3-89	Btu	

Variable	Description	Value	Units	Ref
$N_{preheat}$	Number of preheats per day	1		
$hrs_{preheat}$	Preheat duration	Look up based on qualifying equipment type in Table 3-93	hours	
$Btu/h_{idle,baseline}$	Baseline Equipment idle energy rate	Look up based on qualifying equipment type in Table 3-88	Btu/h	
$Btu/h_{idle,ee}$	Energy Efficient Equipment idle energy rate	Site-specific, if unknown look up based on qualifying equipment type in Table 3-89	Btu/h	
$(lbs/hr)_{baseline}$	Baseline Equipment production capacity	Look up based on qualifying equipment type in Table 3-88	lbs/hr	
$(lbs/hr)_{ee}$	Energy Efficient Equipment production capacity	Site-specific, if unknown look up based on qualifying equipment type in Table 3-89	lbs/hr	
lbs	Total daily food production	Site-specific, if unknown look up based on qualifying equipment type in Table 3-93	lbs	
Q_{food}	Heat to food	Look up based on qualifying equipment type in Table 3-93	Btu/lb	
$Eff_{baseline}$	Baseline Equipment convection/steam mode cooking efficiency	Look up based on qualifying equipment type in Table 3-88	N/A	
Eff_{ee}	Energy Efficient Equipment convection/steam mode cooking efficiency	Site-specific, if unknown look up based on qualifying equipment type in Table 3-89	N/A	
CF	Electric coincidence factor	Lookup in Table 3-94	N/A	[485]
PDF	Gas peak day factor	Lookup in Table 3-94	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-91 Operating Hours

Building Type	Days/Year	Hours/Day
Education – Primary School	180	8
Education -Secondary School	210	11
Education – Community College	237	16
Education – University	192	16
Grocery	364	16
Medical – Hospital	364	24
Medical – Clinic	351	12
Lodging Motel	364	24
Office – Large	234	12
Office – Small	234	12
Restaurant – Sit-Down	364	12
Restaurant – Fast-Food	364	17
Average = Miscellaneous	288	15

Table 3-92 contains values and simplified calculations for $\Delta Btu_{preheat}$, ΔBtu_{idle} and $\Delta Btu_{cooking}$ terms that may be used in the formulation of estimated savings in lieu of utilizing the calculations prescribed above for these terms. These values were established by performing those calculations using assumed values from the Common Variables, Baseline Efficiencies, and Compliance Efficiency sections.

Table 3-92 Default Values

Equipment	$\Delta Btu_{preheat}$	ΔBtu_{idle}	$\Delta Btu_{cooking}$
Convection Oven, Electric, Full Size	1,706	853 x hrs - 2395	2,317
Convection Oven, Electric, Half Size	341	819 x hrs - 2895	2,317
Convection Oven, Gas, Full Size	8,000	2651 x hrs - 6404	5,328
Convection Oven, Gas, Half Size	5,500	7707 x hrs - 20493	36,164
Conveyor Oven, Gas	6,270	15000 x hrs - 47315	55,072
Rack Oven, Gas, Double Rack	15,000	5400 x hrs - 40353	38,736
Rack Oven, Gas, Single Rack	6,000	5267 x hrs - 32553	17,279
Steamer, Electric[103]	0	1740 x hrs - 3201	6,000
Steamer, Gas[104]	11,000	11279 x hrs - 10783	5,291
Fryer, Electric, Standard	1,706	1085 x hrs - 3229	7,456

[103] Assumes 6 pans
[104] Assumes 6 pans

Equipment	$\Delta Btu_{preheat}$	ΔBtu_{idle}	$\Delta Btu_{cooking}$
Fryer, Gas, Standard	2,500	1429 x hrs - 5906	6,577
Griddle, Electric[105]	6,141	2190 x hrs - 11611	15,833
Griddle, Gas[106]	6,000	8592 x hrs - 60262	55,072

Table 3-93 Common Variables

Equipment	$hrs_{preheat}$	lbs	Q_{food}(Btu/lb)	Ref
Convection Oven, Electric, Full Size	0.25	100	250	[469]
Convection Oven, Electric, Half Size	0.25	100	250	[469]
Convection Oven, Gas, Full Size	0.25	100	250	[469]
Convection Oven, Gas, Half Size	0.25	100	250	[469]
Conveyor Oven, Gas	0.25	190	250	[470]
Rack Oven, Gas, Double Rack	0.33	1200	235	[471]
Rack Oven, Gas, Single Rack	0.33	600	235	[471]
Steamer, Electric	0.25	100	105	[471]
Steamer, Gas	0.25	100	105	[472]
Fryer, Electric, Standard	0.25	150	570	[473]
Fryer, Gas, Standard	0.25	150	570	[473]
Griddle, Electric	0.25	100	475	[474]
Griddle, Gas	0.25	100	475	[474]

Peak Factors

Table 3-94 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.9	[485]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 12 years[107].

[105] Assumes 3-foot griddle width, 2-foot griddle depth
[106] Assumes 3-foot griddle width, 2-foot griddle depth
[107] Shared assumption from all PG&E Work Papers referenced in this measure

References

[464] ENERGY STAR® Commercial Food Service Calculator, https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products

[465] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria Version 2.2, October 2015, https://www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification_0.pdf

[466] ENERGY STAR® Program Requirements Product Specification for Commercial Steam Cookers, Eligibility Criteria Version 1.2, August 2003, https://www.energystar.gov/sites/default/files/specs//private/Commercial_Steam_Cookers_Program_Requirements%20v1_2.pdf

[467] ENERGY STAR® Program Requirements Product Specification for Commercial Fryers, Eligibility Criteria Final Draft Version 3.0, October 2016, https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Commercial%20Fryers%20Version%203.0%20%28Rev.%20December%20-%202020%29%20Specification.pdf

[468] ENERGY STAR® Program Requirements Product Specification for Commercial Griddles, Eligibility Criteria Version 1.2, August 2009, https://www.energystar.gov/sites/default/files/Commercial%20Griddles%20Version%201.2%20%28Rev%20December%20-%202020%29.pdf

[469] Pacific Gas & Electric Company, Work Paper PGECOFST101 Commercial Convection Oven-Electric and Gas, Revision 6, August 2016

[470] Pacific Gas & Electric Company, Work Paper PGECOFST117 Commercial Conveyor Oven-Gas, Revision 5, May 2014

[471] Pacific Gas & Electric Company, Work Paper PGECOFST109 Commercial Rack Oven-Gas, Revision 1, October 2018

[472] Pacific Gas & Electric Company, Work Paper PGECOFST104 Commercial Steam Cooker-Electric and Gas, Revision 6, June 2016

[473] Pacific Gas & Electric Company, Work Paper PGECOFST102 Commercial Fryer-Electric and Gas, Revision 6, June 2016

[474] California Technical Forum, Work Paper SWFS004, Commercial Griddle-Electric and Gas, Revision 1, January 2020, available at http://deeresources.net/workpapers

[475] Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator, https://caenergywise.com/calculators/natural-gas-rack-ovens/#calc

[476] Food Service Technology Center: Electric Fryer Life-Cycle Cost Calculator, https://caenergywise.com/calculators/electric-fryers/#calc

[477] Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator, https://caenergywise.com/calculators/natural-gas-fryers/#calc

[478] California Energy Commission, Energy Research and Development Division, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, October 2014, http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf

[479] California Public Utilies Commission, SWFS008, Conveyor Oven, Gas, Commercial, Revision 1, January 2020 available at Ex Ante Database Archive (deeresources.net)

[480] ENERGY STAR® Program Requirements Product Specification for Commercial Fryers, Eligibility Criteria Final Draft Version 2.0, October 2016,

https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/commercial_fryers/Final_Version_2.0_Commercial_Fryer_Specification.pdf?6f81-cd61

[481] California Public Utilies Commission, SWFS001 Commercial Covection Oven – Electric and Gas, Revision 2, May 2020 available at Ex Ante Database Archive (deeresources.net)

[482] California Public Utilies Commission, SWFS014 Rack Oven, Revision 2, May 2020 available at Ex Ante Database Archive (deeresources.net)

[483] California Public Utilies Commission, SWFS005 Commercial Steam Cooker, Revision 2, May 2020 available at Ex Ante Database Archive (deeresources.net)

[484] California Public Utilies Commission, SWFS011 Fryer,Commercial, Revision 4, March 2022 available at Ex Ante Database Archive (deeresources.net)

[485] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs v10, effective date January 1, 2023.

3.4.2 HOLDING CABINETS

Market	Commercial
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

This measure covers the installation of ENERGY STAR® qualified electric commercial hot food holding cabinets. A food holding cabinet is a fully enclosed compartment designed to maintain the temperature of hot food that has been cooked in a separate appliance. Half-size, full-size, and large-size holding cabinets are included in this measure. Half-size holding cabinets are defined as any holding cabinet with an internal measured volume of less than 13 ft^3. Full-size holding cabinets are defined as any holding cabinet with an internal measured volume of greater than or equal to 13 ft^3 and less than or equal to 28 ft^3. Large-size holding cabinets are defined as any holding cabinet with an internal measure volume of greater than 28 ft^3. This measure does not include cook-and-hold or re-therm equipment.

Baseline Case

The baseline condition is an insulated holding cabinet as defined in the Measure Description above with operating characteristics per Table 3-95.

Efficient Case

The compliance condition is ENERGY STAR® food service equipment as defined in the Measure Description above. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from the Summary of Variables and Data Sources table below. Savings for this measure can be claimed only if there is an increase in the qualifying efficiency from the baseline condition.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = hrs \times days \times \frac{\Delta \mathrm{W_{idle}}}{1{,}000}$$

Where,

$$\Delta W_{idle} = W_{idle,b} - W_{idle,q}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs \times days} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-95 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔW_{idle}	Daily idle energy savings	Calculated	Watt	
Hrs	Daily operating hours	Site-specific. If unknown, use 15	Hours/day	[488]
Days	Operating days per year	Site-specific. If unknown, look up in Table 3-96	Days/yr	[487]
1,000	Conversion factor, one kW equals 1,000 watts	1,000	Watts	
$W_{idle,b}$	Baseline equipment idle energy rate by volume	Look up in Table 3-97	Watts	[489]
$W_{idle,q}$	Energy efficient equipment idle energy rate by volume	Site-specific	Watts	
V	Volume of holding cabinet	Site-specific. If unknown, look up in Table 3-97	ft^3	[490]
CF	Electric coincidence factor	Look up in Table 3-98	N/A	
PDF	Gas peak day factor	Look up in Table 3-98	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-96 Operating Days per Year

Building Type	Operating Days per Year
Assembly	355
Auto	355
Big Box	355
Community College	284
Dormitory	355
Fast Food	355
Full Service Restaurant	303
Grocery	365
Hospital	365
Hotel	365
Large Office	303
Light Industrial	251
Motel	365
Multi-story Retail	355
Primary School	218
Religious	355
Secondary School	218
Small Office	303
Small Retail	355
University	284
Warehouse	251

Table 3-97 Default Values

Equipment	$W_{idle,b}$	V
Insulated Holding Cabinet, Large-Size (28 ≤ V)	3.8v + 203.5	35
Insulated Holding Cabinet, Full-Size (13 ≤ V < 28)	2v + 254	25
Insulated Holding Cabinet, Half-Size (0 < V < 13)	21.5v	10

Peak Factors

Table 3-98 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.9	[488]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years [486].

References

[486] DEER 2014 EUL IDs: Various. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

[487] California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E.

[488] PG&E Work Paper PGECOFST105 Revision 5, pg. 7. Available to download at http://deeresources.net/workpapers

[489] ENERGY STAR® Program Requirements for Commercial Hot Food Holding Cabinets, Eligibility Criteria Version 2.0, July 2011, where v is holding cabinet volume (ft^3). https://www.energystar.gov/sites/default/files/asset/document/Commercial_HFHC_Program_Requirements_2.0.pdf#:~:text=ENERGY%20STAR%C2%AE%20Program%20Requirements%20Product%20Specification%20for%20Commercial,has%20also%20been%20changed%20from%202010%20to%202011.

[490] PG&E Work Paper PGECOFST105 Revision 5, Table 6, pg. 5.

3.4.3 DISHWASHERS

Market	Commercial
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	N/A
Measure Last Reviewed	January 2023
Changes Since Last Version	• Added fuel parameters and default assumption

Description

This measure describes the installation of ENERGY STAR qualified, high-efficiency stationary and conveyor-type commercial dishwashers used in commercial kitchen establishments that use non-disposable dishes, glassware, and utensils. Commercial dishwashers can clean and sanitize a large quantity of kitchenware in a short amount of time by utilizing hot water, soap, rinse chemicals, and significant amounts of energy. ENERGY STAR qualified models use less water and have lower idling rates than non-ENERGY STAR rated models.

The savings derived below are heavily dependent on the assumed dishwasher hours of operation, which are consistent with a high-usage restaurant or cafeteria operation. If dishwashers are found to be installed in applications with significantly different hours of operation, the hours and savings shall be revised in a custom calculation.

This measure is not applicable to flight machines, which are continuous conveyor machines built specifically for large institutions.

Baseline Case

This is defined as a time of sale measure. The baseline condition is a commercial dishwasher meeting ENERGY STAR Version 2.0 requirements.[491]

Efficient Case

The efficient condition is a high-efficiency commercial dishwasher meeting ENERGY STAR Version 3.0 requirements. [492]

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{WaterHeater} + \Delta kWh_{BoosterHeater} + \Delta kWh_{Idle}$$

Where,

$$\Delta kWh_{WaterHeater} = \left(WU_b - WU_q\right) \times RW \times Days \times \frac{\Delta T_{in} \times 1.0 \times 8.2}{RE \times 3{,}412} \times F_{Elec,WH}$$

$$\Delta kWh_{Idle} = \left(kW_b \times Days \times \left(HD - \frac{RW \times WT}{60}\right)\right) - \left(kW_q \times Days \times \left(HD - \frac{RW \times WT}{60}\right)\right)$$

If electric booster heater installed:

$$\Delta kWh_{BoosterHeater} = \left(WU_b - WU_q\right) \times RW \times Days \times \frac{\Delta T_{in} \times 1.0 \times 8.2}{RE \times 3{,}412}$$

If no electric booster heater installed:

$$\Delta kWh_{BoosterHeater} = 0$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{WaterHeater} = \left(WU_b - W_q\right) \times RW \times Days \times \frac{\Delta T_{in} \times 1.0 \times 8.2}{RE \times 100{,}000} \times F_{FF,WH}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta \text{kWh} \times \frac{CF}{HD \times Days}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-99 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	

Variable	Description	Value	Units	Ref
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta kWh_{WaterHeater}$	Annual water heater electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{BoosterHeater}$	Annual booster heater electric energy savings	Calculated	kWh/yr	
ΔkWh_{Idle}	Annual dishwasher idle electric energy savings	Calculated	kWh/yr	
WU_q	Water use per rack of qualifying dishwasher, varies by machine type and sanitation method	Site-specific	Gallons	
kW_q	Idle power draw of ENERGY STAR 3.0 dishwasher, varies by machine type and sanitation method	Site-specific	kW	
Days	Annual days of dishwasher consumption per year	Site-specific, if unknown use 365	Days/Year	[491]
WU_b	Water use per rack of baseline dishwasher, varies by machine type and sanitation method	Look up in Table 3-100	Gallons	[492]
RW	Number of racks washed per day, varies by machine type and sanitation method	Look up in Table 3-100	Racks Washed/Day	[491]
ΔT_{in}	Temperature rise in water delivered by building water heater or booster water heater, value varies by type of water heater source	Building WH = 70 Booster WH = 40	°F	[491]
RE	Recovery efficiency of water heater	Site-specific, if unknown use 0.98 for electric and 0.80 for gas		[491]
kW_b	Idle power draw of baseline dishwasher, varies by machine type and sanitation method	Look up in Table 3-100	kW	[492]
HD	Hours per day of dishwasher operation	Site-specific, if unknown use 18 hours/day	Hours/Day	[491]
WT	Wash time per dishwasher, varies by machine type and sanitation method	Look up in Table 3-100	Minutes	[491]
$H2O_b$	Annual water consumption of baseline unit	Look up in Table 3-101	gallons	[491]
$H2O_q$	Annual water consumption of efficient unit	Look up in Table 3-101	gallons	[491]
$F_{Elec,WH}$	Factor to account for building water heat	If building water heat is electric: 1 If building water heat is not electric: 0 If unknown: 0.28		
$F_{FF,WH}$	Factor to account for fossil fuel building water heat	If building water heat is electric: 0 If building water heat is not electric: 1 If unknown: 0.79		

Variable	Description	Value	Units	Ref
8.2	Density of Water	8.2	Lbs/gal	[493]
60	Conversion factor	60	Min/hr	
3,412	Conversion factor	3,412	Btu/kWh	
1.0	Conversion factor	1.0	Btu/lb-°F	
100,000	Conversion factor	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 3-102	N/A	[494]
PDF	Gas peak day factor	Look up in Table 3-102	N/A	
EUL	Effective useful life	See Measure Life	Years	

Table 3-100 Default Inputs for ENERGY STAR 2.0 Commercial Dishwasher

Machine Type	Temperature	WU_{base}	RW	WT	kW_{base}
Under Counter	Low	1.19	75	2.0	0.50
Stationary Single Tank Door		1.18	280	1.5	0.60
Single Tank Conveyor		0.79	400	0.3	1.50
Multi Tank Conveyor		0.54	600	0.3	2.00
Under Counter	High	0.86	75	2.0	0.5
Stationary Single Tank Door		0.89	280	1.0	0.7
Single Tank Conveyor		0.70	400	0.3	1.5
Multi Tank Conveyor		0.54	600	0.2	2.25
Pot, Pan, and Utensil		0.58	280	3.0	1.20

Table 3-101 Annual Water Consumption

Machine Type	Temperature	$H2O_b$	$H2O_q$
Under Counter	Low	47,359	32,576
Stationary Single Tank Door		214,620	120,596
Single Tank Conveyor		191,260	115,340
Multi Tank Conveyor		227,760	118,260
Under Counter	High	29,839	23,543
Stationary Single Tank Door		131,838	90,958
Single Tank Conveyor		127,020	102,200

Machine Type	Temperature	$H2O_b$	$H2O_q$
Multi Tank Conveyor		212,430	118,260
Pot, Pan, and Utensil		71,540	59,276

Peak Factors

Table 3-102 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.9	[494]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Non-Energy Impacts

$$\Delta H2O = H2O_b - H2O_q$$

Measure Life

The effective useful life (EUL) is listed in Table 3-103 [491].

Table 3-103 Measure Life

Machine Type	Measure Life (years)
Under Counter	10
Stationary Single Tank Door	15
Single Tank Conveyor	20
Multi Tank Conveyor	20
Pot, Pan, and Utensil	10

References

[491] ENERGY STAR Savings Calculator for Certified Commercial Kitchen Equipment. http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx

[492] ENERGY STAR Program Requirements for Commercial Dishwashers Version 2.0, ENERGY STAR, February 2013.

[493] Dishwasher inlet temperature assumed at 140 degrees F. https://water.usgs.gov/edu/density.html.

[494] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs v10, effective date January 1, 2023.

3.4.4 ICE MACHINES

Market	Commercial
Baseline Condition	TOS/DI
Baseline	Code/Dual
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

This measure covers the installation of ENERGY STAR® qualified ice makers. Ice makers are factory-made assemblies consisting of a condensing unit and ice-making section operating as an integrated unit, with means for making and harvesting ice. This measure includes batch-type (cube type) and continuous-type (flake or nugget type) ice makers. Batch-type ice makers have distinct freezing and harvesting periods whereas continuous-type ice makers produce ice through a continuous freezing and harvesting process. Ice makers that have earned the ENERGY STAR® label use approximately 11% less energy and 25% less water than comparable non-qualified models [495].

This measure covers ice making head, remote condensing, and self-contained air-cooled ice makers. Water-cooled ice makers, ice and water dispensing systems, and air-cooled remote condensing units that are designed only for connection to remote rack compressors are not eligible for energy savings.

Baseline Case

TOS: The baseline condition is a commercial ice maker as defined in the Measure Description section above with Equipment Type and Ice Harvest Rate equivalent to the efficient case. Baseline daily energy use per 100 lbs of ice shall be established based on efficient equipment Ice Harvest Rate in accordance with current federal standards for batch type [496] and continuous type [496] ice makers, as specified in the Code of Federal Regulations and provided in Table 3-105.

DI: Use dual baseline. For the remaining useful life of the replaced equipment, the baseline is the site-specific existing unit. For the duration of the measure life of the installed unit, use TOS baseline described above.

Efficient Case

The compliance condition is an ENERGY STAR® version 3.0 qualified commercial ice maker as defined in the Measure Description above. Efficient condition daily energy use per 100 pounds of ice are established based on efficient equipment Ice Harvest Rate in accordance with ENERGY STAR® v. 3.0 maximum qualifying specifications, as shown in Table 3-105 [497]. An efficient ice maker also needs to meet the potable water consumption requirement as shown in Table 3-105 [497].

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times 365 \times Cycle \times \left(\frac{IHR}{100}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta \text{kWh}}{8{,}760 \times \text{Cycle}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-104 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Baseline electric energy consumption per 100 pounds of ice	Look up in Table 3-105	kWh/lbs	[496]
kWh_q	Energy efficient electric energy consumption per 100 pounds of ice	Site-specific. If unknown, look up in Table 3-105	kWh/lbs	[497]
IHR	Rated Ice Harvest Rate of the energy efficient measure	Site-specific	lbs/day	
Cycle	Duty cycle, defined as the ratio of the actual ice harvest rate to the equipment rated ice harvest rate	0.75	N/A	[499]
365	Days per year	365	Days/yr	
100	Factor to convert IHR to units of 100 lbs/day	100	lbs/day	
8,760	Hours in one year	8,760	Hrs/yr	
CF	Electric coincidence factor	Look up in Table 3-106	N/A	[498]
PDF	Gas peak day factor	Look up in Table 3-106	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[500]
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-105 Equipment Type and Ice Harvest Rate

Equipment Type	Ice Harvest Rate (IHR)	Baseline Daily Energy Use per 100 ilbs (kWh_b)	Measure Daily Energy Use per 100 lbs (kWh_q)	Potable Water Use (gal/100 lbs ice)
Batch Type, Ice-Making Head	< 300	10 – 0.01233 x IHR	9.20 – 0.01134 x IHR	≤ 20.0
	≥ 300 and < 800	7.05 – 0.0025 x IHR	6.49 – 0.0023 x IHR	≤ 20.0
	≥ 800 and < 1,500	5.55 – 0.00063 x IHR	5.11 – 0.00058 x IHR	≤ 20.0
	≥ 1,500 and < 4,000	4.61	4.24	≤ 20.0
Batch Type, Remote Condensing	< 988	7.97 – 0.00342 x IHR	7.17 – 0.00308 x IHR	≤ 20.0
	≥ 988 and < 4,000	4.59	4.13	≤ 20.0
Batch Type, Self-Contained	< 110	14.79 – 0.0469 x IHR	12.57 – 0.0399 x IHR	≤ 25.0
	≥ 110 and < 200	12.42 – 0.02533 x IHR	10.56 – 0.0215 x IHR	≤ 25.0
	≥ 200 and < 4,000	7.35	6.25	≤ 25.0
Continuous Type, Ice-Making Head	< 310	9.19 – 0.00629 x IHR	7.90 – 0.005409 x IHR	≤ 15.0
	≥ 310 and < 820	8.23 – 0.0032 x IHR	7.08 – 0.002752 x IHR	≤ 15.0

Equipment Type	Ice Harvest Rate (IHR)	Baseline Daily Energy Use per 100 ilbs (kWh_b)	Measure Daily Energy Use per 100 lbs (kWh_q)	Potable Water Use (gal/100 lbs ice)
	≥ 820 and < 4,000	5.61	4.82	≤ 15.0
Continuous Type, Remote Condensing	< 800	9.7 – 0.0058 x IHR	7.76 – 0.00464 x IHR	≤ 15.0
	≥ 800 and < 4,000	5.06	4.05	≤ 15.0
Continuous Type, Self-Contained	< 200	14.22 – 0.03 x IHR	12.37 – 0.0261 x IHR	≤ 15.0
	≥ 200 and < 700	9.47 – 0.00624 x IHR	8.24 – 0.005429 x IHR	≤ 15.0
	≥ 700 and < 4,000	5.1	4.44	≤ 15.0

Peak Factors

Table 3-106 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.9	[498]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-107 Measure Life

Equipment	EUL	RUL	Ref
Ice Machines	10	3.3	[500]

References

[495] "Commercial Ice Maker Key Product Criteria." n.d. www.energystar.gov. Accessed January 17, 2023. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers/key_product_criteria

[496] "10 CFR § 431.136 (c) and (d) - Energy Conservation Standards and Their Effective Dates." n.d. LII / Legal Information Institute. Accessed January 17, 2023. https://www.law.cornell.edu/cfr/text/10/431.136

[497] "ENERGY STAR Program Requirements for Automatic Commercial Ice Makers -Partner Commitments ENERGY STAR ® Program Requirements for Automatic Commercial Ice Makers Partner Commitments." n.d. Accessed January 17, 2023. https://www.energystar.gov/sites/default/files/Final%20V3.0%20ACIM%20Specification%205-17-17_1.pdf

[498] Pacific Gas & Electric Work Paper SWFS SWFS006-01 Commercial Ice Machines, January 2020, pg. 12. www.deeresources.net/workpapers

[499] Pacific Gas & Electric Work Paper SWFS SWFS006-01 Commercial Ice Machines, January 2020, pg. 9. www.deeresources.net/workpapers

[500] Pacific Gas & Electric Work Paper SWFS SWFS006-01 Commercial Ice Machines, January 2020, pg. 11. www.deeresources.net/workpapers

3.5 HVAC

3.5.1 AIR CONDITIONER, MINI-SPLIT AC, AND PTAC

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• New measure (separated cooling-only equipment from air-source heat pump measure) • Updated peak demand algorithms to use EER2 instead of SEER2

<u>Description</u>

This measure targets the use of air conditioners and packaged terminal air conditioners (PTAC) in commercial and multifamily high-rise applications as further described below. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing commercial or multifamily high-rise building for HVAC applications.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol as outlined in Table 3-113, Table 3-109 and Table 3-110 below.

<u>Baseline Case</u>

For time of sale or new construction projects, the baseline equipment is an air conditioner or packaged terminal system (PTAC) minimally compliant with ASHRAE 90.1-2019 (see Appendix E).

For early replacement or direct install projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the ASHRAE 90.1 version in force when the equipment was new (if equipment vintage is unknown, use ASHRAE 90.1 2013 efficiency requirements from Appendix E).
- For the duration of the measure life after the end of the RUL, the baseline is a current code-compliant version of the replaced equipment.

Efficient Case

A air conditioner or packaged terminal system (PTAC) that meets ENERGY STAR Light Commercial HVAC v4.0 criteria [508], or otherwise meets program eligibility requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Calculate kWh_b using the algorithms in Table 3-113 for the appropriate baseline equipment type.

Calculate kWh_q using the algorithms in Table 3-114 for the appropriate efficient equipment type.

Note: Conversions from SEER to SEER2 and EER to EER2 can be found in Appendix E.

Table 3-108 Baseline Energy Consumption Equations

Baseline Equipment	Baseline Cooling kWh (kWh_b)
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$
Air Conditioner (Cooling Capacity ≥ 65 kBtu/h)	$\frac{Cap_c}{IEER_b \times 1{,}000} \times EFLH_c$
PTAC	$\frac{Cap_c}{EER_b \times 1{,}000} \times EFLH_c$

Table 3-109 Energy Efficient Energy Consumption Equations

Qualifying Equipment	Efficient Cooling kWh (kWh_q)
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_q \times 1{,}000} \times EFLH_c$
Air Conditioner (Cooling Capacity ≥ 65 kBtu/h)	$\frac{Cap_c}{IEER_q \times 1{,}000} \times EFLH_c$
PTAC	$\frac{Cap_c}{EER_q \times 1{,}000} \times EFLH_c$

Peak Demand Savings

Table 3-110 Peak Demand Savings Equations

Qualifying Equipment	Peak Demand Savings (ΔkW_{Peak})
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$
Air Conditioner (Cooling Capacity ≥ 65 kBtu/h)	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$

Qualifying Equipment	Peak Demand Savings (ΔkW_{Peak})
PTAC	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER_b} - \frac{1}{EER_q}\right) \times CF$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-111 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Cap_c	Cooling capacity of installed unit	Site-specific	Btu/hr	
$SEER2_q$	SEER2 of qualifying unit[108]	Site-specific	Btu/W-h	
$IEER_q$	IEER of qualifying unit	Site-specific	Btu/W-h	
EER_q	EER of qualifying unit	Site-specific	Btu/W-h	
$EER2_q$	EER of qualifying unit	Site-specific	Btu/W-h	
$SEER2_b$	SEER2 of baseline unit[1]	TOS/NC: Look up in Appendix E for current code-compliant efficiency	Btu/W-h	[508][510]

[108] SEER to SEER2 conversion found in Appendix E.

Variable	Description	Value	Units	Ref
		EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or ASHRAE 2013 if vintage is unknown		
$IEER_b$	IEER of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or ASHRAE 2013 if vintage is unknown	Btu/W-h	[508][510]
EER_b	EER of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or ASHRAE 2013 if vintage is unknown	Btu/W-h	[508][510]
$EER2_b$	EER2 of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or ASHRAE 2013 if vintage is unknown	Btu/W-h	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Look up in Appendix C	Hours	[511]
1,000	Conversion from hp to Kw	1,000	w/kW	
CF	Electric coincidence factor	0.5	N/A	[512]
EUL	Effective useful life	See Measure Life Section	Years	[513]

Measure Life

For dual baseline scenarios, the remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-112 Measure Life

Equipment	EUL	RUL	Ref
A/C and PTAC	15	5	[513]

References

[501] ENERGY STAR Light Commercial HVAC Version 4.0, https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20LC%20HVAC%20Version%204.0%20Specification%20Rev%20April%202022.pdf?_gl=1*n9oet2*_ga*MTUwMjg5MDYyNC4xNjY0NDc5NDA0*_ga_S0KJTVVLQ6*MTY4MDU0NjcxNi4zNS4xLjE2ODA1NDY5NjAuMC4wLjA

[502] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[503] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[504] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[505] C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods.

[506] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[507] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, section 430.32 b) Room Air Conditioners,

3.5.2 AIR SOURCE HEAT PUMPS AND MINI-SPLIT HEAT PUMPS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	May 2024
Changes Since Last Version	• Moved cooling-only equipment (central A/C, PTAC) to separate measure • Added partial displacement algorithm, updated description accordingly

Description

This prescriptive measure targets the use of air source heat pumps (ASHP) and mini split heat pumps in commercial and multifamily high-rise applications. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing commercial or multifamily high-rise building for HVAC applications.

In certain instances, air source heat pumps and mini-split heat pumps may only partially meet the heating load, requiring a supplementary heating system to meet the facility's full heating load. As such, this measure presents two displacement scenarios: partial and whole.

- **Partial displacement:** the heat pump fulfils a portion of the facility's heating load. Partial displacements occur in either of the two scenarios: 1) the installation of a heat pump that shares the facility's heating load with a separate supplemental heating system or 2) the installation of a "dual fuel" heat pump that incorporates a backup fossil fuel furnace to supplement the heat pump output. Partial displacements are addressed in the equations below by a load factor parameter (F_{load}), which represents the actual heating output of the heat pump as compared to the total theoretical heating output.[109] The partial displacement scenario only applies to heating displacement; this measure assumes that the installed heat pump will serve the entire cooling load of the zone(s) affected by the installation. If the installed heat pump is <u>not</u> a cold-climate heat pump, assume a partial displacement scenario unless there is evidence for a whole displacement installation (such as proof that any pre-existing heating systems were removed).
- **Whole displacement:** the heat pump and any integrated supplemental resistance meets the facility's entire heating load, with no supplemental equipment. May assume whole displacement scenario if the installed heat pump is a cold-climate heat pump.

[109] F_{load} is represented by the fraction of annual heating degree hours that are above the switchover temperature. See Table 2-64 for more information.

This measure does not accommodate the interactive effects of concurrent weatherization upgrades.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol presented in this measure. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

For whole building new construction, the baseline equipment is a unitary packaged or split-system heat pump meeting the compliance requirements of ASHRAE 90.1-2019 for commercial and multifamily high-rise buildings (see Appendix E: Code-Compliant Efficiencies). For multifamily low-rise buildings (three stories or lower), refer to residential measure (Section 3.3.1).

For replacement of failed equipment, or end of useful life, the baseline would be a minimally code compliant version of the replaced system type and fuel. If the baseline system fuel is unknown, such as in a midstream delivery method, calculate savings using a gas baseline (fuel switching project, assume 14% boilers and 86% furnaces as baseline equipment) and electric baseline (non fuel switching project, assume ASHP as baseline equipment) and calculate the weighted average using the weights in the table below.[110]

	Fuel switch	Non fuel switch
ACE	0.130	0.870
JCPL	0.216	0.784
RECO	0.013	0.987
PSEG	0.412	0.588
Average	**0.193**	**0.807**

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the ASHRAE 90.1 version in force when the equipment was new (if equipment vintage is unknown, use ASHRAE 90.1 2013 efficiency requirements from Appendix E: Code-Compliant Efficiencies).

  For the duration of the measure life after the end of the RUL, the baseline is a code-compliant version of the replaced equipment.

For spaces with no existing heating: For previously unheated spaces in an existing building that has an existing central heating system, the customer may have planned to install a heat pump regardless of program intervention, or the customer may have planned to extend the existing central HVAC system to heat the new space. The baseline can therefore vary between a new equipment scenario and a retrofit scenario. For such installations, the baseline energy consumption

[110] Weights calculated by quantity of heat pump projects designated as fuel switching by measure name in the Tri 2 utility filings workbooks.

algorithm is designed to blend the baseline energy consumptions of the new equipment scenario and retrofit scenario using a baseline factor, $F_{baseline,h}$.[111]

$$\begin{pmatrix}Baseline\ heating\\ consumption\end{pmatrix} = F_{baseline,h} \times \begin{pmatrix}New\ equipment\\ scenario\ consumption\end{pmatrix} + \left(1 - F_{baseline,h}\right) \times \begin{pmatrix}Existing\ equipment\\ scenario\ consumption\end{pmatrix}$$

- New equipment scenario: absent the program, the customer would have purchased new heating equipment instead of extending the existing central heating system. The new equipment scenario baseline is a code-compliant air-source heat pump of the same size as the installed heat pump.
- Retrofit scenario: absent the program, the customer would have extended the existing central heating system instead of purchasing new heating equipment. The retrofit scenario baseline is the existing central heating equipment.

For spaces with no existing cooling: For buildings without existing cooling, or spaces without cooling in an existing home that has an existing central cooling system, the customer may have planned to install a cooling regardless of program intervention, or the customer may have planned to leave the space without any cooling. The baseline can therefore vary between a new load scenario and a non-new load scenario. For such installations, the baseline energy consumption algorithm is designed to blend the baseline energy consumptions of the new equipment scenario and retrofit scenario using a baseline factor, $F_{baseline,c}$.[112]

$$\begin{pmatrix}Baseline\ cooling\\ consumption\end{pmatrix} = F_{baseline,c} \times \begin{pmatrix}New\ load\\ scenario\ consumption\end{pmatrix} + \left(1 - F_{baseline,c}\right) \times \begin{pmatrix}Non-new\ load\\ consumption\end{pmatrix}$$

- New load scenario: absent the program, the customer would not install any cooling. The new load scenario baseline is no existing cooling.
- Non-new load scenario: absent the program, the customer would have added cooling to the space. The non-new load scenario cooling baseline is the existing central cooling system if one exists, or a code-compliant air conditioner of the same cooling capacity as the installed heat pump.

Efficient Case

An air source heat pump or mini split heat pump that meets ENERGY STAR Light Commercial HVAC v4.0 criteria [508], or otherwise exceeds ASHRAE 90.1-2019 requirements if not included in ENERGY STAR specification.

[111] The baseline heating factors presented in Table 2-63 are based on reference [520]. $F_{baseline,h}$ is calculated as the total percent of respondents who would install new baseline equipment, averaged across heating fuel types in table 2-17 of the report.

[112] The baseline cooling factors presented in Table 2-63 are based on reference [520]**Error! Reference source not found.**. $F_{baseline,c}$ is calculated as the percent of respondents without existing cooling who would not have installed an alternative cooling system without the heat pump. The percent of respondents who installed a central heat pump with no existing cooling was assumed to be 46%, based on the known proportion of respondents who installed a minisplit with no existing cooling.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = kWh_{c,b} + kWh_{h,b}$$

For partial displacement applications,

$$kWh_q = kWh_{c,q} + F_{load} \times kWh_{h,q} + (1 - F_{load}) \times kWh_{supplement}$$

If supplemental heat is an existing electric resistance heating system:

$$kWh_{supplement} = \frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$$

If supplemental heat is an existing fossil fuel system:

$$kWh_{supplement} = 0$$

For whole displacement applications,

$$kWh_q = kWh_{c,q} + kWh_{h,q}$$

Calculate $kWh_{c,b}$, $kWh_{h,b}$, $Kwh_{supplement}$ using the algorithms in Table 3-113 for the appropriate baseline and supplemental equipment type, if applicable.

Calculate $kWh_{c,q}$ and $kWh_{h,q}$ using the algorithms in Table 3-114 for the appropriate efficient equipment type.

Note:

- Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in Appendix E: Code-Compliant Efficiencies.
- The oversize derating factor (OSF) in the equations above is applicable for heat pump applications where the heat pump is sized based on heating capacity but is oversized for cooling. The appropriate OSF should be determined from site-specific conditions if possible, otherwise use the default values provided below.

Table 3-113 Baseline Electric Energy Consumption Equations

Baseline Equipment	Cooling kWh ($kWh_{c,b}$)	Heating kWh ($kWh_{h,b}$ or $kWh_{supplement}$)
No existing cooling	$(1 - F_{baseline,c}) \times \frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	N/A
No existing heating, central fossil fuel system	N/A	$F_{baseline,h} \times \frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h$

Baseline Equipment	Cooling kWh ($kWh_{c,b}$)	Heating kWh ($kWh_{h,b}$ or $kWh_{supplement}$)
No existing heating, central electric resistance/electric furnace	N/A	$F_{baseline,h} \times \frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h + (1 - F_{baseline,h}) \times \frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
Mini-split heat pump, ASHP (Cooling Capacity < 65 kBtu/h) or whole building new construction	$OSF \times \frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h$
ASHP (Cooling Capacity > 65 kBtu/h & IEER Available)	$OSF \times \frac{Cap_c}{IEER_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_b \times 3.412 \times 1{,}000} \times EFLH_h$
ASHP (Cooling Capacity > 65 kBtu/h & IEER not available)	$OSF \times \frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_b \times 3.412 \times 1{,}000} \times EFLH_h$
Air Source Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	N/A
Air Source Air Conditioner (Cooling Capacity > 65 kBtu/h & IEER Available)	$\frac{Cap_c}{IEER_b \times 1{,}000} \times EFLH_c$	N/A
Air Source Air Conditioner (Cooling Capacity > 65 kBtu/h & IEER not available)	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	N/A
PTAC with electric resistance heat	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
PTAC with fossil fuel heat	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	N/A
PTHP	$OSF \times \frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_b \times 3.412 \times 1{,}000} \times EFLH_h$
Electric resistance/electric furnace heating	N/A	$\frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
Room Air Conditioner	$\frac{Cap_c}{CEER_b \times 1{,}000} \times EFLH_c$	N/A

Table 3-114 Energy Efficient Electric Energy Consumption Equations

Qualifying Equipment	Efficient Cooling kWh ($kWh_{c,q}$)	Efficient Heating kWh ($kWh_{h,q}$)
Mini-split heat pump, ASHP (Cooling Capacity < 65 kBtu/h)	$OSF \times \frac{Cap_c}{SEER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{HSPF2_q \times 1{,}000} \times EFLH_h$
ASHP (Cooling Capacity > 65 kBtu/h & IEER Available)	$OSF \times \frac{Cap_c}{IEER_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_q \times 3.412 \times 1{,}000} \times EFLH_h$
ASHP (Cooling Capacity > 65 kBtu/h & IEER not available)	$OSF \times \frac{Cap_c}{EER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_q \times 3.412 \times 1{,}000} \times EFLH_h$
PTHP	$OSF \times \frac{Cap_c}{EER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_q \times 3.412 \times 1{,}000} \times EFLH_h$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = see \text{ Table 3-115 } for\ appropriate\ baseline\ equipment\ type$$

For partial displacement applications where the heat pump adds on to an existing fossil fuel system,

$$Therms_q = (1 - F_{load}) \times Therms_b$$

For partial displacement applications where a new supplemental fossil fuel heating system is installed,

$$Therms_q = (1 - F_{load}) \times Therms_{q,ff}$$

$$Therms_{q,ff} = see \text{ Table 3-116 } for\ appropriate\ qualifying\ equipment\ type$$

For whole displacement applications,

$$Therms_q = 0$$

Table 3-115 Baseline Fossil Fuel Consumption

Baseline Equipment	Baseline fuel consumption ($Therms_b$)
Fossil Fuel (Gas, Oil, Propane) Furnace/Boiler	$\frac{Cap_h}{Eff_{b,fuel} \times 100{,}000} \times EFLH_h$
No existing heating	$(1 - F_{baseline,h}) \times \frac{Cap_h}{Eff_{b,fuel} \times 100{,}000} \times EFLH_h$

Table 3-116 Energy Efficient Fossil Fuel Consumption

Qualifying Equipment	Efficient fuel consumption ($Therms_{q,ff}$)
New Supplemental Fossil Fuel (Gas, Oil, Propane) Furnace/Boiler	$\frac{Cap_h}{Eff_{q,fuel} \times 100{,}000} \times EFLH_h$

To calculate savings in gallons of delivered fuel, use Table 3-200.

Table 3-117 Fuel Savings in Gallons

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{Oil} = \frac{\Delta Therms}{1.4}$

Delivered Fuel	Fuel savings (gallons)
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Peak Demand Savings

$$\Delta kW_{Peak} = OSF \times Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Use single baseline for whole displacement new construction and replace on failure.

Use dual baseline for early replacement and addition to existing equipment. In both cases, the RUL is defined by the smaller of the pre-existing heating or cooling system RUL.

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-118 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	

Variable	Description	Value	Units	Ref
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔGal_{Oil}	Oil savings	Calculated	Gallons	
$\Delta Gal_{Propane}$	Propane savings	Calculated	Gallons	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Cap_c	Cooling capacity of installed unit	Site-specific	Btu/hr	
Cap_h	Heating capacity of installed heat pump heating equipment	Site-specific	Btu/hr	
$SEER2_q$	SEER2 of qualifying unit	Site-specific	Btu/W-h	
$IEER_q$	IEER of qualifying unit	Site-specific	Btu/W-h	
$EER2_q$	EER2 of qualifying unit	Site-specific	Btu/W-h	
COP_q	Coefficient of performance at 47F of the qualifying unit	Site-specific	N/A	
$HSPF_q$	Heating seasonal performance factor of the installed unit	Site-specific	Btu/W-h	
$SEER2_b$	SEER of baseline unit	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	Btu/W-h	[508][510]
$IEER_b$	IEER of baseline unit	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	Btu/W-h	[508][510]
$EER2_b$	EER2 of baseline unit	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	Btu/W-h	[508][510]
$HSPF2_b$	Heating seasonal performance factor of the baseline unit	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies.	Btu/W-h	[508][510]
$CEER_b$	Combined Energy Efficiency Ratio of baseline room air conditioner[113]	Use federal standard values in Appendix E: Code-Compliant Efficiencies. If unknown, use 11.0	Btu/W-h	[514]

[113] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides

Variable	Description	Value	Units	Ref
$Eff_{b,fuel}$	Efficiency of baseline boiler/furnace	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	N/A	[508][510]
$Eff_{q,fuel}$	Efficiency of newly installed supplemental boiler/furnace	Site-specific	N/A	
OSF	Oversize derating factor[114]	Site-specific, if unknown use 0.8	N/A	
F_{load}	Partial Displacement Factor to account for the portion of heating load met by the heat pump	Lookup in Table 2-64, using switchover point of 35°F unless site-specific switchover point is known and documented	N/A	[88][90]
$F_{baseline,h}$	Fraction of projects where, absent the program, the customer would have purchased new heating equipment for a previously unheated space instead of extending existing central system	If installed heat pump is a ductless minisplit: 0.18 If installed heat pump is a ducted ASHP: 0.27	N/A	[520]
$F_{baseline,c}$	Fraction of projects where, absent the program, the customer would not have installed cooling in previously uncooled space, so the added cooling represented added electrical load	If installed heat pump is a ductless minisplit: 0.74 If installed heat pump is a ducted ASHP: 0.34	N/A	[520]
$kWh_{c,b}$	Baseline cooling electrical consumption	Look up in Table 3-113	kWh/yr	
$kWh_{h,b}$	Baseline heating electrical consumption	Look up in Table 3-113	kWh/yr	
$kWh_{c,q}$	Energy efficient cooling electrical consumption	Look up in Table 3-114	kWh/yr	
$kWh_{h,q}$	Energy efficient heating electrical consumption	Look up in Table 3-114	kWh/yr	
$kWh_{supplement}$	Energy efficient heating electrical consumption of supplemental heating system	Calculated	kWh/yr	
$Therms_{b}$	Baseline fuel consumption	Look up in Table 3-115	Therms/yr	
$Therms_{q}$	Energy efficient fuel consumption	Calculated	Therms/yr	
$Therms_{q,ff}$	Fuel consumption of new efficient fuel equipment for partial displacement applications where a new supplemental fossil fuel heating system is installed	Calculated	Therms/yr	
$EFLH_{c}$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in Appendix C: Heating and Cooling EFLH	Hours	[511]

[114] Heat pump systems may be sized to meet the peak heating load and will be oversized for cooling. The cooling EFLH assumes a nominal 20% oversizing. This derating factor has been added to account for the oversizing of heat pump cooling capacity when the unit is sized based on heating capacity. A user with a more accurate estimation of the oversizing can use a different factor than the one mentioned above to account for oversizing.

Variable	Description	Value	Units	Ref
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Appendix C: Heating and Cooling EFLH	Hours	[511]
COP_b	Coefficient of performance of the baseline unit at 47F	Look up in Appendix E: Code-Compliant Efficiencies	N/A	[508][510]
1,000	Conversion from W to kW	1,000	w/kW	
3.412	Conversion factor from kWh to kBtu	3.412	kBtu/kWh	
1.4	Conversion from therms to gallons	1.4	Therms/gal	0
0.916	Conversion from therms to gallons	0.916	Therms/gal	0
CF	Cooling coincidence factor	Look up in Table 3-120	N/A	[512]
PDF	Gas peak day factor	Look up in Table 3-120	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[513]
RUL	Remaining useful life	See Measure Life Section	Years	

Table 3-119 Partial Displacement Factors at Different Switchover Points[115]

NJ Climate Region	Switchover Point					
	15°F	25°F	30°F	35°F (default)	40°F	45°F
Northern	0.95	0.78	0.68	0.43	0.29	0.17
Southern	0.99	0.82	0.71	0.43	0.29	0.19
Coastal	0.98	0.91	0.85	0.64	0.46	0.30
Central	0.99	0.83	0.74	0.47	0.31	0.19
Pine Barrens	1.00	0.86	0.76	0.46	0.31	0.19
Statewide Average	**0.98**	**0.84**	**0.75**	**0.48**	**0.33**	**0.20**

Use switchover point of 35°F unless alternative site-specific switchover point is known and supported with documentation such as a photo of programmed controls.

[115] Partial displacement factor represents the fraction of the heating load provided by the heat pump. It is based on the percentage of heating degree hours above the "switchover point," or the point at which heating is assumed to switch from the heat pump to the supplemental system. Assume a default switchover point of 35°F unless a site-specific switchover point is known and supported with documentation such as a photo of programmed controls.

Peak Factors

Table 3-120 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[512]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-121 Measure Life

Equipment	EUL	RUL	Ref
Central A/C	15	5	[513]
Air source heat pump	15	5	[513]
Mini split heat pump	15	5	[513]
PTAC/PTHP	15	5	[513]
Room air conditioner	12	4	[513]
Fossil fuel furnace/boiler	20	6.7	[513]
Electric resistance/electric furnace	20	6.7	[513]

References

[508] ENERGY STAR Light Commercial HVAC Version 4.0, https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20LC%20HVAC%20Version%204.0%20Specification%20Rev%20April%202022.pdf?_gl=1*n9oet2*_ga*MTUwMjg5MDYyNC4xNjY0NDc5NDA0*_ga_S0KJTVVLQ6*MTY4MDU0NjcxNi4zNS4xLjE2ODA1NDY5NjAuMC4wLjA

[509] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[510] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[511] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[512] C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods.

[513] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[514] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, section 430.32 b) Room Air Conditioners,

[515] Oak Ridge National Laboratory*, Fuel Conversions Needed in the Weatherization Assistant*, https://weatherization.ornl.gov/wp-content/uploads/2018/05/FuelConversions.pdf

[516] TMY3 data for NJ climate zone representative cities: Northern – Allentown, PA; Central – Trenton, NJ; Pine Barrens – McGuire AFB NJ; Southwest – Philadelphia, PA International Airport; Coastal – Atlantic City, NJ.

[517] Determined by calculating the percentage of the heating degree hours (using 65°F balance point) exceeding the switchover point, which represents the proportion of the heating load presumed to be met by the heat pump. Metered data from New York shows that customers typically switch from heat pump to supplemental heating at around 35°F.

[518] GDS Associates, Inc. 2007. *Review of Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM)*. Https://Library.cee1.org. June 2007. https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf

[519] *Energy Saver 101: Everything you need to know about Home Heating* https://www.energy.gov/sites/prod/files/2014/01/f6/homeHeating.pdf

[520] Guidehouse, *[R2246] Residential Heat Pump Metering Study*, May 2024. https://app.box.com/s/6u94k3zij1ocwmqlh7oxl5vnie1fmn7c

3.5.3 GEOTHERMAL AND WATER SOURCE HEAT PUMPS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	May 2024
Changes Since Last Version	• Algorithm revisions

Description

This prescriptive measure targets the use of water-to-air ground loop heat pumps, water-to-air groundwater heat pumps, brine-to-air ground loop heat pumps, brine-to-air groundwater loop heat pumps in commercial and multifamily applications as further described below. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing commercial or multifamily building for HVAC applications.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

This measure is limited to single-zone equipment; complex built-up systems should follow custom analysis. This measure requires that:

- The heat pump system will be installed in lost opportunity projects *or* in retrofit/early retirement projects in buildings with viable existing ductwork.
- The heat pump system will be the sole source of heating and cooling in the space; it will not be installed in association with another non-electric source of auxiliary heat.

Baseline Case

For whole building new construction and time of sale applications, the baseline equipment is a unitary packaged or split-system air source heat pump (or other industry standard equipment type for the facility) compliant with ASHRAE 90.1-2019 (see Appendix E: Code-Compliant Efficiencies).

For replacement of failed equipment, or end of useful life, the baseline would be a minimally code compliant version of the replaced system type and fuel.

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the ASHRAE 90.1 version in force when the equipment was new (if equipment vintage is unknown, use ASHRAE 90.1 2013 efficiency requirements from Appendix E: Code-Compliant Efficiencies).
- For the duration of the measure life after the end of the RUL, the baseline is a current code-compliant version of the replaced equipment.

Note: the algorithms in this section assume that the installed heat pump replaces 100% of the heating and cooling load of the existing equipment. In a partial displacement scenario, the consumption algorithms must be adjusted to account for the actual percent of building load supplied by HVAC equipment.

Efficient Case

A water-to-air groundwater loop water-to-air ground loop, brine-to-air groundwater loop, or brine-to-air ground loop heat pump that meets or exceeds code requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = kWh_{c,b} + kWh_{h,b} + kWh_{p,b}$$

$$kWh_q = kWh_{c,q} + kWh_{h,q} + kWh_{p,q}$$

Calculate $kWh_{c,b}$, $kWh_{h,b}$, and $kWh_{p,b}$ using the algorithms in Table 3-122 for the appropriate baseline equipment type.

Calculate $kWh_{c,q}$, $kWh_{h,q}$, and $kWh_{p,q}$ using the algorithms in Table 3-123 for the appropriate efficient equipment type.

Note: Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in Appendix E: Code-Compliant Efficiencies.

The cooling output of the installed unit (Qc) and the heating output of the installed unit (Qh) are calculated as follows.

$$Q_c = Cap_c \times EFLH_c \times OSF$$

$$Q_h = Cap_h \times EFLH_h$$

Note: The oversize derating factor (OSF) in the equations above is applicable for heat pump applications where the heat pump is sized based on heating capacity but is oversized for cooling. The appropriate OSF should be determined from site-specific conditions if possible, otherwise use a default value of 0.8.

Table 3-122 Baseline Energy Consumption Equations

Baseline Equipment	Baseline Cooling kWh ($kWh_{c,b}$)	Baseline Heating kWh ($kWh_{h,b}$)	Auxiliary Energy Use kWh ($kWh_{au,b}$)[116]
Air Source Heat Pump (< 65 kBtu/h)	$\frac{Q_c}{SEER2_b \times 1{,}000}$	$\frac{Q_h}{HSPF2_b \times 1{,}000}$	N/A
Air Source Air Conditioner (< 65 kBtu/h)	$\frac{Q_c}{SEER2_b \times 1{,}000}$	N/A	N/A
Air Source Heat Pump (≥ 65 kBtu/h)	$\frac{Q_c}{IEER_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	N/A
Air Source Air Conditioner (≥ 65 kBtu/h)	$\frac{Q_c}{IEER_b \times 1{,}000}$	N/A	N/A
PTAC with electric resistance heat	$\frac{Q_c}{EER2_b \times 1{,}000}$	$\frac{Q_h}{3.412 \times 1{,}000}$	N/A
PTHP	$\frac{Q_c}{EER2_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	N/A
Ground Source Heat Pump (< 65 kBtu/h)	$\frac{Q_c}{EER_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_b \times FLH_{pump}}{Eff_{motor,b}}$
GSHP (Cooling Capacity > 65 kBtu/h)	$\frac{Q_c}{EER_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_b \times FLH_{pump}}{Eff_{motor,b}}$
Electric Resistance/electric furnace heating	N/A	$\frac{Q_h}{3.412 \times 1{,}000}$	N/A
Room Air Conditioner	$\frac{Q_c}{CEER_b \times 1{,}000}$	N/A	N/A
Fossil Fuel Furnace[117]	N/A	N/A	$4.9 \times Cap_{furnace} + 128.1$

Table 3-123 Energy Efficient Energy Consumption Equations

Efficient Cooling kWh ($kWh_{c,q}$)	Efficient Heating kWh ($kWh_{h,q}$)	Efficient Circulating Pump kWh ($kWh_{p,q}$)
$\frac{Q_c}{EER_{season,q} \times 1{,}000}$	$\frac{Q_h}{COP_{season,q} \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_q \times FLH_{pump}}{Eff_{motor,q}}$

Calculate seasonal efficiencies as follows:

If heat pump is part-load capable:

[116] This parameter represents the additional energy consumption aside from direct cooling or heating. For ground source heat pumps, it represents the pump energy to circulate the heat exchange fluid through the ground loop. For furnaces, it represents the fan energy to distribute the heated air.

[117] This equation was derived by constructing a simple linear regression model that relates the output furnace heating capacity to the fan auxiliary usage using data downloaded from the AHRI website for all active residential-sized furnaces.

$$EER_{season,q} = F_{full} \times EER_{full,q} \times 1.09 \times F_{pump,full} + F_{part} \times EER_{part,q} \times F_{pump,part}$$

$$COP_{season,q} = F_{full} \times COP_{full,q} \times 1.08 \times F_{pump,full} + F_{part} \times COP_{part,q} \times F_{pump,part}$$

If heat pump is not part-load capable:

$$EER_{season,q} = rated\ EER$$

$$COP_{season,q} = rated\ COP$$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = see \text{ Table 3-124 } for\ appropriate\ baseline\ equipment\ type$$

$$Therms_q = 0 \text{ \textit{(If the unit uses a furnace backup, use equation from Table 3-124)}}$$

Table 3-124 Baseline Fuel Consumption

Baseline Equipment	Baseline fuel consumption ($Therms_b$)
Fossil fuel furnace	$\frac{Q_h}{Eff_{b,fuel} \times 100{,}000}$
Electric heating (heat pump, electric resistance)	0

To calculate savings in gallons of delivered fuel, use Table 3-125

Table 3-125 Fuel Savings in Gallons

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{Oil} = \frac{\Delta Therms}{1.4}$
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Peak Demand Savings

$$\Delta kW_{Peak} = kW_{peak,cool} + kW_{peak,pump}$$

Where,

$$\Delta kW_{peak,cool} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF_c$$

$$\Delta kW_{peak,pump} = 0.746 \times \left\{ \left(HP_b \times LF \times \frac{1}{Eff_{motor,b}} \right) - \left(HP_q \times LF \times \frac{1}{Eff_{motor,q}} \times DSF_{VFD} \right) \right\} \times CF_{pump}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-126 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔGal_{Oil}	Oil savings	Calculated	Gallons	
$\Delta Gal_{Propane}$	Propane savings	Calculated	Gallons	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Q_c	Cooling output of qualifying unit	Calculated	Btu	

Variable	Description	Value	Units	Ref
Q_h	Heating output of qualifying unit	Calculated	Btu	
Cap_c	Cooling capacity of qualifying unit	Site-specific	Btu/hr	
Cap_h	Heating capacity of qualifying unit	Site-specific	Btu/hr	
$Cap_{furnace}$	Heating capacity of pre-existing furnace (MBH)	Site-specific	MBH	
F_{full}	Seasonal weighting factor for full load efficiency	0.25	N/A	[523]
$EER_{season,q}$	Adjusted EER of qualifying unit	Calculated	Btu/W-h	
$EER_{full,q}$	Full load EER of qualifying unit	Site-specific	Btu/W-h	
$F_{pump,full}$	Factor to adjust the full load efficiency to account for additional pumping power used by the system	0.90	N/A	[523]
F_{part}	Seasonal weighting factor for part load efficiency	0.75	N/A	[523]
$EER_{part,q}$	Part load EER of qualifying unit (if part load capable), per manufacturer literature or AHRI certification	Site-specific	Btu/W-h	
$F_{pump,part}$	Factor to adjust the part load efficiency to account for additional pumping power used by the system	0.84	N/A	[523]
$COP_{season,q}$	Adjusted coefficient of performance of the qualifying unit	Calculated	N/A	
$COP_{full,q}$	Full load coefficient of performance of the qualifying unit, per manufacturer literature or AHRI certification	Site-specific	N/A	
$COP_{part,q}$	Part load coefficient of performance of the qualifying unit (if part-load capable), per manufacturer literature or AHRI certification	Site-specific	N/A	
HP_q	Horsepower of qualifying ground/groundwater loop circulating pump motor	Site-specific	HP	
HP_b	Horsepower of base case ground/groundwater loop circulating pump motor	Site-specific, if unknown use HP_q	HP	
$SEER2_b$	SEER2 of baseline unit	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	Btu/W-h	[528][529]

Variable	Description	Value	Units	Ref
$IEER_b$	IEER of baseline unit	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	Btu/W-h	[528][529]
$EER2_b$	EER2 of baseline unit	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	Btu/W-h	[528][529]
$HSPF2_b$	Heating seasonal performance factor of the baseline unit	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies.	Btu/W-h	[528][529]
$CEER_b$	Combined Energy Efficiency Ratio of baseline room air conditioner[118]	Use federal standard values in Appendix E, if unknown, use 11.0	Btu/W-h	See footnote
$Eff_{motor,b}$	Efficiency of base case ground/groundwater loop circulating pump motor	Site-specific, if unknown look up in Table 3-127	N/A	[530]
$Eff_{motor,q}$	Efficiency of qualifying ground/groundwater loop circulating pump motor	Site-specific, if unknown look up in Table 3-127	N/A	[530]
$Eff_{b,fuel}$	Efficiency of baseline of furnace	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	N/A	[528][529]
OSF	Oversize derating factor	Site-specific, if unknown use 0.8	N/A	
$kWh_{c,b}$	Baseline cooling electrical consumption	Look up in Table 3-122	kWh/yr	
$kWh_{h,b}$	Baseline heating electrical consumption	Look up in Table 3-122	kWh/yr	
$kWh_{p,b}$	Baseline pump electrical consumption	Look up in Table 3-122	kWh/yr	
$kWh_{c,q}$	Energy efficient cooling electrical consumption	Look up in Table 3-123	kWh/yr	
$kWh_{h,q}$	Energy efficient heating electrical consumption	Look up in Table 3-123	kWh/yr	
$kWh_{p,q}$	Energy efficient ground/groundwater loop circulating pump electrical consumption	Look up in Table 3-123	kWh/yr	
$Therms_b$	Baseline fuel consumption	Look up in Table 3-124	Therms/yr	
$Therms_q$	Energy efficient fuel consumption	0	Therms/yr	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in Appendix C: Heating and Cooling EFLH	Hours	[521]

[118] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides

Variable	Description	Value	Units	Ref
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Appendix C: Heating and Cooling EFLH	Hours	[521]
COP_b	Coefficient of performance of the baseline unit	Look up in Appendix E: Code-Compliant Efficiencies	N/A	[528][529]
1.09	Correction for 9% increase in EER as the entering fluid temperature decreases from 77°F to 68°F	1.09	N/A	[523]
1.08	Correction for 8% increase in COP as entering fluid temperature increases from 32°F to 40°F	1.08	N/A	[523]
1,000	Conversion from W to kW	1,000	w/kW	
3.412	Conversion factor from kWh to kBtu	3.412	kBtu/kWh	
0.746	Conversion from HP to kW	0.746	kW/hp	
1.4	Conversion from therms to gallons	1.4	Therms/gal	
0.916	Conversion from therms to gallons	0.916	Therms/gal	
LF	Load factor of pump motor	0.75	N/A	[524]
DSF_{VFD}	Demand savings factor to account for variable speed pumping in qualifying unit	If variable speed pump: 0.210 If constant speed: 1.0		See section 3.5.17
FLH_{pump}	Annual full-load hours of ground/groundwater loop circulating pump motor, approximated as $EFLH_c$ + $EFLH_h$	Look up in Appendix D: HVAC Fan and Pump Operating Hours	Hours	
CF_c	Cooling coincidence factor	Look up in Table 3-128	N/A	
CF_{pump}	Pump coincidence factor	Look up in Table 3-128	N/A	
PDF	Gas peak day factor	Look up in Table 3-128	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life	See Measure Life Section	Years	

Table 3-127 Federal Baseline Motor Efficiencies

Motor HP	Motor Nominal Full-Load Efficiencies (percent)							
	2 Poles		4 poles		6 Poles		8 Poles	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0

Motor HP	Motor Nominal Full-Load Efficiencies (percent)							
	2 Poles		4 poles		6 Poles		8 Poles	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
2	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0

Peak Factors

Table 3-128 Peak Factors

Peak Factor	Value	Ref
Cooling coincidence factor (CF_c)	0.5	[525]
Pump coincidence factor (CF_{pump})	If unit runs 24/7/365, CF=1.0, else use 0.5	[525]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-129 Measure Life

Equipment	EUL	RUL	Ref
Water source Pump	15	5	[527]
Ground source heat pump	25	8.33	[527]
Central A/C	15	5	[527]
Air source heat pump	15	5	[527]
PTAC/PTHP	15	5	[527]
Room air conditioner	12	4	[527]
Fossil fuel furnace	20	6.7	[527]

Equipment	EUL	RUL	Ref
Electric resistance/electric furnace	20	6.7	[527]

References

[521] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[522] VEIC estimate. Extrapolation of manufacturer data.

[523] From NY TRM V11, pg 287-288

[524] *Determining Electric Motor Load and Efficiency*. (DOE, 2014), pg 1, https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

[525] C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods.

[526] Available at: http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2_0.pdf

[527] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[528] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[529] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[530] *§ CFR431.25 Energy conservation standards and effective dates*, (2023) Table 1, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-B/subject-group-ECFR03b7039d87b7cc6/section-431.25

[531] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1

3.5.4 GAS HEAT PUMPS

Market	Commercial
Baseline Condition	NC/TOS/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• New measure

Description

This measure targets the use of gas heat pumps in commercial applications as further described below. Gas-fired heat pumps are a subset of heat pumps whose primary input drive energy is a gaseous fuel, instead of an electrically-driven compressor. This measure may apply to early replacement of an existing system, replacement on failure, or installation of a new unit in a new or existing commercial building for HVAC applications.

Baseline Case

For whole building new construction, the baseline equipment is a gas-fired hot water boiler, direct expansion cooling system, and a water heater all compliant with ASHRAE 90.1-2019 (see Appendix E: Code-Compliant Efficiencies).

For replacement of failed equipment, or end of useful life, the baseline is a minimally code compliant (ASHRAE 90.1-2019) version of the replaced system type and fuel.

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the ASHRAE 90.1 version in force when the equipment was new (if equipment vintage is unknown, use ASHRAE 90.1 2013 efficiency requirements from Appendix E: Code-Compliant Efficiencies).
- For the duration of the measure life after the end of the RUL, the baseline is a minimally code-compliant (ASHRAE 90.1-2019 or current code at end of RUL) version of the replaced equipment.

Efficient Case

A gas heat pump for space heating/cooling and domestic hot water heating that meets program eligibility requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = Therms_{Space} + Therms_{DHW}$$

Where,

$$Therms_{space} = EFLH_h \times Cap_h \times \frac{(Eff_q - Eff_b)}{Eff_b \times 100{,}000}$$

$$Therms_{DHW} = (T_{out} - T_{in}) \times GPD \times 365 \times 8.33 \times 1.0 \times \left(\frac{1}{Eff_{b,DHW}} - \frac{1}{Eff_{q,DHW}}\right) \times \frac{1}{100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \text{N/A}$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 1-2 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Space}$	Space Heating Savings	Calculated	Therms/yr	
$\Delta Therms_{DHW}$	Domestic hot water savings	Calculated	Therms/yr	
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Appendix C: Heating and Cooling EFLH	Hours	[511]
Cap_h	Heating capacity of qualifying unit	Site-specific	Btu/hr	
Eff_b	Efficiency of baseline space heating unit	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	N/A	[508][510]

Variable	Description	Value	Units	Ref
Eff_q	Space heating efficiency of gas heat pump	Site-specific	N/A	
T_{out}	Tank temperature	Site-specific, if unknown, use 125	°F	[538]
T_{in}	Supply water temperature in water main[119]	60	°F	[537]
GPD	Estimated annual hot water consumption	Site-specific , if unknown look up in Table 3-349	Gal/day	
365	Days per year	365	Day/yr	
8.33	Specific weight capacity of water	8.33	lbs/gal	
1.0	Specific heat of water	1.0	Btu/lb°F	
100,000	Conversion from Btu to Therms	100,000	Btu/Therms	
$EEF_{b,DHW}$	Rated efficiency of baseline water heater	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP: Site-specific, if unknown use code efficiency in force when equipment was new. If vintage is unknown, look up in Appendix E Table 9-8	N/A	[510]
$EEF_{q,DHW}$	Rated efficiency of the commercial gas heat pump as certified expressed as Uniform Energy Factor (UEF) or Coefficient of Performance	Site-specific COP or calculate UEF with equations in Appendix E Table 9-7	N/A	[510]
PDF	Gas peak day factor	Look up in Table 3-120	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[513]
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Peak Factors

Table 3-130 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

[119] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F

Measure Life

The effective useful life (EUL) for the gsa heat pump is 15 years [1]. The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

References

[532] *2024 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 12 Volume 2: Commerical and Industrial Measures* (September 2023), Pg 600, https://icc.illinois.gov/api/web-management/documents/downloads/public/il-trm-12/IL-TRM_Effective_010124_v12.0_Vol_2_C_and_I_09222023_FINAL_clean.pdf

[533] ENERGY STAR Light Commercial HVAC Version 4.0, https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20LC%20HVAC%20Version%204.0%20Specification%20Rev%20April%202022.pdf?_gl=1*n9oet2*_ga*MTUwMjg5MDYyNC4xNjY0NDc5NDA0*_ga_S0KJTVVLQ6*MTY4MDU0NjcxNi4zNS4xLjE2ODA1NDY5NjAuMC4wLjA

[534] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[535] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[536] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[537] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature*. National Renewable Energy Laboratory. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf

[538] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

3.5.5 INFRARED HEATER

Market	Commercial/Multifamily
Baseline Condition	NC/TOS/DI
Baseline	Code/Dual
End Use Subcategory	Gas Space Heating Equipment
Measure Last Reviewed	November 2022
Changes Since Last Version	• Corrected statewide HDD value

Description

This measure outlines the savings for the installation of a gas-fired, low intensity infrared (IR) heating system in place of a unit heater, furnace, or other standard efficiency equipment in commercial and industrial facilities.

Savings are based on the reduced input capacity requirement with the radiant heating of an IR Heater (efficient) as opposed to convective heating of a conventional heating system (baseline). The thermal efficiency is assumed to be equivalent between the baseline and efficient case.

The algorithms do not include potential savings as a result of a few baseline assumptions. For example, if the baseline is assumed to be a furnace, there will be kwh savings associated with reduction in fan energy reduction.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Code-compliant furnace, unit heater, or other standard efficiency equipment. For new construction, a gas-fired warm unit heater shall be assumed.

Efficient Case

The efficient case condition is a low-intensity, gas-fired infrared heater. The prescribed methodology assumes a reduction of 10°F to maintain occupant comfort. [541]

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = Cap_{in} * \left(1 - \frac{HDD_{55}/(55 - T_{design})}{HDD_{65}/(65 - T_{design})}\right) * \frac{EFLH_h}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-131 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_{in}	Input capacity of qualifying unit	Site-specific	kBtu/hr	
HDD_{55}	Heating degree days: number of degrees the average daily temperature is below 55°F	Look up in Table 3-132	°F-day	[539]

Variable	Description	Value	Units	Ref
HDD_{65}	Heating degree days: number of degrees the average daily temperature is below 65°F	Look up in Table 3-132	°F-day	[539]
T_{design}	Equipment design temperature	Look up in Table 3-132	°F	[542]
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	See Appendix C: Heating and Cooling EFLH	hour/yr	[540]
100	Conversion from kBtu to therms	100	kBtu/therms	
CF	Electric coincidence factor	Look up in Table 3-133	N/A	
PDF	Gas peak day factor	Look up in Table 3-133	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-132 Heating Degree Days and Equipment Design Temperature

Climate Zone	HDD_{65}	HDD_{55}	T_{design}
Northern	6,136	3,759	8.1
Central	5,588	3,331	11.6
Pine Barrens	5,529	3,294	10.5
Southwest	5,658	3,418	13.8
Coastal	4,795	2,573	11.6
Statewide Average	5,553	3,288	11.1

Peak Factors

Table 3-133 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

Table 3-134 Measure Life

Equipment	EUL	RUL	Ref
Infrared Heater	17	5.7	[544]

References

[539] TMY3 data for NJ climate zone representative cities: Northern – Allentown, PA; Central – Trenton, NJ; Pine Barrens – McGuire AFB NJ; Southwest – Philadelphia, PA International Airport; Coastal – Atlantic City, NJ.

[540] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[541] 2012 ASHRAE Handbook – HVAC Systems and Equipment, Chapter 16, Infrared Radiant Heating.

[542] ASHRAE Fundamentals 2021, Chapter 14 Climactic Design Conditions, https://handbook.ashrae.org/Handbook.aspx#. Based on NJ climate zone representative cities: Northern – Allentown, PA; Central – Trenton, NJ; Pine Barrens – McGuire AFB NJ; Southwest – Philadelphia, PA International Airport; Coastal – Atlantic City, NJ.

[543] GDS Associates, Inc. "Natural Gas Efficiency Potential Study." DTE Energy. July 29, 2016. Available from: https://www.michigan.gov/documents/mpsc/DTE_2016_NG_ee_potential_study_w_appendices_vFINAL_554360_7.pdf

[544] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

3.5.6 FURNACES, UNIT HEATERS AND BOILERS

Market	Commercial/Multifamily
Baseline Condition	NC/TOS/DI/EREP
Baseline	Code/ISP/Dual
End Use Subcategory	Gas Space Heating Equipment
Measure Last Reviewed	November 2022
Changes Since Last Version	• Corrected capacity parameter nomenclature in algorithm

Description

This measure encourages the installation of high-efficiency, natural gas-fired furnaces, unit heaters and closed loop space heating boilers meeting program eligibility requirements. Equipment sizing assumes compliance with ASHRAE 90.1 - 2019 sizing requirements.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

For NC and TOS programs, , the baseline unit is a code compliant unit of the same type and size as the installed unit with efficiency as required by ASHRAE Std. 90.1 – 2019 and IECC 2021, which are the current codes adopted by the State of New Jersey (see Appendix E: Code-Compliant Efficiencies). For New Construction, an Industry Standard Practice baseline which is 15% more efficient than Code applies to furnaces.

For early replacement projects, use dual baselines:

- For the remaining useful life of the existing equipment, the baseline is the actual existing equipment if the site specific efficiency of the existing equipment is unknown, use the ASHRAE 90.1-2013 efficiency for the existing equipment type (see Appendix E: Code-Compliant Efficiencies).
- For the duration of the measure life, the baseline is a code-compliant unit of the same type and size of the installed unit with efficiency as required by ASHRAE Std. 90.1 – 2019 and IECC 2021 (see Appendix E: Code-Compliant Efficiencies).

Efficient Case

Equipment with an efficiency higher than Code or ISP that meets program eligibility requirements. No size limits on furnaces or unit heaters.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = \frac{Cap_{out}}{HSPF_b \times 1{,}000} \times EFLH_h \ (Electric\ Resistance\ Baseline)$$

$$kWh_b = 0\ (Gas\ Equipment\ Baseline)$$

$$kWh_q = 0$$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = \frac{Cap_{out}}{Eff_{AF} \times Eff_b \times 100{,}000} \times EFLH_h \ (Gas\ Equipment\ Baseline)$$

$$Therms_b = 0\ (Electric\ Baseline)$$

$$Therms_q = \frac{Cap_h}{Eff_q \times 100{,}000} \times EFLH_h$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-135 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Lifetime}$	Lifetime fuel savings	Calculated	Therms	
Cap_{out}	Output capacity of qualifying unit	Site-specific	Btu/hr	
Eff_q	Equipment Proposed Efficiency	Site-specific	Varies	
$HSPF_b$	Heating seasonal performance factor of baseline electric unit	3.412		
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Look up in Appendix C: Heating and Cooling EFLH	Hrs/yr	[545]
Eff_b	Gas equipment baseline efficiency	Look up in Table 3-136	Varies	[546][547]
Eff_{AF}	Equipment baseline efficiency ISP adjustment Factor	1.15 (New Construction furnaces only) 1.0 (all others)	N/A	[548]
1,000	Conversion factor	1,000	Watts/kW	
100,000	Conversion factor	100,000	Btu/Therm	
CF	Electric coincidence factor	Look up in Table 3-137 Peak Factors	N/A	
PDF	Gas peak day factor	Look up in Table 3-137 Peak Factors	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-136 Baseline Efficiencies

Equipment	Type	Size Category (kBtu input)	ASHRAE Standard 90.1-2019 Efficiency
Furnace	Gas Fired	< 225	Nonweatherized 80% AFUE Weatherized 81% AFUE or 80% Et
	Gas Fired	≥ 225	81% Et
	Oil Fired	< 225	Nonweatherized excluding mobile home 83% AFUE Nonweatherized mobile home 75% AFUE Weatherized 78% AFUE
	Oil Fired	≥ 225	82% Et
Unit Heater	Gas Fired, Oil Fired	All Capacities	80% Ec
Hot Water Boiler	Gas Fired	<300	82% AFUE
		≥300 and ≤ 2,500	80% Et
		>2,500	82% Ec
	Oil Fired	<300	84% AFUE
		≥300 and ≤ 2,500	82% Et
		>2,500	84% Ec
Steam Boiler	Gas Fired	<300	82% AFUE
	Gas Fired All Except Natural Draft	≥300 and ≤ 2,500	79% Et
		>2,500	79% Et
	Gas Fired Natural Draft	≥300 and ≤ 2,500	79% Et
		>2,500	79% Et
	Oil Fired	<300	85% AFUE
		≥300 and ≤ 2,500	81% Et
		>2,500	81% Et

Peak Factors

Table 3-137 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-138 Measure Life

Equipment	EUL	RUL	Ref
Furnace	20	6.67	[549]
Unit Heater	18	6	[550]
Boiler	20	6.67	[549]
Electric Resistance Heating	20	6.67	[551]

References

[545] Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[546] *ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings*. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[547] *2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES* (IECC 2021), Table C403.3.2(5) https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency

[548] *New Jersey Commercial New Construction Industry Standard Practice Analysis.* Prepared for Rutgers University by DNV. June 2022.

[549] California Database of Energy Efficient Resources (DEER) http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

[550] Ecotope, *Natural Gas Efficiency and Conservation Measure Resource Assessment*, 2003, section 5.2.3, https://ecotope-publications-database.ecotope.com/2003_007_NaturalGasEfficiency.pdf

[551] *Energy Saver 101: Everything you need to know about Home Heating* https://www.energy.gov/sites/prod/files/2014/01/f6/homeHeating.pdf

3.5.7 BOILER CONTROLS

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	November 2022

Description

Boiler reset controls automatically adjust the boiler water temperature based on the outdoor air temperature. Boiler cut-out controls use sensors to determine when outside air has reached a specific temperature and turn off the boiler and its connected heating system. Optionally, a timer to control when heating equipment comes on and when it goes off may also be included. These controls are most often installed together using controls that accomplish both functions.

This measure is limited to cut-out controls on non-condensing boilers since boiler reset savings is minimal for non-condensing boilers. Both boiler reset and cut-out controls are applicable to condensing boilers.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Existing boiler without controls.

Efficient Case

Installation of boiler reset and/or cut-out controls. The system's minimum temperature setpoint must be set no more than 10 degrees above manufacturer's recommended minimum return temperature.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = SF \times \frac{EFLH_h \times Cap_{in}}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = N/A$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EU$$

Calculation Parameters

Table 3-139 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
SF	Savings Factor: estimated percent reduction in heating load due to controls being installed.	Lookup in Table 3-140	%	[552] [553]
$EFLH_h$	Equivalent full load hours for heating	Look up in Appendix C:	hrs	[554]
Cap_{in}	Input capacity of boiler	Site-specific	kBtu/hr	
EUL	Effective useful life	See Measure Life Section	yrs	
100	Conversion from kBtu to therm	100	kBtu	

Table 3-140 Savings Percentage

Control Type	Savings	Ref
Boiler Reset	5.0%	[552]
Boiler Cut-Out	1.7%	[553]
Boiler Reset & Cut-Out	5%	

Peak Factors

Table 3-141 Peak Factors

Peak Factor	Value	Ref
Coincidence Factor (CF)	N/A	
Natural gas peak day factor (PDF)	Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) of boiler controls is limited to the smaller of the measure life or the remaining useful life (RUL) of the boiler. If boiler RUL unknown, assume 1/3 of the boiler EUL.

Table 3-142 Measure Life

Equipment	EUL	RUL	Ref
Boiler Controls	Smaller of: boiler RUL or 7.33	N/A	
Boiler (steel water-tube)	22	7.33	[555]
Boiler (steel fire-tube)	25	8.33	[555]
Boiler (cast iron)	35	11.67	[555]

References

[552] GDS Associates, Inc. Natural Gas Energy Efficiency Potential in Massachusetts, 2009, p. 38 Table 6-4. https://ma-eeac.org/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

[553] Arkansas Technical Reference Manual, Version 9.1, Volume 2, page 223 , https://apsc.arkansas.gov/wp-content/uploads/AR_TRM_V9.1_Volume_1_2_and_3_on_8-31-22.pdf

[554] Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

[555] ASHRAE Handbook 2019, HVAC Applications. Chapter 38 *Owning and Operating Costs*, Table 4.

3.5.8 BOILER ECONOMIZER

Market	Commercial/Multifamily
Baseline Condition	NC/RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	November 2022

Description

This measure covers the installation of a boiler economizer, also known as stack economizers and feedwater economizers. Boiler economizers are designed to recover heat from hot flue gases which is then used to pre-heat boiler feedwater thereby reducing heating requirements. Condensing and conventional non-condensing economizers are the two principal types of boiler economizers.

Non-condensing or conventional economizers are typically air-to-water heat exchangers and operate above the flue gas dew point to avoid condensation [556].

Condensing economizers allow condensing of the exhaust gas components and reduce the flue gas temperature below its dew point. This results in latent heat being recaptured, thereby improving the effectiveness of waste heat recovery [558].

This measure is applicable to the installation of condensing and non-condensing economizers on boilers serving space heating loads and process loads and is restricted to non-condensing, forced draft burner boilers.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is a non-condensing, forced draft burner boiler serving space heating or process loads without a boiler economizer.

Efficient Case

The compliance condition is a non-condensing, forced draft burner boiler serving space heating or process loads with a non-condensing or condensing boiler economizer.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

Economizer for Boilers Serving HVAC Loads:

$$\Delta Therms = Cap_{in} \times \frac{ESF \times EFLH_h}{100}$$

Where,

$$ESF = \frac{T_b - T_q}{40} \times TRE$$

Economizer for Boilers Serving Process Loads:

$$\Delta Therms = Cap_{in} \times \frac{ESF \times 8{,}766 \times UF}{100}$$

Where,

$$ESF = \frac{T_b - T_q}{40} \times TRE$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = N/A$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-143 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	

Variable	Description	Value	Units	Ref
ESF	Energy Savings Factor	Calculated	N/A	[559]
Cap_{in}	Input capacity of qualifying unit	Site-specific	kBtu/hr	
T_b	Baseline full-fire boiler flue gas temperature as it exits the stack	Site-specific. If unknown, use the default of 420°F for hot water boilers and 500°F for steam boilers[120]	°F	[560]
T_q	Energy efficient full-fire boiler flue gas temperature as it exits the stack	Site-specific. If unknown, look up in Table 3-144	°F	[557]
TRE	Temperature Reduction Efficiency; percentage efficiency increases for stack temperature reduction, per 40ºF reduction in net stack temperature	Site-specific. If unknown, use a default of 0.01	N/A	[559]
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Look up in Appendix C:	Hrs/yr	[560]
100	Conversion from kBtu to therms	100	kBtu/Therms	
40	Stepped reduction in net stack temperature, in ºF	40	°F	
8,766	Process load boiler operating hours	8,766	Hrs/yr	[563]
UF	Utilization factor	0.419	N/A	[563]
PDF	Gas peak day savings factor	Look up in Table 3-145	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-144 Energy Efficient Boiler Flue Gas Temperature

Equipment Type	Conventional Economizer[121,122]	Condensing Economizer[123,124]
Hot Water Boiler	335 °F	247.5 °F
Steam Boiler	375 °F	287.5 °F

[120] Assumes hot water boiler efficiency of 82% and steam boiler efficiency of 80%

[121] As cited in U.S. DOE, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer, the minimum stack temperature for a non-condensing economizer is 250°F. The average temperature drop is assumed to be halfway between the baseline and efficient temperature minimum: (420°F + 250°F) / 2 = 335°F

[122] Ibid, the minimum stack temperature for a non-condensing economizer is 250°F: (500°F + 250°F) / 2 = 375°F

[123] Ibid, the minimum stack temperature for a condensing economizer is 75°F: (420°F + 75°F) / 2 = 247.5°F

[124] Ibid, the minimum stack temperature for a condensing economizer is 75°F: (500°F + 75°F) / 2 = 287.5°F

Peak Factors

Table 3-145 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) of the boiler economizer is limited to the remaining useful life (RUL) of the boiler. If unknown, assume 1/3 of the boiler EUL.

Table 3-146 Measure Life

Equipment	EUL	RUL	Ref
Boiler	20	6.67	[555]

References

[556] US DOE, "Improving Steam System Performance: A Sourcebook for Industry, Second Edition", 2004. https://www.energy.gov/sites/prod/files/2014/05/f15/steamsourcebook.pdf

[557] US DOE, "ADVANCED MANUFACTURING OFFICE Energy Tips: STEAM Steam Tip Sheet #26A." n.d. https://www.energy.gov/sites/prod/files/2014/05/f16/steam26a_condensing.pdf

[558] US DOE, "ADVANCED MANUFACTURING OFFICE Energy Tips: STEAM Steam Tip Sheet #26B." n.d. https://www.energy.gov/sites/prod/files/2014/05/f16/steam26b_condensing.pdf

[559] US DOE, "ADVANCED MANUFACTURING PROGRAM Energy Tips: STEAM Steam Tip Sheet #3 Use Feedwater Economizers for Waste Heat Recovery." n.d. https://www.energy.gov/sites/prod/files/2014/05/f16/steam3_recovery.pdf

[560] ECCCNYS 2020 Table C403.3.2(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers & Table C404.2: Minimum Performance of Water Heating Equipment. https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-ce-commercial-energy-efficiency

[561] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[562] California Database of Energy Efficient Resources (DEER). http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

[563] *2022 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 10.0: Volume 2* (2022), Pg 357. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

3.5.9 GAS CHILLERS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC
Baseline	Code
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023
Changes Since Last Version	• Corrected EFLHc nomenclature in parameter table

Description

This measure describes the energy savings resulting from installing a gas-fueled absorption chiller more efficient than code. The calculation of energy savings for C&I gas fired chillers and in time of sale and new construction applications is based on algorithms with key variables captured on the application form or from manufacturer's data sheets.

Note that this measure applies to only absorption chillers, in keeping with ASHRAE 90.1-2019 efficiency specifications. For other types of gas chillers, or complex cooling systems, consider using a custom analysis approach.

Baseline Case

Minimally code-compliant gas-fueled absorption chiller with a baseline efficiency as defined in ASHRAE 90.1-2019.

Efficient Case

A new efficient gas-fueled absorption chiller, more efficient than code.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = Cap \times (\frac{1}{COP_b} - \frac{1}{COP_q}) \times EFLH_c \times 10$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = N/A$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-147 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{winter}$	Annual winter fuel savings	Calculated	Therms/yr	
$Therms_{summer}$	Annual summer fuel usage	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
IR	Input rating	Site-specific	MMBtu/hr	
Cap	Cooling capacity of gas chiller	Site-specific	MMBtu/hr	
COP_b	Coefficient of performance of baseline unit	Site-specific, if unknown look up in Table 3-148	N/A	[565]
COP_q	Coefficient of performance of energy efficient unit	Site-specific	N/A	
$EFLH_c$	Equivalent full load hours, cooling	Look up in Appendix C:		
CF	Electric coincidence factor	Look up in Table 3-149	N/A	
PDF	Gas peak day factor	Look up in Table 3-149	N/A	
10	Unit conversion, Therms/MMBtu	10	Therms/MMBtu	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-148 Minimum Gas Chiller Efficiencies, AHRAE 90.1-2019

Equipment	Minimum COP
Air cooled absorption, single effect	0.6 FL
Water cooled absorption, single effect	0.7 FL
Absorption double effect, indirect fired	1.0 FL 1.05 IPLV
Absorption double effect, direct fired	1.0 FL 1.0 IPLV

Peak Factors

Table 3-149 Peak Factors

Peak Factor	Value
Electric coincidence factor (CF)	N/A
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors

Measure Life

The effective useful life (EUL) is 20 years [564].

References

[564] DEER 2014

[565] ASHRAE 90.1 2019 Table 6.8.1-3

3.5.10 ELECTRIC CHILLERS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	December 2022
Changes Since Last Version	• Updated measure to accommodate EREP baseline condition

Description

This prescriptive measure targets the use of electric chillers in all commercial facilities.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline chiller is a minimally code-compliant chiller with an efficiency as required by ASHRAE Std. 90.1 – 2019, which is the current code adopted by the state of New Jersey.

Baseline Case

New Construction/Replacement of Failed Equipment/End of Useful Life: Chiller compliant with ASHRAE Std. 90.1–2019.

Early replacement: Use dual baseline. Baseline is site-specific pre-existing equipment for first baseline period. Baseline is chiller compliant with ASHRAE Std. 90.1-2019 for second baseline period.

Efficient Case

Chiller with an efficiency greater than code.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Tons \times EFLH_c \times (IPLV_b - IPLV_q)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Tons \times CF \times (FLV_b - FLV_q)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-150 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Tons/Unit	Rated capacity of cooling equipment.	Site-specific	Tons	
$IPLV_b$	Integrated Part Load Value of baseline equipment, the efficiency of the chiller under partial-load conditions	TOS/NC: Look up in Table 3-151 EREP: Site-specific. If unknown, look up in Table 3-151	kW/ton	[567]
$IPLV_q$	Integrated Part Load Value of qualifying unit, the efficiency of the chiller under partial-load conditions	Site-specific	kW/ton	

Variable	Description	Value	Units	Ref
FLV_b	Full Load Value of baseline equipment, the efficiency of the chiller under full-load conditions	TOS/NC: Look up in Table 3-151 EREP: Site-specific. If unknown, look up in Table 3-151	kW/ton	[567]
FLV_q	Full Load Value of qualifying equipment, the efficiency of the chiller under full-load conditions	Site-specific	kW/ton	
$EFLH_c$	Equivalent Full Load Cooling Hours	Look up in Appendix C: Heating and Cooling EFLH	hr	[568]
CF	Electric coincidence factor	Table 3-152	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-151 Water-Chilling Minimum Efficiency, ASHRAE 90.1–2019 (Table 6.8.1-3)

Equipment Type	Size Category	Path A		Path B	
		FLV (kW/ton)	IPLV (kW/ton)	FLV (kW/ton)	IPLV (kW/ton)
Air Cooled	tons < 150	1.188	0.876	1.237	0.759
	tons > 150	1.188	0.857	1.237	0.745
Water Cooled Positive Displacement (rotary screw and scroll)	tons < 75	0.750	0.600	0.780	0.500
	75 +< tons < 150	0.720	0.560	0.750	0.490
	150 =< tons < 300	0.660	0.540	0.680	0.440
	300 =< tons < 600	0.610	0.520	0.625	0.410
	tons => 600	0.560	0.500	0.585	0.380
Water Cooled Centrifugal	tons < 150	0.610	0.550	0.695	0.440
	150 < tons < 300	0.610	0.550	0.635	0.400
	300 < tons < 400	0.560	0.520	0.595	0.390
	400 < tons < 600	0.560	0.500	0.585	0.380
	tons > 600	0.560	0.500	0.585	0.380

Notes:

1. Path A is generally used with equipment designed to maximize full load efficiency. Either Path A or Path B may be used to demonstrate compliance.
2. Path B is generally used with equipment designed to maximize part-load efficiency. Either Path A or Path B may be used to demonstrate compliance.
3. Typically, constant speed chillers use Path A values whereas variable speed chillers use Path B values.

Peak Factors

Table 3-152 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.67	[566]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 23 years. [569]

References

[566] New Jersey Board of Public Utilities, *New Jersey's Clean Energy Program Protocols to Measure Resource Savings: FY2022 Addendum*. (New Jersey Board of Public Utilities, 2022), pg 27.

[567] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-3. https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[568] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

[569] GDS Associates, Inc. 2007. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for the New England State Program Working Group (SPWG).

3.5.11 MAKE-UP AIR UNIT

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/DI
Baseline	Code/Dual
End Use	HVAC
Measure Last Reviewed	December 2022

Description

This section provides energy savings algorithms for make-up air systems in commercial applications. These systems utilize an indirect gas-fired process to heat 100% outside air (OA) to provide ventilation or make-up air to commercial and industrial spaces. The unitary package must contain an indirect gas-fired warm air furnace section.

The annual OA heating load per cfm of OA (Q_{OA}) was determined for each New Jersey location by scaling the heating load derived from the Illinois TRM V9.0 using heating degree days for each location.

The IL TRM Q_{OA} Values were determined based on hourly differences between a range of supply air temperatures (SAT) and outside air temperature (OAT) using TMY3 Data. 3 different base temperatures were used to calculate the heating loads, 45 °F, 55 °F, and 65 °F. The loads are then summed for the entire year.

To determine the appropriate value, follow the guidance below to use Table 3-154 through Table 3-166.

First, select the most representative operating schedule for the application from among the four scenarios listed below. Second, select the representative HDD base temperature. If that base temperature is not readily determined, select the TRM default base temperature of 55 °F (HDD55) for heating in C&I settings. Third, select the climate zone. Fourth, select an appropriate heated to supply air (SA) temperature. Use the resulting Q_{OA} value.

The four scenarios available are indicative of the following building applications and operating schedules:

1. 24-hour-a-day and 7-day-a-week (24/7) operation, with HVAC operating schedule of 8,760 hours per year, typical of large retail stores with DOAS, hotel/multifamily buildings with corridor MUAS, and healthcare facilities with DOAS. Use Table 3-155 through Table 3-157.
2. 6:00 AM to 1:00 AM every day operation, with HVAC operating schedule of 7,300 hours per year, typical of full service and quick service restaurants with kitchen MUAS. Use Table 3-158 through Table 3-160.
3. 7:00 AM to 9:00 PM Monday-Friday, 7:00 AM to 10:00 PM Saturday, and 9:00 AM to 7:00 PM Sunday operations, with HVAC operating schedule of 5,266 hours per year, typical of non-24/7 retail stores with DOAS. Use Table 3-161 through Table 3-163.
4. 7:00 AM to 9:00 PM Monday-Friday operation, with HVAC operating schedule of 3,911 hours per year, typical of school buildings with DOAS. Use Table 3-164 through Table 3-166.

Baseline Case

The baseline case is a make-up air unit that contains a non-condensing gas-fired warm air furnace compliant with ASHRAE Std. 90.1 – 2019 and IECC 2021.

Efficient Case

The efficient case is an efficient make-up air unit that contains a condensing gas-fired warm air furnace with a thermal efficiency higher than code.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \frac{t_{fan} \times CFM \times \Delta P}{Eff_{fan,motor} \times 8{,}520}$$

Annual Fuel Savings

$$\Delta Therms = \frac{Q_{OA} \times CFM \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right)}{100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{t_{fan}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-153 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
t_{fan}	Supply air fan runtime	Use one of the 4 scenarios in the description above	Hours	
CFM	Supply fan airflow	Site-specific	ft^3/min	
ΔP	Additional pressure drop of the condensing heat exchanger of warm air furnace section	-0.15	Inch w.g.	[570]
$Eff_{fan,motor}$	Combined fan and motor efficiency	0.6	N/A	[570]
8,520[125]	Conversion factor	8,520	N/A	
Q_{OA}	Annual outside air heating load per cfm of OA	Look up in Table 3-155 through Table 3-166	Btu/cfm	[570]
Eff_b	Baseline non condensing efficiency	Look up in Table 3-154	N/A	[571]
Eff_q	Efficient condensing efficiency	Site-specific. Use the same efficiency metric as Eff_b	N/A	
100,000	Conversion from Btu to therm	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 3-167	N/A	
PDF	Gas peak demand factor	Look up in Table 3-167	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

[125] Fan horsepower (HP) calculation constant of 6,356 for standard air conditions adjusted by 1 HP = 0.746 kW, or (6,356 / 0.746) = 8,520 for this kW calculation.

Table 3-154 Furnace Baseline Efficiencies

Furnace Type	Size Category (kBtu input)	Standard 90.1-2019
Gas Fired	< 225	Nonweatherized 80% AFUE Weatherized 81% AFUE
Gas Fired	≥ 225	81% Et
Oil Fired	< 225	Nonweatherized excluding mobile home 83% AFUE Nonweatherized mobile home 75% AFUE Weatherized 78% AFUE
Oil Fired	≥ 225	82% Et

Table 3-155 8760 Annual Operation Scenario for HDD45

t_{fan} = 8760 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	138,650	169,078	199,506	229,934
Southwest	123,809	150,980	178,151	205,322
Coastal	76,756	93,601	110,446	127,291
Central	117,464	143,242	169,021	194,800
Pine Barrens	115,338	140,651	165,962	191,275
Statewide Average	115,016	140,258	165,499	190,741

Table 3-156 8760 Hour Annual Operation Scenario for HDD55

t_{fan} = 8760 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	182,976	227,595	272,214	316,833
Southwest	166,370	206,940	247,510	288,079
Coastal	125,238	155,777	186,317	216,856
Central	162,154	201,695	241,236	280,777
Pine Barrens	160,335	199,433	238,531	277,628
Statewide Average	160,051	199,079	238,108	277,136

Table 3-157 8760 Hour Annual Operation Scenario for HDD65

t_{fan} = 8760 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	218,007	280,807	343,606	406,405
Southwest	201,016	258,922	316,827	374,732
Coastal	170,353	219,425	268,498	317,570
Central	198,527	255,715	312,904	370,091
Pine Barrens	196,445	253,034	309,623	366,211
Statewide Average	197,376	254,232	311,089	367,945

Table 3-158 7300 Annual Operation Scenario for HDD45

t_{fan} = 7300 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	111,241	135,739	160,237	184,734
Southwest	99,334	121,210	143,085	164,960
Coastal	61,583	75,145	88,707	102,268
Central	94,243	114,998	135,752	156,506
Pine Barrens	92,538	112,917	133,296	153,674
Statewide Average	92,280	112,602	132,924	153,245

Table 3-159 7300 Annual Operation Scenario for HDD55

t_{fan} = 7300 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	146,885	182,811	218,738	254,664
Southwest	133,554	166,220	198,886	231,552
Coastal	100,535	125,125	149,715	174,305
Central	130,169	162,007	193,845	225,683
Pine Barrens	128,709	160,190	191,671	223,152
Statewide Average	128,481	159,906	191,331	222,756

Table 3-160 7300 Annual Operation Scenario for HDD65

t_{fan} = 7300 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	174,841	225,198	275,554	325,911
Southwest	161,214	207,647	254,079	300,512
Coastal	136,622	175,972	215,321	254,671
Central	159,218	205,075	250,932	296,790
Pine Barrens	157,549	202,925	248,301	293,678
Statewide Average	158,295	203,886	249,477	295,069

Table 3-161 5266 Annual Operation Scenario for HDD45

t_{fan} = 5266 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	76,284	93,254	110,223	127,194
Southwest	68,118	83,272	98,425	113,579
Coastal	42,231	51,625	61,019	70,414
Central	64,627	79,004	93,381	107,758
Pine Barrens	63,458	77,575	91,691	105,808
Statewide Average	63,281	77,358	91,435	105,513

Table 3-162 5266 Annual Operation Scenario for HDD55

t_{fan} = 5266 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	100,163	124,786	149,408	174,031
Southwest	91,073	113,461	135,848	158,237
Coastal	68,557	85,409	102,262	119,115
Central	88,765	110,585	132,405	154,226
Pine Barrens	87,769	109,345	130,920	152,496
Statewide Average	87,614	109,151	130,688	152,226

Table 3-163 5266 Annual Operation Scenario for HDD65

t_{fan} = 5266 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	119,326	153,797	188,268	222,738
Southwest	110,026	141,810	173,595	205,378
Coastal	93,242	120,178	147,114	174,049
Central	108,663	140,054	171,445	202,835
Pine Barrens	107,524	138,586	169,647	200,708
Statewide Average	108,033	139,242	170,451	201,659

Table 3-164 3911 Annual Operation Scenario for HDD45

t_{fan} = 3911 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	54,942	67,170	79,398	91,626
Southwest	49,061	59,980	70,900	81,819
Coastal	30,416	37,185	43,955	50,724
Central	46,546	56,906	67,266	77,625
Pine Barrens	45,704	55,876	66,049	76,221
Statewide Average	45,577	55,720	65,865	76,008

Table 3-165 3911 Annual Operation Scenario for HDD55

t_{fan} = 3911 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	72,525	90,433	108,340	126,247
Southwest	65,943	82,225	98,507	114,789
Coastal	49,640	61,896	74,153	86,410
Central	64,272	80,141	96,011	111,880
Pine Barrens	63,551	79,242	94,934	110,625
Statewide Average	63,438	79,102	94,766	110,429

Table 3-166 3911 Annual Operation Scenario for HDD65

t_{fan} = 3911 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75ºF	85ºF	95ºF	105ºF
Northern	87,018	112,390	137,763	163,136
Southwest	80,236	103,631	127,026	150,422
Coastal	67,996	87,823	107,649	127,476
Central	79,242	102,348	125,453	148,559
Pine Barrens	78,411	101,275	124,138	147,001
Statewide Average	78,782	101,754	124,725	147,697

Peak Factors

Table 3-167 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	[570]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-168 Measure Life

Equipment	EUL	RUL	Ref
Make-up Air Unit	15	5	[572]

References

[570] *2022 Illinois Statewide Technical Reference Manual for Energy Efficiency V10: Volume 2 Commercial and Industrial Measures*. (2021), Pg 405-412, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf.

[571] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards.

[572] DEER 2014 EUL http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx.

3.5.12 HEAT OR ENERGY RECOVERY VENTILATOR

Market	Commercial/Multifamily
Baseline Condition	NC/RF/TOS
Baseline	Code/Existing
End Use Subcategory	Heat Recovery
Measure Last Reviewed	January 2023

Description

This measure covers the installation of Energy Recovery Ventilators (ERV) and Heat Recovery Ventilators (HRV). ERVs and HRVs reduce heating and cooling loads while maintaining required ventilation rates by facilitating heat transfer between outgoing conditioned air and incoming outdoor air. ERVs and HRVs employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of pre-conditioning outdoor air prior to supplying the conditioned air to the space, either directly or as part of an air-conditioning system. For new construction, this measure only applies in cases where ERV/HRV functionality is not required by federal, state, local or municipal codes or standards. This measure is also applicable to retrofit of existing buildings. For the purposes of this measure, ERVs and HRVs are distinguished as follows:

- Energy Recovery Ventilator (ERV): Transfers both sensible (heat content) and latent (moisture content) heat between supply and exhaust airstreams.
- Heat Recovery Ventilator (HRV): Transfers sensible heat only between supply and exhaust airstreams.

Baseline Case

The baseline condition for this measure is a commercial or multifamily high-rise building with an ASHRAE 62.2-compliant exhaust fan system with no heat or energy recovery.

Efficient Case

The compliance condition for this measure is a commercial or multifamily high-rise building with an ASHRAE 62.2-compliant exhaust fan system equipped with AHRI certified ERV or HRV components.

Annual Energy Savings Algorithms

Note: Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in Appendix E: Code-Compliant Efficiencies.

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_c + \Delta kWh_h + \Delta kWh_{fan}$$

Cooling energy savings:

For ERVs:

$$\Delta kWh_c = \frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,c} - H_{indoor,c}\right)}{1{,}000 \times Eff_{elec,c}} \times hrs_c$$

For HRVs:

$$\Delta kWh_c = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{outdoor,c} - T_{indoor,c}\right)}{1{,}000 \times Eff_{elec,c}} \times hrs_c$$

Heating energy savings (both ERVs and HRVs):

$$\Delta kWh_h = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,h} - T_{outdoor,h}\right)}{1{,}000 \times HSPF2} \times F_{ElecHeat} \times hrs_h$$

Fan energy savings:

$$\Delta kWh_{fan} = \left(kW_{fan,b} - kW_{fan,q}\right) \times (hrs_h + hrs_c)$$

Calculate baseline and qualifying fan kW as follows.[126] Use first equation if values are known, otherwise use second equation:

$$kW_{fan} = \sum \left(\frac{CFM \times \Delta P}{33{,}013/5.202 \times Eff_{fan,mech} \times Eff_{fan,motor}} \times 0.746 \right)$$

$$kW_{fan} = \sum \left(\frac{HP \times LF}{Eff_{fan,motor}} \times 0.746 \right)$$

Annual Fuel Savings

$$\Delta Therms = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,h} - T_{oudoor,h}\right)}{100{,}000 \times Eff_{fuel,h}} \times F_{FuelHeat} \times hrs_h$$

Summer Peak Demand Savings

For ERVs:

$$\Delta kW_{Peak} = \left(\frac{4.5 \times CFM \times Eff_{hx,total} \times (H_{outdoor,c,peak} - H_{indoor,c})}{1{,}000 \times EER2} + (kW_{fan,b} - kW_{fan,q}) \right) \times CF$$

For HRVs:

$$\Delta kW_{Peak} = \left(\frac{1.08 \times CFM \times Eff_{hx,sense} \times (T_{outdoor,c,peak} - T_{indoor,c})}{1{,}000 \times EER2} + (kW_{fan,b} - kW_{fan,q}) \right) \times CF$$

[126] Represents total electric power of ERV/HRV supply and exhaust fans (kW). Sigma operator included to indicate that this term shall include consideration of all ERV/HRV fans.

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Lif} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-169 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_{c}	Annual electric energy savings during cooling season	Calculated	kWh	
ΔkWh_{h}	Annual electric energy savings during heating season	Calculated	kWh	
ΔkWh_{fan}	Annual electric energy savings due to fan operation	Calculated	kWh	
$kW_{fan,b}$	Total electric power of baseline supply and exhaust fans	Calculated	kW	
$kW_{fan,q}$	Total electric power of efficient supply and exhaust fans	Calculated	kW	
CFM	Volume of supply air	Site-specific	Ft^3/min	
$Eff_{hx,total}$	Total effectiveness of heat exchanger per rating in accordance with AHRI Standard 1060	Site-specific	N/A	[573]
$Eff_{hx,sens}$	Sensible effectiveness of heat exchanger per rating in accordance with AHRI Standard	Site-specific	N/A	[573]

Variable	Description	Value	Units	Ref
$Eff_{elec,c}$	Seasonal average energy efficiency of electric cooling equipment (SEER or IEER)	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies for equipment type and size	Btu/watt-hour	[574]
EER2	Energy efficiency ratio of electric cooling equipment[127]	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies for equipment type and size	Btu/watt-hour	
HSPF2	Heating seasonal performance factor of electric heating equipment[128]	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies for equipment type and size	Btu/watt-hour	
$Eff_{fuel,h}$	Efficiency of fossil fuel heating equipment (AFUE, E_t or E_c)	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies for equipment type and size	N/A	
$T_{indoor,h}$	Indoor heating setpoint temperature	Site-specific, if unknown use 70°F	°F	
$T_{indoor,c}$	Indoor cooling setpoint temperature	Site-specific, if unknown use 70°F	°F	
H_{indoor}	Enthalpy of indoor air	Look up in Table 3-170 based on T_{indoor}	Btu/lb	
$Eff_{fan,mech}$	Mechanical efficiency of ERV fans	Site-specific, if unknown use 0.67	N/A	[575]
$Eff_{fan,motor}$	Efficiency of ERV fan motors	Site-specific, if unknown use 0.7[129]	N/A	[576]
ΔP	Pressure drop at nominal airflow in the ERV as rated in accordance with AHRI Standard 1060	Site-specific	Inches of H_2O	
HP	Total fan horsepower	Site-specific	HP	
LF	Load factor	Site-specific, if unknown use 0.92	N/A	[581]
hrs_c	Operating hours in the cooling season	Look up in Table 3-171	hrs	[579]
hrs_h	Operating hours in the heating season	Look up in Table 3-171	hrs	[579]
$H_{outdoor,c}$	Enthalpy of outside air during cooling	**Look up in** Table 3-172	Btu/lb	[580]
$H_{outdoor,h}$	Enthalpy of outside air during heating	**Look up in** Table 3-172	Btu/lb	[580]
$T_{outdoor,c}$	Avg. outdoor temperature during cooling season.	**Look up in** Table 3-172	°F	[580]
$T_{outdoor,h}$	Avg. outdoor temperature during heating season	**Look up in** Table 3-172	°F	[580]

[127] If needed, calculate EER as follows:
$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$
[128] If needed, convert COP to HSPF as follows:
$HSPF = COP \times 3.412$
[129] Based on ¼ hp, 4-pole polyphase motor. 10 CFR 431.446

Variable	Description	Value	Units	Ref
$T_{outdoor,c,peak}$	Peak outdoor temperature during cooling season	Look up in Table 3-173	°F	[582]
$H_{outdoor,c,peak}$	Peak Enthalpy of outdoor air during cooling season	Look up in Table 3-173	°F	[582]
$F_{ElecHeat}$	Electric heating factor, to account for presence of electric heat	Use 1 if electric heat, otherwise use 0	N/A	
$F_{FuelHeat}$	Fuel heating factor, to account for presence of fuel heat	Use 1 if fuel heat, otherwise use 0	N/A	
1.08	Specific heat of air × density of inlet air @ 70°F × 60 min/hr	1.08	BTU/h.°F.CFM	
4.5	Density of inlet air at 70 °F x 60 min/hr	4.5	$Lb.min/ft^3.hr$	
60	Minutes per hour	60	Min/hr	
1,000	Conversion factor, one kW equals 1,000 Watts	1,000	kW/W	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
0.746	Conversion from horsepower to kW	0.746	kW/HP	
33,013	Conversion factor from horsepower to ft.lb/min	33,013	(ft.lb/min)/ hp	
5.202	Conversion factor from inches of water to pounds per square ft	5.202	$lb/ft^2)/ inH_2O$	
CF	Electric coincidence factor	Look up in Table 3-174	N/A	
PDF	Gas peak day factor	Look up in Table 3-174	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-170 Indoor Enthalpy

Temperature, T_{indoor} (°F)	Enthalpy, H_{indoor} at 50% Relative Humidity (Btu/lb)
65	22.7
66	23.2
67	23.7
68	24.2
69	24.8
70	25.3
71	25.8
72	26.4

Temperature, T_{indoor} (°F)	Enthalpy, H_{indoor} at 50% Relative Humidity (Btu/lb)
73	27.0
74	27.5
75	28.1
76	28.7
77	29.3
78	29.9

Table 3-171 Heating and Cooling Hours[130]

NJ Climate Region	Heating Hours, hrs_h	Cooling Hours, hrs_c
Northern	4,970	1,670
Southwest	4,896	1,783
Coastal	4,981	1,954
Central	4,969	1,810
Pine Zones	4,899	1,828
Statewide Average	4,953	1,820

Table 3-172 Outdoor Air Temperature and Enthalpy[131]

NJ Climate Region	Relative Humidity[132] (%)	Avg. outdoor temperature[133] during cooling season, $T_{outdoor,c}$ (°F)	Avg. outdoor temperature[133] during heating season, $T_{outdoor,h}$ (°F)	Avg enthalpy[134] of outdoor air at duing cooling season, $H_{outdoor,c}$ (Btu/lb)	Avg enthalpy[134] of outdoor air at duing cooling season, $H_{outdoor,c}$ (Btu/lb)
Northern	69.77	74.60	42.10	32.05	14.39
Southwest	67.39	74.50	42.70	31.51	14.49

130 Calculated from TMY3 data for representative weather stations for each NJ climate zone. Cooling hours are defined as any hour when outdoor air temperature is above 65°F for the months of June through August and heating hours are defined as any hour when outdoor air temperature is below 65°F for the months of October through April. The heating and cooling hours above represent the count of each in a typical meteorological year. Note: these values may over-estimate hours for buildings with limited operating hours such as offices, schools, etc. Site-specific estimate should be used when possible.

132 Average of NOAA hourly relative humidity from January 2020 – December 2022 for each climate zone representative weather station (Northern = Allentown, PA; Southern = Philadelphia, PA; Coastal = Atlantic City, NJ; Central = Trenton, NJ; Pine Barrens = McGruire Air Force Base, NJ)

133 Calculated from TMY3 data for representative weather stations for each NJ climate zone. Cooling hours are defined as any hour when outdoor air temperature is above 65°F for the months of June through August and heating hours are defined as any hour when outdoor air temperature is below 65°F for the months of October through April. The average heating and cooling temperatures are the average temperature of these hours for the typical meteorological year.

134 Calculated via ASHRAE Dayton's online psychometric tool, using the average NJ elevation of 228 ft above sea level. https://daytonashrae.org/psychrometrics/psychrometrics_imp.html#start

NJ Climate Region	Relative Humidity[132] (%)	Avg. outdoor temperature[133] during cooling season, $T_{outdoor,c}$ (°F)	Avg. outdoor temperature[133] during heating season, $T_{outdoor,h}$ (°F)	Avg enthalpy[134] of outdoor air at duing cooling season, $H_{outdoor,c}$ (Btu/lb)	Avg enthalpy[134] of outdoor air at duing cooling season, $H_{outdoor,c}$ (Btu/lb)
Coastal	74.63	73.00	46.20	31.87	16.47
Central	75.77	74.30	43.20	33.09	15.23
Pine Barrens	74.34	73.70	43.40	32.33	15.22
Statewide Average	72.61	73.91	43.82	32.14	15.31

Table 3-173 Peak Outdoor Air Temperature and Enthalpy

NJ Climate Region	Peak outdoor temperature during cooling season, $T_{outdoor,c,peak}$ (°F)	Peak Enthalpy of outdoor air at duing cooling season, $H_{outdoor,c,peak}$ (Btu/lb)
Northern	89	40.24
Southwest	93	42.28
Coastal	90	41.26
Central	93	42.28
Pine Barrens	94	41.22
Statewide Average	91	41.32

Peak Factors

Table 3-174 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[577]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 14 years[578].

References

[573] *Performance Rating of air-to-air exchanges for Energy Recovery Ventilation Equipment*, (AHRI, 2018). https://www.ahrinet.org/sites/default/files/2022-06/AHRI_Standard_1061_SI_2018.pdf

[574] 10 CFR 430.32 (c)(1) , December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

[575] ASHRAE 90.1 2013, Section 6.5.3.1.3, June 2014. http://arkanarzesh.com/wp-content/uploads/2016/09/ASHRAE%2090.1-2013%20%20-IP.pdf

[576] 10 CFR 431.446 , December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431

[577] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, and supported by research conducted by Cadmus on behalf of the RM Management Committee, September 2011.

[578] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report, August 2009 https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

[579] ONJSC: Monthly/Annual Temperature Normals (1991-2020), December 2022 http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html.

[580] NSRDB, TMY3 data, December 2022. https://nsrdb.nrel.gov/data-sets/tmy

[581] *Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors*, Cascade Energy, November 5, 2012. Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012

[582] ASHRAE Fundamentals 2021 - Chapter 14 Climactic Design Conditions - https://handbook.ashrae.org/Handbook.aspx#

3.5.13 DEMAND CONTROLLED VENTILATION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

Maintaining acceptable air quality requires standard ventilation systems designers to determine ventilation rates based on maximum estimated occupancy levels and published CFM/occupant requirements. During low occupancy periods, this approach results in higher ventilation rates than are required to maintain acceptable levels of air quality. This excess ventilation air must be conditioned and therefore results in wasted energy.

Building occupants exhale CO_2, and the CO_2 concentration in the air increases in proportion to the number of occupants. The CO_2 concentration provides a good indicator of overall air quality. Demand control ventilation (DCV) systems monitor indoor air CO_2 concentrations and use this data to automatically modulate dampers and regulate the amount of outdoor air that is supplied for ventilation. DCV is most suited for facilities where occupancy levels are known to fluctuate considerably.

Saving factors were calculated based on IL TRM values for Chicago, adjusted by ratio of Degree Days for each listed NJ Climate Zone and Chicago, based on TMY 3 Data using base 65 F balance point. See the ‘Demand Controlled Ventilation’ Section of the Illinois Statewide Technical Reference Manual V11 for further explanation [583].

Baseline Case

The baseline system is an existing cooling and heating systems with no demand control ventilation or ventilation heat recovery equipment installed.

Efficient Case

The compliance condition is a DCV system added to the return air system to supply air based on occupancy demands.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{A}{1{,}000} \times SF_{ElecCool} + \frac{A}{1{,}000} \times SF_{ElecHeat} \times F_{ElecHeat}$$

Annual Fuel Savings

$$\Delta Therms = \frac{A}{1{,}000} \times SF_{fuel} \times F_{FuelHeat}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-175 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
A	Total area square footage of the conditioned space impacted by the measure	Site-specific	Ft^2	
$SF_{ElecCool}$	DCV energy savings factor for cooling	Look up in Table 3-176	kWh/1,000 ft^2	[583]
$SF_{ElecHeat}$	DCV energy savings factor for electric heating	Look up in Table 3-177, Table 3-178	kWh/1,000 ft^2	[583]
$F_{elecHeat}$	Electric heating factor, used to account for the presence or absence of an electric heating system	1 (if electric heat) 0 (otherwise)	N/A	
SF_{Fuel}	DCV fuel savings factor for heating	Look up in Table 3-179	Therms/1,000 ft^2	[583]

Variable	Description	Value	Units	Ref
$F_{FuelHeat}$	Fuel heating factor, used to account for the presence or absence of a fossil fuel heating system	1 (if fossil fuel heat) 0 (otherwise)	N/A	
CF	Electric coincidence factor	Look up in Table 3-180	N/A	
PDF	Gas peak day factor	Look up in Table 3-180	N/A	
10	Unit conversion, Therm/MMBtu	10	Therm/MMBtu	
EUL	Effective useful life	See Measure Life Section	Years	[584]

Table 3-176 Energy Savings Factor for Cooling (kWh/1,000 ft²)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average[135]
Office - Low-rise (1 to 3 Stories)	267	362	368	366	359	334
Office - Mid-rise (4 to 11 Stories)	211	286	291	289	283	264
Office - High-rise (12+ Stories)	250	340	345	344	337	314
Religious Building	720	978	994	989	970	903
Restaurant	471	640	650	647	634	590
Retail - Department Store	363	493	501	498	489	455
Retail - Strip Mall	251	341	347	345	338	315
Convenience Store	330	448	455	453	444	413
Elementary School	339	460	468	465	456	425
High School	332	450	457	455	446	415
College/ University	393	534	543	540	530	493
Healthcare Clinic	327	444	451	449	440	410
Lodging (Hotel/Motel)	378	513	521	518	508	473
Manufacturing	163	222	226	224	220	205
Special Assembly Auditorium	537	729	740	737	722	672
Other	356	483	491	488	479	446
Enclosed Parking Garage	854	1,160	1,179	1,173	1,150	1070

[135] Weighted average based on NJ climate zone distribution.

Table 3-177 Electric Heating Savings with Heat Pump (kWh/1,000 ft²)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average[135]
Office - Low-rise (1 to 3 Stories)	185	149	163	158	163	167
Office - Mid-rise (4 to 11 Stories)	125	100	110	106	109	112
Office - High-rise (12+ Stories)	167	135	147	143	147	151
Religious Building	1,206	970	1,062	1,028	1,057	1,087
Restaurant	870	700	767	742	763	785
Retail - Department Store	298	239	262	254	261	268
Retail - Strip Mall	194	156	171	166	171	175
Convenience Store	147	119	130	126	129	133
Elementary School	517	416	456	441	454	467
High School	505	406	445	430	443	455
College/ University	1007	811	888	859	884	909
Healthcare Clinic	358	288	316	305	314	323
Lodging (Hotel/Motel)	166	134	147	142	146	150
Manufacturing	103	83	91	88	90	93
Special Assembly Auditorium	1,414	1,138	1,246	1,207	1,241	1,276
Other	484	389	426	413	424	436
Enclosed Parking Garage	185	149	163	158	163	167

Table 3-178 Electric Heating Savings with Electrical Resistance (kWh/1,000 ft²)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	556	448	490	474	488	493
Office - Mid-rise (4 to 11 Stories)	374	301	329	319	328	331
Office - High-rise (12+ Stories)	501	403	441	427	439	443
Religious Building	3617	2910	3186	3085	3172	3202
Restaurant	2610	2100	2300	2226	2289	2311
Retail - Department Store	893	718	786	761	783	790
Retail - Strip Mall	584	470	515	498	512	517

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Convenience Store	441	355	389	376	387	391
Elementary School	1551	1248	1367	1323	1360	1374
High School	1513	1218	1333	1291	1327	1340
College/ University	3022	2432	2662	2577	2650	2676
Healthcare Clinic	1074	865	947	916	942	952
Lodging (Hotel/Motel)	498	401	439	425	437	441
Manufacturing	310	250	273	265	272	275
Special Assembly Auditorium	4242	3414	3738	3619	3721	3757
Other	1452	1169	1280	1239	1274	1286

Table 3-179 Fuel Heating Savings (therms/1000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	24	19	21	20	21	21
Office - Mid-rise (4 to 11 Stories)	16	13	14	14	14	14
Office - High-rise (12+ Stories)	22	17	19	19	19	19
Religious Building	155	124	136	132	136	137
Restaurant	111	90	98	95	98	99
Retail - Department Store	38	31	33	32	33	33
Retail - Strip Mall	25	20	22	22	22	22
Convenience Store	19	15	17	16	17	17
Elementary School	66	53	58	56	58	58
High School	64	52	57	55	56	57
College/ University	129	104	114	110	113	114
Healthcare Clinic	46	37	41	39	40	41
Lodging (Hotel/Motel)	21	17	18	18	18	18
Manufacturing	14	11	12	12	12	12
Special Assembly Auditorium	181	146	159	154	159	160
Other	61	49	54	52	54	54

Peak Factors

Table 3-180 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

Use the smaller of the measure life (10 yr) or the remaining useful life (RUL) of host equipment [584]. If applied to a packaged HVAC system, the RUL of the host equipment is 5 years.

References

[583] *2023 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 11 Volume 2: Commerical and Industrial Measures* (September 2022), Pg 357, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010123_v11.0_Vol_2_C_and_I_092222_FINAL.pdf

[584] ERS (2005). *Measure Life Study prepared for The Massachusetts Joint Utilities*.

3.5.14 DEMAND CONTROLLED KITCHEN VENTILATION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

Installation of variable speed drives (VSD) on commercial kitchen exhaust fans and make-up air fans allows the variation of ventilation based on cooking load and/or time of day. This measure is targeted to non-residential customers whose kitchen exhaust fans and make-up air fans are equipped with a VSD that varies the exhaust rate of kitchen ventilation based on the energy and effluent output from the cooking appliances (i.e., the more heat and smoke/vapors generated, the more ventilation needed). This involves installing a temperature sensor in the hood exhaust collar and/or an optic sensor on the end of the hood that sense cooking conditions which allows the system to automatically vary the rate of exhaust to what is needed by adjusting the fan speed.

Baseline Case

The baseline equipment is a constant speed commercial kitchen ventilation system.

Efficient Case

The energy efficient condition is a commercial kitchen ventilation system equipped with a VSD and demand ventilation controls and sensors.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{fan} + \Delta kWh_{cooling}$$

$$\Delta kWh_{fan} = \left(\frac{CFM}{1400}\right) \times Hours \times Days \times Weeks \times \sum_{0\%}^{100\%} \%FF \times PLR$$

$$\Delta kWh_{cooling} = SF_{cool} \times \%MUA_{cool} \times \Delta kWh_{fan}$$

Annual Fuel Savings

$$\Delta Therms = SF_{heat} \times \Delta kWh_{fan} \times 10$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{\Delta kWh}{Hours \times Days \times Weeks}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Lif} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-181 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
CFM	Uncontrolled design hood exhaust flow in cubic feet per minute.	Site-specific If actual flow is unknown, estimate flow from hood dimensions. For unlisted hoods estimate 100 CFM per square foot of plan area. For UL listed hoods estimate 250 CFM per length of hood in feet.	cfm	[588]
1,400	Estimation of CFM delivered per kW consumed from both exhaust and make-up air fan motor	1,400	Cfm/kW	[586]
Hours	Hours per day hood is operated	Site-specific, if actual hours are unknown assume 5 hours per meal served.	hrs	[588]
Days	Number of days kitchen is in operation per week	Site-specific	Days	

Variable	Description	Value	Units	Ref
Weeks	Number of weeks kitchen is in operation	Site-specific, if actual weeks are unknown assume 50 weeks per year.	Weeks	[588]
%FF	Percentage of run-time spent within a given flow fraction range	Site-specific, if actual values unknown assume 30% of time at full flow, 30% of time at 75% flow, and 40% of time at 50% flow	N/A	[588]
PLR	Part load ratio for a given flow fraction range	Look up Table 3-182	N/A	[588]
SF_{cool}	Cooling savings factor	0.471	N/A	[587]
$\%MUA_{cool}$	During the cooling season, the percentage of make-up air that is conditioned	If kitchen is cooled, then %MUA = 1.0. If kitchen is not cooled, then must calculate the percentage of make-up air that is being pulled from the dining room or other conditioned space. = If actual value is unknown, then assume 30%, or 0.3.	N/A	[588]
SF_{heat}	Heating savings factor	Lookup Table 3-183. If percent of make-up air from dining room is unknown, assume 30% from dining room	MMBtu/kWh	[587] [588]
CF	Electric coincidence factor	Look up in Table 3-184	N/A	
PDF	Gas peak day factor	Look up in Table 3-184	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-182 Part Load Ratios by Control and Fan Type and Flow Fraction (PLR)

Control Type	Flow Fraction									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
VFD	0.09	0.10	0.11	0.15	0.20	0.28	0.41	0.57	0.77	1.00

Table 3-183 Heating Savings Factor (SF_{Heat})

Percent of Make-up Air from Nearby Conditioned Space (Dining Room)	Make-up Air Directly Supplied to Kitchen is NOT Heated	Make-up Air Directly Supplied to Kitchen is Heated
0%	0	0.0088
10%	0.0013	0.0093
20%	0.0026	0.0097
30%	0.0039	0.0101
40%	0.0042	0.0105

Percent of Make-up Air from Nearby Conditioned Space (Dining Room)	Make-up Air Directly Supplied to Kitchen is NOT Heated	Make-up Air Directly Supplied to Kitchen is Heated
50%	0.0065	0.0109
60%	0.0078	0.0113
70%	0.0091	0.0118
80%	0.0104	0.0122
90%	0.0117	0.0126
100%	0.0130	0.0130

Peak Factors

Table 3-184 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0 if kitchen operates during dinner 0.0 if the kitchen does not operate during dinner	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 15 years. [585]

References

[585] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

[586] Estimation of CFM delivered per kW consumed from both exhaust and make-up air fan motor. Derived from proprietary Navigant DCKW tool.

[587] Savings factor calculated from proprietary Navigant DCKW tool using TMY3 temperature data from Baltimore, MD. The tool does a bin hour calculation of the cooling energy required to condition make-up air.

[588] *Mid-Atlantic Technical Reference Manual: Version 10* (May 2020), https://neep.org/mid-atlantic-technical-reference-manual-trm-v10, Pg 404

3.5.15 DESTRATIFICATION FAN

Market	Commercial
Baseline Condition	NC/RF
Baseline	ISP/Existing
End Use Subcategory	HVAC
Measure Last Reviewed	September 2024
Changes Since Last Version	• Corrected parameter nomenclature in algorithms and corresponding definitions

Description

This measure applies to buildings with high bay ceiling construction without fans currently installed for the purpose of destratifying air. Air stratification leads to higher temperatures at the ceiling and lower temperatures at the ground. During the heating season, destratification fans improve air temperature distribution in a space by circulating warmer air from the ceiling back down to the floor level, thereby enhancing comfort and saving energy. Energy savings are realized by a reduction of heat loss through the roof-deck and walls as a result of a smaller temperature differential between indoor temperature and outdoor air. This measure does not attempt to quantify savings from shorter heating system runtimes due to air mixing.

Limitations

- For use in conditioned, high bay structures. Recommended minimum ceiling height of 20 ft.
- This measure should only be applied to spaces in which the ceiling is subject to heat loss to outdoor air (i.e., single story or top floor spaces) and where there is sufficient space to allow for appropriate spacing of the fans. Other applications require custom analysis.
- Installation must follow manufacturer recommendations sufficient to effectively destratify the entire space.
- Measure does not currently support facilities with night setbacks on heating equipment. Custom analysis is needed in this case.
- Certain heating systems may not be a good fit for destratification fans, such as locations with: high velocity vertical throw unit heaters, radiant heaters, and centralized forced air systems. In these cases, measured evidence of stratification should be confirmed, and custom analysis may be necessary.

Baseline Case

No destratification fans or other means to effectively mix indoor air.

Efficient Case

High Volume, Low Speed (HVLS) fans with a minimum diameter of 14 ft with Variable Speed Drive (VSD) installed.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_h - kWh_{fan}$$

In all cases:

$$kWh_{fan} = W_{fan} \times hrs_{fan}$$

If building is electricially heated:

$$\Delta kWh_h = \frac{(\Delta Q_r + \Delta Q_w) \times hrs_{heat} \times 29.31}{100{,}000 \times COP}$$

Where,

$$\Delta Q_r = \frac{1}{R_r} \times A_r \times \left(T_{r,s} - T_{r,d}\right)$$

$$\Delta Q_w = \frac{1}{R_w} \times A_w \times (T_{w,s} - T_{w,d})$$

$$T_{r,s} = m_s \times h_r + (T_{stat} - m_s \times h_{stat})$$

$$T_{r,d} = T_{stat} + 1$$

$$T_{w,s} = m_s \times \frac{h_r}{2} + (T_{stat} - m_s \times h_{stat})$$

$$T_{w,d} = T_{stat} + 0.5$$

If building is not electricially heated:

$$\Delta kWh_h = 0$$

Annual Fuel Savings

$$\Delta Therms = \frac{(\Delta Q_r + \Delta Q_w) \times hrs_{heat}}{100{,}000 \times Eff}$$

Annual Peak Demand Savings

$$\Delta kWh_{peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-185 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_h	Savings due to reduced heat loss from air destratification (if building is electrically heated)	Calculated	kWh	
kWh_{fan}	Annual electric consumption of fan	Calculated	kWh	
ΔQ_r	Heat loss reduction through the roof due to the destratification fan	Calculated	Btu/hr	
ΔQ_w	Heat loss reduction through the exterior walls due to destratification fan	Calculated	Btu/hr	
$T_{w,s}$	Average indoor air temperature for wall heat loss, stratified case	Calculated	°F	[589]
$T_{w,d}$	Average indoor air temperature for wall heat loss, destratified case	Calculated	°F	[589]
W_{fan}	Rated fan wattage	Site-specific	W	
hr_{fan}	Annual fan operating hours	Site-specific, if unknown look up in Appendix D: HVAC Fan and Pump Operating Hours		
$T_{r,s}$	Indoor temperature at roof deck, stratified case	Site-specific or calculated	°F	[589]
$T_{r,d}$	Indoor temperature at roof deck, destratified case	Site-specific or calculated	°F	[589]

Variable	Description	Value	Units	Ref
COP	Heating efficiency of electric heating system	Site-specific, calculate if needed: COP = HSPF/3.413	N/A	[589]
Eff	Fuel heating system efficiency	Site-specific	N/A	[589]
R_r	Overall thermal resistance through the roof	**Site-specific, if unknown look up in** Table 3-186	Hr*ft2*F/Btu	[589]
A_r	Roof area	Site-specific	Ft2	[589]
R_w	Overall thermal resistance through the exterior walls	**Site-specific, if unknown look up in** Table 3-186	Hr*ft2*F/Btu	[589]
A_w	Area of exterior walls	Site-specific	Ft^2	[589]
h_r	Ceiling height/roof deck	Site-specific	ft	[589]
T_{stat}	Temperature set point at the thermostat	Site-specific	°F	[589]
h_{stat}	Vertical distance between the floor and the thermostat	Site-specific, if unknown use 5	Ft	[589]
m_s	Estimated heat gain per foot elevation, stratified case	0.8	F/ft	[589]
Hrs_{heat}	Total annual heating hours	Site-specific, if unknown look up in Table 3-187	Hours	[589]
29.31	Conversion factor	29.31	kWh/therm	[589]
100,000	Conversion factor	100,000	Btu/therm	[589]
PDF	Peak day factor	Look up in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	[589]

Table 3-186 Thermal Resistance Factors

Location	Retrofit	New Construction
Roof (Rr)	15.0	30.0
Wall (Rw)	6.5	13.0

Table 3-187 Annual Heating Hours by Climate Zone

Climate Zone	Annual Heating Hours[136]
Northern	4,970
Southwest	4,896
Coastal	4,981
Central	4,969
Pine Barrens	4,899
Statewide Average	**4,955**

Peak Factors

Table 3-188 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A: No peak demand savings because no savings from cooling	[589]
Natural gas peak day factor (PDF)	Look up in Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 10 years [589].

References

[589] Illinois TRM v11, Destratification Fan, pg. 424. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010123_v11.0_Vol_2_C_and_I_092222_FINAL.pdf

[136] Annual heating hours calculated as the total number of hours colder than 65°F for each climate zone, using representative climate stations and TMY3 weather data.

3.5.16 DUCT SEALING AND DUCT INSULATION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Category	HVAC
Measure Last Reviewed	January 2023
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure describes evaluating the savings associated with performing duct sealing using mastic sealant, metal tape or aerosol sealant to the distribution systems of small commercial buildings with duct systems in unconditioned and semi-conditioned spaces. The application of the measure is limited to residential sized systems less than 65,000 Btu/hr of cooling capacity applied to small commercial buildings. Savings calculations are based on test in / test out duct leakage measurements.

Baseline Case

The baseline condition is existing leaky duct work within an unconditioned or semi-conditioned space in the building.

Efficient Case

The efficient condition is sealed duct work within an unconditioned or semi-conditioned space in the building.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where,

$$\Delta kWh_{cooling} = \frac{CFM_{25B} - CFM_{25Q}}{400 \times Cap_{cool}} \times Cap_{cool} \times EFLH_{cool} \times TRF_{cool} \frac{12}{DE_{pre} \times SEER}$$

$$\Delta kWh_{heating} = \frac{CFM_{25B} - CFM_{25Q}}{17 \times Cap_{heat}} \times Cap_{heat} \times EFLH_{heat} \times TRF_{heat} \times \frac{1}{DE_{pre} \times HSPF}$$

Annual Fuel Savings

$$\Delta Therms = \frac{CFM_{25B} - CFM_{25Q}}{17 \times Cap_{heat}} \times Cap_{heat} \times EFLH_{heat} \times TRF_{heat} \times \frac{1}{DE_{pre} \times AFUE\ x\ 100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh_{cooling}}{EFLH_{cool}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-189 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{cooling}$	Annual electric energy savings, cooling	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual electric energy savings, heating	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_{cool}	Capacity of air cooling system	Site-specific	ton	
Cap_{heat}	Output capacity of air heating system	Site-specific	kBtu/hr	
CFM_{25B}	Standard duct leakage test result at 25 Pascal pressure differential of the duct system prior to sealing	Site-specific	CFM	
CFM_{25Q}	Standard duct leakage test result at 25 Pascal pressure differential of the duct system after sealing	Site-specific	CFM	
SEER	Seasonal energy efficiency ratio	Site-specific, if unknown look up in Table 2-95	Btu/W·hr	[126]

Variable	Description	Value	Units	Ref
HSPF	Heating seasonal performance factor	Site-specific, if unknown look up in Table 2-95	Btu/W·hr	[126]
DE_{pre}	Distribution efficiency before duct sealing and insulation	0.89	N/A	[592]
AFUE	Annual fuel utilization efficiency	Look up in Table **2-96**xx	N/A	[126]
$EFLH_{cool}$	Cooling equivalent full load hours	See Appendix C	Hrs	
$EFLH_{heat}$	Heating equivalent full load hours	See Appendix C	Hrs	
400	Rule of Thumb, CFM/ton	Site-specific, if unknown use 400	CFM/ton	
TRF_{cool}	Cooling thermal regain factor based on duct location	Semi-conditioned space: 0.0 Unconditioned space or outdoors: 1.0	N/A	[592]
TRF_{heat}	Heating thermal regain factor based on duct location	Semi-conditioned space: 0.4 Unconditioned space or outdoors: 1.0	N/A	[592]
12	Unit conversion, kBtu/hr·ton	12	kBtu/ hr·ton	
100	Unit conversion, kBtu/therm	100	kBtu/therm	
CF	Electric coincidence factor	Look up in Table 2-97	N/A	
PDF	Gas peak day factor	Look up in Table 2-97	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-190 SEER and HSPF Values

Product Class	SEER	HSPF
Split systems – air conditioners	13	-
Split systems – heat pumps	14	8.2
Single package units – air conditioners	14	-
Single package units – heat pumps	14	8.0

Table 3-191 AFUE Values

Product Class	AFUE
Non-weatherized gas furnaces	0.80
Weatherized gas furnaces	0.81

Peak Factors

Table 3-192 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[592]
Natural gas peak day factor (PDF)	See Appendix H: Net-to-Gross Factors	

Measure Life

Table 3-193 Measure Life

Equipment	EUL	Ref
Duct Sealing	15	[130]

References

[590] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[591] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[592] Home Energy Services Impact Evaluation, prepared for the Massachusetts Residential Retrofit and Low Income Program Area Evaluation, Cadmus Group, Inc., August 2012.

3.5.17 EC MOTORS

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Motor
Measure Last Reviewed	December 2022

Description

This measure covers the retrofit installation of an Electronically Commuted (EC) motor to replace an existing HVAC supply fan motor or hydronic circulator pump motor.

This measure is not applicable to exhaust fan motors. New construction and replace-on-burnout scenarios are not eligible because ECM technology is required in new equipment by federal efficiency standards [593].

Interactive factors should be applied for motors that supply cooling or heating to account for the reduced cooling load, or increased heating load, associated with the lower wattage ECM motor. Interactive factors do not apply if the motor is located outside of the conditioned air or hydronic pathway.

Baseline Case

An existing HVAC fan or pump with a single-speed, shaded-pole (SP) or permanent-split capacitor (PSC) motor. Baseline wattage should be derived from the nameplate rating of the existing motor.

Efficient Case

HVAC fan or pump with an Electronically Commuted (EC) Motor

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_h + \Delta kWh_c$$

For blower fans:

$$\Delta kWh_h = \frac{(W_b \times ESF_h)}{1{,}000} \times LF \times Hrs_h \times (1 - HVAC_e)$$

$$\Delta kWh_c = \frac{(W_b \times ESF_c)}{1{,}000} \times LF \times Hrs_c \times (1 + HVAC_e)$$

For circulator pumps:

$$\Delta kWh_h = \frac{(W_b - W_q)}{1{,}000} \times Hrs_h \times (1 - HVAC_e)$$

$$\Delta kWh_c = \frac{(W_b - W_q)}{1{,}000} \times Hrs_c \times (1 + HVAC_e)$$

If motor wattage is unknown, estimate as:

$$W = \frac{0.746 \times HP}{Eff_{motor}}$$

Annual Fuel Savings

$$\Delta herms = \frac{W_b \times ESF_h}{1{,}000} \times LF \times Hrs_h \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{(W_b \times ESF_c)}{1{,}000} \times LF \times (1 + HVAC_d) \times CF$$

Peak Daily Fuel Savings:

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-194 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_h	Annual electric heating savings	Calculated	kWh/yr	
ΔkWh_c	Annual electric cooling savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
W_b	Wattage of baseline motor	Site-specific, if unknown calculate from HP	Watts	
W_q	Wattage of efficient motor	Site-specific	Watts	

Variable	Description	Value	Units	Ref
Eff_{motor}	Motor efficiency	Site-specific, if unknown look up in Table 3-195	N/A	[596]
Hrs_h	Motor operating hours, heating	Site-specific, if unknown see Appendix D: HVAC Fan and Pump Operating Hours	Hrs	
Hrs_c	Motor operating hours, cooling	Site-specific, if unknown see Appendix D: HVAC Fan and Pump Operating Hours	Hrs	
ESF_h	Energy savings factor, heating	0.23	N/A	[595]
ESF_c	Energy savings factor, cooling	0.38		[595]
LF	Motor load factor	0.9	N/A	[595]
$HVAC_e$	HVAC interactivity factor, electric	See Appendix F: HVAC Interactivity Factors	N/A	
$HVAC_d$	HVAC interactivity factor, demand	See Appendix F: HVAC Interactivity Factors	N/A	
$HVAC_{ff}$	HVAC interactivity factor, fossil fuel	See Appendix F: HVAC Interactivity Factors	N/A	
CF	Coincidence factor	Look up in Table 3-196	N/A	
PDF	Gas peak demand factor	Look up in Table 3-196	N/A	
0.746	Conversion factor	0.746	kWh/HP	
1,000	Conversion factor	1,000	Watts/kW	
100	Conversion factor	100	kBtu/Therms	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-195 Default Motor Efficiency by Motor Type

Motor Type	Assumed Efficiency
Shaded Pole (SP)	0.40
Permanent Split Capacitor (PSC)	0.50
ECM	0.70

Peak Factors

Table 3-196 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[594]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for retrofit projects is assumed to equal to the smaller or the motor EUL or the RUL of the host equipment. Default RUL of the host equipment is 1/3 of the EUL.

References

[593] Federal standards: U.S. Department of Energy, *Federal Register. 164th ed. Vol. 79*, July 3, 2014. https://www.govinfo.gov/content/pkg/FR-2014-07-03/pdf/FR-2014-07-03.pdf

[594] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential Multifamily, and Commercial/Industrial Measures. Version 6. April 16, 2018.

[595] US DOE, *Evaluation of Retrofit Variable-Speed Furnace Fan Motors*, January 2014. https://www.nrel.gov/docs/fy14osti/60760.pdf

[596] DOE Building Technologies Office. Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment. https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf. Accessed December 2022.

3.5.18 ECONOMIZER CONTROLS

Market	Commercial/Multifamily
Baseline Condition	NC/RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure involves the installation of a dual enthalpy economizer to provide free cooling during the appropriate ambient conditions. Enthalpy refers to the total heat content of the air. A dual enthalpy economizer uses two sensors — one measuring return air enthalpy and one measuring outdoor air enthalpy. Dampers are modulated for optimum and lowest enthalpy to be used for cooling. Retrofit installations are only eligible for savings if the existing HVAC system does not have a functioning economizer.

New construction installations are only eligible for savings when economizers are not already required by the IECC 2021 Energy Code, Section C403.5.

Baseline Case

RF: The baseline condition is the site-specific HVAC unit with fixed outside air (no economizer). Use site-specific tonnage for calculation.

NC: New construction installations only eligible if economizer not required by code. The NC baseline is the site-specific and code-compliant HVAC unit with fixed outside air. Use site-specific tonnage for calculation.

Efficient Case

The efficiency condition is assumed to be an enthalpy economizer equipped with sensors that monitor the enthalpy of outside air and return air and modulate the outside air damper to optimize energy performance.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Tons \ x \left(\frac{kWh}{ton}\right)_{Econ}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therm_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-197 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Tons	Rated capacity of the cooling system retrofitted with an economizer	Site specific	Tons	
$(kWh/ton)_{Econ}$	Annual electric energy savings per ton of cooling	Look up in Table 3-198	Hrs/yr	[597]
CF	Electric coincidence factor	Look up in Table 3-199	N/A	
PDF	Gas peak demand factor	Look up in Table 3-199	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-198 Economizer savings kWh per Cooling Ton

Building Type	$(kWh/ton)_{Econ}$
Assembly	27
Big Box Retail	152
Fast Food Restaurant	39
Full Service Sertaurant	31

Building Type	$(kWh/ton)_{Econ}$
Light Industrial	25
Elementary School	42
Small Office	186
Small Retail	95
Religious	6
Warehouse	2
Other	61

Peak Factors

Table 3-199 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 10 years [598].

References

[597] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10*. (New York State Joint Utilities, 2022), Appendix J Pg 1289-1290 https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

[598] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

3.5.19 ELECTRONIC FUEL-USE ECONOMIZER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	HVAC
Measure Last Reviewed	March 2024
Changes Since Last Version	• New Measure

Description

These devices are microprocessor-based fuel-saving controls for commercial heating systems. They optimize energy consumption by adjusting burner run patterns to match the system's load. They can be used to control gas or oil consumption for any type of boiler or forced air furnace system.

Baseline Case

Any boiler or furnace system without an electronic fuel use economizer.

Efficient Case

Any boiler or furnace system with an electric fuel use economizer.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = Therms_{Annual} \times 0.127$$

Where,

$$Therms_{Annual} = \frac{Cap}{Eff \times 100{,}000} \times EFLH_h$$

To calculate savings in gallons of delivered fuel, use Table 3-200.

Table 3-200 Fuel Savings in Gallons

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{Oil} = \frac{\Delta Therms}{1.4}$
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Annual Peak Demand Savings

$$\Delta k \quad _{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \mathrm{N/A}$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-201 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Therms_{Annual}$	Annual consumption of uncontrolled boiler or furnace	Calculated	Therms/yr	
Cap	Heating capacity of uncontrolled boiler or furnace	Site-specific	Btu/h	
Eff	Heating efficiency of uncontrolled boiler or furnace	Site-specific	N/A	
$EFLH_h$	Effective full-load hours, heating	Look up in Appendix E	Hr/yr	
0.127	Approximate energy savings factor related to installation of fuel use economizers	0.127	N/A	[600]

Variable	Description	Value	Units	Ref
100,000	Conversion from Btu to therm	100,000	Therm/Btu	
1.4	Conversion from therms to gallons of oil	1.4	Therms/gal	0
0.916	Conversion from therms to gallons of propane	0.916	Therms/gal	0
PDF	Gas peak day factor	Lookup in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life	Years	

Peak Factors

Table 3-202 Peak Factors

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	Look up in Appendix G	

Measure Life

The effective useful life (EUL) is the smaller of the economizer EUL of 15 years or the RUL of the host equipment [599].

References

[599] New Jersey Board of Public Utilities, New Jersey's Clean Energy Program™ Protocols to Measure Resource Savings, FY2021 Addendum, Appendix A Measure Lives

[600] Intellidyne LLC & Brookhaven National Laboratories, *NYSERDA: A Technology Demonstration and Validation Project for Intellidyne Energy Saving Control*, March 2007, Page 3, Table 2, Average of the Four Degree Day Adjusted Heating Sites http://smartbuildingproducts.com/casestudies/files/NYSERDA%20final%20report%203-23-07.pdf

Oak Ridge National Laboratory*, Fuel Conversions Needed in the Weatherization Assistant*, https://weatherization.ornl.gov/wp-content/uploads/2018/05/FuelConversions.pdf

3.5.20 GUEST ROOM EMS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	HVAC controls
Measure Last Reviewed	November 2022

Description

This measure covers the installation of an Energy Management System (EMS) in hotel/motel guest rooms or dormitories which automatically adjust the temperature setback during unoccupied periods. Network controlled systems must also include occupancy sensors in guest rooms. Room occupancy is typically detected by occupancy sensors, infrared sensors or key cards. During unoccupied periods the default setting for controlled units should differ by at least 5 degrees from the operating setpoint. Savings are based on the EMS system's ability to automatically adjust the temperature setpoint of the guest room for various occupancy modes reducing the consumption of electricity and/or gas by requiring less heating and/or cooling when a room or a facility is vacant or unoccupied. Measure applicable to Motel, Hotel and Dormitory building types only.

Baseline Case

Hotel/motel rooms or dormitories with manual heating/cooling temperature set-points and on/off controls.

Efficient Case

Hotel/motel guest room or dormitory with an EMS that automatically adjusts room temperature based on room occupancy during unoccupied periods.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

If electric heat:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

If fuel heat:

$$\Delta kWh = kWh_{cool}$$

Where,

$$\Delta kWh_{cool} = \left(\frac{T_c \times (Hrs_{wk} + 7) + S_c \times (168 - (Hrs_{wk} + 7)}{168} - T_c\right) \times \frac{P_c \times Cap_c \times 12 \times EFLH_c}{EER}$$

$$\Delta kWh_{heat} = \left(T_h - \frac{T_h \times (Hrs_{wk} + 7) + S_h \times (168 - (Hrs_{wk} + 7))}{168}\right) \times \frac{P_h \times Cap_h \times EFLH_h}{COP \times 3{,}412}$$

Annual Fuel Savings

If fuel heat:

$$\Delta Therms = \left(T_h - \frac{T_h \times (Hrs_{wk} + 7) + S_h \times (168 - (Hrs_{wk} + 7))}{168}\right) \times \frac{P_h \times ap_h \times EFLH_h}{AFUE \times 100{,}000}$$

Peak Demand Savings

$$\Delta kWh_{Peak} = \frac{\Delta kWh_{cool}}{EFLH_c} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-203 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{cool}	Annual cooling electric energy savings	Calculated	kWh/yr	
ΔkWh_{heat}	Annual heating electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_h	Heating Capacity	Site-specific	Btu/hr	

Variable	Description	Value	Units	Ref
Cap_c	Cooling capacity	Site-specific	Tons	
T_h	Occupied heating setpoint temperature	Site-specific	°F	
T_c	Occupied cooling setpoint temperature	Site-specific	°F	
COP	Electric heating system coefficient of performance	Site-specific; use 1.0 for electric resistance heat	N/A	
AFUE	Heating Annual Fuel Utilization Efficiency	Site-specific. If unknown, use code compliant efficiency when the equipment was new. If equipment age unknown, use vintage efficiency for site-specific equipment type in Appendix E: Code-Compliant Efficiencies	N/A	
EER	Cooling Energy Efficiency Ratio	Site-specific. If unknown, use code compliant efficiency when the equipment was new. If equipment age unknown, use vintage efficiency for site-specific equipment type in Appendix E: Code-Compliant Efficiencies	Btu/hr-W	
Hrs_{wk}	Weekly occupied hours[137]	Site-specific; default to 84	Hr/wk	
S_h	Heating setback temperature	Site-specific; default to T_h - 5	°F	
S_c	Cooling setback temperature	Site-specific; default to T_c + 5	°F	
P_h	Heating savings fraction per degree of setback	0.03	N/A	[601]
P_c	Cooling savings fraction per degree of setback	0.06	N/A	[601]
$EFLH_h$	Heating Equivalent Full Load Hours. Measure applicable to Motel, Hotel and Dormitory building types only.	Look up in Appendix C:	Hr	[602]
$EFLH_c$	Cooling Equivalent Full Load Hours. Measure applicable to Motel, Hotel and Dormitory building types only.	Look up in Appendix C:	Hr	[602]
12	Conversion from tons to kBtu/hr	12	kBtu/h/ton	
168	Hours per week	168	Hr/wk	

[137] Default value assumes operating hours is 12 hours a day, 7 days a week.

Variable	Description	Value	Units	Ref
7	Weekly hours for setback/setup adjustment based on 1 setback/setup per day, 7 days per week	7	Hr/wk	
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
CF	Coincidence factor	Look up in Table 3-204	kW/kWh	
PDF	Peak day factor	Look up in Table 3-204		
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-204 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.65	[603]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) for add-on equipment is limited to the remaining useful life (RUL) of the underlying system. If unknown, assume 1/3 of the EUL of the base HVAC equipment (look up in relevant HVAC measure).

References

[601] ENERGY STAR Programmable Thermostat Calculator. Savings assumptions per 2004 Industry Data.

[602] Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

[603] Average of Massachusetts Utilities summer coincidence factors. Massachusetts eTRM, 2020 update, measure code COM-HVAC-HOS. Available online: https://www.masssavedata.com/Public/TechnicalReferenceLibrary

3.5.21 SMART THERMOSTATS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/RF
Baseline	Code/ISP/Existing
End Use Subcategory	HVAC Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

The smart thermostat measure involves the replacement of a manually operated or conventional programmable thermostat with a "smart" thermostat (defined below). This measure only applies to thermostats that control central A/C, heat pump, furnace, or rooftop units (RTUs) with capacity up to 300,000 Btu/h that serve normal conditioned spaces, not semi-conditioned spaces or spaces with large, frequently open doors (e.g., loading docks and car repair shops). Thermostats for larger systems should be treated as custom measures. This measure may be a time of sale, retrofit, direct install, or new construction measure.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Retrofit and DI: As a retrofit measure, the baseline equipment is the in-situ manually operated or properly programmed thermostat that was replaced. If a manually operated non-programmable thermostat baseline is claimed, supporting photographic documentation should be collected.

Time of Sale or New Construction: The baseline condition is a programmable thermostat meeting minimum efficiency standards as presented in the 2021 International Energy Conservation Code (IECC 2021).

Efficient Case

The efficient condition is a smart thermostat that has earned ENERGY STAR certification[605] or has followed the ENERGY STAR product requirements[606].

Annual Energy Savings Algorithms

As smart thermostats are control technologies, when possible, heating and cooling savings should be calculated based on data from installed thermostats [607]. Otherwise, cooling savings should only be claimed for buildings with central air conditioning. Heating savings may be claimed for buildings with electric resistance, heat pump, or non-electric heating.

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_c + \Delta kWh_h$$

Where,

$$\Delta kWh_c = CCAP \times EFLH_{cool} \times \frac{1}{Eff_{cool}} \times SF_{elec,c}$$

$$\Delta kWh_h = HCAP_{elec} \times EFLH_{heat} \times \frac{1}{HSPF} \times SF_{elec,h}$$

Annual Fuel Savings

$$\Delta Therms = HCAP_{fuel} \times EFLH_{heat} \times \frac{1}{AFUE} \times SF_{fuel}$$

Peak Demand Savings[138]

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-205 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	

[138] The smart thermostat measure as defined here (i.e., without a corresponding demand reduction program) is assumed to have no demand savings. Smart thermostats with a demand response program added on top may generate demand savings.

Variable	Description	Value	Units	Ref
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
CCAP	Cooling capacity of existing AC unit	Site-specific	kBtu/hr	
Eff_{cool}	Cooling efficiency of controlled unit (SEER, SEER2, or IEER). For GSHP, use EER.	Site-specific, if unknown look up in Appendix	Btu/W-h	
$HCAP_{fuel}$	Heating capacity of existing furnace unit	Site-specific	MMBtu/hr	
AFUE	Annual Fuel Utilization Efficiency	Site-specific, if unknown look up in Appendix	N/A	
$HCAP_{elec}$	Heating capacity of existing heat pump or electric resistance unit	Site-specific	kBtu/hr	
HSPF	Heating seasonal performance factor of controlled unit	Site-specific, if unknown look up in Appendix. For electric resistance heat, use 3.412	Btu/W-h	
$SF_{elec,c}$	Electrical cooling percent savings from thermostat relative to baseline control	Look up in Table 3-206	%	[609][610]
$SF_{elec,h}$	Electrical heating percent savings from thermostat relative to baseline control	Look up in Table 3-206	%	[609][610]
SF_{fuel}	Heating fuel percent savings from thermostat relative to baseline control.	Look up in Table 3-206	%	[609][610]
$EFLH_c$	Full load hours for cooling equipment	Look up in Appendix	Hrs/yr	[604]
$EFLH_h$	Full load hours for heating equipment	Look up in Appendix	Hrs/yr	[604]
CF	Electric coincidence factor	Look up in Table 3-207	N/A	
PDF	Gas peak day factor	Look up in Table 3-207	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-206 Saving Factors for Smart Thermostats by Baseline Technology

Fuel and Function	Baseline Technology		
	Manual Thermostat	Programmable Thermostat	Unknown
Savings factor for electric cooling, $SF_{elec,c}$	5%	3%	3%
Savings factor for electric heating, $SF_{elec,h}$	4%	2%	2%
Savings factor for fuel heating, SF_{fuel}	5%	2%	2%

Peak Factors

Table 3-207 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) IS 7.5 years [608].

References

[604] Simulations of prototypical buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

[605] ENERGY STAR's qualified products list for smart thermostats: https://data.energystar.gov/dataset/ENERGY-STAR-Certified-Connected-Thermostats/7p2p-wkbf

[606] ENERGY STAR Smart Thermostat Specification, from which most requirements based: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Program%20Requirements%20for%20Connected%20Thermostats%20Version%201.0.pdf

[607] NEEP has developed a Guidance Document detailing methodology to claim savings from smart thermostats, available here: https://neep.org/sites/default/files/resources/ClaimingSavingsfromSmartThermostatsGuidanceDocumentFinal.pdf. This guidance uses the metric developed for the ENERGY STAR certification to develop geographically and temporally specific savings averages for program claims. These calculated savings numbers are expected to be more accurate and potentially yield higher level of savings than the estimates provided in the TRM.

[608] Based on professional judgment of TRM technical team. EULs observed for residential applications include: 11 years in AR TRM and 10 years in IL TRM, both of which are based on programmable thermostat EULs. CA workpapers conclude 3-year EUL using persistence modeling. RTF concludes a 5-year EUL based on CA workpapers and concerns that there is little basis for assuming long-time persistence of savings, considering past challenges with manual overrides and "know-how" needed to use wifi-connected devices, including communicating hardware and software downloading. For discussion, see Northwest Regional Technical Forum April 2017. https://nwcouncil.box.com/v/ResConnectedTstatsv1-2

[609] The savings percentages claimed for manual thermostats include the savings associated with upgrading from manual thermostats to programmable thermostats, which a 2015 MEMD study reported as about 3% savings for gas customers and 2% savings for electric customers. http://www.michigan.gov/documents/mpsc/CI_Programmable_TStats_MEMD_6_15_15_491808_7.pdf

[610] Relative to a programmable thermostat, smart thermostats have savings opportunities available from a "smart recovery" function, which enables users to set the time they would like the building to reach a temperature as opposed to setting a time that the unit should start operating. Savings are also available from improved error detection and from locking out building occupants' ability to override programmed schedules. Individual case studies have demonstrated savings in a variety of small commercial applications, but large-scale evaluations of smart thermostat savings have so far been limited to thermostats installed in residential applications. CLEAResult's "Guide to Smart Thermostats" reports the ranges of savings measured in recent

residential evaluations, relative to a baseline that blended programmable and manual thermostats: 10–13% for gas savings; 14–18% for electric cooling savings; and 6–13% for electric heating savings. https://www.clearesult.com/insights/whitepapers/guide-to-smart-thermostats/

[611] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

3.5.22 STEAM TRAP REPAIR/REPLACE

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Controls
Measure Last Reviewed	May 2023

Description

This measure covers the repair or replacement of leaking or blow-through steam traps in existing commercial steam systems served by fossil fuel-fired boilers. Steam traps that fail open allow excess steam to escape, thus increasing the amount of steam that must be generated to meet end-use requirements. This measure is intended for the repair or replacement of steam traps failed open only and requires the completion of a steam trap assessment to ensure the number of failed open steam traps are properly quantified. This measure does not apply to municipal steam systems. Energy savings from the installation of a stream trap monitoring system may not be claimed in conjunction with the saving presented in this measure.

The savings in this measure are per-steam trap. Savings should be multiplied by the total number of steam traps replaced. This measure is applicable to low pressure (≤15 psig) and high pressure (>15 psig) steam traps.

Baseline Case

The baseline case is the existing leaking or blow-through steam traps.

Efficient Case

The efficient case is the repaired or replaced steam traps.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = Loss_{steam} \times \frac{\Delta H_{vap}}{Eff} \times \frac{hrs}{1{,}000{,}000} \times F_{hrs} \times F_{CR}$$

Where,

$$Loss_{steam} = 60 \times \frac{\pi}{4} \times ID^2 \times psia^{0.97} \times F_{discharge} \times F_{loss}$$

$$psia = psig + p_{atm}$$

Annual Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times N/A$$

Lifetime Fuel Savings

$$\Delta herms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-208 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Loss_{steam}$	Hourly steam loss per failed trap	Calculated	Lb/hr	
psia	Absolute steam pressure	Calculated	psi	
psig	Steam gauge pressure	Site-specific, if unknown look up in Table 3-210	psi	[612]
Eff	Thermal efficiency of boiler	Site-specific, if unknown look up in Table 3-210	Et or AFUE	[612]
Hrs	Annual hours trap pressurized	Site-specific, if unknown look up in Table 3-210	Hours	[612]
ID	Internial diameter of steam trap orifice	Site-specific, if unknown look up in Table 3-210	Inches	
F_{CR}	Condensate return factor, used to account for the proportion of energy lost that is returned to the system via condensate line	If no condensate return: 1.00 Otherwise, look up in Table 3-210	N/A	[612]
ΔH_{vap}	Heat of vaporization (latent heat) at system operating pressure	Look up in Table 3-209	Btu/lb	

Variable	Description	Value	Units	Ref
$F_{discharge}$	Discharge coefficient	Look up in Table 3-210	N/A	[612]
F_{loss}	Steam loss adjustment factor	Look up in Table 3-210	N/A	[612]
p_{atm}	Atmospheric pressure	14.7	psi	
60	Empirically derived constant in Grashof's equation	60	$lbm/\ in^{0.06}$-$lb^{0.97}$-hr	[613]
π/4	Orifice area development factor	π/4	N/A	
0.97	Empirically derived constant in Grashof's equation	0.97	N/A	[613]
100,000	Conversion factor	100,000	Btu/therm	
PDF	Gas peak day factor	Lookup in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	

Table 3-209 Heat of Vaporization

Gauge Pressure (psig)	Heat of Vaporization (Btu/lb)	Gauge Pressure (psig)	Heat of Vaporization (Btu/lb)
0	970	90	886
1	968	100	880
2	966	110	875
5	960	120	871
10	952	125	868
15	945	130	866
20	939	140	861
25	934	150	857
30	929	160	853
40	920	180	845
50	912	200	837
60	905	225	829
70	898	250	820
80	892		

Table 3-210 Default Steam Trap Parameters

Parameter	Low Pressure (≤15 psig)	High Pressure (>15psig)
Guage pressure (psig)	7.2	86.7
Orifice size (ID)	0.25	0.156
Annual hours	2,525	6,558
Boiler efficiency	0.80	0.80
Steam loss adjustment factor (F_{loss})	0.369	0.369
Discharge coefficient ($F_{discharge}$)	0.70	0.70
Condensate return factor (F_{CR})	0.363	0.363

Peak Factors

Table 3-211 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	Look up in Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 6 years [613].

References

[612] ERS, “Two-Tier Steam Trap Savings Study”, April 26, 2018. pg 5.

[613] Massachusetts Program Administrators and Energy Efficiency Advisory Council, “Steam Trap Evaluation Phase 2” March 8, 2017. Pg. 6.

3.5.23 MAINTENANCE

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Maintenance
Measure Last Reviewed	December 2022
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This section provides energy savings algorithms for existing HVAC tune ups in commercial applications. Efficiency of various HVAC Units degrades with age and a "tune-up" or preventative maintenance can help restore some of the lost efficiency.

For gas applications, a tune-up of non-residential fossil space heating boilers or furnaces involves cleaning and inspection, adjusting air flow, reduce stack temperatures (for boilers), and adjust burner input among other steps.

Electric Units such as Central A/C and heat pumps also benefit greatly from tune ups. A tune up typically includes air filter replacement, cleaning of coils and fans, repair of case insulation,refrigerant charge adjustments, and air flow adjustments. This measure only applies to central AC Systems or heat pumps of 20 tons (65,000 BTU/h) or less.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Gas: Commercial fossil space heating boiler or furnace that has not received a tune-up in 3 years or more.

Electric: An existing pre tune-up central A/C or heat pumpthat has not received a tune-up in 3 years or more.

Efficient Case

Gas: Commercial space heating boiler or furnace that has undergone a tune-up in accordance with the program requirements.

Electric: Central A/C System or heat pump after receiving tune up.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{Cool} + \Delta kWh_{Heat}$$

Where,

$$\Delta kWh_{Cool} = Cap_c \times EFLH_c \times \frac{1}{SEER_b} \times F_{improv}$$

$$\Delta kWh_{Heat} = Cap_h \times EFLH_h \times \frac{1}{HSPF_b} \times F_{Improv}$$

$$F_{improv} = \frac{Eff_{improv,q} - Eff_{improv,b}}{Eff_{improv,q}}$$

Annual Fuel Savings

For boilers,

$$\Delta Therms = \frac{Cap_{in}}{100} \times \left(1 - \frac{Eff_{c,b}}{Eff_{c,q}}\right) \times EFLH_h$$

For furnaces,

$$\Delta Therms = \frac{F_{furnace} \times Cap_{in} \times EFLH_h}{100}$$

Where,

$$F_{furnace} = \frac{Eff_{f,b} + \Delta Eff_{f,q}}{Eff_{f,b}} - 1$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{1}{EER_b} \times F_{improv} \times CF \times Cap_{in}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-212 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
ΔkWh_{cool}	Annual cooling energy savings	Calculated	kWh/yr	
ΔkWh_{heat}	Annual heating energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
F_{improv}	Percent improvement in EER/HSPF[139]	Calculated; if EER unknown look up in Table 3-213[140]	N/A	[614][618]
$Eff_{improv,b}$	EER/EER2 of existing AC Unit or HSPF of existing Heat pumps	Site-specific	EER: BTU/watts HSPF: BTU/watt-hr	
$Eff_{improv,q}$	EER/EER2 of efficient AC Unit or HSPF of efficient Heat pumps	Site-specific	EER: BTU/watts HSPF: BTU/watt-hr	
EER_b	EER or EER2 of existing AC Unit	Site-specific	BTU/watts	
Cap_c	Cooling Capacity of existing AC Unit	Site-specific	kBTU/hr	
Cap_h	Heating Capacity of existing Heat Pumps	Site-specific	kBTU/hr	
Cap_{in}	Fuel input rating per boiler/furnace	Site-specific	kBTU/hr	
$Eff_{c,b}$	Baseline combustion efficiency as determined via flue gas analysis	Site-specific	N/A	
$Eff_{c,q}$	Post-implementation boiler combustion efficiency as determined via flue gas analysis	Site-specific	N/A	
$Eff_{f,b}$	Actual combustion efficiency of the furnace before tune-up, based on flue gas analysis	Site-specific	N/A	
$Eff_{f,q}$	Post-implementation furnace combustion efficiency as determined via flue gas analysis	Site-specific	N/A	

[139] For heat pumps: HSPF = COP x 3.413, where COP is coefficient of performance

[140] IL TRM derives savings estimates by applying the findings from DNV-GL "Impact Evaluation of 2013-2014 HVAC3 Commercial Quality Maintenance Programs", April 2016, to simulate the inefficient condition within select eQuest models and across climate zones. The percent savings were consistent enough across building types and climate zones that it was determined appropriate to apply a single set of assumptions for all. See 'eQuest C&I Tune up Analysis.xlsx' for more information.

Variable	Description	Value	Units	Ref
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	See Appendix C:	Hours	[615]
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	See Appendix C:	Hours	[615]
$SEER_b$	SEER or SEER2 of actual unit, before the tune-up	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies	Btu/W-h	
100	Conversion from kBtu to therms	100	kBtu/Therms	
$F_{furnace}$	Energy Savings Factor furnace	For Large Commercial - Calculated; For Small Commercial (<225 MBH) = 0.05	N/A	[616]
CF	Electric coincidence factor (CF)	Look up in Table 3-214	N/A	[618]
PDF	Gas peak demand factor	Look up in Table 3-214	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-213 Percent Improvement in EER (F_{improv})

Maintenance or Tune-Up Component	% Savings
Condenser Cleaning	6.10
Evaporator Cleaning	0.22
Refrigeration Charge Offset <=20%	0.68
Refrigeration Charge Offset >20%	8.44

Peak Factors

Table 3-214 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.478	[618]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

Measure Life for HVAC tune-up /maintenance measures is 3 yrs [617].

References

[614] Energy Center of Wisconsin, *Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research* (May 2008)

[615] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[616] Washington State University Energy Program, Building Tune-Up and Operations Program Evaluation (March 2007), Pg 5

[617] DEER 2014 EUL http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

[618] *2022 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 10.0 Volume 2: Commercial and Industrial Measures* (2022), Pg 221-223 https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

3.5.24 ADVANCED ROOFTOP CONTROLS

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Controls
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI baseline condition and dual baseline

Description

This measure covers the installation of advanced rooftop unit control (ARC) on a constant volume rooftop HVAC unit with a single-speed supply fan. This involves the following 3 components, adding demand-controlled ventilation (DCV), Dual enthalpy economizers, and a supply fan with a variable frequency drive (VFD). DCV systems monitor the CO_2 levels and accordingly vary the supply outdoor air as needed, resulting in the reduction of heating and cooling loads. Dual enthalpy economizers reduce cooling loads by supplying outside air to the space when the outside air is deemed suitable for cooling. Multi/variable-speed fan motors reduce the fan speed for first stage cooling and ventilation.

Saving factors were calculated based on IL TRM values for Chicago, adjusted by ratio of Degree Days for each listed NJ Climate Zone and Chicago, based on TMYx Data using base 65 F balance point. See the 'Demand Controlled Ventilation' Section of the Illinois Statewide Technical Reference Manual V11 for further explanation [621].

It is important to note that only those components that are not required by code are eligible for savings. See ASHRAE 90.1-2019 section 6.4.3.

Baseline Case

Constant volume rooftop HVAC unit with a single-speed supply fan and no occupancy-based ventilation or functioning airside economizer

Efficient Case

Rooftop HVAC Unit with an advanced rooftop unit controller added providing DCV, VFD fan speed controls, and dual enthalpy air-side economizer control

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{fan} + \Delta kWh_{DCV} + \Delta kWh_{Econ}$$

Where

$$\Delta kWh_{fan} = hp \times ESF_{fan} \times hrs$$

$$\Delta kWh_{DCV} = \frac{A}{1{,}000} \times SF_{ElecCool} + \frac{A}{1{,}000} \times SF_{ElecHeat} \times F_{ElecHeat}$$

$$\Delta kWh_{Econ} = tons \times SF_{Econ}$$

Annual Fuel Savings

$$\Delta Therms = \frac{A}{1{,}000} \times SF_{fuel} \times F_{FuelHat}$$

Peak Demand Savings

$$\Delta kW_{Peak} = hp \times ESF_{fan} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therm \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-215 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{fan}	Annual electricity energy savings resulting from supply fan control	Calculated	kWh/yr	
ΔkWh_{DCV}	Annual electricity energy savings resulting from DCV	Calculated	kWh/yr	
ΔkWh_{Econ}	Annual electricity energy savings resulting from economizer	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
hp	Horsepower of RTU supply fan	Site-specific	hp	
ESF_{fan}	Energy savings factor for supply fan control[141]	0.580	kWh/hp/hr	[619]
hrs	Annual operating hours of RTU supply fan	Site-specific if unknown use default values in Table 3-216	Hrs/yr	[620]
A	Total area square footage of the conditioned space impacted by the measure	Site-specific	Ft^2	
$SF_{ElecCool}$	DCV energy savings factor for cooling	Look up in Table 3-217	kWh/1,000 ft^2	[621]
$SF_{ElecHeat}$	DCV energy savings factor for electric heating	Look up in Table 3-218, Table 3-219	kWh/1,000 ft^2	[621]
$F_{elecHeat}$	Electric heating factor, used to account for the presence or absence of an electric heating system	1 (if electric heat) 0 (otherwise)	N/A	
tons	Tons of air conditioning supplied by RTU, based on nameplate data	Site-specific	tons	
SF_{econ}	Annual electric energy savings per ton of cooling resulting from economizer	Look up in Table 3-221	kWh/ton	[622]
SF_{Fuel}	DCV fuel savings factor for heating	Look up in Table 3-220	therms/1,000 ft^2	[621]
$F_{FuelHeat}$	Fuel heating factor, used to account for the presence or absence of a fossil fuel heating system	1 (if fossil fuel heat) 0 (otherwise)	N/A	
CF	Electric coincidence factor	Look up in Table 3-222	N/A	[623]
PDF	Gas peak day factor	Look up in Table 3-222	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-216 Hours of Use Based on Building Type

Building Type	Hours
Office – Small Commercial	2,950
Office – Large Commercial	2,969
Religious Building	4,573
Restaurant	4,573

[141] Unweighted average of kWh/hp/hour fan savings across all test cases in Advanced Rooftop Control (ARC) Retrofit: Field-Test Results, PNNL22656, Table 10: TMY weather normalized annual savings for all units. Fan Energy Savings (kWh) is divided by RTU Fan Power (hp) and Annual RTU Running Time (hr) to determine Energy Savings Factor for supply fan controls (kWh/hp/hr)

Building Type	Hours
Retail - Department Store	4,920
Retail – Strip Mall	4,926
Grocery	7,134
School	2,575
Healthcare Clinic	3,909
Hospital	8,760
Lodging (Hotel/Motel)	4,573
Multifamily – Common Areas	5,950
Multifamily – In-Unit	679
Warehouse – Small Commercial	3,799
Warehouse – Large Commercial/Industrial	4,116
Other	4,573
Enclosed Parking Garage	3,338

Table 3-217 Energy Savings Factor for Cooling Associated with DCV (kWh/1,000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	267	362	368	366	359	334
Office - Mid-rise (4 to 11 Stories)	211	286	291	289	283	264
Office - High-rise (12+ Stories)	250	340	345	344	337	314
Religious Building	720	978	994	989	970	903
Restaurant	471	640	650	647	634	590
Retail - Department Store	363	493	501	498	489	455
Retail - Strip Mall	251	341	347	345	338	315
Convenience Store	330	448	455	453	444	413
Elementary School	339	460	468	465	456	425
High School	332	450	457	455	446	415
College/ University	393	534	543	540	530	493
Healthcare Clinic	327	444	451	449	440	410
Lodging (Hotel/Motel)	378	513	521	518	508	473

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Manufacturing	163	222	226	224	220	205
Special Assembly Auditorium	537	729	740	737	722	672
Other	356	483	491	488	479	446
Enclosed Parking Garage	854	1,160	1,179	1,173	1,150	1,070

Table 3-218 Electric Heating Savings with Heat Pump Associated with DCV (kWh/1,000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	185	149	163	158	163	167
Office - Mid-rise (4 to 11 Stories)	125	100	110	106	109	112
Office - High-rise (12+ Stories)	167	135	147	143	147	151
Religious Building	1206	970	1062	1028	1057	1087
Restaurant	870	700	767	742	763	785
Retail - Department Store	298	239	262	254	261	268
Retail - Strip Mall	194	156	171	166	171	175
Convenience Store	147	119	130	126	129	133
Elementary School	517	416	456	441	454	467
High School	505	406	445	430	443	455
College/ University	1007	811	888	859	884	909
Healthcare Clinic	358	288	316	305	314	323
Lodging (Hotel/Motel)	166	134	147	142	146	150
Manufacturing	103	83	91	88	90	93
Special Assembly Auditorium	1414	1138	1246	1207	1241	1276
Other	484	389	426	413	424	436
Enclosed Parking Garage	185	149	163	158	163	167

Table 3-219 Electric Heating Savings with Electrical Resistance Associated with DCV (kWh/1,000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	556	448	490	474	488	493
Office - Mid-rise (4 to 11 Stories)	374	301	329	319	328	331

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - High-rise (12+ Stories)	501	403	441	427	439	443
Religious Building	3617	2910	3186	3085	3172	3202
Restaurant	2610	2100	2300	2226	2289	2311
Retail - Department Store	893	718	786	761	783	790
Retail - Strip Mall	584	470	515	498	512	517
Convenience Store	441	355	389	376	387	391
Elementary School	1551	1248	1367	1323	1360	1374
High School	1513	1218	1333	1291	1327	1340
College/ University	3022	2432	2662	2577	2650	2676
Healthcare Clinic	1074	865	947	916	942	952
Lodging (Hotel/Motel)	498	401	439	425	437	441
Manufacturing	310	250	273	265	272	275
Special Assembly Auditorium	4242	3414	3738	3619	3721	3757
Other	1452	1169	1280	1239	1274	1286

Table 3-220 Fuel Heating Savings Associated with DCV (therm/1,000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	24	19	21	20	21	21
Office - Mid-rise (4 to 11 Stories)	16	13	14	14	14	14
Office - High-rise (12+ Stories)	22	17	19	19	19	19
Religious Building	155	124	136	132	136	137
Restaurant	111	90	98	95	98	99
Retail - Department Store	38	31	33	32	33	33
Retail - Strip Mall	25	20	22	22	22	22
Convenience Store	19	15	17	16	17	17
Elementary School	66	53	58	56	58	58
High School	64	52	57	55	56	57
College/ University	129	104	114	110	113	114
Healthcare Clinic	46	37	41	39	40	41
Lodging (Hotel/Motel)	21	17	18	18	18	18
Manufacturing	14	11	12	12	12	12
Special Assembly Auditorium	181	146	159	154	159	160

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Other	61	49	54	52	54	54

Table 3-221 Economizer Savings kWh Per Cooling Ton

Building Type	$(kWh/ton)_{Econ}$
Office	186
Religious Building	6
Restaurant – Full-Service	31
Restaurant – Fast Food	39
Retail - Department Store	152
Retail – Strip Mall	95
Convenience Store	95
Elementary School	42
High School	61
College/University	61
Healthcare Clinic	61
Lodging (Hotel/Motel)	61
Manufacturing	25
Special Assembly Auditorium	27
Warehouse	2
Other	61

Peak Factors

Table 3-222 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[623]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 5 years [624]

References

[619] *Advanced Rooftop Control (ARC) Retrofit: Field-Test Results.* (US DOE 2013) Table 10, https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22656.pdf

[620] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1,2017 – May 31, 2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs*, (2018)

[621] Saving factors were calculated based on IL TRM values for Chicago, adjusted by ratio of Degree Days for each listed NJ Climate Zone and Chicago, based on TMY 3 Data using base 65 F balance point. *2023 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 11 Volume 2: Commercial and Industrial Measures* (September 2022), Pg 357, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010123_v11.0_Vol_2_C_and_I_092222_FINAL.pdf

[622] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10*. (New York State Joint Utilities, 2023), Appendix J Pg 1279-1280 https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

[623] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10. (New York State Joint Utilities, 2023), Pg 818 https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

[624] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10. (New York State Joint Utilities, 2023), Pg 1366 https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

3.6 SHELL

3.6.1 HIGH-RISE MULTIFAMILY AIR SEALING

Market	Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Shell
Measure Last Reviewed	January 2023

Description

This section provides energy savings algorithms for the sealing air leakage paths to reduce the natural air infiltration rate through the installation of products and repairs to the building envelope. It is assumed that air sealing is the first priority among candidate space conditioning measures. Expected percentage savings is based on previous experiences with measured savings from similar programs.

The method below only applies to high-rise multifamily applications where blower door testing is not conducted.

Baseline Case

The baseline case is a building envelope with natural air infiltration through air leakage paths.

Efficient Case

The exterior envelope, as well as interior walls/partitions between conditioned and unconditioned spaces should be inspected and all gaps sealed. At a minimum, the following items shall be inspected, and sealing measures may be implemented based upon inspection results:

- Caulk and weather strip doors and windows that leak air
- Repair or replace doors leading from conditioned to unconditioned space
- Seal air leaks between unconditioned (including unconditioned basement and attics) and conditioned spaces to include, but not limited to, plumbing, ducting, electrical wiring, wall top plates, chimneys, flues, and dropped soffits
- Use foam sealant on larger gaps around windows, baseboards, and other places where air leakage, either infiltration or exfiltration may occur

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{SF}{1{,}000} \times \left(\frac{\Delta kWh}{1{,}000\ ft^2}\right)$$

ΔAnnual Fuel Savings

$$\Delta Therms = \frac{SF}{1{,}000} \times \left(\frac{\Delta Therms}{1{,}000\ ft^2}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{SF}{1{,}000} \times \left(\frac{\Delta kW}{1{,}000\ ft^2}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-223 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
SF	Building square feet of conditioned floor area affected by installation	Site-specific	ft^2	
$\frac{\Delta kWh}{1{,}000\ ft^2}$	Annual electric energy savings per thousand square feet	Lookup Table 3-224	kWh/ft^2	[626]
$\frac{\Delta kW}{1{,}000\ ft^2}$	Peak coincident demand electric savings per thousand square feet	Lookup Table 3-224	kWh/ft^2	[626]
$\frac{\Delta Therms}{1{,}000\ ft^2}$	Annual gas energy savings per thousand square feet	Lookup Table 3-224	$Therms/\ ft^2$	[626]
1,000	Conversion Factor from square feet (SF) to 1,000 square feet (kSF)	1000	N?A	

Variable	Description	Value	Units	Ref
CF	Coincidence factor	Lookup in Table 3-225	N/A	
PDF	Gas peak day factor	Lookup in Table 3-225	N/A	
EUL	Effective useful life	See Measure Life section	Years	

Table 3-224 Impact per thousand square feet[142]

Vintage	$\frac{\Delta kWh}{1,000\ ft^2}$	$\frac{\Delta kW}{1,000\ ft^2}$	$\frac{\Delta Therms}{1,000\ ft^2}$
Old	118	0.119	29
Average	56	0.098	17

Peak Factors

Table 3-225 Peak Factors

Peak Factor	Value	Ref
Coincidence factor	0.69	[627]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 15 years [625].

References

[625] GDS Associates, Inc. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures. 2007. https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf

[626] New York State Joint Utilities, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, V10, pg. 1222, January 2023.

[627] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the RM Management Committee.

[142] The baseline infiltration rate for old building is 1.0 ACH and average building is 0.5 ACH. The energy savings are based on a 15% reduction.

3.7 LIGHTING

3.7.1 LIGHTING FIXTURES

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Existing
End Use Subcategory	Lighting Fixtures
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed dual baseline references, use AML instead • Updated headings in Table 3-235 to reflect AML • Updated measure lives in Table 3-235 to round to nearest integer

Description

This section provides energy savings algorithms for qualifying lighting improvements implemented in commercial and industrial settings. This measure includes both retrofit of existing lamps and new construction projects. For in-unit lamps and lamps installed in common areas of multifamily low-rise buildings, refer to the Residential Section. For lamps/fixtures installed in common areas of multifamily high-rise buildings, use the algorithms below.

Replacement programs includes fixture replacements for existing commercial and industrial customers. It is targeted for facilities performing efficiency upgrades to their lighting systems. New fixtures and technologies available after publication will be periodically updated. Baselines will be established based on the guidelines noted below.

For new construction and entire facility rehabilitation projects, savings are calculated by comparing the lighting power density (LPD) of fixtures being installed to the baseline LPD, or "lighting power allowance," from the building code. For the state of New Jersey, the applicable building code is IECC 2021 [629].

For interior lighting power allowance, ASHRAE 90.1 allows either a space by space method or a building area method to calculate the overall lighting power allowance. The space by space method involves applying a different LPD for each space using values from Table 3-228 whereas the building area method involves applies applying a uniform LPD to the entire building using values from Table 3-227.

The exterior lighting power allowance is calculated as follows.

1. Determine the lighting zone from Table 3-229.
2. Determine the applicable category and space type from Table 3-230
3. Based on lighting zone, category, and space type, determine the applicable exterior LPD.
4. The LPD is multiplied with the appropriate unit to get lighting power allowance.

There are 2 types of surfaces in Table 3-230, tradable and non tradable surfaces. Tradable surfaces are surfaces where if you don't use all the lighting allowed on one of the surfaces you can use the left over on another one of the tradable surfaces. Non-tradable surfaces are allowed a certain amount of lighting and you cannot use the excess somewhere else nor can you use excess from somewhere else on these surfaces.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

New Construction Interior Lighting: Baseline lighting LPD based on the IECC 2021 Code [629] with adjustments for standard practice [7].

New Construction Exterior Lighting: Baseline lighting LPA based on the IECC 2021 Code [629] with adjustments for standard practice [7].

Replacement: Actual existing fixture/lamp wattage. If unknown, use wattage from Appendix L: Lighting Wattages Table 15.2 [628].

Mid-Stream Lighting: Lookup in Appendix L: Lighting Wattages Table 15.1

Efficient Case

New Construction Interior Lighting: LPD of qualified fixtures, equal to the sum of installed fixture wattage divided by floor area of the space where the fixtures are installed.

New Construction Exterior Lighting: LPA of qualified fixtures, equal to the sum of installed fixture wattage

Retrofit: Wattage of new fixture.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

New Construction Interior Lighting:

$$\Delta kWh = \frac{LPD_b \times LPD_{AF} - LPD_q}{1{,}000} \times A \times Hrs \times (1 + HVAC_c)$$

New Construction Exterior Lighting:

$$\Delta kWh = \frac{\left(LPA_b \times LPA_{AF} - LPA_q\right)}{1{,}000} \times AL \times Hrs$$

Replacement/Midstream Interior Lighting:

$$\Delta kWh = \frac{Qty_b \times W_b - Qty_q \times W_q}{1{,}000} \times Hrs \times (1 + HVAC_c)$$

Replacement/Midstream Exterior Lighting:

$$\Delta kWh = \frac{Qty_b \times W_b - Qty_q \times W_q}{1{,}000} \times Hrs$$

Annual Fuel Savings

Replacement/Midstream Interior Lighting:

$$\Delta Therms = \frac{\left(Qty_b \times W_b - Qty_q \times W_q\right)}{1{,}000} \times Hrs \times HVAC_{ff} \times 10$$

New Construction Interior Lighting:

$$\Delta Therms = \frac{LPD_b \times LPD_{AF} - LPD_q}{1{,}000} \times A \times Hrs \times HVAC_{ff} \times 10$$

Note: *No fuel impacts are claimed in exterior lighting installation.*

Peak Demand Savings

Retrofit Interior Lighting:

$$\Delta kW_{Peak} = \frac{Qty_b \times W_b - Qty_q \times W_q}{1{,}000} \times CF \times (1 + HVAC_d)$$

Retrofit Exterior Lighting:

$$\Delta kW_{Peak} = \frac{Qty_b \times W_b - Qty_q \times W_q}{1{,}000} \times CF$$

New Construction Interior Lighting:

$$\Delta kW_{Peak} = \frac{LPD_b \times LPD_{AF} - LPD_q}{1{,}000} \times A \times CF \times (1 + HVAC_d) \times (1 + SVG_b)$$

New Construction Exterior Lighting

$$\Delta kW_{peak} = \frac{\left(LPA_b \times LPA_{AF} - LPA_q\right)}{1{,}000} \times AL \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms * PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

For NC/TOS:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

For EREP/DI:

$$\Delta kWh_{Life} = \Delta kWh \times AML$$

Lifetime Fuel Energy Savings

For NC/TOS:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

For EREP/DI:

$$\Delta Therms_{Life} = \Delta Therms \times AML$$

Calculation Parameters

Table 3-226 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
Qty_b	Quantity of replaced fixtures	Site-specific	N/A	
Qty_q	Quantity of qualifying fixtures	Site-specific	N/A	
W_b	Wattage of baseline fixture	Site-specific, if unknown see Appendix L: Lighting Wattages	W	[628]
W_q	Wattage of qualifying fixture (per DLC or ENERGY STAR certification, or manufacturer's cutsheet if certification not required by program)	Site-specific	W	
LPD_q	Installed lighting power density	Site-specifiic	W/Sq Ft	
LPD_b	Baseline lighting power density	Site-specific, if unknown look up in Table 3-227, Table 3-228, Table 3-230	W/Sq Ft	

Variable	Description	Value	Units	Ref
LPA_b	Baseline lighting power allowance	Site-specific, if unknown look up in Table 3-230	W/Sq Ft or W/ Linear Ft	[629]
LPA_q	Installed lighting power allowance	Site-specific, if unknown look up in Table 3-230	W/Sq Ft or W/ Linear Ft	[629]
AL	If LPA unit is W/Sq Ft: AL is Area If LPA Unit is W/linear ft: AL is linear ft	Site-specific	Sq Ft or Linear Ft	
A	Area in Square Feet	Site-Specific	Square Foot	
Hrs	Annual Hours of Operation	Site-specific, if unknown use Table 3-231	Hrs/yr	[620]
LPD_{AF} (interior)	Interior Lighting LPD adjustment factor (25% better)	0.75	N/A	[634]
LPA_{AF} (exterior)	Exterior Lighting LPA adjustment factor (35% better)	0.65	N/A	[634]
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in Table 3-232	N/A	[651][653]
$HVAC_{ff}$	HVAC Interactive Factor for Annual Fossil Fuel Savings	Look up in Appendix F: HVAC Interactivity Factors	MMBtu/kWh	[638]
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in Table 3-232	N/A	[651][653]
CF	Coincidence Factor	Look up in Table 3-231	N/A	[620]
SVG_b	Savings control factor	Look up in Table 3-233		[637]
PDF	Gas peak day factor	Look up in Table 3-234		
AML	Adjusted measure life for EREP/DI	See Measure Life Section	Years	
EUL	Effective useful life for NC/TOS	See Measure Life Section	Years	
1,000	Conversion from watts to kW	1,000	W/kW	
10	Conversion from MMBtu to therms	10	Therms/MMBtu	

Table 3-227 Baseline Lighting Power Density (Building Area Method) – IECC 2021 Standard Section C405.3.2(1) [629]

Building Area Type	LPD (Watts/ft^2)	Building Area Type	LPD (Watts/ft^2)
Automotive facility	0.75	Multifamily	0.45
Convention center	0.64	Museum	0.55
Court house	0.79	Office	0.64

Building Area Type	LPD (Watts/ft²)	Building Area Type	LPD (Watts/ft²)
Dining: bar lounge/leisure	0.80	Parking garage	0.18
Dining: cafeteria/fast food	0.76	Penitentiary	0.69
Dining: family	0.71	Performing arts theatre	0.84
Dormitory	0.53	Police/fire station	0.66
Exercise center	0.72	Post office	0.65
Fire station	0.56	Religious building	0.67
Gymnasium	0.76	Retail	0.84
Health care clinic	0.81	School/university	0.72
Hospital	0.96	Sports arena	0.76
Hotel/motel	0.56	Town hall	0.69
Library	0.83	Transportation	0.50
Manufacturing facility	0.82	Warehouse	0.45
Motion picture theatre	0.44	Workshop	0.91

Table 3-228 Baseline Lighting Power Density (Space by Space Method) 2021 IECC section C405.3.2(2) [2]

Space Types	LPD (watts/ft²)	Space Types	LPD (watts/ft²)
Atrium		**Laundry/washing area**	0.53
Less than 40 feet in height	0.48	**Library**	
Greater than 40 feet in height	0.6	*In a reading area*	0.96
Audience seating area		*In the stacks*	1.18
In an auditorium	0.61	**Loading dock, interior**	0.88
In a gymnasium	0.23	**Lobby**	
In a motion picture theater	0.27	*For an elevator*	0.65
In a penitentiary	0.67	*In a facility for the visually impaired (and not used primarily by the staff)[b]*	1.69
In a performing arts theater	1.16	*In a hotel*	0.51
In a religious building	0.72	*In a motion picture theater*	0.23
In a sports arena	0.33	*In a performing arts theater*	1.25
Otherwise	0.33	*Otherwise*	0.84
Automotive (see Vehicular maintenance area)		**Locker room**	0.52
Banking activity area	0.61	**Lounge/breakroom**	
Breakroom (See Lounge/breakroom)		*In a healthcare facility*	0.42
Classroom/lecture hall/training room		*Otherwise*	0.59
In a penitentiary	0.89	**Manufacturing facility**	

Space Types	LPD (watts/ft²)
Otherwise	0.71
Computer room, data center	0.94
Conference/meeting/multipurpose room	0.97
Convention Center—exhibit space	0.61
Copy/print room	0.31
Corridor	
In a facility for the visually impaired (and not used primarily by the staff)[b]	0.71
In a hospital	0.71
Otherwise	0.41
Courtroom	1.2
Dining area	
In bar/lounge or leisure dining	0.86
In cafeteria or fast food dining	0.4
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.27
In family dining	0.6
In a penitentiary	0.42
Otherwise	0.43
Dormitory—living quarters[c, d]	0.5
Electrical/mechanical room	0.43
Emergency vehicle garage	0.52
Facility for the visually impaired[b]	
In a chapel (and not used primarily by the staff)	0.7
In a recreation room (and not used primarily by the staff)	1.77
Fire Station—sleeping quarters[c]	0.23
Food preparation area	1.09
Guestroom[c, d]	0.41
Gymnasium/fitness center	
In an exercise area	0.9
In a playing area	0.85
Healthcare facility	
In an exam/treatment room	1.4
In an imaging room	0.94
In a medical supply room	0.62
In a nursery	0.92
In a nurse's station	1.17
In an operating room	2.26

Space Types	LPD (watts/ft²)
In a detailed manufacturing area	0.8
In an equipment room	0.76
In an extra-high-bay area (greater than 50 feet floor-to-ceiling height)	1.42
In a high-bay area (25–50 feet floor-to-ceiling height)	1.24
In a low-bay area (less than 25 feet floor-to-ceiling height)	0.86
Museum	
In a general exhibition area	0.31
In a restoration room	1.1
Office	
Enclosed	0.74
Open plan	0.61
Parking area, interior	0.15
Pharmacy area	1.66
Performing arts theater—dressing room	0.41
Post office—sorting area	0.76
Religious buildings	
In a fellowship hall	0.54
In a worship/pulpit/choir area	0.85
Restroom	
In a facility for the visually impaired (and not used primarily by the staff[b]	1.26
Otherwise	0.63
Retail facilities	
In a dressing/fitting room	0.51
In a mall concourse	0.82
Sales area	1.05
Seating area, general	0.23
Stairwell	0.49
Sports arena—playing area	
For a Class I facility[e]	2.94
For a Class II facility[f]	2.01
For a Class III facility[g]	1.3
For a Class IV facility[h]	0.86
Storage room	0.38
Transportation facility	
At a terminal ticket counter	0.51
In a baggage/carousel area	0.39

Space Types	LPD (watts/ft^2)
In a patient room[c]	0.68
In a physical therapy room	0.91
In a recovery room	1.25
Laboratory	
In or as a classroom	1.11
Otherwise	1.33

Space Types	LPD (watts/ft^2)
In an airport concourse	0.25
Vehicular maintenance area	0.6
Warehouse—storage area	
For medium to bulky, palletized items	0.33
For smaller, hand-carried items	0.69
Workshop	1.26

a. In cases where both a common space type and a building area specific space type are listed, the building area specific space type shall apply.

b. A 'Facility for the Visually Impaired' is a facility that is licensed or will be licensed by local or state authorities for senior long-term care, adult daycare, senior support or people with special visual needs.

c. Where sleeping units are excluded from lighting power calculations by application of Section R404.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.

d. Where dwelling units are excluded from lighting power calculations by application of Section R404.1, neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.

e. Class I facilities consist of professional facilities; and semiprofessional, collegiate, or club facilities with seating for 5,000 or more spectators.

f. Class II facilities consist of collegiate and semiprofessional facilities with seating for fewer than 5,000 spectators; club facilities with seating for between 2,000 and 5,000 spectators; and amateur league and high school facilities with seating for more than 2,000 spectators.

g. Class III facilities consist of club, amateur league and high school facilities with seating for 2,000 or fewer spectators.

h. Class IV facilities consist of elementary school and recreational facilities; and amateur league and high school facilities without provision for spectators.

Table 3-229 Exterior Lighting Zones - 2021 IECC section C405.5.2 (1)

Lighting Zone	Description
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use, and residential mixed-use areas
3	All other areas not classified as Lighting Zone 1, 2, or 4
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

Table 3-230 Exterior Lighting Power Allowances – 2021 IECC Standard Section C405.5.2(2) and Section C405.5.2(3)

Category		Space	Units	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance			W	350	400	500	900
Tradable Surfaces	Uncovered Parking Areas	Parking areas and drives	W/ft^2	0.03	0.04	0.06	0.08
	Building Grounds	Walkways and ramps less than 10 feet wide	W/Linear Foot	0.50	0.50	0.60	0.70
	Building Grounds	Walkways and ramps 10 feet wide or greater, plaza areas	W/ft^2	0.10	0.10	0.11	0.14
	Building Grounds	Dining areas	W/ft^2	0.65	0.65	0.75	0.95
	Building Grounds	Stairways	W/ft^2	0.60	0.70	0.70	0.70
	Building Grounds	Pedestrian tunnels	W/ft^2	0.12	0.12	0.14	0.21
	Building Grounds	Landscaping	W/ft^2	0.03	0.04	0.04	0.04

Category	Space	Units	Zone 1	Zone 2	Zone 3	Zone 4
Building Entrances and Exits	Pedestrian and vehicular entrances and exits	W/Linear Foot of opening	14	14	21	21
Building Entrances and Exits	Entry canopies	W/ft^2	0.20	0.25	0.40	0.40
Building Entrances and Exits	Loading docks	W/ft^2	0.35	0.35	0.35	0.35
Sales Canopies	Canopies (free-standing and attached)	W/ft^2	0.40	0.40	0.6	0.7
Outdoor Sales	Open areas (including vehicle sales lots)	W/ft^2	0.20	0.20	0.35	0.50
Outdoor Sales	Street frontage for vehicle sales lots in addition to "Open Area" allowance	W/Linear Foot	-	7	7	21
Non-Tradable Surfaces	Building facades	W/ft^2 of gross above-grade wall area	-	0.075	0.113	0.15
Non-Tradable Surfaces	Automated teller machines (ATMs) and night depositories	W per location	135 plus 45 per additional ATM	135 plus 45 per additional ATM	135 plus 45 per additional ATM	135 plus 45 per additional ATM
Non-Tradable Surfaces	Uncovered entrances and gatehouse inspection stations at guarded facilities	W/ft^2	0.5	0.5	0.5	0.5
Non-Tradable Surfaces	Uncovered loading areas for law enforcement, fire, ambulance, and other emergency vehicles	W/ft^2	0.35	0.35	0.35	0.35
Non-Tradable Surfaces	Drive-up windows and doors	W/drive-through	200	200	200	200
Non-Tradable Surfaces	Parking near 24-hour retail entrances	W/main entry	400	400	400	400

Table 3-231 Hours of Use and Coincidence Factor by Building Type

Building Type	Sector	CF	Hours
Grocery	Large Commercial/Industrial & Small Commercial	0.96	7,134
Medical – Clinic	Large Commercial/Industrial & Small Commercial	0.8	3,909
Medical - Hospital	Large Commercial/Industrial & Small Commercial	1	8,760[143]
Office	Large Commercial/Industrial	0.7	2,969
	Small Commercial	0.67	2,950
Other	Large Commercial/Industrial & Small Commercial	0.66	4,573
Retail	Large Commercial/Industrial	0.96	4,920
	Small Commercial	0.86	4,926

[143] Assumes hospital operations are year round.

Building Type	Sector	CF	Hours
School	Large Commercial/Industrial & Small Commercial	0.50	2,575
Warehouse/ Industrial	Large Commercial/Industrial	0.7	4,116
	Small Commercial	0.68	3,799
Outside/Outdoor Area	All	0.11	3,604
Parking Garage	All	0.98	8,678
Multifamily – Common Areas[144]	Multifamily	0.86	5,950
Multifamily – In-Unit	Multifamily	0.06	679
Multifamily –Exterior	Multifamily	0.00	3,338
College/University - Cafeteria[145]	All	0.79	2,713
College/University – Classes[3]	All	0.54	2,586
College/University - Dormitory[3]	All	0.92	3,066
Religious Building[3]	All	0.89	1,955
Nursing Home[3]	All	0.92	5,840
Restaurant - Dine-In[145]	All	0.79	4,182
Restaurant - Fast food[145]	All	0.79	6,456
Museum[145]	All	0.89	3,748

Table 3-232 HVAC Interactive Effects[146]

Building Type	HVAC Interactive Factor for Peak Demand Savings ($HVAC_d$)		HVAC Interactive Factor for Annual Energy Savings ($HVAC_e$)			
	AC (Utility)	AC (PJM)	AC/NonElec	AC/ElecRes	Heat Pump	NoAC/ElecRes
Office	0.35	0.32	0.10	-0.15	-0.06	-0.25
Retail	0.27	0.26	0.06	-0.17	-0.05	-0.23
Education	0.44	0.44	0.10	-0.19	-0.04	-0.29
Warehouse	0.22	0.23	0.02	-0.25	-0.11	-0.27

[144] NEEP Mid-Atlantic TRM V9, p. 24.
[145] From NY TRM V10, Pg 862
[146] These values only apply for conditioned spaces. For unconditioned spaces, the ineractive factors are equal to zero.

Building Type	HVAC Interactive Factor for Peak Demand Savings ($HVAC_d$)		HVAC Interactive Factor for Annual Energy Savings ($HVAC_e$)			
	AC (Utility)	AC (PJM)	AC/NonElec	AC/ElecRes	Heat Pump	NoAC/ElecRes
Mid-Stream/Other[147]	0.34	0.32	0.08	-0.18	-0.07	-0.26

Table 3-233 Baseline SVG Values

Building Type	SVGbase
Education	17%
Exterior	0%
Grocery	5%
Health	8%
Industrial/Manufacturing – 1 Shift	0%
Industrial/Manufacturing – 2 Shift	0%
Industrial/Manufacturing – 3 Shift	0%
Institutional/Public Service	12%
Lodging	15%
Miscellaneous/Other	6%
Office	15%
Parking Garage	0%
Restaurant	5%
Retail	5%
Warehouse	14%
Custom	Based on Code

[147] The 'Other' building type should be used when the building type is known but not explicitly listed above. A description of the actual building type should be recorded in the project documentation. For multifamily high-rise building common areas, use this type. For in unit lamps/fixtures and multifamily low-rise building common areas refer to the Residential Section.

Peak Factors

Table 3-234 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Look up in Table 3-231	[620]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

Table 3-235 Measure Life

Equipment Type	AML (for EREP/DI)	EUL (for NC/TOS)	Ref
LED Fixture	5	Fixture rated life in hours ÷ operating hours from Table 3-231. Not to exceed 15 yr.	[635]
LED Fixture with Controls	7	Fixture rated life in hours ÷ operating hours from Table 3-231. Not to exceed 15 yr.	[635]
TLED	5	N/A	[635]
High Bay/Low Bay LED Fixture	7	Fixture rated life in hours ÷ operating hours from Table 3-231. Not to exceed 15 yr.	[635]
High Bay/Low Bay LED Fixture with Controls	8	Fixture rated life in hours ÷ operating hours from Table 3-231. Not to exceed 15 yr.	[635]
High Bay/Low Bay TLED	6	N/A	[635]
Exterior/Outdoor LED Fixture	7	Fixture rated life in hours ÷ operating hours from Table 3-231. Not to exceed 15 yr.	[635]
Exterior/Outdoor LED Fixture with Controls	8	Fixture rated life in hours ÷ operating hours from Table 3-231. Not to exceed 15 yr.	[635]
Exterior/Outdoor TLED	6	N/A	[635]
Screw-in LEDs	1	N/A	[636]

References

[628] Review of Device Codes and Rated Lighting System Wattage Table Retrofit Program. 2015. National Grid. January 13, 2015. https://www.nationalgridus.com/non_html/2010_Retrofit_Lighting_DeviceCodes_RI.pdf

[629] "2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed November 16, 2022. https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency.

[630] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1,2017 – May 31, 2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs*, (2018)

[631] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs*, (2013)

[632] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory*

[633] Northeast Energy Efficiency Partnerships & KEMA, *C&I Lighting Load Shape Project FINAL Report - Prepared for the Regional Evaluation, Measurement and Verification Forum.* (2011).

[634] DNV, *New Jersey Commercial New Construction Industry Standard Practice Analysis. Prepared for Rutgers University and the NJ Board of Public Utilities.* (2022).

[635] DNV, N*ew Jersey Non-Residential Lighting Market Characterization*. *Prepared for Rutgers University and the NJ Board of Public Utilities.* (2022).

[636] Engineering judgement based on expected existing incandescent or halogen lamp remaining life. Once the existing lamp has burned out, replacement with an EISA-compliant lamp is assumed to be the only option.

[637] *Technical Reference Manual Volume 3: Commercial and Industrial Measures* (August 2019) Pg 21 https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

[638] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Appendix D, Pg 1162

3.7.2 LIGHTING CONTROLS

Market	Commercial/Multifamily
Baseline Condition	NC/RF
Baseline	ISP/Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline • Corrected order of SVG_b and SVG_q variables in savings equations

Description

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

- **Normal Lighting Controls:** Normal lighting controls include occupancy sensors, daylight dimmer systems, and occupancy controlled hi-low controls for fluorescent, LED, and HID fixtures.
- **Networked Lighting Controls:** This measure defines the savings associated with installing a network controlled lighting system. The control system must include luminaire-level lighting control (LLLC) that can switch lights on and off based on occupancy and is capable of full-range dimming based on local light levels. Note: Because networked lighting controls are required to include occupancy sensors and daylight harvesting, savings from occupancy sensors and daylight dimming control cannot be claimed separately. Additional savings may be achieved at no additional hardware cost on a site-specific basis by implementing high-end trimming, personalized local controls, and customized scheduling with no need for additional equipment or software.
- **Bi-level Lighting Controls:** This measure addresses bi-level occupancy control of lighting in stairwells, corridors, parking garages and parking lots via the installation of controls on existing fixtures or installation of luminaires with integrated bi-level occupancy control. Bi-level occupancy control allows for the continuous lighting of spaces at code-mandated minimum illumination levels when the space is unoccupied and at higher light levels when occupied. This measure is only applicable as a retrofit or replacement in existing buildings because multi-level switching at defined lighting power densities and percentages of full connected load is mandated in many space types by federal, state, local, and municipal codes and standards. This measure is restricted to lighting in parking lots and in spaces that are required by fire and safety code to be illuminated continuously. The post-implementation case must comply with all provisions of applicable fire, safety and construction code.

Baseline Case

Retrofit (RF): The baseline condition is the existing lighting system which includes controls such as continuous operation or manual on/off controls

New Construction (NC): The baseline condition is a control system that meets ASHRAE 90.1-2019 or industry standard practice in new construction.

Efficient Case

Retrofit (RF): The efficient condition is the existing lighting system retrofitted with more efficient controls.

New Construction (NC): The efficient condition is the baseline system that meets ASHRAE 90.1-2019 or industry standard practice in new construction with additional controls.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Normal or Networked Lighting

$$\Delta kWh = kW_c \times Hrs \times (SVG_q - SVG_b) \times (1 + HVAC_c)$$

Bi-level Lighting

$$\Delta kWh = \left[\frac{W_b \times Qty_b}{1{,}000} - \left(\frac{W_q \times Qty_q}{1{,}000} \times (1 - SVG_{bl})\right)\right] \times Hrs$$

Where,

$$SVG_{bl} = F_{low} \times \left(1 - \frac{W_{low}}{W_q}\right)$$

Annual Fuel Savings

Normal or Networked Lighting

$$\Delta Therms = kW_c \times Hrs \times (SVG_q - SVG_b) \times HVAC_{ff} \times 10$$

Bi-level Lighting

$$\Delta Therms = N/A$$

Peak Demand Savings

Normal or Networked Lighting

$$\Delta kW_{Peak} = kW_c \times (SVG_q - SVG_b) \times CF \times (1 + HVAC_d)$$

Bi-level Lighting

$$\Delta kW_{Peak} = \left[\frac{W_b \times Qty_b}{1{,}000} - \left(\frac{W_q \times Qty_q}{1{,}000} \times (1 - SVG_{bl,demand})\right)\right] \times CF$$

Where,

$$SVG_{bl,demand} = F_{low} \times \left(1 - \frac{W_{low}}{W_q}\right)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-236 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ESF	Energy savings factor	Calculated	N/A	
SVG_{bl}	Percent of annual lighting energy saved by the bi-level lighting control	Calculated	N/A	
$SVG_{bl,demand}$	Percent of annual lighting demand energy saved by the bi-level lighting control	Calculated	N/A	
kW_c	Lighting load connected to control	Site-specific	kW	
Qty_b	Quantity of existing fixture	Site-specific	N/A	
Qty_q	Quantity of efficient fixture	Site-specific	N/A	
W_b	Wattage of existing fixture	Site-specific	W	
W_q	Wattage of efficient fixture at full light output	Site-specific	W	
W_{low}	Wattage of the efficient fixture in low-power mode	Site-specific	W	
F_{low}	Percentage of annual operating hours that the fixture operated in low-power mode	Site-specific, if unknown lookup in Table 3-238	N/A	[642][643][644][645]

Variable	Description	Value	Units	Ref
SVG_b	Percent of annual lighting energy saved by the baseline lighting control	Lookup in Table 3-237	N/A	[641]
SVG_q	Percent of annual lighting energy saved by the efficient lighting control	Lookup in Table 3-237	N/A	[641]
$HVAC_d$	Secondary demand in reduced HVAC consumption resulting from decreased indoor lighting wattage	Look up in Appendix F: HVAC Interactivity Factors	N/A	[639]
$HVAC_c$	Secondary energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage	Look up in Appendix F: HVAC Interactivity Factors	N/A	[639]
$HVAC_{ff}$	Secondary energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage	Lookup in Appendix F: HVAC Interactivity Factors	MMBtu/kWh	[648]
Hrs	Annual hours of operation prior to installation of controls	Site-specific, if unknown use Table 3-231 (in Section 3.7.1)	Hours	[649]
ISR	In-service rate	Look up by program in Appendix J: In-Service Rates, or use default value = 1	N/A	
1,000	Conversion factor	1,000	kW/W	
10	Conversion factor	10	Therms/MMBtu	
CF	Electric coincidence factor	Lookup in Table 3-239	N/A	[649]
PDF	Gas peak day factor	Lookup in Table 3-239	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-237 SVG

Lighting Control Type	SVG
Networked lighting controls (NLC)	0.49
Luminaire-level lighting controls (LLLC) – Networked & Commissioned	0.49
Integrated fixture with room-based controls[148]	0.38
Dual occupancy and daylight sensors	0.38

[148] 38% is highest savings factor associated with a non-networked fixture with integrated controls. This was determined to be a reasonable assumption for a fixture with three integrated controls that is not networked or verified/commissioned.

Lighting Control Type	SVG
Combination of high-end trim and daylight dimming	0.35
Combination of high-end trim and occupancy sensors	0.33
Daylight dimming	0.28
Occupancy sensors	0.24
No lighting controls	0.00

Table 3-238 Low-Power Mode Factor

Space Type	F_{low}
Stairwell	0.73
Corridor	0.75
Parking Garage	0.56
Parking Lot	0.45

Peak Factors

Table 3-239 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Look up in Table 3-231 (in Section 3.7.1)	[646]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 8 years [572].

References

[639] Average HVAC interactive effects by building type derived from the NEEP Mid-Atlantic TRM 2017, NEEP, *Mid-Atlantic Technical Reference Manual*, V10, Appendix E.

[640] Massachusetts TRM, 2016-2018 Program Years, October 2015. Original source: DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council

[641] DNV. 2022. “X1931-4 ALC PSD Phase 2 Memo.” Connecticut Energy Efficiency Board (EEB) and Evaluation Administrators.

[642] California Energy Commission, Lighting Research Program, Project 5.1 Bi-level Stairwell Fixture Performance Final Report, October 2005 – Average of “Time Dimmed” across the four test sites during weekday operation (Table 2. Weekday daily average energy usage and savings, pg. 22).

[643] CA State Partnership for Energy Efficiency Demonstrations, Interior Lighting Case Study: Adaptive Corridor Lighting, April 2014, pg. 2. https://cltc.ucdavis.edu/sites/default/files/files/publication/CASE_STUDY_UCSF_Adaptive_Corridors_140602.pdf

[644] California Energy Commission Public Interest Energy Research Program, Case Study: Bi-Level LED Parking Garage Luminaires – Average of unoccupied hours across the three test sites. https://cltc.ucdavis.edu/sites/default/files/files/publication/case-study-bi-level-led-garage-luminaires.pdf

[645] Pacific Gas & Electric, Application Assessment of Bi-Level LED Parking Lot Lighting, February 2009, pg. 1. https://www.osti.gov/biblio/1218189

[646] NEEP Mid-Atlantic TRM 2018, NEEP, Mid-Atlantic Technical Reference Manual, V8. May 2018, pp. 462-463.

[647] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

[648] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Appendix D, Pg 1162

[649] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1,2017 – May 31, 2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs*, (2018)

3.7.3 DELAMPING

Market	Commerical/Multifamily
Baseline Condition	ERET/DI
Baseline	Existing/Dual
End Use Subcategory	Lighting
Measure Last Reviewed	September 2024
Changes Since Last Version	• Clarified efficient case definition • Moved HVAC interactive effect look-up to appendix

Description

This measure relates to the permanent removal of a lamp and the associated electrical sockets (or "tombstones") from a fixture.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline conditions will vary dependent upon the characteristics of the existing fixture.

Efficient Case

The efficient condition will vary depending on the existing fixture and the number of lamps removed.

- Total delamping (all lamps removed): efficient wattage = 0
- Parital delamping (not all lamps removed): efficient wattage = pre-existing wattage minus wattage of removed lamps. For replacement with efficient lamps see Section 3.7.1.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Watts_b - Watts_q}{1{,}000} \times Hrs \times (1 + HVAC_c)$$

Annual Fuel Savings

$$\Delta Therms = \frac{Watts_b - Watts_q}{1{,}000} \times Hrs \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{Watts_b - Watts_q}{1,000} \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-240 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Watts_b$	Total Connected load of baseline fixture	Site-specific	Watts	
$Watts_q$	Total Connected load of delamped fixture (equal to baseline watts minus wattage of removed lamps – for replacement with efficient lamps see Section 3.7.1)	Site-specific	Watts	

Variable	Description	Value	Units	Ref
Hrs	Deemed average hours of use per year	Look up in Table 3-231 (in Section 3.7.1)	Hrs/yr	[650]
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[651][653]
$HVAC_{ff}$	HVAC Interactive Factor for Annual Fuel Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[655]
$HVAC_d$	HVAC Interactive Factor for Annual Demand Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[651][653]
CF	Electric coincidence factor	Look up in Table 3-231 (in Section 3.7.1)	N/A	[650]
PDF	Gas peak day factor	Look up in Table 3-241	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-241 Peak Factors

Peak Factor	Value	Ref
Electric Coincedence (CF)	Look up in Table 3-231 (in Section 3.7.1)	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-242 Measure Life

Equipment	EUL	RUL	Ref
Delamping	16	5.33	[652]

References

[650] Navigant, EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1, 2017 – May 31, 2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs, (2018).

[651] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs*, (2013)

[652] GDS Associates, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007 available at https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf

[653] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory*

[654] Northeast Energy Efficiency Partnerships & KEMA, *C&I Lighting Load Shape Project FINAL Report - Prepared for the Regional Evaluation, Measurement and Verification Forum.* (2011).

[655] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Appendix D, Pg 1162

3.7.4 EXIT SIGNS

Market	Commercial/Multifamily
Baseline Condition	DI
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023
Changes Since Last Version	• Removed dual baseline algorithms

Description

This measure relates to the installation of an exit sign illuminated with light emitting diodes (LED). This measure should be limited to early replacement applications. Note: While this measure is characterized as an early replacement, a dual baseline is not used as it is assumed that the existing fixture would have been maintained with new baseline lamps (and ballasts, if required) for the duration of the measure life.

Baseline Case

The baseline condition is an existing exit sign with a non-LED light-source.

Efficient Case

The efficient condition is a new exit sign illuminated with light emitting diodes (LED).

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W_b - W_q}{1{,}000} \times Hrs \times (1 + HVAC_c)$$

Annual Fuel Savings

$$\Delta Therms = \frac{W_b - W_q}{1{,}000} \times Hrs \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{W_b - W_q}{1{,}000} \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-243 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
W_b	Actual Connected load of existing exit sign	Site-specific, if unknown look up in Table 3-244	kW	
W_q	Actual Connected load of LED exit sign	Site-specific, if unknown look up in Table 3-244	kW	
Hrs	Average hours of use per year	Site-specific, if unknown use 8,760	Hours	
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[656][653]
$HVAC_{ff}$	HVAC Interactive Factor for Annual Fuel Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[662]
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[656][653]
CF	Electric coincidence factor	Look up in Table 3-245	N/A	
PDF	Gas peak day factor	Look up in Table 3-245	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-244 Connected Load by Bulb Type

Type	Single-Sided kW	Dual-Sided kW
Incandescent	0.020	0.040
Fluorescent	0.009	0.020
LED	0.002	0.004

Peak Factors

Table 3-245 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.00	[658]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-246 Measure Life

Equipment	EUL	RUL	Ref
Exit Signs	15	5	[659]

References

[656] EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, Navigant, March 31, 2014. WHF values for Washington, D.C. and Delaware assume values from Maryland, Pepco and Maryland, DPL, respectively.

[657] Rundquist, R A, Johnson, K F, and Aumann, D J. 1993. 1993 ASHRAE Journal:"Calculating lighting and HVAC interactions". Typical aspect ratio for perimeter zones. Heating factor applies to perimeter zoneheat, therefore it must be adjusted to account for lighting in core zones.

[658] Efficiency Vermont Technical Reference Manual 2009-55, December 2008.

[659] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

[660] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory*

[661] Northeast Energy Efficiency Partnerships & KEMA, *C&I Lighting Load Shape Project FINAL Report - Prepared for the Regional Evaluation, Measurement and Verification Forum.* (2011).

[662] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Appendix D, Pg 1162

3.7.5 LED SIGN LIGHTING

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Lighting
Measure Last Reviewed	January 2023
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure is applicable to the installation of LED sign lighting fixtures. This technology provides the required illumination at reduced input power. Typically, these signs are constructed from sheet metal sides forming the shape of letters and a translucent plastic lens. Luminance is most commonly provided by single or double strip neon lamps, powered by neon sign transformers. Retrofit kits are available to upgrade existing signage from neon to LED light sources, substantially reducing the electrical power and energy required for equivalent sign luminance. LED drivers can be either electronic switching or linear magnetic, with the electronic switching supplies being the most efficient. The on/off power switch may be found on either the power line or load side of the driver, with the line side location providing significantly lower standby losses when the sign is turned off and is not operating. All new open signs must meet UL-84 (UL-844) requirements. Replacement signs cannot use more than 20% of the input power of the sign that is being replaced.

Baseline Case

The baseline condition is fluorescent lighting or neon type illuminated LED open sign.

Efficient Case

The compliance condition is an LED type illuminated LED open sign.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W_b - W_q}{1{,}000} \times Hrs \times (1 + HVAC_c)$$

Annual Fuel Savings

$$\Delta Therms = \frac{W_b - W_q}{1{,}000} \times Hrs \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{W_b - W_q}{1{,}000} \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-247 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
W_b	Equipment wattage for baseline condition	Site-specific, if unknown use 46	Watts	[663]
W_q	Equipment wattage for energy efficient condition	Site-specific	Watts	
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	0 for Exterior and Unconditioned Spaces; otherwise see Appendix F: HVAC Interactivity Factors	N/A	
$HVAC_d$	HVAC interaction factor at utility summer peak hour	0 for Exterior and Unconditioned Spaces; otherwise see Appendix F: HVAC Interactivity Factors	N/A	

Variable	Description	Value	Units	Ref
$HVAC_{ff}$	HVAC interaction factor for annual fuel consumption	0 for Exterior and Unconditioned Spaces; otherwise see Appendix F: HVAC Interactivity Factors	MMBtu/kWh	
Hrs	Annual hours of operation	Site-specific, If unknown use defaults: Signage with photocell control operate = 4,380 hours Signage with time switch control = 2,190 hours	Hrs	[669][670]
1,000	Conversion factor, one kilowatt equals 1,000 watts	1,000	N/A	
CF	Electric coincidence factor	Lookup in Table 3-52	N/A	[664][665][666][667][668]
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-248 CF by Building Type

Building Type	CF
Education	0.39
Exterior, Photocell-Controlled (All Building Types)	0.11
Exterior, All Other (All Building Types)	0.11
Grocery	0.99
Health	0.47
Industrial Manufacturing – 1 Shift	0.96
Industrial Manufacuring – 2 Shift	0.96
Industrial Manufacturing – 3 Shift	0.96
Institutional/Public Service	0.23
Lodging	0.38
Miscellaneous/Other	0.33
Multifamily Common Areas	0.73
Office	0.26
Parking Garages	0.98
Restaurant	0.55
Retail	0.56

Building Type	CF
Street Lighting	0.00
Warehouse	0.50
Outdoor	0.00

Peak Factors

Table 3-249 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Lookup in Table 3-52	[664][665][666][667][668]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-250 Measure Life

Equipment	EUL	RUL	Ref
LED Sign Lighting	15	5	[663]

References

[663] Measured average demand data. Southern California Edison, “Replace Neon Open Sign with LED Open Sign”, Workpaper SCE13LG070, Revision 2, October 2015. Pg. 10.

[664] Illinois Statewide Technical Reference Manual for Energy Efficiency v7.0. Multifamily common area value based on DEER 2008. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final_9-28-18/IL-TRM_Effective_010119_v7.0_Vol_2_C_and_I_092818_Final.pdf Accessed December 2018.

[665] Pennsylvania Statewide Act 129 2014 Commercial & Residential Lighting Metering Study. Prepared for Pennsylvania Public Utilities Commission. January 13, 2015. http://www.puc.pa.gov/pcdocs/1340978.pdf

[666] U.S. Naval Observatory. Duration of Daylight/Darkness Table for One Year. https://aa.usno.navy.mil/data/docs/Dur_OneYear.php Assumes values for Philadelphia.

[667] Mid-Atlantic Technical Reference Manual v8.0, https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V7_FINAL.pdf

[668] UI and CL&P Program Savings Documentation for 2013 Program Year, United Illuminating Company, September 2012.

[669] ConEd Large C&I Program Impact and Process Evaluation Report prepared by Navigant, August 2019, slide 71.

[670] Time switch control – assume 6 hours per day, 365 days per year

3.7.6 INDOOR HORTICULTURE LED

Market	Commercial
Baseline Condition	NC/TOS/DI
Baseline	ISP/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023
Changes Since Last Version	• Added average row to baseline PPE table

Description

The method below is applicable to the installation of LED fixtures intended for indoor horticultural use that meet the DesignLights Consortium (DLC) Horticultural Lighting Technical Requirements Version 3.0 (Hort V3.0). This measure shall be used only for New Construction or fixture additions. Savings are based on the difference between the photosynthetic photon efficacies (PPE) of the efficient fixture and an industry standard practice fixture.

Baseline Case

The baseline fixtures meet the indoor agriculture industry standard practice photosynthetic photon efficacies (PPE) of 1.7 micromoles per Joule.

Efficient Case

The efficient case is the installation of new DLC qualified LED indoor agriculture fixtures having a PPE that meet is or exceeds the DLC Hort 3.0 standard of 2.3 micromoles per joule.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kW \times hrs \times (1 + HVAC_c)$$

Where,

$$\Delta kW = N_q \times W_q \times (\frac{PPE_q}{PPE_b} - 1)/1000$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kW \times CF \times (1 + HVAC_d)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-251 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkW	Change in connected load from baseline to efficient lighting level	Calculated	kW	
Hrs	Annual hours of operation	Site-specific	hours	
N_q	Number of energy efficient fixtures	Site-specific	fixtures	
W_q	Wattage of energy efficient fixtures	Site-specific	W	
PPE_q	Photosynthetic photon efficacy (PPE) of qualifying equipment	Site-specific	µmol/j	

Variable	Description	Value	Units	Ref
PPE_b	Photosynthetic photon efficacy (PPE) of baseline equipment	Lookup in Table 3-252	µmol/j	[672][673] [674]
$HVAC_c$	HVAC interactive effects for electricity consumption	Look up in Appendix F: HVAC Interactivity Factors	N/A	[674]
$HVAC_d$	HVAC interactive effects for electricity peak demand	Look up in Appendix F: HVAC Interactivity Factors	N/A	[674]
CF	Electric coincidence factor	Lookup in Table 3-253	N/A	
PDF	Gas peak demand factor	Lookup in Table 3-253	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-252 Baseline Photosynthetic Photon Efficacy (PPE)

Crop Type	Baseline Technology Type	Baseline PPE
Flowering Crops (Tomatoes and Peppers)	High Pressure Sodium	1.7
Vegetative Growth	Metal Halide	1.25
Microgreens	T5 HO Fixture	1.0
Propogation	T5 HO Fixture	1.0
Medical Cannabis – Flowering Stage	High Pressure Sodium	1.7
Medical Cannabis – Vegetative Stage	Metal Halide	1.25
Medical Cannabis – Cloning, Seeding, and Propogation	T5 HO Fixture	1.0
Recreational Cannabis – Flowering Stage	HID/LED/Other	2.2
Recreational Cannabis – Vegetative Stage	HID/LED/Other	2.2
Recreational Cannabis – Cloning, Seeding, and Propogation	T5/LED/Other	2.2
Unknown	Average	1.55

Peak Factors

Table 3-253 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	[675]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-254 Measure Life

Equipment	EUL	RUL	Ref
Indoor Horticulture LED	12	4	[676]

References

[671] Radetsky, Leora, "LED and HID Horticultural Luminaire Testing Report Prepared for Lighting Energy Alliance Members and Natural Resources Canada." Rensselaer Polytechnic Institute, May 3, 2018; https://www.lrc.rpi.edu/programs/energy/pdf/HorticulturalLightingReport-Final.pdf

[672] Runkle, Erik and Bugbee, Bruce "Plant Lighting Efficiency and Efficacy; µmols per joule", Greenhouse Product News: https://gpnmag.com/article/plant-lighting-efficiency-and-efficacy-%CE%BCmol%C2%B7j-%C2%B9/

[673] "LED Grow Light Buyer's Guide." 2016. Chilled Tech-LED Grow Lights & Spectrum Control. October 22, 2016. https://chilledgrowlights.com/education/led_buyers_guide

[674] *2022 Illinois Statewide Technical Reference Manual Version 10: Volume 2 Commercial and Industrial Measures*. (2022), Pg 38, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

[675] Indoor Horticulture Lighting Study, Sacramento Municipal Utility District, March 14, 2018; available at: https://www.smud.org/-/media/Documents/Business-Solutions-and-Rebates/Advanced-Tech-Solutions/LED-Reports/Amplified-Farms-Indoor-Horticulture-LED-Study-Final.ashx

[676] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

3.8 MOTORS AND DRIVES

3.8.1 MOTORS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Existing/Dual
End Use Subcategory	Motors
Measure Last Reviewed	January 2023

Description

This measure covers the installation of high efficiency, three-phase electric motors of 200 hp or less in commercial and industrial applications. Estimated energy savings are based on increased operating efficiency.

Efficient motors generally run at slightly higher RPM than standard motors. Unless the motor drive system is modified to correct for higher RPM operation, the power delivered by the motor may increase. This increase in power delivery may negate the effects of improved efficiency. Therefore, when replacing a standard-efficiency motor, a high-efficiency motor with lower or equal full-load speed must be selected to prevent any negation of predicted energy savings resulting from a higher efficiency. To provide the correct flow, it may be necessary to adjust fan sheaves or pump-impeller diameters.

Baseline Case

The baseline condition is a three-phase electric motor of equivalent type, speed and horsepower. For TOS, and NC, a minimally code compliant baseline should be applied. For EREP, the baseline will be of the existing equipment.

Efficient Case

The compliance condition is a three-phase electric HVAC fan or pump motor with a speed at or below that of the baseline motor and full-load efficiency exceeding the NEMA premium full-load efficiency.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = HP \times RLF \times 0.746 \times \left[\left(\frac{1}{Eff_b}\right) - \left(\frac{1}{Eff_q}\right)\right] \times FLH$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = HP \times RLF \times 0.746 \times \left[\left(\frac{1}{Eff_b}\right) - \left(\frac{1}{Eff_q}\right)\right] \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ usig\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-255 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta kW_{Peak,}$	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
HP	Rated horsepower of the efficient equipment	Site-specific	HP	
Eff_q	Full-load efficiency of qualifying efficiency motor	Site-specific	N/A	
Eff_b	Full-load efficiency of code-compliant baseline motor	Site-specific or look up in Table 3-256 & Table 3-257	N/A	[677]
RLF	Ratio of the peak annual motor load to the maximum connected load	Site-specific, if unknown, use 0.75	N/A	[678]

Variable	Description	Value	Units	Ref
FLH	Full-load hours in the energy efficient case	Site-specific, if unknown look up in Table 3-258	Hrs	[679]
0.746	Unit conversion, kW/HP	0.746	kW/HP	
CF	Electric coincidence factor	Look up in Table 3-259	N/A	
PDF	Gas peak day factor	Look up in Table 3-259	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-256 Baseline Efficiencies for NEMA Design A and NEMA Design B Motors[149]

Motor HP	Motor Nominal Full-Load Efficiencies							
	2 Pole (3600 RPM)		4 pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	0.770	0.770	0.855	0.855	0.825	0.825	0.755	0.755
1.5	0.840	0.840	0.865	0.865	0.875	0.865	0.785	0.770
2	0.855	0.855	0.865	0.865	0.885	0.875	0.840	0.865
3	0.865	0.855	0.895	0.895	0.895	0.885	0.855	0.875
5	0.885	0.865	0.895	0.895	0.895	0.895	0.865	0.885
7.5	0.895	0.885	0.917	0.910	0.910	0.902	0.865	0.895
10	0.902	0.895	0.917	0.917	0.910	0.917	0.895	0.902
15	0.910	0.902	0.924	0.930	0.917	0.917	0.895	0.902
20	0.910	0.910	0.930	0.930	0.917	0.924	0.902	0.910
25	0.917	0.917	0.93.6	0.936	0.930	0.930	0.902	0.910
30	0.917	0.917	0.936	0.941	0.930	0.936	0.917	0.917
40	0.924	0.924	0.941	0.941	0.941	0.941	0.917	0.917
50	0.930	0.930	0.945	0.945	0.941	0.94.1	0.924	0.924
60	0.936	0.936	0.950	0.950	0.945	0.945	0.924	0.930

[149] Design indicates the torque/speed characteristics of the motor.
Design A: Maximum five percent slip, High to medium starting current, Normal locked rotor torque, Normal breakdown torque and Suited for a broad variety of applications, such as fans and pumps
Design B: Maximum five percent slip, Low starting current, High locked rotor torque, Normal starting torque, Normal breakdown torque and Suited for a broad variety of applications, such as fans and pumps - - common in HVAC application with fans, blowers and pumps

Motor HP	Motor Nominal Full-Load Efficiencies							
	2 Pole (3600 RPM)		4 pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
75	0.936	0.936	0.954	0.950	0.945	0.945	0.936	0.941
100	0.941	0.936	0.954	0.954	0.950	0.950	0.936	0.941
125	0.950	0.941	0.954	0.954	0.950	0.950	0.941	0.941
150	0.950	0.941	0.958	0.958	0.958	0.954	0.941	0.941
200	0.954	0.950	0.962	0.958	0.958	0.954	0.945	0.941
250	0.958	0.950	0.962	0.958	0.958	0.958	0.950	0.950
300	0.958	0.954	0.962	0.958	0.958	0.958	N/A	N/A
350	0.958	0.954	0.962	0.958	0.958	0.958	N/A	N/A
400	0.958	0.958	0.962	0.958	N/A	N/A	N/A	N/A
450	0.958	0.962	0.962	0.962	N/A	N/A	N/A	N/A
500	0.958	0.962	0.962	0.962	N/A	N/A	N/A	N/A

Table 3-257 Baseline Motor Efficiencies for NEMA Design C Motors[150]

Motor HP	Motor Nominal Full-Load Efficiencies					
	4 Pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	0.855	0.855	0.825	0.825	0.755	0.755
1.5	0.865	0.865	0.875	0.865	0.785	0.770
2	0.865	0.865	0.885	0.875	0.840	0.865
3	0.895	0.895	0.895	0.885	0.855	0.875
5	0.895	0.895	0.895	0.895	0.865	0.885
7.5	0.917	0.910	0.910	0.902	0.865	0.895
10	0.917	0.917	0.910	0.917	0.895	0.902

[150] Design indicates the torque/speed characteristics of the motor.
Design C: Maximum five percent slip, Low starting current, High locked rotor torque, Normal breakdown torque and Suited for equipment with high inertia starts, such as positive displacement pumps

Motor HP	Motor Nominal Full-Load Efficiencies					
	4 Pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
15	0.924	0.930	0.917	0.917	0.895	0.902
20	0.930	0.930	0.917	0.924	0.902	0.910
25	0.936	0.936	0.930	0.930	0.902	0.910
30	0.936	0.941	0.930	0.936	0.917	0.917
40	0.941	0.941	0.941	0.941	0.917	0.917
50	0.945	0.945	0.941	0.941	0.924	0.924
60	0.950	0.950	0.945	0.945	0.924	0.930
75	0.954	0.950	0.945	0.945	0.936	0.941
100	0.954	0.954	0.950	0.950	0.936	0.941
125	0.954	0.954	0.950	0.950	0.941	0.941
150	0.958	0.958	0.958	0.954	0.941	0.941
200	0.962	0.958	0.958	0.954	0.945	0.941

Table 3-258 Full-load Hours Based on Application and Building Type

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Auto Related	4,056	1,878	5,376
Bakery	2,854	1,445	5,376
Banks, Financial Centers	3,748	1,767	5,376
Church	1,955	1,121	5,376
College - Cafeteria	6,376	2,713	5,376
College - Classes/Administrative	2,586	1,348	5,376
College - Dormitory	3,066	1,521	5,376
Commercial Condos	4,055	1,877	5,376
Convenience Stores	6,376	2,713	5,376
Convention Center	1,954	1,121	5,376
Court House	3,748	1,767	5,376
Dining: Bar Lounge/Leisure	4,182	1,923	5,376

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Dining: Cafeteria / Fast Food	6,456	2,742	5,376
Dining: Family	4,182	1,923	5,376
Entertainment	1,952	1,120	5,376
Exercise Center	5,836	2,518	5,376
Fast Food Restaurants	6,376	2,713	5,376
Fire Station (Unmanned)	1,953	1,121	5,376
Food Stores	4,055	1,877	5,376
Gymnasium	2,586	1,348	5,376
Hospitals	7,674	3,180	5,376
Hospitals / Health Care	7,666	3,177	5,376
Industrial - 1 Shift	2,857	1,446	5,376
Industrial - 2 Shift	4,730	2,120	5,376
Industrial - 3 Shift	6,631	2,805	5,376
Laundromats	4,056	1,878	5,376
Library	3,748	1,767	5,376
Light Manufacturers	2,857	1,446	5,376
Lodging (Hotels/Motels)	3,064	1,521	5,376
Mall Concourse	4,833	2,157	5,376
Manufacturing Facility	2,857	1,446	5,376
Medical Offices	3,748	1,767	5,376
Motion Picture Theatre	1,954	1,121	5,376
Multifamily (Common Areas)	7,665	3,177	5,376
Museum	3,748	1,767	5,376
Nursing Homes	5,840	2,520	5,376
Office (General Office Types)	3,748	1,767	5,376
Office/Retail	3,748	1,767	5,376
Parking Garages & Lots	4,368	1,990	5,376
Penitentiary	5,477	2,389	5,376
Performing Arts Theatre	2,586	1,348	5,376
Police / Fire Stations (24 Hr)	7,665	3,177	5,376
Post Office	3,748	1,767	5,376

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Pump Stations	1,949	1,119	5,376
Refrigerated Warehouse	2,602	1,354	5,376
Religious Building	1,955	1,121	5,376
Residential (Except Nursing Homes)	3,066	1,521	5,376
Restaurants	4,182	1,923	5,376
Retail	4,057	1,878	5,376
School / University	2,187	1,205	5,376
Small Services	3,750	1,768	5,376
Sports Arena	1,954	1,121	5,376
Town Hall	3,748	1,767	5,376
Transportation	6,456	2,742	5,376
Warehouse (Not Refrigerated)	2,602	1,354	5,376
Waste Water Treatment Plant	6,631	2,805	5,376
Workshop	3,750	1,768	5,376

Peak Factors

Table 3-259 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[439]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-260 Measure Life

Equipment	EUL	RUL	Ref
Motors	15	5	[681]

References

[677] Energy Conservation Program: Energy Conservation Standards for Commercial and Industrial Electric Motors; Final Rule," 79 Federal Register 103, May 2014. https://www.gpo.gov/fdsys/pkg/FR-2014-05-29/html/2014-11201.htm

[678] U.S. DOE, Determining Electric Motor Load and Efficiency, April 2014, https://energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

[679] Connecticut Program Savings Document, 12th Edition for 2017 Program Year, UIL Holdings Corporation and Eversource Energy Appendix 5, Hours of Use, October 2016.

[680] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf.

[681] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

3.8.2 SWITCHED RELUCTANCE MOTORS

Market	Commercial
Baseline Condition	NC/RF/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Motors and Drives
Measure Last Reviewed	February 2024
Changes Since Last Version	• New measure

Description

A Switched Reluctance Motor (SRM) is a type of brushless DC electric motor that runs by reluctance torque. Unlike other DC motor types, power is delivered to windings in the stator rather than the rotor. This simplifies the mechanical design; power does not need to be delivered to a moving part, but requires a switching system through software control to deliver power to the different windings. Electronic devices can precisely time switch, facilitating SRM configurations. In applications on rooftop units (RTUs), the SRM is comparable or more efficient than an RTU equipped with a variable speed drive supply fan. It results in fan-energy savings and can also include cooling savings if coupled with compressor or ventilation control, compared to a baseline scenario of constant-volume, constant-ventilation operation that is typical of single-zone, packaged HVAC units. Fan energy savings come from the new integrated motor controls that allow for higher efficiency at varying loads and is achieved in all applications.

Baseline Case

The baseline equipment for this measure is a single-zone, packaged HVAC unit (with an existing functional integrated economizer) that lacks demand-controlled ventilation controls and lacks supply-fan speed control via a variable-frequency drive.

Efficient Case

The efficient equipment is a single-zone, packaged HVAC unit with a functional integrated economizer that has been fitted with a SRM supply-fan and integrated speed control.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = 0.746 \times HP \times hrs \times SF_{fan}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Summer Peak Demand Savings

$$\Delta kW_{Peak} = 0.746 \times HP \times SF_{fan} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-261 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
HP	Fan horsepower	Site-specific	HP	
hrs	Annual operating hours for fan motor	Site-specific. If unknown, look up in Appendix D: HVAC Fan and Pump Operating Hours	hrs	
SF_{fan}	Savings factor for fan[151]	Look up in Table 3-170	N/A	[682], [683]
0.746	Conversion from horsepower to kW	0.746	kW/HP	
CF	Electric coincidence factor	Look up in Table 3-174	N/A	[684]
EUL	Effective useful life	See Measure Life Section	Years	[685]

[151] Savings factors are taken from Switched-Reluctance Motor Field Evaluation Final Report (pg. 26) and Performance Evaluation of Three RTU Energy Efficiency Technologies (pg. 24), averaged across building types. Building type average was weighted according to ComStock 2018 commercial building metadata.

Table 3-262 Energy Savings Factors

Energy Savings Factor	Retrofit Type	SRM on Single Stage Compressor	SRM on Single Two Stage Compressor	SRM on Variable Speed Compressor
SF_{fan}	New Construction/Early Replacement	0.390	0.522	0.533

Peak Factors

Table 3-263 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.913	[684]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years [684].

References

[682] NREL, *Performance Evaluation of Three RTU Energy Efficiency Technologies*. (2020), https://www.nrel.gov/docs/fy21osti/75551.pdf

[683] Slipstream, *Switched-Reluctance Motor Field Evaluation*. (2022), https://turntide.com/wp-content/uploads/2022/05/SRM_final_report_03_25_2022-1.pdf

[684] *2024 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 12.0*. (2023). https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_2_C_and_I_09222023_FINAL_clean.pdf

[685] P. Andrada, B. Blanque, E. Martınez, J.I. Perat, J.A. Sanchez, and M. Torrent, *Environmental and life cycle cost analysis of one switched reluctance motor drive and two inverter-fed induction motor drives*. (2010), page 2, https://www.researchgate.net/publication/309187141_Environmental_and_Life_Cycle_Cost_Analysis_of_a_Synchronous_Reluctance_Machine

3.8.3 VFD

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure defines savings associated with installing a variable frequency drive on a motor of 200 hp or less for the following HVAC applications: supply air fans, return air fans, chilled water and condenser water pumps, hot water circulation pumps, water source heat pump circulation pumps, cooling tower fans, and boiler feed water pumps. VFD applications for other end uses are not covered under this measure.

Baseline Case

The baseline condition is a motor, 200 hp or less, without a VFD control.

Efficient Case

The efficient condition is a motor, 200 hp or less, with a VFD control.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = 0.746 \times HP \times \frac{LF}{\eta_{motor}} \times hr \times ESF$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0.746 \times HP \times \frac{LF}{\eta_{motor}} \times \text{DSF}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-264 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
HP	Rated horsepower of the motor	Site-specific	HP	
hr	Annual run hours of the baseline motor	Lookup in Appendix D: HVAC Fan and Pump Operating Hours	hours	
LF	Load Factor	Site-specific, if unknown use fans: 0.76, pumps: 0.79	N/A	[686]
η_{motor}	Motor efficiency at the full-rated load.	Site-specific	N/A	
ESF	Energy Savings Factor	Lookup in Table 3-265	Fraction	[687]
DSF	Demand Savings Factor	Lookup in Table 3-265	Fraction	[687]
0.746	Conversion factor for HP to kW	0.746	kW/HP	
CF	Electric coincidence factor	Look up in Table 3-266	N/A	
PDF	Gas peak demand factor	Look up in Table 3-266	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-265 Energy and Demand Savings Factors

Equipment Type	Baseline Control Type	ESF	DSF
HVAC Fan	Constant Volume	0.500	0.200
	Two-Speed	0.450	0.200

Equipment Type	Baseline Control Type	ESF	DSF
	Air Foil/Backward Incline	0.396	0.220
	Air Foil/Backward Incline with Inlet Guide Vanes	0.210	0.050
	Forward Curved	0.191	0.110
	Forward Curved with Inlet Guide Vanes	0.055	0.010
HVAC Pump	Constant Volume	0.661	0.210
	Throttle Valve	0.523	0.180

Peak Factors

Table 3-266 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 15 years[688].

References

[686] Regional Technical Forum. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012. Appendix C, Table 6.

[687] 2019 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 7.0. Volume 2: Commercial and Industrial Measures. September 28, 2018. https://www.ilsag.info/il_trm_version_7/

[688] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/

3.8.4 ELEVATOR MODERNIZATION

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Controls
Measure Last Reviewed	May 2023

Description

This measure covers the upgrade of existing elevators by replacing critical components in order for elevators to be able to handle new technology, have better performance, and to operate more efficiently. This measure follows the New York TRM v10 [689].

Elevator modernization typically includes motor upgrades, elevator drive system upgrades, and elevator controller replacement. This measure covers the installation of SiliconControlled Rectifier (SCR) drives, Pulse Width Modulation (PWM) drives, and Variable Voltage Variable Frequency (VVVF) drives only. Only the following upgrade configurations are applicable to this measure: VVVF drive systems replace PWM systems, VVVF or PWM drive systems replace SCR systems, and VVVF, PWM, or SCR drive systems replace Motor-Generator (M-G) set systems. The drives may either be regenerative or non-regenerative. This measure is only applicable as a retrofit and only applies to office and multifamily buildings (e.g. small office, large office, low-rise multifamily, high-rise multifamily). This measure does not cover Destination Dispatch optimization technique.

Methods for calculating savings for M-G set baseline systems are presented below separate from SCR or PWM drive baseline systems in order to differentiate the baseline efficiency term as described in the Baseline Efficiency section below, but also to account for AC motor idling energy consumption present in an M-G set drive. There is no idling motor present in PWM or SCR drive systems, and thus no savings associated with idle energy is claimed in those cases.

Baseline Case

The baseline case is an existing M-G set, SCR drive, or PWM drive elevator system.

Efficient Case

The efficient case may be either Silicon-Controlled Rectifier (SCR) drive, Pulse Width Modulation (PWM) drive or ***v***ariable Voltage Variable Frequency (VVVF) based on the baseline condition, as outlined in the table below:

Baseline Case	Efficient Case
M-G set	SCR, PWM, VVVF drives
SCR drive	PWM, VVVF drives
PWM drive	VVVF drive

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Motor-Generator set (M-G) baseline:

$$\Delta kWh = kWh_b - kWh_q + (RegenSF \times \Delta kWh_{regen})$$

$$kWh_b = \left(\frac{\mathrm{lb_b} \times (1 - OCW_b) \times (ft/min)_b}{33{,}000 \times Eff_{hoist}} \times \frac{1}{Eff_b} \times 0.746 \times LF_{avg} \times hrs\right) + \left(\frac{hp \times 0.746 \times LF_{motor,idle}}{Eff_b} \times (8{,}760 - hrs) \times F_{idle}\right)$$

$$kWh_q = \frac{lb_q \times (1 - OCW_q) \times (ft/min)_q}{33{,}000 \times Eff_{hoist}} \times \frac{1}{Eff_q} \times 0.746 \times LF_{avg} \times hrs$$

$$\Delta kWh_{regen} = \frac{lb_q \times (1 - OCW_q) \times (ft/min)_q \times Eff_q \times 0.746}{33{,}000} \times Eff_{regen} \times F_{regen} \times hrs$$

$$Eff_b = Eff_{motor,b} \times Eff_{gear,b} \times Eff_{drive,b}$$

$$Eff_q = Eff_{motor,q} \times Eff_{gear,q} \times Eff_{drive,q}$$

SCR drive or PWM drive baseline:

$$\Delta kWh = kWh_b - kWh_q + (RegenSF \times \Delta kWh_{regen})$$

$$kWh_b = \left(\frac{\mathrm{lb_b} \times (1 - OCW_b) \times (ft/min)_b}{33{,}000 \times Eff_{hoist}} \times \frac{1}{Eff_b} \times 0.746 \times LF_{avg} \times hrs\right)$$

$$kWh_q = \frac{lb_q \times (1 - OCW_q) \times (ft/min)_q}{33{,}000 \times Eff_{hoist}} \times \frac{1}{Eff_q} \times 0.746 \times LF_{avg} \times hrs$$

$$\Delta kWh_{regen} = \frac{lb_q \times (1 - OCW_q) \times (ft/min)_q \times Eff_q \times 0.746}{33{,}000} \times Eff_{regen} \times F_{regen} \times hrs$$

$$Eff_b = Eff_{motor,b} \times Eff_{gear,b} \times Eff_{drive,b}$$

$$Eff_q = Eff_{motor,q} \times Eff_{gear,q} \times Eff_{drive,q}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Annual Peak Demand Savings

Motor-Generator set (M-G) baseline:

$$\Delta kW_{Peak} = \frac{hp \times 0.746 \times LF_{motor,run}}{Eff_b} - \frac{lb_q \times (1 - OCW_q) \times (ft/\min)_q \times 0.746 \times LF_{peak}}{33{,}000 \times Eff_{hoist} \times Eff_q}$$

SCR drive or PWM drive baseline:

$$\Delta kW_{Peak} = \left(\frac{lb_b \times (1 - OCW_b) \times (ft/\min)_b}{Eff_b} - \frac{lb_q \times (1 - OCW_q) \times (ft/\min)_q}{Eff_q}\right) \times \frac{LF_{peak} \times 0.746}{33{,}000 \times Eff_{hoist}}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-267 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual fuel savings	Calculated	Therms/yr	
ΔkWh_{Peak}	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime fuel savings	Calculated	Therms	
kWh_b	Energy consumption of baseline	Calculated	kWh	
kWh_q	Energy consumption of qualifying	Calculated	kWh	
ΔkWh_{regen}	Energy savings due to regenerative braking system	Calculated	kWh	
Eff_b	Energy efficiency, baseline	Calculated	N/A	
Eff_q	Energy efficiency, qualifying	Calculated	N/A	
lb_b	Capacity of car, baseline	Site-specific	Lbs	
lb_q	Capacity of car, qualifying	Site-specific	Lbs	

Variable	Description	Value	Units	Ref
OCW_b	Overweight of counterbalance as fraction of car capacity, baseline	Site-specific	N/A	
$(ft/min)_b$	Rated top velocity of car, baseline	Site-specific	Ft/min	
Hp	Horsepower of M-G set motor	Site-specific	Hp	
OCW_q	Overweight of counterbalance as fraction of car capacity, qualifying	Site-specific	N/A	
$(ft/min)_q$	Rated top velocity of car, qualifying	Site-specific	Ft/min	
$Eff_{motor,b}$	NEMA premium efficiency, baseline	Site-specific	N/A	
$Eff_{motor,q}$	NEMA premium efficiency, qualifying	Site-specific	N/A	
Hrs	Annual hours of elevator operation	Site-specific, if unknown use 2,2750	Hours	[690]
$Eff_{drive,b}$	Efficiency of drive, baseline	Site-specific, if unknown use defaults: SCR6 = 0.85 SCR12 = 0.90 PWM = 0.94	N/A	[691]
$Eff_{drive,q}$	Efficiency of drive, qualifying	Site-specific, if unknown use defaults: SCR6 = 0.85 SCR12 = 0.90 PWM = 0.94 VVF = 0.95	N/A	[691]
$Eff_{gear,b}$	Efficiency of gear system, baseline	Geared system: 0.85 Gearless system: 1.0	N/A	[691]
$Eff_{gear,q}$	Efficiency of gear system, qualifying	Geared system: 0.85 Gearless system: 1.0	N/A	[691]
RegenSF	Savings factor for regererative braking system	Regenerative braking: 1 No regenerative breaking: 0	N/A	[689]
LF_{avg}	Average load factor	0.35	N/A	[692]
Eff_{hoist}	Efficiency of elevator hoise system	0.9	N/A	[690]
$LF_{motor,idle}$	M-G set motor load factor in idling mode	0.11	N/A	[589]
F_{idle}	Idling factor; used to account for fraction of run hours M-G set system in idling mode	Timer incorporated: 0.7 No timer: 1.0 Unknown: 0.7	N/A	[693]
$LF_{motor,run}$	M-G set motor load factor when loaded, assumed value to reflect that motors do not typically fun at 100% of rated power	0.9	N/A	[689]
LF_{peak}	Peak load factor	0.75	N/A	[692]

Variable	Description	Value	Units	Ref
Eff_{regen}	Efficiency of regenerative braking system	0.5	N/A	[689]
F_{regen}	Regenerative breaking factor; used account for fraction of run hours regenerative braking produces energy savings	0.5	N/A	[694]
8,760	Hours in a year	8,760	Hours	
33,000	Conversion factor	33,000	(ft-lb/min)/hp	
0.746	Conversion factor	0.746	kW/hp	
EUL	Effective useful life	See Measure Life section	Years	

Peak Factors

Table 3-268 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A: Appling average load factor at peak is a conservative approach for estimating summer peak demand savings. No further adjustment is required.	[589]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 15 years [695].

References

[689] New York TRM v10, Elevator Modernization, pg. 887. https://dps.ny.gov/technical-resource-manual-trm

[690] The Vertical Transportation Handbook, 4th Edition , by George R. Strakosch and Robert S. Caporale, Table 4.2, Table 4.3, Chart 4.2.

[691] International Association of Elevator Consultants, Presentation in New York City, May 2011, Slide 11.

[692] ISO 25745-2:2015: Energy Performance of Lifts, Escalators and Moving Walks -- Part 2: Energy Calculation and Classification for Lifts (elevators).

[693] Actual idling time is based on specific site operating conditions. A value of 70% has been assumed based on a reasonable and conservative approach.

[694] Baldor Motors and Drives, Elevator Application Guide, pg. 3-6.

[695] Assumes same EUL as VFD measure, source DEER 2014.

3.9 PLUG LOAD

3.9.1 NETWORK POWER MANAGEMENT

Market	Commercial
Baseline Condition	RF
Baseline	ISP
End Use Subcategory	Office Equipment
Measure Last Reviewed	December 2022

Description

This measure covers savings achieved by controlling the power management settings of desktop computers, monitors, and laptops through centralized computer power management software that is installed on a network of computers to monitor and record the usage and manage the power settings of all units. This software is implemented at the network level and manipulates the internal power settings of the central processing unit (CPU) and monitor.

Eligible software should be capable of the following:

- Apply specific power management policies to network groups and monitor workstation keyboard, mouse, CPU and disk activity in determining workstation idleness.
- Allow centralized control and override of computer power management settings of workstations which include both a computer monitor and CPU (i.e. a desktop or laptop computer on a distributed network).
- Wake-on-LAN capability to allow networked workstations to be remotely wakened from or placed into any power-saving mode and to remotely boot or shut down ACPI-compliant workstations.
- Software should be compatible with multiple operating systems and hardware configurations on the same network.
- Have capability to produce system reports to confirm the inventory and performance of equipment on which the software is installed.

Baseline Case

Desktop computer, monitor, or laptop in which power management settings are not controlled by centralized power management software.

Efficient Case

Qualifying software which controls computer and monitor power settings from a central location.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = ESAV \times units$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = DSAV \times units$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-269 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	[696]
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ESAV	Energy Savings per unit	Look up in Table 3-270	kWh/unit	
DSAV	Peak Demand Savings per unit	Look up in Table 3-270	kW/unit	
units	Number of units	Site-specific	units	
CF	Electric coincidence factor	See Peak Factors section	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[697]

To determine savings, the per unit estimate in Table 3-270 will be multiplied by the number of units. The energy savings per unit includes power savings from the PC as well as the monitor. Default savings are based on the Low Carbon IT

Savings Calculator sourced from the ENERGY STAR website [696] and assumes the absence of an enabled network power management as the baseline condition.

Table 3-270 Network Power Controls, Per Unit Summary Table

Measure	Unit	Energy Savings (SAV)	Peak Demand Savings ($DSAV$)
Network PC Plug Load Power Management Software	Workstation – Desktop Computer with Monitor	392	0.0527
Network PC Plug Load Power Management Software	Workstation – Laptop Computer with Monitor[152]	237	0.0319

Peak Factors

Peak savings are incorporated in the demand savings values above.

Measure Life

The effective useful life (EUL) is 5 years [697].

References

[696] ENERGYSTAR Low Carbon IT Savings Calculator: https://www.energystar.gov/sites/default/files/asset/document/LowCarbonITSavingsCalc.xlsx

[697] Computers and peripheral equipment are considered 5-year property. 2016 IRS Publication 946. https://www.irs.gov/pub/irs-prior/p946--2016.pdf.

[152] Savings assume workstation includes desktop with monitor and laptop computer with laptop screen in use. Please refer to ENERGY STAR Low Carbon IT Savings Calculator for different workstation configurations [696].

3.9.2 OFFICE EQUIPMENT

Market	Commercial/Multifamily
Baseline Condition	TOS
Baseline	ISP
End Use Subcategory	Electronics
Measure Last Reviewed	December 2022
Changes Since Last Version	• Moved HVAC interactive factor look-up to appendix

Description

This section provides deemed savings for installing ENERGYSTAR office equipment compliant with Energy Star Computer Specification ver. 8.0 compared to standard efficiency equipment in commercial applications. Per unit savings are primarily derived from the ENERGY STAR calculator for office equipment [698].

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is assumed to be standard equipment of similar type used in a commercial setting.

Efficient Case

The efficient condition is ENERGY STAR equipment meeting the current ENERGY STAR ver. 8.0 Eligibility Criteria [699] and used in a commercial setting.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = ESF \times (1 + HVAC_e)$$

Annual Fuel Savings

$$\Delta Therms = ESF \times HVAC_g$$

Peak Demand Savings

$$\Delta kW_{Peak} = DSF \times (1 + HVAC_d)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-271 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ESF	Energy savings factor	Look up in Table 3-272	kWh/yr	[698]
DSF	Electric Demand savings factor	Look up in Table 3-272	kW	[698]
$HVAC_e$	HVAC Interactive Factor for Annual Energy Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[700][701]
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[700][701]
$HVAC_g$	HVAC Interactive Factor for Annual Fuel Savings	Look up in Appendix F: HVAC Interactivity Factors	N/A	[702]
ΔkW_{Peak}	Peak Demand Savings	Look up in Table 3-272	kW	[698]
CF	Electric coincidence factor	Look up in Table 3-273	N/A	
PDF	Natural gas peak day factor (PDF)	Look up in Table 3-273	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	

Table 3-272 Office Equipment Energy and Demand Savings Factors per Unit

Measure		ESF (kWh)	DSF (kW)	Source
Computer (Desktop)		124	0.0161	[698]
Computer (Laptop)		37	0.0030	[698]
Fax Machine (laser)		16	0.0022	[698]
Copier (monochrome)	≤ 5images/min	37	0.0050	[698]
	5 < images/min ≤ 15	26	0.0035	
	15 < images/min ≤ 20	10	0.0011	
	20 < images/min ≤ 30	42	0.0057	
	30 < images/min ≤ 40	50	0.0068	
	40 < images/min ≤ 65	181	0.0244	
	65 < images/min ≤ 82	372	0.0502	
	82 < images/min ≤ 90	469	0.0633	
	> 90 images/min	686	0.0926	
Printer (laser, monochrome)	≤ 5 images/min	37	0.0050	[698]
	5 < images/min ≤ 15	26	0.0035	
	15 < images/min ≤ 20	24	0.0031	
	20 < images/min ≤ 30	42	0.0057	
	30 < images/min ≤ 40	50	0.0068	
	40 < images/min ≤ 65	181	0.0244	
	65 < images/min ≤ 82	372	0.0502	
	82 < images/min ≤ 90	542	0.0732	
	> 90 images/min	686	0.0926	
Printer (Ink Jet)		6	0.0008	[698]
Multifunction Device (laser, monochrome)	≤ 5 images/min	57	0.0077	[698]
	5 < images/min ≤ 10	48	0.0065	
	10 < images/min ≤ 26	52	0.0070	
	26 < images/min ≤ 30	93	0.0126	
	30 < images/min ≤ 50	248	0.0335	
	50 < images/min ≤ 68	420	0.0567	
	68 < images/min ≤ 80	597	0.0806	
	> 80 images/min	764	0.1031	
Multifunction Device (Ink Jet)		6	0.0008	[698]
Monitor		8	0.0032	[698]

Peak Factors

Table 3-273 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Peak savings incorporated in the DSF Values found in Table 1-2 above	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

Table 3-274 Measure Life [698]

Equipment	Measure Life
Computer	4 years
Monitor	4 years
Fax	4 years
Printer	5 years
Copier	6 years
Multifunction Device	6 years

References

[698] ENERGY STAR Office Equipment Calculator. https://dnr.mo.gov/sites/dnr/files/media/file/2021/01/office-equipment-calculator.xlsx. Default values were used. Using a commercial office equipment load shape, the percentage of total savings that occur during the PJM peak demand period was calculated and multiplied by the energy savings. As of December 1, 2018, the published ENERGY STAR Office Equipment Calculator does not reflect the current specification for computers (ENERGY STAR® Program Requirements Product Specification for Computers Eligibility Criteria Version 8.0). As a result, the savings values for computers presented in this measure entry reflect savings for V6-compliant models. This characterization should be updated when an updated ENERGY STAR Office Equipment Calculator becomes available.

[699] ENERGY STAR Product Specifications & Partner Commitments Search, https://www.energystar.gov/products/spec

[700] Navigant, EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, (2013)

[701] DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory

[702] Northeast Energy Efficiency Partnerships & KEMA, C&I Lighting Load Shape Project FINAL Report - Prepared for the Regional Evaluation, Measurement and Verification Forum. (2011).

3.9.3 SMART STRIP

Market	Commercial/Multifamily
Baseline Type	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	December 2022

Description

This measure covers the installation of Tier 1 Advanced Power Strips (APS) in office workstations. The Tier 1 APS makes use of a control outlet to disconnect the controlled plugs when the load on the control outlet (usually a computer) is reduced below a threshold. In this case, the reduction below threshold of the control plug happens when the computer shuts down or enters standby mode. Therefore, the overall load of a centralized group of equipment (e.g., monitors and other peripherals for the computer) can be reduced. This measure assumes an office operating schedule of 7:30 AM to 5:30 PM from Monday to Fridays.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is an office workstation with no plug load control system.

Efficient Case

The compliance condition is an office workstation with a tier 1 plug load control advanced power strip.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \left(\Delta kW_{wkday} \times \left(Hrs_{wkday} - Hrs_{wkday-open}\right) + \Delta kW_{wkend} \times \left(Hrs_{wkend} - Hrs_{wkend-open}\right)\right) \times Wks$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 3-275 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	0	kW	[705]
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Units	Number of measures installed under the program	Site-specific	N/A	
ΔkW_{wkday}	Average power reduction during weekday off hours	0.0315	kW	[704][705]
Hrs_{wkday}	Total hours during the work week (Monday 7:30 AM to Friday 5:30 PM)	106	Hrs	
$Hrs_{wkday\text{-}open}$	Hours the office is open during the work week	Site-specific. If unknown, assume 50	Hrs	
ΔkW_{wkend}	Average power reduction during weekend off hours	0.0067	kW	[704][705]
Hrs_{wkend}	Total hours during the weekend (Friday 5:30 PM to Monday 7:30 AM)	62	Hrs	
$Hrs_{wkend\text{-}open}$	Hours the office is open during the weekend	Site-specific, if unknown use 0	Hrs	
Wks	Weeks the office is open during the year	Site-specific, if unknown use 8760/168	Weeks/yr	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-276 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The expected lifetime of this measure is 4 years [704].

References

[703] Sheppy, M, I Metzger, D Cutler, G Holland, and A Hanada. 2014. "Reducing Plug Loads in Office Spaces Hawaii and Guam Energy Improvement Technology Demonstration Project." https://www.nrel.gov/docs/fy14osti/60382.pdf.

[704] David Rogers, Power Smart Engineering, "Smart Strip Electrical Savings and Usability," October 2008.

[705] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Pg 494. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

3.9.4 UNINTERRUPTIBLE POWER SUPPLY

Market	Commercial
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Plug Load
Measure Last Reviewed	January 2023

Description

This measure is for replacing an inefficient uninterruptable power supply (UPS) with an efficient ENERGY STAR rated UPS within the scope of the Energy Star Uninterruptable Power Supply ver 2.0 Program Requirements. UPS units provide backup power in data centers and draw power constantly to keep their batteries charged. UPSs are utilized in many organizations to protect themselves from downtime with power distribution and avoid data processing errors due to downtimes. UPS systems are connected between the public power distribution system and mission critical loads.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified through a custom calculation.

Baseline Case

The baseline condition is a non-ENERGY STAR UPS in a telecommunication or similar application meeting minimum Federal Efficiency Standards as defined in 10 CFR 430.32(z)(3)

Efficient Case

The efficient condition is a new UPS meeting ENERGY STAR UPS in a telecommunication or similar application meeting Energy Star UPS version 2.0 criteria. For single-normal mode UPSs, the installed system must meet or exceed the average loading-adjusted efficiency values required by the ENERGY STAR program.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = Size \times \left(\frac{1}{Eff_{AVGBase}} - \frac{1}{Eff_{AVGee}}\right) \times EFLH$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Size \times \left(\frac{1}{Eff_{AVGBase}} - \frac{1}{Eff_{AVGee}}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-277 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Size	Size of UPS in rated output power, kW	Site-specific	kW	
$Eff_{AVGbase}$	Efficiency of existing UPS	**Site-specific, if unknown look up in** Table 3-278	W	[706]
Eff_{AVGee}	Efficiency of new ENERGY STAR UPS	Site-specific, if unknown look up in Table 3-279	W or kW	[707]
E_{MOD}	An allowance of 0.004 for Modular UPSs applicable in the commercial 1500 – 10,000 W range	0.004	N/A	[707]
EFLH	Equivalent Full Load Hours	Look up in Table 3-280	hours	[708]
CF	Electric coincidence factor	Look up in Table 3-281	N/A	
PDF	Gas peak day factor	Look up in Table 3-281	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[709]

Table 3-278 Efficiency of existing UPS

UPS Product Class	Rated Output Power (P) in watts	Minimum Efficiency
Voltage and Frequency Dependent (VFD)	$P \leq 300$ W	$-1.20 \times 10^{-6} \times P^2 + 7.17 \times 10^{-4} \times P + 0.862$
	$300 \text{ W} < P \leq 700$ W	$-7.85 \times 10^{-8} \times P^2 + 1.01 \times 10^{-4} \times P + 0.946$
	$P > 700$ W	$-7.23 \times 10^{-9} \times P^2 + 7.52 \times 10^{-6} \times P + 0.977$

UPS Product Class	Rated Output Power (P) in watts	Minimum Efficiency
Voltage Independent (VI)	P ≤ 300 W	$-1.20 \times 10^{-6} \times P^2 + 7.19 \times 10^{-4} \times P + 0.863$
	300 W < P ≤ 700 W	$-7.67 \times 10^{-8} \times P^2 + 1.05 \times 10^{-4} \times P + 0.947$
	P > 700 W	$-4.62 \times 10^{-9} \times P^2 + 8.54 \times 10^{-6} \times P + 0.979$
Voltage and Frequency Independent (VFI)	P ≤ 300 W	$-3.13 \times 10^{-6} \times P^2 + 1.96 \times 10^{-3} \times P + 0.543$
	300 W < P ≤ 700 W	$-2.60 \times 10^{-7} \times P^2 + 3.65 \times 10^{-4} \times P + 0.764$
	P > 700 W	$-1.70 \times 10^{-8} \times P^2 + 3.85 \times 10^{-5} \times P + 0.876$

Table 3-279 Efficiency of ENERGY STAR UPS Version 2.0

UPS Product Class	Rated Output Power (P) in watts	Minimum Efficiency
Voltage and Frequency Dependent (VFD)	P ≤ 350 W	$5.71 \times 10^{-5} \times P + 0.962$
	350 W < P ≤ 1.5 kW	0.982
	1.5 W < P ≤ 10 kW	$0.981 - E_{MOD}$
	P > 10 kW	0.97
Voltage Independent (VI)	P ≤ 350 W	$5.71 \times 10^{-5} \times P + 0.964$
	350 W < P ≤ 1.5 kW	0.984
	1.5 kW < P ≤ 10 kW	$0.980 - E_{MOD}$
	P > 10 kW	0.940
Voltage and Frequency Independent (VFI)	P ≤ 350 W	$0.011 \times \ln(P) + 0.824$
	350 W < P ≤ 1.5 kW	$0.011 \times \ln(P) + 0.824$
	1.5 W < P ≤ 10 kW	$0.0145 \times \ln(P) + 0.8 - E_{MOD}$
	P > 10 kW	$0.0058 \times \ln(P) + 0.886$

Table 3-280 Equivalent Full Load Hours

Rated Output Power (P) in Watts	UPS Product Class	Time spent at specified proportion of reference test load (t)				EFLH[153]
		25%	50%	75%	100%	
P ≤ 1.5 kW	VFD	0.2	0.2	0.3	0.3	5913
	VI or VFI	0	0.3	0.4	0.3	6570
1.5 kW < P ≤ 10 kW	VFD, VI, or VFI	0	0.3	0.4	0.3	6570
P > 10 kW	VFD, VI, or VFI	0.25	0.5	0.25	0	4380

Peak Factors

Table 3-281 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [709].

References

[706] Code of Federal Regulations, Energy Conservation Standards for Uninterruptible Power Supplies, effective January 10, 2022 (10 CFR 430.32(z)(3). https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[707] ENERGY STAR Uninterruptible Power Supplies Final Version 2.0 Specification, effective January 1, 2019. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Uninterruptible%20Power%20Supplies%20Final%20Version%202.0%20Specification.pdf

[708] Calculation and inputs provided in ENERGY STAR Uninterruptible Power Supplies Final Version 2.0 Specification.

[709] California Municipal Utilities Association. Savings Estimation Technical Reference Manual 2017, Third Edition. Section 8.12, p. 8–15. https://www.cmua.org/files/CMUA-POU-TRM_2017_FINAL_12-5-2017%20-%20Copy.pdf

[153] The EFLH values were derived using the following equation EFLH = ($t_{0.25}$ x 0.25 + $t_{0.5}$ x 0.5 + $t_{0.75}$ x 0.75 + $t_{1.0}$ x 1.0) x 8760 hours. The time spent at specified proportion of reference load (t) was sourced from the ENERGY STAR Uninterruptible Power Supplies Final Version 2.0 Specification document. The 8760 hours assumption is based on the fact that the power is uninterruptible, therefore available year-round, i.e 8760 hours a year.

3.9.5 REFRIGERATED BEVERAGE VENDING MACHINE

Market	Commercial/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Plug Load
Measure Last Reviewed	January 2023

Description

This measure applies to new or rebuilt ENERGY STAR®, Class A, Class B, Combination A or Combination B refrigerated vending machines. ENERGY STAR® vending machines incorporate more efficient compressors, fan motors, and lighting systems as well as a low power mode option that allows the machine to be placed in low-energy lighting and/or low-energy refrigeration states during times of inactivity. Class A machines have 25% or more of the front surface area that is transparent; Class B machines have less than 25% of the front surface area that is transparent. Combination machines have separate refrigerated and non-refrigerated compartments.

Baseline Case

The baseline equipment is a new Class A, Class B, Combination A or Combination B refrigerated vending machine that meets Federal Energy Efficiency Standards for refrigerated vending machines as defined in 10 CFR 431.294.

Efficient Case

A new or rebuilt ENERGY STAR®, Class A, Class B, Combination A or Combination B refrigerated vending machine that meets Energy Star Vending Machine Ver 4.0 program requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times Days$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-282 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Energy usage of baseline vending machine	Site Specific, if unknown calculate using Table 3-283	kWh/day	[710]
kWh_q	Energy usage of ENERGY STAR vending machine	Site Specific, if unknown calculate using Table 3-283	kWh/day	[711]
V	Refrigerated Volume	Site Specific, if unknown use 23.62	Ft^3	[712]
Days	Days of vending machine operation per year	365.25	days	[713]
CF	Electric coincidence factor	Look up in Table 3-284	N/A	
PDF	Gas peak day factor	Look up in Table 3-284	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[712]

Table 3-283 Energy Consumption Default Values

Equipment Class	Baseline (kWh_b) kWh/day	Energy Star (kWh_q) kWh/day
Class A	0.052 x V + 2.43	0.04836 x V + 2.2599
Class B	0.052 x V + 2.20	0.04576 x V + 1.936
Combination A	0.086 × V † + 2.66	0.07998 x V + 2.4738
Combination B	0.111 × V † + 2.04	0.09768 x V + 1.7952

Peak Factors

There are no peak demand savings because this measure is aimed to reduce demand during times of low beverage machine use, which will typically occur during off-peak hours.

Table 3-284 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 14 years [712].

References

[710] 10 CFR §431.296 - Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines.

[711] ENERGY STAR® Version 4.0 requirements for maximum daily energy consumption.

[712] Navigant Consulting, *Energy Savings Potential and R&D Opportunities for Commercial Refrigeration*. September 2009, https://www1.eere.energy.gov/buildings/publications/pdfs/corporate/commercial_refrig_report_10-09.pdf.

[713] ENERGY STAR. US Environmental Protection Agency and US Department of Energy. "ENERGY STAR Certified Vending Machines Spread Sheet" available at https://www.energystar.gov/productfinder/download/certified-vending-machines/

3.9.6 VENDING MACHINE CONTROLS

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

This measure covers the installation of time clocks or occupancy sensors on refrigerated vending machines and novelty coolers to reduce compressor run time and lighting hours while ensuring units maintain desired product temperatures during occupied hours. This measure also covers the installation of either controls on non-refrigerated (snack) vending machines. In this case, savings are derived from a reduction in lighting hours during unoccupied hours. This measure is only applicable to vending machines and novelty coolers containing non-perishable products without a low power mode.

The time clock control mechanism is a programmed-schedule time clock that is assumed to be set to turn the equipment off coincident with the facility closing time and turn equipment on one hour before opening time to allow the products to return to the desired sale temperature.

The occupancy sensor control mechanism uses an infrared sensor to turn off the vending machine when the surrounding area is unoccupied. The device also monitors the ambient temperature and powers up the machine as required to keep products cool. Additionally, the sensor monitors the electrical current used by the machine to ensure it is not turned off during a compressor cycle to prevent a high head pressure start from occurring.

Baseline Case

The baseline equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Efficient Case

The efficient equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Refrigerated Vending Machine and Novelty Cooler

$$\Delta kWh = kW_{unit} \times \left[hrs_{off} + F_{ctrl} \times ESF \times (8{,}760 - hrs_{off})\right]$$

Non-Refrigerated Vending Machine

$$\Delta kWh = kW_{unit} \times \left[hrs_{off} + F_{ctrl} \times ESF \times (8{,}760 - hrs_{off})\right]$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-285 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kW_{unit}	Vending machine power (kW)	Look up in Table 3-286	kW	[714][716]
hrs_{off}	Annual facility closed hours (Daily facility closed hours minus 1 multiplied by operating days)	Site-specific, if unknown see Appendix D: HVAC Fan and Pump Operating Hours	hours	
F_{ctrl}	Control type factor	Occupancy Sensor = 1 Time Clock = 0	N/A	
ESF	Energy savings of occupancy sensing control during building operating hours	0.1	N/A	[715]
CF	Electric coincidence factor	Look up in Table 3-287	N/A	
PDF	Gas peak day factor	Look up in Table 3-287	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-286 Vending Machine Power

Peak Factor	Value
Refrigerated beverage vending machine	0.4
Non-refrigerated snack vending machine	0.02
Glass front refrigerated coolers	0.46

Peak Factors

Table 3-287 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 5 years [717].

References

[714] *2021 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 9: Volume 2 Commercial and Industrial Measures* (2020) Pg. 574 https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010121_v9.0_Vol_2_C_and_I_09252020_Final.pdf

[715] Department of Energy, *Wireless Sensors for Lighting Energy Savings, Wireless Occupancy Sensors for Lighting Controls: An Applications Guide for Federal Facility Managers*, December 2019. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/wireless_occupancy_sensor_guide.pdf

[716] Southern California Edison, *Workpaper SCE17CS005, Revision 1, Beverage Merchandise Controller*, July 23, 2018. http://deeresources.net/workpapers

[717] Energy Resource Solutions, *Measure Life Study: Prepared for the Massachusetts Joint Utilities*, November 2005, https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf.

3.9.7 ELECTRIC VEHICLE CHARGER

Market	Commercial/Multifamily
Baseline Condition	NC/RF
Baseline	ISP/Existing
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

Electric Vehicle Supply Equipment (EVSE) is the infrastructure that is used to charge electric vehicle batteries. At non-residential locations, EVSE may simply be a designated outlet in a parking lot or garage, or may include embedded intelligence that allows a fee to be charged for use of the EVSE and communications with a charging network such as ChargePoint. Additional functionality (the ability to charge a fee or communicate with a network) adds substantially to the cost of EVSE installation and often includes a monthly subscription fee.

Baseline Case

Level 1 - 120 volts Electric Vehicle Supply Equipment at a public or commercial location.

Efficient Case

Level 2 - 240 volts Electric Vehicle Supply Equipment at a public or commercial location.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = 403 \times N_{EVSE}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-288 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
403	Deemed Annual Energy Savings	403	kWh/yr	[718]
N_{EVSE}	Number of EVSE	N/A	N/A	[718]
CF	Electric coincidence factor	Look up in Table 3-289	N/A	[718]
PDF	Gas peak demand factor	Look up in Table 3-289	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[718]

Peak Factors

Table 3-289 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	75%	[718]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is the length of the warranty for EVSE given in the EVSE manufacturer websites. If unknown, use 10 years [718].

References

[718] Vermont Energy Investment Corporation, *Transportation Technical Reference Manual: Guide to Characterize the Savings, Benefits, and Costs of Transportation Efficiency,* June 2014, Page 23 available at https://www.veic.org/Media/default/documents/resources/manuals/veic-transportation-trm.pdf

3.10 REFRIGERATION

3.10.1 ENERGY EFFICIENT GLASS DOORS ON VERTICAL OPEN REFRIGERATED CASES

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Refrigeration
Measure Last Reviewed	November 2022
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure applies to retrofitting vertical, open, refrigerated display cases with high efficiency glass doors without anti-sweat heaters. The deemed savings factors are derived from the results of a controlled test designed to measure the impact of this measure. The results of the test were presented at the 2010 International Refrigeration and Air Conditioning conference.

Baseline Case

The baseline equipment is an existing vertical display case of medium temperature with no doors. The display cases should be medium temperature (typically for dairy, meats, or beverages) as opposed to low temperature (typically for frozen food and ice cream).

Efficient Case

The compliance condition is a vertical refrigerated display case fitted with glass doors without anti-sweat heaters.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = CL \times (\Delta kWh/ft) \times \left(1 - \frac{hrs_{cooling}}{8{,}760} - \frac{COP_{ref}}{COP_{HVAC}}\right)$$

Where,

$$COP_{ref} = \frac{3.517}{(kW/ton)}$$

$$COP_{HVAC} = \frac{EER}{3.412}$$

Annual Fuel Savings

$$\Delta Therms = CL \times \frac{(\Delta kWh/ft) \times 3{,}412}{100{,}000} \times \frac{hrs_{heating}}{8{,}760} \times \frac{1}{Eff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = CL \times \frac{(\Delta kWh/ft)}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-290 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWhLife	Lifetime electric energy savings	Calculated	kWh	
ΔThermsLife	Lifetime fuel savings	Calculated	Therms	
CL	Case Length, open length of the refrigerated case	Site-specific	ft	
ΔkWh/ft	Annual electric energy savings per foot of door opening	Look up in Table 3-291	kWh/yr-ft	[719]
COP_{ref}	Coefficient of performance of refrigeration equipment	Calculated	N/A	
kW/ton	Rated efficiency of the compressor in input kW per ton of refrigeration capacity	Site-specific	kW/ton	
COP_{HVAC}	Coefficient of performance of heating, ventilation, and cooling equipment	Site-specific. If unknown, look up in Table 3-292	N/A	[720]

Variable	Description	Value	Units	Ref
Eff	Fossil fuel-fired heating system efficiency	Site-specific[154]. If unknown, use 0.8		[721]
$Hrs_{cooling}$	Cooling HVAC load hours	Site-specific	Hours	
$Hrs_{heating}$	Heating HVAC load hours	Site-specific	hrs	
3,412	Conversion factor from kWh to Btu	3,412	Btu/kWh	
8,760	Number of hours in a year	8760	Hours	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
CF	Coincidence factor	Look up in Table 3-293	N/A	
PDF	Peak day factor	Look up in Table 3-293	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-291 Annual electric energy savings per foot of door opening

Door Type	ΔkWh/ft[155]
High-Efficiency Doors on Cooler	477
High-Efficiency Doors on Freezer	747
Standard Doors on Cooler	183
Standard Doors on Freezer	392

Table 3-292 Coefficient of performance of HVAC systems

Location[156]	COP_{HVAC}
Grocery Store	2.93
Other	3.57

[154] E_c, E_t or AFUE shall be used, based on nameplate rating metric of existing equipment
[155] Fricke, Brian and Becker, Bryan, "Energy Use of Doored and Open Vertical Refrigerated Display Cases". Energy savings of high efficiency doors are calculated by eliminating anti-condensation heater energy draw and proportionally reducing associated work required from the refrigeration equipment while assuming an HVAC system COP of 3.28, refrigeration COP of 3.03 for coolers and 1.66 for freezers. Measured energy savings on medium temperature units was adjusted with COPcooler/COPfreezer ratios to develop savings for standard doors installed on freezer units.
[156] Grocery Store default assumes a 25-ton packaged RTU (cooling only); Other default assumes a 10-ton packaged RTU (cooling only)

Peak Factors

Table 3-293 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0[157]	[722]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-294 Measure Life

Equipment	EUL	RUL	Ref
Case Doors	4	1.3	[723]

References

[719] Fricke, Brian and Becker, Bryan, "Energy Use of Doored and Open Vertical Refrigerated Display Cases" (2010). International Refrigeration and Air Conditioning Conference. Paper 1154. http://docs.lib.purdue.edu/iracc/1154

[720] ASHRAE 90.1 2010 Energy Standard for Buildings Except Low Rise Residential Buildings: Standard for Unitary HVAC. https://www.ashrae.org/technical-resources/standards-and-guidelines

[721] Gas boiler efficiency of 80% -ASHRAE Standards 90.1-2007 and 2016, Energy Standard for Buildings Except Low Rise Residential Buildings, Table 6.8.1F. https://www.ashrae.org/technical-resources/standards-and-guidelines

[722] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, Version 10, January 2023

[723] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020. http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

[157] No source specified – update pending availability and review of applicable references.

3.10.2 DOOR CLOSER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Controls
Measure Last Reviewed	February 2024
Changes Since Last Version	• Updated the deemed kWh and kW savings values for freezers and coolers • Updated the peak factors for freezers and coolers

Description

This section provides energy savings algorithms for the installation of auto-closer to the main insulated opaque door(s) of a walk-in freezer or cooler. Auto-closers can reduce the amount of time that doors are open, thereby reducing infiltration and refrigeration loads. This measure applies to retrofit of doors not previously equipped with auto-closers, and assume the doors have strip curtains.

The auto-closer must be able to firmly close the door when it is within one inch of full closure. The walk-in door perimeter must be ≥ 16 feet.

Baseline Case

Walk in cooler/freezer without an auto closer and the doors have strip curtains.

Efficient Case

Walk in cooler/freezer with an auto closer.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = look\ up\ in \text{ Table 3-296}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = look\ up\ in \text{ Table 3-296}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-295 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Look up in Table 3-296	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Look up in Table 3-296	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
CF	Electric coincidence factor	Lookup in Table 3-296	N/A	[1]
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-296 Deemed savings for Walk-in Freezer and Coolers

Location	ΔkWh_{cooler}	ΔkW_{cooler}	$\Delta kWh_{freezer}$	$\Delta kW_{freezer}$
Northern	2,951	0.93	8,590	1.46
Central	2,894	0.91	8,425	1.43
Pine barrens	2,737	0.86	7,969	1.35
Southwest	2,864	0.90	8,338	1.42
Coastal	2,539	0.80	7,392	1.26
Statewide Average	2,825	**0.89**	8,225	**1.40**

Peak Factors

Peak demand is accounted for in the deemed savings values presented in Table 3-296.

Measure Life

The effective useful life (EUL) is 8 years [3].

References

[1] Illinois Statewide Technical Reference Manual for Energy Efficiency , Volume 2: Commercial and Industrial Measures, v12.0, 2024, page 794, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_2_C_and_I.pdf

[2] Southern California Edison, Commercial Refrigeration: Auto-Closer for Refrigerated Storage Door (SWCR005-02), California eTRM, November 16, 2020). http://www.deeresources.net/workpapers.

[3] "DEER2014-EUL-table-update_2014-02-05". 2014. Deeresources.com. Accessed December 12, 2022. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

3.10.3 DOOR GASKETS

Market	Commercial
Baseline Condition	RF/DI
Baseline	Existing/Dual
End Use Subcategory	Load reduction
Measure Last Reviewed	January 2023

Description

This measure involves the replacement of worn-out gaskets with new, better-fitting gaskets on the doors of walk-in and/or reach-in coolers and freezers. When damaged and/or missing, the warmer, more humid air present in the store will infiltrate the case, increasing the refrigeration system load while often reducing the efficiency of the evaporator unit as a result of additional frost accumulation. Replacing the damaged gaskets reduces compressor run time and improves the overall heat removal effectiveness of the cooler/freezer.

Baseline Case

The baseline condition is a low-temperature walk-in and/or reach-in freezer and/or a medium-temperature walk-in and/or reach-in with damaged and/or missing gaskets with at least six inches of damage for reach-in units and at least two feet of damage for walk-in units.

Efficient Case

The efficient case is the installation of new, tight fitting door gaskets to reduce infiltration.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{\Delta kWh}{Door} \times Doors$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kW}{Door} \times Doors$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Thrms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-297 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkWh/Door	Annual Energy Savings per Foot of gasket	Lookup in Table 3-298	kWh	[4][5]
ΔkW/Door	Demand Savings per Foot of gasket	Lookup in Table 3-298	kW	[4][5]
Doors	Total number of gasket doors replaced	Site-specific	N/A	[4][5]
CF	Electric coincidence factor	Lookup in Table 3-299	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[6]
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-298 Door Gasket Savings Per Foot of Gasket for Walk-in and Reach-in Coolers and Freezers

Type	Coolers		Freezers	
	ΔkW/door	ΔkWh/door	ΔkW/door	ΔkWh/door
Reach-in	0.032	248	0.032	243
Walk-in	0.027	204	0.045	347

Peak Factors

Table 3-299 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-300 Measure Life

Equipment	EUL	RUL	Ref
Door Gaskets	4	1.3	[6]

References

[4] Database for UES Measures, Regional Technical Forum. Door Gasket Replacement, version 1.5. December 2016. https://rtf.nwcouncil.org/measure/door-gasket-replacement

[5] Pennsylvania TRM 2021, August 2019 available at https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

[6] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

3.10.4 NIGHT COVERS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Refrigeration
Measure Last Reviewed	November 2022
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure covers the installation of retractable curtains on open horizontal or multi-deck refrigerated display cases in grocery stores. These covers serve as a barrier between the contents of the refrigerated case and the ambient air during off-business hours. They conserve energy by reducing the infiltration of ambient air into the refrigerated space, thereby reducing the load on the refrigeration system. Grocery stores operating 24 hours per day are not eligible for energy savings.

Baseline Case

The baseline condition is a vertical or horizontal open refrigerated display case left uncovered during off-business hours and meeting the minimum federal energy standards presented in Table 3-302 and Table 3-303 [7]. Eq*uipment with an operating temperature above 32°F is classified as Medium with a rating temperature of 38°F, while equipment with an operating temperature of 32°F or below is classified as Low with a rating temperature of 0°F. Ice Cream freezers have a rating temperature of -15°F and operate at temperatures below -5°F.*

Total Daily Energy *Consumption (TDEC) shall be calculated per Table* 3-302 *and Table* 3-303 *for the appropriate display case type, configuration and rating temperature. For refrigeration equipment with two or more compartments (i.e. hybrid refrigerators, freezers, refrigerator-freezers and non-hybrid refrigerator freezers), the TDEC shall be established as the sum of the TDEC values associated with each component compartment.*

Efficient Case

The compliance condition is a vertical or horizontal open refrigerated display case with retractable night covers installed.

Operating Hours

Energy savings are based on installation of refrigerated case night covers in an 18-hour supermarket assumed to operate 365 days per year. Therefore, the annual hours that night covers are assumed to be in use are (24 – 18) x 365 = 2,190 hours [8].

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = TDEC \times ESF \times 365$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithm

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

3-301 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
TDA[158]	Total Display Area of the open case	Site-specific	Ft^2	
units	Number night covers installed	Site-specific	N/A	
TDEC	Total Daily Energy Consumption	Look up in Table 3-302, Table 3-303	kWh/day	[7]
ESF	Energy Savings Factor	0.09	N/A	[8]
365	Number of days in a year	365	days/yr	

[158] TDA = L * H, where L is length of the display case opening (ft) and H is height (vertical) or depth (horizontal) of the display case opening (ft). These parameters are site specific.

Variable	Description	Value	Units	Ref
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-302 Baseline Efficiencies for Refrigerators, Freezers, or Refrigerator-freezers Manufactured on or after March 27, 2017

Equipment Family	Condensing Unit Configuration	Rating Temperature	TDEC (kWh/day)
Vertical Open	Remote Condensing	Medium (38°F)	0.64 x TDA + 4.07
Vertical Open	Remote Condensing	Low (0°F)	2.20 x TDA + 6.85
Vertical Open	Remote Condensing	Ice Cream (-15°F)	2.79 x TDA + 8.70
Vertical Open	Self-Contained	Medium (38°F)	1.69 x TDA + 4.71
Vertical Open	Self-Contained	Low (0°F)	4.25 x TDA + 11.82
Vertical Open	Self-Contained	Ice Cream (-15°F)	5.40 x TDA + 15.02
Horizontal Open	Remote Condensing	Medium (38°F)	0.35 x TDA + 2.88
Horizontal Open	Remote Condensing	Low (0°F)	0.55 x TDA + 6.88
Horizontal Open	Remote Condensing	Ice Cream (-15°F)	0.70 x TDA + 8.74
Horizontal Open	Self-Contained	Medium (38°F)	0.72 x TDA + 5.55
Horizontal Open	Self-Contained	Low (0°F)	1.90 x TDA + 7.08
Horizontal Open	Self-Contained	Ice Cream (-15°F)	2.42 x TDA + 9.00

Table 3-303 Baseline Efficiencies for Refrigerators, Freezers, and Refrigerator-freezers Manufactured before March 27, 2017

Equipment Family	Condensing Unit Configuration	Rating Temperature	TDEC (kWh/day)
Vertical Open	Remote Condensing	Medium (38°F)	0.82 × TDA + 4.07
Vertical Open	Remote Condensing	Low (0°F)	2.27 × TDA + 6.85
Vertical Open	Remote Condensing	Ice Cream (-15°F)	2.89 × TDA + 8.70
Vertical Open	Self-Contained	Medium (38°F)	1.74 × TDA + 4.71
Vertical Open	Self-Contained	Low (0°F)	4.37 × TDA + 11.82
Vertical Open	Self-Contained	Ice Cream (-15°F)	5.55 × TDA + 15.02
Horizontal Open	Remote Condensing	Medium (38°F)	0.35 × TDA + 2.88

Equipment Family	Condensing Unit Configuration	Rating Temperature	TDEC (kWh/day)
Horizontal Open	Remote Condensing	Low (0°F)	0.57 × TDA + 6.88
Horizontal Open	Remote Condensing	Ice Cream (-15°F)	2.44 × TDA + 9.00
Horizontal Open	Self-Contained	Medium (38°F)	0.77 × TDA + 5.55
Horizontal Open	Self-Contained	Low (0°F)	1.92 × TDA + 7.08
Horizontal Open	Self-Contained	Ice Cream (-15°F)	2.44 × TDA + 9.00

Peak Factors

Table 3-304 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-305 Measure Life

Equipment	EUL	RUL	Ref
Night Covers	5	1.67	[9]

References

[7] 10 CFR 431.66 Energy conservation standards and their effective dates. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431#431.66

[8] Southern California Edison, Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case, August 1997. https://www.econofrost.com/acrobat/sce_report_long.pdf

[9] DEER 2014 EUL ID: GrocDisp-DispCvrs.

3.10.5 STRIP CURTAINS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Load Reduction
Measure Last Reviewed	September 2024
Changes Since Last Version	• Updated doorway area assumptions • Removed references to DI Baseline Condition and dual baseline

Description

This measure involves the installation of strip curtains on the main door of walk-in freezers and walk-in coolers. Strip curtains prevent infiltration of non-refrigerated air into refrigerated spaces when the main door is open for routine stocking activity. In the absence of strip curtains, the warmer, more humid air present in the store will infiltrate the unit, increasing the load of the refrigeration system and often reducing the efficiency of the evaporator unit as frost accumulates, impairing its effectiveness. The total refrigeration load due to infiltration through the main door into the unit depends on the temperature differential between the refrigerated and non-refrigerated space, the door area and height, and the duration and frequency of door openings. The avoided infiltration depends on the efficacy of the newly installed strip curtains as infiltration barriers. Algorithms and assumptions in this measure are drawn from a Strip Curtains measure maintained by the Northwest Regional Technical Forum (RTF), which calculates savings using the formulas outlined in ASHRAE's Refrigeration Handbook for calculating refrigeration load from infiltration by air exchange.

Baseline Case

The baseline case is a walk-in cooler or freezer that previously had either no strip curtain installed or on old ineffective strip curtain installed. The baseline condition efficiency is a walk-in cooler or freezer door with damaged or missing strip curtains in excess of 15% of the door area. The most likely areas of application are large and small grocery stores, supermarkets, restaurants, and refrigerated warehouses.

Efficient Case

The efficient equipment is a strip curtain added to a walk-in cooler or freezer. Strip curtains must be at least 0.06 inches thick. Low-temperature strip curtains must be used on low-temperature applications.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{\Delta kWh}{ft^2} \times A$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{ft^2} \times \frac{A}{Hrs}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-307 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta kWh/ft^2$	Average annual kWh savings per square foot of insulation barrier	Look up in Table 3-308	kWh/ft^2	[10]
A	Doorway area	Site-specific, if unknown look up in Table 3-309	ft^2	[10]
Hrs	Annual hours of operation	Site-specific, if unknown use 8766	Hours	
CF	Electric coincidence factor	Look up in Table 3-310	N/A	
PDF	Gas peak demand factor	Look up in Table 3-310	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-308 Default Annual Energy Savings for Strip Curtains per Square Foot

Type	Energy Savings for no pre-exisitng curtains, $\frac{\Delta kWh}{ft^2}$	Energy Savings for pre-exisitng curtains, $\frac{\Delta kWh}{ft^2}$
Grocery - Cooler	119.88	40.87
Grocery - Freezer	494.32	168.52
Convenience Store - Cooler	23.58	6.27
Convenience Store - Freezer	33.15	9.99
Restaurant - Cooler	22.50	6.19
Restaurant - Freezer	114.01	32.37
Refrigerated Warehouse - Cooler	153.36	53.42

Table 3-309 Doorway Area Assumptions

Type	Doorway Area, ft^2
Grocery - Cooler	22.5
Grocery - Freezer	22.5
Convenience Store - Cooler	22.5
Convenience Store - Freezer	22.5
Restaurant - Cooler	22.5
Restaurant - Freezer	22.5
Refrigerated Warehouse - Cooler	120

Peak Factors

Table 3-310 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-311 Measure Life

Equipment	EUL	RUL	Ref
Strip Curtains	4	1.33	[11]

References

[10] IL TRM v10, pg 650.

[11] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx. Accessed December 2018.

[12] JCPL PY2 Evaluation Report

3.10.6 ANTI-SWEAT HEAT CONTROL

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Refrigeration
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

Anti-sweat door heaters (ASDH) prevent condensation on cooler and freezer doors. Anti-sweat heater (ASH) controls sense the humidity in the store outside of reach-in, glass door refrigerated cases, and turn off anti-sweat heaters during periods of low humidity. Without controls, anti-sweat heaters run continuously whether they are necessary or not.

There are two commercially available control strategies – (1) ON/OFF controls and (2) micro pulse controls that respond to a call for heating, which is typically determined using either a door moisture sensor or an indoor air temperature and humidity sensor to calculate the dew point. In the first strategy, the ON/OFF controls turn the heaters on and off for minutes at a time, resulting in a reduction in run time. In the second strategy, the micro pulse controls pulse the door heaters for fractions of a second, in response to the call for heating. Savings are realized from the reduction in energy used by not having the heaters running at all times. In addition, secondary savings result from reduced cooling load on the refrigeration unit when the heaters are off.

Baseline Case

The baseline condition is assumed to be a commercial glass door cooler or refrigerator and freezer with a standard heated door running 24 hours a day, seven days per week (24/7), with no controls installed.

Efficient Case

The efficient equipment is assumed to be a door heater control on a commercial glass door cooler or refrigerator and freezer utilizing either ON/OFF or micro pulse controls.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kW_d \times \left(\%ON_b - \%ON_q\right) \times N \times Hrs \times IF_e$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = kW_d \times IF_e \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-312 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kW_d	Connected load kW per connected door	Site-specific, if unknown use 0.13	kW/door	[13]
N	Number of doors	Site-specific	N/A	
$\%ON_b$	Effective runtime of the uncontrolled ASDH	Site-specific, if unknown use 90.7%	N/A	[13]
$\%ON_q$	Effective runtime of the controlled ASDH	Look up in Table 3-313	N/A	[13]
IF_e	Interactive effects factor for energy to account for cooling savings from offset refrigeration load	Look up in Table 3-314	N/A	[13]
CF	Electric coincidence factor	Look up in Table 3-315 Coincidence Factors	N/A	[13]
Hrs	Hours of operation	8,760	Hrs	
EUL	Effective useful life	See Measure Life Section	Years	[14]

Table 3-313 Effective run time of controlled ASDH

Control Type	Value	Ref
ON/OFF control style	58.9%	[13]
Micropulse control style	42.8%	[13]
Unknown control style	45.6%	[13]

Table 3-314 Interactive effects factor for energy[159]

System Type	IF_eValue	Ref
Cooler or Refrigerator	1.26	[13]
Freezer	1.51	[13]

Coincidence Factor

Table 3-315 Coincidence Factors[160]

Control Type	CF Value	Ref
ON/OFF control style	0.32	[13]
Micropulse control style	0.45	[13]
Unknown control style	0.44	[13]

Measure Life

The effective useful life (EUL) is 12 years [14].

References

[13] Commercial Refrigeration Loadshape Project, 2015 available at https://cadmusgroup.com/wp-content/uploads/2016/02/NEEP-CRL_Report_FINAL_clean.pdf?submissionGuid=cb214243-bab8-479a-a4c4-c8e5c64ae7b2

[14] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/

159 Interactive effects factor for energy is calculated by dividing the PJM Summer Peak kW equipment and interactive savings for ASDH by the equipment savings from Table 52 of the report reference [13].

160 Coincidence factors developed by dividing the PJM Summer Peak kW Savings for ASDH Controls from Table 52 of the reference [13] (0.057 kW/door for unknown control style, 0.041 kW/door for on/off controls, and 0.058 kW/door for micropulse controls) by the average wattage of ASDH per connected door (0.13 kW)

3.10.7 DEFROST CONTROLS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure is applicable to existing refrigerated cases, walk in freezers, and walk in coolers with a traditional electric defrost mechanism. This control system overrides the defrost of evaporator coils when unnecessary, reducing annual energy consumption. The estimates for savings take into account savings from the reduced number of defrost cycles as well as the reduction in heat gain from the defrost process.

Baseline Case

The baseline case is an electric defrost system that uses a time clock mechanism to initiate defrost.

Efficient Case

The high-efficiency case is a defrost system with electric defrost controls.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{Defrost} + \Delta kWh_{Heat}$$

Where,

$$\Delta kWh_{Defrost} = kW_{Defrost} \times Hours \times DRF$$

$$\Delta kWh_{Heat} = \Delta kWh_{Defrost} \times 0.28 \times Eff_{RS}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8760} \; X \; CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-316 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta kWh_{Defrost}$	Energy savings resulting from an increase in operating efficiency due to the addition of electronic defrost controls.	Calculated	kWh	
ΔkWh_{Heat}	Energy savings due to reduced heat from the reduced number of defrost cycles	Calculated	kWh	
$kW_{Defrost}$	Load of electric defrost	Site-specific, if unknown use 0.9 kW	kW	
Hours	Number of hours defrost occurs over a year without the defrost controls	From Application, if unknown use 487[161]	Hrs/yr	[17]
DRF	Defrost reduction factor- percent reduction in defrosts required per year	35%		[15]
Eff_{RS}	Efficiency of typical refrigeration system	From Application, if unknown 3.35 (cooler), 1.88 (freezer)	kW/ton	[18]
0.28	Conversion constant	0.28	ton/kW	
CF	Electric coincidence factor	Look up in Table 3-317	N/A	
PDF	Gas peak demand factor	Look up in Table 3-317	N/A	

[161] The refrigeration system is assumed to be in operation every day of the year, while savings from the evaporator coil defrost control will only occur during set defrost cycles. This is assumed to be (4) 20-minute cycles per day, for a total of 487 hours.

Variable	Description	Value	Units	Ref
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-317 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [27].

References

[15] Supported by third party evaluation: Independent Testing was performed by Intertek Testing Service on a Walk-in Freezer that was retrofitted with Smart Electric Defrost capability

[16] Vermont Technical Reference User Manual (TRM), March 16, 2015. Pg. 171. This is a conservative estimate is based on a discussion with Heatcraft based on the components expected life

[17] Brian A. Fricke, Vishal Sharma, *Demand Defrost Strategies in Supermarket Refrigeration Systems*. (Oct 2011), Pg 2, https://info.ornl.gov/sites/publications/files/pub31296.pdf.

[18] Naikaj Pandya and Jon Maxwell *X1931-5 PSD Commercial Refrigeration Efficiency Update Study* (EnergizeCT, 2022) https://energizect.com/sites/default/files/documents/CT%20x1931-5%20Commercial%20Refrigeration%20ACOP%20Final%20Report_051222.pdf

3.10.8 LED CASE LIGHTING

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

This measure applies to the installation of LED lamps in vertical and horizontal display refrigerators, coolers, and freezers replacing T8 or T12 linear fluorescent lamps. Replacing fluorescent lamps with low heat generating LEDs reduces the energy consumption associated with the lighting components and reduces the amount of heat generated from the lamps that must be overcome through additional cooling.

Baseline Case

Existing T8 or T12 refrigerated case linear fluorescent lamps.

Efficient Case

DesignLights Consortium (DLC) version 5.1 qualified LED vertical or horizontal refrigerated case luminaires.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{W_b - W_q}{1{,}000}\right) \times units \times hrs \times \left(1 + \left(Eff_{comp} \times 0.284\right)\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{W_b - W_q}{1{,}000}\right) \times units \times CF \times \left(1 + \left(Eff_{comp} \times 0.284\right)\right)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-318 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
W_b	Rated baseline fixture wattage	Site-specific, if unknown: T8 Case Lighting System = 15.2/Linear Feet T12HO Case Lighting System = 18.7/Linear Feet	Watts	[23]
W_q	Rated energy efficient wattage	Site-specific	Watts	
Units	Number of LED fixtures installed under the program	Site-specific	N/A	
Hrs	Hours of use	Site-specific, if unknown assume 6,205	Hrs/yr	[19]
Eff_{comp}	Compressor efficiency	Site-specific, if unknown look up in Table 3-319	kW/ton	[20]
0.284	Conversion factor from kW to tons of refrigeration	0.284	Tons/kW	
CF	Electric coincidence factor	Look up in Table 3-320	N/A	
PDF	Gas peak demand factor	Look up in Table 3-320	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-319 Compressor Efficiency

Case Type	Eff_{comp}
Cooler	1.00
Freezer	1.92

Peak Factors

Table 3-320 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.92	[21]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is smaller of the measure EUL (16 years [22]) and the case RUL.

References

[19] Theobald, M. A., Emerging Technologies Program: Application Assessment Report #0608, LED Supermarket Case Lighting Grocery Store, Northern California, Pacific Gas and Electric Company, January 2006. Assumes refrigerated case lighting typically operates 17 hours per day, 365 days per year.

[20] Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect average efficiencies of R22 systems.

[21] Pennsylvania PUC, Technical Reference Manual, June 2016, p. 258.

[22] DEER 2014 EUL ID: GrocDisp-FixtLtg-LED

[23] Pacific Gas & Electric. May 2007. LED Refrigeration Case Lighting Workpaper 053007 rev1. Values normalized on a per linear foot basis.

3.10.9 REFRIGERATED CASE LIGHT OCCUPANCY SENSORS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure documents the energy savings attributed to installing occupancy sensors to control LED refrigerated case lighting. Energy savings can be achieved from the installation of sensors that dim or turn off the lights when the space or aisle is unoccupied. Energy savings result from a combination of reduced lighting energy and reduced cooling load within the case.

Baseline Case

No motion-based controls.

Efficient Case

This measure requires the installation of motion-based lighting controls that allow the LED case lighting to be dimmed or turned off completely during unoccupied conditions.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W}{1{,}000} \times Hrs \times RRF \times (1 + IF_e)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

There are no peak demand savings associated, as the savings are assumed to occur off-peak.

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-321 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
W	Connected wattage of controlled refrigerated lighting fixtures	Site-specific	Watts	
Hrs	Annual operating hours	Site-specific. If unknown assume 6,205	Hours	[24]
IF_e	Interactive effects factor for energy to account for colling savings from offset refrigeration load	Lookup in Table 3-322	N/A	[25]
RRF	Runtime reduction factor	Lookup in Table 3-323	N/A	[26]
1,000	Conversion factor	1,000	W/kW	
CF	Electric coincidence factor	Lookup in Table 3-324	N/A	
PDF	Gas peak day factor	Lookup in Table 3-324	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-322 Interactive Effects Factor

Refrigerator and Cooler	Freezer
0.29	0.50

Table 3-323 Runtime Reduction Factor

24 Hour Facility	18 Hour Facility
0.39	0.29

Peak Factors

Table 3-324 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-325 Measure Life

Equipment	EUL	RUL	Ref
Refrigeratred Case Lighting	8	2.66	[27]

References

[24] Matteson, Mary, Marc Senior, and Energy Analyst. n.d. *Pacific Gas and Electric Company Emerging Technologies Program Application Assessment Report #0608 LED Supermarket Case Lighting Grocery Store, Northern California Pacific Gas and Electric Company.* Assumes 6,205 annual operating hours and 50,000 lifetime hours. Most case lighting runs continuously (24/7) but some can be controlled. 6,205 annual hours of use can be used to represent the mix. Using grocery store hours of use (4,660 hr) is too conservative since case lighting is not tied to store lighting. https://www.etcc-ca.com/sites/default/files/OLD/images/stories/pdf/ETCC_Report_204.pdf

[25] 2021 Pennsylvania TRM, Volume 3, Commercial and Industrial Measures. Table 3 8: Interactive Factors for All Bulb Types. https://www.puc.pa.gov/pcdocs/1692532.docx

[26] "ComGroceryDisplayCaseMotionSensors_v3_3.Xlsm | Powered by Box." n.d. Nwcouncil.app.box.com. Accessed January 20, 2023. https://nwcouncil.app.box.com/s/brl01usbhxvtrjbp0i2xcqk016lndfd1

[27] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020. http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

3.10.10 EVAPORATOR FAN EC MOTOR

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure covers energy and demand savings associated with the replacement of existing shaded-pole (SP) evaporator fan motors or Permanent Split Capacitor (PSC) motors in refrigerated cases with an Electronically Commutated motor (ECM) or a Permanent Magnet Synchronous (PMS) motor. The baseline condition assumes the evaporator fan motor is uncontrolled (i.e., it runs continuously). This measure applies to equipment manufactured before January 1, 2009 only, as the Code of Federal Regulations requires the use of EC or three-phase motors in evaporator fans in equipment manufactured on or after that date. Savings are calculated per motor replaced.

There are two sources of energy and demand savings through this measure:

1) The direct savings associated with replacement of an inefficient motor with a more efficient one;

2) The indirect savings of a reduced cooling load on the refrigeration unit due to less heat gain from the more efficient evaporator fan motor in the air-stream.

Baseline Case

The baseline case is a walk-in cooler/freezer or refrigerated display case with shaded pole (SP) or permanent split capacitor (PSC) evaporator fan motors.

Efficient Case

The efficient case is a walk-in cooler/freezer or refrigerated display case with Permanent Magnet Synchronous (PMS) motor or electronically commutated evaporator fan motors (ECM) with full load efficiency exceeding that prescribed by federal energy conservation standards for electric motors in 10 CFR 431.446 and/or 10 CFR 431.25 as applicable.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kW_b - kW_q\right) \times F_{uncontrolled} \times 8{,}760 \times IF_e$$

If motor power is unknown, calculate using the algorithms below:

$$kW_b = HP_b \times \frac{0.746}{Eff_b} \times LF$$

$$kW_q = HP_q \times \frac{0.746}{Eff_q} \times LF$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-326 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kW_b	Input wattage of the baseline motor	Site-specific, if unknown, calculated from motor HP	kW	
kW_q	Input wattage of the efficient motor	Site-specific, if unknown, calculated from motor HP	kW	
$F_{uncontrolled}$	Effective runtime fraction of the uncontrolled motor	Site-specific, if unknown, use 0.978	N/A	[28]
HP_b	Rated horsepower of the baseline motor	Site-specific, if unknown use HP_q	HP	

Variable	Description	Value	Units	Ref
HP_q	Rated horsepower of the efficient motor	Site-specific	HP	
LF	Load factor	Site-specific[162], if unknown, use 0.9		[30]
IF_e	Interactive effects factor for energy to account for cooling savings from offset refrigeration load	Look up in Table 3-327	N/A	[28]
8,760	Annual operating hours of Evaporator Fan	8,760	hours	
0.746	Unit conversion, kW/HP	0.746	kW/HP	
Eff_b	Efficiency of the baseline motor	SP: 30% PSC: 60%	N/A	[29]
Eff_q	Efficiency of the qualifying motor	ECM: 70% PMS: 73%	N/A	[29]
CF	Electric coincidence factor	Look up in Table 3-328	N/A	
PDF	Gas peak day factor	Look up in Table 3-328	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-327 Interactive Factor for Energy

Equipment Type	IF_e Value
SP Base, Cooler	0.38
PSC Base, Cooler	0.19
SP Base, Freezer	0.76
PSC Base, Freezer	0.38

Peak Factors

Table 3-328 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is smaller of the RUL of the host equipment or 16 years [31].

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[162] Load Factor is the ratio between the actual load and rated load. This can be estimated by spot metering and nameplate reading.

References

[28] Cadmus, *Commercial Refrigeration Loadshape Project* (2015). https://cadmusgroup.com/wp-content/uploads/2016/02/NEEP-CRL_Report_FINAL_clean.pdf

[29] Department of Energy. "Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment." December 2013. Motor efficiencies for the baseline motors are drawn from Table 2.1, which provides peak efficiency ranges for a variety of motors. The motor efficiency for an ECM is drawn from the discussion in 2.4.3. https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf

[30] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential Multifamily, and Commercial/Industrial Measures. Version 6*. (April 16, 2018)

[31] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

3.10.11 EVAPORATOR FAN CONTROLLER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline • Added effective runtime assumption for unknown control type

Description

This measure is for the installation of evaporator fan controls in walk-in refrigerators or freezers with no pre-existing controls. An evaporator fan controller is a device or system that lowers airflow across an evaporator when there is no refrigerant flow through the evaporator (i.e., when the compressor is in an off-cycle). Evaporator fans run constantly to provide cooling when the compressor is running, and to provide air circulation when the compressor is not running. There are two commercially available strategies – ON/OFF controls and multispeed controls – that respond to a call for cooling. In the first strategy, the ON/OFF controls turn the motors on and off in response to the call for cooling, generating energy and demand savings as a result of a reduction in run time. In the second strategy, the multispeed controls change the speed of the motors in response to the call for cooling, saving energy and reducing demand by reducing operating power and run time (multispeed controls can also turn the motor off).

A fan controller saves energy by reducing fan usage, by reducing the refrigeration load resulting from the heat given off by the fan and by reducing compressor energy resulting from the electronic temperature control. This measure documents the energy savings attributed to evaporator fan controls.

Baseline Case

The baseline case is assumed to be a shaded pole (SP) motor or PSC motor in walk-in evaporators without controls or an electronically-commutated motor (ECM) without controls.

Efficient Case

The efficient equipment is assumed to be an evaporator fan powered by an ECM, SP or PSC motor utilizing either ON/OFF or multispeed controls.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kW \times \left(\%ON_b - \%ON_q\right) \times Hrs \times IF_e$$

Where,

$$kW = HP \times LF \times 0.746/\eta$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times UL$$

Calculation Parameters

Table 3-329 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kW	Input wattage of the SP, PSC or ECM motor	Site-specific, if unknown calculated	kW	
0.746	Conversion factor	0.746	kW/HP	[34]
LF	Load Factor - Ratio between the actual load and the rated load.	Site-specific, if unknown use 0.9	N/A	[34]
HP	Horsepower of SP, PSC or ECM motor	Site-specific	HP	
η	Motor efficiency of the SP, PSC or ECM motor	SP: 30% PSC: 60% ECM: 70%		[35]
$\%ON_b$	Effective runtime of the uncontrolled motor	Site-specific, if unknown use 97.8%	N/A	[32]

Variable	Description	Value	Units	Ref
$\%ON_q$	Effective runtime of the controlled motor	Site-specific, if unknown look up in Table 3-330	N/A	[32]
IF_e	Interactive effects factor for energy to account for cooling savings from offset refrigeration load	Look up in Table 3-331	N/A	[32]
CF	Electric coincidence factor	Look up in Table 3-332	N/A	[32]
Hrs	Hours of operation	8,760	Hrs	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-330 Effective run time of controlled motors

Control Type	Value	Ref
ON/OFF style controls	63.6%	[32]
Multi-speed style controls	69.2%	[32]
Unknown	66.5%	[32]

Table 3-331 Interactive Effects Factor for Energy[163]

System Type	IF_e Value	Ref
Cooler or Refrigerator	1.38	[32]
Freezer	1.76	[32]

Coincidence Factor

Table 3-332 Coincidence Factors[164]

Control Type	CF Value	Ref
ON/OFF control style	0.087	[32]
Micropulse control style	0.102	[32]
Unknown control style	0.094	[32]

Measure Life

The effective useful life (EUL) is 16 years [33].

[163] Interactive effects factor for energy is calculated by dividing the annual energy savings (kWh/HP) for "Equipment and Interactive" (shown in Table 43 of the reference [13]) by annual energy savings (kWh/HP) for the "Equipment Only" equipment type (also shown in Table 43).

[164] Coincidence factors are developed by dividing the PJM summer peak kW/HP savings for evaporator fan controls (shown in Table 47 of the report reference [13]) by the average annual energy savings (kWh/HP) for evaporator fan controls (shown in Table 43 of the report reference [13]).

References

[32] Commercial Refrigeration Loadshape Project, 2015 available at https://cadmusgroup.com/wp-content/uploads/2016/02/NEEP-CRL_Report_FINAL_clean.pdf?submissionGuid=cb214243-bab8-479a-a4c4-c8e5c64ae7b2

[33] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020 available at http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[34] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory*

[35] Department of Energy. "Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment." December 2013. Motor efficiency for SP motors is drawn from Table 2.1, which provides peak efficiency ranges for a variety of motors. The motor efficiency for an ECM is drawn from the discussion in 2.4.3. https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf

3.10.12 FLOATING HEAD PRESSURE CONTROL

Market	Commerical
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

Installers conventionally design a refrigeration system to condense at a set pressure-temperature point, typically 90°F. By installing a floating head pressure control (FHPCs) condenser system, the refrigeration system can change condensing temperatures in response to different outdoor temperatures. This means that the minimum condensing head pressure from a fixed setting (180 psig for R-22) is lowered to a saturated pressure equivalent at 70°F or less. Reduced head pressure improves the compressor efficiency at the expense of additional condenser fan power, with a net overall decrease in the compressor plus condenser fan power. Either a balanced-port or electronic expansion valve that is sized to meet the load requirement at a 70°F condensing temperature must be installed. Alternatively, a device may be installed to supplement the refrigeration feed to each evaporator attached to a condenser that is reducing head pressure.

Baseline Case

The baseline case is a refrigeration system without FHPC.

Efficient Case

The efficient case is a refrigeration system with FHPC.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = HP_{compressor} \times \frac{kWh}{HP}$$

If the refrigeration system is rated in tonnage:

$$\Delta kWh = \frac{4.715}{COP} \times Tons \times \frac{kWh}{HP}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 3-333 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$HP_{compressor}$	Rated horsepower per compressor	Site-specific	HP	
Tons	Refrigerator tonnage of the system	Site-specific	ton	
kWh/HP	Annual Savings per HP	Look up in Table 3-334	kWh/HP	[36][39]
COP	Coefficient of Performance	Look up in Table 3-335	N/A	[36][38]
4.715	Unit Conversion, HP/ton	4.715	HP/ton	
CF	Electric coincidence factor	Look up in Table 3-336	N/A	
PDF	Gas peak demand factor	Look up in Table 3-336	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Annual Savings per HP

Table 3-334 Annual Savings per HP

System Type/Size	kWh/hp
Unitary Condenser, Low Temp, 0-3 hp	252.03
Unitary Condenser, Low Temp, >3-6 hp	241.86
Unitary Condenser, Low Temp, >6-10 hp	248.68

System Type/Size	kWh/hp
Unitary Condenser, Low Temp, >10 hp	282.24
Unitary Condenser, Medium Temp, 0-3 hp	131.45
Unitary Condenser, Medium Temp, >3-6 hp	127.32
Unitary Condenser, Medium Temp, >6-10 hp	128.1
Unitary Condenser, Medium Temp, >10 hp	132.58
Remote Condenser, Low Temp, 0-3 hp	505.37
Remote Condenser, Low Temp, >3-6 hp	481.06
Remote Condenser, Low Temp, >6-10 hp	484.96
Remote Condenser, Low Temp, >10 hp	503.32
Remote Condenser, Medium Temp, 0-3 hp	393.38
Remote Condenser, Medium Temp, >3-6 hp	387.53
Remote Condenser, Medium Temp, >6-10 hp	396.89
Remote Condenser, Medium Temp, >10 hp	404.66

Table 3-335 COP for refrigeration equipment

System Type	Freezer (Low Temp)	Refrigerator (Medium Temp)	Ref
Unitary Condenser	1.4	2.6	[36]
Remote Condenser	1.88	3.35	[38]

Peak Factors

Table 3-336 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 15 years [37] or one-third of the EUL of the host equipment.

References

[36] Regional Technical Forum (RTF) as part of the Northwest Power & Conservation Council, Commerical Grocery Floating Head Pressure Controls Single Compressor v3.0, April 18, 2022; available at https://rtf.nwcouncil.org/measure/floating-head-pressure-controls-single-compressor-systems/
Assumed the kWh/hp savings for NJ will be equivalent to the kWh/hp savings derived for NYC location.

[37] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020 available at http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[38] DNV. 2022. "X1931-5 PSD Commercial Refrigeration Efficiency Update Study." Connecticut Energy Efficiency Board.

[39] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 10, January 2023 available at https://www3.dps.ny.gov/W/PSCWeb.nsf/PFPage/72C23DECFF52920A85257F1100671BDD?OpenDocument

3.10.13 VFD COMPRESSOR

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Refrigeration
Measure Last Reviewed	January 2023
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

Variable frequency drive (VFD) compressors are used to control and reduce the speed of the compressor during times when the refrigeration system does not require the motor to run at full capacity. VFD control is an economical and efficient retrofit option for existing compressor installations. The performance of variable speed compressors can more closely match the variable refrigeration load requirements thus minimizing energy consumption.

Baseline Case

Existing rotary screw compressor with slide valve control system.

Efficient Case

Rotary screw compressor with VFD control system.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = 0.212 \times \frac{1}{COP} \times HP_{compressor} \times ES_{value}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0.212 \times \frac{1}{COP} \times HP_{compressor} \times DS_{value} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-337 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$HP_{compressor}$	Rated horsepower per compressor	Site-specific	hp	
ES_{value}	Energy savings value	1,696	kWh/ton	[40]
DS_{value}	Demand savings value	0.22	Kw/ton	[40]
COP	Coefficient of performance	Site-specific, if unknown look up in Table 3-338	N/A	[41]
0.212	Conversion factor from HP to ton	0.212	Ton/hp	
CF	Electric coincidence factor	Look up in Table 3-339	N/A	
PDF	Gas peak demand factor	Look up in Table 3-339	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-338 COP for refrigeration equipment

Equipment	COP
Coolers	3.35
Freezers	1.88

Peak Factors

Table 3-339 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 15 years[42].

References

[40] 2005 DEER (Database for Energy Efficiency Resources). This measure considered the associated savings by vintage and by climate zone for compressors. The deemed value was an average across all climate zones and all vintages (excluding new construction). http://www.deeresources.com/index.php/deer2005

[41] Connecticut Energy Efficiency Board (EEB) “PSD Commercial Refrigeration Efficiency Update Study”, May 2022 https://energizect.com/sites/default/files/documents/CT%20x1931-5%20Commercial%20Refrigeration%20ACOP%20Final%20Report_051222.pdf

[42] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/

3.11 WATER HEATING

3.11.1 STORAGE WATER HEATER

Market	Commercial/Multifamily
Baseline Condition	NC/TOS/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of gas and electric storage tank water heaters designed to heat and store water at a thermostatically controlled temperature. This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating.

Storage type units include commercial gas-fired storage water heaters with a nominal input of greater than 75,000 BTU/h and no more than one gallon of water per 4,000 BTU/h of input, and commercial electric storage water heaters with a nominal input of greater than 12 kilowatts and no more than one gallon of water per 4,000 BTU/h of input.

This measure applies to replacement of existing storage type water heaters using the same heating as the efficient case. For new construction, this measure assumes baseline to be a standard efficiency water heater using the same heating fuel as the efficient equipment.

This measure applies to commercial grade water heaters only. For residential-duty water heaters installed in commercial settings, the Residential Storage Tank and Instantaneous Domestic Water Heater methodology detailed in this document shall be employed utilizing typical GPD values as defined in the "Gallons per Day (GPD)" section below.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

New Construction, Time of Sale:

The baseline condition for replacement measures is a standard efficiency fossil fuel or electric storage type water heater (based on proposed conditions) with tank volume and input capacity equivalent to the efficient case, UA value calculated as prescribed in the savings algorithm and a thermal efficiency of 0.80 (fossil fuel) or 0.98 (electric).

Early Replacement

The baseline condition for the Early Replacement measure is the existing water heater for the remaining useful life of the unit, and then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard.

Efficient Case

The compliance condition is a fossil fuel or electric storage type water heater as defined in the Measure Description section above, which exceeds the efficiency of the baseline equipment.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \left(\frac{1}{E_{t,b}} - \frac{1}{E_{t,q}}\right)$$

Where,

$$\Delta T_{main} = T_{set} - T_{main}$$

$$SL_b = \frac{Q_b}{800} + 110\sqrt{v_b}$$

Annual Fuel Savings

$$\Delta Therms_{NR} = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{E_{t,b}} - \frac{1}{E_{t,q}}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\left(UA_b - UA_q\right) \times \Delta T_{amb}}{3{,}412} \times CF$$

Where,

$$\Delta T_{amb} = T_{set} - T_{amb}$$

$$UA_q = \frac{SL_q}{70}$$

$$UA_b = \frac{SL_b}{70}$$

For baseline of large electric storage type water heaters (> 12kW and > 20 gallons):

$$SL_b = \frac{\left(0.3 + \frac{27}{v_b}\right)}{100} \times 70 \times v_b \times 8.33$$

For baseline of large oil and gas storage type water heaters (> 75,000 BTU/h input capacity (Q) and storage size > 1 gallon per 4000 BTU/h):

$$SL_b = \frac{Q_b}{800} + 110\sqrt{v_b}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-340 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔT_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main	Calculated	°F	
ΔT_{amb}	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature	Calculated	°F	
UA_b	Overall heat loss coefficient of the baseline condition	Calculated	Btu/h-°F	

Variable	Description	Value	Units	Ref
GPD	Gallons per day	Site Specific, if unknown look up in Table 3-341	Gal/day	[53][54][55][56]
UA_q	Overall heat loss coefficient of the energy efficient measure	Site-specific	Btu/h-°F	
SL_b	Standby loss of baseline unit	Code baseline: calculated Existing baseline: site-specific, calculated if unknown	kBtu/hr	
SL_q	Standby loss of efficient unit from AHRI rating	Site-specific	kBtu/hr	
T_{set}	Water heater set point temperature	Site-specific, if unknown use 125	°F	[47]
$E_{t,b}$	Thermal efficiency of the baseline condition	Site-specific. If unknown, look up in Table 3-342	N/A	[256][397]
$E_{t,q}$	Thermal efficiency of the energy efficient condition	Site-specific	N/A	
v_b	Baseline tank volume, equal to the storage capacity of the efficient equipment	Site-specific	gal	
Q_b	Baseline input capacity, equal to the input capacity of the efficient equipment	Site-specific	Btu/hr	
T_{main}	Supply water temperature in water main[165]	60	°F	[250]
T_{amb}	Surrounding ambient air temperature	70	°F	[48]
365	Days per year	365	Days/yr	
3,412	Conversion factor	3,412	Btu/kWh	
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal°F	
100,000	Conversion factor	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 3-343	N/A	
PDF	Gas peak day factor	Look up in Table 3-343	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life	See Measure Life Section	Years	

[165] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6 °F.

Table 3-341 GPD[166]

Building Type	GPD	Rate	Notes/Assumptions	Source	REf
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF	EIA926: Public Assembly	[43]
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 5,150 SF	EIA: Other	[43]
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 130,500 SF	EIA: Mercantile	[43]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL927: School with Showers	[44]
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation928	[45]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[44]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC929: Quick Service	[46]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[46]
Grocery	172	3.43 GPD per 1,000 SF	Assumes, 50,000 SF	EIA: Mercantile	[43]
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[44]
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 250,000 SF	EIA: Health Care, Inpatient	[43]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 200,000 SF	EIA: Lodging	[43]
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[44]
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 130,000 SF	EIA: Mercantile	[43]
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF	EIA: Other	[43]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF	EIA: Lodging	[43]
Multifamily High-Rise	4,600	46 GPD per unit	Assumes 100 units	Water Research Foundation	[45]
Multifamily Low-Rise	552	46 GPD per unit	Assumes 12 units	Water Research Foundation	[45]
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 92,000 SF	EIA: Warehouse and Storage	[43]
Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF	EIA: Public Assembly	[43]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[44]
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF	EIA: Mercantile	[43]
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[44]

[166] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes/Assumptions	Source	REf
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF	EIA: Warehouse and Storage	[43]
Other	Calculate	4.89 GPD per 1,000 SF		EIA: Other	[43]

Table 3-342 Thermal efficiency baseline

Electric	Gas
0.98	0.80

Peak Factors

Table 3-343 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[52]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Equipment	EUL	RUL	Ref
Commercial Storage Water Heater	15	5	[50]

References

[43] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012

[44] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011

[45] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016

[46] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010

[47] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[48] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.

[49] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B/appendix-Appendix%20E%20to%20Subpart%20B%20of%20Part%20430

[50] 10 CFR 431.110 (a) – Energy conservation standards and their effective dates. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-G/subject-group-ECFR4c2d09a7e7a11ca/section-431.110California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

[51] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory, 2022

[52] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf.

3.11.2 TANKLESS WATER HEATER

Market	Commercial/Multifamily
Baseline Type	NC/TOS/RF/DI/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Water Heating
Measure Last Reviewed	December 2022

Description

This measure covers the installation of high-efficiency fossil fuel and electric instantaneous water heaters, which heat water but contain no more than one gallon of water per 4,000 Btu/h of input. It is applicable to fossil fuel-fired instantaneous water heaters with a rated input greater than 200,000 Btu/h and electric instantaneous water heaters with a rated input greater than 12 kW. This measure applies to potable hot water delivery only; it is not applicable to water heaters used for process loads or space heating.

This measure applies to replacement of existing storage type water heaters using the same heating fuel (fossil fuel or electric) as the efficient case. For new construction, this measure assumes baseline to be a standard efficiency water heater using the same heating fuel (fossil fuel or electric) as the efficient case.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is a standard efficiency fossil fuel or electric storage type water heater (fuel type equivalent to the efficient case) with tank volume and input capacity equivalent to those of the existing equipment, UA value calculated as prescribed below and a thermal efficiency of 0.80 (fossil fuel) or 0.98 (electric). If existing tank volume is unknown, assume a 120-gallon storage type water heater with an input capacity of 200,000 Btu/h.

Efficient Case

The compliance condition is a fossil fuel or electric instantaneous water heater as defined in the Measure Description section above. Fossil fuel tankless water heaters must meet the minimum qualifying efficiency for ENERGY STAR® certification of a thermal efficiency greater than or equal to 0.94. Electric tankless water heaters must meet or exceed the efficiency of the baseline condition with a thermal efficiency greater than or equal to 0.98.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

$$\Delta kWh = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \left(\frac{1}{E_{t,b}} - \frac{1}{E_{t,q}}\right) + \frac{UA_b \times \Delta T_{amb} \times 8{,}760}{E_{t,b} \times 3{,}412}$$

Where,

$$kWh_b = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412 \times E_{t,b}} + \frac{UA_b \times \Delta T_{amb} \times 8{,}760}{E_{t,b} \times 3{,}412}\ (Electric\ Baseline)$$

$$kWh_b = 0\ (Fossil\ Fuel\ Baseline)$$

$$kWh_q = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412 \times E_{t,q}}\ (Electric\ Energy\ Efficient\ Case)$$

$$kWh_q = 0\ (Fossil\ Fuel\ Energy\ Efficient\ Case)$$

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

$$UA_b = \frac{SL_b}{70}$$

For baseline of large electric storage type water heaters (> 12kW and > 20 gallons):

$$SL_b = \frac{\left(0.3 + \frac{27}{v_b}\right)}{100} \times 70 \times v_b \times 8.33$$

Annual Fuel Savings

$$\Delta Therms = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{E_{t,b}} - \frac{1}{E_{t,q}}\right) + \frac{UA_b \times \Delta T_{amb} \times 8{,}760}{E_{t,b} \times 100{,}000}$$

Where,

$$\Delta Therms = Therms_b - Therms_q$$

$$Therms_b = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000 \times E_{t,b}} + \frac{UA_b \times \Delta T_{amb} \times 8{,}760}{E_{t,b} \times 100{,}000}\ (Fossil\ Fuel\ Baseline)$$

$$Therms_b = 0\ (Electric\ Baseline)$$

$$Therms_q = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000 \times E_{t,q}}\ (Fossil\ Fuel\ Energy\ Efficient\ Case)$$

$$Therms_q = 0\ (Electric\ Energy\ Efficient\ Case)$$

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

$$UA_b = \frac{SL_b}{70}$$

For baseline of large oil and gas storage type water heaters (> 75,000 BTU/h input capacity (Q) and storage size > 1 gallon per 4000 Btu/h):

$$SL_b = \frac{Q_b}{800} + 110\sqrt{v_b}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-344 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔT_{main}	Average temperature difference between water heater set point and the supply water temperature in water main	Calculated	°F	
ΔT_{amb}	Average temperature difference between water heater set point and the surrounding ambient air temperature	Calculated	°F	
UA_b	Overall heat loss coefficient of the baseline condition, calculate based on baseline standby loss	Calculated	N/A	
$E_{t,q}$	Thermal efficiency for energy efficient measure	Site-specific	N/A	
GPD	Gallons per day	Site-specific, if unknown look up in Table 3-345	Gal/day	[53][54] [55][56]
v_b	Baseline tank volume	Site-specific, if unknown use 120	gal	
Q_b	Baseline input capacity	Site-specific, if unknown use 200,000	Btu/h	
$E_{t,b}$	Thermal efficiency of the baseline condition	For retrofit, use site-specific existing value. If unknown, use 0.80 for fossil fuel and 0.98 for electric. For new construction, look up in Appendix E: Code-Compliant Efficiencies	N/A	[59]
T_{set}	Water heater set point temperature	Site-specific, if unknown use 125	°F	[57]
T_{main}	Supply water temperature in water main	60	°F	[58]
T_{amb}	Surrounding ambient air temperature	70[167]	°F	
365	Days per year	365	Days/yr	
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal°F	

[167] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.

Variable	Description	Value	Units	Ref
100,000	Conversion from Btu to therms	100,000	Btu/therm	
70	Temperature difference associated with standby loss specification	70	(°F)	
CF	Coincident Factor	Look up in Table 3-346	N/A	
PDF	Peak day factor	Look up in Table 3-346	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

The average daily hot water usage, expressed in gallons per day, for several commercial facility types is tabulated below. Daily hot water usage can be calculated based on the GPD and site-specific metric in the Rate column, or default values can be referenced directly from the GPD column.

Table 3-345 GPD by Facility Type[168]

Building Type	GPD	Rate	Notes	Source	Ref
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF, 10% hot water	EIA: Public Assembly	[53]
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 5,150 SF, 10% hot water	EIA: Other	[53]
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 130,500 SF, 10% hot water	EIA: Mercantile	[53]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL School with Showers	[54]
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation	[55]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[54]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC: Quick Service	[56]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[56]
Grocery	172	3.43 GPD per 1,000 SF	Assumes 50,000 SF, 10% hot water	EIA: Mercantile	[53]
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[54]
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 40% hot water, 250,000 SF	250,000 SF EIA: Health Care, Inpatient	[53]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 40% hot water, 200,000 SF	EIA: Lodging	[53]

[168] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes	Source	Ref
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[54]
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 130,000 SF, 10% hot water	EIA: Mercantile	[53]
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF, 10% hot water	EIA: Other	[53]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF, 40% hot water	EIA: Lodging	[53]
Multifamily High-Rise	4,550	45.5 GPD per unit	Assumes 100 units	Water Research Foundation	[55]
Multifamily Low-Rise	546	45.5 GPD per unit	Assumes 12 units	Water Research Foundation	[55]
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 92,000 SF, 10% hot water	EIA: Warehouse and Storage	[53]
Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF,10% hot water	EIA: Public Assembly	[53]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[54]
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF, 10% hot water	EIA: Mercantile	[53]
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[54]
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF, , 10% hot water	EIA: Warehouse and Storage	[53]
Other	Calculate	4.89 GPD per 1,000 SF	Assumes 10% hot water	EIA: Other	[53]

Peak Factors

Table 3-346 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[60]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for retrofit projects is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-347 Measure Life

Equipment	New construction EUL	Retrofit RUL	Ref
Instantaneous Water Heater	20	6.66	[61]

References

[53] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012.

[54] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011.

[55] *Water Research Foundation: Residential End Uses of Water, Version 2*, (April 2016) Pg 5. https://www.circleofblue.org/wp-content/uploads/2016/04/WRF_REU2016.pdf

[56] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010.

[57] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[58] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory, 2022.

[59] Fuel: 10 CFR 431.110 (a), December 2022.

[60] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 10, January 2023. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

[61] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020. http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

3.11.3 HEAT PUMP WATER HEATER

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	September 2024
Changes Since Last Version	• Clarified baseline definition • Corrected efficiency parameter nomenclature • Added default GPD assumption • Added space heat fuel and equipment type default splits

Description

This measure covers the installation of electric storage tank water heaters that use heat pump technology to move heat from the air (in conditioned or unconditioned spaces) to the water storage tank and are designed to heat and store potable water at a thermostatically controlled temperature of less than 180°F. It is not intended for equipment delivering process or space heating hot water. The best applications of heat pump water heater is in a space where cooling is desired year round. Heat pump water heater interactions with the HVAC system should be calculated according to the existing HVAC system (TOS) in existing buildings or the planned HVAC system in new construction (NC). If the HVAC system is unknown, one may calculate savings for each scenario and use the average savings, using the following space heat fuel splits:

• Gas = 93%	• Boiler = 37% of gas heat • Furnace = 63% of gas heat
• Electric heat = 7%	• Air source heat pump = 22% of electric heat • Other = 78% of electric heat

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Baseline equipment for TOS/NC projects is a minimally code-compliant, electric storage type water heater.

For EREP/DI projects, use dual baselines. The baseline equipment for the first baseline period is the site-specific existing equipment. The baseline equipment for the second baseline period is a minimally code-compliant water heater of the same type and fuel as the existing equipment.

Efficient Case

The efficient condition is an ENERGY STAR version 5.0 qualified commercial heat pump water heater.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{dhw} + \Delta kWh_{cooling} - \Delta kWh_{heating}$$

Where,

$$Load_{dhw} = GPD \times 365 \times 8.33 \times (T_{set} - T_{main})$$

$$\Delta kWh_{dhw} = \frac{Load_{dhw}}{3{,}412} \times \left(\frac{F_{dhw,electric}}{UEF_b} - \frac{1}{UEF_q \times F_{derate}}\right)$$

$$\Delta kWh_{cooling} = \frac{Load_{dhw}}{1{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times \frac{F_{cool}}{IEER}$$

$$\Delta kWh_{heating} = \frac{Load_{dhw}}{1{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times F_{heat,electric} \times \frac{F_{heat}}{COP\ x\ 3.412}$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{dhw} - \Delta Therms_{heating}$$

Where,

$$\Delta Therms_{dhw} = \frac{Load_{dhw}}{100{,}000} \times \left(\frac{F_{dhw,ff}}{UEF_b}\right)$$

$$\Delta Therms_{heating} = \frac{Load_{dhw}}{100{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times F_{heat,ff} \times \frac{F_{heat}}{E_t}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times F_{ETD}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-348 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{dhw}	Annual domestic hot water electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{cooling}$	Annual cooling electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual heating electric energy impacts	Calculated	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{dhw}$	Annual domestic hot water fuel savings	Calculated	Therms/yr	
$\Delta Therms_{heat}$	Annual space heating fuel impacts	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Load_{dhw}$	Annual hot water load	Calculated	Btu	
GPD	Gallons per day	Look up in Table 3-349	Gal/day	[67]

Variable	Description	Value	Units	Ref
		If building type or size unknown, use 64		
v_r	Rated storage volume	Site-specific	Gal	
E_t	Thermal efficiency of space heating boiler or furnace	Site-specific, if unknown, look up in Table 3-354	N/A	[64]
UEF_q	Uniform energy factor of efficient unit	Site-specific, if unknown look up in Table 3-351	N/A	[63]
UEF_b	Uniform energy factor of baseline unit	Look up in Appendix E: Code-Compliant Efficiencies	N/A	[63]
F_{derate}	Efficiency derating factor	Look up in Table 3-356	N/A	[64]
$F_{location}$	Installation location factor	Look up in Table 3-356	N/A	
$F_{DHW,electric}$	Electric water heating factor	Look up in Table 3-350	N/A	
$F_{DHW,ff}$	Fossil fuel water heating factor	Look up in Table 3-350	N/A	
$F_{DHW,boiler}$	Fossil fuel boiler heating factor	Look up in Table 3-350	N/A	
$F_{heat.electric}$	Electric heating factor	Look up in Table 3-350	N/A	
$F_{heat,ff}$	Fossil fuel heating factor	Look up in Table 3-350	N/A	
F_{heat}	Heating factor, used to account for the percentage of heat extracted from ambient air by the heat pump water heater that increases space heating load	0.49	N/A	[68]
F_{cool}	Cooling factor, used to account for the percentage of heat extracted from ambient air by the heat pump water heater that reduces space cooling load	0.51	N/A	[68]
IEER	Space cooling Integrated energy efficiency ratio	Look up in Table 3-353	Btu/W·hr	[67]
COP	Space heating COP	Look up in Table 3-351	N/A	[67]
T_{main}	Supply water temperature in water main	Look up in Table 3-355	°F	[66]
F_{ETD}	Energy to demand factor	Look up in Table 3-356	N/A	

Variable	Description	Value	Units	Ref
T_{set}	Water heater setpoint temperature	Site-specific, if unknown use 125	°F	[62]
365	Days per year	365	Days/yr	
8.33	Unit conversion, Btu/gal·°F	8.33	Btu/gal·°F	
3,412	Unit conversion, Btu/kWh	3,412	Btu/kWh	
3.412	Unit conversion, Btu/W·hr	3.412	Btu/W·hr	
1000	Unit conversion, Watt/kW	1000	W/kW	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 3-357	N/A	
PDF	Gas peak demand factor	Look up in Table 3-357	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-349 Gallons Per Day[169]

Building Type	GPD	Rate	Notes/Assumptions	Source	Ref
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF	EIA926: Public Assembly	[69]
Auto Repair	25	48.9 GPD per 1,000 SF	Assumes 5,150 SF	EIA: Other	[69]
Big Box Retail	448	34.3 GPD per 1,000 SF	Assumes 130,500 SF	EIA: Mercantile	[69]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL927: School with Showers	[70]
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation928	[71]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[70]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC929: Quick Service	[72]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[72]
Grocery	172	3.43 GPD per 1,000 SF	Assumes, 50,000 SF	EIA: Mercantile	[69]
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[70]

[169] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes/Assumptions	Source	Ref
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 250,000 SF	EIA: Health Care, Inpatient	[69]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 200,000 SF	EIA: Lodging	[69]
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[70]
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 130,000 SF	EIA: Mercantile	[69]
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF	EIA: Other	[69]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF	EIA: Lodging	[69]
Multifamily High-Rise	4,600	46 GPD per unit	Assumes 100 units	Water Research Foundation	[71]
Multifamily Low-Rise	552	46 GPD per unit	Assumes 12 units	Water Research Foundation	[71]
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 92,000 SF	EIA: Warehouse and Storage	[69]
Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF	EIA: Public Assembly	[69]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[70]
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF	EIA: Mercantile	[69]
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[70]
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF	EIA: Warehouse and Storage	[69]
Other	Calculate	4.89 GPD per 1,000 SF		EIA: Other	[69]

Table 3-350 DHW and Heating Savings Factors

Baseline Scenario	$F_{DHW,electric}$	$F_{DHW,ff}$	$F_{heat,electric}$	$F_{heat,ff}$
NC/TOS: Use electric baseline	1.0	0	1.0	0
EREP/DI with electric dhw and electric heat baseline	1.0	0	1.0	0
EREP/DI with fuel dhw and fuel heat baseline	0	1.0	0	1.0
EREP/DI with electric dhw and fuel heat baseline	1.0	0	0	1.0
EREP/DI with fuel dhw and electric heat baseline	0	1.0	1.0	0

Table 3-351 Efficient COP_q

Product Class	COP_q
Commercial Heat Pump Water Heater	3.0

Table 3-352 Derating Factors

Area	F_{derate}	$F_{location}$
Unconditioned Space	0.77	0
Conditioned Space	1.16	1
Kitchen	1.45	1
Unknown (Midstream Delivery)	1.00	1

Table 3-353 IEER and COP Values

Type	IEER	COP
Air Conditioner	12.7	1.0
Air-Source Heat Pump	12.7	3.3

Table 3-354 E_t Values

Equipment Type	Size Range	E_t
Warm Air Furnace, Gas Fired	All Capacities	0.80
Boiler, Hot Water, Gas Fired	All Capacities	0.80
Boiler, Steam, Gas Fired	All Capacities	0.77

Table 3-355 Supply Water Temperature

Climate Region	T_{main}
Northern	56
Southwest	58
Coastal	60
Central	58
Pine Barrens	58
Statewide Average	58

Table 3-356 F_{ETD} by building type

Building Type	ETDF
Education - Other	0.0002545
Health - Hospital	0.0002011
Health - Other	0.0003020

Building Type	ETDF
Lodging	0.0001210
Miscellaneous/Other	0.0002590
Office	0.0002490
Restaurant	0.0001525
Retail	0.0002560
Warehouse - Refrigerated	0.0003018

Peak Factors

Peak coincidence is incorporated in the energy to demand factor presented above.

Table 3-357 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

3-358 Measure Life

Equipment	EUL	RUL	Ref
Heat Pump Water Heater	10	3.37	[65]

References

[62] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[63] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[64] ENERGY STAR Program Requirements Product Specification for Commercial Water Heaters, Eligibility Criteria, Version2.0. (2021),

[65] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx. Accessed November 13, 2018

[66] NSRDB, TMY3 data, December 2022. https://nsrdb.nrel.gov/data-sets/tmy

[67] International Energy Conservation Code (IECC) 2022

[68] From NY TRM V10, Pg 128
[69] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012
[70] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011
[71] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016
[72] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010

3.11.4 FAUCET AERATORS AND SHOWERHEADS

Market	Commercial/Multifamily
Baseline Condition	TOS, RF
Baseline	Code, Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Updated baseline and efficient case description • Updated baseline and efficient flowrates • Updated the electric DHW recovery hours algorithm for faucet aerator

Description

This measure covers the installation of low-flow faucet aerators and showerheads in commercial, industrial, and multifamily applications. In multifamily applications, only units installed in common areas are eligible for this measure. Savings for low-flow faucet aerator and showerhead measures are determined using the total change in flow rate (gallons per minute) per unit from the baseline (existing) fixture to the efficient low-flow fixture.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

For TOS, the baseline is a standard faucet or a showerhead meeting maximum flow given in the NJ A5160 [73]. For retrofit applications,, the actual flow rate of the existing faucet should be used in the algorithm below.

Efficient Case

The efficient condition is an energy efficient faucet aerator or showerhead with rated flow rate less than maximum flow rate given in the NJ A5160 [6]. Actual flow rates of the installed fixture are used to estimate the savings.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta H_2O \times \left(T_{operating} - T_{main}\right) \times \frac{8.33}{3{,}412 \times E_{t,elec}}$$

Where,

$$\Delta H_2O = (GPM\_b \times F\_(Throttle, b) - GPM\_q \times F\_(Throttle, q)\ ) \times t\_(min/day) \times Days$$

$$t_{min/day} = t_{min/use} \times N_{uses/day}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\Delta H_2O \times (T_{operating} - T_{main}) \times 8.33}{(100{,}000 \times E_{t,fuel})}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hours} \times CF$$

Where,

$$Hours_{FA} = \frac{GPM_b \times t_{min/use} \times N_{uses/day} \times days \times 0.44}{GPH}$$

$$Hours_{SH} = \frac{GPM_b \times t_{min/use} \times N_{uses/day} \times days \times 0.608}{GPH}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-359 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔH_2O	Annual water savings	Calculated	Gal/yr	
$Hours_{FA}$	Annual electric DHW recovery hours for faucet aerators	Calculated	hr/yr	

Variable	Description	Value	Units	Ref
$Hours_{SH}$	Annual electric DHW recovery hours for showerheads	Calculated	hr/yr	
$t_{min/day}$	Average minutes of fixture use per day	Calculated. If unknown, use 30 (faucet) or 20 (showerhead)	min/day	[75]
GPM_b	Flowrate of baseline fixture	For DI: Site-specific For RF: Look up in Table 3-360	Gal/min	[73]
GPM_q	Flowrate of efficient fixture	Site-specific	Gal/min	
$N_{uses/day}$	Number of times the fixture is used per day	Site-specific. If unknown, use 60 (faucet) or 2.4 (showerhead)	/day	[75]
days	Days fixture used per year	Site-specific. If unknown, look up in Table 3-361	days/yr	[82]
$T_{operating}$	Fixture operating temperature	Look up in Table 3-360	°F	
T_{main}	Temperature of supply water temperature in water main[170]	60	°F	[76]
$F_{throttle,b}$	Flowrate restricted: ratio of user setting to full throttle flow rate for baseline fixture	0.83 (faucets) 0.90 (showerheads)	N/A	[74]
$F_{throttle,q}$	Flowrate rescrticted: ratio of user setting to full throttle flowrate for efficient fixture	0.95 (faucets) 0.90 (showerheads)	N/A	[74]
$t_{min/use}$	Average duration a fixture runs each time it is used	0.5 (faucet) 8.2 (showerhead)	min	[75]
GPH	Gallon per hour recovery of electric water heater	53.9	Gal/hr	
$E_{t,elec}$	Thermal efficiency of electric water heater	0.98	N/A	[78]
$E_{t,fuel}$	Thermal efficiency of fossil fuel water heater	0.80	N/A	[78]
0.44	Proportion of hot 140°F water mixed with 50.7°F supply water to give 90°F mixed faucet water	0.44	N/A	
0.608	Proportion of hot 140°F water mixed with 50.7°F supply water to give 105°F shower water	0.608	N/A	

[170] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F.

Variable	Description	Value	Units	Ref
8.33	Energy required to heat one gallon of water by one degree Farenheit	8.33	Btu/gal°F	
3,412	Conversion factor from Btu/h to kW	3,412	Btu/h/kW	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
CF	Coincidence factor	Look up in Table 3-362	N/A	[81]
PDF	Peak day factor	Look up in Table 3-362	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	

Table 3-360 Installed Flowrates and Fixture Operating Temperatures

Fixture Type	Location	GPM_b	$T_{operating}$(°F)
Faucet aerator	Kitchen	1.8	93
	Public restroom	0.5	86
	Private restroom	1.5	86
Showerhead	Any	2.0	105

Table 3-361 Operating Days per Year

Building Type	Operating Days per Year
Assembly	355
Auto	355
Big Box	355
Community College	284
Dormitory	355
Fast Food	355
Full Service Restaurant	303
Grocery	365
Hospital	365
Hotel	365
Large Office	303
Light Industrial	251
Motel	365

Building Type	Operating Days per Year
Multi-story Retail	355
Primary School	218
Religious	355
Secondary School	218
Small Office	303
Small Retail	355
University	284
Warehouse	251

Peak Factors

Table 3-362 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF) – Faucet Aerators	Lookup in Table 3-363	[81]
Electric coincidence factor (CF) – Showerheads	0.0278	[81]
Natural gas peak day factor (PDF)	See Appendix G	

Table 3-363 Electric Coincidence Factors for Faucet Aerators

Building Type	Coincidence Factor
Small Office	0.0064
Large Office	0.0288
Fast Food Restaurant	0.0084
Sit-Down Restaurant	0.0184
Retail	0.0043
Grocery	0.0043
Warehouse	0.0064
Elementary School	0.0096
Jr High/High School	0.0288
Health	0.0144
Motel	0.0006
Hotel	0.0004
Other	0.0128

Non-Energy Impacts

Water savings:

$$\Delta H2O = units \times \left(GPM_b \times F_{throttle,b} - GPM_q \times F_{throttle,q}\right) \times \frac{min}{day} \times days$$

Measure Life

Table 3-364 Measure Life

Equipment	EUL	Ref
Faucet Aerators and Showerheads	10	[79]

References

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[74] Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes, American Council for an Energy-Efficient Economy, August 2008, pg. 1-265.

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[76] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory. https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/AlgorithmForMainsWaterTemperature.pdf

[77] FEMP Cost Calculator: https://www.ces.ncsu.edu/wp-content/uploads/2014/03/Federal-Energy-Management-Program-Energy-Cost-Calculator-for-Faucets-and-Showerheads.htm

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[79] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.energizect.com/sites/default/files/Measure%20Life%20Report%202007

[80] Existing faucet flow rate assumption taken from Pennsylvania Technical Reference Manual; effective June 2016, pp. 114ff. http://www.puc.pa.gov/pcdocs/1370278.docx

[81] *IL 2022 Illinois Statewide Technical Reference Manual for Energy Efficiency : Version 10* (2022), Pg 171 (faucet aerators) and pg 177 (showerheads). https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

[82] Operating days per year estimates based on simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

3.11.5 COMBINATION BOILER

Market	Commercial/Multifamily
Baseline Type	TOS/NC/EREP/DI
Baseline Condition	Code/Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	December 2022
Changes Since Last Version	• Added GPD assumption for unknown building type or size

Description

This section provides energy savings algorithms for qualifying gas combination boilers installed in commercial and industrial settings. A combination boiler is a space heating system that also has the capability to provide instantaneous domestic hot water. The input values are based on the specifications of the actual equipment being installed, federal equipment efficiency standards, DOE2.2 simulations completed by the NJ SWE and regional estimates of average baseline water heating energy usage.

For new construction, replacement of failed equipment, and end of useful life, the baseline unit is a code compliant unit with an efficiency as required by ASHRAE Std. 90.1 – 2019 and IECC 2021, which are the current codes adopted by the State of New Jersey.

For retrofit programs where an existing boiler is replaced , the baseline efficiency is the existing boiler efficiency. For early replacement programs, the baseline efficiency is the existing boiler efficiency for the remaining life of the existing boiler and a code efficiency boiler for the remaining life of the measure.

Baseline Case

Space Heating Component:

- New Construction/Replacement of Failed Equipment/End of Useful Life: Boiler compliant with ASHRAE Std. 90.1 – 2019 and IECC 2021.
- Retrofit/Direct Install: Existing boiler efficiency for first baseline. If unknown, use minimally code-compliant efficiency based on boiler age. As second baseline, use current code for measure remaining life.

Domestic Hot Water Component:

- New Construction/Replacement of Failed Equipment/End of Useful Life: Water heater compliant with ASHRAE Std. 90.1 – 2019 and IECC 2021.
- Retrofit: Existing water heater efficiency for first baseline. If unknown use minimally code compliant efficiency based on water heater age. As second baseline, use current code for measure remaining life.

Efficient Case

The compliance condition is a combi-boiler unit with a heating efficiency higher than code. Qualifying systems must not have a water storage tank.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{Boiler} + \Delta Therms_{DHW}$$

Where,

$$\Delta Therms_{Boiler} = Cap_{in} \times EFLH_h \times \frac{Eff_q/Eff_b - 1}{100}$$

$$\Delta Therms_{DHW} = \frac{GPD \times 365 \times 8.33 \times (T_{set} - T_{main})}{100{,}000} \times \left(\frac{1}{E_{t,b}} - \frac{1}{Eff_q}\right) + \frac{UA_b}{E_{t,b}} \times \frac{(T_{set} - T_{amb})}{100{,}000} \times 8{,}760$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-365 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Boiler}$	Annual fuel savings from space heating	Calculated	Therms/day	
$\Delta Therms_{DHW}$	Annual fuel savings from water heating	Calculated	Therms/day	
Cap_{in}	Input capacity of qualifying boiler	Site-specific	kBtu/hr	
Eff_q	Boiler proposed efficiency	Site-specific	N/A	
$EFLH_h$	Boiler equivalent full load hours of operation during heating season	Look up in Appendix C:	Hours	[83]
Eff_b	Boiler baseline efficiency	Look up in Appendix E: Code-Compliant Efficiencies	N/A	[89][90][91]
GPD	Gallons per day of hot water use	Look up in Table 3-366 If building type or size unknown, use 64 GPD[171]	Gal/day	[92][93][94][95]
100	Unit conversion from kBtu to therm	100	kBtu/therm	
365	Days per year	365	Day/yr	
8.33	Unit conversion, Btu/gal·F	8.33	Btu/gaİ·F	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	
$E_{t,b}$	Baseline water heating designation thermal efficiency	0.8	N/A	[86]
T_{set}	Water heater setpoint temperature	Site-specific, if unknown use 125	°F	[84]
T_{main}	Incoming water main temperature[172]	60	°F	[85]

[171] Based on PSEG implementor review of NREL NJ commercial building stock data

[172] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6 deg F.

Variable	Description	Value	Units	Ref
UA_b	Overall heat loss coefficient of the baseline condition[173]	7.85	Btu/h·F	[87]
T_{amb}	Surrounding ambient air temperature[174]	70	°F	
8,760	Hours in one year	8760	Hours	
PDF	Peak day factor	Look up in Table 3-367	N/A	
EUL	Estimated useful life	See Measure Life Section	Years	[88]

Table 3-366 Gallons Per Day (GPD)[175]

Building Type	GPD	Rate	Notes	Source	Ref
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF, 10% hot water	EIA: Public Assembly	[93]
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 5,150 SF, 10% hot water	EIA: Other	[93]
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 130,500 SF, 10% hot water	EIA: Mercantile	[93]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL School with Showers	[94]
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation	[95]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[94]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC: Quick Service	[96]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[96]
Grocery	172	3.43 GPD per 1,000 SF	Assumes 50,000 SF, 10% hot water	EIA: Mercantile	[93]

[173] Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters. Heat loss coefficient was calculated for a minimally code compliant fuel storage water heater found to be the most typical in terms of storage and input capacity, representing storage type water heaters of between 20 and 55 gallon capacity (40 gallon, 40,000 Btu/h assumed). Results of heat loss coefficient evaluation for this assumed baseline is used to represent the UAbaseline term.

[174] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.

[175] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes	Source	Ref
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[94]
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 40% hot water, 250,000 SF	250,000 SF EIA: Health Care, Inpatient	[93]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 40% hot water, 200,000 SF	EIA: Lodging	[93]
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[94]
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 130,000 SF, 10% hot water	EIA: Mercantile	[93]
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF, 10% hot water	EIA: Other	[93]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF, 40% hot water	EIA: Lodging	[93]
Multifamily High-Rise	4,550	45.5 GPD per unit	Assumes 100 units	Water Research Foundation	[95]
Multifamily Low-Rise	546	45.5 GPD per unit	Assumes 12 units	Water Research Foundation	[95]
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 92,000 SF, 10% hot water	EIA: Warehouse and Storage	[93]
Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF,10% hot water	EIA: Public Assembly	[93]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[94]
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF, 10% hot water	EIA: Mercantile	[93]
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[94]
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF, , 10% hot water	EIA: Warehouse and Storage	[93]
Other	Calculate	4.89 GPD per 1,000 SF	Assumes 10% hot water	EIA: Other	[93]

Peak Factors

Table 3-367 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-368 Measure Life

Equipment	EUL	RUL	Ref
Combination Boiler	22	7.3	[88]

References

[83] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[84] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[85] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature* (National Renewable Energy Laboratory). https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf

[86] eCFR :: 10 CFR 431.110 -- Energy conservation standards and their effective dates December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

[87] “Regulations.gov.” n.d. www.regulations.gov. Accessed December 13, 2022. Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters. Heat loss coefficient was calculated for a minimally code compliant fuel storage water heater found to be the most typical in terms of storage and input capacity, representing storage type water heaters of between 20 and 55 gallon capacity (40 gallon, 40,000 Btu/h assumed). Results of heat loss coefficient evaluation for this assumed baseline is used to represent the UAbaseline term.

[88] https://www.regulations.gov/document/EERE-2015-BT-TP-0007-0004

[89] *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces*. (DOE, 2016), Table 8.2.17.

[90] *ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings*. (ASHRAE, 2019), Table 6.8.1-5. https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[91] *ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings*. (ASHRAE, 2019), Table 6.8.1-5. https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[92] *2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES* (IECC 2021), Table C403.3.2(6) https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency

[93] U.S. Energy Information Administration, *2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings*, Table WD1. Daily water consumption in large commercial buildings, 2012

[94] National Renewable Energy Laboratory, *Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines*, Table 1. Hot Water Use By Building Type, June 2011.

[95] Water Research Foundation: *Residential End Uses of Water, Version 2* (April 2016), Pg 5. https://www.circleofblue.org/wp-content/uploads/2016/04/WRF_REU2016.pdf

[96] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010 E

3.11.6 PRE-RINSE SPRAY VALVES (PRSV)

Market	Commercial/Multifamily
Baseline Condition	RF/ TOS
Baseline	Existing
End Use Subcategory	Water Conservation
Measure Last Reviewed	December 2022
Changes Since Last Version	• Added fuel parameters and default assumption

Description

This measure section documents the energy savings and demand reductions attributed to efficient low flow pre-rinse sprayers in grocery and food service applications including fast food restaurants, full-service restaurants, multifamily buildings, and other. The most likely areas of application are kitchens in restaurants and hotels.

Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper. The spray valves usually have a clip to lock the handle in the "on" position. Pre-rinse valves are inexpensive and easily interchangeable with different manufacturers' assemblies. The primary impacts of this measure are water savings. Energy savings depend on the facility's water heating fuel - if the facility does not have electric water heating, there are no electric savings for this measure; if the facility does not have fossil fuel water heating, there are no MMBtu (Therms) savings for this measure.

Baseline Case

The baseline for the Retrofit/Early Replacement vintage is based on the EPA 2005 standard. Baseline flowrates are site specific. If unknown, they are assumed to be 1.6 gallons/minute.

Efficient Case

High efficiency PRSV with a flowrate less than the max flow rate by product class as defined by DOE/WaterSense.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N_{units} \times \frac{hours}{day} \times 60 \times \frac{days}{year} \times \left(GPM_b - GPM_q\right) \times 8.33 \times \frac{\Delta T}{E_{t,elec} \times 3{,}412} \times F_{Elec}$$

Where,

$$\Delta T = T_{PRSV} - T_{Main}$$

Annual Fuel Savings

$$\Delta Therms = N_{units} \times \frac{hours}{day} \times 60 \times \frac{days}{year} \times \left(GPM_b - GPM_q\right) \times 8.33 \times \frac{\Delta T}{E_{t,fuel} \times 100{,}000} \times F_{Fuel}$$

Where,

$$\Delta T = T_{PRSV} - T_{Main}$$

Peak Demand Savings

$$\Delta kW_{Peak} = ETDF \times Energy\ Savings$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-369 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔT	Average temperature different between PRSV operating temperature and the supply water temperature	60	°F	[99][101]
N_{units}	Number of fixtures	Site-specific	N/A	
GPM_q	Flow rate of the installed prsv	Site-specific. If unknown, use 1.28	Gal/min	[106]
Days/year	Number of days the fixture is in use in one year	Site-specific. If unknown, look up in Table 3-371	Days/year	[109]

Variable	Description	Value	Units	Ref
$E_{t, elc}$	Thermal Efficiency for electrical heaters	Site-specific. If unknown, assume 98%	N/A	[107]
$E_{t, fuel}$	Thermal efficiency for fuel heaters	Site-specific. If unknown, assume 80%	N/A	[108]
ETDF	Energy to Demand Factor	Look up in Table 3-372	(kW/ kWh/yr)	[105]
GPM_b	Flow rate of the baseline prsv	Site-specific. If unknown, use 1.6	Gal/min	[97] [98]
Hours/day	Operating hours of fixture usage per day	Look up in Table 3-370 Operating Hours/Day	Hours/day	
F_{Elec}	Factor to account for electric water heat[176]	If building water heat fuel is electric: 1 If building water heat fuel is not electric: 0 If unknown: 0.28		
F_{Fuel}	Factor to account for fuel water heat	If building water heat fuel is electric: 0 If building water heat fuel is not electric: 1 If unknown: 0.72		
8.33	Specific mass in pounds of one gallon of water	8.33	lbs/gal	
3,412	Btu to kWh electric conversion factor	3,412	Btu/kwh	
CF	Electric coincidence factor	Lookup in Table 3-373	N/A	
PDF	Gas peak day factor	Lookup in Table 3-373	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-370 Operating Hours/Day

Facility Type	Hours of Pre-Rinse Spray Value Use Per Day (hours)	Ref
Full Service Restaurant	4	[101]
Limited Service (fast food) Restaurant	1	[101]
Other	1.067	[102]

[176] Unknown electric and fuel water heat factors from PSE&G PY3 Evaluation report

Table 3-371 Operating Days per Year

Building Type	Operating Days per Year
Assembly	355
Warehouse	251
Auto	355
Big Box	355
Community College	284
Dormitory	355
Fast Food	355
Full Service Restaurant	303
Grocery	365
Hospital	365
Hotel	365
Large Office	303
Light Industrial	251
Motel	365
Multi-story Retail	355
Primary School	218
Religious	355
Secondary School	218
Small Office	303
Small Retail	355
University	284

Table 3-372 ETDF

Facility Type	ETDF
Quick-service Restaurant	0.000186
Full-Service Restaurant	0.0001189
Standalone Retail (Grocery)	0.000237
Default – Unknown	0.000259

Peak Factors

Table 3-373 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	Appendix G: Natural Gas Peak Day Factors	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-374 Measure Life

Equipment	EUL	RUL	Ref
PRSV	5	1.67	[105]

References

[97] The Energy Policy Act (EPAct) of 2005. http://www.psc.state.ga.us/electric/federal/EPA/EPA2005.pdf

[98] Impact and Process Evaluation Final Report for California Urban Water Conservation Council 2004-5 Pre-Rinse Spray Valve Installation Program (Phase 2), SBW Consulting, 2007, Table 3-4, p. 23. https://p2infohouse.org/ref/50/49026.pdf

[99] *CEE Commercial Kitchens Initiative Program Guidance on Pre-Rinse Spray Valves*, (CEE 2005), pg. 3. https://library.cee1.org/system/files/library/4252/PRSV%20Program%20Guidance.pdf

[100] Burch, J., and C. Christensen*, Towards Development of an Algorithm for Mains Water Temperature.* American Solar Energy Annual Conference Proceedings (2007).

[101] Hours estimates based on PG&E savings estimates, algorithms, sources (2005). Food Service Pre-Rinse Spray Valves.

[102] "WaterSense Specification for Commercial Pre-Rinse Spray Valves Supporting Statement" n.d. WaterSense® Draft Specification for Commercial Pre-Rinse Spray Valves - Supporting Statement (epa.gov)

[103] "Federal Register :: Request Access." n.d. Unblock.federalregister.gov. Accessed December 8, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

[104] *Technical Reference Manual Volume 3: Commercial and Industrial Measures* Pg 138 (August 2019). https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

[105] *Technical Support Document: Energy Efficiency Program For Consumer Products And Commercial And Industrial Equipment:Commercial Prerinse Spray Valves* (December 2015) Pg 8-13. https://www.regulations.gov/document/EERE-2014-BT-STD-0027-0046

[106] EPA WaterSense Specification for Commercial Pre-Rinse Spray Valves. https://www.epa.gov/watersense/pre-rinse-spray-valves

[107] *2022 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 10.0: Volume 2* (2022), Pg 124, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

[108] ASHRAE Standards 90.1-2019, *Energy Standard for Buildings Except Low Rise Residential Buildings*. https://www.ashrae.org/standards-research--technology/standards--guidelines

[109] Operating days per year estimates based on simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

3.11.7 RECIRCULATING PUMP CONTROL

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure covers the installation of temperature modulation or demand controls on central domestic hot water (DHW) systems with recirculation:

- Temperature modulation controls reduce circulator pump energy and recirculation heat losses by modulating DHW system supply temperatures when hot water demand is expected to be low (usually based on occupancy schedules).
- Demand controls limit energy consumption by activating recirculation loops based on demand detected by a flow sensing device on the makeup water pipe and a temperature sensor installed on the recirculating return pipe.
- Temperature control. An aquastat control is used to switch the recirculating pump on and off to maintain a target temperature in the loop.
- Timer control. A timer is used to turn the recirculating pump on during peak usage times and off overnight.

Temperature modulation and demand controls achieve savings without significant interruptions to hot water availability. Recirculation systems are commonly used in larger buildings because the hot water must be quickly provided to spaces that are far from the water heating plant. The recirculation pump reduces wait time at the faucets by keeping the domestic hot water (DHW) piping loop hot as it gradually loses heat to the surrounding air. Without the recirculation pump, occupants would have to run their faucets until the cooled, stagnant water is removed from the piping between the faucet and the DHW plant and would waste water in the process; however, constant pumping operation increases energy consumption by exposing supply and return line piping to continuous heat loss, even in absence of the demand for hot water.

This measure is not applicable in facilities where twenty-four hour recirculation and delivered hot water temperature is required by code (refer to Section 7: Service Water Heating of ASHRAE 90.1 2019 to check for code requirements) [126]. This measure is not applicable to new construction or gut rehab installations.

Baseline Case

The base case for this measure category is existing, un-controlled recirculation pumps on central domestic hot water systems that continuously recirculates maintaining a constant supply temperature of the DHW.

Efficient Case

The efficient case is a central DHW recirculation system with a control system that regulates circulation pump operation based on demand and/or temperature or through timing and is in compliance with the current safety codes and standards in New Jersey**.**

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{Pump} + \Delta kWh_{HW}$$

Where,

$$\Delta kWh_{Pump} = \frac{HP \times 0.746}{Eff_{Pump}} \times LF \times Hrs_{Recirc,B} \times ESF_{Pump}$$

$$\Delta kWh_{HW} = \frac{GPD \times 365 \times 8.33 \times (T_{Set} - T_{Main})}{3{,}412} \times \frac{F_{DHW,Elec}}{E_{T,Elec}} \times \frac{Hrs_{Recirc,B}}{8{,}760} \times ESF_{HW}$$

Annual Fuel Savings

$$\Delta Therms = \frac{GPD \times 365 \times 8.33 \times (T_{Set} - T_{Main})}{100{,}000} \times \frac{F_{DHW,Fuel}}{E_{T,Fuel}} \times \frac{Hrs_{Recirc,B}}{8{,}760} \times ESF_{HW}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs_{Recirc,B}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-375 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Pump}	Annual electric energy savings from pump	Calculated	kWh/yr	
ΔkWh_{HW}	Annual electric energy savings from hot water	Calculated	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Hrs_{Recirc, B}$	Annual hours of operation of recirculation system in baseline condition	Site-specific, if unknown use 8760	Hrs/yr	
HP	Pump nameplate horsepower	Site-specific	HP	
Eff_{Pump}	Pump efficiency	Site-specific, if unknown look up in Table 3-376	N/A	
LF	Load factor	Site-specific, if unknown use 0.9	N/A	[112]
GPD	Average daily hot water usage	Site-specific, if unknown look up in Table 3-377	Gal/day	
T_{Set}	Water heater set point temperature	Site-specific, if unknown use 125	°F	[117]
$E_{T, Fuel}$	Thermal efficiency of fossil fuel water heater	Site-specific, if unknown use 0.8	N/A	[121]
ESF_{HW}	Hot water energy savings factor	Look up in Table 3-379	N/A	[125]
$F_{DHW, Elec}$	Electric water heating factor	Look up in Table 3-378	N/A	
$F_{DHW, Fuel}$	Fossil fuel water heating factor	Look up in Table 3-378	N/A	
CF	Electric coincidence factor	Look up in Table 3-380	N/A	
PDF	Gas peak demand factor	Look up in Table 3-380	N/A	

Variable	Description	Value	Units	Ref
T_{Main}	Supply water temperature in water main[177]	60	°F	[118]
$E_{T,Elec}$	Thermal efficiency of electric water heater	0.98	N/A	[124]
ESF_{Pump}	Pump energy savings factor	0.87	N/A	[123]
365	Days per year	365	Day/yr	
0.746	Unit conversion, kW/HP	0.746	kW/HP	
8.33	Unit conversion, Btu/gal·°F	8.33	Btu/gal·°F	
3,412	Unit conversion, Btu/kWh	3,412	Btu/kWh	
8,760	Unit conversion, Hrs/yr	8,760	Hrs/yr	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-376 Pump Efficiency

Pump Type	Value	Reference
PSC	0.60	[110]
ECM	0.80	[111]
Unknown	0.80	

Table 3-377 Average Daily Hot Water Usage[178]

Building Type	GPD	Rate	Notes	Source	Reference
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF, 10% hot water	EIA: Public Assembly	[113]
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 5,150 SF, 10% hot water	EIA: Other	[113]
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 130,500 SF, 10% hot water	EIA: Mercantile	[113]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL School with Showers	[114]

[177] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F.
[178] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes	Source	Reference
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation	[115]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[114]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC: Quick Service	[116]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[116]
Grocery	172	3.43 GPD per 1,000 SF	Assumes 50,000 SF, 10% hot water	EIA: Mercantile	[113]
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[114]
Hospital	16,938	54.42 GPD per 1,000 SF		250,000 SF EIA: Health Care, Inpatient	[113]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 40% hot water, 200,000 SF	EIA: Lodging	[113]
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[114]
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Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF, 10% hot water	EIA: Other	[113]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF, 40% hot water	EIA: Lodging	[113]
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Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF, 10% hot water	EIA: Public Assembly	[113]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[114]
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF, 10% hot water	EIA: Mercantile	[113]

Building Type	GPD	Rate	Notes	Source	Reference
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[114]
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF, 10% hot water	EIA: Warehouse and Storage	[113]
Other	Calculate	4.89 GPD per 1,000 SF		EIA: Other	[113]

Table 3-378 Water Heating Factors

DHW System	$F_{DHW,Elec}$	$F_{DHW,Fuel}$
Electric	1.0	0.0
Fossil Fuel	0.0	1.0

Table 3-379 Hot Water Energy Savings Factors

Control Type	ESF_{HW}
Demand Control	0.07
Temperature Modulation	0.02
Demand Control and Temperature Modulation	0.15

Peak Factors

Table 3-380 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[122]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 15 years [120].

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[121] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 7.8, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

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[124] 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*

[125] NREL, Control Strategies to Reduce the Energy Consumption of Central Domestic Hot Water Systems, June 2016, https://www.nrel.gov/docs/fy16osti/64541.pdf

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3.11.8 PIPE INSULATION

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Insulation
Measure Last Reviewed	November 2022
Changes Since Last Version	• Removed references to DI Baseline Condition and dual baseline

Description

This measure covers the installation of fiberglass, rigid foam, and cellular glass pipe insulation on exposed and uninsulated metal or steel piping with a nominal diameter between 0.50" and 8.00" for hot water and steam type space heating and/or domestic hot water (DHW) distribution systems in commercial, industrial, and multifamily high-rise buildings. The measure is restricted to insulation of hot water distribution pipe in conditioned and unconditioned spaces. Space heating pipe insulation is limited to insulation installed in unheated spaces only. Insulation of CPVC, PEX, and HDPE piping is not eligible for savings under this measure due to low potential of savings.

In New Jersey, the current state energy code (ASHRAE 90.1 2019 in 2023) defines the energy code standards for buildings except low rise residential. Hence, this has been used to define default thermal efficiencies of heating systems. However, when it does not include service water heating provisions, it leaves federal equipment efficiency standards to define baseline.

This measure caters for all insulation types given that they are ASHRAE 90.1 2019 code compliant and are installed by certified professionals. The R-value of an insulation is the thermal resistance of its constituent material, which is derived by dividing the thickness of the material by the material's thermal conductivity, or k-value. Thermal transmittance, or the material's U-factor, is the inverse of the R-value.

Baseline Case

The baseline condition is bare copper (metal) or steel domestic hot water or space heating piping in an unconditioned space.

Efficient Case

An insulated pipe in an unconditioned spaced conforming to the requirements of ASHRAE 2019 Section 6.8.3, Table 3-1.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \frac{\left[\left(\frac{UA}{L}\right)_b - \left(\frac{UA}{L}\right)_q\right] \times L \times \left(T_{pipe} - T_{amb}\right) \times hrs \times SF_{elec}}{Et_{elec} \times 3{,}412}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\left[\left(\frac{UA}{L}\right)_b - \left(\frac{UA}{L}\right)_q\right] \times L \times \left(T_{pipe} - T_{amb}\right) \times hrs \times SF_{fuel}}{Et_{fuel} \times 100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-381 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{life}$	Lifetime fuel savings	Calculated	Therms	
L	Length of installed insulation	Site-specific	ft	
T_{pipe}	Average temperature of hot water or steam in distribution system piping	Site-specific, if unknown lookup in Table 3-386	°F	[130][131][134]
T_{amb}	Surrounding average ambient air temperature	Site-specific, if unknown: DHW: 70 Space Heat: 50	°F	[138]
Et_{fuel}	Recovery Efficiency of fuel water heaters or AFUE of boiler for space heating	Site-specific, if unknown: DHW[179]: 0.8 Space Heating Boilers: Lookup in Table 3-384	N/A	[135][136]
Et_{elec}	Recovery Efficiency of electric water heaters	Site-specific, if unknown: Non-Heat Pump DHW[180]: 0.98 Heat Pump DHW: Lookup in Table 3-385	N/A	[307][129]
hrs	Equivalent full load heating hours	Site-specific, if unknown: DHW: 8,760 Boilers: Lookup heating EFLH in Appendix C:	hrs	[233][233]

[179] The 80% default assumption comes from most ASHRAE 90.1 2019 minimum thermal efficiencies listed for water heater.
[180] ASHRAE 90.1 2019 does not list thermal efficiencies for electric water heaters. Instead it references UEF values for the respective classes. The 98% assumption comes from the Code of Federal regulations. The 98% default value should not be used for heat pump water heaters.

Variable	Description	Value	Units	Ref
		Heating and Cooling EFLH		
$(UA/L)_b$	Product of Overall Heat Transfer Coefficient and Pipe Area (UA) per foot from uninsulated pipe[181]	Lookup in Table 3-382	Btu/hr-°F-ft	[132]
$(UA/L)_q$	Product of Overall Heat Transfer Coefficient and Pipe Area (UA) per foot from insulated pipe[181]	Lookup in Table 2-207	Btu/hr-°F-ft	[140]
SF_{elec}	Adjustment to electric water heating energy savings when water heating fuel is unknown	Electric WH: 1.0 Unknown WH: 0.55	N/A	[133]
SF_{fuel}	Adjustment to fossil fuel water heating energy savings based on water heating fuel[f]	Fossil Fuel WH & Space Heating: 1.0 Unknown WH: 0.56	N/A	[133]
CF	Electric coincidence factor	Lookup in Table 3-152	N/A	
PDF	Gas peak day factor	Lookup in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	

Table 3-382 Product of Overall Heat Transfer Coefficient and Pipe Area per foot from Uninsulated Pipe $(UA/L)_b$

Nominal Pipe Size (in)	Bare Copper Piping			Bare Steel Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat
0.50	0.44	0.48	0.53	0.53	0.59
0.75	0.54	0.58	0.64	0.65	0.72
1.00	0.65	0.70	0.78	0.79	0.88
1.25	0.80	0.86	0.96	0.97	1.09
1.50	0.90	0.97	1.09	1.10	1.23
2.00	1.10	1.19	1.33	1.34	1.51
2.50	1.31	1.42	1.58	1.60	1.80
3.00	1.57	1.70	1.90	1.92	2.16
3.50	1.77	1.92	2.15	2.18	2.45
4.00	1.98	2.14	2.40	2.43	2.73

[181] Also called Building Load Coefficienct per unit length

Nominal Pipe Size (in)	Bare Copper Piping			Bare Steel Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat
5.00	2.41	2.61	2.92	2.97	3.34
6.00	2.84	3.07	3.45	3.50	3.94
8.00	3.64	3.94	4.42	4.50	5.06

Table 3-383 Product of Overall Heat Transfer Coefficient and Pipe Area per foot from Insulated Pipe $(UA/L)_q$

Nominal Pipe Size (in)	Fiberglass						Rigid Foam/Cellular Glass					
	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in
0.50	0.13	0.09	0.08	0.07	0.06	0.06	0.15	0.12	0.10	0.09	0.09	0.08
0.75	0.14	0.11	0.09	0.08	0.07	0.07	0.17	0.13	0.11	0.10	0.10	0.09
1.00	0.17	0.12	0.10	0.09	0.08	0.07	0.19	0.15	0.13	0.12	0.11	0.10
1.25	0.20	0.14	0.11	0.10	0.09	0.08	0.23	0.17	0.15	0.13	0.12	0.11
1.50	0.22	0.15	0.12	0.11	0.10	0.09	0.25	0.19	0.16	0.14	0.13	0.12
2.00	0.26	0.18	0.14	0.12	0.11	0.10	0.29	0.22	0.18	0.16	0.14	0.13
2.50	0.30	0.20	0.16	0.14	0.12	0.11	0.34	0.25	0.20	0.18	0.16	0.15
3.00	0.35	0.24	0.18	0.16	0.14	0.12	0.39	0.29	0.23	0.20	0.18	0.16
3.50	0.40	0.26	0.20	0.17	0.15	0.13	0.44	0.32	0.26	0.22	0.20	0.18
4.00	0.44	0.29	0.22	0.18	0.16	0.14	0.48	0.35	0.28	0.24	0.21	0.19
5.00	0.52	0.34	0.26	0.22	0.19	0.17	0.58	0.41	0.33	0.28	0.25	0.22
6.00	0.61	0.39	0.30	0.25	0.21	0.19	0.67	0.47	0.37	0.32	0.28	0.25
8.00	0.77	0.49	0.37	0.30	0.26	0.23	0.84	0.59	0.46	0.39	0.34	0.30

Table 3-384 Gas- and Oil-Fired Boilers—Minimum Efficiency Requirements

Equipment Type	Subcategory or Rating Condition	Size Category (Input)	Efficiency as of 3/2/2022	Test Procedure
Boilers, hot water	Gas fired	<300,000 Btu/h	82% AFUE	10 CFR 430 Appendix N
		≥300,000 Btu/h and ≤2,500,000 Btu/h	80% Et	10 CFR 431.86
		>2,500,000 Btu/h	82% Ec	

Equipment Type	Subcategory or Rating Condition	Size Category (Input)	Efficiency as of 3/2/2022	Test Procedure
	Oil fired	<300,000 Btu/h	84% AFUE	10 CFR 430 Appendix N
		≥300,000 Btu/h and ≤2,500,000 Btu/h	82% Et	10 CFR 431.86
		>2,500,000 Btu/h	84% Ec	
Boilers, steam	Gas fired	<300,000 Btu/h	80% AFUE	10 CFR 430 Appendix N
	Gas fired—all, except natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h	79% Et	10 CFR 431.86
		>2,500,000 Btu/h	79% Et	
	Gas fired—natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h	79% Et	
		>2,500,000 Btu/h	79% Et	
	Oil fired	<300,000 Btu/h	82% AFUE	10 CFR 430 Appendix N
		≥300,000 Btu/h and ≤2,500,000 Btu/h	81% Et	10 CFR 431.86
		>2,500,000 Btu/h	81% Et	

Table 3-385 Default Heat Pump Water Heater COPs and UEF by Tank Storage Capacity

Size (Gallons)	UEF	Calculated COP
50	3.30	2.83
50	3.50	2.92
50	3.75	3.14
65	3.30	2.85
65	3.50	2.94
65	3.75	3.24
80	3.30	2.85
80	3.50	3.01
80	3.75	3.38
Unknown Size[182]	-	3.016

[182] Unknown COP is the average of storage tank heat pump water heater's COP for medium to high draw types covering a storage capacity range of 50 gallons to 80 gallons taken from California Energy Data and Reporting System's DEER Water Heater Calculator [129]

Table 3-386 Average Temperature of Hot Water or Steam in Distribution System Piping

System Type	Facility Type	Pipe Temperature °F
Hot Water	Commercial	138
Hot Water	Industrial	134
Low Pressure Steam[183]	C&I	240
Medium Pressure Steam	Commercial	304
Medium Pressure Steam	Industrial	258

Peak Factors

Table 3-387 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Electric DHW: 1.0 Hot Water: N/A	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 13 years for electric water heaters and 11 years for gas water heaters [141].

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[136] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-6, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

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3.12 PROCESS

3.12.1 VSD AIR COMPRESSORS

Market	Commercial and Industrial
Baseline Condition	TOS/NC
Baseline	Code
End Use Subcategory	Compressed Air
Measure Last Reviewed	December 2022

Description

Variable-Speed Drive (VSD) Air Compressors use a variable speed drive on the motor to match motor output to the load, resulting in greater efficiency than fixed-speed air compressors. Baseline compressors choke off inlet air to modulate the compressor output, resulting in increased energy consumption and peak demand. This measure relates to the installation of a new air compressor of 100 HP or less with a variable speed drive. Projects involving compressors larger than 100 HP should be treated as custom projects.

Baseline Case

The baseline condition is a typical load/unload compressor.

Efficient Case

A screw compressor with variable speed control on the motor to match output to the load.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = 0.9 \times HP \times Hrs \times (COMP_b - COMP_q)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 3-388 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
HP	Compressor motor nominal HP	Site-specific	hp	
$COMP_b$	Baseline compressor factor	Look up in Table 3-390	N/A	[144]
$COMP_q$	Installed compressor factor, actual	Site-specific, if unknown use 0.705	N/A	[142]
Hrs	Compressor total hours of operation	Site-specific, if unknown look up in Table 3-389	Hrs/yr	[142]
CF	Coincidence factor	Look up in Table 3-389	N/A	[142]
PDF	Gas peak demand factor	Look up in Table 3-391	N/A	
0.9	Compressor motor nominal hp to full load kW Conversion factor	0.9	N/A	[142]
EUL	Effective useful life of new unit	See Measure Life Section	Years	

Table 3-389 Compressor Total Hours of Operation and Coincidence Factors

Number of Shifts	Description	Annual Operating Hours	Coincidence Factor (CF)
Single shift	7 AM – 3 PM, weekdays, minus holidays and scheduled down time	1,976	0.59
2 - shift	7AM – 11 PM, weekdays, minus holidays and scheduled down time	3,952	0.95
3 - shift	24 hours per day, weekdays, minus holidays and scheduled down time	5,928	0.95

Number of Shifts	Description	Annual Operating Hours	Coincidence Factor (CF)
4 - shift	24 hours per day, 7 days a week minus holidays and scheduled down time	8,320	0.95

Table 3-390 Baseline Compressor Factor

Baseline Compressor	Compressor Factor $COMP_b$ (≤45 hp)	Compressor Factor $COMP_b$ (>45 hp)
Modulating w/ Blowdown	0.890	0.863
Load/No Load w/ 1 Gallon-of-storage/ CFM_{Max}	0.909	0.887
Load/No Load w/ 3 Gallon-of-storage/ CFM_{Max}	0.831	0.811
Load/No Load w/ 5 Gallon-of-storage/ CFM_{Max}	0.806	0.786

Peak Factors

Table 3-391 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Look up in Table 3-389	[142]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 13 years [143].

References

[142] Mid Atlantic Technical Reference Manual Version 10.0, (2020), https://neep.org/mid-atlantic-technical-reference-manual-trm-v10 Compressor factors were developed using DOE part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors less than or equal to 40 hp, as sourced from the Efficiency Vermont TRM. (The “variable speed drive” compressor factor has been adjusted up from the 0.675 presented in the analysis to 0.705 to account for the additional power draw of the VSD).

[143] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

[144] Compressor factors for ≤40 hp motors were developed using DOE part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors less than or equal to 40 hp, as

sourced from the Efficiency Vermont TRM. (The "variable speed drive" compressor factor has been adjusted up from the 0.675 presented in the analysis to 0.705 to account for the additional power draw of the VSD). Compressor factors for >50 hp motors were developed using DOE part-load data for different compressor control types as well as load profiles from 45 compressors and 20 facilities. This data comes from ComEd Custom and Insustrial Systems programs. The compressors were filtered to reflect only rotary screw compressors, between 50 and 200 hp, and operating a minimum of 4 hour per day, Additionally, compressors with clear and consistent baseload profiles were excluded from this analysis.

3.12.2 COMPRESSED AIR LEAK DETECTION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Maintenance
Measure Last Reviewed	March 2023

Description

This measure presents energy savings associated with reducing compressed air losses through ultrasonic leak detection and the repair of compressed air leaks.

Baseline Case

Industrial compressed air system with suspected leaks.

Efficient Case

Compressed air system with identified and repaired leaks.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N_{leaks} \times CFM_{leaks} \times Eff_{comp} \times Hrs \times F_{control}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-392 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
N_{leaks}	Number of leaks repaired	Site-specific	N/A	
Hrs	Hours of operation per year	Site-specific, if unknown use 6,240	Hrs/yr	[149]
CFM_{leak}	CFM loss per leak	Site-specific, look up in Table 3-393	CFM	[145]
Eff_{comp}	Compresser efficiency	Site-specific, if unknown look up in Table 3-394	kW/CFM	[146]
$F_{control}$	Control factor, percent kW divided by percent load	Look up in Table 3-395	N/A	[147]
CF	Electric coincidence factor	Look up in Table 3-152	N/A	[148]
PDF	Gas peak day factor	Look up in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	

Table 3-393 CFM per Leak Size and Compressed Air Pressure

Pressure (psig)	Orifice Diameter (inches)					
	1/64	1/32	1/16	1/8	1/4	3/8
70	0.29	1.16	4.66	18.62	74.4	167.8
80	0.32	1.26	5.24	20.76	83.1	187.2
90	0.36	1.46	5.72	23.1	92.0	206.6

Pressure (psig)	Orifice Diameter (inches)					
	1/64	1/32	1/16	1/8	1/4	3/8
100	0.40	1.55	6.31	25.22	100.9	227.0
125	0.48	1.94	7.66	30.65	122.2	275.5

Values should be multiplied by 0.97 for well-rounded orifices and by 0.61 for sharp orifices.

Table 3-394 Default Compressor Efficiencies

Compressor Type	Efficiency (kW/CFM)
Single-acting reciprocating air compressor	0.23
Double-acting reciprocating air compressor	0.155
Lubricant-injected rotary screw compressor	0.185
Lubricant-free rotary screw compressor	0.2
Centrifugal compressor	0.18
Average	0.19

Table 3-395 Efficiency Factors per Control Type

Control Type	$F_{control}$ (% kW / % load)
Reciprocating – on/off control	1.00
Reciprocating – load/unload	0.74
Screw – load/unload oil free	0.73
Screw – load/unload 1 gal/CFM	0.43
Screw – load/unload 3 gal/CFM	0.53
Screw – load/unload 5 gal/CFM	0.63
Screw – load/unload 10 gal/CFM	0.73
Screw – inlet modulation	0.30
Screw – inlet modulation w/unloading	0.30
Screw – variable displacement	0.60
Screw – variable speed drive	0.97

Peak Factors

Table 3-396 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Calculate as: CF = (annual operating hours) / 8,760	
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 1 year. [150]

References

[145] NREL, Chapter 22: Compressed Air Evaluation Protocol. https://www.energystar.gov/sites/default/files/buildings/tools/compressed_air3.pdf

[146] Data from Compressed Air Challenge "Fundamentals of Compressed Air Systems" Pgs. 28-32

[147] NREL, Chapter 22: Compressed Air Evaluation Protocol, October 2017. Pg 16

[148] KEMA, New Jersey’s Clean Energy Program Energy Impact Evaluation and Protocol Review, July 10, 2009.

[149] This is based on 3 shifts per day, 5 days per week. This figure is supported by a survey of previous compressed air projects within Michigan and Ohio energy efficiency programs.

[150] One year measure life is based on typical recommendation of annual leak survey.

3.13 WHOLE BUILDING

3.13.1 COMBINED HEAT AND POWER

Market	Commercial
Baseline Condition	NC/RF
Baseline	Code/Existing
End Use Subcategory	HVAC
Measure Last Reviewed	August 2024
Changes Since Last Version	• Addition of emissions reduction calculations under non-energy impacts

Description

This measure applies to the installation of Combined Heat and Power (CHP) System in a commercial setting, defined as a system that sequentially generates both electrical energy and useful thermal energy from one fuel source. Eligible systems include: powered by non-renewable or renewable fuel sources, gas internal combustion engine, gas combustion turbine, microturbine, steam turbine, and fuel cells.

The measurement of energy and savings for CHP systems is based primarily on the characteristics of the individual systems subject to the general principles set out below. The majority of the inputs used to estimate energy and demand impacts of CHP systems will be drawn from individual project applications.

The methodology presented in the measure is based on the National Renewable Energy Laboratory's Combined Heat and Power, The Uniform Methods Project: Methods for Determining Energy- Efficiency Savings for Specific Measures 698[151].If a CHP system cannot be evaluated using the methodology in this measure (due to complexity of the system or other factors), the project may be evaluated using a custom engineering analysis.

CHP systems typically use fossil fuels to generate electricity that displaces electric generation from other sources. Therefore, the electricity generated from a CHP system should not be reported as either electric energy savings or renewable energy generation. Exceptions may be made to this standard, such as CHP systems that use an absorption chiller to convert useful heat to cooling energy, and thus operates in the summer; or cases where the CHP system generates more electricity than consumed and is allowed to export electricity to the grid. Alternatively, electric generation and capacity from CHP systems should be reported as Distributed Generation (DG) separate from energy savings and renewable energy generation. However, any waste heat recaptured and utilized should be reported as energy savings as discussed below.

Baseline Case

If the CHP system is replacing or adding on to an existing HVAC system, the baseline is the site-specific existing equipment. If the CHP system uses an absorption chiller, the baseline equipment is assumed to be a code-compliant electric chiller. For new construction, the baseline scenario is a standalone (no power generation) code-compliant HVAC system of the same capacity and fuel as the CHP system.

Efficient Case

The efficient case is the installed CHP system, defined as a system that sequentially generates both electrical energy and useful thermal energy from one fuel source. Eligible systems include: powered by non-renewable or renewable fuel sources, gas internal combustion engine, gas combustion turbine, microturbine, steam turbine, and fuel cells with and without heat recovery.

Annual Energy Savings Algorithms

Note: The alogirithms presented below are simplified. Users should adopt a level of rigor that matches the program needs and available data. As long as the energy impacts are calculated in an equivalent manner, alternative methodologies such as conducting a site-specific hourly/daily analysis are acceptable.

Annual Electric Energy Savings

$$\Delta kW\mathrm{h} = kWh_{Net} + kWh_{ChillerOffset}$$

Where,

$$kWh_{Net} = kWh_{Gross} - kWh_{Consumed}$$

$$kWh_{ChillerOffset} = kWh_{Net} \times UHRR_C \times COP \times \frac{Eff_{ElecChiller}}{12} \ (if\ CHP\ is\ driving\ an\ absorption\ chiller)$$

$$UHRR_c = \frac{UHR_c}{kWh_{Net}}$$

$$kWh_{ChillerOffset} = 0\ (if\ no\ absorption\ chiller\ is\ involved)$$

Annual Fuel Savings

$$\Delta Therms = \frac{Fuel_{Offset} - Fuel_{Consumed}}{100}$$

Where,

$$Fuel_{Offset} = \frac{kWh_{Net} \times UHRR_H}{Eff_{Boiler}}$$

$$Fuel_{Consumed} = \frac{kWh_{Gross}}{Eff_{NetElec}} \times 3.412$$

$$UHRR_h = \frac{UHR_h}{kWh_{Net}}$$

$$Eff_{NetElec} = \frac{\Delta kWh \times 3.412}{Fuel_{input}}$$

Annual Peak Demand Savings

Calculation of peak demand savings requires site-specific hourly analysis. See UMP: Section 3.1 Determining Electricity Impacts Pg 11 for more detail.

Daily Peak Fuel Savings

Calculation of peak fuel savings requires site-specific hourly analysis. See UMP: Section 3.2 Determining Fuel Impacts Pg 12 for more detail.

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-397 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Annual peak demand savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Fuel_{Offset}$	Reduction in fuel consumption that would have been used for heating that can be attributed to the CHP system	Calculated	kBtu	
$Fuel_{Consumed}$	Utility delivered fuel consumed by CHP system	Calculated	kBtu	
$Eff_{NetElec}$	Net electrical efficiency, a measure of how much of the energy in the fuel input is converted to net electricity	Calculated	N/A	

Variable	Description	Value	Units	Ref
$UHRR_C$	Useful heat recovery rate for absorption chiller	Calculated	kBtu/kWh	
$UHRR_h$	Useful heat recovery rate associated with heating offset	Calculated	kBtu/kWh	
$KWh_{ChillerOffset}$	Annual electrical energy offset from electrical chillers if heat from the CHP measure is driving an absorption chiller	Calculated	kWh/yr	
kWh_{gross}	Overall electricity generated by CHP System	Site-specific/engineering calculation	kWh/yr	
$kWh_{consumed}$	Annual electricity consumed by CHP system: parasitic losses due to fan and pump motors, dedicated HVAC system, and lighting	Site-specific; if unknown, assume 3% of kWh_{gross}	kWh/yr	
UHR_h	Useful heat recovered: heat that is expected to be recovered from CHP system, including any heat recovered for absorption chiller use and used on-site	Site-specific/engineering calculation	kBtu	
UHR_c	Useful heat recovered: heat that is used to drive an absorption chiller	Site-specific/engineering calculation	kBtu	
kWh_{Net}	Net electricity generation by CHP: overall electricity generated by CHP System minus annual electricity consumed by CHP system	Site-specific/engineering calculation	kWh/year	
$Fuel_{Input}$	Annual Fuel input to CHP system	Site-specific/engineering cacluation	kBtu	
COP	COP of absorption chiller	Site-specific	N/A	
$Eff_{ElecChiller}$	Efficiency of baseline electric chiller	Site-specific, use 0.65 if unknown	kW/ton	[153]
12	Conversion factor	12	kBtu/ton	
Eff_{Boiler}	Efficiency of boiler that would serve heating loads in absence of CHP system	Site-specific, use 0.8 if unknown	N/A	[126]
100	Conversion factor	100	kBtu/therm	
3.412	Conversion factor	3.412	kBtu/kWh	
EUL	Effective useful life	See Measure Life	Years	

Peak Factors

Peak factors should be analyzed on a site-specific basis.

Non-Energy Impacts

CHP systems will result in emissions reductions in addition to energy savings. Annual and lifetime air emission reductions resulting from electric generation, electric savings, and net gas impacts at the system level shall be calculated as specified below:

Annual Emissions Reductions

$$\Delta CO2_{MT} = \Big[\Delta MWh_{sav} \times LLF_{elec} \times F_{CO2,elec} + \frac{\Delta Therms}{10} \times LLF_{gas} \times F_{CO2,gas} + \Delta MWh_{gen} \times \Big(LLF_{elec} \times F_{CO2,elec} - \frac{F_{CO2,CHP}}{2,000}\Big)\Big] \times \frac{2,000}{2,205}$$

$$\Delta SO2_{MT} = \Big[\Delta MWh_{sav} \times LLF_{elec} \times F_{SO2,elec} + \Delta MWh_{gen} \times \Big(LLF_{elec} \times F_{SO2,elec} - \frac{F_{SO2,CHP}}{2,000}\Big)\Big] \times \frac{2,000}{2,205}$$

$$\Delta NOx_{MT} = \Big[\Delta MWh_{sav} \times LLF_{elec} \times F_{NOx,elec} + \frac{\Delta Therms}{10} \times LLF_{gas} \times F_{NOx,gas} + \Delta MWh_{gen} \times \Big(LLF_{elec} \times F_{NOx,elec} - \frac{F_{NOx,CHP}}{2,000}\Big)\Big] \times \frac{2,000}{2,205}$$

$$\Delta Hg_{g} = [\Delta MWh_{sav} \times LLF_{elec} \times F_{Hg,elec}] \times \frac{1}{1,000}$$

Lifetime Emissions Reductions

$$\Delta CO2_{MT,Life} = \Big[\Delta MWh_{sav,Life} \times LLF_{elec} \times AVG(F_{CO2,elec}) + \frac{\Delta Therms_{Life}}{10} \times LLF_{gas} \times F_{CO2,gas} + \Delta MWh_{gen,Life} \times \Big(LLF_{elec} \times AVG(F_{CO2,elec}) - \frac{F_{CO2,CHP}}{2,000}\Big)\Big] \times \frac{2,000}{2,205}$$

$$\Delta SO2_{MT,Life} = \Big[\Delta MWh_{sav,Life} \times LLF_{elec} \times AVG(F_{SO2,elec}) + \Delta MWh_{gen,Life} \times \Big(LLF_{elec} \times AVG(F_{SO2,elec}) - \frac{F_{SO2,CHP}}{2,000}\Big)\Big] \times \frac{2,000}{2,205}$$

$$\Delta NOx_{MT,Life} = \Big[\Delta MWh_{sav,Life} \times LLF_{elec} \times AVG(F_{NOx,elec}) + \frac{\Delta Therms_{Life}}{10} \times LLF_{gas} \times F_{NOx,gas} + \Delta MWh_{gen} \times \Big(LLF_{elec} \times AVG(F_{NOx,elec}) - \frac{F_{NOx,CHP}}{2,000}\Big)\Big] \times \frac{2,000}{2,205}$$

$$\Delta Hg_{g,Life} = [\Delta MWh_{sav.Life} \times LLF_{elec} \times F_{Hg,elec}] \times \frac{1}{1,000}$$

Table 3-398 Calculation Parameters

Variable	Description	Value	Units	Ref
$\Delta CO2_{MT}$	Annual CO2 Emissions Reductions, in Metric Tons	Calculated	MT/yr	
$\Delta SO2_{MT}$	Annual SO2 Emissions Reductions, in Metric Tons	Calculated	MT/yr	
ΔNOx_{MT}	Annual NOx Emissions Reductions, in Metric Tons	Calculated	MT/yr	
ΔHg_{g}	Annual Hg Emissions Reductions, in grams	Calculated	g/yr	
$\Delta CO2_{MT,Life}$	Lifetime CO2 Emissions Reductions, in Metric Tons	Calculated	MT	
$\Delta SO2_{MT,Life}$	Lifetime SO2 Emissions Reductions, in Metric Tons	Calculated	MT	
$\Delta NOx_{MT,Life}$	Lifetime NOx Emissions Reductions, in Metric Tons	Calculated	MT	
$\Delta Hg_{g,Life}$	Lifetime Hg Emissions Reductions, in grams	Calculated	g	
ΔMWh_{sav}	Annual electric energy savings	Site-specific/engineering calculation	MWh/yr	
ΔTherms	Annual fuel savings	Site-specific/engineering calculation	Therms/yr	
ΔMWh_{gen}	Annual electric generation	Site-specific/engineering calculation	MWh/yr	
$\Delta MWh_{sav,Life}$	Lifetime electric energy savings	Site-specific/engineering calculation	MWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Site-specific/engineering calculation	Therms	
$\Delta MWh_{gen,Life}$	Lifetime electric generation	Site-specific/engineering calculation	MWh	
LLF_{elec}	Electric line loss factor	1.087	N/A	[156]
LLFgas	Gas line loss factor	1.023	N/A	[156]
$F_{CO2,elec}$	Grid electric CO_2 emissions factor	Lookup from NJBPU Order [156], Attachment B, Table 6 based on year of installation	tons/MWh	[156]
$F_{SO2,elec}$	Grid electric SO_2 emissions factor	Lookup from NJBPU Order [156], Attachment B, Table 6 based on year of installation	tons/MWh	[156]
$F_{NOx,elec}$	Grid electric NO_x emissions factor	Lookup from NJBPU Order [156], Attachment B, Table 6 based on year of installation	tons/MWh	[156]
$F_{Hg,elec}$	Grid electric Hg emissions factor	1.1	mg/MWh	[157]
$F_{CO2,gas}$	Natural gas CO_2 emissions factor	0.058325	tons/MMBtu	[158]

Variable	Description	Value	Units	Ref
$F_{NOx,gas}$	Grid electric NO_x emissions factor	0.000046	tons/MMBtu	[157]
$F_{CO2,CHP}$	CHP system electric generation CO_2 emissions factor	Site-specific	tons/MWh	
$F_{SO2,CHP}$	CHP system electric generation SO_2 emissions factor	Site-specific	tons/MWh	
$F_{NOx,CHP}$	CHP system electric generation NO_x emissions factor	Site-specific	tons/MWh	
AVG($F_{CO2,elec}$)	Average lifetime grid electric CO_2 emissions factor	Average of annual emissions factors over the lifetime of the CHP system from NJBPU Order [156], Attachment B, Table 6 based on year of installation and EUL	tons/MWh	[156]
AVG($F_{SO2,elec}$)	Average lifetime grid electric SO_2 emissions factor	Average of annual emissions factors over the lifetime of the CHP system from NJBPU Order [156], Attachment B, Table 6 based on year of installation and EUL	tons/MWh	[156]
AVG($F_{NOx,elec}$)	Average lifetime grid electric NO_x emissions factor	Average of annual emissions factors over the lifetime of the CHP system from NJBPU Order [156], Attachment B, Table 6 based on year of installation and EUL	tons/MWh	[156]
10	Conversion factor	10	Therms/MMBtu	
2,000	Conversion factor	2,000	lbs/ton	
2,205	Conversion factor	2,205	lbs/MT	
1,000	Conversion factor	1,000	mg/g	

Emission factors may be updated by future BPU Orders addressing the New Jersey Cost Test and Decarbonization Pilot programs. Please consult the NJ BPU website for the most current information on emission factors.

Measure Life

The effective useful life (EUL) is 10 years [151].[184]

[184] Please note that the UMP estimates a range of 10-25 years for typical CHP lifetime. This measure presents the conservative estimate of 10 years. Note that CHP measure lifetime is dependant on facility operations, fuel, and maintenance; there may be scenarios where a site-specific lifetime estimate is most appropriate.

References

[151] Simons, George, Stephan Barsun, and Charles Kurnik. 2017. Chapter 23: Combined Heat and Power, The Uniform Methods Project: Methods for Determining Energy- Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68579. https://www.nrel.gov/docs/fy17osti/68579.pdf

[152] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-6, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[153] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-3, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[154] Provided by the New Jersey Department of Environmental Protection, Office of Air and Energy Advisor, on May 25, 2018, Using Weighted Average of 2017 PJM On-Peak and Off-Peak annual data https://www.pjm.com/-/media/library/reports-notices/special-reports/20180315-2017-emissions-report.ashx

[155] US Environmental Protection Agency Emissions & Generation Resource Integrated Database (eGRID) Summary Tables 2021. Data viewer accessed 5-19-2023. https://www.epa.gov/egrid/data-explorer

[156] NJBPU ORDER DIRECTING THE UTILITIES TO PROPOSE SECOND TRIENNIUM ENERGY EFFICIENCY AND PEAK DEMAND REDUCTION PROGRAMS

[157] New Jersey's Clean Energy Program Protocols to Measure Resource Savings FY2020

[158] EIA Fuel Emissions

3.13.2 NEW CONSTRUCTION

Market	Commercial/Multifamily
Baseline Condition	NC
Baseline	Code
End Use Category	Whole Building
Measure Last Reviewed	January 2023
Changes Since Last Version	• Expand measure description

Description

This measure addresses high performance commercial and industrial new building design and construction. High performance new construction projects must either perform whole building modeling per ASHRAE guidelines or follow requirements through nationally recognized programs, including US Green Building Council's Leadership in Energy and Environmental Design (LEED) [159], Passive House Institute US [160][338] or Passive House [161].

Minimum energy performance requirements for all new construction projects are measured from baselines reflecting effective, applicable energy codes and standards (e.g., IECC and ASHRAE 90.1) at the time the project permit is pulled. Modeling software requirements shall be dictated by the selected high performance new construction compliance program (i.e., those listed above). Energy and demand savings for measures included in the program but not modeled by the software should be calculated using the appropriate TRM measure section.

For projects pursuing passive house certifications, savings shall be estimated based on a comparison of baseline and proposed/as-built OR minimally passive house compliant prototype models developed in approved program simulation software. Baseline models shall reflect input parameters relevant to climate zones 4A/5A and minimally compliant with effective, applicable energy codes and standards based on project permit date. Submitted proposed/as-built design models are compared against the corresponding baseline model to establish energy consumption savings by fuel type. For electric peak demand savings, where end use-level kWh savings are reported by simulation software, peak kW shall be established per end use and aggregated for project-level reporting. In the absence of end use-level savings, peak kW savings may be approximated per the equation shown below:

$$\Delta kW = \Delta kWh \times \frac{CF}{EFLH_{cool}}$$

Where:

CF = cooling coincidence factor from Section 3.5.1

$EFLH_{cool}$= cooling equivalent full load hours from Section 3.5.1

High performance new construction projects in NJ may target varying levels of energy performance, from a bundled measure approach per ASHRAE 90.1 Addendum AP [162] to simple DOE-2 based modeling (e.g., Slipstream's Sketchbox) to comprehensive modeling per ASHRAE 90.1 Appendix G [163]. Simulation software used for new construction projects must comply with ASHRAE Standard 140 [165].

References

[159] LEED requirements

[160] Passive House Institute US requirements.

[161] Passive House Institute requirements

[162] ASHRAE Addendum AP

[163] ASHRAE 90.1-2016/2019 Appendix G

[164] Commercial New Construction Industry Standard Practice Analysis

[165] ASHRAE Standard 140-2020 Method Of Test For Evaluating Building Performance Simulation Software

3.13.3 OPERATOR TRAINING

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Behavior
Measure Last Reviewed	January 2023

Description

Building Operator Certification (BOC) is a training and certification program for commercial and public sector building operators. The training program teaches participants how to improve building comfort and efficiency by optimizing the building's systems. BOC provide participants with knowledge about system operations, proper maintenance practices, occupant communication, and occupant comfort. Participants realize energy savings by utilizing the knowledge gained to improve their building operations through O&M and capital measures.

Deemed savings for this measure represent a convergence of analyses results from multiple BOC program evaluations that estimated net savings and were developed per square foot of building area to account for building size diversity. All savings algorithms presented in this work paper are for net savings. Participants must complete a rigorous BOC course and can only claim savings for the facilities for which the individual taking the course is responsible.

Measure Requirements

Participants must complete either the BOC Level I or Level II course and obtain a certificate of completion to be eligible for savings. Eligible BOC must cover the following subject areas:

BOC Level 1:

- Efficient Operation of HVAC Systems
- Measuring and Benchmarking Energy
- Efficient Lighting Fundamentals
- HVAC Controls Fundamentals
- Indoor Environmental Quality
- Common Opportunities for Low-Cost Operational Improvement

BOC Level 2:

- Building Scoping and Operational Improvements
- Optimizing HVAC Controls for Energy Efficiency

- Introduction to Building Commissioning
- Water Efficiency for Building Operators
- Project Peer Exchange

The BOC course must include formal instruction (i.e., lectures), individual projects, and group exercises, bringing the total course time to at least 61 hours. Participants must obtain a training certificate of completion to be eligible for savings. Individuals who participate are not eligible for savings more than twice over the measure life, once for BOC Level I and another for BOC Level II. The entire floor area for any given building can only be used once over the measure life, and evaluators will verify attendees' participation year-over-year.

The savings factors for this measure were developed based on an examination of savings using a weighted average approach from several similar BOC programs. It is important to note that the savings information referenced is net. Therefore, this measure does not require the additional application of a net-to-gross ratio.

Note: In the event there are multiple participants who operate the same building (i.e. service address), or group of buildings, care should be taken to ensure that savings are not claimed for based on the same square footage for multiple participants.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = C_e \times Area$$

Annual Fuel Savings

$$\Delta Therms = C_g \times Area$$

Peak Demand Savings

$$\Delta kW_{Peak} = C_d \times Area/1000 \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-399 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
C_e	Unit area kWh savings constant per participant	0.482	kWh/ft²/participant	[166]
Area	Building area operated by the participant	Site-specific	ft²	
C_g	Unit gas savings constant per participant	0.0145	Therms/ft²/participant	[167]
C_d	Unit demand savings constant per participant	0.039	W/ft²/participant	[167]
1,000	Conversion factor	1,000	W/kW	
CF	Electric coincidence factor	Look up in Table 3-400	N/A	
PDF	Gas peak day factor	Look up in Table 3-400	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-400 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 9.2 years [168].

References

[166] Building Operator Certification, BOC Energy Savings Summary and FAQ available at 2020-BOC-Energy-Savings-FAQ_1.0.pdf (theboc.info)

[167] 2022 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 10.0, Page 805

[168] The overall weighted average useful life for BOC savings are 1) Average measure life of capital measures from the ComEd CY2020 evaluation. 2) Useful Life for Custom Measure, Illinois TRM v10 for CY2022.

3.13.4 CUSTOM

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/RF/EREP/ERET/DI
Baseline	Code/ISP/Existing/Dual
End Use Subcategory	Custom
Measure Last Reviewed	January 2023

Description

In addition to the typical measures for which savings algorithms have been developed, it is important to identify and address additional opportunities for energy savings. Custom measures can often provide significant energy savings and can be tailored to the specific needs of a building or facility. If necessary, the utilities may develop specific guidelines for frequent custom measures for use in reporting and contractor tracking. This will ensure that the custom measures are implemented correctly and consistently; and that the energy savings are accurately reported. Additionally, it is important to continuously monitor and evaluate the effectiveness of the custom measures implemented and make adjustments as needed.

To implement custom measures, it is necessary to develop individual calculations for each measure to determine the energy savings. These calculations should take into account factors such as the cost of implementation, the expected energy savings, and any potential changes in operations or maintenance. Once the calculations are complete, the project must be reviewed for reasonableness by either a third-party consulting engineer or a qualified in-house engineer. Before a full review of the project is started, the project package should first be checked for completeness and compliance with program eligibility rules. Once the project review is complete, savings can be reported based on these individual calculations.

Baseline

The project baseline depends on the baseline condition. For time of sale (TOS) and new construction (NC) measures, the baseline is the applicable equipment energy code or standard; or industry standard practice (ISP). For retrofit (RF), early replacement (EREP), early retirement (ER) and direct install (DI) measures, the baseline is the existing equipment. Early replacement and direct install projects replacing functioning equipment must use a dual baseline approach, where the existing equipment defines the first baseline and code or ISP defines the second baseline. In all cases, the baseline should be more efficient than the existing equipment; if the efficiency of the existing equipment exceeds code or ISP, the existing equipment baseline should also be used for the second baseline calculations. When existing functioning equipment is replaced and savings are based on early replacement, documentation of the existing equipment viability should be provided. Such documentation includes a customer affidavit affirming the viability of the equipment to function over its remaining useful life and a video or picture demonstrating the equipment in action. Trend logs, maintenance and repair records, and other evidence of existing equipment viability should be provided for larger projects.

Industry Standard Practice (ISP) shall take precedence over a code baseline when ISP can be established. Projects not subject to codes or standards shall define and document an ISP baseline as part of the project development package. ISP for specific custom projects can be established through interviews with equipment vendors or subject matter experts; or by examining similar equipment installation by customer in other facilities.

Efficient Case

The efficiency of the measure shall exceed the first (and if applicable the second) baseline efficiency, and a rationale for how the project saves energy shall be provided.

Energy Savings Algorithm

Energy and demand savings are calculated on a custom basis for each customer's specific situation. Savings are calculated as the difference between baseline energy usage/peak demand and the energy use/peak demand after implementation of the custom measure. Energy savings estimates should be calibrated against billing or metered data where possible to validate the model and test the reasonableness of energy savings. A project narrative description including system design diagrams should be provided to assist in the project review. Energy savings calculations vary according to the custom project requirements, but generally fall into the following classifications:[185]

Simple Engineering Equations

Custom engineering calculations may be developed to estimate energy savings. These may be presented as a series of simple engineering equations tailored to the custom project measure and process. The engineering calculations must be documented and spreadsheets used to calculate the savings must be provided with live calculations. The engineering analysis must be sufficiently documented to allow an independent calculation of the measure savings.

Bin Methods

One method for calculating energy savings for custom energy efficiency measures is through the use of weather based bin analysis. This method involves analyzing weather data and grouping it into "bins" based on temperature, humidity, and other environmental factors. The bin analysis presents the number hours a particular weather condition exists during the year. Note, bin data to not consider time of day; hours tabulated for each weather bin are disconnected in time. Bin analysis is generally not applicable to time dependent measures.

Simulation

Another method for calculating energy savings for custom energy efficiency measures is through the use of whole building modeling simulations. This approach involves creating a computer model of a building that takes into account factors such as the building's layout, construction materials, HVAC systems, lighting, and other equipment. The model is then used to simulate different scenarios and analyze the building's energy consumption under different conditions. This can be useful for identifying opportunities for energy savings and for evaluating the potential impact of different custom measures. For example, a whole building simulation can be used to analyze the impact of different lighting systems, insulation materials,

[185] See the California Evaluation Framework Chapters 6 and 7 for more information about engineering methods.

or window treatments on energy consumption. The simulation can also be used to analyze the impact of changes in occupancy, equipment usage, or other factors. Whole building modeling simulations can be a powerful tool for identifying and addressing opportunities for energy savings across a package of measures where significant measure interactions are expected.

Pre/Post Billing Analysis

Energy savings may be calculated through an analysis of whole building or submetered energy consumption before and after measure installation. The billing analysis should use a linear or multi-variate regression approach that normalizes the savings for differences in weather conditions, production and so on during the pre and post periods and also corrects for other non-routine conditions. The pre/post billing analysis should follow the International Measurement and Verification Protocol (IPMVP) Option C and/or ASHRAE Guideline 14. Open source software products compliant with IPMVP Option C or ASHRAE Guideline 14 such as OpenEEMeter are acceptable methods to evaluate energy savings under conditions where the energy consumption data can be fit to outdoor temperature or degree-day data and non-rountine events are not present or of insignificant magnitude.

Pre/Post Billing Analysis approaches are best suited for EREP, ERET and DI projects where an existing equipment baseline is appropriate. Pre/Post Billing Analysis approaches are not suitable for NC and TOS projects. When calculating lifetime savings, EREP, ERET and DI projects must adjust savings from an existing equipment baseline to an ISP baseline during the second baseline period.

Calculation Parameters

Energy savings calculations must identify the source of each parameter used in the analysis. Parameters that are uncertain should be identified as candidates for project specific measurement and verification (M&V).

Measurement and Verification

Projects where the input assumptions and savings estimates are uncertain may benefit from site specific measurement and verification (M&V). Project developers and reviewers should consider whether the project should include M&V as part of the project development process. For projects that include M&V, a site specific measurement and verification plan should be developed that documents measurement activities and their use in the energy savings analysis. Depending on the level of uncertainty, M&V may be conducted before measure installation (pre installation M&V) and/or after measure installation (post installation M&V). The International Measurement and Verification Protocol (IPMVP) and/or ASHRAE Guideline 14 should be referenced when developing an M&V plan. The M&V plans may follow IPMVP Option A (partially measured retrofit isolation), Option B (fully measure retrofit isolation) Option C (Whole building billing analysis) or Option D (Calibrated simulation) approaches.

Lifetime Energy Savings Algorithms

Lifetime energy savings for time of Sale (TOS) and new construction (NC) projects are calculated as the product of the first year kWh and/or therm savings and the measure effective useful life (EUL). Projects with multiple measures having different EULs shall use a savings weighted average EUL across all measures in the project.

Lifetime savings for early replacement (EREP), early retirement (ERET) and direct installation (DI) measures where functioning equipment is replaced must use a dual baseline approach. The first baseline savings considers the difference between the existing equipment consumption and the measure consumption for the remaining life (RUL) of the existing equipment. The second baseline savings considers the difference between code or standard practice equipment consumption and the measure consumption for the remaining life of the measure (EUL-RUL).

Peak Factors

The summer coincident peak demand savings shall be calculated consistent with the system peak definition presented in Chapter 1.

Measure Life

Measure life will be specific to each custom measure. For custom measures using technologies that are the same or similar to those addressed in other TRM measures, refer to those measures for measure lives. For measures not covered by the TRM, measure life assumptions shall be documented and justified in the project documentation package such as ASHRAE or manufacturer specifications. The EUL for retrofit (RF) measures shall be calculated as the smaller of the measure EUL or the host equipment remaining useful life (RUL). The overall project EUL shall be the savings weighted EUL of the measures included in the project.

References

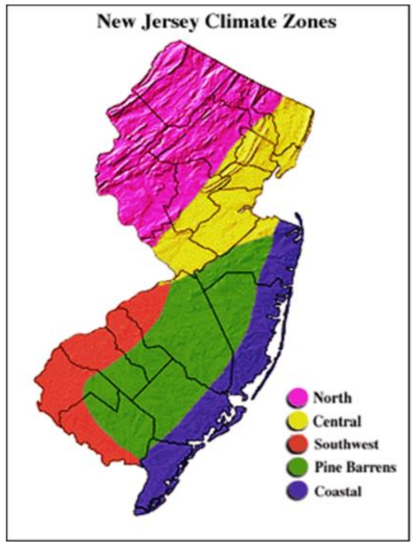
[169] California Evaluation Framework. Available at https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc_public_website/content/utilities_and_industries/energy/energy_programs/demand_side_management/ee_and_energy_savings_assist/caevaluationframework.pdf

[170] International Measurement and Verification Protocol (IPMVP) available at https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp

[171] ASHRAE Guideline 14-2014. Available at https://webstore.ansi.org/standards/ashrae/ashraeguideline142014

4 APPENDIX A: CLIMATE ZONE DESCRIPTIONS

Weather-dependent parameters are presented by climate zone throughout the TRM when applicable. The Office of the State Climatologist divides the state into five climate regions as shown below.[186]



A representative city from the TMY3 long term average weather data set was assigned to each of the climate zones.[187] A population weight derived from 2020 Census data was assigned to each of the climate zones to compute a statewise average value as shown below.[188]

Table 4-1 Climate Zone Representative Cities and Weights

NJ Climate Division	Representative City	Population Weight
Northern Zone	Allentown, PA	0.17
Central Zone	Trenton, NJ	0.45
Pine Barrens Zone	McGuire Air Force Base, NJ	0.11
Southwest Zone	Philadelphia, PA	0.11
Coastal Zone	Atlantic City, NJ	0.16

Please note all utilities should use weighted average value for EFLH, as presented in Appendix C: . For other climate parameters, utilities may differentiate by climate zone or may default to the statewide average value.

186 https://climate.rutgers.edu/stateclim/
187 https://www.nrel.gov/docs/fy08osti/43156.pdf
188 https://www.census.gov/library/stories/state-by-state/new-jersey-population-change-between-census-decade.html

5 APPENDIX B: BUILDING PROTOTYPE DESCRIPTIONS

Analysis used to develop heating and cooling equivalent full load hours is based on DOE-2.2 simulations of a set of prototypical small and large buildings. The prototypical simulation models were derived from the commercial building prototypes used in the California Database for Energy Efficiency Resources (DEER) study, with adjustments made for local building practices and climate.[189] The simulations were driven using Typical Meteorological Year (TMY3) long-term average weather data.[190]

[189] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf.

[190] See: Wilcox and Marion, "Users Manual for TMY3 Data Sets," NREL/TP-581-43156, National Renewable Energy Lab, May 2008. https://www.nrel.gov/docs/fy08osti/43156.pdf

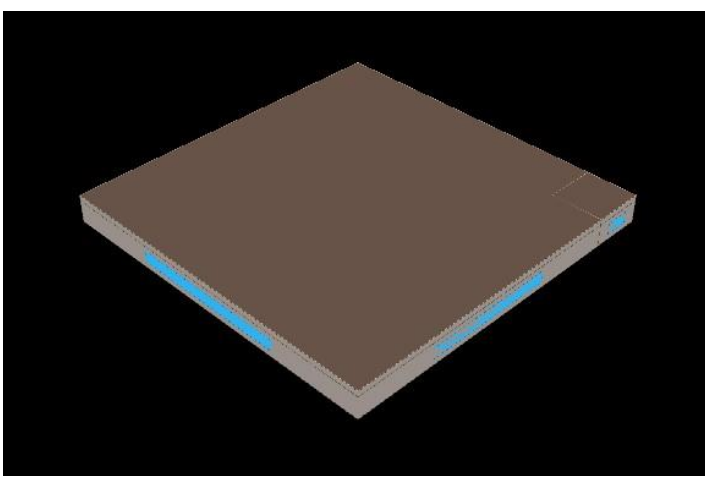
5.1 ASSEMBLY

A prototypical building energy simulation model for an assembly building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

ASSEMBLY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	34,000 square feet Auditorium: 33,240 SF Office: 760 SF
Number of floors	1
Wall construction and R-value	Concrete block, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Auditorium: 3.4 W/SF Office: 2.2 W/SF
Plug load density	Auditorium: 1.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sun: 8am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 - 110 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 79 ºF cooling, 69 ºF heating

A computer-generated sketch of the Assembly Building prototype is shown below.



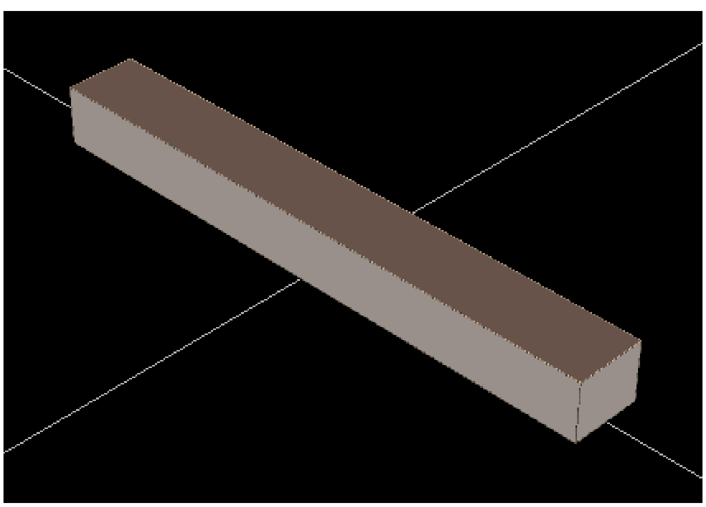
5.2 AUTO REPAIR

A prototypical building energy simulation model for an auto repair building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

AUTO REPAIR PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	5150 square feet
Number of floors	1
Wall construction and R-value	Concrete block, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13,5
Glazing type	Double pane clear; SHGC = ,74U-value = 0,72
Lighting power density	2.2 W/SF
Plug load density	1.2 W/SF
Operating hours	Mon-Sun: 9am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	280 SF/ton
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 81 ºF cooling, 67 ºF heating

A computer-generated sketch of the Auto Repair Building prototype is shown below.



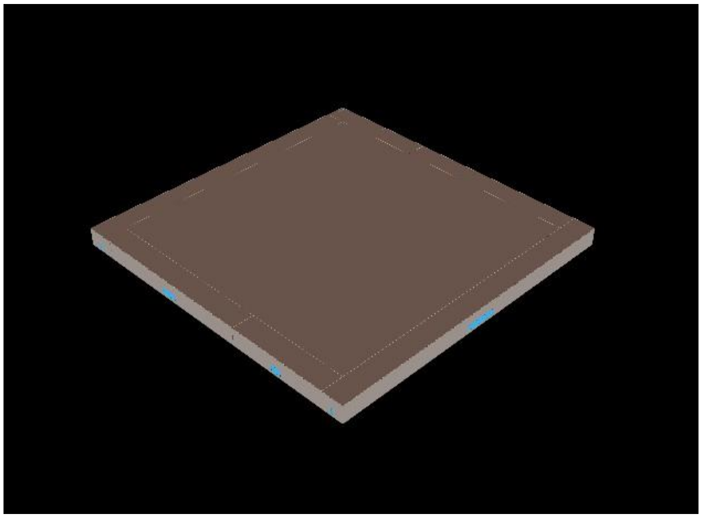
5.3 BIG BOX RETAIL

A prototypical building energy simulation model for a big box retail building was developedusing the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarizedbelow.

BIG BOX RETAIL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	130,500 square feet Sales: 107,339 SF Storage: 11,870 SF Office: 4,683 SF Auto repair: 5,151 SF Kitchen: 1,459 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Storage: 0.88 W/SF Office: 2.2 W/SF Auto repair: 2.15 W/SF Kitchen: 4.3 W/SF
Plug load density	Sales: 1.15 W/SF Storage: 0.23 W/SF Office: 1.73 W/SF Auto repair: 1.15 W/SF Kitchen: 3.23 W/SF
Operating hours	Mon-Sun: 10am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 260 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 79 ºF cooling, 69 ºF heating

A computer-generated sketch of the Big Box Building prototype is shown below.



5.4 COMMUNITY COLLEGE

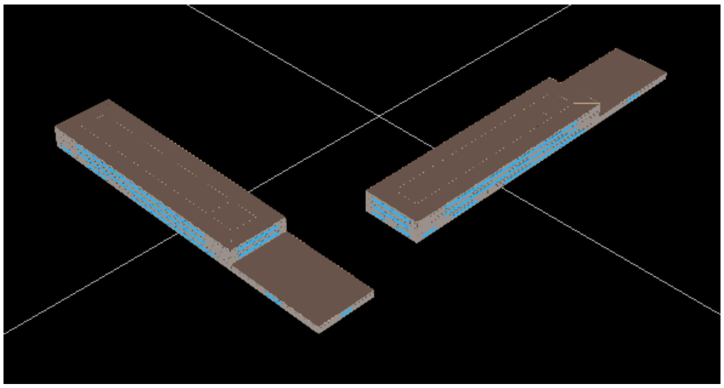
A prototypical building energy simulation model for a community college was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really two identical buildings oriented 90 degreesapart. The characteristics of the prototype are summarized below.

Community College Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 150,000 square feet each; oriented 90° from each other Classroom: 150,825 SF Computer room: 9,625 SF Dining area: 26,250 SF Kitchen: 5,625 SF Office: 70,175 SF Total: 300,000 SF
Number of floors	3
Wall construction and R-value	CMU with brick veneer, plus R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Gymnasium: 1.8 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed
HVAC system type	Combination PSZ and built-up with screw chiller and hot water boiler.
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings.

A computer-generated sketch of the Community College Building prototype is shown below.



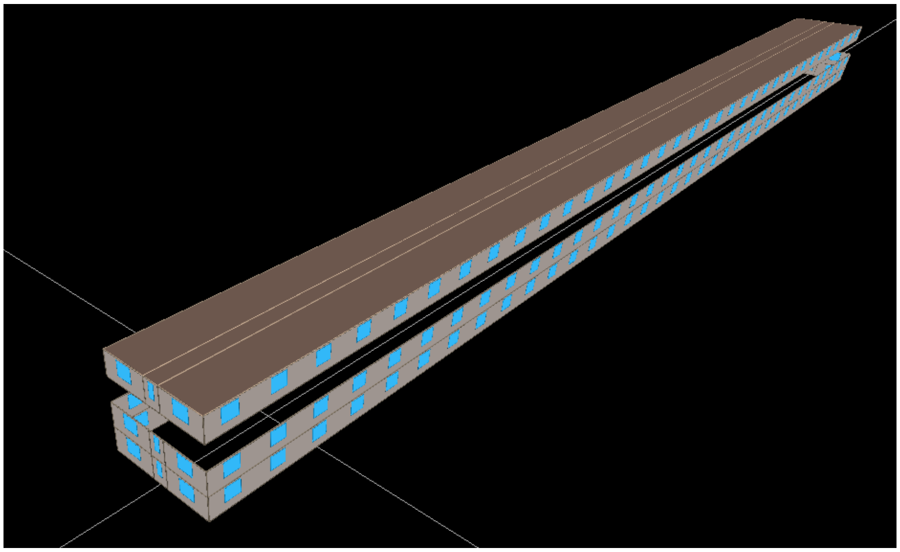
5.5 DORMITORY

A prototypical building energy simulation model for a university dormitory was developed usingthe DOE-2.2 building energy simulation program. The dormitory building was extracted from the DEER university prototype and modeled separately. The model consists of two identical buildings oriented 90 degrees apart. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

DORMITORY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	170,000 square feet
Number of floors	4
Wall construction and R-value	CMU with R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear; SHGC = 0.73; U-value = 0.72
Lighting power density	Rooms: 0.5 W/SF Corridors and common space: 0.8 W/SF
Plug load density	Rooms: 0.6 W/SF Corridors and common space: 0.2 W/SF
Operating hours	24/7 – 365 days
HVAC system type	Fan coils with centrifugal chiller and hot water boiler
HVAC system size	800 SF/ton
Thermostat set points	Daytime hours: 76 ºF cooling, 72 ºF heating Night setback hours: 81 ºF cooling, 67 ºF heating

A computer-generated sketch of the Dormitory Building prototype is shown below.



Note: The middle floors, since they thermally equivalent, are simulated as a single floor, and theresults are multiplied by 2 to represent the energy consumption of the 2 middle floors.

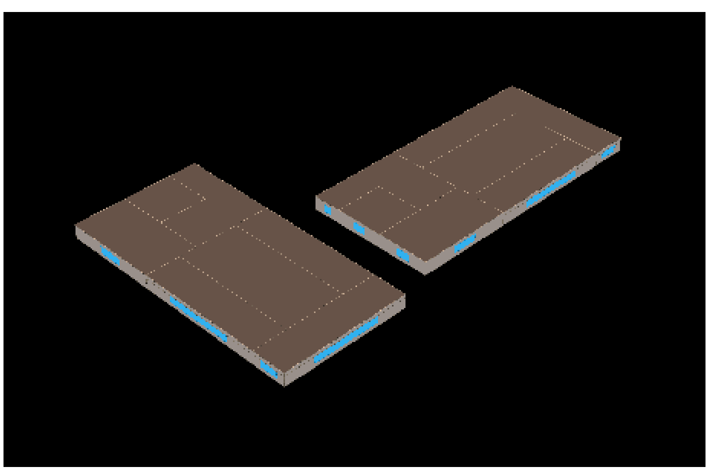
5.6 ELEMENTARY SCHOOL

A prototypical building energy simulation model for an elementary school was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of two identical buildings oriented in two different directions. The characteristics of the prototype are summarized below.

ELEMENTARY SCHOOL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 25,000 square feet each; oriented 90º from each other Classroom: 15,750 SF Cafeteria: 3,750 SF Gymnasium: 3,750 SF Kitchen: 1,750 SF
Number of floors	1
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Classroom: 4.4 W/SF Cafeteria: 1.7 W/SF Gymnasium: 2.1 W/SF Kitchen: 4.3 W/SF
Plug load density	Classroom: 1.2 W/SF Cafeteria: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 4.2 W/SF
Operating hours	Mon-Fri: 8am – 6pm Sun: 8am – 4pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	160 - 180 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 79 ºF cooling, 69 ºF heating

A computer-generated sketch of the Elementary School Building prototype is shown below.



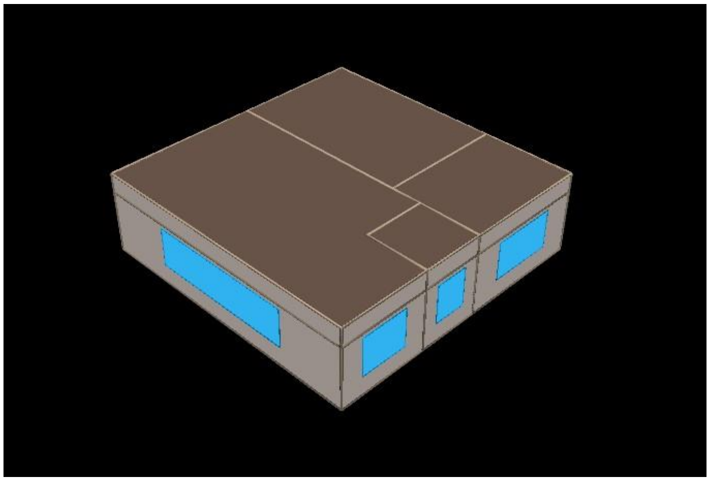
5.7 FAST FOOD RESTAURANT

A prototypical building energy simulation model for a fast food restaurant was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

FAST FOOD RESTAURANT PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square feet 1,000 SF dining 600 SF entry/lobby 300 SF kitchen 100 SF restroom
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	1.7 W/SF dining 2.5 W/SF entry/lobby 4.3 W/SF kitchen 1.0 W/SF restroom
Plug load density	0.6 W/SF dining 0.6 W/SF entry/lobby 4.3 W/SF kitchen 0.2 W/SF restroom
Operating hours	Mon-Sun: 6am – 11pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 – 120 SF/ton depending on climate
Thermostat set points	Occupied hours: 77 ^{o}F cooling, 72 ^{o}F heating Unoccupied hours: 80 ^{o}F cooling, 69 ^{o}F heating

A computer-generated sketch of the Fast Food Building prototype is shown below.



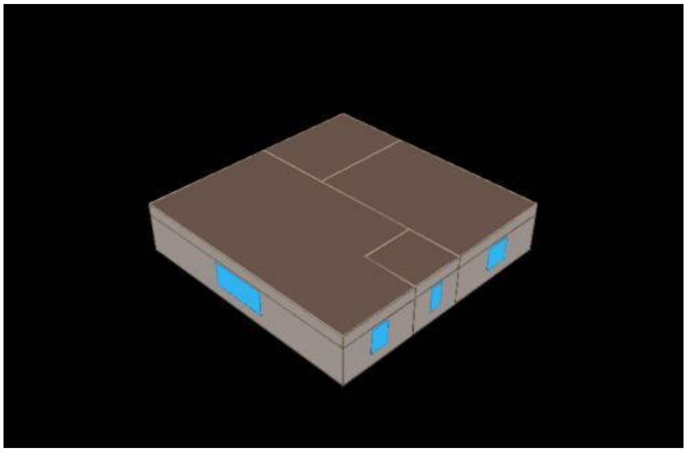
5.8 FULL-SERVICE RESTAURANT

A prototypical building energy simulation model for a full-service restaurant was developedusing the DOE-2.2 building energy simulation program. The simulations were driven usingTMY3 long-term average weather data. The characteristics of the full service restaurant prototype are summarized below.

FULL SERVICE RESTAURANT PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square foot dining area 600 square foot entry/reception area 1200 square foot kitchen 200 square foot restrooms
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Dining area: 1.7 W/SF Entry area: 2.5 W/SF Kitchen: 4.3 W/SF Restrooms: 1.0 W/SF
Plug load density	Dining area: 0.6 W/SF Entry area: 0.6 W/SF Kitchen: 3.1 W/SF Restrooms: 0.2 W/SF
Operating hours	9am – 12am
HVAC system type	Packaged single zone, no economizer
HVAC system size	140 – 160 SF/ton depending on climate
Thermostat set points	Occupied hours: 77 ºF cooling, 72 ºF heating Unoccupied hours: 80 ºF cooling, 69 ºF heating

A computer-generated sketch of the Full-Service Restaurant Building prototype is shown below.



5.9 GROCERY

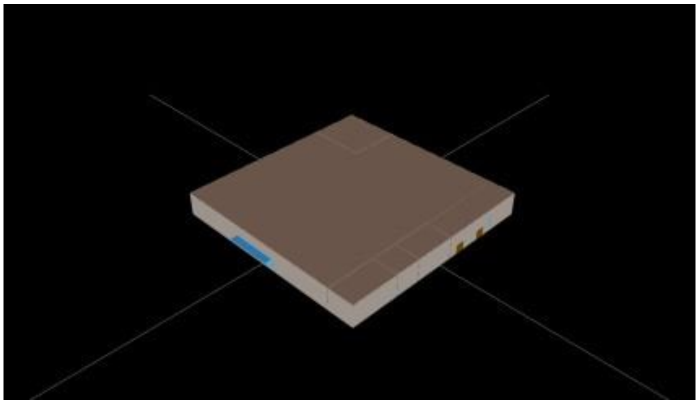
A prototypical building energy simulation model for a grocery building was developed using theDOE-2.2R[191] building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

GROCERY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	50,000 square feet Sales: 40,000 SF Office and employee lounge: 3,500 SF Dry storage: 2,860 SF 50ºF prep area: 1,268 SF 35ºF walk-in cooler: 1,560 SF - 5ºF walk-in freezer: 812 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Office: 2.2 W/SF Storage: 1.82 W/SF 50ºF prep area: 4.3 W/SF 35ºF walk-in cooler: 0.9 W/SF - 5ºF walk-in freezer: 0.9 W/SF
Equipment power density	Sales: 1.15 W/SF Office: 1.73 W/SF Storage: 0.23 W/SF 50ºF prep area: 0.23 W/SF + 36 kBTU/h process load 35ºF walk-in cooler: 0.23 W/SF + 17 kBTU/h process load - 5ºF walk-in freezer: 0.23 W/SF+ 29 kBTU/h process load
Operating hours	Mon-Sun: 6am – 10pm
HVAC system type	Packaged single zone, no economizer
Refrigeration system type	Air cooled multiplex
Refrigeration system size	Low temperature (-20ºF suction temp): 23 compressor ton Medium temperature (18ºF suction temp): 45 compressor ton
Refrigeration condenser size	Low temperature: 535 kBTU/h THR Medium temperature: 756 kBTU/h THR
Thermostat set points	Occupied hours: 74ºF cooling, 70ºF heating Unoccupied hours: 79ºF cooling, 65ºF heating

[191] DOE-2.2R is a specialized version of the DOE-2.2 program, designed specifically to model refrigeration systems.

A computer-generated sketch of the Grocery Building prototype is shown below.



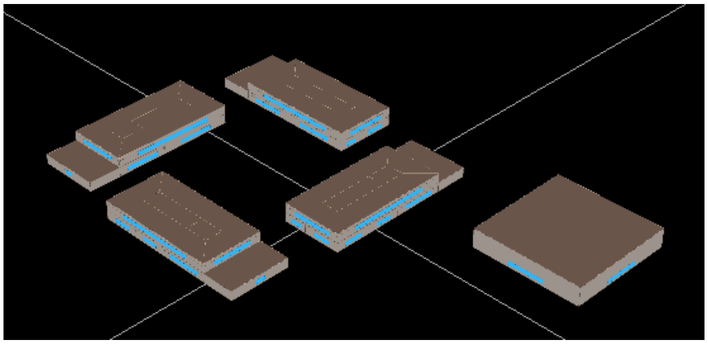
5.10 HIGH SCHOOL

A prototypical building energy simulation model for a high school was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of four identical buildings oriented in four different directions, with a common gymnasium. The characteristics of the prototype are summarized below.

HIGH SCHOOL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	4 buildings, 25,000 square feet each; oriented 90º from each other Classroom: 88,200 SF Computer room: 3,082 SF Dining area: 22,500 SF Gymnasium: 22,500 SF Kitchen: 10,500 SF Office: 3,218 SF Total: 150,000 SF
Number of floors	2
Wall construction and R-value	CMU with brick veneer, plus R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Gymnasium: 1.8 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed
HVAC system type	Combination PSZ and built-up with screw chiller and hot waterboiler.
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76ºF cooling, 72 ºF heating Unoccupied hours: 81ºF cooling, 67 ºF heating

A computer-generated sketch of the High School Building prototype is shown below.



5.11 HOSPITAL

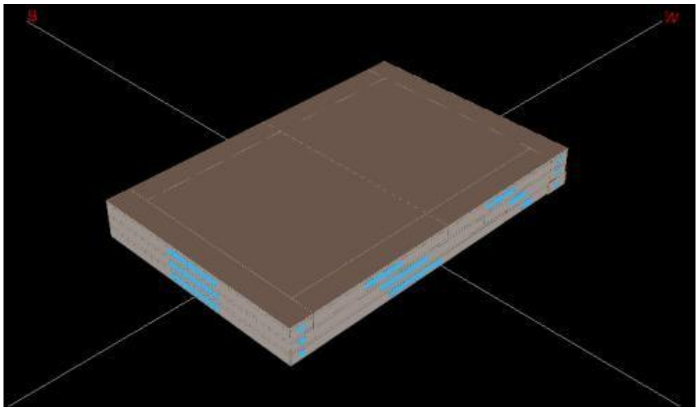
A prototypical building energy simulation model for a large hospital building was developedusing the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarizedbelow.

LARGE HOSPITAL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	250,000 square feet
Number of floors	3
Wall construction and R-value	Brick and CMU, R=7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84; U-value = 0.72
Lighting power density	Patient rooms: 2.3 W/SF Office: 2.2 W/SF Lab: 4.4 W/SF Dining: 1.7 W/SF Kitchen and food prep: 4.3 W/SF
Plug load density	Patient rooms: 1.7 W/SF Office: 1.7 W/SF Lab: 1.7 W/SF Dining: 0.6 W/SF Kitchen and food prep: 4.6 W/SF
Operating hours	24/7, 365
HVAC system types	Patient Rooms: 4 pipe fan coil Kitchen: Rooftop DX Remaining space; 1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizingassumed.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves
Chilled water system control	Constant CHW Temp, 45 ºF set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves
Hot water system control	Constant HW Temp, 180ºF set point
Thermostat set points	Occupied hours: 76ºF cooling, 72 ºF heating Unoccupied hours: 79 ºF cooling, 69 ºF heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. Thispresents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Hospital Building prototype is shown below.



5.12 HOTEL

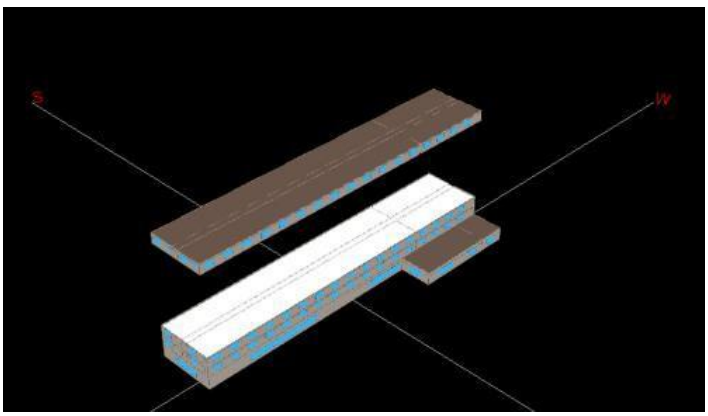
A prototypical building energy simulation model for a hotel building was developed using theDOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

HOTEL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	200,000 square feet total Bar, cocktail lounge – 800 SF Corridor – 20,100 SF Dining Area – 1,250 SF Guest rooms – 160,680 SF Kitchen – 750 SF Laundry – 4,100 SF Lobby – 8,220 SF Office – 4,100 SF
Number of floors	11
Wall construction and R-value	Block construction, R-7.5
Roof construction and R-value	Wood deck with built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Bar, cocktail lounge – 1.7 W/SF Corridor – 1.0 W/SF Dining Area – 1.7 W/SF Guest rooms – 0.6 W/SF Kitchen – 4.3 W/SF Laundry – 1.8 W/SF Lobby – 3.1 W/SF Office – 2.2 W/SF
Plug load density	Bar, cocktail lounge – 1.2 W/SF Corridor – 0.2 W/SF Dining Area – 0.6 W/SF Guest rooms – 0.6 W/SF Kitchen – 3.0 W/SF Laundry – 3.5 W/SF Lobby – 0.6 W/SF Office – 1.7 W/SF
Operating hours	Rooms: 60% occupied, 40% unoccupied All others: 24 hr / day
HVAC system type	Central built-up system: All except corridors and rooms 1. Central constant volume system with perimeter hydronic reheat, without economizer; 2. Central constant volume system with perimeter hydronic reheat, with economizer; 3. Central VAV system with perimeter hydronic reheat, with economizer PTAC (Packaged Terminal Air Conditioner): Guest rooms PSZ: Corridors

Characteristic	Value
HVAC system sizeM	Based on ASHRAE design day conditions, 10% over-sizing assumed
Minimum outdoor air fraction	Built up system 0.3; PSZ: 0.14; PTAC: 0.11 is typical
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves
Chilled water system control	Constant CHW Temp, 45 ºF set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves
Hot water system control	Constant HW Temp, 180 ºF set point
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 81 ºF cooling, 67 ºF heating

A computer-generated sketch of the Hotel Building prototype is shown below.



5.13 LARGE OFFICE

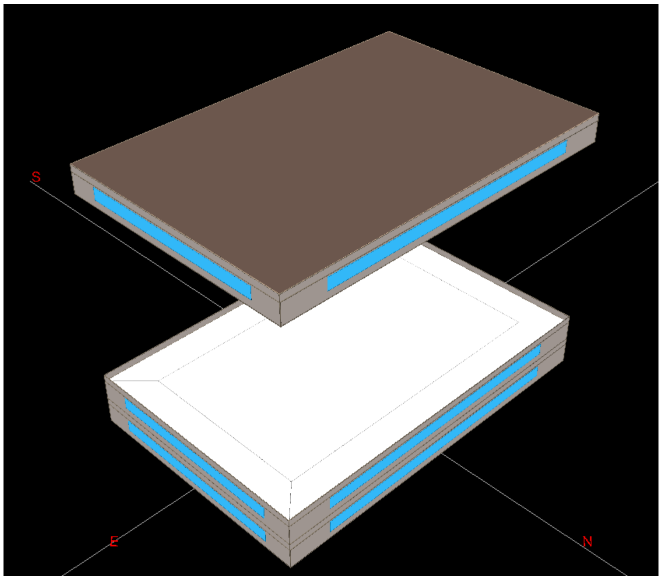
A prototypical building energy simulation model for a large office building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

LARGE OFFICE PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	350,000 square feet
Number of floors	10
Wall construction and R-value	Glass curtain wall, R-7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84; U-value = 0.72
Lighting power density	Perimeter offices: 1.55 W/SF Core offices: 1.45 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system types	1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves
Chilled water system control	Constant CHW Temp, 45 ºF set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves
Hot water system control	Constant HW Temp, 180 ºF set point
Thermostat set points	Occupied hours: 75 ºF cooling, 70 ºF heating Unoccupied hours: 78 ºF cooling, 67 ºF heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. Thispresents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Office Building prototype is shown below.



Note: The middle floors, since they thermally equivalent, are simulated as a single floor, and theresults are multiplied by 8 to represent the energy consumption of the eight middle floors.

5.14 LARGE RETAIL

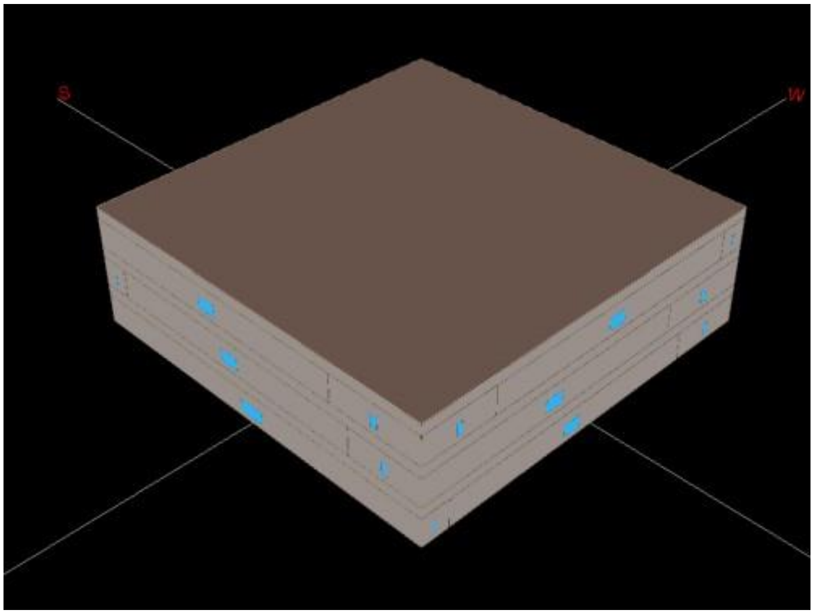
A prototypical building energy simulation model for a large retail building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

LARGE RETAIL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	130,000 square feet Sales area: 96,000 SF Storage: 18,000 SF Office: 6,000 SF
Number of floors	3
Wall construction and R-value	Brick and CMU with R-7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; SHGC= 0.73; U-value = 0.72
Lighting power density	Sales area: 2.8 W/SF Storage: 0.8 W/SF Office: 1.8 W/SF
Plug load density	Sales area: 1.1 W/SF Storage: 0.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sat: 9am – 10pm Sun: 9am – 7pm
HVAC system types	1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	340 SF/ton
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves
Chilled water system control	Constant CHW Temp, 45 ºF set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves
Hot water system control	Constant HW Temp, 180 ºF set point
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 81 ºF cooling, 67 ºF heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. Thispresents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Retail Building prototype is shown below.



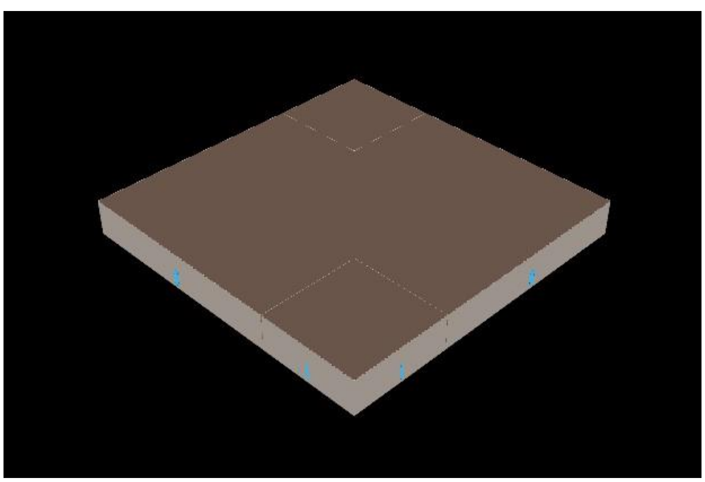
5.15 LIGHT INDUSTRIAL

A prototypical building energy simulation model for a light industrial building was developedusing the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

LIGHT INDUSTRIAL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	100,000 square feet total 80,000 SF factory 20,000 SF warehouse
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Factory – 2.1 W/SF Warehouse – 0.9 W/SF
Plug load density	Factory – 1.2 W/SF Warehouse – 0.2 W/SF
Operating hours	Mon-Fri: 6am – 6pm Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	500 - 560 SF/ton depending on climate
Thermostat set points	Occupied hours: 78 cooling, 70 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the Light Industrial Building prototype is shown below.



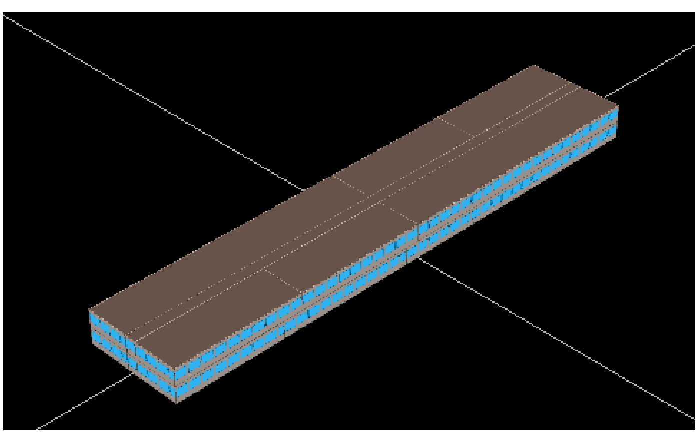
5.16 MOTEL

A prototypical building energy simulation model for a motel was developed using the DOE-2.2building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

MOTEL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	30,000 square feet
Number of floors	2
Wall construction and R-value	Frame with R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear; SHGC = .87 U-value = 1.2
Lighting power density	0.6 W/SF
Plug load density	0.6 W/SF
Operating hours	24/7 - 365
HVAC system type	PTAC with electric heat
HVAC system size	540 SF/ton
Thermostat set points	Daytime hours: 76^{o}F cooling, 72 ^{o}F heating Night setback hours: 81 ^{o}F cooling, 67 ^{o}F heating

A computer-generated sketch of the Motel Building prototype is shown below.



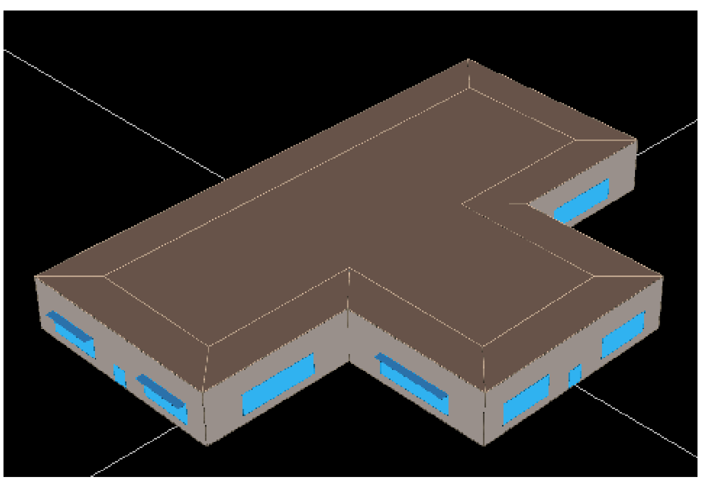
5.17 RELIGIOUS

A prototypical building energy simulation model for a religious worship building was developedusing the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

RELIGIOUS WORSHIP PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	11,000 square feet
Number of floors	1
Wall construction and R-value	Brick with R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear; SHGC = .87, U-value = 1.2
Lighting power density	1.7 W/SF
Plug load density	1.2 W/SF
Operating hours	Mon-Sat: 12pm-6pm Sun: 9am-7pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76ºF cooling, 70 ºF heating Unoccupied hours: 82 ºF cooling, 64 ºF heating

A computer-generated sketch of the Religious Building prototype is shown below.



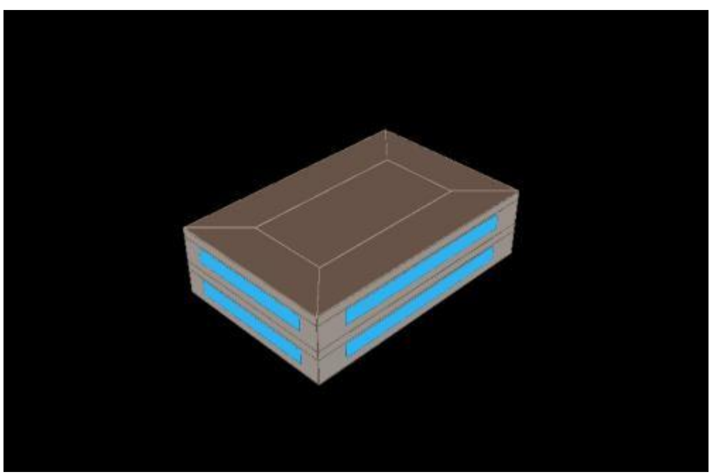
5.18 SMALL OFFICE

A prototypical building energy simulation model for a small office was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the small office prototype are summarized below.

SMALL OFFICE PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	**Existing (1970s) vintage**
Size	10,000 square feet
Number of floors	2
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Perimeter offices: 2.2 W/SF Core offices: 1.5 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 245 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 79 ºF cooling, 69 ºF heating

A computer-generated sketch of the Small Office Building prototype is shown below.



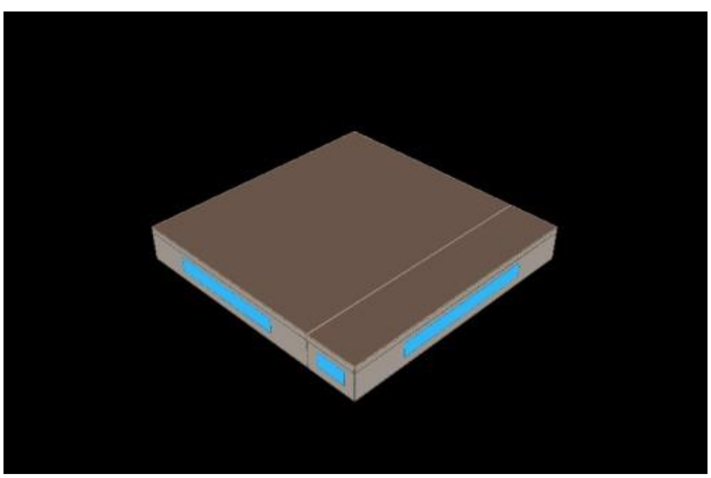
5.19 SMALL RETAIL

A prototypical building energy simulation model for a small retail building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the small retail building prototype are summarized below.

SMALL RETAIL PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	Sales Area: 6400 SF Storage Area:1600 SF Total: 8000 SF
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales area: 3.4 W/SF Storage area: 0.9 W/SF
Plug load density	Sales area: 1.2 W/SF Storage area: 0.2 W/SF
Operating hours	Mon-Sat: 10 – 10 Sun: 10 – 8
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 – 250 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 79 ºF cooling, 69 ºF heating

A computer-generated sketch of the Small Retail Building prototype is shown below.



5.20 UNIVERSITY

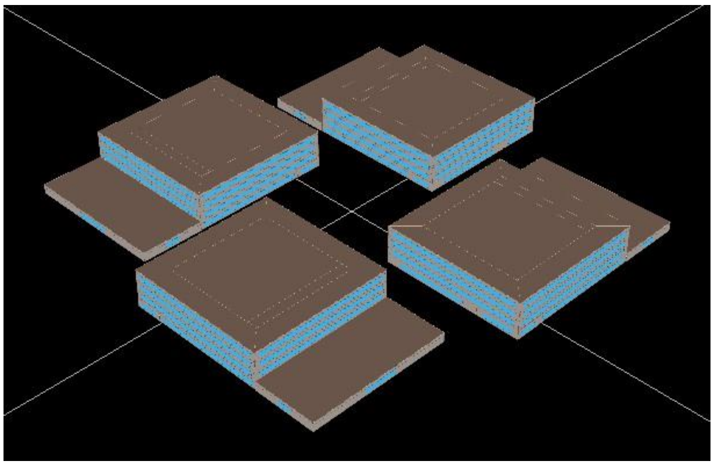
A prototypical building energy simulation model for a university building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really four identical buildings oriented 90 degrees apart. The characteristics of the prototype are summarized below.

UNIVERSITY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	4 buildings, 200,000 square feet each; oriented 90º from each other Classroom: 431,160 SF Computer room: 27,540 SF Dining area: 24,000 SF Kitchen: 10,500 SF Office: 226,800 SF Total: 800,000 SF
Number of floors	4
Wall construction and R-value	Insulated frame wall with R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Office: 2.0 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Office: 1.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 10pm Sat: 8am – 7pm Sun: closed
HVAC system type	Combination PSZ and built-up with centrifugal chiller and hot water boiler.
HVAC system size	400 SF/ton
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 81 ºF cooling, 67 ºF heating
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves
Chilled water system control	Constant CHW Temp, 45 ºF set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves
Hot water system control	Constant HW Temp, 180 ºF set point

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. Thispresents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the University Building prototype is shown below.



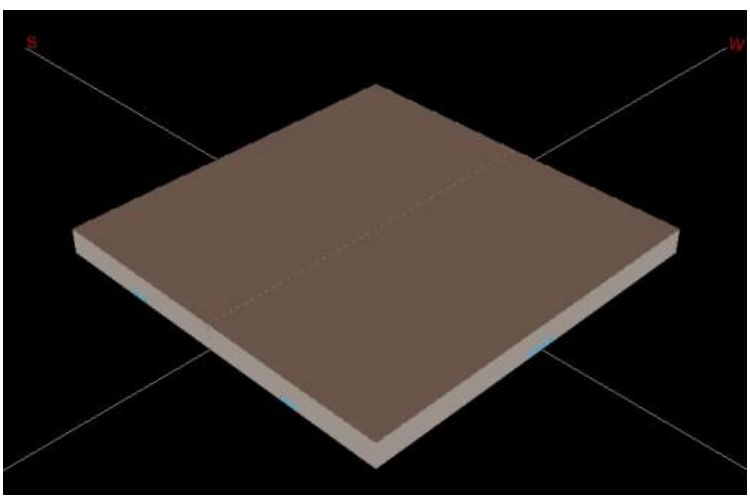
5.21 WAREHOUSE

A prototypical building energy simulation model for a warehouse building was developed usingthe DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

WAREHOUSE PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	500,000
Number of floors	1
Wall construction and insulation R-value	Concrete block, R-5
Roof construction and insulation R-value	Wood deck with built-up roof, R-12
Glazing type	Multi-pane; Shading-coefficient = 0.84U-value = 0.72
Lighting power density	0.9 W/SF
Plug load density	0.2 W/SF
Operating hours	Mon-Fri: 7am – 6pm Sat-Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Thermostat set points	Occupied hours: 80 ºF cooling, 68 ºF heating Unoccupied hours: 85 ºF cooling, 63 ºF heating

A computer-generated sketch of the Warehouse Building prototype is shown below.



6 APPENDIX C: HEATING AND COOLING EFLH

6.1.1 RESIDENTIAL EFLH

This appendix provides heating and cooling full load hours by home type and vintage.

Table 6-1 Residential Heating and Cooling Full Load Hours

Home Type	Old (built prior to 1979)		Average (built 1979-2006)		New (built 2007-present)	
	Cooling EFLH	Heating EFLH	Cooling EFLH	Heating EFLH	Cooling EFLH	Heating EFLH
Single-family detached (Weight = 0.61)	854	965	854	965	854	965
Multi-family low-rise (Weight = 0.37)	600	965	600	965	600	965
Multi-family high-rise (Weight 0.03)	600	965	600	965	600	965
Weighted Average	761	965	761	965	761	965

6.1.2 C&I BUILDING TYPES

This appendix provides heating and cooling full load hours by building type. A description of each building type is shown in the table below. The primary distinction between small and large buildings is the number of floors and HVAC system type rather than a specific conditioned floor area criterion. Small buildings in this study utilize packaged or split unitary system HVAC systems or packaged terminal air conditioners (PTAC). Large buildings use built-up HVAC systems with chillers and boilers.

Table 6-2 C&I Building Type Descriptions

Building Type	Description
Assembly	Public buildings that include community centers, libraries, performance and movie theaters, auditoria, police and fire stations, gymnasia, sports arenas, and transportation terminals
Auto	Repair shops and auto dealerships, including parking lots and parking structures.
Big Box	Single story, high-bay retail stores with ceiling heights of 25 feet or more. Majority of floor space is dedicated to non-food items, but could include refrigerated and non-refrigerated food sales areas.
Community College	Community college campus and post-secondary technical and vocational education buildings, including classroom, computer labs, dining and office. Conditioned by packaged HVAC systems
Dormitory	College or University dormitories
Fast Food	Self-service restaurants with primarily disposable plates, utensils etc.
Full Service Restaurant	Full service restaurants with full dishwashing facilities

Building Type	Description
Grocery	Refrigerated and non-refrigerated food sales, including convenience stores and specialty food sales
Heavy Industrial	Single or multistory buildings containing industrial processes including pump stations, water and wastewater treatment plants; may be conditioned or unconditioned.
Hospital	Inpatient and outpatient care facility conditioned by built-up HVAC systems. Excludes medical offices
Hotel	Multifunction lodging facility with guest rooms, meeting space, foodservice conditioned by built-up HVAC system
Large Office	Office space in buildings greater than 3 stories conditioned by built-up HVAC system.
Light Industrial	Single story work space with heating and air-conditioning; conditioned by packaged HVAC systems.
Multifamily high-rise	Multifamily building with more than 3 stories conditioned by built up HVAC system
Multifamily low-rise	Multifamily building with 3 stories or less conditioned by packaged HVAC system
Motel	Lodging facilities with primarily guest room space served by packaged HVAC systems
Multi Story Retail	Retail building with 2 or more stories served by built-up HVAC system
Primary School	K-8 school
Religious	Religious worship
Secondary School	9-12 school
Single-family residential	Single-family detached residences
Small Office	Office occupancy in buildings 3 stories or less served by packaged HVAC systems; includes Medical offices
Small Retail	Single story retail with ceiling height of less than 25 feet; primarily non-food retail and storage areas served by packaged HVAC systems. Includes service businesses, post offices, Laundromats, and exercise facilities.
University	University campus buildings, including classroom, computer labs, biological and/or chemical labs, workshop space, dining and office. Conditioned by built-up HVAC systems
Warehouse	Primarily non-refrigerated storage space could include attached offices served by packaged HVAC system.

Other building types not included above can be matched to the standard building types as shown below:

Table 6-3 Building Type Correlation Examples

Building Type	Best Match
Agricultural	Light industrial
Funeral home	Small retail
Police and fire stations	Public assembly

Building Type	Best Match
Courthouse	Large office
Detention facility	Multifamily highrise
Municipal airport	Assembly
Nursing home	Hospital
Kennel	Small retail
Rental office in Multifamily Building	Small office
Multifamily Interior hallways	Multifamily (hallways included in model)

Note: for commercial buildings that cannot be reasonably associated with one the building types above, savings values for the "other" category should be used.

6.1.3 C&I EFLH VALUES

The tables below show EFLH values by facility type for the five climate zone described in Appendix A: Climate Zone Descriptions.

Please note:

- Multifamily (low and high-rise) EFLH values are presented in section 6.1.1.
- All utilities should use weighted average value for EFLH.
- If the facility type and size is unknown, weight small commercial values by 0.8 and large commercial values by 0.2 (based on CBECS data). Resulting default EFLH are 842 for cooling and 791 for heating.

Table 6-4 Small Commercial (less than 3 stories) Cooling Equivalent Full Load Hours ($EFLH_c$)

Facility Type	HVAC Type	Northern	Central	Pine Barrens	South-west	Coastal	Wt Average
Assembly	Packaged or split unitary system	608	742	690	680	654	693
Auto repair	Packaged or split unitary system	375	486	468	479	408	452
Light industrial	Packaged or split unitary system	481	548	496	574	485	523
Lodging – Motel	Packaged Terminal AC	947	1,023	1,065	1,063	1,039	1,022
Office – small	Packaged or split unitary system	842	931	883	941	880	904
Other	Packaged or split unitary system	707	793	766	786	741	766
Religious worship	Packaged or split unitary system	304	326	353	322	309	322

Facility Type	HVAC Type	Northern	Central	Pine Barrens	South-west	Coastal	Wt Average
Restaurant – fast food	Packaged or split unitary system	553	695	631	670	608	647
Restaurant – full service	Packaged or split unitary system	533	660	602	625	573	614
Retail – big box	Packaged or split unitary system	923	1,031	996	1,006	967	996
Retail – Grocery	Packaged or split unitary system	2,100	2,058	1,994	2,036	1,994	2,045
Retail – small	Packaged or split unitary system	846	929	899	931	873	903
School – primary	Packaged or split unitary system	332	398	410	443	369	388
Warehouse	Packaged or split unitary system	324	393	357	392	327	367

Table 6-5 Small Commercial (less than 3 stories) Heating Equivalent Full Load Hours ($EFLH_h$)

Facility Type	HVAC Type	Northern	Central	Pine Barrens	South-west	Coastal	Wt Average
Assembly	Packaged or split unitary system	775	666	653	703	796	708
Auto repair	Packaged or split unitary system	2,387	2,056	2,081	2,090	2,140	2,132
Light industrial	Packaged or split unitary system	1,044	776	768	865	927	854
Lodging – Motel	Packaged Terminal AC	521	404	415	407	478	437
Office – small	Packaged or split unitary system	586	407	427	405	472	449
Other	Packaged or split unitary system	914	749	741	785	852	796
Religious worship	Packaged or split unitary system	837	727	710	739	775	753
Restaurant – fast food	Packaged or split unitary system	1,098	894	863	958	1,056	958
Restaurant – full service	Packaged or split unitary system	1,095	904	885	953	1,061	964
Retail – big box	Packaged or split unitary system	430	345	332	358	398	368

Facility Type	HVAC Type	Northern	Central	Pine Barrens	South-west	Coastal	Wt Average
Retail – Grocery	Packaged or split unitary system	1,022	913	861	997	1,140	971
Retail – small	Packaged or split unitary system	765	581	580	604	655	626
School – primary	Packaged or split unitary system	1,060	873	850	945	1,019	933
Warehouse	Packaged or split unitary system	602	486	483	501	505	510

Table 6-6 Large Commercial (more than 3 stories) Cooling Equivalent Full Load Hours ($EFLH_c$)

Building Type	HVAC System	Northern	Central	Pine Barrens	Southwest	Coastal	Wt Average
Dormitory	Fan coil	736	880	874	842	886	852
School – Community college	CV econ	708	826	877	859	804	812
	CV noecon	988	1,108	1,132	1,124	1,088	1,089
	VAV	560	569	674	699	586	596
	Unknown	649	692	776	790	697	706
School – secondary	CV econ	424	499	502	487	475	482
	CV noecon	824	899	870	873	879	877
	VAV	300	369	396	369	353	358
	Unknown	400	471	486	465	453	457
Hospital	CV econ	1,229	1,433	1,380	1,405	1,374	1,380
	CV noecon	2,167	2,306	2,230	2,209	2,222	2,250
	VAV	1,035	1,214	1,170	1,195	1,167	1,169
	Unknown	1,141	1,319	1,271	1,293	1,268	1,273
Hotel	CV econ	2,836	2,881	2,909	2,930	2,908	2,886
	CV noecon	3,028	3,065	3,092	3,113	3,100	3,072
	VAV	2,871	2,897	2,883	2,915	2,894	2,892
	Unknown	2,932	2,973	3,000	3,021	3,004	2,979
Large Office	CV econ	648	727	725	725	698	708
	CV noecon	2,223	2,265	2,230	2,235	2,246	2,248
	VAV	634	725	689	708	675	696
	Unknown	746	833	799	816	786	805

Building Type	HVAC System	Northern	Central	Pine Barrens	Southwest	Coastal	Wt Average
Large Retail	CV econ	1,006	1,167	1,157	1,130	1,107	1,125
	CV noecon	1,754	1,876	1,836	1,807	1,846	1,839
	VAV	832	993	972	946	940	950
	Unknown	920	1,077	1,056	1,029	1,026	1,035
School – postsecondary	CV econ	855	872	844	921	934	881
	CV noecon	1,118	1,159	1,153	1,136	1,225	1,160
	VAV	567	667	649	620	607	634
	Unknown	697	775	757	747	753	753
Other	CV econ	1,101	1,201	1,199	1,208	1,186	1,182
	CV noecon	1,729	1,811	1,792	1,785	1,801	1,791
	VAV	971	1,062	1,062	1,065	1,032	1,042
	Unknown	1,069	1,163	1,164	1,166	1,141	1,144

Table 6-7 Large Commercial (more than 3 stories) Heating Equivalent Full Load Hours ($EFLH_h$)

Building Type	HVAC System	Northern	Central	Pine Barrens	Southwest	Coastal	Wt Average
Dormitory	Fan coil	577	452	471	463	504	485
School – Community college	CV econ	1,501	1,371	1,383	1,485	1,358	1,404
	CV noecon	1,340	1,214	1,244	1,343	1,218	1,253
	VAV	481	390	335	509	378	410
	Unknown	772	670	638	789	660	694
School – secondary	CV econ	968	949	918	887	1,000	950
	CV noecon	907	868	844	832	914	875
	VAV	363	254	271	309	327	292
	Unknown	541	457	460	480	522	484
Hospital	CV econ	4,530	3,702	4,009	3,951	4,180	3,980
	CV noecon	4,725	4,103	4,305	3,711	3,904	4,157
	VAV	531	374	373	412	449	416
	Unknown	1,186	938	979	959	1,024	1,001
Hotel	CV econ	1,087	963	974	1,052	1,362	1,059
	CV noecon	832	713	730	772	992	786
	VAV	342	272	294	263	342	297
	Unknown	959	838	852	912	1,177	923

Building Type	HVAC System	Northern	Central	Pine Barrens	Southwest	Coastal	Wt Average
Large Office	CV econ	2,270	2,087	2,128	1,989	2,233	2,136
	CV noecon	2,301	2,101	2,141	1,999	2,278	2,157
	VAV	416	366	376	277	418	375
	Unknown	677	608	623	517	675	623
Large Retail	CV econ	2,083	2,031	2,030	2,047	2,134	2,058
	CV noecon	1,997	1,955	1,971	1,991	2,090	1,989
	VAV	726	645	632	648	787	681
	Unknown	936	861	851	867	999	895
School – postsecondary	CV econ	1,368	1,247	1,170	1,174	1,210	1,245
	CV noecon	1,314	1,108	1,070	1,081	1,086	1,132
	VAV	523	705	356	782	390	592
	Unknown	776	851	593	889	625	777
Other	CV econ	1,972	1,764	1,802	1,798	1,925	1,833
	CV noecon	1,917	1,723	1,758	1,676	1,783	1,764
	VAV	483	429	377	457	442	438
	Unknown	835	746	714	773	812	771

7 APPENDIX D: HVAC FAN AND PUMP OPERATING HOURS

This section presents HVAC fan and pump operating hours by C&I building type. These values are the result of building prototype models in Appendix B: Building Prototype Descriptions. The operating hours are differentiated by facility type, HVAC system (large commercial only), and climate region. If climate region is unavailable, default to statewide average values.

Table 7-1 Small Commercial HVAC Fan and Pump Hours

Facility Type	Climate	HVAC Fan Motor	Heating Pumps
Assembly	Central	6,884	3,741
Assembly	Coastal	6,812	3,847
Assembly	Northern	6,877	4,039
Assembly	Pine Barrens	6,784	3,674
Assembly	Southwest	6,861	3,687
Assembly	**Statewide Average**	**6,858**	**3,795**
Auto repair	Central	6,341	4,377
Auto repair	Coastal	6,312	4,463
Auto repair	Northern	6,408	4,683
Auto repair	Pine Barrens	6,311	4,296
Auto repair	Southwest	6,287	4,302
Auto repair	**Statewide Average**	**6,339**	**4,426**
Big box	Central	5,669	2,725
Big box	Coastal	5,429	2,729
Big box	Northern	5,485	2,963
Big box	Pine Barrens	5,641	2,696
Big box	Southwest	5,634	2,697
Big box	**Statewide Average**	**5,592**	**2,760**
Fast food restaurant	Central	6,940	3,958
Fast food restaurant	Coastal	6,854	4,025
Fast food restaurant	Northern	6,893	4,210
Fast food restaurant	Pine Barrens	6,818	3,845
Fast food restaurant	Southwest	6,868	3,895
Fast food restaurant	**Statewide Average**	**6,897**	**3,992**
Full service restaurant	Central	6,002	3,614

Facility Type	Climate	HVAC Fan Motor	Heating Pumps
Full service restaurant	Coastal	5,964	3,693
Full service restaurant	Northern	6,083	3,931
Full service restaurant	Pine Barrens	5,967	3,551
Full service restaurant	Southwest	5,997	3,588
Full service restaurant	**Statewide Average**	**6,005**	**3,671**
Grocery	Central	8,760	8,760
Grocery	Coastal	8,760	8,760
Grocery	Northern	8,760	8,760
Grocery	Pine Barrens	8,760	8,760
Grocery	Southwest	8,760	8,760
Grocery	**Statewide Average**	**8,760**	**8,760**
Light industrial	Central	4,752	2,596
Light industrial	Coastal	4,778	2,781
Light industrial	Northern	4,983	3,044
Light industrial	Pine Barrens	4,733	2,571
Light industrial	Southwest	4,825	2,706
Light industrial	**Statewide Average**	**4,801**	**2,711**
Motel	Central	4,540	2,216
Motel	Coastal	4,540	2,239
Motel	Northern	4,540	2,325
Motel	Pine Barrens	4,540	2,181
Motel	Southwest	4,540	2,188
Motel	**Statewide Average**	**4,540**	**2,231**
Primary school	Central	5,991	4,104
Primary school	Coastal	6,012	4,229
Primary school	Northern	6,080	4,432
Primary school	Pine Barrens	5,917	4,045
Primary school	Southwest	6,011	4,081
Primary school	**Statewide Average**	**6,004**	**4,171**
Religious	Central	3,493	1,915
Religious	Coastal	3,493	1,934
Religious	Northern	3,493	1,957

Facility Type	Climate	HVAC Fan Motor	Heating Pumps
Religious	Pine Barrens	3,493	1,835
Religious	Southwest	3,493	1,877
Religious	**Statewide Average**	**3,493**	**1,912**
Small office	Central	5,423	2,456
Small office	Coastal	5,465	2,567
Small office	Northern	5,615	2,916
Small office	Pine Barrens	5,360	2,391
Small office	Southwest	5,473	2,482
Small office	**Statewide Average**	**5,461**	**2,548**
Small retail	Central	5,767	3,169
Small retail	Coastal	5,767	3,304
Small retail	Northern	5,931	3,544
Small retail	Pine Barrens	5,711	3,118
Small retail	Southwest	5,770	3,196
Small retail	**Statewide Average**	**5,789**	**3,252**
Warehouse	Central	3,604	1,521
Warehouse	Coastal	3,604	1,610
Warehouse	Northern	3,604	1,672
Warehouse	Pine Barrens	3,604	1,489
Warehouse	Southwest	3,604	1,548
Warehouse	**Statewide Average**	**3,604**	**1,560**

Table 7-2 Large Commercial HVAC Fan and Pump Hours

Facility Type	Climate	HVAC System	HVAC Fan Motor	Chilled Water Pump	Hot Water Pump	Condenser Water Pump	Cooling Tower Fan
Community College	Central	CV econ	3,480	2,216	2,780	2,644	878
Community College	Coastal	CV econ	3,480	2,204	2,725	2,640	854
Community College	Northern	CV econ	3,480	2,161	2,826	2,582	697
Community College	Pine Barrens	CV econ	3,480	2,245	2,784	2,679	923
Community College	Southwest	CV econ	3,480	2,166	2,810	2,666	939
Community College	**Statewide Average**	**CV econ**	**3,480**	**2,202**	**2,783**	**2,639**	**855**
Community College	Central	CV noecon	3,480	2,331	2,738	2,825	964
Community College	Coastal	CV noecon	3,480	2,314	2,684	2,836	942
Community College	Northern	CV noecon	3,480	2,272	2,755	2,767	785
Community College	Pine Barrens	CV noecon	3,480	2,347	2,747	2,844	1,008
Community College	Southwest	CV noecon	3,480	2,271	2,769	2,844	1,027
Community College	**Statewide Average**	**CV noecon**	**3,480**	**2,313**	**2,737**	**2,821**	**942**
Community College	Central	VAV	2,049	3,364	3,357	2,450	611
Community College	Coastal	VAV	2,121	3,364	3,357	2,415	579
Community College	Northern	VAV	2,173	3,364	3,357	2,360	437
Community College	Pine Barrens	VAV	2,105	3,364	3,357	2,461	639
Community College	Southwest	VAV	2,075	3,364	3,357	2,475	671
Community College	**Statewide Average**	**VAV**	**2,091**	**3,364**	**3,357**	**2,433**	**586**
Community College	Central	Unknown	2,493	3,026	3,172	2,538	707
Community College	Coastal	Unknown	2,543	3,021	3,155	2,515	678
Community College	Northern	Unknown	2,578	3,008	3,181	2,457	532
Community College	Pine Barrens	Unknown	2,531	3,033	3,173	2,554	740
Community College	Southwest	Unknown	2,511	3,009	3,181	2,562	768
Community College	**Statewide Average**	**Unknown**	**2,522**	**3,021**	**3,172**	**2,525**	**683**
Dorm	Central	FPFC	3,833	3,824	3,772	2,765	489
Dorm	Coastal	FPFC	3,833	3,824	3,772	2,762	499
Dorm	Northern	FPFC	3,833	3,824	3,772	2,729	359
Dorm	Pine Barrens	FPFC	3,833	3,824	3,772	2,763	486
Dorm	Southwest	FPFC	3,834	3,824	3,772	2,772	485
Dorm	**Statewide Average**	**FPFC**	**3,833**	**3,824**	**3,772**	**2,759**	**468**

Facility Type	Climate	HVAC System	HVAC Fan Motor	Chilled Water Pump	Hot Water Pump	Condenser Water Pump	Cooling Tower Fan
Dorm	Central	Unknown	3,833	3,824	3,772	2,765	489
Dorm	Coastal	Unknown	3,833	3,824	3,772	2,762	499
Dorm	Northern	Unknown	3,833	3,824	3,772	2,729	359
Dorm	Pine Barrens	Unknown	3,833	3,824	3,772	2,763	486
Dorm	Southwest	Unknown	3,834	3,824	3,772	2,772	485
Dorm	**Statewide Average**	**Unknown**	**3,833**	**3,824**	**3,772**	**2,759**	**468**
Hospital	Central	CV econ	5,635	6,641	6,372	5,944	1,067
Hospital	Coastal	CV econ	5,588	6,615	6,752	5,904	969
Hospital	Northern	CV econ	5,635	6,632	6,477	5,864	798
Hospital	Pine Barrens	CV econ	5,651	6,624	6,449	5,940	1,023
Hospital	Southwest	CV econ	5,603	6,613	6,680	5,943	1,056
Hospital	**Statewide Average**	**CV econ**	**5,626**	**6,630**	**6,493**	**5,923**	**999**
Hospital	Central	CV noecon	5,639	6,970	6,808	6,068	1,149
Hospital	Coastal	CV noecon	5,584	6,930	6,789	5,996	1,048
Hospital	Northern	CV noecon	5,627	7,000	6,631	5,993	881
Hospital	Pine Barrens	CV noecon	5,657	6,954	6,897	6,067	1,102
Hospital	Southwest	CV noecon	5,600	6,916	6,581	6,055	1,135
Hospital	**Statewide Average**	**CV noecon**	**5,626**	**6,961**	**6,759**	**6,042**	**1,081**
Hospital	Central	VAV	5,712	6,656	5,312	5,909	991
Hospital	Coastal	VAV	5,690	6,631	6,137	5,882	906
Hospital	Northern	VAV	5,732	6,619	5,909	5,844	745
Hospital	Pine Barrens	VAV	5,736	6,626	4,730	5,912	957
Hospital	Southwest	VAV	5,704	6,628	5,997	5,912	985
Hospital	**Statewide Average**	**VAV**	**5,714**	**6,639**	**5,557**	**5,894**	**931**
Hospital	Central	Unknown	5,700	6,680	5,517	5,925	1,009
Hospital	Coastal	Unknown	5,673	6,653	6,238	5,893	922
Hospital	Northern	Unknown	5,716	6,651	6,012	5,857	760
Hospital	Pine Barrens	Unknown	5,723	6,652	5,040	5,927	974
Hospital	Southwest	Unknown	5,687	6,650	6,098	5,926	1,003
Hospital	**Statewide Average**	**Unknown**	**5,699**	**6,664**	**5,728**	**5,908**	**949**

Facility Type	Climate	HVAC System	HVAC Fan Motor	Chilled Water Pump	Hot Water Pump	Condenser Water Pump	Cooling Tower Fan
Hotel	Central	CV econ	8,664	6,026	7,310	6,992	2,490
Hotel	Coastal	CV econ	8,665	5,744	7,309	6,939	2,347
Hotel	Northern	CV econ	8,668	5,918	7,328	6,839	2,025
Hotel	Pine Barrens	CV econ	8,665	5,772	7,313	6,988	2,438
Hotel	Southwest	CV econ	8,664	6,042	7,306	7,016	2,516
Hotel	**Statewide Average**	**CV econ**	**8,665**	**5,936**	**7,313**	**6,960**	**2,385**
Hotel	Central	CV noecon	8,664	6,527	7,234	7,967	3,335
Hotel	Coastal	CV noecon	8,665	6,243	7,227	7,940	3,233
Hotel	Northern	CV noecon	8,668	6,424	7,248	7,826	2,850
Hotel	Pine Barrens	CV noecon	8,665	6,249	7,238	7,958	3,284
Hotel	Southwest	CV noecon	8,664	6,539	7,228	7,967	3,336
Hotel	**Statewide Average**	**CV noecon**	**8,665**	**6,435**	**7,235**	**7,938**	**3,231**
Hotel	Central	VAV	8,619	5,372	6,172	6,857	2,210
Hotel	Coastal	VAV	8,617	5,142	7,179	6,801	2,062
Hotel	Northern	VAV	8,618	5,456	6,178	6,689	1,733
Hotel	Pine Barrens	VAV	8,619	5,593	6,178	6,856	2,150
Hotel	Southwest	VAV	8,619	5,384	7,185	6,875	2,206
Hotel	**Statewide Average**	**VAV**	**8,619**	**5,375**	**6,446**	**6,822**	**2,098**
Hotel	Central	Unknown	8,664	6,026	7,310	6,992	2,490
Hotel	Coastal	Unknown	8,665	5,744	7,309	6,939	2,347
Hotel	Northern	Unknown	8,668	5,918	7,328	6,839	2,025
Hotel	Pine Barrens	Unknown	8,665	5,772	7,313	6,988	2,438
Hotel	Southwest	Unknown	8,664	6,042	7,306	7,016	2,516
Hotel	**Statewide Average**	**Unknown**	**8,665**	**5,936**	**7,313**	**6,960**	**2,385**
High School	Central	CV econ	1,953	1,127	1,319	1,644	612
High School	Coastal	CV econ	1,953	1,126	1,322	1,643	595
High School	Northern	CV econ	1,953	1,108	1,351	1,610	518
High School	Pine Barrens	CV econ	1,953	1,142	1,400	1,663	639
High School	Southwest	CV econ	1,953	1,141	1,317	1,654	609
High School	**Statewide Average**	**CV econ**	**1,953**	**1,127**	**1,333**	**1,641**	**596**

Facility Type	Climate	HVAC System	HVAC Fan Motor	Chilled Water Pump	Hot Water Pump	Condenser Water Pump	Cooling Tower Fan
High School	Central	CV noecon	1,953	1,372	1,311	1,881	855
High School	Coastal	CV noecon	1,953	1,398	1,313	1,882	848
High School	Northern	CV noecon	1,953	1,342	1,259	1,848	768
High School	Pine Barrens	CV noecon	1,953	1,344	1,350	1,875	860
High School	Southwest	CV noecon	1,953	1,335	1,310	1,872	835
High School	**Statewide Average**	**CV noecon**	**1,953**	**1,364**	**1,307**	**1,874**	**838**
High School	Central	VAV	1,522	1,120	969	1,583	489
High School	Coastal	VAV	1,502	1,132	1,042	1,571	462
High School	Northern	VAV	1,480	1,099	1,007	1,539	384
High School	Pine Barrens	VAV	1,520	1,146	973	1,592	512
High School	Southwest	VAV	1,507	1,141	995	1,581	477
High School	**Statewide Average**	**VAV**	**1,510**	**1,124**	**990**	**1,574**	**468**
High School	Central	Unknown	1,655	1,160	1,076	1,638	565
High School	Coastal	Unknown	1,642	1,172	1,128	1,631	542
High School	Northern	Unknown	1,627	1,138	1,099	1,598	464
High School	Pine Barrens	Unknown	1,654	1,176	1,098	1,647	585
High School	Southwest	Unknown	1,645	1,171	1,094	1,638	553
High School	**Statewide Average**	**Unknown**	**1,647**	**1,161**	**1,093**	**1,631**	**545**
Large Office	Central	CV econ	4,956	2,938	2,435	4,273	558
Large Office	Coastal	CV econ	4,966	2,972	2,495	4,328	476
Large Office	Northern	CV econ	4,963	2,922	2,529	4,290	379
Large Office	Pine Barrens	CV econ	4,950	2,967	2,465	4,329	512
Large Office	Southwest	CV econ	4,917	2,973	2,462	4,323	567
Large Office	**Statewide Average**	**CV econ**	**4,954**	**2,948**	**2,467**	**4,297**	**510**
Large Office	Central	CV noecon	4,955	3,418	2,421	5,076	678
Large Office	Coastal	CV noecon	4,960	3,473	2,479	5,183	605
Large Office	Northern	CV noecon	4,953	3,431	2,512	5,133	499
Large Office	Pine Barrens	CV noecon	4,946	3,435	2,449	5,137	633
Large Office	Southwest	CV noecon	4,904	3,450	2,446	5,134	689
Large Office	**Statewide Average**	**CV noecon**	**4,949**	**3,434**	**2,452**	**5,116**	**632**

Facility Type	Climate	HVAC System	HVAC Fan Motor	Chilled Water Pump	Hot Water Pump	Condenser Water Pump	Cooling Tower Fan
Large Office	Central	VAV	3,866	2,810	2,268	3,937	289
Large Office	Coastal	VAV	3,862	2,815	2,295	3,957	239
Large Office	Northern	VAV	3,914	2,779	2,338	3,949	182
Large Office	Pine Barrens	VAV	3,900	2,827	2,291	3,964	266
Large Office	Southwest	VAV	3,837	2,848	2,291	3,985	304
Large Office	**Statewide Average**	**VAV**	**3,874**	**2,811**	**2,289**	**3,951**	**262**
Large Office	Central	Unknown	4,018	2,861	2,290	4,040	335
Large Office	Coastal	Unknown	4,016	2,872	2,322	4,069	282
Large Office	Northern	Unknown	4,060	2,835	2,364	4,056	218
Large Office	Pine Barrens	Unknown	4,047	2,879	2,314	4,072	309
Large Office	Southwest	Unknown	3,987	2,899	2,314	4,089	350
Large Office	**Statewide Average**	**Unknown**	**4,025**	**2,865**	**2,313**	**4,056**	**305**
Large Retail	Central	CV econ	4,540	2,364	2,183	3,531	1,124
Large Retail	Coastal	CV econ	4,540	2,334	2,181	3,503	1,051
Large Retail	Northern	CV econ	4,540	2,283	2,191	3,457	905
Large Retail	Pine Barrens	CV econ	4,540	2,368	2,184	3,552	1,123
Large Retail	Southwest	CV econ	4,540	2,369	2,185	3,539	1,130
Large Retail	**Statewide Average**	**CV econ**	**4,540**	**2,347**	**2,184**	**3,517**	**1,075**
Large Retail	Central	CV noecon	4,540	2,633	2,123	3,840	1,314
Large Retail	Coastal	CV noecon	4,540	2,614	2,118	3,813	1,257
Large Retail	Northern	CV noecon	4,540	2,568	2,127	3,774	1,088
Large Retail	Pine Barrens	CV noecon	4,540	2,632	2,125	3,845	1,306
Large Retail	Southwest	CV noecon	4,540	2,637	2,124	3,838	1,315
Large Retail	**Statewide Average**	**CV noecon**	**4,540**	**2,619**	**2,123**	**3,825**	**1,266**
Large Retail	Central	VAV	4,201	2,276	1,901	3,215	746
Large Retail	Coastal	VAV	4,176	2,251	1,893	3,181	685
Large Retail	Northern	VAV	4,172	2,203	1,910	3,144	560
Large Retail	Pine Barrens	VAV	4,201	2,279	1,901	3,207	732
Large Retail	Southwest	VAV	4,183	2,280	1,898	3,229	750
Large Retail	**Statewide Average**	**VAV**	**4,190**	**2,260**	**1,901**	**3,198**	**704**

Facility Type	Climate	HVAC System	HVAC Fan Motor	Chilled Water Pump	Hot Water Pump	Condenser Water Pump	Cooling Tower Fan
Large Retail	Central	Unknown	4,255	2,311	1,941	3,291	822
Large Retail	Coastal	Unknown	4,234	2,287	1,934	3,258	760
Large Retail	Northern	Unknown	4,231	2,239	1,950	3,219	630
Large Retail	Pine Barrens	Unknown	4,256	2,315	1,941	3,286	809
Large Retail	Southwest	Unknown	4,240	2,316	1,939	3,303	826
Large Retail	**Statewide Average**	**Unknown**	**4,246**	**2,296**	**1,941**	**3,274**	**778**
University	Central	CV econ	3,943	2,792	3,318	3,307	1,319
University	Coastal	CV econ	3,943	2,867	3,280	3,292	1,276
University	Northern	CV econ	3,943	2,869	3,311	3,268	1,142
University	Pine Barrens	CV econ	3,943	2,555	3,277	3,336	1,386
University	Southwest	CV econ	3,943	2,850	3,287	3,316	1,360
University	**Statewide Average**	**CV econ**	**3,943**	**2,797**	**3,303**	**3,302**	**1,294**
University	Central	CV noecon	3,943	3,212	3,228	3,714	1,866
University	Coastal	CV noecon	3,943	3,286	3,240	3,680	1,832
University	Northern	CV noecon	3,943	3,163	3,273	3,652	1,676
University	Pine Barrens	CV noecon	3,943	3,213	3,244	3,679	1,870
University	Southwest	CV noecon	3,943	3,207	3,224	3,693	1,883
University	**Statewide Average**	**CV noecon**	**3,943**	**3,215**	**3,239**	**3,692**	**1,830**
University	Central	VAV	2,548	2,503	2,977	3,246	1,192
University	Coastal	VAV	2,608	2,368	2,452	3,253	1,175
University	Northern	VAV	2,553	2,503	2,618	3,196	1,002
University	Pine Barrens	VAV	2,642	2,531	2,349	3,275	1,268
University	Southwest	VAV	2,605	2,257	3,116	3,267	1,248
University	**Statewide Average**	**VAV**	**2,575**	**2,457**	**2,778**	**3,244**	**1,172**
University	Central	Unknown	2,980	2,658	3,069	3,328	1,316
University	Coastal	Unknown	3,021	2,588	2,702	3,325	1,293
University	Northern	Unknown	2,984	2,662	2,827	3,278	1,128
University	Pine Barrens	Unknown	3,045	2,640	2,632	3,347	1,380
University	Southwest	Unknown	3,020	2,496	3,159	3,341	1,364
University	**Statewide Average**	**Unknown**	**2,999**	**2,627**	**2,931**	**3,322**	**1,293**

8 APPENDIX E: CODE-COMPLIANT EFFICIENCIES

This appendix includes code-compliant effincies for HVAC and hot water equipment. These efficiency ratings should be used as baseline parameters according to the following guidelines, unless otherwise specified in the measure:

- When a measure calls for code baseline (TOS/NC), use the current NJ building code. At the time of this writing, NJ energy code is defined by ASHRAE 90.1-2019 and IECC 2021.
- When a measure calls for exising baseline (EREP/RF/ERET), use the actual site-specific efficiency if possible. If the site-specific efficiency is unknown, use the code-compliant efficiency from the year of installation. Code-compliant efficiencies from 2013 (10 year vintage) are included here and may be used if the installation year cannot be estimated.

8.1 CONVERTING BETWEEN SEER/SEER2, HSPF/HSPF2

To covert between SEER and SEER2 or HSPF and HSPF2, use the table below (interpolate as needed)

Table 8-1 SEER/SEER2 and HSPF/HSPF2 Conversions

SEER2	SEER	HSPF2	HSPF
13.4	14	6.7	8.0
14.3	15	7.1	8.5
15.2	16	7.5	8.8
16	17	7.8	9.2
17	18	8	9.5
18	19	8.4	10
19	20	8.5	10.2
20	21	8.9	10.8
21	22	9.1	11
22	23	9.3	11.3
23	24	9.7	11.9
		10	12.4
		10.4	12.9

EER2 may be calculated from the ratio of SEER to SEER2:

$$EER2 = EER \times \frac{SEER2}{SEER}$$

For example, EER2 values for SEER rated split system air conditioners and split system heat pumps are shown below.

Table 8-2 EER/EER2 Conversions

Equipment Type	SEER	SEER2	EER	EER2	EER2/EER
Split system Air conditioner	14	13.4	11.3	10.8	0.96
Split system heat pump	15	14.3	12.1	11.5	0.95

8.2 HVAC EFFICIENCIES – CURRENT CODE

The minimum efficiencies in this section reflect current NJ energy code requirements. At the time of this writing, NJ energy code is defined by ASHRAE 90.1-2019 (commercial) and IECC 2021 (residential). Note that IECC 2021 Section R403.7 states "New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law." As such, the values for residential sized equipment are from The Code of Federal Regulations 10 CFR 430.32, 2024. The values for commercial sized equipment, or any equipment not present in the 10 CFR 430.32, are from ASHRAE 90.1-2019.

Table 8-2 Central AC and Air Source Heat Pumps

Equipment Capacity	Heating Type	Minimum Cooling Efficiency	Minimum Heating Efficiency
Air Source Air Conditioners			
< 65,000 Btu/h	All	13.4 SEER2	N/A
≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance	11.2 EER, 14.8 IEER	N/A
	Other	11 EER, 14.6 IEER	
≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance	11 EER, 14.2 IEER	N/A
	Other	10.8 EER, 14 IEER	
≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance	10 EER, 13.2 IEER	N/A
	Other	9.8 EER, 13 IEER	
≥ 760,000 Btu/h	Electric Resistance	9.7 EER, 12.5 IEER	N/A
	Other	9.5 EER, 12.3 IEER	

Equipment Capacity	Heating Type	Minimum Cooling Efficiency	Minimum Heating Efficiency
Air Source Heat Pumps			
< 65,000 Btu/h	All	14.3 SEER2 (Split), 13.4 SEER2 (Package)	7.5 HSPF2 (Split), 6.7 HSPF2 (Package)
≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance	11.0 EER, 14.1 IEER	3.4 COPH (47F db/43F wb OA) 2.25 COPH (17F db/15F wb OA)
	Other	10.8 EER, 13.9 IEER	
≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance	10.6 EER, 13.5 IEER	3.2 COPH (47F db/43F wb OA) 2.05 COPH (17F db/15F wb OA)
	Other	10.4 EER, 13.3 IEER	
≥ 240,000 Btu/h	Electric Resistance	9.5 EER, 12.5 IEER	3.2 COPH (47F db/43F wb OA) 2.05 COPH (17F db/15F wb OA)
	Other	9.3 EER, 12.3 IEER	
Water-cooled air conditioner			
< 65,000 Btu/h	All	12.1 EER, 12.3 IEER	N/A
≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance	12.1 EER, 13.9 IEER	N/A
	Other	11.9 EER, 13.7 IEER	
≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance	12.5 EER, 13.9 IEER	N/A
	Other	12.3 EER, 13.7 IEER	
≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance	12.4 EER, 13.6 IEER	N/A
	Other	12.2 EER, 13.4 IEER	
≥ 760,000 Btu/h	Electric Resistance	12.2 EER, 13.5 IEER	N/A
	Other	12.0 EER, 13.3 IEER	
Evaporatively-cooled Air Conditioner			
< 65,000 Btu/h	All	12.1 EER, 12.3 IEER	N/A
≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance	12.1 EER, 12.3 IEER	N/A
	Other	11.9 EER, 12.1 IEER	
≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance	12.0 EER, 12.2 IEER	N/A
	Other	11.8 EER, 12.0 IEER	

Equipment Capacity	Heating Type	Minimum Cooling Efficiency	Minimum Heating Efficiency
≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance	11.9 EER, 12.1 IEER	N/A
	Other	11.7 EER, 11.9 IEER	
≥ 760,000 Btu/h	Electric Resistance	11.7 EER, 11.9 IEER	N/A
	Other	11.5 EER, 11.7 IEER	

Table 8-3 Water Source and Ground Source Heat Pumps

Equipment Type	Size Category	Minimum Cooling Efficiency	Minimum Heating Efficiency
Water-to-air, water loop	< 17,000 Btu/h	12.2 EER	4.3 COP
	≥ 17,000 Btu/h and < 65,000 Btu/h	13.0 EER	4.3 COP
	≥ 65,000 Btu/h and < 135,000 Btu/h	13.0 EER	4.3 COP
Water-to-air, ground water	< 135,000 Btu/h	18.0 EER	3.7 COP
Brine-to-air, ground loop	< 135,000 Btu/h	14.1 EER	3.2 COP
Water-to-water, water loop	< 135,000 Btu/h	10.6 EER	4.3 COP
Water-to-water, ground water	< 135,000 Btu/h	16.3 EER	3.1 COP
Brine-to-water, ground loop	< 135,000 Btu/h	12.1 EER	2.5 COP

Table 8-4 PTAC, PTHP, SVAC, SVHP

Equipment Type	Size Category (Input)	Minimum Cooling Efficiency	Minimum Heating Efficiency
PTAC (standard size)	< 7,000 Btu/h	11.9 EER	
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h	14.0 - (0.300 x Cap/1,000) EER	
	> 15,000 Btu/h	9.5 EER	
PTAC (nonstandard size)	< 7,000 Btu/h	9.4 EER	
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h	10.9 - (0.213 x Cap/1,000) EER	
	> 15,000 Btu/h	7.7 EER	
PTHP (standard size)	< 7,000 Btu/h	11.9 EER	3.3 COP

Equipment Type	Size Category (Input)	Minimum Cooling Efficiency	Minimum Heating Efficiency
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h	14.0 - (0.300 x Cap/1,000) EER	3.7 - (0.052 x Cap/1,000) COP
	> 15,000 Btu/h	9.5 EER	2.9 COP
PTHP (nonstandard size)	< 7,000 Btu/h	9.3 EER	2.7 COP
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h	10.8 - (0.213 x Cap/1,000) EER	2.9 - (0.026 x Cap/1000) COP
	> 15,000 Btu/h	7.6 EER	2.5 COP
SPVAC	< 65,000 Btu/h	11 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	10 EER	
	≥ 135,000 Btu/h and ≤ 240,000 Btu/h	10.1 EER	
SPVHP	< 65,000 Btu/h	11 EER	3.3 COP
	≥ 65,000 Btu/h and < 135,000 Btu/h	10 EER	3.0 COP
	≥ 135,000 Btu/h and ≤ 240,000 Btu/h	10.1 EER	3.0 COP

Table 8-5 Boilers

Boiler Type	Size Category (kBtu input)	Minimum Efficiency
Hot Water- Gas Fired	Residential only	84% AFUE
	<300	82% AFUE
	≥300 and ≤ 2,500	80% Et
	>2,500	82% Ec
Hot Water- Oil Fired	Residential only	86% AFUE
	<300	84% AFUE
	≥300 and ≤ 2,500	82% Et
	>2,500	84% Ec
Steam- Gas Fired	Residential only	82% AFUE
	<300	80% AFUE
Steam- Gas Fired All except Natural Draft	≥300 and ≤ 2,500	79% Et
	>2,500	79% Et
Steam- Gas Fired Natural Draft	≥300 and ≤ 2,500	79% Et

Boiler Type	Size Category (kBtu input)	Minimum Efficiency
	>2,500	79% Et
Steam-Oil Fired	Residential only	82% AFUE
	<300	82% AFUE
	≥300 and ≤ 2,500	81% Et
	>2,500	81% Et

Table 8-6 Furnaces

Equipment Type	Size Category (kBtu input)	Minimum Efficiency
Gas Fired Furnace	< 225	Nonweatherized 80% AFUE
		Weatherized 81% AFUE
Gas Fired Furnace	≥ 225	81% Et
Oil Fired Furnace	< 225	Nonweatherized excluding mobile home: 83% AFUE
		Nonweatherized mobile home: 75% AFUE
		Weatherized: 78% AFUE
Oil Fired Furnace	≥ 225	82% Et
Gas Fired Unit Heaters	All Capacities	80% Ec
Oil Fired Unit Heaters	All Capacities	80% Ec

Table 8-7 Room AC

Equipment Type	Size Category (Btu/h input)	Minimum Efficiency
Room air conditioners without reverse cycle with louvered sides	<6,000 Btu/h	11.0 CEER
	≥6,000 Btu/h and <8,000 Btu/h	11.0 CEER
	≥8,000 Btu/h and <14,000 Btu/h	10.9 CEER
	≥14,000 Btu/h and <20,000 Btu/h	10.7 CEER
	≥20,000 Btu/h and <28,000 Btu/h	9.4 CEER
	≥28,000 Btu/h	9.0 CEER
Room air conditioners without reverse cycle without louvered sides	<6,000 Btu/h	10.0 CEER
	≥6,000 Btu/h and <8,000 Btu/h	10.0 CEER
	≥8,000 Btu/h and <11,000 Btu/h	10.0 CEER
	≥11,000 Btu/h and <14,000 Btu/h	9.6 CEER
	≥14,000 Btu/h and <20,000 Btu/h	9.5 CEER
	≥20,000 Btu/h	9.3 CEER
	<6,000 Btu/h	9.4 CEER
	<20,000 Btu/h	9.8 CEER

Room air conditioners with reverse cycle, with louvered sides	≥20,000 Btu/h	9.3 CEER
Room air conditioners with reverse cycle without louvered sides	<14,000 Btu/h	9.3 CEER
	≥14,000 Btu/h	8.7 CEER
Room air conditioners, casement only	All	9.5 CEER
Room air conditioners, casement slider	All	10.4 CEER

8.3 HVAC EFFICIENCIES – VINTAGE CODE

The minimum efficiencies in this section reflect NJ energy code requirements from approximately 10 years ago. At the time of this writing, NJ energy code is defined by ASHRAE 90.1-2019 (commercial) and IECC 2021 (residential). Note that IECC 2021 Section R403.7 states "New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law." As such, the values for residential sized equipment are from The Code of Federal Regulations 10 CFR 430.32, 2010. The values for commercial sized equipment, or any equipment not present in the CFR, are from ASHRAE 90.1-2013.

Table 8-8 Central AC and Air Source Heat Pumps

Equipment Type and Capacity	Heating Type	Minimum Cooling Efficiency	Minimum Heating Efficiency
Air Source Air Conditioners			
< 65,000 Btu/h	All	13 SEER	N/A
≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance	11.2 EER, 12.9 IEER	N/A
	Other	11.0 EER, 12.7 IEER	
≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance	11.0 EER, 12.4 IEER	N/A
	Other	10.8 EER, 12.2 IEER	
≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance	10.0 EER, 11.6 IEER	N/A
	Other	9.8 EER, 11.4 IEER	
≥ 760,000 Btu/h	Electric Resistance	9.7 EER, 11.2 IEER	N/A
	Other	9.5 EER, 11.0 IEER	
Air Source Heat Pumps			
< 65,000 Btu/h	All	14 SEER	8.2 HSPF (Split), 8.0 HSPF (Package)
≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance	11 EER, 12.2 IEER	3.3 COP_H (47F db/43F wb OA) 2.25 COP_H (17F db/15F wb OA)
	Other	10.8 EER, 12.0 IEER	
≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance	10.6 EER, 11.6 IEER	3.2 COP_H (47F db/43F wb OA) 2.05 COP_H (17F db/15F wb OA)
	Other	10.4 EER, 11.4 IEER	

≥ 240,000 Btu/h	Electric Resistance	9.5 EER, 10.6 IEER	3.2 COP_H (47F db/43F wb OA) 2.05 COP_H (17F db/15F wb OA)
	Other	9.3 EER, 10.4 IEER	
Water-cooled air conditioner			
< 65,000 Btu/h	All	12.1 EER, 12.3 IEER	N/A
≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance	12.1 EER, 13.9 IEER	N/A
	Other	11.9 EER, 13.7 IEER	
≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance	12.5 EER, 13.9 IEER	N/A
	Other	12.3 EER, 13.7 IEER	
≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance	12.4 EER, 13.6 IEER	N/A
	Other	12.2 EER, 13.4 IEER	
≥ 760,000 Btu/h	Electric Resistance	12.2 EER, 13.5 IEER	N/A
	Other	12.0 EER, 13.3 IEER	
Evaporatively-cooled Air Conditioner			
< 65,000 Btu/h	All	12.1 EER, 12.3 IEER	N/A
≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance	12.1 EER, 12.3 IEER	N/A
	Other	11.9 EER, 12.1 IEER	
≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance	12.0 EER, 12.2 IEER	N/A
	Other	11.8 EER, 12.0 IEER	
≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance	11.9 EER, 12.1 IEER	N/A
	Other	11.7 EER, 11.9 IEER	
≥ 760,000 Btu/h	Electric Resistance	11.7 EER, 11.9 IEER	N/A
	Other	11.5 EER, 11.7 IEER	

Table 8-9 Water and Ground Source Heat Pump

Equipment Type	Size Category	Minimum Cooling Efficiency	Minimum Heating Efficiency
Water-to-air, water loop	< 17,000 Btu/h	12.2 EER	4.3 COP
	≥ 17,000 Btu/h and < 65,000 Btu/h	13.0 EER	4.3 COP
	≥ 65,000 Btu/h and < 135,000 Btu/h	13.0 EER	4.3 COP
Water-to-air, ground water	< 135,000 Btu/h	18.0 EER	3.7 COP
Brine-to-air, ground loop	< 135,000 Btu/h	14.1 EER	3.2 COP
Water-to-water, water loop	< 135,000 Btu/h	10.6 EER	3.7 COP
Water-to-water, ground water	< 135,000 Btu/h	16.3 EER	3.1 COP
Brine-to-water, ground loop	< 135,000 Btu/h	12.1 EER	2.5 COP

Table 8-10 PTAC, PTHP, SPVAC, SVHP

Equipment Type	Size Category (Input)	Minimum Cooling Efficiency	Minimum Heating Efficiency
PTAC	All	13.8 - (0.30 x Cap/1,000) EER	
PTHP	All	14 - (0.30 x Cap/1,000) EER	3.2 - (0.023 x Cap/1,000) COP
SPVAC	< 65,000 Btu/h	9.0 EER	
SVHP	< 65,000 Btu/h	9.0 EER	3.0 COP

Table 8-11 Boilers

Boiler Type	Size Category (kBtu input)	Minimum Efficiency
Hot Water- Gas Fired	Residential only	82% AFUE
	<300	80% AFUE
	≥300 and ≤ 2,500	80% Et
	>2,500	82% Ec
Hot Water- Oil Fired	Residential only	84% AFUE
	<300	80% AFUE
	≥300 and ≤ 2,500	82% Et
	>2,500	84% Ec
Steam- Gas Fired	Residential only	80% AFUE
	<300	75% AFUE
Steam- Gas Fired All except Natural Draft	≥300 and ≤ 2,500	79% Et
	>2,500	79% Et
Steam- Gas Fired Natural Draft	≥300 and ≤ 2,500	77% Et
	>2,500	77% Et
Steam-Oil Fired	Residential only	82% AFUE
	<300	80% AFUE
	≥300 and ≤ 2,500	81% Et

Table 8-12 Furnaces

Equipment Type	Size Category (kBtu input)	Minimum Efficiency
Gas Fired Furnace	< 225	78% AFUE or 80% E_t

Gas Fired Furnace	≥ 225	80% Ec
Oil Fired Furnace	< 225	78% AFUE or 80% E_t
Oil Fired Furnace	≥ 225	81% Et
Gas Fired Unit Heaters	All Capacities	80% Ec
Oil Fired Unit Heaters	All Capacities	80% Ec

Table 8-13 Room AC

Equipment Type	Size Category (kBtu input)	Minimum Efficiency
Room air conditioners without louvered sides	<8,000 Btu/h	9.0 EER
	≥8,000 Btu/h and <20,000 Btu/h	8.5 EER
	≥20,000 Btu/h	8.5 EER
Room air conditioner heat pumps with louvered sides	<20,000 Btu/h	9.0 EER
	≥20,000 Btu/h	8.5 EER
Room air conditioner heat pumps without louvered sides	<14,000 Btu/h	8.5 EER
	≥14,000 Btu/h	8.0 EER
Room air conditioner, casement only	All	8.7 EER
Room air conditioner, casement slider	All	9.5 EER

8.4 WATER HEATING EFFICIENCIES - CURRENT CODE

The minimum efficiencies in this section reflect current NJ energy code requirements. At the time of this writing, NJ energy code is defined by ASHRAE 90.1-2019 (commercial) and IECC 2021 (residential). Note that IECC 2021 Section R403.7 states "New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law." The values in the table below are the same in the Code of Federal Regulations 10 CFR 430.32(d) 2024 and ASHRAE 90.1-2019.

Table 8-14 Minimum Uniform Energy Factor (UEF)

Product Class	Rated Storage Volume and Input Rating	First Hour Rating	Draw Pattern	UEF
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	< 18 gallons	Very Small	$0.8808 - (0.0008 \times v_t)$
		≥ 18 and < 51 gallons	Low	$0.9254 - (0.0003 \times v_t)$
		≥ 51 and < 75 gallons	Medium	$0.9307 - (0.0002 \times v_t)$
		≥ 75 gallons	High	$0.9349 - (0.0001 \times v_t)$
	> 55 gal and ≤ 120 gal	< 18 gallons	Very Small	$1.9236 - (0.0011 \times v_t)$
		≥ 18 and < 51 gallons	Low	$2.0440 - (0.0011 \times v_t)$
		≥ 51 and < 75 gallons	Medium	$2.1171 - (0.0011 \times v_t)$

Product Class	Rated Storage Volume and Input Rating	First Hour Rating	Draw Pattern	UEF
		≥ 75 gallons	High	$2.2418 - (0.0011 \times v_t)$
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	< 18 gallons	Very Small	$0.3456 - (0.0020 \times v_t)$
		≥ 18 and < 51 gallons	Low	$0.5982 - (0.0019 \times v_t)$
		≥ 51 and < 75 gallons	Medium	$0.6483 - (0.0017 \times v_t)$
		≥ 75 gallons	High	$0.6920 - (0.0013 \times v_t)$
	> 55 gal and ≤ 100 gal	< 18 gallons	Very Small	$0.6470 - (0.0006 \times v_t)$
		≥ 18 and < 51 gallons	Low	$0.7689 - (0.0005 \times v_t)$
		≥ 51 and < 75 gallons	Medium	$0.7897 - (0.0004 \times v_t)$
		≥ 75 gallons	High	$0.8072 - (0.0003 \times v_t)$
Instantaneous Electric Water Heater	<2 gal	N/A	Very small	0.91
			Low	0.91
			Medium	0.91
			High	0.92
Instantaneous Gas-Fired Water Heater	<2 gal and >50,000 Btu/h	N/A	Very small	0.80
			Low	0.81
			Medium	0.81
			High	0.81

Vt = rated storage volume in gallons

8.5 WATER HEATING EFFICIENCIES – VINTAGE CODE

The minimum efficiencies in this section reflect NJ energy code requirements from approximately 10 years ago. At the time of this writing, NJ energy code is defined by ASHRAE 90.1-2019 (commercial) and IECC 2021 (residential). Note that IECC 2021 Section R403.7 states “New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law.” As such, the values for residential equipment are from The Code of Federal Regulations 10 CFR 430.32, 2010 for products manufactured after January 2024 and before April 2015. The values for commercial sized equipment are from ASHRAE 90.1-2013.

Table 8-15 Residential Minimum Energy Factor (EF)

Product Class	EF
Electric Storage Water Heater	$0.97 - (0.00132 \times v_t)$
Electric Instantaneous Water Heater	$0.93 - (0.00132 \times v_t)$
Gas-Fired Storage Water Heater	$0.67 - (0.0019 \times v_t)$
Gas Intantaneous Water Heater	$0.62 - (0.0019 \times v_t)$
Oil Storage Water Heater	$0.59 - (0.0019 \times v_t)$

Vt = rated storage volume in gallons

Table 8-16 Commercial Minimum Energy Factor (EF)

Product Class	EF
Electric Storage Water Heater	$0.97 - (0.00035 \times v_t)$
Electric Instantaneous Water Heater	Default to CFR: $0.93 - (0.00132 \times v_t)$
Gas-Fired Storage Water Heater	$0.67 - (0.0005 \times v_t)$
Gas Intantaneous Water Heater	$0.62 - (0.0005 \times v_t)$
Oil Storage Water Heater	$0.59 - (0.0005 \times v_t)$

9 APPENDIX F: HVAC INTERACTIVITY FACTORS

The values below are taken from NY TRM v10, Appendix D, for NYC. NYC climate is the most similar to a statewide NJ approximation of the NY weather cities. These values are to be used if there is not a measure-specific value presented. If the building and/or HVAC system type is unknown, the default values in Table 9-1 may be used.

Table 9-1 Default Values

HVACc	HVACd	HVACff
0.080	0.175	-0.002

Table 9-2 Residential and Small Commercial

Building Type	AC with fuel heat			Heat Pump			AC with electric heat			Electric heat only			Fuel Heat only		
	HVACc	HVACd	HVACff	HVACc	HVACd	HVACff	HVACc	HVACd	HVACff	HVACc	HVACd	HVACff	HVACc	HVACd	HVACff
Single-Family Residential	0.077	0.085	-0.002	-0.105	0.111	0.000	-0.579	0.085	0.000	-0.403	0.000	0.000	0.000	0.000	-0.002
Multifamily low rise	0.055	0.136	-0.002	-0.064	0.163	0.000	-0.260	0.136	0.000	-0.320	0.000	0.000	-0.005	0.000	-0.002
Assembly	0.160	0.200	-0.002	-0.052	0.200	0.000	-0.243	0.200	0.000	-0.400	0.000	0.000	0.000	0.000	-0.002
Auto Repair	0.076	0.200	-0.004	-0.308	0.200	0.000	-0.795	0.200	0.000	-0.891	0.000	0.000	0.000	0.000	-0.004
Big Box	0.170	0.200	-0.001	0.055	0.200	0.000	-0.065	0.200	0.000	-0.226	0.000	0.000	0.000	0.000	-0.001
Elementary School	0.110	0.200	-0.003	-0.150	0.200	0.000	-0.481	0.200	0.000	-0.646	0.000	0.000	0.000	0.000	-0.003
Fast Food	0.110	0.200	-0.003	-0.471	0.200	0.000	-0.471	0.200	0.000	-0.827	0.000	0.000	0.000	0.000	-0.004
Full Service Restaurant	0.110	0.200	-0.003	-0.486	0.200	0.000	-0.486	0.200	0.000	-0.637	0.000	0.000	0.000	0.000	-0.003
Grocery	0.170	0.200	-0.001	0.055	0.200	0.000	-0.065	0.200	0.000	-0.226	0.000	0.000	0.000	0.000	-0.001
Light Industrial	0.100	0.200	-0.002	-0.083	0.200	0.000	-0.313	0.200	0.000	-0.415	0.000	0.000	0.000	0.000	-0.002
Motel	0.114	0.200	-0.002	-0.155	0.200	0.000	-0.340	0.200	0.000	-0.482	0.000	0.000	0.000	0.000	-0.002
Religious	0.092	0.200	-0.001	-0.060	0.200	0.000	-0.199	0.200	0.000	-0.291	0.000	0.000	0.000	0.000	-0.001
Small Office	0.120	0.200	-0.002	-0.003	0.200	0.000	-0.157	0.200	0.000	-0.239	0.000	0.000	0.000	0.000	-0.001
Small Retail	0.130	0.200	-0.002	-0.044	0.200	0.000	-0.258	0.200	0.000	-0.375	0.000	0.000	0.000	0.000	-0.002
Warehouse	0.078	0.200	-0.002	-0.109	0.200	0.000	-0.273	0.200	0.000	-0.352	0.000	0.000	0.000	0.000	-0.002
Other	0.114	0.200	-0.002	-0.155	0.200	0.000	-0.340	0.200	0.000	-0.482	0.000	0.000	0.000	0.000	-0.002

Table 9-3 Multifamily High Rise and College Dormitory

	Fan coil with chiller and hot water boiler			Steam heat only		
	HVACc	HVACd	HVACff	HVACc	HVACd	HVACff
Multifamily high rise	0.101	0.194	-0.002	0.000	0.000	-0.002
College dormitory	0.025	0.200	-0.001	0.000	0.000	-0.001

Table 9-4 Large Commercial

Facility Type	CV No Econ			CV Econ			VAV Econ		
	HVACc	HVACd	HVACff	HVACc	HVACd	HVACff	HVACc	HVACd	HVACff
Community College	0.044	0.200	-0.003	0.019	0.200	-0.002	0.124	0.200	0.000
High School	0.042	0.200	-0.003	0.022	0.200	-0.003	0.049	0.200	-0.002
Hospital	0.033	0.200	-0.002	0.019	0.200	-0.002	0.065	0.200	-0.001
Hotel	0.033	0.200	-0.002	0.019	0.200	-0.002	0.065	0.200	-0.001
Large Office	0.033	0.200	-0.002	0.019	0.200	-0.002	0.065	0.200	-0.001
Large Retail	0.037	0.200	-0.002	0.023	0.200	-0.002	0.057	0.200	-0.002
University	0.048	0.200	-0.003	0.020	0.200	-0.003	0.142	0.200	-0.001

Table 9-5 Refrigerated Warehouse

Facility Type	Water Cooled Ammonia Screw Compressors	
	HVACc	HVACd
Refrigerated Warehouse	0.390	0.200

10 APPENDIX G: NATURAL GAS PEAK DAY FACTORS

Peak gas savings are calculated on a therm/day basis, using peak day heating degree-days representing the weather conditions under which the natural gas distribution system reaches peak capacity. Design day conditions from the London Economics study are used to calculate peak gas savings:[192]

Table 10-1 Design Day Conditions

Condition	Average Heating Degree days base 65 (Deg F – day)	Average Daily Temperature (Deg F)
Winter Design Day	66.4	-1.4

Peak Day Factors (PDF) are defined as the ratio of the gas savings during the gas peak day to the annual gas savings. Peak day factors are defined using one of four methods depending on the measure type:

Table 10-2 Peak Day Factor Methods

Peak Day Factor Method	Definition	Measure Type
1 - day per year ratio	= 1/days per year	Used for non weather sensitive measure that may be in operation for different number of days per year.
2 - FLH ratio	FLH (peak gas day) / Annual FLH	Weather sensitive measures where the annual savings are expressed as a function of heating equivalent full load hours
3 - HDD ratio	HDD peak gas day / Annual HDD	Weather sensitive measures where the annual savings are expressed as a function of heating degree days
4 - hr per year ratio	24 / annual heating hr per year	HVAC interactive effects of lighting or other internal loads on heating energy

10.1 MEASURE LIST

The following Table shows the PDF method assignment and the PDF value or PDF table lookup for each measure in the TRM. Note, if the PDF method is N/A, the measure does not save gas during the peak day and the PDF is zero.

Table 10-3 Residential Measure PDF Method Assignment

End-Use	Measure Name	PDF method	PDF
Appliance Recycling	Dehumidifier recycling	N/A	
Appliance Recycling	Refrigerator & Freezer recycling	N/A	
Appliance Recycling	Room A/C recycling	N/A	

[192] Reference London Economics study

End-Use	Measure Name	PDF method	PDF
Appliances	Air purifier	N/A	
Appliances	Clothes dryer	1 - day per year ratio	0.002740
Appliances	Clothes washer	1 - day per year ratio	0.002740
Appliances	Dehumidifier	N/A	
Appliances	Dishwasher	1 - day per year ratio	0.002740
Appliances	Freezer	N/A	
Appliances	Range	1 - day per year ratio	0.002740
Appliances	Refrigerator	N/A	
Appliances	Room A/C	N/A	
Appliances	Water cooler	N/A	
HVAC	Boiler controls	N/A	
HVAC	Ceiling fan	N/A	
HVAC	Central AC, Heat Pumps, Mini-Splits, PTAC, PTHP	2 - FLH ratio	See Table 10-8
HVAC	Duct insulation & sealing	2 - FLH ratio	See Table 10-8
HVAC	EC Motors	2 - FLH ratio	See Table 10-8
HVAC	Filter whistle	N/A	
HVAC	Furnace	2 - FLH ratio	See Table 10-8
HVAC	Ground Loop and Air-to-Water Heat Pump	N/A	
HVAC	Heat or energy recovery ventilator	2 - FLH ratio	See Table 10-8
HVAC	Maintenance	2 - FLH ratio	See Table 10-8
HVAC	Smart Thermostat	2 - FLH ratio	See Table 10-8
HVAC	Ventilation fan	N/A	
Lighting	Controls	2 - FLH ratio	See Table 10-8
Lighting	Lamps and fixtures	2 - FLH ratio	See Table 10-8
Plug load	EV charger	N/A	
Plug load	Office equipment	1 - day per year ratio	0.002740
Plug load	Smart strip	N/A	
Plug load	Sound bar	N/A	
Plug load	Televisions	N/A	
Shell	Air sealing	3 - HDD ratio	See Table 10-11
Shell	Insulation	3 - HDD ratio	See Table 10-11
Water heating	Faucet aerator	1 - day per year ratio	0.002740

End-Use	Measure Name	PDF method	PDF
Water heating	Heat pump water heater	1 - day per year ratio	0.002740
Water heating	Indirect water heater	1 - day per year ratio	0.002740
Water heating	Pipe insulation	1 - day per year ratio	0.002740
Water heating	Pool pump	N/A	
Water heating	Storage water heater	1 - day per year ratio	0.002740
Water heating	Tankless water heater	1 - day per year ratio	0.002740
Water heating	Thermostatic showerhead	1 - day per year ratio	0.002740
Water heating	Water heating controls	1 - day per year ratio	0.002740
Whole building	Behavior	2 - FLH ratio	See Table 10-8
Whole building	Home Performance with Energy Star (HPwES)	2 - FLH ratio	See Table 10-8

Table 10-4 Commercial and Industrial Measures PDF Method Assignment

End-Use	Measure Name	PDF method	PDF
Agriculture	Auto Milker Takeoff	N/A	
Agriculture	Dairy pump VFD	N/A	
Agriculture	Dairy Refrigeration Tune-Up	N/A	
Agriculture	Dairy Scroll Compressor	N/A	
Agriculture	Engine Block Heater Timer	N/A	
Agriculture	Heat Reclaimers	1 - day per year ratio	0.002740
Agriculture	Livestock waterer	N/A	
Agriculture	Low pressure irrigation	N/A	
Agriculture	Ventilation fans	N/A	
Appliance Recycling	Dehumidifier Recycling	N/A	
Appliance Recycling	Freezer & Refrigerator Recycling	N/A	
Appliance Recycling	Room A/C Unit Recycling	N/A	
Appliance	Clothes dryer	1 - day per year ratio	See Table 10-6

End-Use	Measure Name	PDF method	PDF
Appliance	Clothes Dryer modulating valve	1 - day per year ratio	See Table 10-6
Appliance	Clothes washer	1 - day per year ratio	See Table 10-6
Appliance	Dehumidifier	N/A	
Appliance	Freezers	N/A	
Appliance	Refrigerators	N/A	
Appliance	Room Air Conditioner	N/A	
Appliance	Water Cooler	N/A	
Foodservice	Dishwashers	1 - day per year ratio	See Table 10-6
Foodservice	Griddles	1 - day per year ratio	See Table 10-6
Foodservice	Holding cabinets	N/A	
Foodservice	Ice Machines	N/A	
HVAC	Advanced Rooftop Controls (ARC)	2 - FLH ratio	See Table 10-9 and Table 10-10
HVAC	Boiler controls	N/A	
HVAC	Boiler economizer	2 - FLH ratio	See Table 10-9 and Table 10-10
HVAC	Central A/C, Air Source Heat Pumps, Mini-Splits, PTAC	N/A	
HVAC	Chillers	N/A	
HVAC	Demand controlled kitchen ventilation	3 - HDD ratio	See Table 10-11
HVAC	Demand controlled ventilation	2 - FLH ratio	See Table 10-9 and Table 10-10
HVAC	EC Motors	4 - hr per year ratio	See Table 10-12 and Table 10-13
HVAC	Economizer controls	N/A	
HVAC	Furnace	2 - FLH ratio	See Table 10-9 and Table 10-10
HVAC	Gas chillers	2 - FLH ratio	See Table 10-9 and Table 10-10
HVAC	Geothermal and Water Source Heat Pumps	N/A	
HVAC	Guest Room EMS	2 - FLH ratio	See Table 10-9 and Table 10-10

End-Use	Measure Name	PDF method	PDF
HVAC	Heat and energy recovery ventilators	2 - FLH ratio	See Table 10-9 and Table 10-10
HVAC	Infrared heating	2 - FLH ratio	See Table 10-9 and Table 10-10
HVAC	Maintenance	2 - FLH ratio	See Table 10-9 and Table 10-10
HVAC	Makeup air unit	2 - FLH ratio	See Table 10-9 and Table 10-10
HVAC	Programmable & Smart Tstats	2 - FLH ratio	See Table 10-9 and Table 10-10
Lighting	Delamping	4 - hr per year ratio	See Table 10-12 and Table 10-13
Lighting	Exit signs	4 - hr per year ratio	See Table 10-12 and Table 10-13
Lighting	Indoor Ag	N/A	
Lighting	LED sign lighting	N/A	
Lighting	Lighting controls	4 - hr per year ratio	See Table 10-12 and Table 10-13
Lighting	Lighting Fixtures	4 - hr per year ratio	See Table 10-12 and Table 10-13
Motors and Drives	Motors	N/A	
Motors and Drives	VFD	N/A	
Plug Load	EV charger	N/A	
Plug Load	Network Power Management	N/A	
Plug Load	Office Equipment	N/A	
Plug Load	Smart strip	N/A	
Plug Load	UPS	N/A	
Plug Load	Vending Machine	N/A	
Plug Load	Vending machine controls	N/A	
Process	Air Compressor	N/A	
Refrigeration	Anti-Sweat Heat Control	N/A	
Refrigeration	Case doors	N/A	
Refrigeration	Case light sensor	N/A	

End-Use	Measure Name	PDF method	PDF
Refrigeration	Defrost controls	N/A	
Refrigeration	Door closer	N/A	
Refrigeration	Door gaskets	N/A	
Refrigeration	Evaporator fan control	N/A	
Refrigeration	Evaporator fan EC motor	N/A	
Refrigeration	Floating head pressure	N/A	
Refrigeration	LED case lighting	N/A	
Refrigeration	Night covers	1 - day per year ratio	See Table 10-6
Refrigeration	Strip curtains	1 - day per year ratio	See Table 10-6
Refrigeration	System controller	N/A	
Refrigeration	VFD compressor	N/A	
Water heating	Aerators & Showerheads	1 - day per year ratio	See Table 10-6
Water heating	Combi boiler	2 - FLH ratio	See Table 10-9 and Table 10-10
Water heating	Heat pump water heater	1 - day per year ratio	See Table 10-6
Water heating	Pipe insulation	1 - day per year ratio	See Table 10-6
Water heating	PRSV	1 - day per year ratio	See Table 10-6
Water heating	Recirc pump	1 - day per year ratio	See Table 10-6
Water heating	Storage water heater	1 - day per year ratio	See Table 10-6
Water heating	Tankless water heater	1 - day per year ratio	See Table 10-6
Whole Building	Custom	2 - FLH ratio	See Table 10-9 and Table 10-10
Whole Building	Operator training	N/A	

10.2 TYPE 1 – DAYS PER YEAR RATIO

The days per year ratio method is used for non-weather sensitive measures and is defined as follows:

PDF = 1/operating days per year

Note the default value is 365 days per year. Operating days per year for Residential and Commercial/Industrial building types and the associated peak day factor is shown in the Tables below:

Table 10-5 Peak Day Factors for Residential Buildings Using the Day per Year Ratio Method

Building Type	Prototype Operation Description	Operating Days/Wk	Operating Wk/Yr	Holidays	Operating Days/Yr	PDF
Single Family	24/7 – 365 days	7	52	0	365	0.00274
Multifamily Low Rise	24/7 – 365 days	7	52	0	365	0.00274
Multifamily High- Rise	24/7 – 365 days	7	52	0	365	0.00274

Table 10-6 Peak Day Factors for Commercial and Industrial Buildings Using the Day Per Year Ratio

Building Type	Prototype Operation Description	Operating Days/Wk	Operating Wk/Yr	Holidays	Operating Days/Yr	PDF
Agricultural	24/7 – 365 days	7	52	0	365	0.00274
Assembly	Mon-Sun: 8am – 9pm	7	52	10	355	0.002817
Auto	Mon-Sun: 9am – 9pm	7	52	10	355	0.002817
Big Box	Mon-Sun: 10am – 9pm	7	52	10	355	0.002817
Community College	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed	6	49	10	284	0.003521
Dormitory	24/7 – 365 days	7	52	10	355	0.002817
Fast Food	Mon-Sun: 6am – 11pm	7	52	10	355	0.002817
Full Service Restaurant	9am – 12am	6	52	10	303	0.003302
Grocery	Mon-Sun: 6am – 10pm	7	52	0	365	0.00274
Hospital	24/7, 365	7	52	0	365	0.00274
Hotel	Rooms: 60% occupied, 40% unoccupied All others: 24 hr / day	7	52	0	365	0.00274
Large Office	Mon-Sat: 9am – 6pm Sun: Unoccupied	6	52	10	303	0.003302
Light Industrial	Mon-Fri: 6am – 6pm Sat Sun: Unoccupied	5	52	10	251	0.003989
Motel	24/7 - 365	7	52	0	365	0.00274
Multi-story Retail	Mon-Sat: 9am – 10pm Sun: 9am – 7pm	7	52	10	355	0.002817

Building Type	Prototype Operation Description	Operating Days/Wk	Operating Wk/Yr	Holidays	Operating Days/Yr	PDF
Primary School	Mon-Fri: 8am – 6pm Sun: 8am – 4pm	6	38	10	218	0.004587
Religious	Mon-Sat: 12pm-6pm Sun: 9am-7pm	7	52	10	355	0.002817
Secondary School	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed	6	38	10	218	0.004587
Small Office	Mon-Sat: 9am – 6pm Sun: Unoccupied	6	52	10	303	0.003302
Small Retail	Mon-Sat: 10 – 10 Sun: 10 – 8	7	52	10	355	0.002817
University	Mon-Fri: 8am – 10pm Sat: 8am – 7pm Sun: closed	6	49	10	284	0.003521
Warehouse	Mon-Fri: 7am – 6pm Sat-Sun: Unoccupied	5	52	10	251	0.003989

10.3 TYPE 2 – FULL LOAD HOUR RATIO

The full load hour method is used for weather sensitive measures where the annual savings are expressed as a function of heating equivalent full load hours. The PDF using this method is defined as:

PDF = FLH (peak gas day) / Annual FLH

The heating equivalent full load hours are calculated based on the assumed oversizing fraction at the ASHRAE heating design temperature for each climate zone and the peak gas day average daily temperature. The amount of heating system oversizing is assumed to vary linearly with the difference between the building heating base temperature and the outdoor temperature. The system oversizing and the number of heating equivalent full load hours during the peak gas day are shown in the Table below:

Table 10-7 Full Load Hours during the Peak Gas Day

Parameter	Northern	Central	Pine Barrens	Southwest	Coastal	Statewide Average
ASHRAE 1% Heating Design Temperature	6	7	3	10	14	
Heating base temperature	65	65	65	65	65	

Parameter	Northern	Central	Pine Barrens	Southwest	Coastal	Statewide Average
Peak Gas Design Temperature	-1.4	-1.4	-1.4	-1.4	-1.4	
Oversizing Factor at ASHRAE Design Temperature	1.2	1.2	1.2	1.2	1.2	
Oversizing Factor at Peak Gas Design Temperature	1.07	1.05	1.12	0.99	0.92	
Peak Gas Day Full Load Hours	22.5	22.9	21.4	24.0	24.0	23.0

For example, the PDF for a high school with a VAV system in the Central climate region is calculated as follows:

PDF = FLH (peak gas day) / Annual FLH

= 22.9 / 254

= 0.09

Residential PDFs are defined as shown in the Table below:

Table 10-8 Residential Building PDFs Using the Full Load Hour Method

Facility Type	Northern	Central	Pine Barrens	Southwest	Coastal	Statewide Average
Single Family	0.023446	0.023851	0.022312	0.025	0.025	0.023923
Multi Family Low Rise	0.023446	0.023851	0.022312	0.025	0.025	0.023923
Multi Family High Rise	0.023446	0.023851	0.022312	0.025	0.025	0.023923

The PDFs by commercial building type and climate zone are calculated from the heating full load hours shown in Appendix C: . The PDFs associated with small commercial buildings by climate zone are shown below:

Table 10-9 Small Commercial Building PDFs using the Full Load Hour Method

Facility Type	Northern	Central	Pine Barrens	Southwest	Coastal	SW average
Assembly	0.02906	0.03437	0.03282	0.03413	0.03016	0.03244
Auto repair	0.00943	0.01113	0.01029	0.01148	0.01121	0.01077
Light industrial	0.02157	0.02949	0.02788	0.02775	0.02589	0.02687
Lodging – Motel	0.04320	0.05674	0.05163	0.05894	0.05018	0.05254
Office – small	0.03844	0.05627	0.05021	0.05929	0.05090	0.05109
Other	0.02462	0.03057	0.02889	0.03058	0.02817	0.02883
Religious worship	0.02689	0.03150	0.03016	0.03245	0.03095	0.03050

Facility Type	Northern	Central	Pine Barrens	Southwest	Coastal	SW average
Restaurant – fast food	0.02050	0.02561	0.02482	0.02504	0.02272	0.02396
Restaurant – full service	0.02055	0.02534	0.02420	0.02519	0.02262	0.02380
Retail – big box	0.05236	0.06632	0.06460	0.06699	0.06025	0.06240
Retail – Grocery	0.02203	0.02508	0.02487	0.02407	0.02105	0.02364
Retail – small	0.02940	0.03941	0.03692	0.03971	0.03662	0.03665
School – primary	0.02124	0.02622	0.02521	0.02540	0.02355	0.02460
Warehouse	0.03736	0.04709	0.04432	0.04789	0.04750	0.04500

Table 10-10 Large Commercial Building PDFs using the Full Load Hour Method

Facility Type	HVAC System	Northern	Central	Pine Barrens	Southwest	Coastal	SW average
Dormitory	Fan coil	0.03899	0.05067	0.04547	0.05187	0.04759	0.04736
Community college	CV econ	0.01500	0.01670	0.01549	0.01617	0.01767	0.01635
	CV noecon	0.01680	0.01886	0.01722	0.01787	0.01971	0.01832
	VAV	0.04677	0.05876	0.06401	0.04717	0.06348	0.05596
	Unknown	0.02914	0.03419	0.03357	0.03041	0.03635	0.03303
High school	CV econ	0.02326	0.02413	0.02334	0.02707	0.02400	0.02418
	CV noecon	0.02482	0.02638	0.02538	0.02886	0.02627	0.02624
	VAV	0.06197	0.09023	0.07910	0.07765	0.07338	0.07863
	Unknown	0.04159	0.05013	0.04657	0.05004	0.04595	0.04741
Hospital	CV econ	0.00497	0.00618	0.00534	0.00607	0.00574	0.00577
	CV noecon	0.00476	0.00558	0.00498	0.00647	0.00615	0.00553
	VAV	0.04240	0.06126	0.05741	0.05824	0.05347	0.05512
	Unknown	0.01897	0.02440	0.02189	0.02502	0.02344	0.02295
Hotel	CV econ	0.02071	0.02377	0.02198	0.02282	0.01762	0.02169
	CV noecon	0.02707	0.03211	0.02932	0.03111	0.02419	0.02921
	VAV	0.06579	0.08427	0.07278	0.09111	0.07017	0.07746
	Unknown	0.02346	0.02732	0.02513	0.02632	0.02039	0.02489
Large Office	CV econ	0.00992	0.01097	0.01006	0.01207	0.01075	0.01076
	CV noecon	0.00978	0.01090	0.01000	0.01201	0.01053	0.01065
	VAV	0.05415	0.06252	0.05692	0.08673	0.05746	0.06138
	Unknown	0.03323	0.03765	0.03441	0.04641	0.03555	0.03691

Facility Type	HVAC System	Northern	Central	Pine Barrens	Southwest	Coastal	SW average
Large Retail	CV econ	0.01080	0.01127	0.01055	0.01172	0.01125	0.01116
	CV noecon	0.01127	0.01171	0.01087	0.01205	0.01148	0.01154
	VAV	0.03100	0.03548	0.03388	0.03706	0.03048	0.03375
	Unknown	0.02404	0.02659	0.02517	0.02768	0.02402	0.02565
University	CV econ	0.01645	0.01836	0.01830	0.02045	0.01983	0.01844
	CV noecon	0.01713	0.02066	0.02002	0.02220	0.02210	0.02028
	VAV	0.04307	0.03250	0.06014	0.03071	0.06146	0.03870
	Unknown	0.02900	0.02690	0.03612	0.02700	0.03838	0.02952

10.4 TYPE 3 – HEATING DEGREE-DAY RATIO

The Heating Degree Day Ratio Method is used for weather sensitive measures where the annual savings are expressed as a function of heating degree days. The PDF is define as:

PDF = HDD peak gas day / Annual HDD

Annual degree day data for each of the NJ climate zones along with the daily HDD during the peak day and the associated PDFs are shown in the table below:

Table 10-11 Peak Day Factors Using the Degree Day Ratio Method

	Climate zone					
	Northern	Central	Pine barrens	Southwest	Coastal	SW Average
Annual HDD(65)	6,136	5,588	5,529	5,658	4,795	5,553
Gas Peak Day HDD(65)	66.4	66.4	66.4	66.4	66.4	66.4
PDF	0.0108	0.0119	0.0120	0.0117	0.0138	0.0120

10.5 TYPE 4 – HOURS PER YEAR RATIO

The hours per year ratio method is based on the ratio of the number of heating system operating hours during the peak gas day to the annual number of heating system operating hours. This method is used to calculate PDFs for HVAC interactive effects of lighting or other internal loads on heating energy. The PDF is defined as:

PDF = 24 / annual heating hr per year

Heating system operating hours by building type and climate zone are shown in the Tables below:

Table 10-12 Heating System Operating Hours and Peak Day Factors for Small Commercial Buildings

Building	Climate	Heating Hours	PDF
Assembly	Central	3,741	0.006415
Assembly	Coastal	3,847	0.006239
Assembly	Northern	4,039	0.005942
Assembly	Pine Barrens	3,674	0.006532
Assembly	Southwest	3,687	0.006509
Assembly	Statewide Average	3,795	0.006324
Auto repair	Central	4,377	0.005483
Auto repair	Coastal	4,463	0.005378
Auto repair	Northern	4,683	0.005125
Auto repair	Pine Barrens	4,296	0.005587
Auto repair	Southwest	4,302	0.005579
Auto repair	Statewide Average	4,426	0.005423
Big box	Central	2,725	0.008807
Big box	Coastal	2,729	0.008794
Big box	Northern	2,963	0.0081
Big box	Pine Barrens	2,696	0.008902
Big box	Southwest	2,697	0.008899
Big box	Statewide Average	2,760	0.008696
Fast food restaurant	Central	3,958	0.006064
Fast food restaurant	Coastal	4,025	0.005963
Fast food restaurant	Northern	4,210	0.005701
Fast food restaurant	Pine Barrens	3,845	0.006242
Fast food restaurant	Southwest	3,895	0.006162
Fast food restaurant	Statewide Average	3,992	0.006012
Full service restaurant	Central	3,614	0.006641
Full service restaurant	Coastal	3,693	0.006499
Full service restaurant	Northern	3,931	0.006105
Full service restaurant	Pine Barrens	3,551	0.006759
Full service restaurant	Southwest	3,588	0.006689
Full service restaurant	Statewide Average	3,671	0.006538
Grocery	Central	8,760	0.00274

Building	Climate	Heating Hours	PDF
Grocery	Coastal	8,760	0.00274
Grocery	Northern	8,760	0.00274
Grocery	Pine Barrens	8,760	0.00274
Grocery	Southwest	8,760	0.00274
Grocery	Statewide Average	8,760	0.00274
Light industrial	Central	2,596	0.009245
Light industrial	Coastal	2,781	0.00863
Light industrial	Northern	3,044	0.007884
Light industrial	Pine Barrens	2,571	0.009335
Light industrial	Southwest	2,706	0.008869
Light industrial	Statewide Average	2,711	0.008852
Motel	Central	2,216	0.01083
Motel	Coastal	2,239	0.010719
Motel	Northern	2,325	0.010323
Motel	Pine Barrens	2,181	0.011004
Motel	Southwest	2,188	0.010969
Motel	Statewide Average	2,231	0.010756
Primary school	Central	4,104	0.005848
Primary school	Coastal	4,229	0.005675
Primary school	Northern	4,432	0.005415
Primary school	Pine Barrens	4,045	0.005933
Primary school	Southwest	4,081	0.005881
Primary school	Statewide Average	4,171	0.005754
Religious	Central	1,915	0.012533
Religious	Coastal	1,934	0.01241
Religious	Northern	1,957	0.012264
Religious	Pine Barrens	1,835	0.013079
Religious	Southwest	1,877	0.012786
Religious	Statewide Average	1,912	0.012551
Small office	Central	2,456	0.009772
Small office	Coastal	2,567	0.009349
Small office	Northern	2,916	0.00823

Building	Climate	Heating Hours	PDF
Small office	Pine Barrens	2,391	0.010038
Small office	Southwest	2,482	0.00967
Small office	Statewide Average	2,548	0.00942
Small retail	Central	3,169	0.007573
Small retail	Coastal	3,304	0.007264
Small retail	Northern	3,544	0.006772
Small retail	Pine Barrens	3,118	0.007697
Small retail	Southwest	3,196	0.007509
Small retail	Statewide Average	3,252	0.007381
Warehouse	Central	1,521	0.015779
Warehouse	Coastal	1,610	0.014907
Warehouse	Northern	1,672	0.014354
Warehouse	Pine Barrens	1,489	0.016118
Warehouse	Southwest	1,548	0.015504
Warehouse	Statewide Average	1,560	0.015381

Table 10-13 Heating System Operating Hours and Peak Day Factors for Large Commercial buildings

Building	System	Climate	Heating hours	PDF
Community College	Any	Statewide Average	3,364	0.007135
Dorm	Any	Statewide Average	3,824	0.006276
Hospital	Any	Statewide Average	8,756	0.002741
Hotel	Any	Statewide Average	8,665	0.00277
High School	Any	Statewide Average	1,947	0.01233
Large Office	Any	Statewide Average	5,516	0.004351
Large Retail	Any	Statewide Average	4,540	0.005287
University	Any	Statewide Average	3,833	0.006262

11 APPENDIX H: NET-TO-GROSS FACTORS

11.1 COMMERCIAL NTG

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.1.1	CI Auto Milker Takeoff	Downstream	Electric	0.95							
3.1.2	CI Dairy Pump VFD	Downstream	Electric	0.95							
3.1.3	CI Dairy Refrigeration Tune Up	Downstream	Electric	0.95							
3.1.4	CI Dairy Scroll Compressor	Downstream	Electric	0.95							
3.1.5	CI Livestock Waterer	Downstream	Electric	0.95							
3.1.6	CI Low Pressure Irrigation	Downstream	Electric	0.95							
3.1.7	CI Ventilation Fans	Downstream	Electric	0.95							
3.1.8	CI Heat Reclaimers	Downstream	Electric	0.95							
3.1.9	CI Engine Block Heater Timer	Downstream	Electric	0.95							
3.10.10	CI Evaporator Fan EC Motor	Direct Install	Electric	0.91							
3.10.10	CI Evaporator Fan EC Motor	Downstream	Electric	0.75							
3.10.11	CI Evaporator Fan Controller	Direct Install	Electric	0.91							
3.10.11	CI Evaporator Fan Controller	Downstream	Electric	0.75							
3.10.12	CI Floating Head Pressure Control	Downstream	Electric	0.93							
3.10.13	CI VFD Compressor	Downstream	Electric	0.93							

[193] Taken from 2023 Trinennial TRM Appendx H Column labled "2024."

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.10.1	CI Energy Efficient Glass Doors on Vertical Open Refrigerated Cases	Direct Install	Electric	0.91							
3.10.1	CI Energy Efficient Glass Doors on Vertical Open Refrigerated Cases	Downstream	Electric	0.93							
3.10.2	CI Door Closer	Downstream	Electric	0.93							
3.10.3	CI Door Gaskets	Downstream	Electric	0.93							
3.10.4	CI Night Covers	Direct Install	Electric	0.91							
3.10.4	CI Night Covers	Downstream	Electric	0.93							
3.10.5	CI Strip Curtains	Downstream	Electric	0.93							
3.10.6	CI Anti-sweat heat Control	Direct Install	Electric	0.91							
3.10.6	CI Anti-sweat heat Control	Downstream	Electric	0.93							
3.10.7	CI Defrost Controls	Direct Install	Electric	0.91							
3.10.8	CI LED Case Lighting	Direct Install	Electric	0.91							
3.10.8	CI LED Case Lighting	Downstream	Electric	0.58							
3.10.9	CI Refrigerated Case Light Occupancy Sensors	Direct Install	Electric	0.91							
3.10.9	CI Refrigerated Case Light Occupancy Sensors	Downstream	Electric	0.93							
3.11.1	CI Storage Water Heater	Direct Install	Natural Gas	0.91					0.99		
3.11.1	CI Storage Water Heater	Downstream	Natural Gas	0.71							

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.11.2	CI Tankless Water Heater	Direct Install	Natural Gas	0.91					0.99		
3.11.2	CI Tankless Water Heater	Downstream	Natural Gas	0.71							
3.11.3	CI Heat Pump Water Heater	Direct Install	Electric	0.88							
3.11.3	CI Heat Pump Water Heater	Downstream	Electric	0.71							
3.11.4	CI Faucet Aerators and Showerheads	Direct Install	Electric	0.91							
3.11.4	CI Faucet Aerators and Showerheads	Direct Install	Natural Gas	0.91					0.99		
3.11.6	CI Pre-Rinse Spray Valves (PRSV)	Direct Install	Electric	0.91							
3.11.6	CI Pre-Rinse Spray Valves (PRSV)	Direct Install	Natural Gas	0.91					0.99		
3.11.6	CI Pre-Rinse Spray Valves (PRSV)	Downstream	Electric	0.81							
3.11.6	CI Pre-Rinse Spray Valves (PRSV)	Downstream	Natural Gas	0.81							
3.11.7	CI Recirculating Pump Control	Downstream	Natural Gas	0.84							
3.11.8	CI Pipe Insulation	Direct Install	Electric	0.91			0.83				
3.11.8	CI Pipe Insulation	Direct Install	Natural Gas	0.91					0.99		
3.12.1	CI VSD Air Compressors	Downstream	Electric	0.88							
3.13.3	CI Operator Training	Downstream	Electric	0.95							

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.13.3	CI Operator Training	Downstream	Natural Gas	0.95							
3.13.4.1	CI Custom Lighting	Downstream	Electric	0.53	0.99		0.91		0.9		
3.13.4.2	CI Custom HVAC	Downstream	Electric	0.77							
3.13.4.2	CI Custom HVAC	Downstream	Natural Gas	0.82							
3.13.4.3	CI Custom Water Heating	Downstream	Electric	0.71							
3.13.4.3	CI Custom Water Heating	Downstream	Natural Gas	0.71							
3.13.4.4	CI Custom Other	Downstream	Electric	0.77							
3.13.4.4	CI Custom Other	Downstream	Natural Gas	0.82							
3.2.1	CI Clothes Washer	Downstream	Electric	0.51							
3.2.1	CI Clothes Washer	Downstream	Natural Gas	0.51							
3.2.2	CI Clothes Dryers	Downstream	Electric	0.58							
3.2.2	CI Clothes Dryers	Downstream	Natural Gas	0.58							
3.2.4.1	CI Res Refrigerator	Downstream	Electric	0.47							
3.2.4	CI Refrigerators	Downstream	Electric	0.81							
3.2.5.1	CI Res Freezer	Downstream	Electric	0.52							
3.2.5	CI Freezers	Downstream	Electric	0.81							

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.2.6	CI Dehumidifier	Downstream	Electric	0.49							
3.2.7	CI Room Air Conditioner	Downstream	Electric	0.54							
3.2.8	CI Water Cooler	Downstream	Electric	0.52							
3.3.1.1	CI Refrigerator Recycling	Downstream	Electric	0.51							
3.3.1.2	CI Freezer Recycling	Downstream	Electric	0.58							
3.3.2	CI Room AC Unit Recycling	Downstream	Electric	0.5							
3.3.3	CI Dehumidifier Recycling	Downstream	Electric	0.41							
3.4.1	CI Ovens, Fryer, Steamer & Griddle	Downstream	Electric	0.81							
3.4.1	CI Ovens, Fryer, Steamer & Griddle	Downstream	Natural Gas	0.81							
3.4.1	CI Ovens, Fryer, Steamer & Griddle	Midstream	Electric	0.81							
3.4.1	CI Ovens, Fryer, Steamer & Griddle	Midstream	Natural Gas	0.81							
3.4.2	CI Holding Cabinets	Downstream	Electric	0.81							
3.4.3	CI Dishwashers	Downstream	Electric	0.81							
3.4.3	CI Dishwashers	Downstream	Natural Gas	0.81							
3.4.4	CI Ice Machines	Downstream	Electric	0.81							
3.5.1.1	CI Split or Packaged AC	Downstream	Electric	0.93							
3.5.2.1	CI Split or Packaged ASHP	Direct Install	Electric	0.88							
3.5.2.1	CI Split or Packaged ASHP	Downstream	Electric	0.83							

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.5.2.2	CI Mini-split AC or HP	Downstream	Electric	0.83							
3.5.2.3	CI PTAC/PTHP	Downstream	Electric	0.83							
3.5.2.4	CI Single Package Vertical AC or HP	Downstream	Electric	0.83							
3.5.1.5	CI Packaged Water Cooled AC	Downstream	Electric	0.93							
3.5.12	CI Heat or Energy Recovery Ventilator	Downstream	Natural Gas	0.64							
3.5.13	CI Demand Controlled Ventilation	Direct Install	Electric	0.91							
3.5.13	CI Demand Controlled Ventilation	Downstream	Electric	0.86							
3.5.14	CI Demand Controlled Kitchen Ventilation	Downstream	Electric	0.81							
3.5.17	CI EC Motors	Direct Install	Electric	0.91							
3.5.17	CI EC Motors	Downstream	Electric	0.75							
3.5.18	CI Economizer Controls	Direct Install	Electric	0.91							
3.5.18	CI Economizer Controls	Downstream	Electric	0.86							
3.5.18	CI Economizer Controls	Downstream	Natural Gas	0.84							
3.5.20	CI Guest Room EMS	Downstream	Electric	0.8							
3.5.21	CI Smart Tstats	Direct Install	Electric	0.91							
3.5.21	CI Smart Tstats	Direct Install	Natural Gas	0.91					0.99		
3.5.21	CI Smart Tstats	Downstream	Electric	0.82							

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.5.21	CI Smart Tstats	Downstream	Natural Gas	0.8							
3.5.23	CI Maintenance	Downstream	Natural Gas	0.84							
3.5.1	CI Central AC, Mini-Split AC, PTAC	Midstream	Electric	0.63							
3.5.2	CI Central ASHP, Minisplit HP, PTHP	Midstream	Electric	0.63							
3.5.3	CI Geothermal and Water Source Heat Pumps	Direct Install	Electric	0.88							
3.5.3	CI Geothermal and Water Source Heat Pumps	Downstream	Electric	0.83							
3.5.5	CI Infrared Heater	Direct Install	Electric	0.91							
3.5.5	CI Infrared Heater	Downstream	Natural Gas	0.64							
3.5.6.3	CI Boiler	Direct Install	Natural Gas	0.91					0.99		
3.5.6.3	CI Boiler	Downstream	Natural Gas	0.84							
3.11.5	CI Combination Boiler	Downstream	Natural Gas	0.84							
3.5.6	CI Furnaces, Unit Heaters and Boilers	Direct Install	Natural Gas	0.91					0.99		
3.5.6	CI Furnaces, Unit Heaters and Boilers	Downstream	Natural Gas	0.84							

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.5.7	CI Boiler Controls	Direct Install	Natural Gas	0.91					0.99		
3.5.7	CI Boiler Controls	Downstream	Natural Gas	0.84							
3.5.19	CI Electronic Fuel Use Economizer	Direct Install	Electric	0.91							
3.5.19	CI Electronic Fuel Use Economizer	Direct Install	Natural Gas	0.91					0.99		
3.5.9	CI Gas Chillers	Downstream	Natural Gas	0.9							
3.5.10	CI Electric Chillers	Downstream	Electric	0.77							
3.5.11	CI Make-Up Air Unit	Downstream	Natural Gas	0.64							
3.7.1.1	CI LED Indoor Fixture	Direct Install	Electric	0.76							
3.7.1.1	CI LED Indoor Fixture	Downstream	Electric	0.58	0.99		0.91		0.9		
3.7.1.1	CI LED Indoor Fixture	Midstream	Electric	0.58							
3.7.1.2	CI LED Indoor High/Low bay	Downstream	Electric	0.643	0.99		0.91		0.9		
3.7.1.2	CI LED Indoor High/Low bay	Midstream	Electric	0.643							
3.7.1.3	CI LED Exterior Fixture	Downstream	Electric	0.643	0.99				0.9		
3.7.1.3	CI LED Exterior Fixture	Midstream	Electric	0.643							
3.7.1.4	CI LED Stairwell Fixture	Downstream	Electric	0.58							
3.7.1.5	CI LED Indoor Fixture replacing Regulated GSL	Downstream	Electric	0							

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.7.1.6	CI LED Regulated GSL	Direct Install	Electric	0							
3.7.1.6	CI LED Regulated GSL	Downstream	Electric	0							
3.7.1.6	CI LED Regulated GSL	Midstream	Electric	0							
3.7.1.7	CI Fluorescent Indoor fixture	Downstream	Electric	0.58							
3.7.1.8	CI Indoor Energy Star Fixture	Downstream	Electric	0.53							
3.7.1.9	CI Roadway Lighting	Downstream	Electric	0.75							
3.7.2.1	CI Lighting Controls - Occupancy Sensors	Downstream	Electric	0.62							
3.7.2.2	CI Lighting Controls - Normal Lighting Controls	Direct Install	Electric	0.76							
3.7.2.2	CI Lighting Controls - Normal Lighting Controls	Downstream	Electric	0.69	0.99		0.91		0.9		
3.7.2.3	CI Lighting Controls - Networked Controls	Downstream	Electric	0.69							
3.7.2.3	CI Lighting Controls - Networked Controls	Midstream	Electric	0.69							
3.7.3	CI Delamping	Downstream	Electric	0.53							
3.7.4	CI Exit Signs	Downstream	Electric	0.53							
3.7.5	CI LED Sign Lighting	Downstream	Electric	0.643							
3.7.6	CI Indoor Horticulture LED	Downstream	Electric	0.53							
3.8.1	CI Motors	Direct Install	Electric	0.91							
3.8.3	CI VFD	Direct Install	Electric	0.91							

2024 TRM Measure Section	Measure	Delivery	Fuel	Default PY4 NTGR[193]	PY4 Updated NTGR from PY2 Evaluations						
					ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
3.8.3	CI VFD	Downstream	Electric	0.65							
3.9.2	CI Office Equipment	Downstream	Electric	0.27							
3.9.3	CI Smart Strip	Downstream	Electric	0.9							
3.9.4	CI UnInterruptible Power supply	Downstream	Electric	0.27							
3.9.5	CI Refrigerated Beverage Vending Machine	Downstream	Electric	0.81							
3.9.6	CI Vending Machine Controls	Direct Install	Electric	0.91							
3.9.6	CI Vending Machine Controls	Downstream	Electric	0.77							
3.9.7	CI Electric Vehicle Charger	Downstream	Electric	0.9							

11.2 RESIDENTIAL NTG

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.1.1	Res Clothes Washer	Appliance Rebates	Downstream	Electric	0.51	0.44				0.49		
2.1.1.1	MF Clothes Washer	Appliance Rebates	Downstream	Electric	0.56	0.54						
2.1.10	Res Room Air Conditioner	Appliance rebates	All modes	Electric	0.594					0.84		
2.1.2	Res Clothes Dryer	Appliance Rebates	Downstream	Electric	0.58	0.54				0.53		
2.1.2	Res Clothes Dryer	Appliance Rebates	Downstream	Natural Gas	0.58	0.57			0.44	0.53		
2.1.3	Res Dishwasher	Appliance Rebates	Downstream	Electric	0.52	0.54						
2.1.3.1	MF Dishwasher	Appliance Rebates	Downstream	Electric	0.572	0.54						
2.1.4	Res Induction Range/Cooktop	Appliance Rebates	Downstream	Electric	0.67	0.54						
2.1.5	Res Refrigerators	Appliance rebates	Downstream	Electric	0.47	0.43				0.48		
2.1.5.1	MF Refrigerators	Appliance rebates	Downstream	Electric	0.52	0.54						
2.1.5.1	MF Refrigerators	Moderate Income	Direct Install	Electric	0.52							
2.1.6	Res Freezers	Appliance Rebates	Downstream	Electric	0.52	0.54						
2.1.7	Res Water Cooler	Appliance Rebates	Downstream	Electric	0.52	0.54						
2.1.8	Res Air Purifier	Appliance Markdown	Upstream	Electric	0.65							
2.1.8	Res Air Purifier	Marketplace	Online	Electric	0.65			0.71		0.84		

[194] Taken from 2023 Trinennial TRM Appendx H Column labled "2024."

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.1.9	Res Dehumidifier	Appliance Rebates	Upstream	Electric	0.49							
2.1.9	Res Dehumidifier	Marketplace	Online	Electric	0.49			0.71		0.84		
2.2.1.1	Res Refrigerator Recycling	Appliance recycling	Downstream	Electric	0.51					0.6		
2.2.1.2	Res Freezer Recycling	Appliance Recycling	Downstream	Electric	0.58					0.62		
2.2.2	Res Room AC Unit Recycling	Appliance recycling	Downstream	Electric	0.5					0.62		
2.2.3	Res Dehumidifier Recycling	Appliance Recycling	Downstream	Electric	0.41					0.62		
2.3.1.1	Res ASHP	HVAC	Downstream	Electric	0.65	0.46		0.66				
2.3.1.1	Res ASHP	HVAC	Hybrid	Electric	0.684							
2.3.1.1	Res Cold Climate ASHP	Moderate Income	Direct Install	Electric	0.76							
2.3.1.1	Res ASHP	Moderate Income	Direct Install	Electric	0.72[195]							
2.3.1.1	MF PTAC	Moderate Income	Direct Install	Electric	0.93							
2.3.1.1	MF PTHP	Moderate Income	Direct Install	Electric	0.93							
2.3.1.1	MF ASHP	Moderate Income	Direct Install	Electric	0.93							
2.3.1.1	MF Ductless HP	Moderate Income	Direct Install	Electric	0.93							
2.3.10	Res Boiler Controls	HVAC	Downstream	Natural Gas	0.75	0.56						
2.3.10	Res Boiler Controls	HVAC	Hybrid	Natural Gas	0.8							

[195] Average of Tier 1 (0.69) and Tier 2 (0.75) NTGRs from NMR NTG study.

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.3.10	Res Boiler Controls	Moderate Income	Direct Install	Natural Gas	0.85							
2.3.11	Res Filter Whistle	Existing Homes	Direct Install	Electric	0.595	0.8						
2.3.11	Res Filter Whistle	Existing Homes	Direct Install	Natural Gas	0.595	0.81						
2.3.12	Res Ceiling Fan	HVAC	Upstream	Electric	0							
2.3.13	Res Smart Thermostat	HVAC	Downstream	Electric	0.74	0.46		0.74		0.66		
2.3.13	Res Smart Thermostat	HVAC	Downstream	Natural Gas	0.74	0.56				0.66		
2.3.13	Res Smart Thermostat	HVAC	Hybrid	Electric	0.7785							
2.3.13	Res Smart Thermostat	HVAC	Hybrid	Natural Gas	0.7785							
2.3.13	Res Smart Thermostat	HVAC	Upstream	Electric	0.74							
2.3.13	Res Smart Thermostat	HVAC	Upstream	Natural Gas	0.74							
2.3.13	Res Smart Thermostat	Marketplace	Online	Electric	0.74		0.852	0.73		0.81		
2.3.13	Res Smart Thermostat	Marketplace	Online	Natural Gas	0.74		0.852	0.73	0.74	0.81	0.83	
2.3.13	Res Smart Thermostat	Moderate Income	Direct Install	Electric	0.82				1			
2.3.13	Res Smart Thermostat	Moderate Income	Direct Install	Natural Gas	0.82				1			
2.3.2.1	Res Central AC	HVAC	Downstream	Electric	0.74	0.6		0.74				
2.3.2.1	Res Central AC	HVAC	Hybrid	Electric	0.78							
2.3.2.1	Res Central AC	Moderate Income	Direct Install	Electric	0.81							
2.3.2.2	Res Mini Split AC	HVAC	Downstream	Electric	0.65	0.56		0.66				
2.3.2.2	Res Mini Split AC	HVAC	Hybrid	Electric	0.684							
2.3.2.2	Res Mini Split AC	Moderate Income	Direct Install	Electric	0.72							

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.3.2.2	Res Mini Split Heat Pump	Moderate Income	Direct Install	Electric	0.78							
2.3.2.3	Res PTAC	Multi-Family	Downstream	Electric	0.93							
2.3.2.3	Res PTAC	Multi-Family	Hybrid	Electric	0.93							
2.3.2.3	Res PTAC	Moderate Income	Direct Install	Electric	0.93							
2.3.3	Res Geothermal Heat Pump	Moderate Income	Direct Install	Electric	0.77							
2.3.4.1	Res Gas furnace	HVAC	Downstream	Natural Gas	0.76	0.56						
2.3.4.1	Res Gas furnace	HVAC	Hybrid	Natural Gas	0.8							
2.3.4.1	Res Gas furnace	Moderate Income	Direct Install	Natural Gas	0.84					0.9		
2.3.4.2	Res Gas boiler	HVAC	Downstream	Natural Gas	0.76	0.56						
2.3.4.2	Res Gas boiler	HVAC	Hybrid	Natural Gas	0.8							
2.3.4.2	Res Gas boiler	Moderate Income	Direct Install	Natural Gas	0.84					0.9		
2.3.5	Res High Efficiency Bathroom Exhaust Fan	HVAC	Downstream	Electric	0.595	0.46		0.66				
2.3.5	Res High Efficiency Bathroom Exhaust Fan	HVAC	Hybrid	Electric	0.63							
2.3.5	Res High Efficiency Bathroom Exhaust Fan	Moderate Income	Direct Install	Electric	0.66				1			
2.3.6	Res EC Motor	HVAC	Downstream	Electric	0.63	0.46		0.66				
2.3.6	Res EC Motor	HVAC	Hybrid	Electric	0.66							
2.3.6	Res EC Motor	Moderate Income	Direct Install	Electric	0.69							

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.3.7	Duct Insulation	Moderate Income	Direct Install	Electric	0.66		0.99		0.89	0.9	0.99	
2.3.7	Duct Insulation	Moderate Income	Direct Install	Natural Gas	0.66		0.99		0.89	0.9	0.99	
2.3.8	Res Energy Recovery Ventilator	Moderate Income	Direct Install	Electric	0.85							
2.3.9	Res Maintenance	HVAC	Downstream	Electric	0.595	0.46						
2.3.9	Res Maintenance	HVAC	Downstream	Natural Gas	0.595	0.56						
2.3.9	Res Maintenance	HVAC	Hybrid	Electric	0.595							
2.3.9	Res Maintenance	HVAC	Hybrid	Natural Gas	0.595				0.67			
2.3.9	Res Maintenance	Moderate Income	Direct Install	Electric	0.66				0.99	0.9		
2.3.9	Res Maintenance	Moderate Income	Direct Install	Natural Gas	0.66				0.99	0.9		
2.4.1.1	Res LED Lamp	Welcome Kit	Non-requested Kit	Electric	0					0.71		
2.4.1.1	Res LED desk lamp	Welcome Kit	Non-requested Kit	Electric	0					0.93		
2.4.1.4	Res LED night light	Welcome Kit	Non-requested Kit	Electric	0					0.83		
2.4.1.1	Res LED lamp	Marketplace	Online	Electric	0			0.71		0.79		
2.4.1.1	Res LED lamp	Midstream Lighting	Upstream	Electric	0							
2.4.1.1	Res LED Lamp	QHEC	Direct Install	Electric	0.15	0.75				0.82		
2.4.1.1	Res LED Specialty Lamp	Moderate Income	Direct Install	Electric	0.17				0.57	0.78		
2.4.1.1	Res LED Lamp	Moderate Income	Direct Install	Electric	0.17				0.57	0.78		
2.4.1.2	Res LED fixture	Marketplace	Online	Electric	0			0.71		0.84		

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.4.1.2	Res LED fixture	Midstream Lighting	Upstream	Electric	0							
2.4.1.3	Res LED Holiday Lights	Marketplace	Online	Electric	0.45			0.71		0.84		
2.4.1.3	Res LED Holiday Lights	Midstream Lighting	Upstream	Electric	0.45							
2.4.1.4	Res LED Nightlight	Existing Homes	Direct Install	Electric	0.45	0.75				0.83		
2.4.2	Res Occupancy Sensor	Marketplace	Online	Electric	0.75			0.71		0.84		
2.4.2	Res Occupancy Sensor	Midstream Lighting	Upstream	Electric	0.75							
2.5.1.1	Res Computers	Appliance Rebates	Downstream	Electric	0.27	0.54						
2.5.1.1	Res Computers	Appliance Rebates	Upstream	Electric	0.27							
2.5.1.2	Res Imaging	Appliance Rebates	Downstream	Electric	0.27	0.54						
2.5.1.2	Res Imaging	Appliance Rebates	Upstream	Electric	0.27							
2.5.1.3	Res Monitors	Appliance Rebates	Downstream	Electric	0.27	0.54						
2.5.1.3	Res Monitors	Appliance Rebates	Upstream	Electric	0.27							
2.5.2	Res Televisions	Appliance Rebates	Downstream	Electric	0.83	0.54						
2.5.2	Res Televisions	Appliance Rebates	Upstream	Electric	0.83							
2.5.3	Res Smart Strip	Marketplace	Online	Electric	0.9			0.71		0.88		
2.5.3	Res Smart Strip	Midstream Markdown	Upstream	Electric	0.9							
2.5.3	Res Smart Strip	QHEC	Direct Install	Electric	0.9	0.85				0.9		
2.5.3	Res Smart Strip	Welcome Kit	Non-requested Kit	Electric	0.9					0.79		
2.5.3	Res Smart Strip	Moderate Income	Direct Install	Electric	1					0.84		
2.5.4	Res SoundBar	Appliance Rebates	Downstream	Electric	0.83	0.54						

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.5.5	Res Electric Vehicle Chargers	Appliance Rebates	Downstream	Electric	0.77	0.54						
2.5.5.1	MF Electric Vehicle Chargers	Appliance Rebates	Downstream	Electric	0.87	0.54						
2.6.1	Res Residential/Low-rise Multifamily Air Sealing	Existing Homes	direct install	Electric	0.595	0.8	0.93			0.83		
2.6.1	Res Residential/Low-rise Multifamily Air Sealing	Existing Homes	direct install	Natural Gas	0.595	0.81	0.93			0.93	0.97	
2.6.1	Res Residential/Low-rise Multifamily Air Sealing	Moderate Income	direct install	Electric	0.66		0.93		0.91	0.95	0.97	
2.6.1	Res Residential/Low-rise Multifamily Air Sealing	Moderate Income	direct install	Natural Gas	0.66		0.93		0.91	0.95	0.97	
2.6.2	Res Shell Insulation	Existing Homes	Direct Install	Electric	0.87		1					
2.6.2	Res Shell Insulation	Existing Homes	Direct Install	Natural Gas	0.87		1					
2.6.2	Res Shell Insulation	Moderate Income	Direct Install	Electric	0.96		1			0.95	0.98	
2.6.2	Res Shell Insulation	Moderate Income	Direct Install	Natural Gas	0.96		1			0.95	0.98	
2.7.10	Res Pool Pumps	Appliance Rebates	Downstream	Electric	0.86	0.54						
2.7.1	Res Heat Pump Water Heater	Moderate Income	Direct Install	Electric	0.86							
2.7.2	Indirect fired water heater	Moderate Income	Direct Install	Natural Gas	0.84							
2.7.3	Res Storage Water Heater	HVAC	Downstream	Electric	0.78			0.66		0.61		

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.7.3	Res Storage Water Heater	HVAC	Downstream	Natural Gas	0.76					0.61		
2.7.3	Res Storage Water Heater	HVAC	Upstream	Electric	0.78							
2.7.3	Res Storage Water Heater	HVAC	Upstream	Natural Gas	0.76							
2.7.3	Res Storage Water Heater	Moderate Income	Direct Install	Natural Gas	0.84					0.9		
2.7.4	Res Tankless Water Heater	HVAC	Downstream	Natural Gas	0.76							
2.7.4	Res Tankless Water Heater	HVAC	Upstream	Natural Gas	0.76							
2.7.4	Res Tankless Water Heater	Moderate Income	Direct Install	Natural Gas	0.84					0.9		
2.7.5	Res Gas combi heat	HVAC	Downstream	Natural Gas	0.76		0.803				0.779	
2.7.5	Res Gas combi heat	HVAC	Hybrid	Natural Gas	0.8							
2.7.5	Res Gas combi heat	Moderate Income	Direct Install	Natural Gas	0.84							
2.7.6	Res Water Heating Setback	Existing Homes	Direct Install	Electric	0.595	0.8				0.83		
2.7.6	Res Water Heating Setback	Existing Homes	Direct Install	Natural Gas	0.595	0.81	1.28			0.93	1.23	
2.7.6	Res Water Heater Setback	Moderate Income	Direct Install	Natural Gas	0.655				0.96	0.81		

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.7.7.1	Res Faucet Aerator		Direct Install	Electric	0.6					0.97		
2.7.7.1	Res Faucet Aerator		Direct Install	Natural Gas	0.6					0.97		
2.7.7.1	Res Faucet Aerator	Moderate Income	Direct Install	Electric	0.66					0.92		
2.7.7.1	Res Faucet Aerator	Moderate Income	Direct Install	Natural Gas	0.66					0.92		
2.7.7.2	Res Showerheads		Direct Install	Electric	0.6					0.92		
2.7.7.2	Res Showerheads		Direct Install	Natural Gas	0.6					0.92		
2.7.7.2	Res Showerheads	Moderate Income	Direct Install	Electric	0.66					0.87		
2.7.7.2	Res Showerheads	Moderate Income	Direct Install	Natural Gas	0.66					0.87		
2.7.7.1	Res Bathroom Aerator	Welcome Kit	Non-requested Kit	Electric	0.6					0.99		
2.7.7.1	Res Bathroom Aerator	Welcome Kit	Non-requested Kit	Natural Gas	0.6					0.99		
2.7.7.1	Res Kitchen Aerator	Welcome Kit	Non-requested Kit	Electric	0.6					0.92		
2.7.7.1	Res Kitchen Aerator	Welcome Kit	Non-requested Kit	Natural Gas	0.6					0.92		
2.7.7.2	Res Showerheads	Welcome Kit	Non-requested Kit	Electric	0.6					0.87		
2.7.7.2	Res Showerheads	Welcome Kit	Non-requested Kit	Natural Gas	0.6					0.87		
2.7.7.1	Res Faucet aerator	Marketplace	Online	Electric	0.595			0.71		0.82		
2.7.7.1	Res Faucet aerator	Marketplace	Online	Natural Gas	0.595				0.74	0.82	0.81	

2024 TRM Measure Section	Measure	Subprogram	Delivery	Fuel	Default PY4 NTGR[194]	PY2 NTGR for 2024 TRM update						
						ACE	ETG	JCPL	NJNG	PSEG	SJG	RECO
2.7.7.2	Res Low flow showerhead	Marketplace	Online	Electric	0.595			0.71		0.87		
2.7.7.2	Res Low flow showerhead	Marketplace	Online	Natural Gas	0.595				0.74	0.87	0.81	
2.7.8	Res Thermostatic Showerheads	Existing Homes	Direct Install	Electric	0.9	0.8				0.92		
2.7.8	Res Thermostatic Showerheads	Existing Homes	Direct Install	Natural Gas	0.9	0.81	1.28			0.92	1.23	
2.7.8	Res Thermostatic Showerheads	Moderate Income	Direct Install	Electric	0.9	0.8				1.01		
2.7.8	Res Thermostatic Showerheads	Moderate Income	Direct Install	Natural Gas	0.9	0.81	1.28			1.01	1.23	
2.7.9	Res Pipe Insulation	HVAC	Downstream	Electric	0.595			0.66		0.92		
2.7.9	Res Pipe Insulation	HVAC	Downstream	Natural Gas	0.595					0.92		
2.7.9	Res Pipe Insulation		Direct Install	Electric	0.6					0.92		
2.7.9	Res Pipe Insulation		Direct Install	Natural Gas	0.6					0.92		
2.7.9	Res Pipe Insulation	Moderate Income	Direct Install	Electric	0.66					0.79		
2.7.9	Res Pipe Insulation	Moderate Income	Direct Install	Natural Gas	0.66					0.79		
2.8.2	Res Whole Building	HPwES	Direct Install	Natural Gas	0.74		0.91		0.88	0.91	0.91	
2.8.2	Res Whole Building	HPwES	Direct Install	Electric	0.74				0.88	0.9		
2.8.4	Res Whole Building	Moderate Income	Direct Install	Natural Gas	0.78		0.99		0.9	0.89	0.98	
2.8.4	Res Whole Building	Moderate Income	Direct Install	Electric	0.78		0.99		0.9	0.78	0.98	

12 APPENDIX I: REALIZATION RATES

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
ACE	Efficient Products	Appliance Rebates	Room Air Conditioners	125%	128%		2023 TRM
ACE	Efficient Products	Appliance Recycling	Freezers	101%	101%		2023 TRM
ACE	Efficient Products	Online Marketplace	Power Strips	100%	102%		2023 TRM
ACE	Efficient Products	Online Marketplace	Smart Thermostats	100%	101%		2023 TRM
ACE	Energy Efficient Products	Appliance Rebates	Clothes Dryers	101%	101%		2023 TRM
ACE	Energy Efficient Products	Appliance Rebates	Dehumidifiers	111%	111%		2023 TRM
ACE	Energy Efficient Products	Appliance Rebates	Refrigerators	100%	100%		2023 TRM
ACE	Energy Efficient Products	Appliance Rebates	All Other	111%	110%		PY 2 Evaluations
ACE	Energy Efficient Products	HVAC	Smart Thermostats	100%	101%		2023 TRM
ACE	Energy Efficient Products	HVAC	All other	102%	101%	95%	PY 2 Evaluations
ACE	Energy Solutions for Business	Prescriptive/Custom	All	102%	100%	86%	PY 2 Evaluations
ACE	Energy Solutions for Business	SBDI	All	101%	101%	105%	PY 2 Evaluations
ACE	Existing Homes	HER	All	88%	121%		PY 2 Evaluations

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
ACE	Existing Homes	HPwES	Whole building	100%			PY 2 Evaluations
ACE	Existing Homes	MI Weatherization	Whole building	100%	100%	100%	PY 2 Evaluations
ACE	Existing Homes	Multi-Family	All	103%	100%	100%	PY 2 Evaluations
ACE	Existing Homes	QHEC	All	100%	100%	100%	PY 2 Evaluations
ETG	Energy Efficient Products	Downstream	Central Air Conditioners	93%			PY 2 Evaluations
ETG	Energy Efficient Products	Downstream	Gas Combination Heaters			92%	PY 2 Evaluations
ETG	Energy Efficient Products	Downstream	Gas Furnaces			108%	PY 2 Evaluations
ETG	Energy Efficient Products	Downstream	All Other	103%	84%	99%	PY 2 Evaluations
ETG	Energy Efficient Products	Online Marketplace	Smart Thermostat	100%	308%	100%	PY 2 Evaluations
ETG	Energy Efficient Products	Online Marketplace	All Other	102%	358%	99%	PY 2 Evaluations
ETG	Energy Solutions for Business	Custom	All Other			90%	PY 2 Evaluations
ETG	Energy Solutions for Business	Prescriptive	All Other			102%	PY 2 Evaluations
ETG	Energy Solutions for Business	SBDI	All Other	99%	109%	106%	PY 2 Evaluations
ETG	Existing Homes	HER	All Other			110%	PY 2 Evaluations
ETG	Existing Homes	Multi-Family	All Other	100%	100%	101%	PY 2 Evaluations

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
ETG	Existing Homes	QHEC	Bathroom Faucet Aerators			100%	PY 2 Evaluations
ETG	Existing Homes	QHEC	LEDs	228%	167%	7%	PY 2 Evaluations
ETG	Existing Homes	QHEC	Pipe Insulation	407%		356%	PY 2 Evaluations
ETG	Existing Homes	QHEC	All Other	214%	154%	100%	PY 2 Evaluations
JCPL	Efficient Products	Appliance Rebates	Clothes Dryer – ENERGY STAR	99%	99%		2023 TRM
JCPL	Efficient Products	Appliance Rebates	Clothes Dryer – ENERGY STAR MOST EFFICIENT	99%	99%		2023 TRM
JCPL	Efficient Products	Online Marketplace	Smart Thermostat	99%		99%	2023 TRM
JCPL	Energy Efficient Products	Appliance Recycling	Refrigerator or Freezer Recycling	138%	118%		PY 2 Evaluations
JCPL	Energy Efficient Products	Appliance Recycling	All Other	100%	100%		PY 2 Evaluations
JCPL	Energy Efficient Products	HVAC	All Other	100%	100%		PY 2 Evaluations
JCPL	Energy Efficient Products	HVAC Rebates	CAC	100%	100%		PY 2 Evaluations
JCPL	Energy Efficient Products	Online Marketplace	Air Purifier	81%	109%		PY 2 Evaluations
JCPL	Energy Efficient Products	Online Marketplace	All Other	112%	90%		PY 2 Evaluations
JCPL	Energy Solutions for Business	Prescriptive/Custom	All Other	88%	84%		PY 2 Evaluations

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
JCPL	Energy Solutions for Business	SBDI	All Other	100%	100%		2023 TRM
JCPL	Existing Homes	HEEM	Home Energy Reports	95%	80%		PY 2 Evaluations
JCPL	Existing Homes	HEEM	Online Audits	100%	100%		PY 2 Evaluations
JCPL	Existing Homes	QHEC	Domestic Hot Water Setback	108%	108%		2023 TRM
NJNG	Energy Efficient Products	HVAC	Combination Boiler			100%	PY 2 Evaluations
NJNG	Energy Efficient Products	HVAC	Furnace			100%	PY 2 Evaluations
NJNG	Energy Efficient Products	HVAC	All Other			100%	PY 2 Evaluations
NJNG	Energy Efficient Products	Online Marketplace	Thermostats			86%	PY 2 Evaluations
NJNG	Energy Efficient Products	Online Marketplace	All Other			73%	PY 2 Evaluations
NJNG	Energy Efficient Products	Washer/Dryer	ENERGY STAR Clothes Washer			100%	PY 2 Evaluations
NJNG	Energy Efficient Products	Washer/Dryer	ENERGY STAR Gas Clothes Dryer			100%	PY 2 Evaluations
NJNG	Energy Efficient Products	Washer/Dryer	All Other			100%	PY 2 Evaluations
NJNG	Energy Solutions for Business	Energy management	All Other			101%	PY 2 Evaluations

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
NJNG	Energy Solutions for Business	Engineered Solutions	All Other			NA	PY 2 Evaluations
NJNG	Energy Solutions for Business	Prescriptive/Custom	All Other			100%	PY 2 Evaluations
NJNG	Energy Solutions for Business	SBDI	All Other			95%	PY 2 Evaluations
NJNG	Existing Homes	HPwES	Whole building			82%	PY 2 Evaluations
NJNG	Existing Homes	MI Weatherization	Whole building	87%		88%	PY 2 Evaluations
NJNG	Existing Homes	Multi-Family	All Other	100%		100%	PY 2 Evaluations
NJNG	Existing Homes	QHEC	All Other			85%	PY 2 Evaluations
PSEG	Energy Efficient Products	Downstream Rebates	Refrigerators	99%	99%		2023 TRM
PSEG	Energy Efficient Products	Downstream Rebates	Storage Water heater			101%	2023 TRM
PSEG	Energy Efficient Products	Midstream HVAC	Central Air Conditioner	98%	98%		2023 TRM
PSEG	Energy Efficient Products	Midstream HVAC	Gas Boiler			102%	2023 TRM
PSEG	Energy Efficient Products	Midstream HVAC	Qualifying Gas Heat with qualifying Gas Water Heat			99%	2023 TRM
PSEG	Energy Efficient Products	Midstream HVAC	Water Heater			92%	2023 TRM
PSEG	Energy Efficient Products	Midstream Lighting	LED Specialty - ESTAR V2.0	102%	102%		2023 TRM

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
PSEG	Energy Efficient Products	Appliance Recycling	Appliance Recycling	112%	145%		PY 2 Evaluations
PSEG	Energy Efficient Products	Appliance Recycling	All Other	112%	145%		PY 2 Evaluations
PSEG	Energy Efficient Products	Downstream	Downstream	99%	99%	96%	PY 2 Evaluations
PSEG	Energy Efficient Products	Downstream	All Other	99%	99%	96%	PY 2 Evaluations
PSEG	Energy Efficient Products	HVAC	All Other	118%	100%	99%	PY 2 Evaluations
PSEG	Energy Efficient Products	Midstream HVAC	Midstream HVAC	118%	100%	99%	PY 2 Evaluations
PSEG	Energy Efficient Products	Midstream Lighting	All Other	86%	86%		PY 2 Evaluations
PSEG	Energy Efficient Products	Midstream Markdown	All Other	85%	83%	135%	PY 2 Evaluations
PSEG	Energy Efficient Products	Online Marketplace	Online Marketplace	99%	109%	98%	PY 2 Evaluations
PSEG	Energy Efficient Products	Online Marketplace	All Other	99%	109%	98%	PY 2 Evaluations
PSEG	Energy Efficient Products	Welcome Kits	Welcome Kits	102%	95%	91%	PY 2 Evaluations
PSEG	Energy Efficient Products	Welcome Kits	All Other	102%	95%	91%	PY 2 Evaluations
PSEG	Energy Solutions for Business	Custom	All Other	92%	103%	92%	PY 2 Evaluations

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
PSEG	Energy Solutions for Business	Prescriptive	HVAC	108%	98%	100%	PY 2 Evaluations
PSEG	Energy Solutions for Business	Prescriptive	Lighting	101%	100%	103%	PY 2 Evaluations
PSEG	Energy Solutions for Business	Prescriptive	Midstream	105%	100%	100%	PY 2 Evaluations
PSEG	Energy Solutions for Business	Prescriptive	Other	107%	86%	105%	PY 2 Evaluations
PSEG	Energy Solutions for Business	Prescriptive	All Other	104%	100%	100%	PY 2 Evaluations
PSEG	Energy Solutions for Business	SBDI	All Other	100%	96%	106%	PY 2 Evaluations
PSEG	Energy Solutions for Business	SBDI UEZ	Lighting	101%	100%		PY 2 Evaluations
PSEG	Existing Homes	HER	All Other	94%		109%	PY 2 Evaluations
PSEG	Existing Homes	HPwES	Whole building	152%		89%	PY 2 Evaluations
PSEG	Existing Homes	MLI	Whole building	103%	103%	100%	PY 2 Evaluations
PSEG	Existing Homes	Multifamily	Smart Strip	100%	100%		PY 2 Evaluations
PSEG	Existing Homes	QHEC	LED Reflector	111%	111%		PY 2 Evaluations
PSEG	Existing Homes	QHEC	LED Specialty	116%	116%		PY 2 Evaluations
PSEG	Existing Homes	QHEC	LED Standard	100%	100%		PY 2 Evaluations
PSEG	Existing Homes	QHEC	ShowerStart	100%	100%	76%	PY 2 Evaluations

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
PSEG	Existing Homes	QHEC	Smart Strip	97%	97%		PY 2 Evaluations
PSEG	Existing Homes	QHEC	Smart thermostat	100%		100%	PY 2 Evaluations
PSEG	Existing Homes	QHEC	All Other	99%	99%	95%	PY 2 Evaluations
PSEG	Multifamily	Direct Install	ShowerStart Showerhead Adapter			61%	2023 TRM
RECO	Energy Efficient Products	Appliance Markdown	All	93%	101%		PY 2 Evaluations
RECO	Energy Efficient Products	Appliance Rebates	All	104%	34%		PY 2 Evaluations
RECO	Energy Efficient Products	Appliance Recycling	All	101%	100%		PY 2 Evaluations
RECO	Energy Efficient Products	Behavioral	All	100%			PY 2 Evaluations
RECO	Energy Efficient Products	HVAC	All	105%	100%		PY 2 Evaluations
RECO	Energy Efficient Products	Marketplace	Lighting	141%	105%		PY 2 Evaluations
RECO	Energy Efficient Products	Marketplace	Power Strips	122%	121%		PY 2 Evaluations
RECO	Energy Efficient Products	Marketplace	Smart Thermostat	113%			PY 2 Evaluations
RECO	Energy Efficient Products	Marketplace	All Other	124%	126%		PY 2 Evaluations
RECO	Energy Efficient Products	Midstream Lighting	All	100%	100%		PY 2 Evaluations

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
RECO	Energy Solutions for Business	Midstream Lighting	All	109%	104%		PY 2 Evaluations
RECO	Energy Solutions for Business	Prescriptive/Custom	All	110%	101%		PY 2 Evaluations
RECO	Energy Solutions for Business	SBDI	All	100%	108%		PY 2 Evaluations
RECO	Existing Homes	MI Weatherization	Whole building	100%	100%		PY 2 Evaluations
SJG	Energy Efficient Products	Downstream	All Other	94%	63%	102%	PY 2 Evaluations
SJG	Energy Efficient Products	Downstream Rebates	Central Air Conditioners	85%	85%		2023 TRM
SJG	Energy Efficient Products	Downstream Rebates	Tankless Water Heaters			103%	2023 TRM
SJG	Energy Efficient Products	Online Marketplace	Low-Flow Showerheads	135%		91%	PY 2 Evaluations
SJG	Energy Efficient Products	Online Marketplace	Smart Thermostat	100%		100%	PY 2 Evaluations
SJG	Energy Efficient Products	Online Marketplace	All Other	102%	308%	98%	PY 2 Evaluations
SJG	Energy Solutions for Business	Prescriptive	All Other			96%	PY 2 Evaluations
SJG	Energy Solutions for Business	SBDI	Prescriptive Lighting - Interior	100%	144%	100%	PY 2 Evaluations
SJG	Energy Solutions for Business	SBDI	All Other	98%	148%	98%	PY 2 Evaluations

Utility	Program	Subprogram	Measure	2024 kWh RR	2024 kW RR	2024 Therm RR	Source
SJG	Existing Homes	HER	All Other			94%	PY 2 Evaluations
SJG	Existing Homes	Multi-Family	All Other	51%	100%	102%	PY 2 Evaluations
SJG	Existing Homes	QHEC	LEDs	259%	190%		PY 2 Evaluations
SJG	Existing Homes	QHEC	Low-Flow Showerheads	96%		96%	PY 2 Evaluations
SJG	Existing Homes	QHEC	All Other	233%	183%	102%	PY 2 Evaluations

13 APPENDIX J: IN-SERVICE RATES

The table below presents ISR values differentiated by measure, program, and IOU. If no data is provided, use default value provided in measure.

IOU	Program	Sub Program	Measure	ISR
ACE	EE Products	Appliance Rebates	Air Purifiers	0.99
ACE	EE Products	Appliance Rebates	Clothes Dryer	0.98
ACE	EE Products	Appliance Rebates	Clothes Washers	0.98
ACE	EE Products	Appliance Rebates	Dehumidifiers	0.98
ACE	EE Products	Appliance Rebates	Heat Pump Water Heaters	1.00
ACE	EE Products	Appliance Rebates	Refrigerators	0.99
ACE	EE Products	Appliance Rebates	Room Air Conditioners	1.00
ACE	EE Products	Online Marketplace	Advanced Power Strip	0.98
ACE	EE Products	Online Marketplace	Air Purifiers	1.00
ACE	EE Products	Online Marketplace	Lighting	1.03
ACE	EE Products	Online Marketplace	Smart Thermostat	0.99
ACE	Energy Solutions for Business	Prescriptive and Custom	Lighting	1.00
ACE	Existing Homes	Multifamily	LED Lighting	0.93
ETG	EE Products	Online Marketplace	Bathroom Aerator	1.00
ETG	EE Products	Online Marketplace	Kit Kitchen Aerator	0.92
ETG	EE Products	Online Marketplace	Kit Low-Flow Showerhead	0.91
ETG	EE Products	Online Marketplace	Kitchen Aerator	0.92
ETG	EE Products	Online Marketplace	Low-Flow Showerhead	0.91
ETG	EE Products	Online Marketplace	Smart Thermostat	0.86
ETG	Existing Homes	QHEC	LED Bulb	0.85
ETG	Existing Homes	QHEC	Pipe Insulation	0.92
ETG	EE Products	Upstream	Smart Thermostat	1.0
JCPL	C&I	C&I	Lighting	0.96
JCPL	EE Products	Appliance Rebates	Air Purifier	1.00
JCPL	EE Products	Appliance Rebates	Clothes Dryer	1.00
JCPL	EE Products	Appliance Rebates	Dehumidifier	1.00
JCPL	EE Products	Appliance Rebates	Refrigerator	1.00

IOU	Program	Sub Program	Measure	ISR
JCPL	EE Products	Appliance Recycling	Refrigerator Recycling	0.99
JCPL	EE Products	Appliance Recycling	Freezer Recycling	1.0
JCPL	EE Products	Kits	Advanced Power Strip	0.69
JCPL	EE Products	Kits	Faucet Aerator	0.23
JCPL	EE Products	Kits	Furnace Whistle	0.04
JCPL	EE Products	Kits	LED Bulb	0.85
JCPL	EE Products	Kits	LED Nightlight	0.62
JCPL	EE Products	Kits	Low-Flow Showerhead	0.19
JCPL	EE Products	Lighting	All except foodbank kit	0.95
JCPL	EE Products	Online Marketplace	LED Bulb	0.81
JCPL	EE Products	Res HVAC Rebates	CAC	1.00
JCPL	EE Products	Res HVAC Rebates	GSHP	1.00
JCPL	EE Products	Res HVAC Rebates	Minisplit	1.00
JCPL	EE Products	Res HVAC Rebates	Smart Thermostat	0.94
JCPL	Energy Solutions for Business	Downstream Lighting	All	0.993
JCPL	SBDI	SBDI	Lighting	0.99
PSEG	EE Products	Downstream Rebates	Clothes Dryer	0.99
PSEG	EE Products	Downstream Rebates	Clothes Washer	1.00
PSEG	EE Products	Downstream Rebates	Refrigerator	0.99
PSEG	EE Products	Downstream Rebates	Smart thermostat	0.91
PSEG	EE Products	Downstream Rebates	Water heater	1.00
PSEG	EE Products	Midstream HVAC	HVAC	1.00
PSEG	EE Products	Midstream Lighting	Lighting	0.92
PSEG	EE Products	Online Marketplace	Advanced power strip	0.79
PSEG	EE Products	Online Marketplace	Air Purifier	0.85
PSEG	EE Products	Online Marketplace	Dehumidifier	1.00
PSEG	EE Products	Online Marketplace	Energy saving kit	0.88
PSEG	EE Products	Online Marketplace	Faucet Aerator	0.89
PSEG	EE Products	Online Marketplace	LED bulb	0.75
PSEG	EE Products	Online Marketplace	Low-Flow Showerhead	0.79
PSEG	EE Products	Online Marketplace	Smart thermostat	0.72

IOU	Program	Sub Program	Measure	ISR
PSEG	EE Products	Online Marketplace	Water conservation kit	0.60
PSEG	EE Products	Online Marketplace	Window AC	0.67
PSEG	EE Products	Welcome kits	Advanced Power Strip	0.74
PSEG	EE Products	Welcome kits	ENERGY STAR certified desk lamp	0.79
PSEG	EE Products	Welcome kits	LED Bulb	0.70
PSEG	EE Products	Welcome kits	LED Nightlight	0.78
PSEG	EE Products	Welcome kits - gas	Bathroom Aerator	0.40
PSEG	EE Products	Welcome kits - gas	Kitchen Aerator	0.36
PSEG	EE Products	Welcome kits - gas	Low-Flow Showerhead	0.38
PSEG	Existing Homes	Multifamily	Lighting	0.96
PSEG	Existing Homes	Multifamily	Faucet Aerator	0.96
PSEG	Existing Homes	Multifamily	Low-Flow Showerhead	0.98
PSEG	Existing Homes	Multifamily	Smart Strips	0.95
PSEG	Existing Homes	QHEC	Advanced Power Strip	0.92
PSEG	Existing Homes	QHEC	Faucet Aerator	0.94
PSEG	Existing Homes	QHEC	LED Bulb	0.96
PSEG	Existing Homes	QHEC	LED Reflector	0.96
PSEG	Existing Homes	QHEC	LED Specialty	0.96
PSEG	Existing Homes	QHEC	Low-Flow Showerhead	0.94
PSEG	Existing Homes	QHEC	Pipe Insulation	1.00
PSEG	Existing Homes	QHEC	ShowerStart	0.94
PSEG	Existing Homes	QHEC	Smart Thermostat	1.00
PSEG	Existing Homes	QHEC	Smart Strip	0.92
PSEG	Existing Homes	Residential Income-Eligible	Advanced Power Strip	0.92
PSEG	Existing Homes	Residential Income-Eligible	Faucet Aerator	0.88
PSEG	Existing Homes	Residential Income-Eligible	Food bank LED	0.83
PSEG	Existing Homes	Residential Income-Eligible	Food Bank LED nightlight	0.20

IOU	Program	Sub Program	Measure	ISR
PSEG	Existing Homes	Residential Income-Eligible	LED bulb	0.98
PSEG	Existing Homes	Residential Income-Eligible	LED Reflector	0.98
PSEG	Existing Homes	Residential Income-Eligible	LED Specialty	0.98
PSEG	Existing Homes	Residential Income-Eligible	Low-Flow Showerhead	0.88
PSEG	Existing Homes	Residential Income-Eligible	Pipe Insulation	1.00
PSEG	Existing Homes	Residential Income-Eligible	ShowerStart	0.94
PSEG	Existing Homes	Residential Income-Eligible	Smart Thermostat	1.00
PSEG	Existing Homes	Residential Income-Eligible	Water Heater Setback	1.00
RECO	EE Products	Online Marketplace	LIghting	0.97
RECO	EE Products	Online Marketplace	Tier 1 and 2 Smart Strip	1.00
RECO	EE Products	Online Marketplace	Power Strips	1.0
RECO	EE Products	Online Marketplace	Smart Thermostat	0.98
RECO	EE Products	Online Marketplace	All Other	0.88
RECO	EE Products	Appliance Markdown	All	0.87
RECO	EE Products	Appliance Rebate	All	1.0
RECO	EE Products	Appliance Recycling	All	1.0
RECO	EE Products	Midstream Lighting	All	0.98
RECO	Energy Solutions for Business	Midstream Lighting	All	1.0
RECO	Energy Solutions for Business	Prescriptive/Custom	All	0.81
RECO	Energy Solutions for Business	SBDI	All	1.0
SJG	EE Products	Appliance Rebates	Clothes Dryer	1.00
SJG	EE Products	Appliance Rebates	Clothes Washer (Tier 1)	1.00
SJG	EE Products	Appliance Rebates	Clothes Washer (Tier 2)	1.00
SJG	EE Products	HVAC	Central Air Conditioners (Tier 1)	0.96

IOU	Program	Sub Program	Measure	ISR
SJG	EE Products	HVAC	Gas Boiler	1.00
SJG	EE Products	HVAC	Gas Combination Heater	0.92
SJG	EE Products	HVAC	Gas Furnace	0.95
SJG	EE Products	HVAC	Gas Furnace with Water Heater	0.94
SJG	EE Products	HVAC	Gas Storage Tank Water Heater	0.97
SJG	EE Products	HVAC	Tankless Water Heater	0.97
SJG	EE Products	Online Marketplace	Bathroom Aerator	0.85
SJG	EE Products	Online Marketplace	Kitchen Aerator	0.84
SJG	EE Products	Online Marketplace	Low-Flow Showerhead	0.92
SJG	EE Products	Online Marketplace	Smart thermostat	0.86
SJG	EE Products	Upstream	Low-Flow Showerhead	0.92
SJG	EE Products	Upstream	Smart thermostat	1.00
SJG	EE Products	Upstream	LED bulb	0.85
SJG	Existing Homes	QHEC	Advanced Power Strips	0.91
SJG	Existing Homes	QHEC	LED Bulb	0.97
SJG	Existing Homes	QHEC	Pipe Insulation	1.00
SJG	Existing Homes	QHEC	Bathroom Faucet Aerators	1.00
SJG	Existing Homes	QHEC	Low-Flow Showerheads	0.96

14 APPENDIX K: DHW AND SPACE HEAT FUEL SPLIT

The values below should be used when customer DHW or space heat fuel type is unknown. If a measure is not listed in Table 14-1, use default values presented in Table 14-2 or in measure section.

Table 14-1 Fuel Split by Program and Measure

IOU	Program	Measure	Parameter	Value
ACE	Appliance Rebates	Any	% gas water heat	0.63
ACE	Appliance Rebates	Any	% elec water heat	0.30
ACE	Appliance Rebates	Any	% gas space heat	0.78
ACE	Appliance Rebates	Any	% elec space heat	0.09
ACE	HVAC Rebates	Any	% gas space heat	0.83
ACE	HVAC Rebates	Any	% elec space heat	0.17
ACE	Marketplace	Any	% gas space heat	0.66
ACE	Marketplace	Any	% elec space heat	0.19
ACE	Marketplace	Any	% gas water heat	0.57
ACE	Marketplace	Any	% elec water heat	0.31
ETG	Down-stream	Any	% gas water heat	0.87
ETG	Down-stream	Any	% elec water heat	0.13
ETG	Down-stream	Any	% gas space heat	0.90
ETG	Down-stream	Any	% elec space heat	0.10
ETG	HER	Any	% gas water heat	0.87
ETG	HER	Any	% elec water heat	0.13
ETG	HER	Any	% gas space heat	0.90
ETG	HER	Any	% elec space heat	0.10
ETG	Marketplace	Any	% gas water heat	0.91
ETG	Marketplace	Any	% elec water heat	0.09
ETG	Marketplace	Any	% gas space heat	0.94
ETG	Marketplace	Any	% elec space heat	0.06
ETG	Non-Participant	Any	% gas water heat	0.80
ETG	Non-Participant	Any	% elec water heat	0.20
ETG	Non-Participant	Any	% gas space heat	0.84
ETG	Non-Participant	Any	% elec space heat	0.16
ETG	QHEC	Any	% gas water heat	0.84

IOU	Program	Measure	Parameter	Value
ETG	QHEC	Any	% elec water heat	0.16
ETG	QHEC	Any	% gas space heat	0.95
ETG	QHEC	Any	% elec space heat	0.05
ETG	Upstream	Faucet Aerators	% gas water heat	0.83
ETG	Upstream	Faucet Aerators	% elec water heat	0.17
ETG	Upstream	Showerheads	% gas water heat	0.82
ETG	Upstream	Showerheads	% elec water heat	0.18
JCPL	Appliance Rebates	Clothes Washer	% elec water heat	0.53
JCPL	Appliance Rebates	Clothes Washer	% gas water heat	0.47
JCPL	EE Kits	Faucet Aerator	% elec water heat	0.68
JCPL	EE Kits	Faucet Aerator	% gas water heat	0.32
JCPL	EE Kits	Shower Head	% elec water heat	0.71
JCPL	EE Kits	Shower Head	% gas water heat	0.29
JCPL	All	Smart Thermostat	% heat pump heating	0.07
PSEG	EE Kits	Any	% elec space heat	0.38
PSEG	EE Kits	Any	% gas space heat	0.61
PSEG	EE Kits	Any	% elec water heat	0.36
PSEG	EE Kits	Any	% gas water heat	0.63
PSEG	Online Marketplace	Any	% elec space heat	0.11
PSEG	Online Marketplace	Any	% gas space heat	0.86
PSEG	Online Marketplace	Any	% elec water heat	0.13
PSEG	Online Marketplace	Any	% gas water heat	0.87
SJG	Down-stream	Any	% gas water heat	0.88
SJG	Down-stream	Any	% elec water heat	0.12
SJG	Down-stream	Any	% gas space heat	0.94
SJG	Down-stream	Any	% elec space heat	0.06
SJG	HER	Any	% gas water heat	0.92
SJG	HER	Any	% elec water heat	0.08
SJG	HER	Any	% gas space heat	0.92
SJG	HER	Any	% elec space heat	0.08
SJG	Marketplace	Any	% gas water heat	0.84
SJG	Marketplace	Any	% elec water heat	0.16

IOU	Program	Measure	Parameter	Value
SJG	Marketplace	Any	% gas space heat	0.92
SJG	Marketplace	Any	% elec space heat	0.08
SJG	Non-Participant	Any	% gas water heat	0.83
SJG	Non-Participant	Any	% elec water heat	0.17
SJG	Non-Participant	Any	% gas space heat	0.90
SJG	Non-Participant	Any	% elec space heat	0.10
SJG	QHEC	Any	% gas water heat	0.87
SJG	QHEC	Any	% elec water heat	0.12
SJG	QHEC	Any	% gas space heat	0.92
SJG	QHEC	Any	% elec space heat	0.09
SJG	Upstream	Faucet Aerators	% gas water heat	0.83
SJG	Upstream	Faucet Aerators	% elec water heat	0.17
SJG	Upstream	Showerheads	% gas water heat	0.84
SJG	Upstream	Showerheads	% elec water heat	0.16

Table 14-2 Default Fuel Split Values

IOU	Program	Measure	Parameter	Value
Any	Any	Clothes washer	% gas water heat	0.69
Any	Any	Clothes washer	% elec water heat	0.31
Any	Any	Dishwasher	% elec water heat	0.20
Any	Any	Dishwasher	% gas water heat	0.54
Any	Any	Smart Thermostat	% elec space heat	0.15
Any	Any	Smart Thermostat	% gas space heat	0.85
Any	Any	Aerators or showerheads	% elec water heat	0.25
Any	Any	Aerators or showerheads	% gas water heat	0.71
Any	Any	Thermostatic showerhead	% elec water heat	0.18
Any	Any	Thermostatic showerhead	% gas water heat	0.82
Any	Any	Pipe insulation	% elec water heat	0.18
Any	Any	Pipe insulation	% gas water heat	0.82

15 APPENDIX L: LIGHTING WATTAGES

15.1 C&I MIDSTREAM LIGHTING BASELINE WATTAGES

This section provides baseline wattages for Midstream lighting fixtures, built by NJ Utilities a baseline wattage table for these fixtures by using Pennsylvania, New Jersey, Illinois and Mid-Atlantic TRMs as reference.

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
Energy Star LED Bulb - A Lamp 250-449 Lumens	250	449	25
Energy Star LED Bulb - A Lamp 450-799 Lumens	450	799	29
Energy Star LED Bulb - A Lamp 800-1099 Lumens	800	1099	43
Energy Star LED Bulb - A Lamp 1100-1599 Lumens	1100	1599	53
Energy Star LED Bulb - A Lamp 1600-1999 Lumens	1600	1999	72
Energy Star LED Bulb - A Lamp 2000-2549 Lumens	2000	2549	125
Energy Star LED Bulb - A Lamp 2500-3000 Lumens	2550	3000	150
Energy Star LED Bulb - A Lamp 3001-3999 Lumens	3001	3999	200
Energy Star LED Bulb - A Lamp 4000-6000 Lumens	4000	6000	300
Energy Star LED Bulb - G30 250-349 Lumens	250	349	0
Energy Star LED Bulb - G30 350-499 Lumens	350	499	0
Energy Star LED Bulb - G30 500-574 Lumens	500	574	43
Energy Star LED Bulb - G30 575-649 Lumens	575	649	53
Energy Star LED Bulb - G30 650-1099 Lumens	650	1099	72
Energy Star LED Bulb - G30 1100-1300 Lumens	1100	1300	150
Energy Star LED Bulb - G40 250-349 Lumens	250	349	0
Energy Star LED Bulb - G40 350-499 Lumens	350	499	0
Energy Star LED Bulb - G40 500-574 Lumens	500	574	43
Energy Star LED Bulb - G40 575-649 Lumens	575	649	53
Energy Star LED Bulb - G40 650-1099 Lumens	650	1099	72
Energy Star LED Bulb - G40 1100-1300 Lumens	1100	1300	150
Energy Star LED Bulb - PAR30 220-299 Lumens	200	299	30
Energy Star LED Bulb - PAR30 300-599 Lumens	300	599	40
Energy Star LED Bulb - PAR30 600-849 Lumens	600	849	50
Energy Star LED Bulb - PAR30 850-999 Lumens	850	999	55
Energy Star LED Bulb - PAR30 1000-1300 Lumens	1000	1300	65

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
Energy Star LED Bulb - PAR30 1400-1599 Lumens	1400	1599	120
Energy Star LED Bulb - PAR30 1600-2099 Lumens	1600	2099	150
Energy Star LED Bulb - PAR30 ≥2100 Lumens	2100	∞	250
Now Inactive			
Now Inactive			
Energy Star LED Bulb - PAR40			
Energy Star LED Bulb - R30			
Energy Star LED Bulb - BR30 200-299 Lumens	200	299	30
Energy Star LED Bulb - BR30 300-449 Lumens	300	499	40
Energy Star LED Bulb - BR30 450-499 Lumens	450	499	45
Energy Star LED Bulb - BR30 500-1419 Lumens	500	1419	65
Energy Star LED Bulb - BR40 200-299 Lumens	200	299	30
Energy Star LED Bulb - BR40 300-449 Lumens	300	449	40
Energy Star LED Bulb - BR40 450-499 Lumens	450	499	45
Energy Star LED Bulb - BR40 500-1419 Lumens	500	1419	65
Energy Star LED Bulb - R14 200 - 299 Lumens	200	299	30
Energy Star LED Bulb - R14 300 - 599 Lumens	300	599	40
Energy Star LED Bulb - R14 600 - 849 Lumens	600	849	50
Energy Star LED Bulb - R14 850 - 999 Lumens	850	999	55
Energy Star LED Bulb - R14 1000 - 1300 Lumens	1000	11300	65
Energy Star LED Bulb - R16 200 - 299 Lumens	200	299	30
Energy Star LED Bulb - R16 300 - 599 Lumens	300	599	40
Energy Star LED Bulb - R16 600 - 849 Lumens	600	849	50
Energy Star LED Bulb - R16 850 - 999 Lumens	850	999	55
Energy Star LED Bulb - R16 1000 - 1300 Lumens	1000	11300	65
Energy Star LED Bulb - G16.5 250-349 Lumens	250	349	0
Energy Star LED Bulb - G16.5 350-499 Lumens	350	499	0
Energy Star LED Bulb - G16.5 500-574 Lumens	500	574	43
Energy Star LED Bulb - G16.5 575-649 Lumens	575	649	53
Energy Star LED Bulb - G16.5 650-1099 Lumens	650	1099	72
Energy Star LED Bulb - G16.5 1100-1300 Lumens	1100	1300	150

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
Energy Star LED Bulb - G25 250-349 Lumens	250	349	0
Energy Star LED Bulb - G25 350-499 Lumens	350	499	0
Energy Star LED Bulb - G25 500-574 Lumens	500	574	43
Energy Star LED Bulb - G25 575-649 Lumens	575	649	53
Energy Star LED Bulb - G25 650-1099 Lumens	650	1099	72
Energy Star LED Bulb - G25 1100-1300 Lumens	1100	1300	150
Energy Star LED Bulb - PAR16 200-299 Lumens	200	299	30
Energy Star LED Bulb - PAR16 300-599 Lumens	300	599	40
Energy Star LED Bulb - PAR16 600-849 Lumens	600	849	50
Energy Star LED Bulb - PAR16 850-999 Lumens	850	999	55
Energy Star LED Bulb - PAR16 1000-1300 Lumens	1000	1300	65
	200	299	30
Energy Star LED Bulb - PAR20 300-599 Lumens	300	599	40
Energy Star LED Bulb - PAR20 600-849 Lumens	600	849	50
Energy Star LED Bulb - PAR20 850-999 Lumens	850	999	55
Energy Star LED Bulb - PAR20 1000-1300 Lumens	1000	1300	65
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
Energy Star LED Bulb - R20 200-299 Lumens	200	299	30
Energy Star LED Bulb - R20 300-399 Lumens	300	399	40
Energy Star LED Bulb - R20 400-449 Lumens	400	449	40
Energy Star LED Bulb - R20 450-715 Lumens	450	715	45
Energy Star LED Bulb - R20 716-849 Lumens	716	849	50
Energy Star LED Bulb - R20 850-999 Lumens	850	999	55
Energy Star LED Bulb - R20 1000-1300 Lumens	1000	1300	65
N/A			
Energy Star LED Bulb - BR20			
Energy Star LED Bulb - Other			
Energy Star LED Fixture - Bath Vanity			
Energy Star LED Fixture - Bath Vanity <1,499 Lumens		1499	51.875

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
Energy Star LED Fixture - Bath Vanity 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Bath Vanity >3,000 Lumens	3000		200
Energy Star LED Fixture - Ceiling Mount			
Energy Star LED Fixture - Ceiling Mount <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Ceiling Mount 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Ceiling Mount >3,000 Lumens	3000		200
Energy Star LED Fixture - Close to Ceiling Mount			
Energy Star LED Fixture - Close to Ceiling Mount <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Close to Ceiling Mount 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Close to Ceiling Mount >3,000 Lumens	3000		200
Energy Star LED Fixture - Cove Mount			
Energy Star LED Fixture - Cove Mount <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Cove Mount 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Cove Mount >3,000 Lumens	3000		200
Energy Star LED Fixture - Decorative Pendant			
Energy Star LED Fixture - Decorative Pendant <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Decorative Pendant 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Decorative Pendant >3,000 Lumens	3000		200
Energy Star LED Fixture - Downlight Pendant			
Energy Star LED Fixture - Downlight Pendant <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Downlight Pendant 1,500 to 2,999 Lumens	1500	2999	136.25

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
Energy Star LED Fixture - Downlight Pendant >3,000 Lumens	3000		200
Energy Star LED Fixture - Solid State Retrofit			
Energy Star LED Fixture - Solid State Retrofit <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Solid State Retrofit 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Solid State Retrofit >3,000 Lumens	3000		200
Energy Star LED Fixture - Downlight Surface Mount			
Energy Star LED Fixture - Downlight Surface Mount <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Downlight Surface Mount 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Downlight Surface Mount >3,000 Lumens	3000		200
Energy Star LED Fixture - Outdoor Pole-Mount			
Energy Star LED Fixture - Outdoor Pole-Mount <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Outdoor Pole-Mount 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Outdoor Pole-Mount >3,000 Lumens	3000		200
Energy Star LED Fixture - Security			
Energy Star LED Fixture - Security <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Security 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Security >3,000 Lumens	3000		200
Energy Star LED Fixture - Wall Sconces			
Energy Star LED Fixture - Wall Sconces <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Wall Sconces 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Wall Sconces >3,000 Lumens	3000		200
Energy Star LED Fixture - Other			

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
Energy Star LED Fixture - Other <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Other 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Other >3,000 Lumens	3000		200
Energy Star LED Fixture - Outdoor (Various Types)			
Energy Star LED Fixture - Outdoor (Various Types) <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Outdoor (Various Types) 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Outdoor (Various Types) >3,000 Lumens	3000		200
Energy Star LED Fixture - Pendant			
Energy Star LED Fixture - Pendant <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Pendant 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Pendant >3,000 Lumens	3000		200
Energy Star LED Fixture - Recessed Downlight			
Energy Star LED Fixture - Recessed Downlight <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Recessed Downlight 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Recessed Downlight >3,000 Lumens	3000		200
Energy Star LED Fixture - Torchiere <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Torchiere 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Torchiere >3,000 Lumens	3000		200
Energy Star LED Fixture - Wrapped Lens			
Energy Star LED Fixture - Wrapped Lens <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Wrapped Lens 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Wrapped Lens >3,000 Lumens	3000		200
Energy Star LED Fixture - Linear Strip			
Energy Star LED Fixture - Linear Strip <1,499 Lumens		1499	51.875

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
Energy Star LED Fixture - Linear Strip 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Linear Strip >3,000 Lumens	3000		200
Energy Star LED Fixture - Under Cabinet			
Energy Star LED Fixture - Under Cabinet <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Under Cabinet 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Under Cabinet >3,000 Lumens	3000		200
Energy Star LED Fixture - Accent Light Line Voltage			
Energy Star LED Fixture - Accent Light Line Voltage <1,499 Lumens		1499	51.875
Energy Star LED Fixture - Accent Light Line Voltage 1,500 to 2,999 Lumens	1500	2999	136.25
Energy Star LED Fixture - Accent Light Line Voltage >3,000 Lumens	3000		200
LED Wall-Wash Luminaires			17.7
LED Track or Mono-point Directional Lighting Fixtures: 400-472 Lumens	400	472	10
LED Track or Mono-point Directional Lighting Fixtures: 473-524 Lumens	473	524	11
LED Track or Mono-point Directional Lighting Fixtures: 525-714 Lumens	525	714	14
LED Track or Mono-point Directional Lighting Fixtures: 715-937 Lumens	715	937	18
LED Track or Mono-point Directional Lighting Fixtures: 938-1259 Lumens	938	1259	24
LED Track or Mono-point Directional Lighting Fixtures: 1260-1399 Lumens	1260	1399	30
LED Track or Mono-point Directional Lighting Fixtures: 1400-1739 Lumens	1400	1739	35
LED Track or Mono-point Directional Lighting Fixtures: 1740-2174 Lumens	1740	2174	43
LED Track or Mono-point Directional Lighting Fixtures: 2175-2624 Lumens	2175	2624	53

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
LED Track or Mono-point Directional Lighting Fixtures: 2625-2999 Lumens	2625	2999	62
LED Track or Mono-point Directional Lighting Fixtures: 3000-3300 Lumens	3000	3300	70
2 x 4 LED new luminaire 3000-4500 Lumens	3000	4500	59.48
2 x 4 LED new luminaire 4501-6000 Lumens	4501	6000	96.24
2 x 4 LED new luminaire 6001-7500 Lumens	6001	7500	128.32
2 x 4 LED integrated retrofit kit	3000	4500	59.48
2 x 4 LED integrated retrofit kit	4501	6000	96.24
2 x 4 LED integrated retrofit kit	6001	7500	128.32
2 x 2 LED new luminaire	2000	3500	59.48
2 x 2 LED new luminaire	3501	5000	96.24
2 x 2 LED integrated retrofit kit	2000	3500	59.48
2 x 2 LED integrated retrofit kit	3501	5000	96.24
1 x 4 LED new luminaire	1500	3000	30.06
1 x 4 LED new luminaire	3001	4500	59.48
1 x 4 LED new luminaire	4501	6000	96.24
1 x 4 LED integrated retrofit kit	1500	3000	30.06
1 x 4 LED integrated retrofit kit	3001	4500	59.48
1 x 4 LED integrated retrofit kit	4501	6000	96.24
LED direct/indirect linear ambient 2 ft. new luminaire 1500-3500 Lumens	1500	3500	33
LED direct/indirect linear ambient 2 ft. new luminaire 3501-5500 Lumens	3501	5500	61
LED direct/indirect linear ambient 3 ft. new luminaire			23
LED direct/indirect linear ambient 4 ft. new luminaire <=2132		2132	31
LED direct/indirect linear ambient 4 ft. new luminaire 2133-4261 Lumens	2133	4261	59
LED direct/indirect linear ambient 4 ft. new luminaire 4262-6392 Lumens	4262	6392	89
LED direct/indirect linear ambient 4 ft. new luminaire 6393-9400 Lumens	6393	9400	112

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
LED direct/indirect linear ambient 6 ft. new luminaire			
LED direct/indirect linear ambient 8 ft. new luminaire <=3290 Lumens		3290	58
LED direct/indirect linear ambient 8 ft. new luminaire 3291 - 6580 Lumens	3291	6580	109
LED direct/indirect linear ambient 8 ft. new luminaire 6581-9870 Lumens	6581	9870	167
LED direct/indirect linear ambient 8 ft. new luminaire >=9871 Lumens	9871		219
LED direct linear ambient 2 ft retrofit kit 1500-3500 Lumens	1500	3500	33
LED direct linear ambient 2 ft retrofit kit 3501-5500 Lumens	3501	5500	61
LED direct linear ambient 4 ft retrofit kit <=2132 Lumens		2132	31
LED direct linear ambient 4 ft retrofit kit 2133-4261 Lumens	2133	4261	59
LED direct linear ambient 4 ft retrofit kit 4262-6392 Lumens	4262	6392	89
LED direct linear ambient 4 ft retrofit kit 6393-9400	6393	9400	112
LED direct linear ambient 8 ft retrofit kit <=3290 Lumens		3290	58
LED direct linear ambient 8 ft retrofit kit 3291-6580 Lumens	3291	6580	109
LED direct linear ambient 8 ft retrofit kit 6581-9870 Lumens	6581	9870	167
LED direct linear ambient 8 ft retrofit kit >=9871 Lumens	9871		219
1 Lamp External Driver Type C			
2 Lamp External Driver Type C			
3 Lamp External Driver Type C			
4 Lamp External Driver Type C			
6 Lamp External Driver Type C			
Highbay Aisle Luminaire ≤125W 10001-15000 Lumens	10001	15000	196

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
Highbay Aisle Luminaire>125W & ≤250W 150001-20000 Lumens	15001	20000	294
Highbay Aisle Luminaire >250W >=20000 Lumens	20000		392
High-Bay Luminaires for Commercial and Industrial Buildings ≤125W 10001-15000 Lumens	10001	15000	196
High-Bay Luminaires for Commercial and Industrial Buildings >125W & ≤250W 15001-20000 Lumens	15001	20000	294
High-Bay Luminaires for Commercial and Industrial Buildings >250W >=20000 Lumens	20000		392
Low-Bay Luminaires for Commercial and Industrial Buildings ≤125W <=10000 Lumens	10000	157	
Low-Bay Luminaires for Commercial and Industrial Buildings >125W & ≤250W			
Low-Bay Luminaires for Commercial and Industrial Buildings >250W			
Retrofit Kits for High-Bay Luminaires for Commercial and Industrial Buildings ≤125W 10001-15000 Lumens	10001	15000	196
Retrofit Kits for High-Bay Luminaires for Commercial and Industrial Buildings > 125 - ≤250W 15001-20000 Lumens	15001	20000	294
Retrofit Kits for High-Bay Luminaires for Commercial and Industrial Buildings >250W >=20000 Lumens	20000		392
Retrofit Kits for Low-Bay Luminaires for Commercial and Industrial Buildings ≤125W <=10000 Lumens	10000	157	
High Bay LED - 5,000 to 9,999 Lumens	5000	9999	157
High Bay LED - 10,000 to 19,999 Lumens	10000	19999	262.5
High Bay LED - 20,000 to 29,999 Lumens	20000	29999	634
High Bay LED - 30,000 to 39,999 Lumens	30000	39999	767.5
High Bay LED - ≥40,000 Lumens	40000		901
Low Bay LED - 5,000 to 9,999 Lumens	5000	9999	151.5
Low Bay LED - 10,000 to 19,999 Lumens	10000	19999	272.5
Low Bay LED - 20,000 to 29,999 Lumens	20000	29999	634
Low Bay LED - 30,000 to 39,999 Lumens	30000	39999	767.5
Low Bay LED - ≥40,000 Lumens	40000		901
HID Replacement Lamp ≤125W			171

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
HID Replacement Lamp>125W - ≤250W			288
HID Replacement Lamp >250W			452
2' Replacement Lamp			16.5
3' Replacement Lamp			26
4' Replacemnet Lamp		3200	29.5
4' High Output Replacement Lamp	3200		54
8' Replacement Lamp		4000	59
8' Replacement Lamp	4001		86
U -Bend Lamp	1500	2000	29.5
U -Bend Lamp	2001	3276	54
Horizontally-Mounted Lamps 760-934 Lumens	760	934	13
Horizontally-Mounted Lamps 935-1349 Lumens	935	1349	18
Horizontally-Mounted Lamps 1350-1834 Lumens	1350	1834	26
Horizontally-Mounted Lamps 1835-2549 Lumens	1835	2549	32
Horizontally-Mounted Lamps 2550-3199 Lumens	2550	3199	42
Vertically-Mounted Lamps 760-934 Lumens	760	934	13
Vertically-Mounted Lamps 935-1349 Lumens	935	1349	18
Vertically-Mounted Lamps 1350-1834 Lumens	1350	1834	26
Vertically-Mounted Lamps 1835-2549 Lumens	1835	2549	32
Vertically-Mounted Lamps 2550-3199 Lumens	2550	3199	42
2G11 Base Lamps 760-934 Lumens	760	934	13
2G11 Base Lamps 935-1349 Lumens	935	1349	18
2G11 Base Lamps 1350-1834 Lumens	1350	1834	26
2G11 Base Lamps 1835-2549 Lumens	1835	2549	32
2G11 Base Lamps 2550-3199 Lumens	2550	3199	42
Display Case Luminaire			7.1 per ft
Refrigerated Case Lighting 4'			60.8
Refrigerated Case Lighting 5'			76
Refrigerated Case Lighting 6'			91.2
LED Architectural Flood and Spot Luminaries			
LED Architectural Flood and Spot Luminaries - Up to 4,999 Lumens		4999	133

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
LED Architectural Flood and Spot Luminaries - 5,000 to 9,999 Lumens	5000	9999	215
LED Architectural Flood and Spot Luminaries - 10,000 to 19,999 Lumens	10000	19999	295
LED Architectural Flood and Spot Luminaries - 20,000 to 29,999 Lumens	20000	29999	462
LED Architectural Flood and Spot Luminaries - 30,000 to 39,999 Lumens	30000	39999	843
LED Architectural Flood and Spot Luminaries - ≥40,000 Lumens	40000		1090
LED Bollard Fixtures			
LED Bollard Fixtures - Up to 4,999 Lumens		4999	113.6
LED Bollard Fixtures - 5,000 to 9,999 Lumens	5000	9999	198.9
LED Bollard Fixtures - 10,000 to 19,999 Lumens	10000	19999	284.1
LED Bollard Fixtures - 20,000 to 29,999 Lumens	20000	29999	
LED Bollard Fixtures - 30,000 to 39,999 Lumens	30000	39999	
LED Bollard Fixtures - ≥40,000 Lumens	40000		
LED Fuel Pump Canopy			
LED Fuel Pump Canopy - Up to 4,999 Lumens		4999	133
LED Fuel Pump Canopy - 5,000 to 9,999 Lumens	5000	9999	215
LED Fuel Pump Canopy - 10,000 to 19,999 Lumens	10000	19999	295
LED Fuel Pump Canopy - 20,000 to 29,999 Lumens	20000	29999	462
LED Fuel Pump Canopy - 30,000 to 39,999 Lumens	30000	39999	843
LED Fuel Pump Canopy - ≥40,000 Lumens	40000		1090
LED Landscape/Accent Flood and Spot Luminaires			
LED Landscape/Accent Flood and Spot Luminaires - Up to 4,999 Lumens		4999	133
LED Landscape/Accent Flood and Spot Luminaires - 5,000 to 9,999 Lumens	5000	9999	215
LED Landscape/Accent Flood and Spot Luminaires - 10,000 to 19,999 Lumens	10000	19999	295
LED Landscape/Accent Flood and Spot Luminaires - 20,000 to 29,999 Lumens	20000	29999	462
LED Landscape/Accent Flood and Spot Luminaires - 30,000 to 39,999 Lumens	30000	39999	843

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
LED Landscape/Accent Flood and Spot Luminaires - ≥40,000 Lumens	40000		1090
LED Outdoor Pole/Arm-Mounted Area and Roadway Luminaires			
LED Outdoor Pole/Arm-Mounted Area and Roadway Luminaires - Up to 4,999 Lumens		4999	133
LED Outdoor Pole/Arm-Mounted Area and Roadway Luminaires - 5,000 to 9,999 Lumens	5000	9999	215
LED Outdoor Pole/Arm-Mounted Area and Roadway Luminaires - 10,000 to 19,999 Lumens	10000	19999	295
LED Outdoor Pole/Arm-Mounted Area and Roadway Luminaires - 20,000 to 29,999 Lumens	20000	29999	462
LED Outdoor Pole/Arm-Mounted Area and Roadway Luminaires - 30,000 to 39,999 Lumens	30000	39999	843
LED Outdoor Pole/Arm-Mounted Area and Roadway Luminaires - ≥40,000 Lumens	40000		1090
LED Large Outdoor Pole/Arm-Mounted Area and Roadway Retrofit			
LED Outdoor Pole/Arm-Mounted Decorative Luminaires			
LED Outdoor Wall-Mounted Area Luminaires			
LED Outdoor Wall-Mounted Area Luminaires - Up to 4,999 Lumens		4999	133
LED Outdoor Wall-Mounted Area Luminaires - 5,000 to 9,999 Lumens	5000	9999	215
LED Outdoor Wall-Mounted Area Luminaires - 10,000 to 19,999 Lumens	10000	19999	295
LED Outdoor Wall-Mounted Area Luminaires - 20,000 to 29,999 Lumens	20000	29999	462
LED Outdoor Wall-Mounted Area Luminaires - 30,000 to 39,999 Lumens	30000	39999	843
LED Outdoor Wall-Mounted Area Luminaires - ≥40,000 Lumens	40000		1090
LED Parking Garage Luminaires			
LED Parking Garage Luminaires - Up to 4,999 Lumens		4999	133
LED Parking Garage Luminaires - 5,000 to 9,999 Lumens	5000	9999	215

Measure Name	Min Lumen	Max Lumen	Baseline Wattage
LED Parking Garage Luminaires - 10,000 to 19,999 Lumens	10000	19999	295
LED Parking Garage Luminaires - 20,000 to 29,999 Lumens	20000	29999	462
LED Parking Garage Luminaires - 30,000 to 39,999 Lumens	30000	39999	843
LED Parking Garage Luminaires - ≥40,000 Lumens	40000		1090
LED Stairwell and Passageway Luminaires			
LED Stairwell and Passageway Luminaires - Up to 4,999 Lumens		4999	133
LED Stairwell and Passageway Luminaires - 5,000 to 9,999 Lumens	5000	9999	215
LED Stairwell and Passageway Luminaires - 10,000 to 19,999 Lumens	10000	19999	295
LED Stairwell and Passageway Luminaires - 20,000 to 29,999 Lumens	20000	29999	462
LED Stairwell and Passageway Luminaires - 30,000 to 39,999 Lumens	30000	39999	843
LED Stairwell and Passageway Luminaires - ≥40,000 Lumens	40000		1090

15.2 FIXTURE WATTAGES BY TYPE

The values below are taken from Rhode Island TRM, 2020 Appendix A, table 3.

Table 15-1 Fixture Wattages By Type

Fixture Code	Description	Rated Watts
	LED Exit Signs	
1E0002	2.0 WATT LED	2
1E0003	3.0 WATT LED	3
1E0005	5.0 WLED	5
1E0005C	0.5 WATT LEC	0.5
1E0008	8.0 WLED	8
1E0015	1.5 WATT LED	1.5

Fixture Code	Description	Rated Watts
	Compact Fluorescents	
1C0005S	5W COMPACT HW	7
1C0007S	7W COMPACT HW	9
1C0009S	9W COMPACT HW	11
1C0011S	11W COMPACT HW	13
1C0013S	13W COMPACT HW	15
1C0018E	18W COMPACT HW ELIG	20
1C0018S	18W COMPACT HW	20
1C0022S	22W COMPACT HW	24
1C0023E	1/23W COMPACT HW ELIG	25
1C0026E	26W COMPACT HW ELIG	28
1C0026S	26W COMPACT HW	28
1C0028S	28W COMPACT HW	30
1C0032E	32W COMPACT HW ELIG	34
1C0032S	32W CIRCLINE HW	34
1C0042E	1/42W COMPACT HW ELIG	48
1C0044S	44W CIRCLINE HW	46
1C0057E	1/57W COMPACT HW ELIG	65
2C0005S	2/5W COMPACT HW	14
2C0007S	2/7W COMPACT HW	18
2C0009S	2/9W COMPACT HW	22
2C0011S	2/11W COMPACT HW	26
2C0013E	2/13W COMPACT HW ELIG	28
2C0013S	2/13W COMPACT HW	30
2C0018E	2/18W COMP. HW ELIG	40
2C0026E	2/26W COMP. HW ELIG	54
2C0032E	2/32W COMPACT HW ELIG	68
2C0042E	2/42W COMPACT HW ELIG	100
3C0009S	3/9W COMPACT HW	33
3C0013S	3/13W COMPACT HW	45
3C0018E	3/18W COMPACT HW ELIG	60

Fixture Code	Description	Rated Watts
3C0026E	3/26W COMPACT HW ELIG	82
3C0032E	3/32W COMPACT HW ELIG	114
3C0042E	3/42W COMPACT HW ELIG	141
4C0013S	4/13W COMPACT HW	60
4C0018E	4/18W COMPACT HW ELIG	80
4C0026E	4/26W COMPACT HW ELIG	108
4C0032E	4/32W COMPACT HW ELIG	152
4C0042E	4/42W COMPACT HW ELIG	188
6C0026E	6/26W COMPACT HW ELIG	162
6C0032E	6/32W COMPACT HW ELIG	228
6C0042E	6/42W COMPACT HW ELIG	282
8C0026E	8/26W COMPACT HW ELIG	216
8C0032E	8/32W COMPACT HW ELIG	304
8C0042E	8/42W COMPACT HW ELIG	376
T5 Systems		
10F54HSE	10L4’ 54W T5HO/ELIG	585
1F14SSE	1L2’ 14W T5/ELIG	16
1F21SSE	1L3’ 21W T5/ELIG	24
1F24HSE	1L2’ 24W T5HO/ELIG	29
1F28SSE	1L4’ 28W T5/ELIG	32
1F39HSE	1L3’ 39W T5HO/ELIG	42
1F54HSE	1L4’ 54W T5HO/ELIG	59
2F14SSE	2L2’ 14W T5/ELIG	32
2F21SSE	2L3’ 21W T5/ELIG	47
2F24HSE	2L2’ 24W T5HO/ELIG	52
2F28SSE	2L4’ 28W T5/ELIG	63
2F39HSE	2L3’ 39W T5HO/ELIG	85
2F54HSE	2L4’ 54W T5HO/ELIG	117
3F24HSE	3L2’ 24W T5HO/ELIG	80
3F28SSE	3L4’ 28W T5 ELIG	95
3F54HSE	3L4’ 54W T5HO/ELIG	177

Fixture Code	Description	Rated Watts
4F54HSE	4L4’ 54W T5HO/ELIG	234
5F54HSE	5L4’ 54W T5HO/ELIG	294
6F54HSE	6L4’ 54W T5HO/ELIG	351
8F54HSE	8L4’ 54W T5HO/ELIG	468
Two Foot High Efficient T8 Systems		
1F17ESH	1L2’ 17W T8EE/ELEE HIGH PWR	20
1F17ESL	1L2’ 17W T8EE/ELEE LOW PWR	14
1F17ESN	1L2’ 17W T8EE/ELEE	17
1F28BXE	1L2’ F28BX/ELIG	32
2F17ESH	2L2’ 17W T8EE/ELEE HIGH PWR	40
2F17ESL	2L2’ 17W T8EE/ELEE LOW PWR	27
2F17ESN	2L2’ 17W T8EE/ELEE	32
2F28BXE	2L2’ F28BX/ELIG	63
3F17ESH	3L2’ 17W T8EE/ELEE HIGH PWR	61
3F17ESL	3L2’ 17W T8EE/ELEE LOW PWR	39
3F17ESN	3L2’ 17W T8EE/ELEE	46
3F28BXE	3L2’ F28BX/ELIG	94
Three Foot High Efficient T8 Systems		
1F25ESH	1L3’ 25W T8EE/ELEE HIGH PWR	30
1F25ESL	1L3’ 25W T8EE/ELEE LOW PWR	21
1F25ESN	1L3’ 25W T8EE/ELEE	24
2F25ESH	2L3’ 25W T8EE/ELEE HIGH PWR	60
2F25ESL	2L3’ 25W T8EE/ELEE LOW PWR	40
2F25ESN	2L3’ 25W T8EE/ELEE	45
3F25ESH	3L3’ 25W T8EE/ELEE HIGH PWR	90
3F25ESL	3L3’ 25W T8EE/ELEE LOW PWR	58
3F25ESN	3L3’ 25W T8EE/ELEE	67
Four Foot High Efficient T8 Systems		
1F25EEE	1L4’ 25W T8EE/ELEE	22
1F25EEH	1L4’ 25W T8EE/ELEE HIGH PWR	30
1F25EEL	1L4’ 25W T8EE/ELEE LOW PWR	19

Fixture Code	Description	Rated Watts
1F28EEE	1L4’ 28W T8EE/ELEE	24
1F28EEH	1L4’ 28W T8EE/ELEE HIGH PWR	33
1F28EEL	1L4’ 28W T8EE/ELEE LOW PWR	22
1F30EEE	1L4’ 30W T8EE/ELEE	26
1F30EEH	1L4’ 30W T8EE/ELEE HIGH PWR	36
1F30EEL	1L4’ 30W T8EE/ELEE LOW PWR	24
1F32EEE	1L4’ 32W T8EE/ELEE	28
1F32EEH	1L4’ 32W T8EE/ELEE HIGH PWR	38
1F32EEL	1L4’ 32W T8EE/ELEE LOW PWR	25
2F25EEE	2L4’ 25W T8EE/ELEE	43
2F25EEH	2L4’ 25W T8EE/ELEE HIGH PWR	57
2F25EEL	2L4’ 25W T8EE/ELEE LOW PWR	37
2F28EEE	2L4’ 28W T8EE/ELEE	48
2F28EEH	2L4’ 28WT8EE/ELEE HIGH PWR	64
2F28EEL	2L4’ 28W T8EE/ELEE LOW PWR	42
2F30EEE	2L4’ 30W T8EE/ELEE	52
2F30EEH	2L4’ 30WT8EE/ELEE HIGH PWR	69
2F30EEL	2L4’ 30W T8EE/ELEE LOW PWR	45
2F32EEE	2L4’ 32W T8EE/ELEE	53
2F32EEH	2L4’ 32W T8EE/ELEE HIGH PWR	73
2F32EEL	2L4’ 32W T8EE/ELEE LOW PWR	47
3F25EEE	3L4’ 25W T8EE/ELEE	64
3F25EEH	3L4’ 25W T8EE/ELEE HIGH PWR	86
3F25EEL	3L4’ 25W T8EE/ELEE LOW PWR	57
3F28EEE	3L4’ 28W T8EE/ELEE	72
3F28EEH	3L4’ 28W T8EE/ELEE HIGH PWR	96
3F28EEL	3L4’ 28W T8EE/ELEE LOW PWR	63
3F30EEE	3L4’ 30W T8EE/ELEE	77
3F30EEH	3L4’ 30W T8EE/ELEE HIGH PWR	103
3F30EEL	3L4’ 30W T8EE/ELEE LOW PWR	68
3F32EEE	3L4’ 32W T8EE/ELEE	82

Fixture Code	Description	Rated Watts
3F32EEH	3L4’ 32W T8EE/ELEE HIGH PWR	109
3F32EEL	3L4’ 32W T8EE/ELEE LOW PWR	72
4F25EEE	4L4’ 25W T8EE/ELEE	86
4F25EEH	4L4’ 25W T8EE/ELEE HIGH PWR	111
4F25EEL	4L4’ 25W T8EE/ELEE LOW PWR	75
4F28EEE	4L4’ 28W T8EE/ELEE	94
4F28EEH	4L4’ 28W T8EE/ELEE HIGH PWR	126
4F28EEL	4L4’ 28W T8EE/ELEE LOW PWR	83
4F30EEE	4L4’ 30W T8EE/ELEE	101
4F30EEH	4L4’ 30W T8EE/ELEE HIGH PWR	133
4F30EEL	4L4’ 30W T8EE/ELEE LOW PWR	89
4F32EEE	4L4’ 32W T8EE/ELEE	107
4F32EEH	4L4’ 32W T8EE/ELEE HIGH PWR	141
4F32EEL	4L4’ 32W T8EE/ELEE LOW PWR	95
6F32EEE	6L4’ 32W T8EE/ELEE	168
6F32EEH	6L4’ 32W T8EE/ELEE HIGH PWR	218
6F32EEL	6L4’ 32W T8EE/ELEE LOW PWR	146
Eight Foot T8 Systems		
1F59SSE	1L8’ T8/ELIG	60
1F80SSE	1L8’ T8 HO/ELIG	85
2F59SSE	2L8’ T8/ELIG	109
2F59SSL	2L8’ T8/ELIG LOW PWR	100
2F80SSE	2L8’ T8 HO/ELIG	160
LED Lighting Fixtures		
1E0002	2.0 WATT LED	2
1E0003	3.0 WATT LED	3
1E0015	1.5 WATT LED	1.5
1E0105	10.5 WATT LED	10.5
1L002	2 WATT LED	2
1L003	3 WATT LED	3
1L004	4 WATT LED	4

Fixture Code	Description	Rated Watts
1L005	5 WATT LED	5
1L006	6 WATT LED	6
1L007	7 WATT LED	7
1L008	8 WATT LED	8
1L009	9 WATT LED	9
1L010	10 WATT LED	10
1L011	11 WATT LED	11
1L012	12 WATT LED	12
1L013	13 WATT LED	13
1L014	14 WATT LED	14
1L015	15 WATT LED	15
1L016	16 WATT LED	16
1L017	17 WATT LED	17
1L018	18 WATT LED	18
1L019	19 WATT LED	19
1L020	20 WATT LED	20
1L021	21 WATT LED	21
1L022	22 WATT LED	22
1L023	23 WATT LED	23
1L024	24 WATT LED	24
1L025	25 WATT LED	25
1L026	26 WATT LED	26
1L027	27 WATT LED	27
1L028	28 WATT LED	28
1L029	29 WATT LED	29
1L030	30 WATT LED	30
1L031	31 WATT LED	31
1L032	32 WATT LED	32
1L033	33 WATT LED	33
1L034	34 WATT LED	34
1L035	35 WATT LED	35

Fixture Code	Description	Rated Watts
1L036	36 WATT LED	36
1L037	37 WATT LED	37
1L038	38 WATT LED	38
1L039	39 WATT LED	39
1L040	40 WATT LED	40
1L041	41 WATT LED	41
1L042	42 WATT LED	42
1L043	43 WATT LED	43
1L044	44 WATT LED	44
1L045	45 WATT LED	45
1L046	46 WATT LED	46
1L047	47 WATT LED	47
1L048	48 WATT LED	48
1L049	49 WATT LED	49
1L050	50 WATT LED	50
1L051	51 WATT LED	51
1L052	52 WATT LED	52
1L053	53 WATT LED	53
1L054	54 WATT LED	54
1L055	55 WATT LED	55
1L056	56 WATT LED	56
1L057	57 WATT LED	57
1L058	58 WATT LED	58
1L059	59 WATT LED	59
1L060	60 WATT LED	60
1L061	61 WATT LED	61
1L062	62 WATT LED	62
1L063	63 WATT LED	63
1L064	64 WATT LED	64
1L065	65 WATT LED	65
1L066	66 WATT LED	66

Fixture Code	Description	Rated Watts
1L067	67 WATT LED	67
1L068	68 WATT LED	68
1L069	69 WATT LED	69
1L070	70 WATT LED	70
1L071	71 WATT LED	71
1L072	72 WATT LED	72
1L073	73 WATT LED	73
1L074	74 WATT LED	74
1L075	75 WATT LED	75
1L076	76 WATT LED	76
1L077	77 WATT LED	77
1L078	78 WATT LED	78
1L079	79 WATT LED	79
1L080	80 WATT LED	80
1L081	81 WATT LED	81
1L082	82 WATT LED	82
1L083	83 WATT LED	83
1L084	84 WATT LED	84
1L085	85 WATT LED	85
1L086	86 WATT LED	86
1L087	87 WATT LED	87
1L088	88 WATT LED	88
1L089	89 WATT LED	89
1L090	90 WATT LED	90
1L091	91 WATT LED	91
1L092	92 WATT LED	92
1L093	93 WATT LED	93
1L094	94 WATT LED	94
1L095	95 WATT LED	95
1L096	96 WATT LED	96
1L097	97 WATT LED	97

Fixture Code	Description	Rated Watts
1L098	98 WATT LED	98
1L099	99 WATT LED	99
1L100	100 WATT LED	100
1L110	110 WATT LED	110
1L116	116 WATT LED	116
1L120	120 WATT LED	120
1L125	125 WATT LED	125
1L130	130 WATT LED	130
1L135	135 WATT LED	135
1L140	140 WATT LED	140
1L145	145 WATT LED	145
1L150	150 WATT LED	150
1L155	155 WATT LED	155
1L160	160 WATT LED	160
1L165	165 WATT LED	165
1L170	170 WATT LED	170
1L175	175 WATT LED	175
1L180	180 WATT LED	180
1L185	185 WATT LED	185
1L190	190 WATT LED	190
1L200	200 WATT LED	200
1L210	210 WATT LED	210
1L220	220 WATT LED	220
1L240	240 WATT LED	240
1L376	4X94 WATT LED	376
1L405	3x135 WATT LED	405
Electronic Metal Halide Lamps		
1M0150E	150W METAL HALIDE EB	160
1M0200E	200W METAL HALIDE EB	215
1M0250E	250W METAL HALIDE EB	270
1M0320E	320W METAL HALIDE EB	345

Fixture Code	Description	Rated Watts
1M0350E	350W METAL HALIDE EB	375
1M0400E	400W METAL HALIDE EB	430
1M0450E	400W METAL HALIDE EB	480
MH Track Lighting		
1M0020E	20W MH SPOT	25
1M0025E	25W MH SPOT	25
1M0035E	35W MH SPOT	44
1M0039E	39W MH SPOT	47
1M0050E	50W MH SPOT	60
1M0070E	70W MH SPOT	80
1M0100E	100W MH SPOT	111
1M0150E	150W MH SPOT	162
Incandescent Lamps		
1I0015	15W INC	15
1I0020	20W INC	20
1I0025	25W INC	25
1I0034	34W INC	34
1I0036	36W INC	36
1I0040	40W INC	40
1I0042	42W INC	42
1I0045	45W INC	45
1I0050	50W INC	50
1I0052	52W INC	52
1I0054	54W INC	54
1I0055	55W INC	55
1I0060	60W INC	60
1I0065	65W INC	65
1I0067	67W INC	67
1I0069	69W INC	69
1I0072	72W INC	72
1I0075	75W INC	75

Fixture Code	Description	Rated Watts
1I0080	80W INC	80
1I0085	85W INC	85
1I0090	90W INC	90
1I0093	93W INC	93
1I0100	100W INC	100
1I0120	120W INC	120
1I0125	125W INC	125
1I0135	135W INC	135
1I0150	150W INC	150
1I0200	200W INC	200
1I0300	300W INC	300
1I0448	448W INC	448
1I0500	500W INC	500
1I0750	750W INC	750
1I1000	1000W INC	1000
1I1500	1500W INC	1500
Low Voltage Halogen Fixture (includes Transformer)		
1R0020	20W LV HALOGEN FIXT	30
1R0025	25W LV HALOGEN FIXT	35
1R0035	35W LV HALOGEN FIXT	45
1R0042	42W LV HALOGEN FIXT	52
1R0050	50W LV HALOGEN FIXT	60
1R0065	65W LV HALOGEN FIXT	75
1R0075	75W LV HALOGEN FIXT	85
Halogen/Quartz Lamps		
1T0035	35W HALOGEN LAMP	35
1T0040	40W HALOGEN LAMP	40
1T0042	42W HALOGEN LAMP	42
1T0045	45W HALOGEN LAMP	45
1T0047	47W HALOGEN LAMP	47
1T0050	50W HALOGEN LAMP	50

Fixture Code	Description	Rated Watts
1T0052	52W HALOGEN LAMP	52
1T0055	55W HALOGEN LAMP	55
1T0060	60W HALOGEN LAMP	60
1T0072	72W HALOGEN LAMP	72
1T0075	75W HALOGEN LAMP	75
1T0090	90W HALOGEN LAMP	90
1T0100	100W HALOGEN LAMP	100
1T0150	150W HALOGEN LAMP	150
1T0200	200W HALOGEN LAMP	200
1T0250	250W HALOGEN LAMP	250
1T0300	300W HALOGEN LAMP	300
1T0350	350W HALOGEN LAMP	350
1T0400	400W HALOGEN LAMP	400
1T0425	425W HALOGEN LAMP	425
1T0500	500W HALOGEN LAMP	500
1T0750	750W HALOGEN LAMP	750
1T0900	900W HALOGEN LAMP	900
1T1000	1000W HALOGEN LAMP	1000
1T1200	1200W HALOGEN LAMP	1200
1T1500	1500W HALOGEN LAMP	1500
2T0075	2-75W HALOGEN LAMP	1800
Mercury Vapor (MV)		
1V0040S	40W MERCURY	50
1V0050S	50W MERCURY	75
1V0075S	75W MERCURY	95
1V0100S	100W MERCURY	120
1V0175S	175W MERCURY	205
1V0250S	250W MERCURY	290
1V0400S	400W MERCURY	455
1V0700S	700W MERCURY	775
1V1000S	1000W MERCURY	1075

Fixture Code	Description	Rated Watts
2V0400S	2/400W MERCURY	880
	Low Pressure Sodium (LPS)	
1L0035S	35W LPS	60
1L0055S	55W LPS	85
1L0090S	90W LPS	130
1L0135S	135W LPS	180
1L0180S	180W LPS	230
	High Pressure Sodium (HPS)	
1H0035S	35W HPS	45
1H0050S	50W HPS	65
1H0070S	70W HPS	90
1H0100S	100W HPS	130
1H0150S	150W HPS	190
1H0200S	200W HPS	240
1H0225S	225W HPS	275
1H0250S	250W HPS	295
1H0310S	310W HPS	350
1H0360S	360W HPS	435
1H0400S	400W HPS	460
1H0600S	600W HPS	675
1H0750S	750W HPS	835
1H1000S	1000W HPS	1085
	Metal Halide (MH)	
1M0032S	32W METAL HALIDE	40
1M0050S	50W METAL HALIDE	65
1M0070S	70W METAL HALIDE	95
1M0100S	100W METAL HALIDE	120
1M0150E	150W METAL HALIDE EB	160
1M0150S	150W METAL HALIDE	190
1M0175S	175W METAL HALIDE	205
1M0200E	200W METAL HALIDE EB	215

Fixture Code	Description	Rated Watts
1M0250E	250W METAL HALIDE EB	270
1M0250S	250W METAL HALIDE	295
1M0320E	320W METAL HALIDE EB	345
1M0350E	350W METAL HALIDE EB	375
1M0360S	360W METAL HALIDE	430
1M0400E	400W METAL HALIDE EB	430
1M0400S	400W METAL HALIDE	455
1M0450E	400W METAL HALIDE EB	480
1M0750S	750W METAL HALIDE	825
1M1000S	1000W METAL HALIDE	1075
1M1500S	1500W METAL HALIDE	1615
1M1800S	1800W METAL HALIDE	1875
Pulse Start Metal Halide Lamp/Ballast		
1M0100P	100W MH CWA	128
1M0100R	100W MH LINEAR	118
1M0150P	150W MH CWA	190
1M0150R	150W MH LINEAR	172
1M0175P	175W MH CWA	208
1M0175R	175W MH LINEAR	190
1M0200P	200W MH CWA	232
1M0200R	200W MH LINEAR	218
1M0250P	250W MH CWA	288
1M0250R	250W MH LINEAR	265
1M0300P	300W MH CWA	342
1M0300R	300W MH LINEAR	324
1M0320P	320W MH CWA	365
1M0320R	320W MH LINEAR	345
1M0350P	350W MH CWA	400
1M0350R	350W MH LINEAR	375
1M0400P	400W MH CWA	455
1M0400R	400W MH LINEAR	430

Fixture Code	Description	Rated Watts
1M0450P	450W MH CWA	508
1M0450R	450W MH LINEAR	480
1M0750P	750W MH CWA	815
1M0750R	750W MH LINEAR	805
1M1000P	1000W MH CWA	1080
Two Foot T8/T12 Systems		
12F40BE	12L2’ F40BX/ELIG	408
12F50BE	12L2’ F50BX/ELIG	648
12F55BE	12L2’ F55BX/ELIG	672
1F55BXE	1L2’ F55BX/ELIG	56
1F80BXE	1L2’ F80BXE/ELIG	90
2F17SSE	2L2’ 17W T8/ELIG	37
2F17SSL	2L2’ 17W T8/ELIG LOW POWER	27
2F17SSM	2L2’ 17W T8/EEMAG	45
2F24HSS	2L2’ 24 T12HO/STD/STD	85
2F40BXE	2L2’ F40BX/ELIG	72
2F50BXE	2L2’ F50BX/ELIG	108
2F55BXE	2L2’55BXE/ELIG	112
3F17SSE	3L2’ 17W T8/ELIG	53
3F17SSL	3L2’ 17W T8/ELIG LOW POWER	39
3F40BXE	3L2’ F40BX/ELIG	102
3F50BXE	3L2’ F50BX/ELIG	162
3F55BXE	3L2’ F55BX/ELIG	168
4F17SSE	4L2’ 17W T8/ELIG	62
4F36BXE	4L2’ F36BX/ELIG	148
4F40BXE	4L2’ F40BX/ELIG	144
4F50BXE	4L2’ F50BX/ELIG	216
4F55BXE	4L2’ F55BX/ELIG	224
5F40BXE	5L2’ F40BX/ELIG	190
5F50BXE	5L2’ F50BX/ELIG	270
5F55BXE	5L2’ F55BX/ELIG	280

Fixture Code	Description	Rated Watts
6F36BXE	6L2’ F36BX/ELIG	212
6F40BXE	6L2’ F40BX/ELIG	204
6F50BXE	6L2’ F50BX/ELIG	324
6F55BXE	6L2’ F55BX/ELIG	336
8F36BXE	8L2’ F36BX/ELIG	296
8F40BXE	8L2’ F40BX/ELIG	288
8F50BXE	8L2’ F50BX/ELIG	432
8F55BXE	8L2’ F55BX/ELIG	448
9F36BXE	9L2’ F36BX/ELIG	318
9F40BXE	9L2’ F40BX/ELIG	306
9F50BXE	9L2’ F50BX/ELIG	486
9F55BXE	9L2’ F55BX/ELIG	504
Three Foot T8/T12 Systems		
1F25SSE	1L3’ 25W T8/ELIG	24
1F30SEM	1L3’ 30W T12 EE/EEMAG	38
1F30SES	1L3’ 30W T12 EE/STD	42
1F30SSS	1L3’ 30W T12 STD/STD	46
2F25SSE	2L3’ 25W T8/ELIG	47
2F25SSM	2L3’ 25W T8/EEMAG	65
2F30SEE	2L3’ 30W T12 EE/ELIG	49
2F30SEM	2L3’ 30W T12 EE/EEMAG	66
2F30SES	2L3’ 30W T12 EE/STD	73
2F30SSS	2L3’ 30W T12 STD/STD	80
3F25SSE	3L3’ 25W T8/ELIG	68
3F30SES	3L3’ 30W T12 EE/STD	127
3F30SSS	3L3’ 30W T12 STD/STD	140
4F25SSE	4L3’ 25W T8/ELIG	88
Four Foot F48		
1F48HES	1L4’ F48HO/EE/STD	80
1F48HSS	1L4’ F48HO/STD/STD	85
1F48SES	1L4’ F48T12EE/STD	50

Fixture Code	Description	Rated Watts
1F48SSS	1L4’ F48T12/STD	60
1F48VES	1L4’ F48VHO/EE/STD	123
1F48VSS	1L4’ F48VHO/STD/STD	138
2F48HES	2L4’ F48HO/EE/STD	135
2F48HSS	2L4’ F48HO/STD/STD	145
2F48SES	2L4’ F48T12EE/STD	82
2F48SSS	2L4’ F48T12/STD	102
2F48VES	2L4’ F48VHO/EE/STD	210
2F48VSS	2L4’ F48VHO/STD/STD	240
3F48HES	3L4’ F48HO/EE/STD	215
3F48HSS	3L4’ F48HO/STD/STD	230
3F48SES	3L4’ F48T12EE/STD	132
3F48SSS	3L4’ F48T12/STD	162
3F48VES	3L4’ F48VHO/EE/STD	333
3F48VSS	3L4’ F48VHO/STD/STD	378
4F48HES	4L4’ F48HO/EE/STD	270
4F48HSS	4L4’ F48HO/STD/STD	290
4F48SES	4L4’ F48T12EE/STD	164
4F48SSS	4L4’ F48T12/STD	204
4F48VES	4L4’ F48VHO/EE/STD	420
4F48VSS	4L4’ F48VHO/STD/STD	480
Four Foot T12 Systems		
1F40SEE	1L4’ EE/ELIG	38
1F40SEM	1L4’ EE/EEMAG	40
1F40SES	1L4’ EE/STD	50
1F40SSE	1L4’ STD/ELIG	46
1F40SSM	1L4’ STD/EEMAG	50
1F40SSS	1L4’ STD/STD	57
1F48SES	1L4’ F48T12EE/STD	50
1F48SSS	1L4’ F48T12/STD	60
2F40SEE	2L4’ EE/ELIG	60

Fixture Code	Description	Rated Watts
2F40SEM	2L4’ EE/EEMAG	70
2F40SES	2L4’ EE/STD	80
2F40SSE	2L4’ STD/ELIG	72
2F40SSM	2L4’ STD/EEMAG	86
2F40SSS	2L4’ STD/STD	94
2F48SES	2L4’ F48T12EE/STD	82
2F48SSS	2L4’ F48T12/STD	102
3F40SEE	3L4’ EE/ELIG	90
3F40SEM	3L4’ EE/EEMAG	110
3F40SES	3L4’ EE/STD	130
3F40SSE	3L4’ STD/ELIG	110
3F40SSM	3L4’ STD/EEMAG	136
3F40SSS	3L4’ STD/STD	151
3F48SES	3L4’ F48T12EE/STD	132
3F48SSS	3L4’ F48T12/STD	162
4F40SEE	4L4’ EE/ELIG	120
4F40SEM	4L4’ EE/EEMAG	140
4F40SES	4L4’ EE/STD	160
4F40SSE	4L4’ STD/ELIG	144
4F40SSM	4L4’ STD/EEMAG	172
4F40SSS	4L4’ STD/STD	188
4F48SES	4L4’ F48T12EE/STD	164
4F48SSS	4L4’ F48T12/STD	204
6F40SSS	6L4’ STD/STD	282
Four Foot T8 Systems		
1F32SSE	1L4’ T8/ELIG	30
1F32SSL	1L4 T8/ELIG LOW POWER	26
1F32SSM	1L4’ T8/EEMAG	37
2F32SSE	2L4’ T8/ELIG	60
2F32SSH	2L4’ T8/ELIG HIGH LMN	78
2F32SSL	2L4 T8/ELIG LOW PWR	52

Fixture Code	Description	Rated Watts
2F32SSM	2L4’ T8/EEMAG	70
3F32SSE	3L4’ T8/ELIG	88
3F32SSH	3L4’ T8/ELIG HIGH LMN	112
3F32SSL	3L4 T8/ELIG LOW POWER	76
3F32SSM	3L4’ T8/EEMAG	107
4F32SSE	4L4’ T8/ELIG	112
4F32SSH	4L4’ T8/ELIG HIGH LMN	156
4F32SSL	4L4 T8/ELIG LOW PWR	98
4F32SSM	4L4’ T8/EEMAG	140
5F32SSE	5L4’ T8/ELIG	148
5F32SSH	5L4’ T8/ELIG HIGH LMN	190
6F32SSE	6L4’ T8/ELIG	174
8F32SSH	8L4’ T8/ELIG HIGH LMN	312
Five Foot T8/T12 Systems		
1F40HSE	1L5’ HO/STD/ELIG	59
1F60HSM	1L5’ HO/STD/EEMAG	90
1F60SSM	1L5’/STD/EEMAG	73
1F60TSM	1L5’ T1OHO/STD/EEMAG	135
2F40HSE	2L5’ HO/STD/ELIG	123
2F40TSE	2L5’T8/ELIG	68
2F60HSM	2L5’ HO/STD/EEMAG	178
2F60SSM	2L5’/STD/EEMAG	122
3F40TSE	3L5’T8/ELIG	106
Six Foot T12 and T12HO Systems		
1F72HSE	1L6’ T8HO/ELIG	80
1F72HSS	1L6’ F72HO/STD/STD	113
1F72SSM	1L6’ STD/EEMAG	80
1F72SSS	1L6’ STD/STD	95
2F72HSE	2L6’T8 HO/ELIG	160
2F72HSM	2L6’ F72HO/STD/EEMAG	193
2F72HSS	2L6’ F72HO/STD	195

Fixture Code	Description	Rated Watts
2F72SSM	2L6’ STD/EEMAG	135
2F72SSS	2L6’ STD/STD	173
Eight Foot T12VHO Systems		
1F96VES	1L8’ VHO/EE/STD	200
1F96VSS	1L8’ VHO/STD/STD	230
2F96VES	2L8’ VHO/EE/STD	390
2F96VSS	2L8’ VHO/STD/STD	450
3F96VES	3L8’ VHO/EE/STD	590
3F96VSS	3L8’ VHO/STD/STD	680
4F96VES	4L8’ VHO/EE/STD	780
4F96VSS	4L8’ VHO/STD/STD	900
Eight Foot T8 System		
1F59SSE	1L8’ T8/ELIG	60
1F80SSE	1L8’ T8 HO/ELIG	85
2F59SSE	2L8’ T8/ELIG	109
2F59SSL	2L8’ T8/ELIG LOW PWR	100
2F80SSE	2L8’ T8 HO/ELIG	160
Eight Foot T12 System		
1F96SEE	1L8’ EE/ELIG	60
1F96SES	1L8’ EE/STD	83
1F96SSE	1L8’ STD/ELIG	70
1F96SSS	1L8’ STD/STD	100
2F96SEE	2L8’ EE/ELIG	109
2F96SEM	2L8’ EE/EEMAG	123
2F96SES	2L8’ EE/STD	138
2F96SSE	2L8’ STD/ELIG	134
2F96SSM	2L8’ STD/EEMAG	158
2F96SSS	2L8’ STD/STD	173
3F96SES	3L8’ EE/STD	221
3F96SSS	3L8’ STD/STD	273
4F96SEE	4L8’ EE/ELIG	218

Fixture Code	Description	Rated Watts
4F96SEM	4L8’ EE/EEMAG	246
4F96SES	4L8’ EE/STD	276
4F96SSE	4L8’ STD/ELIG	268
4F96SSM	4L8’ STD/EEMAG	316
4F96SSS	4L8’ STD/STD	346

16 APPENDIX M: NON-ENERGY BENEFITS

This section provides non-energy benefit multipliers for low-income and non low-income programs for use in calculating program cost effectivess.[196]

Non-energy benefits (NEB) for non low-income programs

Adder applied to all non-low-income programs to account for non-energy benefits not already included in the NJCT that are difficult to quantify (including public health, water and sewer benefits, economic development, etc.)

15% applied to avoided wholesale energy costs.

Low-income benefits

Adder applied to account for additional benefits (including health and safety) to low-income participants and community

30% (15% NEB + 15% additional LI) applied to avoided wholesale energy costs.

[196] Non-Energy Benefits (NEBs) multipliers are taken from the New Jersey Cost Test (NJCT) attachment to the May 23, 2024 Board Order. See nj.gov › boardorders › 8B ORDER Energy Efficiency Triennium 2