New Jersey Energy Master Plan

RATEPAYER IMPACT STUDY

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Executive Summary

The State of New Jersey is committed to achieving a 100% clean energy economy by 2050, consistent with the mandates in the Global Warming Response Act, the Clean Energy Act, and Governor Murphy's Executive Order 28.[1] The New Jersey Board of Public Utilities (NJBPU) and other state agencies are following through on these commitments with a range of policies and strategies described in the 2019 Energy Master Plan (EMP).[2] While the 2019 EMP evaluated a core set of policy strategies for achieving these economy-wide greenhouse gas (GHG) reduction outcomes in the most cost-effective manner and established a "Least Cost Pathway" to achieving targeted GHG outcomes, it did not evaluate the net cost of these incremental programs to customers. This Study refers to these collectively as the EMP Programs. Subsequently, the NJBPU contracted The Brattle Group to quantify the impact of the EMP on customers' energy costs through a comprehensive analysis of rate impacts and overall energy costs as of 2030.

In this Study, we incorporate the findings of the 2019 EMP into a comprehensive model of customer rate and energy cost impacts across the State of New Jersey. First, we quantify statewide electricity and natural gas program costs expected to be incurred to meet the goals of the EMP. Next, we disaggregate the associated costs by utility, mode of energy consumption, and customer segment. This approach allows us to quantify the "total energy cost" in 2030 for average customers from each class and for each electric and natural gas utility combination studied.[3] Total energy cost for a residential customer includes their energy expenses for electricity, natural gas, and transportation. For small and large commercial and industrial (C&I) customers, we include electricity and natural gas expenses. This comprehensive look at the customers' energy spending allows us to capture the impacts of energy efficiency and electrification of heating and transportation on customers' overall energy use and resulting costs. It is important to note that this Study does not include the costs of purchasing or maintaining vehicles or other heating and cooling equipment (such as heat pumps). It also does not include the costs of taxpayer-funded programs.

1 *See* State of New Jersey Department of Environmental Protection, "New Jersey's Clean Energy Picture" and New Jersey Government Executive Order No. 28.

2 *See* State of New Jersey Energy Master Plan.

3 Throughout this Study, we calculate the rates and energy costs for 2030. Shorter term energy cost fluctuations in the interim years are not modeled.

In order to undertake this Study, we relied on a wide range of data sources. These include the 2019 Energy Master Plan (and other policies enacted since then), NJBPU Board orders, data provided by the utilities, and energy market projections.

The Study evaluates expected ratepayer energy costs in 2030 under three scenarios and compares them to costs in 2020 (all cost comparisons are done in 2022 dollars). These three scenarios are:

1. **Current Policy Pathway**: Includes the total costs and benefits of clean energy programs that are currently enshrined in New Jersey policies and consistent with the current market trajectory.
2. **EMP Achievement Pathway**: Includes total costs and benefits of clean energy programs that would be necessary to meet the EMP's "Least Cost Pathway," which is designed to result in 100% clean energy by 2050.
3. **Ambitious Pathway**: Evaluates relative energy costs associated with earlier achievement of 100% clean electricity in 2035 instead of 2050.

While we developed the ratepayer energy costs for residential, small C&I and large C&I customer classes for each utility combination studied and for all three scenarios, below *we present the results for one of the electric-gas utility combinations, namely customers of Atlantic City Electric and South Jersey Gas and for the EMP Achievement Pathway*, with an emphasis on *non-low-income and low-income residential customers. Results for other utility combinations are directionally similar, although levels differ from one utility combination to the other.* Details on other customer classes, utility combinations and scenarios are discussed in the rest of the report and Appendices.

We generated four residential customer types for our analysis (Table ES.1). Customer [1] has the same amount of electricity and natural gas consumption as in 2020. Customer [2] implements energy efficiency improvements in line with statewide energy efficiency targets under each scenario and continues to drive an internal combustion engine (ICE) vehicle. Customer [3] adopts the same level of EE and switches to driving an electric vehicle. Customer [4] adopts the same level of EE, switches to driving an electric vehicle (EV), and adopts electric heat pumps for space and water heating while staying on the natural gas system for other end-uses.[4]

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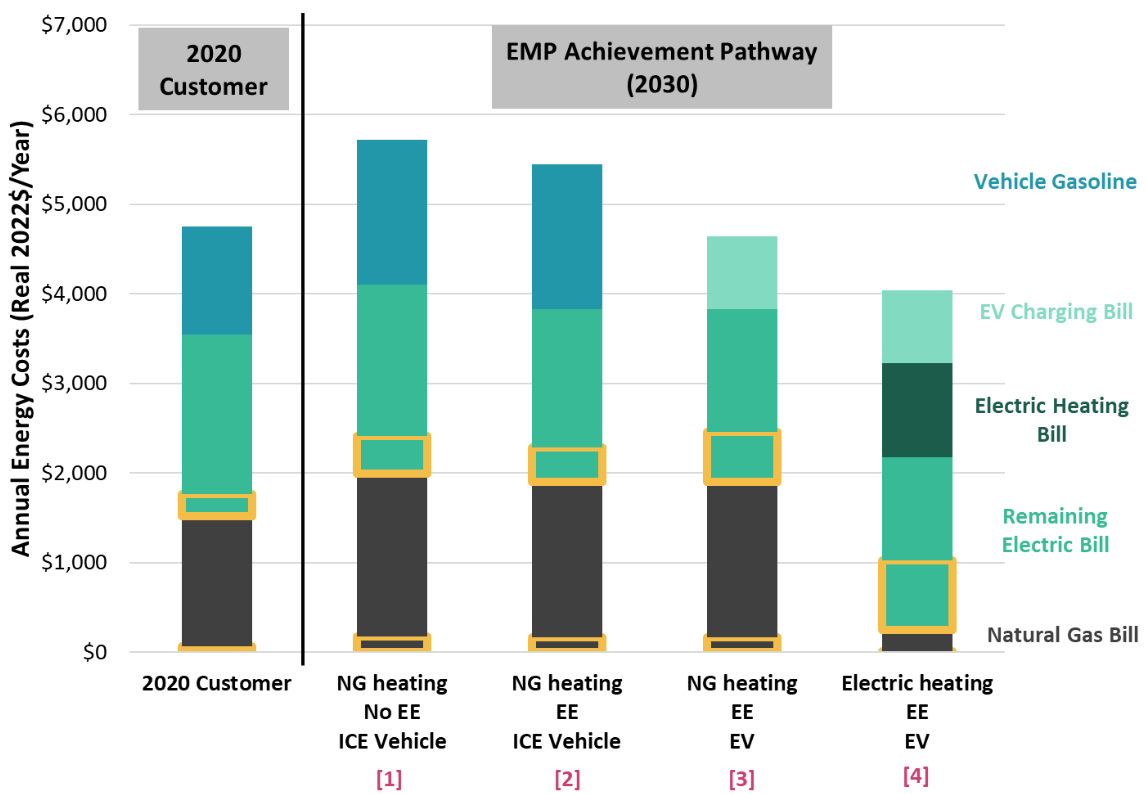
[4] Space and water heating constitute 93% of natural gas consumption for residential customers in the U.S. Mid-Atlantic region according to EIA 2015 Residential Energy Consumption Survey (RECS), Table CE 4.1.

TABLE ES.1: RESIDENTIAL CUSTOMER TYPES IN 2030

Customer Type	Heating	Energy Efficiency	EV or ICE Vehicle
[1]	Natural Gas	No	ICE
[2]	Natural Gas	Yes	ICE
[3]	Natural Gas	Yes	EV
[4]	Electricity	Yes	EV

FIGURE ES.1: ANNUAL ENERGY COSTS FOR RESIDENTIAL NON-LOW-INCOME CUSTOMERS UNDER THE EMP ACHIEVEMENT PATHWAY[5]



Under the **EMP Achievement Pathway** and for the non-low-income residential customers, we find that:

- In 2020, an average non-low-income residential customer spent approximately $4,800/year for electricity and natural gas bills and fuel costs for driving an ICE vehicle.
- In 2030, a customer's total energy costs depend on whether they take advantage of electrification and energy efficiency opportunities. We envision that a growing number of customers will fit in profiles [3] and [4] by 2030.

5 Yellow boxes represent the clean energy program costs within the distribution portion of the bills.

- Total energy cost impacts are higher under the EMP Achievement Pathway, but only moderately relative to the Current Policy Pathway.
  - Customer [2] cost increases by 15% relative to the 2020 Customer under the EMP. This is **5 percentage points higher** than the impact under the Current Policy Pathway.
  - Customer [4] cost decreases by 15% relative to the 2020 Customer. This is **1 percentage point lower** than that achieved under the Current Policy Pathway.

These results imply that non-low-income residential customer total energy costs are expected to increase through 2030 if they do not change their energy consumption patterns by taking advantage of the energy efficiency programs enabled by EMP, adopting electric vehicles, or switching to electric heating. However, if the customers are able to adopt these technologies and pair them with energy efficiency program participation, their 2030 energy costs are expected to be lower than their current costs, in real dollars.

Results are similar in direction for the low-income customers. In 2030, Customer [2] total energy cost is 16% higher compared to the 2020 Customer; Customer [4] total energy cost is 16% lower compared to the 2020 Customer. The main difference is that the low-income customer consumes less energy, which leads to lower costs. However, the key metric for the low-income customer group is the impact of these changes in rates and usage levels on their "energy burden."[6] Assuming an annual income of $35,000, we find that a low-income customer has an energy burden of 6.7–8% in 2030 under the EMP Achievement Pathway. When expanded to include the spending on vehicle operating costs (as it is a component of customers' total energy expenditure), a low-income customer has an energy burden of 9–12.5%. We find that low-income customers are already experiencing a high energy burden in 2020 (7.3% without vehicle costs and 10.8% including vehicle costs). However, energy burden may fall or at least stay the same through 2030 despite increases in electricity and gas rates, if low-income customers adopt electric vehicles, EE, and heat pumps. This implies that energy assistance programs targeting low-income customers may be necessary to help with upfront costs of electrification and energy efficiency improvements. These programs may range from providing rebate assistance for the purchase of efficient appliances and electric vehicles to on-bill financing for income qualifying customers to be able to undertake projects with high initial capital cost requirements.

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[6] Energy burden is defined as total energy bills as a share of income. Total energy bill is traditionally defined to include electricity and natural gas bills; customers are deemed to experience "high energy burden" if they spend more than 6% of income on home energy bills and "severe energy burden" if spending more than 10% of income on home energy bills. The original definition of energy burden does not include vehicle operating costs.

For C&I customers, we find that the direction of cost impacts is similar to that for residential customers, although magnitudes of the bills differ. C&I customers are a very diverse group in terms of their business activities and the resulting energy consumption values. In this Study, we obtain an *average* small C&I and an *average* large C&I profile for New Jersey and we focus on electricity and natural gas bills only and do not include transportation costs. Total energy costs of C&I customers increase under all scenarios for a customer who continues to use the same amount of electricity and natural gas in 2030. However, energy efficiency and electrification of heating can lead to cost savings.

As expected in a forward-looking study, there is uncertainty involved in the Study findings. In order to inform the sensitivity of our results to key Study assumptions, we undertook a sensitivity analysis (See Appendix D). This analysis informs the expected lower and upper bounds for one of the key Study outcomes, total residential energy cost, when each of these assumptions are changed one at a time.[7] There are other elements of uncertainty, such as potential changes in the future clean energy program design, unexpected shocks to the local and global economy which might affect supply chains for new technologies and increasing levels of grid modernization requirements.

The Board and Brattle acknowledge that the EMP will play a major role in reducing emissions and adverse effects of climate change, including public health impacts caused by fossil-fuel-generated air pollution, water pollution, and the increasing direct effects of climate change, like stronger and more frequent storms and flooding. Because this Study is designed to evaluate the **impacts of the EMP on the ratepayers** and how implementation of the EMP recommendations affects customers' total energy burden, considering both direct costs and benefits, these other important and sizable benefits of the EMP are outside the scope of this particular Study. However, Board Staff acknowledges the potential usefulness of conducting a rigorous study in the future of climate and health benefits. While we did not quantify these benefits in this Study, we calculated the avoided cost of greenhouse gas emissions in 2030 using the Social Cost of Carbon and found that the annual benefit of **reduced GHG emissions** is $1.75 billion/year in 2030 under the EMP Achievement Pathway. Annual greenhouse gas emissions decrease by 30% from 2020 levels by 2030 under the EMP Achievement Pathway, which is equivalent to avoided emissions from 3.4 million homes' energy use for one year, or 5.8 million gasoline vehicles driven for one year.

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[7] While recent increases in gasoline prices are not factored into the Study assumptions due to Study's focus on 2030 impacts, the impact of higher gasoline cost is explored as part of the sensitivity analysis.

I. Introduction

Study Scope

The State of New Jersey is committed to achieving a 100% clean energy economy by 2050, consistent with the mandates in the Global Warming Response Act, the Clean Energy Act, and Governor Murphy's Executive Order 28.[8] The NJBPU and other state agencies are following through on these commitments with a range of policies and strategies described in the 2019 Energy Master Plan (EMP).[9] Policies, practices, and infrastructure across the energy landscape must adapt and advance in order to achieve these commitments at the most affordable cost.

While the 2019 EMP evaluated a core set of policy strategies for achieving these economy-wide greenhouse gas (GHG) reduction outcomes in the most cost-effective manner and established a "Least Cost Pathway" to achieving targeted GHG outcomes, it did not evaluate the net cost of these incremental programs to customers. Subsequently, the NJBPU contracted The Brattle Group to quantify the impact of the EMP on customers' energy costs through a comprehensive analysis of rate impacts and overall energy costs as of 2030**.**

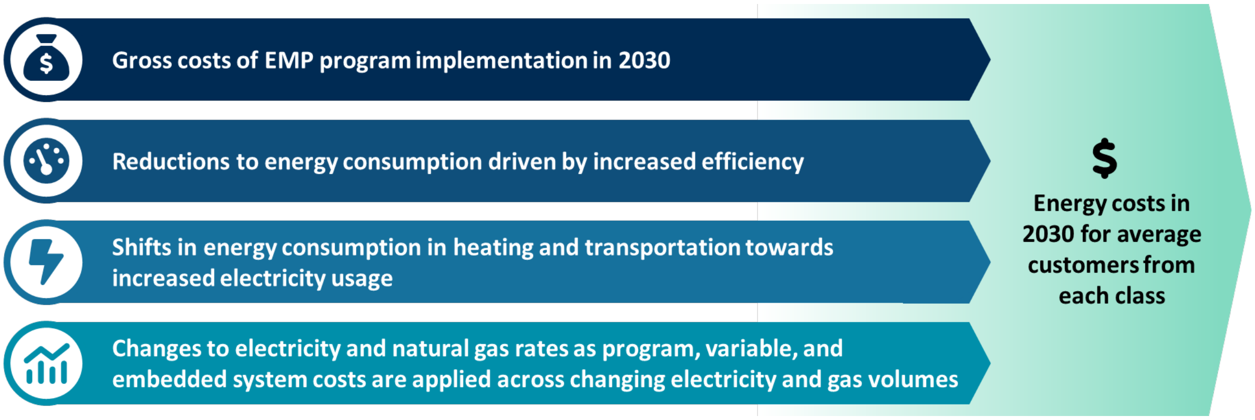
In this Study, we incorporate the findings of the 2019 EMP into a comprehensive model of customer rate and energy cost impacts across the State of New Jersey. First, we quantify statewide electricity and natural gas program costs expected to be incurred to meet the goals of the EMP. Next, we disaggregate the associated costs by utility, mode of energy consumption, and customer segment. This approach allows us to quantify the "total energy cost" in 2030 for average customers from each class and for each public electric and gas utility combination studied.[10] This comprehensive look at the customers' energy spending allows us to capture the impacts of energy efficiency and electrification of heating and transportation on customers' overall energy use and resulting costs. Figure 1 presents the building blocks of this Study.

8 *See* State of New Jersey Department of Environmental Protection, "New Jersey's Clean Energy Picture" and New Jersey Government Executive Order No. 28.

9 *See* State of New Jersey Energy Master Plan.

10 Throughout this Study, we calculate the rates and energy costs for 2030, and not for the interim years.

FIGURE 1: NJBPU RATEPAYER IMPACT STUDY BUILDING BLOCKS



Total energy cost for a residential customer includes their energy expenses for electricity, natural gas, and transportation. For small and large C&I customers, we include electricity and natural gas expenses. This Study does not include the costs of purchasing or maintaining vehicles or other equipment, or costs for public transportation. It also does not include the costs of taxpayer-funded programs.

The Study evaluates expected ratepayer energy costs in 2030 under three scenarios and compares them to costs in 2020 (all cost comparisons are done in 2022 dollars unless otherwise noted). These three scenarios are:

1. **Current Policy Pathway**: Includes the total costs and benefits of clean energy programs that are currently enshrined in New Jersey policies and consistent with the current market trajectory.
2. **EMP Achievement Pathway**: Includes total costs and benefits of clean energy programs that would be necessary to meet the EMP's "Least Cost Pathway," which is designed to result in 100% clean energy by 2050.
3. **Ambitious Pathway**: Evaluates relative energy costs associated with earlier achievement of 100% clean electricity in 2035 instead of 2050.

It is important to note that each of these scenarios will evaluate the costs and benefits of legally binding policies that have been enacted since the development of the 2019 EMP: i) requirements of the Solar Act of 2021[11] ; ii) Executive Order No. 92,[12] which increased New

[11] State of New Jersey Legislature, Solar Act of 2021, July 9, 2021. .

[12] State of New Jersey, Executive Order No. 92, November 19, 2019.

Jersey's offshore wind targets to 7,500 MW by 2035; iii) Executive Order No. 274,[13] which directed the State to reduce GHG emissions to 50% below 2006 levels by 2030; and iv) the Board's energy efficiency orders and other comparable requirements related to electric vehicles (EVs) and other programs.

In addition to these three scenarios, the Study incorporates a **sensitivity analysis** to examine the change to emissions and total consumer energy costs that would be estimated under alternative Study assumptions, such as higher levels of electric vehicle adoption or building decarbonization efforts. Appendix D present the results of the sensitivity analysis.

Primary Study Questions

For each of the "Current Policy Pathway," EMP Achievement Pathway," and "Ambitious Pathway" scenarios, this Study aims to answer the following questions:

1. What are the **expected total consumer energy costs as of 2030,** considering direct costs of clean energy programs and associated changes to electricity and natural gas rates to recover these costs?
2. What are the **economic benefits and savings** to consumers, such as through reduced gasoline, natural gas, and electricity consumption?
3. What are the **net consumer costs** in the form of "total energy costs" when considering consumers' total energy costs for all primary uses of energy (electricity, natural gas, and transportation)?
4. How might **each customer class be impacted** under each of the model scenarios? Are low-income customers at risk of disproportionate impacts associated with the incidence, timing, or details of any elements within the EMP?
5. How would consumer total energy costs be affected under **alternative pathways to meet the State's solar targets** post 2027? How will acceleration of targets for **efficiency and electrification** achievement affect total consumer energy costs?

How to Use This Report

This report provides a comprehensive bottom-up analysis of the costs of programs needed to meet the EMP's Least Cost scenario, changes in total electricity and natural gas sales as a result of these programs, changes in electricity and natural gas commodity and delivery rates, and

13 State of New Jersey, Executive Order No. 274, November 10, 2021.

resulting impacts on the average customer's "total annual energy costs" after accounting for the impacts of the EMP Programs on customer usage patterns. This Study is not a cost-benefit analysis of the EMP; it is a ratepayer impact analysis. The impact on customers' annual energy costs is the "core focus" of this report – that is, it seeks to understand the impact of EMP Programs on customers' energy spending, under various assumptions about the degree to which they engage with future clean energy programs recommended by the EMP, such as energy efficiency programs and electrification. Total energy cost impact analysis was conducted for eight electric-gas utility combinations and for three customer classes (residential, small C&I, and large C&I). Residential class is further segmented into two customer types: non-low-income and low-income customers. We model the EMP Program costs and total energy cost impacts as of 2030, but not for any of the interim years. This Study is not a cost/benefit analysis of the programs necessary to meet the EMP goals and should not be interpreted as such.

Chapter II describes the methodology for the "EMP Ratepayer Impact Study," including the modeling scenarios, assumptions, and architecture, as well as the approach to estimating the EMP Program costs and impacts.

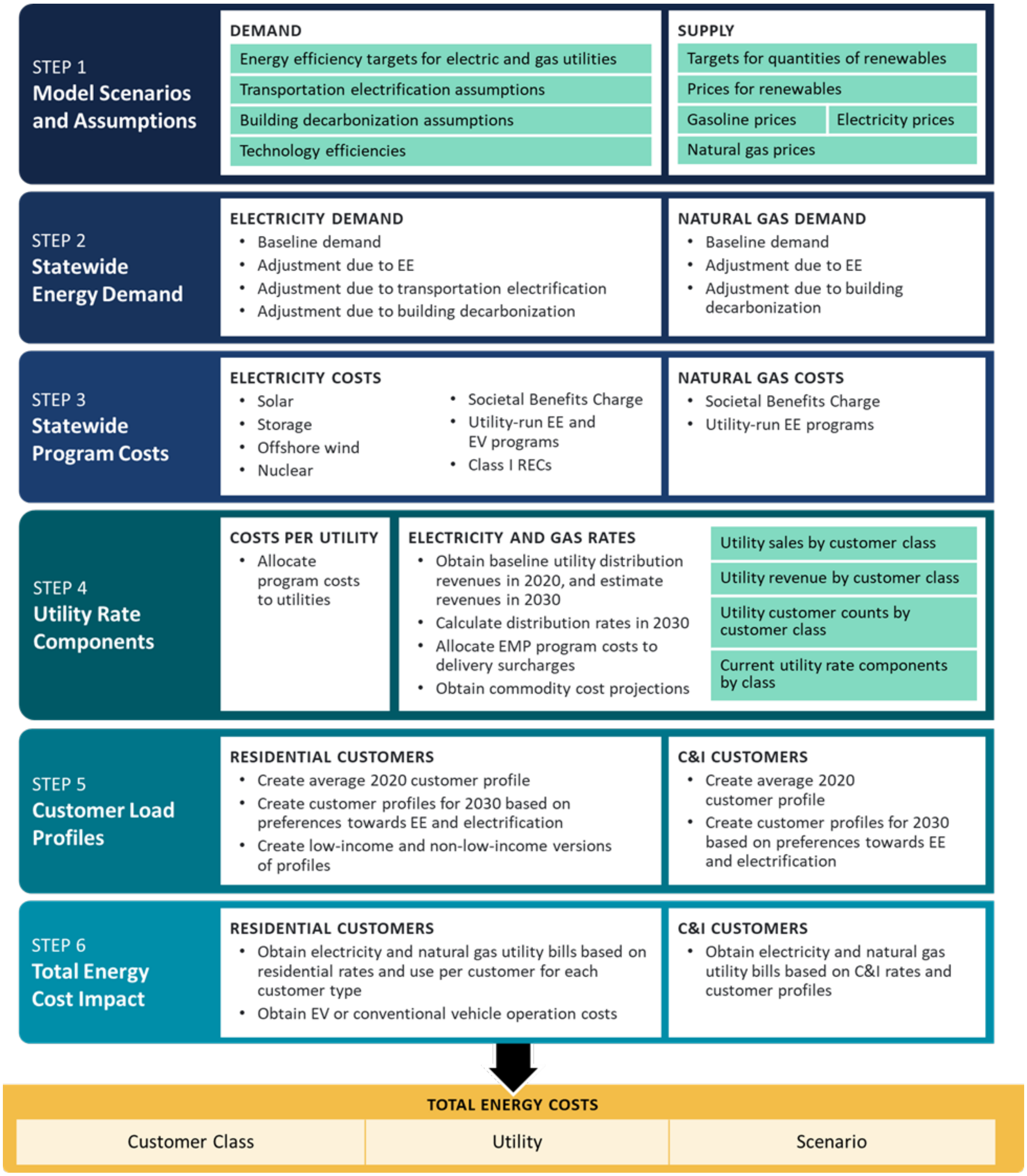
Chapter III summarizes the key findings of our analysis, including the total annual energy cost impacts by customer class.

Chapter IV provides our conclusions from the analysis and initial policy insights.

Chapter V provides the list of sources we relied upon to undertake this Study.

We provide further detail of the analysis in the Appendices. Appendix A contains our assumptions for estimating the EMP Program costs. Appendix B contains details regarding model architecture and related assumptions. Appendix C contains our assumptions for developing customer profiles for cost impact analysis. Appendix D contains the sensitivity analysis for residential customer cost impacts. Appendix E contains the electric-gas utility combinations analyzed for this Study. While Chapter III of the main report discusses results for customers of one of the utility combinations in the state, Appendix F contains the total energy cost impacts results for the remaining seven electric-utility combinations studied.

FIGURE 2: MODEL ARCHITECTURE[14]



[14] Light green boxes in Step 1 and Step 4 represent inputs to the model.

II. Methodology

Model Architecture

We develop a comprehensive model of New Jersey's statewide energy costs, electricity, and natural gas rates, and customer energy costs (Figure 2). This model captures the energy flows across New Jersey's energy economy. From this economy-wide energy flows assessment, we estimate total statewide costs associated with the electricity and natural gas distribution system, commodities, and clean energy programs. We then translate these total statewide energy flows and costs into electricity and natural gas utility rates by considering the changes to the distribution system and increases in New Jersey's clean energy program costs to pursue the EMP goals. We finally translate these rates into customer cost impacts across each utility and customer category.

The model architecture consists of six main steps:

Step 1: Model Scenarios and Assumptions

We define a set of supply-side and demand-side energy market assumptions for 2030 under each scenario. Table 1 presents the key scenario assumptions regarding energy efficiency, transportation and building decarbonization, and energy supply. The input assumptions are obtained from various sources such as the 2019 EMP and other policies enacted since then, NJBPU Board orders, data provided by the utilities, and energy market projections as described below. Further detail on the scenario assumptions can be found in Appendix B.

- **Energy efficiency (EE) assumptions** are based on Board orders,[15] which set energy savings targets for electric and gas utilities until 2026. The Current Policy Pathway keeps the annual targets constant after 2026. The EMP Achievement Pathway and the Ambitious Pathway assume EE targets increase linearly until 2030.
- **Transportation electrification** projections were developed based on a Brattle model[16] for the Current Policy Pathway. This model indicates that approximately 30% of new light duty vehicle sales across the U.S. in 2030 are expected to be electric vehicles (EVs). The EV adoption values in the EMP Achievement Pathway and Ambitious Pathway scenarios are based on the EMP Least Cost scenario assumptions.

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15 New Jersey Board of Public Utilities, Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs, Docket No. QO19010040, Agenda Item 8D, June 10, 2020.

16 Getting to 20 Million EVs by 2030: Opportunities for the Electricity Industry in Preparing for an EV Future, 2020.

- **Building decarbonization** assumptions under the Current Policy Pathway are based on the current market adoption trends for building decarbonization and substitution away from natural gas. The EMP Achievement Pathway assumes that natural gas demand associated with heating declines at a 2.4% YoY rate, which is consistent with the reduction in natural gas demand in the EMP Least Cost scenario. The Ambitious Pathway explores a more ambitious goal (-3% YoY rate) than the EMP Achievement Pathway.
- **Energy supply assumptions** are defined by the Renewable Portfolio Standards (RPS) targets and other clean energy targets under each scenario:
  - 2030 RPS target is 50% based on the Clean Energy Act in the Current Policy Pathway and EMP Achievement Pathway. The Ambitious Pathway achieves higher renewables deployment based on the NJBPU Resource Adequacy Investigation,[17] which identified new policy and market structures to accelerate clean energy deployment at competitive prices.
  - Nuclear capacity is held constant through 2030 across all scenarios assuming existing nuclear power plants continue to operate as planned and no new nuclear power plants are built by 2030.
  - Solar installed capacity in 2030 considers the solar quantities under the Solar Renewable Energy Certificates (SREC) Registration Program (SRP), Transition Incentive (TI) Program, and Successor Solar Incentive (SuSI) Program.[18] SuSI program capacities are the same across all scenarios until 2026.[19] After 2026, the Current Policy Pathway keeps the annual additions constant until 2030 within the SuSI program. The EMP Achievement Pathway assumes the same quantity of solar but assumes generic PJM solar purchases after 2026 rather than procured through the SuSI program. The Ambitious Pathway assumes 58% of statewide electricity consumption will be met by renewable energy resources in 2030 according to the NJBPU Resource Adequacy Investigation.[20] The Ambitious Pathway procures 8% additional renewables beyond the 50% RPS target from PJM generic solar purchases.

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17 New Jersey Board of Public Utilities, Alternative Resource Adequacy Structures for New Jersey, Docket No. EO20030203, June 2021.

18 Existing solar quantities under each program are obtained from New Jersey Board of Public Utilities, Solar Activity Reports.

19 New Jersey Board of Public Utilities, Successor Solar Incentive (SuSI) Program.

20 New Jersey Board of Public Utilities, Alternative Resource Adequacy Structures for New Jersey, Docket No. EO20030203, June 2021.

- Energy storage quantity in the Current Policy Pathway is based on the Clean Energy Act target. The EMP Achievement Pathway and the Ambitious Pathway assumptions are based on the EMP Least Cost scenario.
- Offshore wind capacities are based on Board orders for Solicitation #1[21] and #2[22] for the Current Policy Pathway. The EMP Achievement Pathway and the Ambitious Pathway assumptions also include Solicitation #3.[23]

TABLE 1: KEY SCENARIO ASSUMPTIONS, AS OF 2030

	Current Policy Pathway	EMP Achievement Pathway	Ambitious Pathway
ENERGY EFFICIENCY			
Reduction in energy use	**Cumulative:** 9% electric and 5% natural gas use reduction from 2020 levels. Annual average YoY[24] reduction: 1% for electric, 0.5% for gas	**Cumulative:** 12% electric and 7% natural gas use reduction from 2020 levels. Annual average YoY reduction: 1.3% for electric, 0.7% for gas	**Cumulative:** 12% electric and 7% natural gas use reduction from 2020 levels. Annual average YoY reduction: 1.3% for electric, 0.7% for gas
TRANSPORTATION ELECTRIFICATION			
Light duty EV share	30% of sales, 10% of stock (467K electric vehicles on the road in 2030)	85% of sales, 30% of stock (1.3M electric vehicles on the road in 2030)	85% of sales, 30% of stock (1.3M electric vehicles on the road in 2030)
Medium duty EV share	20% of sales, 4% of stock	65% of sales, 13% of stock	65% of sales, 13% of stock
Heavy duty EV share	13% of sales, 2% of stock	43% of sales, 7% of stock	43% of sales, 7% of stock
BUILDING DECARBONIZATION			
Reduction in natural gas use for heating	Natural gas demand declines 0.2% YoY from 2020 to 2030	Natural gas demand declines 2.4% YoY from 2020 to 2030	Natural gas demand declines 3% YoY from 2020 to 2030
ELECTRICITY SUPPLY			
RPS Class I	50% by 2030	50% by 2030	58% by 2030
Nuclear	3.5 GW	3.5 GW	3.5 GW
Solar	12 GW	12 GW	14.5 GW
Energy storage	2 GW	2.5 GW	2.5 GW
Offshore wind	3.7 GW	4.9 GW	4.9 GW

[21] New Jersey Board of Public Utilities, In the Matter of The Board of Public Utilities Offshore Wind Solicitation For 1,100 MW – Evaluation of the Offshore Wind Applications, Docket No. QO18121289, Agenda Item 8D, June 21, 2019.

[22] New Jersey Board of Public Utilities, In The Matter of the Board of Public Utilities Offshore Wind Solicitation 2 For 1,200 To 2,400 MW – Atlantic Shores Offshore Wind Project 1, LLC, Docket No. QO21050824, Agenda Item 8A-1, January 7, 2022. New Jersey Board of Public Utilities, In The Matter of the Board of Public Utilities Offshore Wind Solicitation 2 For 1,200 To 2,400 MW – Ocean Wind II, LLC, Docket No. QO21050825, Agenda Item 8A-2, January 7, 2021.

[23] New Jersey Board of Public Utilities, New Jersey Offshore Wind Solicitations, accessed on June 14, 2022.

[24] YoY is an acronym for "year-over-year."

Step 2: Statewide Energy Demand

We determine the statewide electricity and natural gas demand in 2030 based on demand from 2020 and the assumptions from the previous step regarding energy efficiency, transportation electrification, and building decarbonization impacts.

The Study's electricity demand projection is based on adjusting PJM's 2030 energy forecast for New Jersey.[25] We adjust PJM's forecast to account for the different assumptions under each scenario regarding building and transportation electrification, energy efficiency, and distributed solar. PJM's energy efficiency, distributed solar, and building electrification assumptions are consistent with the Current Policy Pathway, while we adjust PJM's EV forecast down to reflect the Current Policy Pathway. For the EMP Achievement Pathway and the Ambitious Pathway, we make further adjustments to the PJM forecast to capture more ambitious energy efficiency and electrification. The electricity supply mix that meets the statewide demand is determined based on the statewide clean energy goals. RPS targets for Class I renewable energy sources are met with offshore wind, solar, and residual Class I Renewable Energy Certificates (REC or RECs). The total electricity generation from nuclear power is calculated based on the current capacity of nuclear. Once renewables and nuclear are accounted for, fossil fuel resources meet the rest of electricity demand.

We develop our natural gas demand forecast for 2030 based on the continuation of historical trends, utility sales forecasts, and building decarbonization and energy efficiency targets shown in Table 1. Natural gas use associated with heating is reduced by the amount shown in Table 1 as part of the building decarbonization assumptions. Natural gas use is further reduced due to energy efficiency savings. The EMP Achievement Pathway and the Ambitious Pathway include more ambitious energy efficiency and building decarbonization targets compared to the Current Policy Pathway.

The statewide electricity and natural gas demand values for 2030 are allocated to utilities and utility rate classes based on shares of 2020 sales. Please see Appendix B.2 for further details on statewide demand analysis.

Step 3: Statewide Program Costs

We calculate the statewide clean energy program costs in 2030 based on assumptions regarding the energy supply, incentives, and program implementation goals. We mainly rely on

[25] PJM Resource Adequacy Planning Department, Load Forecast Report, January 2022.

program information from NJBPU and New Jersey utilities for this step. Table 2 describes the approach for calculating the costs for each program at the state level.

TABLE 2: APPROACH FOR ESTIMATING STATEWIDE PROGRAM COSTS IN 2030

Program	Approach
ELECTRICITY	
Class I REC	Costs are calculated based on Class I REC volume and price projections. Class I REC volumes are computed for each scenario depending on total electricity demand, RPS target, and the volumes of solar and offshore wind that are receiving other subsidies such as SRECs, Transition Renewable Energy Certificates (TRECs), SREC IIs, and Offshore wind Renewable Energy Credits (ORECs). The EMP Achievement Pathway and Ambitious Pathway also add solar through generic PJM solar purchases after 2026 rather than only through SuSI. This solar is also assumed to receive Class I REC payments. These are part of the generation component of the electricity bill.
Solar - SREC	SREC costs are calculated as the product of the SREC incentive and the projection of the volume of solar receiving SRECs in 2030. SREC incentives are obtained from NJBPU.[26] The volume of solar is calculated based on the RPS SREC carve-out[27] and the projected statewide electricity load in 2030. These are part of the generation component of the electricity bill.
Solar – SREC EDC surcharge	These represent utilities' costs to administer various solar programs. The total revenue collected through this electric distribution company (EDC) surcharge is assumed to stay constant in real terms.
Solar - TREC	TREC costs are calculated as the product of TREC incentive and the projection of the volume of solar receiving TRECs in 2030. TREC incentive values and the volume of solar registered under the now-closed TREC program are obtained from NJBPU.
Solar - SREC II	SREC II costs are calculated as the product of SREC II incentives and the projection of the volume of solar receiving SREC IIs in 2030. Projects receive a fixed incentive for 15 years.[28] Annual installations of solar under this program until 2030 are tracked and assigned the appropriate incentive values. Solar SREC II incentive values and the volume of solar expected to be registered annually under the SuSI program are obtained from NJBPU.

26 New Jersey Board of Public Utilities, Cost Cap Tool Excel Spreadsheet, accessed on June 14, 2022.

27 Solar carve-out is 1.58% in 2030. Source: New Jersey Board of Public Utilities, Renewable Energy and Energy Efficiency Adopted Amendments: N.J.A.C. 14:8-2.3 and 2.6, September 16, 2019.

28 *See* New Jersey Board of Public Utilities, In the Matter of Solar Successor Incentive Program, Docket No. QO20020184, Agenda Item 8A, July 28, 2021.

Program	Approach
Offshore Wind - OREC	The net ratepayer costs of offshore wind projects are calculated based on the OREC purchase prices and assume projects return revenues from energy and capacity markets to the ratepayers.[29]
Energy Storage	The approach is similar to offshore wind costs; however, there are no set incentives for storage projects yet. The net ratepayer costs of storage projects are calculated based on installed capacity costs minus revenues from energy and capacity markets returned to the ratepayers.
Nuclear - ZEC	The total revenue collected statewide through Zero Emission Credit (ZEC) surcharges is assumed to stay constant through 2030 in nominal terms in the absence of a clear indication that these costs will change in the future. In the future, the Board may change the ZEC surcharges imposed on retail customers; the ZEC subsidy will undergo a 10-year evaluation in 2028.[30]
Societal Benefits Charge	The total revenue collected through Societal Benefits Charge is assumed to stay constant in real terms in the absence of a clear indication that these costs will change in the future.
Utility-run EE Programs	Utility budgets that are approved by NJBPU for program years 1–3 (through 2023) are obtained from utilities. 2023 budgets reported by the utilities are increased 2% YoY in real terms through 2030 for all scenarios. Statewide cost is the sum of the budgets of each utility.
Utility-run EV Programs	Estimated future costs of programs are obtained from utilities for 2023. Budgets are assumed to increase 5% YoY in real terms from 2023 to 2030 for the Current Policy Pathway and 10% YoY for the EMP Achievement and Ambitious Pathway. Statewide cost is the sum of the budgets of each utility.
NATURAL GAS	
Societal Benefits Charge	The total revenue collected through Societal Benefits Charge is assumed to stay constant in real terms in the absence of a clear indication that these costs will change in the future.
Utility-run EE programs	Utility budgets that are approved by NJBPU for program years 1–3 (through 2023) are obtained from utilities. 2023 budgets reported by the utilities are increased 2% YoY in real terms through 2030 for all scenarios. Statewide cost is the sum of the budgets of each utility.

Step 4: Utility Rate Components

In this step, we obtain the 2020 electricity and natural gas rates for each utility and customer class from utility tariffs. Next, we calculate electricity and natural gas utility rates in 2030 for

[29] *See* footnotes 21 and 22 for OREC prices.

[30] New Jersey Board of Public Utilities, In the Matter of the Implementation of L. 2018, C. 16 Regarding the Establishment of a Zero Emission Certificate Program for Eligible Nuclear Power Plants, Docket No. EO18080899, Agenda Item 9C, July 10, 2019.

each utility. Rates are calculated separately for residential class and small and large C&I classes under each scenario. We do not speculate how rate designs will evolve in the next ten years but continue to use the existing rate structures.[31]

At a high level, rate structures consist of three components: distribution charges, distribution surcharges, and commodity charges. We rely on data obtained from utilities on current and historical rates, customer counts, sales, and revenues. We also develop projections regarding the future trends based on U.S. Energy Information Administration (EIA) publications and NJBPU-approved reports.

Distribution Charges. We estimate the distribution base rates in 2030 by combining information on the 2020 rates and projections of revenue requirements, customer counts, sales, and customer charges. This data comes from the individual utility tariffs as well as our correspondence with the utilities. First, we calculate the distribution revenues collected in 2020 for each selected rate class of each utility. We make informed assumptions about the distribution revenue growth and customer charges through 2030. We obtain the revenue to be recovered through distribution base rates in 2030. We calculate the 2030 base rates after taking into account the changes in distribution revenue and the customer charges as well as the expected level of retail sales. Please see Appendix B.6 for details on utility rate calculations.

Distribution Surcharges. The costs of most EMP-related clean energy programs shown in Step 3 will be recovered through distribution surcharges in the utility rate structures. Only Class I RECs and SRECs are a part of the generation component of the electricity bill, although they are associated with statewide programs for providing clean energy. Unlike the SREC costs, the costs of the newer solar TREC and SREC II programs will be recovered directly by the utilities through surcharges.

To obtain the 2030 distribution surcharge values for solar TREC, SREC II, offshore wind OREC, and energy storage, we allocate the statewide program costs to each utility based on their share of retail sales and compute a surcharge for each utility to recover those costs. For the utility-run energy efficiency and electric vehicle programs, we obtain utility-specific costs data and therefore we compute a utility-specific surcharge based on the program budgets and sales

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[31] The Study team acknowledges that there could be significant savings associated with future rate design changes and that time varying rates (TVR) can be an effective tool to mitigate costly grid infrastructure expansion if/when they achieve higher levels of participation. However, these rates are not currently implemented in NJ, and the Study team decided to make the conservative assumption to not include the potential benefits of TVRs in the Study at this time. Once utilities put forward more concrete plans on their rate design proposals, these assumptions can be integrated into the next ratepayer impact study.

of each utility. For other programs listed under Step 3, we keep the 2020 revenues collected by surcharges constant (in real 2022 dollars) through 2030 and redistribute the revenue over the 2030 sales to obtain the 2030 surcharges. Note that distribution surcharges are volumetric; in other words, we divide program costs by utility sales to obtain the surcharge value in $/kWh or $/therm.

Commodity Charges. We estimate the commodity charges based on historical data on Basic Generation Service (BGS) and Basic Generation Supply Service (BGSS) charges from tariffs, auction results, independent market monitor reports, as well as forecasts of commodity prices from PJM, EIA and other sources.

To construct the 2030 commodity prices for electricity, we use the projections of energy, capacity, and Class I REC prices from the offshore wind second solicitation report[32] and PJM,[33] and we obtain the SREC price projections from NJBPU's Cost Cap tool.[34] We develop projections for each utility by preserving the difference between commodity charges between the utility BGS rates in 2020. We use the same projections for each customer class. For natural gas, we rely on projections of commodity prices for natural gas from EIA Annual Energy Outlook (2021) and keep the commodity price constant in real terms for each utility. We apply the same charge to each customer class. Please see Appendix B.7 for details on commodity charge projections.

Step 5: Customer Load Profiles

We develop representative electricity, natural gas, and gasoline consumption profiles for residential, small C&I, and large C&I customers for 2030. Within each customer class, we create profiles that reflect preferences for heating and transportation electrification and energy efficiency implementation. Residential customer profiles include both low-income and non-low-income versions to capture the cost impacts on customers with different income levels.

RESIDENTIAL CUSTOMER LOAD PROFILES[35]

We develop 2030 customer load profiles by adjusting the typical energy consumption profile of New Jersey residential customers in 2020. We assume that the typical customer in 2020 heats

32 Levitan & Associates, Inc., Evaluation Report – New Jersey Offshore Wind Solicitation #2 prepared for The New Jersey Board of Public Utilities, May 25, 2021.

33 Monitoring Analytics, Components of PJM Price, accessed on June 14, 2022.

34 New Jersey Board of Public Utilities, Cost Cap Tool Excel Spreadsheet, accessed on June 14, 2022.

35 In this Study, a residential customer represents a "household" rather than an individual.

their home using a natural gas furnace, drives an internal combustion engine (ICE) vehicle, and primarily uses electricity for non-heating purposes. To account for the relationship between energy consumption and income, we develop profiles for both low-income and non-low-income residential customers.[36, 37]

We develop a set of 2030 customer profiles based on preferences for different heating technologies (natural gas furnace versus heat pump), vehicles (ICE vehicle versus electric vehicle), and whether a customer implements energy efficiency measures or not (Table 3). These customer types are then used to develop the customer load profiles shown in Table 4 and Table 5.

TABLE 3: RESIDENTIAL CUSTOMER TYPES IN 2030

Customer Type	Heating	Energy Efficiency	EV or ICE Vehicle
[1]	Natural Gas	No	ICE
[2]	Natural Gas	Yes	ICE
[3]	Natural Gas	Yes	EV
[4]	Electricity	Yes	EV

Customer [1] consumes the same amount of electricity and natural gas as in 2020. We assume that the energy efficiency improvements that type [2] customers implement are in line with statewide energy efficiency targets under the Current Policy Pathway. For customers who continue to drive an ICE vehicle, fuel efficiency is assumed to stay constant through 2030. For Customers [3] and [4], who adopt an EV, we compute the electricity demand from their electric vehicle by keeping the vehicle miles traveled the same. Customer [4] switches to electric heat pumps for space and water heating while staying on the natural gas system for other end-uses.[38] For customers electrifying their heating load, we compute the electricity needs based on the energy efficiencies of the technologies. Please see Appendix C for details on the development of customer load profiles.

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36 We define low-income customers as those with a household income less than 300% of the federal poverty line based on the 2021 True Poverty report by Legal Services of New Jersey. According to the U.S. Department of Health and Human Services, the 2021 poverty line for a family of four was $26,500. Source: U.S. Department of Health and Human Services, U.S. Federal Poverty Guidelines Used to Determine Financial Eligibility for Certain Programs, February 1, 2021.

37 For both non-low-income and low-income customers, we assume the average annual vehicle miles traveled (VMT) for New Jersey vehicles and therefore same gasoline needs.

38 Space and water heating constitute 93% of natural gas consumption for residential customers in the U.S. Mid-Atlantic region. Source: U.S. Energy Information Administration, Residential Energy Consumption Survey, Table CE4.1 Annual household site end-use consumption by fuel in the U.S. – totals, 2015, accessed on June 14, 2022.

TABLE 4: LOAD PROFILES FOR NON-LOW-INCOME RESIDENTIAL CUSTOMERS

Energy Use Category	Units	2020	2030			
		NG Heating No EE ICE Vehicle	[1] NG Heating No EE ICE Vehicle	[2] NG Heating EE ICE Vehicle	[3] NG Heating EE EV Vehicle	[4] Electric Heating EE EV Vehicle
Electricity (non-EV)	kWh/year	9,834	9,834	8,949	8,949	14,002
Natural gas	Therms/year	1,010	1,010	960	960	66
VEHICLE						
EV Electricity	kWh/year	0	0	0	3,925	3,925
Gasoline	Gallons/year	511	511	511	0	0

TABLE 5: LOAD PROFILES FOR LOW-INCOME RESIDENTIAL CUSTOMERS

Energy Use Category	Units	2020	2030			
		NG Heating No EE ICE Vehicle	[1] NG Heating No EE ICE Vehicle	[2] NG Heating EE ICE Vehicle	[3] NG Heating EE EV Vehicle	[4] Electric Heating EE EV Vehicle
Electricity (non-EV)	kWh/year	6,949	6,949	6,323	6,323	9,890
Natural gas	Therms/year	713	713	677	677	47
VEHICLE						
EV Electricity	kWh/year	0	0	0	3,925	3,925
Gasoline	Gallons/year	511	511	511	0	0

COMMERCIAL AND INDUSTRIAL CUSTOMER LOAD PROFILES

We develop 2030 customer load profiles by adjusting the energy consumption profiles of average small and large C&I customers in 2020. C&I customers are a very diverse group in terms of their business activities and the resulting energy consumption values. Types of customers in this group range from small retail stores to large manufacturing facilities. In this Study, we obtain an *average* small C&I and an *average* large C&I profile for New Jersey; however, do not explicitly model the subcategories within the small and large C&I customers. We focus on electricity and natural gas bills only and do not include transportation costs.

We assume that the average C&I customer in 2020 uses natural gas and electricity for their energy needs. We obtain the statewide average electricity and natural gas consumption of small and large C&I classes from the EIA.[39] For 2030, we develop three customer profiles depending on whether a customer implements energy efficiency to reduce their electricity and natural gas consumption, or electrifies heating loads (Table 6).

TABLE 6: C&I CUSTOMER TYPES IN 2030

Customer Type	Heating	Energy Efficiency
[1]	Natural Gas	No
[2]	Natural Gas	Yes
[3]	Electricity	Yes

Customer [1] continues to consume the same amount of natural gas and electricity as in 2020. Customer [2] implements energy efficiency measures and reduces both electricity and natural gas consumption in line with statewide energy efficiency targets under the Current Policy Pathway. Customer [3] electrifies heating loads by switching to electric heat pumps while staying on the natural gas system for other end-uses.[40] Table 7 and Table 8 present the customer profiles for average small and large C&I customers, respectively. See Appendix C for details on customer load profiles.

[39] See Appendix C for the sources.

[40] Space and water heating constitute 82% of natural gas consumption for C&I customers in the U.S. Mid-Atlantic region. Source: U.S. Energy Information Administration, Commercial Buildings Energy Consumption Survey, Table E7. Natural gas consumption and conditional energy intensities (Btu) by end use, accessed on June 14, 2022.

TABLE 7: LOAD PROFILES FOR SMALL C&I CUSTOMERS

Energy Use Category	Units	2020	2030		
		NG Heating No EE	[1] NG Heating No EE	[2] NG Heating EE	[3] Electric Heating EE
Electricity	kWh/year	31,243	31,243	28,431	53,908
Electricity peak demand	kW	7	7	7	13
Natural gas	Therms/year	5,781	5,781	5,492	988
Natural gas peak demand	Therms	29	29	27	5

Note: Electricity peak demand is defined as the peak demand in a year based on an average C&I load factor. Natural gas peak demand is defined as the average daily usage in the month with the highest usage in a year. See the Appendix C for details.

TABLE 8: LOAD PROFILES FOR LARGE C&I CUSTOMERS

Energy Use Category	Units	2020	2030		
		NG Heating No EE	[1] NG Heating No EE	[2] NG Heating EE	[3] Electric Heating EE
Electricity	kWh/year	187,873	187,873	170,964	564,793
Electricity peak demand	kW	44	44	40	132
Natural gas	Therms/year	89,362	89,362	84,894	15,277
Natural gas peak demand	Therms	447	447	424	76

Note: Electricity peak demand is defined as the peak demand in a year based on an average C&I load factor. Natural gas peak demand is defined as the average daily usage in the month with the highest usage in a year. See the Appendix for more details

Step 6: Total Energy Cost Impact by Utility and Customer Class

We estimate the 2030 electricity and natural gas costs for a variety of customers using the rates from Step 4 and customer load profiles from Step 5. For residential customers, we also estimate annual vehicle operation costs (gasoline or EV charging costs) besides electricity and natural gas utility bills. To obtain the operating cost of internal combustion engines in 2030, we develop projections of motor gasoline prices. Please see Appendix B.7 for these projections.

We calculate the energy costs for customers of eight combinations of electricity and natural gas utilities, which capture almost all utility customers in New Jersey. These eight combinations can be found in Appendix E. For example, one of the utility combinations is "Atlantic City Electric and South Jersey Gas." This combination represents customers who receive their electricity service from Atlantic City Electric and natural gas service from South Jersey Gas. This way, we obtain the 2030 total annual energy costs for individual customer profiles by customer class, by utility combination, and by scenario. This analysis represents the core outcome of the Study and will be discussed in the next section.

III. Key Findings

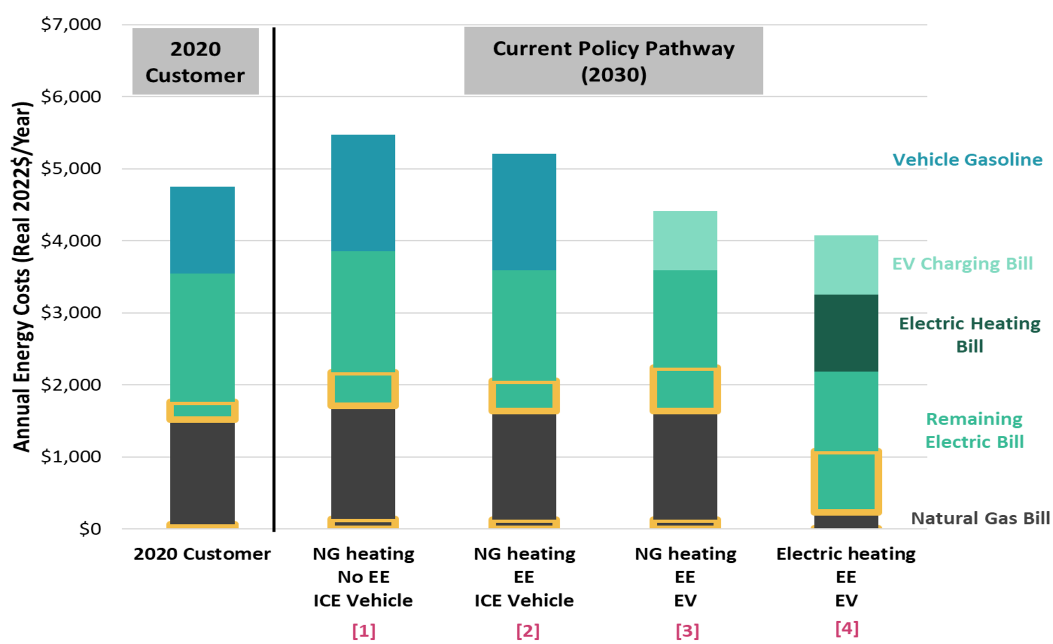
Residential Customer Total Energy Cost Impact

Below, we present the **total annual energy costs** of residential customers for each scenario. Within each scenario, we observe how the costs change from 2020 levels for different customer types due to different preferences regarding electrification and energy efficiency. In this section, we discuss results for one of the utility combinations, namely customers of Atlantic City Electric and South Jersey Gas. Results for the other seven combinations are directionally similar and are presented in Appendix F.

CURRENT POLICY PATHWAY

Customers' total energy cost increases under the Current Policy Pathway, but energy efficiency and electrification offer savings (Figure 3). In 2020, an average non-low-income residential customer spent approximately $4,800/year for electricity and natural gas bills and fuel costs for driving an ICE vehicle. In 2030, a customer's total energy costs depend on whether they take advantage of electrification and energy efficiency opportunities, with a growing number of customers fitting in profiles [3] and [4] by 2030.

FIGURE 3: ANNUAL ENERGY COSTS FOR RESIDENTIAL NON-LOW-INCOME CUSTOMERS UNDER THE CURRENT POLICY PATHWAY[41]



41 Yellow boxes represent the clean energy program costs within the distribution portion of the bills.

- Customer [1]: Keeping energy use constant at 2020 levels, annual energy cost increases by 15% relative to the 2020 Customer in real dollars.
- Customer [2]: Energy efficiency reduces annual energy cost by 5% compared to [1]. However, the total energy cost is still 10% higher compared to the 2020 Customer.
- Customer [3]: EV adoption reduces total energy cost by 15% compared to [2]. Total energy cost is 7% lower compared to the 2020 Customer.
- Customer [4]: Electrified space and water heating further reduces annual cost by 8% compared to [3]. Total energy cost is 14% lower compared to the 2020 Customer.

Changes in Natural Gas Bills

- Natural gas bills increase by 8-13% for customers [1], [2], and [3] who use natural gas for heating in 2030. This increase is mainly due to increasing gas rates.
- Although natural gas commodity prices are assumed to remain constant in real terms through 2030, the all-in volumetric rate increases by 14% compared to the 2020 level as the increasing revenue requirements of utilities are spread over a smaller volume of retail sales due to energy efficiency and electrification.
- Delivery surcharges increase (from $0.07/th to $0.14/th) mainly due to increasing costs of utility-run energy efficiency programs.
- For Customer [4], electrification of heating reduces natural gas bills (-$1,300/year) more than it increases electricity bills (+$1,000/year) compared to 2020 Customer. We assume that Customer [4] remains on the gas system for non-heating uses which represent roughly 7% of initial natural gas use. This leads to higher fixed costs for a smaller volume of natural gas usage. Full electrification would lead to further savings for this customer.

Changes in Electricity Bills

- Electricity bills increase by 6% for Customer [1] who does not implement energy efficiency, but decrease by approximately 3% for Customer [2] who implements EE. In this scenario, the electricity rate increases by 6%, but this increase is offset by EE for Customer [2], which decreases electricity consumption by 9% from 2020 levels.
- Electricity bills increase by 37% for Customer [3] who switches to an EV and needs additional electricity for charging. However, EV reduces fuel costs more than it increases electricity costs. Overall, this leads to savings in annual energy costs. Similarly, for Customer [4], who electrifies both their vehicle and heating, electricity bills increase due to increased

consumption. Even though electricity bills almost double for Customer [4], elimination of vehicle fuel costs and declining natural gas costs lead to overall cost savings.

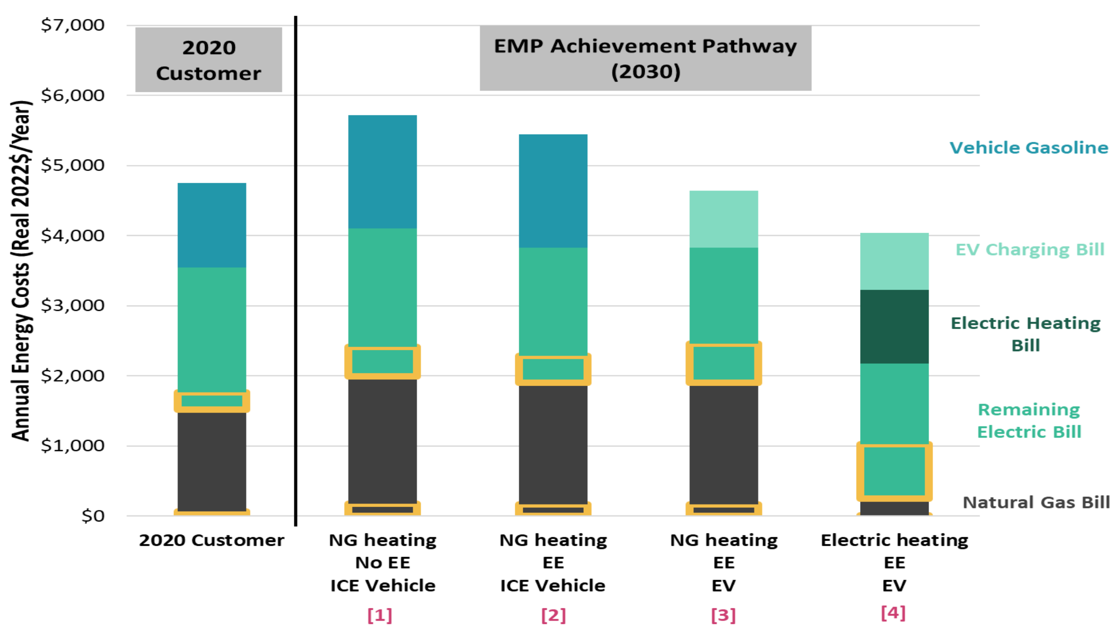
- Electricity rates experience both downward and upward pressure from a variety of factors. Distribution revenue requirements go up by 10%, but sales also go up by 10% leading to a minimal change in delivery base rates on a $/kWh basis. Distribution base rates remain relatively constant at $0.07/kWh on average.
- Distribution surcharges increase (from $0.025/kWh to $0.047/kWh) due to program costs such as OREC, utility-run EE, SREC II, TREC. Commodity prices decrease by 11% in real terms mainly due to decreasing SREC costs.

Changes in Vehicle Operating Costs

- Vehicle operating costs for customers [1] and [2] increase by 35% due to the expected increase in gasoline prices from $2.35/gal in 2020 to $3.16/gal in 2030 in 2022$. For Customers [3] and [4] who switch to an electric vehicle, vehicle operating cost is roughly 50% lower than that of an internal combustion engine vehicle in 2030. Note that the maintenance costs for ICE and EV vehicles are not included in these calculations.

EMP ACHIEVEMENT PATHWAY

FIGURE 4: ANNUAL ENERGY COSTS FOR RESIDENTIAL NON-LOW-INCOME CUSTOMERS UNDER THE EMP ACHIEVEMENT PATHWAY[42]



[42] Yellow boxes represent the clean energy program costs within the distribution portion of the bills.

Figure 4 shows that total energy cost increases are higher under the EMP Achievement Pathway; however, these increases are modest relative to the Current Policy Pathway.

- Customer [1]: Keeping energy use constant at 2020 levels, annual energy cost increases by 20% relative to the 2020 Customer in real dollars. This is 5 percentage points higher than the impact under the Current Policy Pathway.
- Customer [2]: Energy efficiency reduces annual energy cost by 5% compared to [1]. This is the same as the impact under the Current Policy Pathway since we assume that Customer [2] implements the same level of energy efficiency across all scenarios and experiences the same use reductions.
- Customer [3]: EV adoption reduces total energy cost by 15% compared to [2]. This is similar to the impact in the Current Policy Pathway.
- Customer [4]: Electrified space and water heating further reduces annual cost by 13% compared to [3]. This is 5 percentage points higher than that achieved under the Current Policy Pathway.

Changes in Natural Gas Bills

- In this scenario, the increase in the natural gas bills is more pronounced. Gas bills increase by 25-30% for Customers [1], [2], and [3] who use natural gas for heating in 2030. Among these three customers, customers who implement EE (Customers [2] and [3]) face lower bill increases. We assume that these customers reduce their natural gas usage by 5% through EE. However, this effect is dwarfed by the increase in natural gas rates.
- All-in volumetric gas rates increase by 35% compared to the 2020 levels – while the revenue requirements of utilities increase by roughly 10%, retail sales fall by 25% due to higher levels of electrification, as well as energy efficiency. This leads to higher costs being recovered from a smaller volume of sales, thereby increasing the base rates. Surcharges increase for the same reason, despite the fact that we assume that the costs of utility-run EE programs are the same across all scenarios.

Changes in Electricity Bills

- Unlike in natural gas bills, the change in electricity bills is similar in magnitude as well as in direction to the Current Policy Pathway. Electricity bills increase by 4% for Customer [1] who does not implement energy efficiency, but decrease by approximately 5% for Customer [2] who reduces electricity consumption by 9%.

- Electricity rate increases 4% compared to 2020, which is slightly less than what we observed in the Current Policy Pathway. Although the costs of clean energy programs and utility revenue requirements increase, they are spread over a larger volume of sales. Utility sales increase by 20% due to electrification despite reductions from EE. Distribution base rates increase only by 2% compared to 2020. Distribution surcharges increase (from $0.025/kWh to $0.043/kWh) due to clean energy program costs – however, they are lower than the Current Policy Pathway, again led by the increasing sales volume.

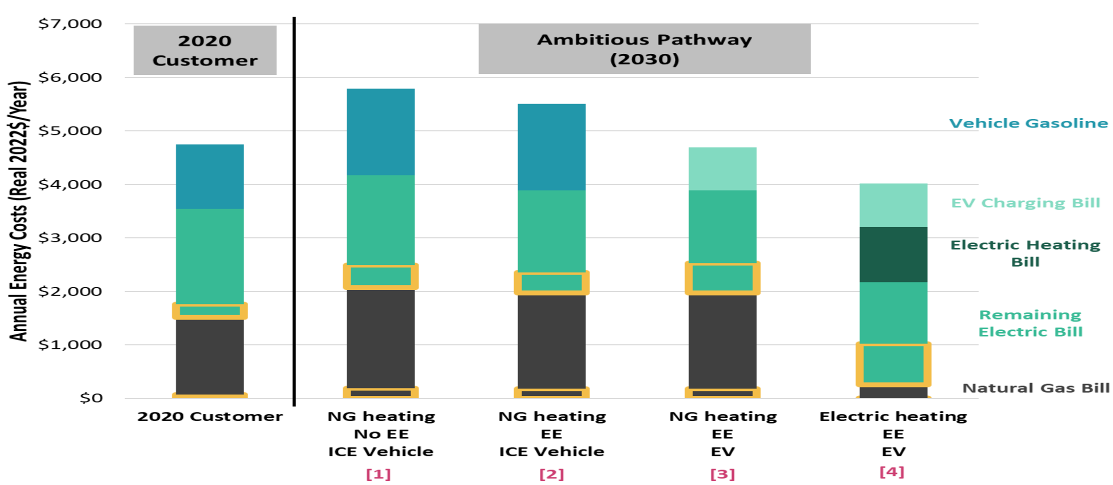
Changes in Vehicle Operating Costs

- Results on vehicle operating are similar to those under the Current Policy Pathway.

The EMP Achievement Pathway assumes higher electrification targets. For example, this scenario assumes New Jersey meets its EV goal of 330,000 in 2025. EV program expenses are modeled higher under this scenario compared to the Current Policy Pathway, but other state incentives/programs will be necessary to increase the likelihood of achieving this aggressive goal. Similarly, heating electrification incentive costs have not been separately reflected in the clean energy program costs, as these programs have not yet been defined at the time of the writing of this report. In both cases, the rate impacts of these initiatives are highly dependent on the availability of Societal Benefits Charge funds to fund these electrification programs, federal and state tax policy, and other factors.

AMBITIOUS PATHWAY

FIGURE 5: ANNUAL ENERGY COSTS FOR RESIDENTIAL NON-LOW-INCOME CUSTOMERS UNDER THE AMBITIOUS PATHWAY[43]



[43] Yellow boxes represent the clean energy program costs within the distribution portion of the bills.

Figure 5 shows that total energy cost increases are only marginally higher in the Ambitious Pathway compared to the EMP Achievement Pathway.

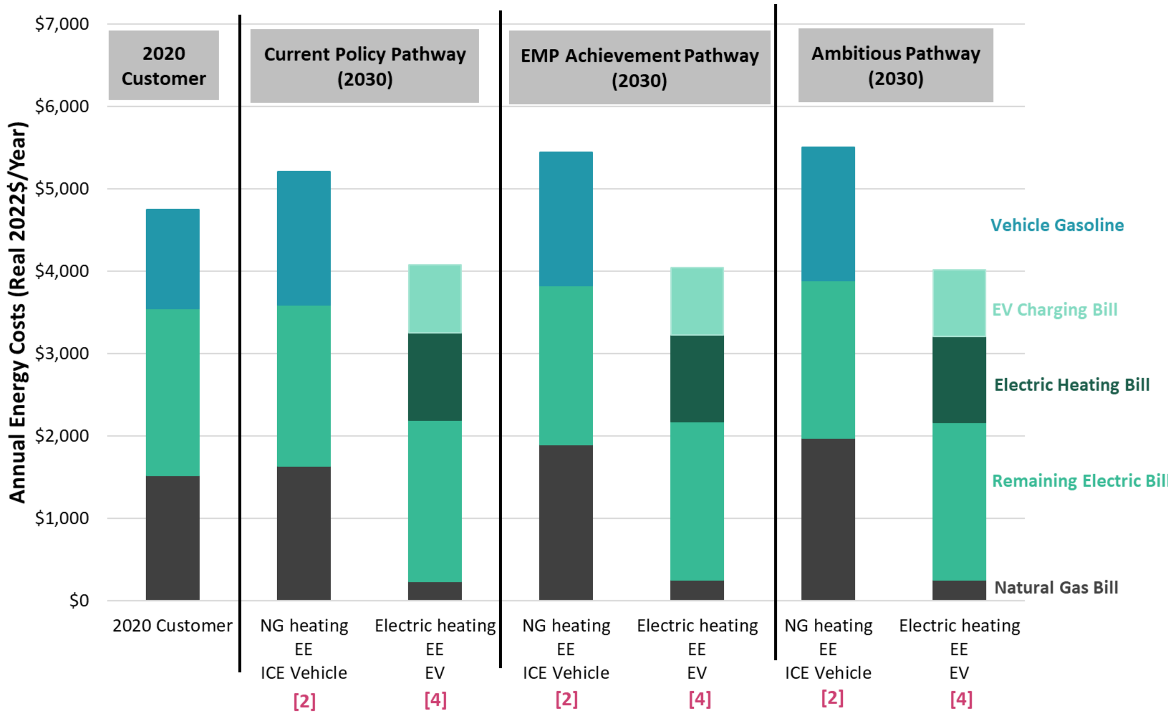
- Customer [1]: Keeping energy use constant at 2020 levels, annual energy cost increases by 22% relative to the 2020 Customer in real dollars. This is 2 percentage points higher than the impact under the EMP Achievement Pathway.
- Customer [2]: Energy efficiency reduces annual energy cost by 5% compared to [1]. This impact is the same under all scenarios since we assume that Customer [2] experiences the same use reductions.
- Customer [3]: EV adoption reduces energy cost by 15% compared to [2]. This impact is the same as that in the EMP Achievement Pathway.
- Customer [4]: Electrified space and water heating further reduces annual cost by 15% compared to [3]. This is 2 percentage points lower than that achieved under the EMP Achievement Pathway.

In the Ambitious Pathway, the direction of the results is the same as that in the EMP Achievement Pathway, and the magnitudes are similar as well. The Ambitious Pathway differs from the EMP Achievement Pathway only in three aspects including the renewables share of electricity, solar generation, and building decarbonization (see key scenario assumptions in Table 1). These lead to only small percentage point differences from the EMP Achievement Pathway results.

COMPARING SCENARIOS

Figure 6 shows the total energy costs for customers who have not electrified their end uses versus customers who have electrified their transportation and heating under all scenarios (Customer [2] versus Customer [4]). The high-level takeaway is that Customer [4], i.e. customers who have electric vehicles and electric heating, experience cost savings (14-15%), while non-electrified customers experience cost increases (10-16%) compared to 2020 levels. Customer [2] experiences increases in natural gas and vehicle fuel costs, and a slight decrease in electricity costs. Customer [4], on the other hand, has lower total costs when natural gas and electricity bills are combined.

FIGURE 6: ANNUAL COSTS FOR ELECTRIFIED VS NON-ELECTRIFIED CUSTOMERS UNDER DIFFERENT SCENARIOS (NON-LOW-INCOME RESIDENTIAL CUSTOMERS)



LOW-INCOME CUSTOMERS

For low-income customers, the direction of the results is the same (Figure 7) as the non-low-income customers. In 2030, Customer [2] total energy cost is 12-17% higher compared to the 2020 Customer; Customer [4] total energy cost is 15-17% lower compared to the 2020 Customer. The main difference is that the low-income customer consumes less energy (see customer profiles in Table 4 and Table 5), which leads to lower costs. However, the key metric for the low-income customer group is the impact of these changes in rates and usage levels on their "energy burden." Energy burden is defined as total energy bills as a share of income. Total energy bill is traditionally defined to include electricity and natural gas bills; customers are deemed to experience "high energy burden" if they spend more than 6% of income on home energy bills and "severe energy burden" if spending more than 10% of income on home energy bills.[44,45] These values do not include vehicle operating costs. Assuming an annual income of $35,000, we find that a low-income customer has an energy burden of 6.6-8.6% as it can be seen in Figure 7.

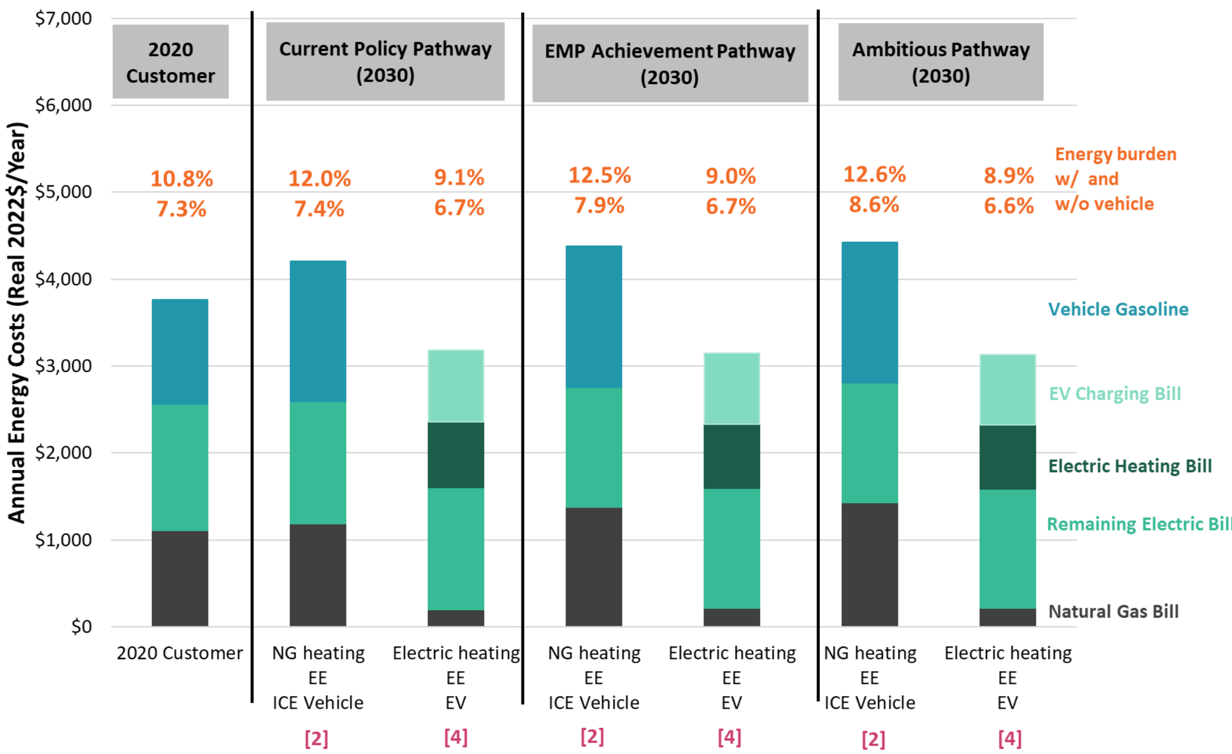
44 U.S. Department of Health and Human Services, LIHEAP Energy Burden Evaluation Study, July 2005.

45 American Council for an Energy-Efficient Economy, How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burdens across the US, September 10, 2020.

We also expanded the energy burden definition to include the spending on vehicle operating costs, as it is a component of customers' total energy expenditure. Again, assuming an annual income of $35,000, a low-income customer has an energy burden of 8.9-12.6% with vehicle operating costs, as shown in Figure 7.

Based on our analysis, we find that low-income customers are already experiencing a high energy burden in 2020 (7.3% without vehicle costs and 10.8% including vehicle costs). We also find that energy burden may fall or at least stay the same if low-income customers adopt electric vehicles and heat pumps. This implies that energy assistance programs targeting low-income customers may be necessary to help with upfront costs of electrification and energy efficiency improvements.

FIGURE 7: ANNUAL COSTS FOR ELECTRIFIED VS NON-ELECTRIFIED CUSTOMERS UNDER DIFFERENT SCENARIOS (LOW-INCOME RESIDENTIAL CUSTOMERS)



C&I Customer Total Energy Cost Impact

Below, we present the **total annual energy costs** of small and large C&I customers for each scenario. Within each scenario, we observe how the costs change from 2020 levels for different customer types due to different preferences regarding electrification and energy efficiency. In this section, we discuss results for one of the electric-gas utility combinations, namely customers of Atlantic City Electric and South Jersey Gas. Results for the other seven combinations are directionally similar and are presented in Appendix F.

We find that the direction of cost impacts is similar to that for residential customers. The driving factors behind the changes in rates and total costs were explained in detail in the context of residential customers above. The same driving factors apply to C&I classes, although the specific rates and the magnitude of the costs are different.

SMALL C&I CUSTOMERS

Figure 8 presents the annual energy costs for small C&I customers. Costs are highest in the Ambitious Pathway; however, the costs are only modestly higher relative to the Current Policy Pathway. Total energy costs of C&I customers increase under all scenarios for Customer [1] who continues to use the same amount of electricity and natural gas in 2030. However, energy efficiency and electrification can lead to cost savings.

Based on the small C&I customer profile we developed, an average small C&I customer spent approximately $16,400/year for electricity and natural gas bills in 2020. *Across all three scenarios*, annual costs for small C&I Customers [1], [2], and [3] change as the following:

- Customer [1]: Keeping energy use constant at 2020 levels, annual energy cost increases by 10-20% relative to the 2020 Customer[46] in real dollars.
- Customer [2]: Energy efficiency reduces annual energy cost by 6% compared to [1]. However, the total energy cost is still 3-15% higher compared to the 2020 Customer.
- Customer [3]: Electrification of heating reduces total energy cost by 20-30% compared to [2]. Total energy cost is approximately 20% lower compared to the 2020 Customer.

Changes in Natural Gas Bills

Natural gas bills increase by 5-15% for Customers [1] and [2] in the Current Policy Pathway, and by 20-30% in the EMP Achievement and Ambitious Pathways compared to 2020 Customer. The increase in gas bills for Customers [1] and [2] is mainly due to increasing gas rates. For Customer [3], electrified heating decreases natural gas bills (-$8,000 to -$10,000 across scenarios) more than it increases electricity bills (approximately +$5,000) compared to 2020

[46] Note that the load profiles for C&I customers are obtained based on 2020 energy consumption data. However the C&I rates for the 2020 Customer are obtained from the tariffs effective as of April 2022 as a proxy for 2020 rates.

Customer. Note that for C&I customers, we assume that Customer [3] remains on the natural gas system for non-heating uses which represent roughly 18% of the initial natural gas use.

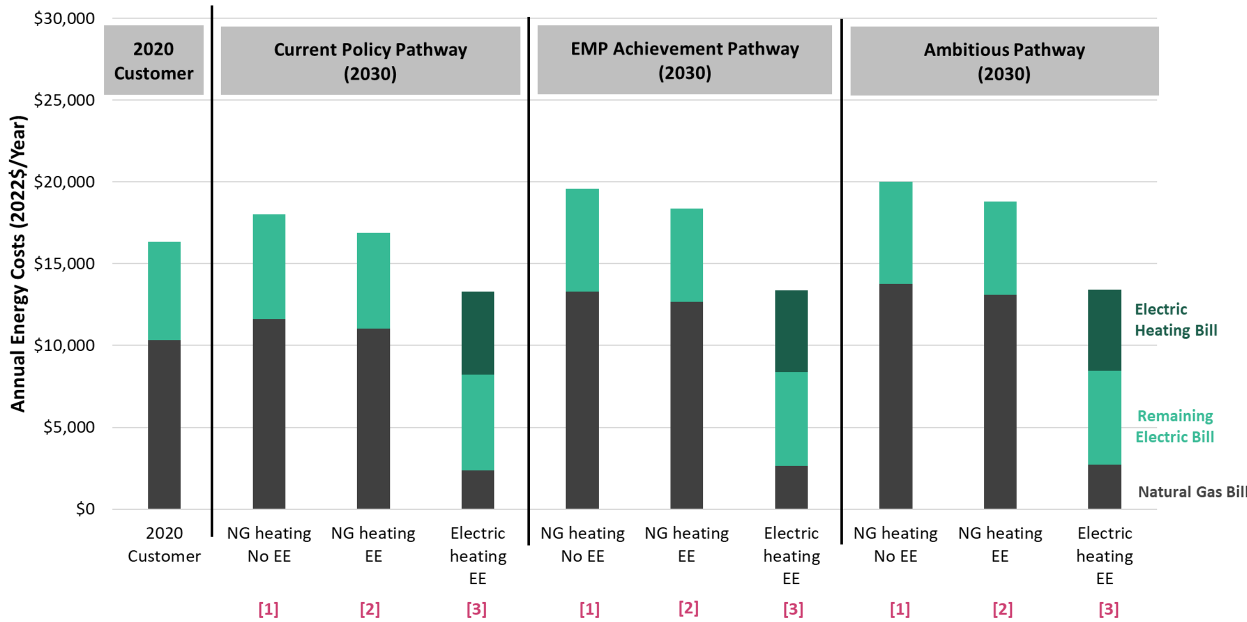
In 2030, across the scenarios, the all-in volumetric natural gas rate increases by 10-35% compared to the 2020 level as the increasing revenue requirements of utilities are spread over a smaller volume of retail sales due to energy efficiency and electrification. Delivery base rates increase by 15% in the Current Policy Pathway and up to 50% in the Ambitious Pathway compared to 2020. Delivery surcharges increase by 35-70% (from approximately $0.21/th in 2020 to $0.28/th in 2030 in the Current Policy Pathway and up to $0.35/th in the Ambitious Pathway). This is mainly due to increasing costs of utility-run energy efficiency programs. Commodity prices are assumed to remain constant in real terms through 2030.

Changes in Electricity Bills

Electricity bills increase only slightly (~5%) across all scenarios for Customer [1] compared to 2020. The increase is the highest for the Current Policy Pathway and lowest for the Ambitious Pathway. For Customer [2] who implements EE, electricity bills decrease by 3-6% compared to 2020. Energy efficiency decreases electricity consumption and offsets the cost impacts of rising electricity rates for this customer. For Customer [3], electricity bills increase by 80% mainly due to additional electricity consumption for heating as discussed above.

Across all scenarios, all-in electricity rates increase by 3-6%. As discussed above for the residential customer, rates experience both downward and upward pressure. Base rates increase only by 1-3% as increasing costs are spread across an increasing volume of sales. Distribution surcharges increase due to program costs such as OREC, utility-run EE, SREC II, TREC, from $0.026/kWh in 2020 to $0.047/kWh in 2030 in the Current Policy Pathway. Surcharges are lower in the other scenarios. Commodity prices decrease by 11% in real terms mainly due to decreasing SREC costs.

FIGURE 8: ANNUAL ENERGY COSTS FOR SMALL C&I CUSTOMERS UNDER DIFFERENT SCENARIOS



LARGE C&I CUSTOMERS

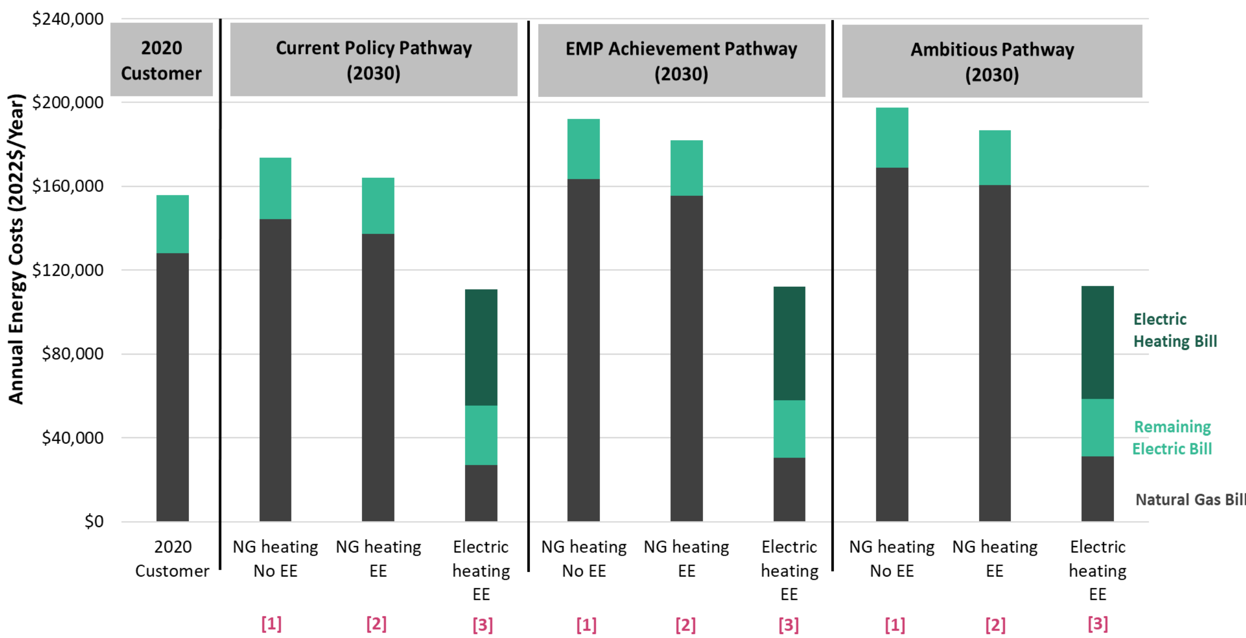
Figure 9 presents the annual energy costs for large C&I customers. Results are similar to those observed for small C&I and residential customers in terms of the direction of changes in the bills and rates; however, magnitudes of the bills differ. The reasons behind the observed trends are the same as discussed above for small C&I and residential customers.

Total energy costs of C&I customers increase under all scenarios for Customer [1] who continues to use the same amount of electricity and natural gas in 2030. Energy efficiency and electrification can lead to cost savings. For the large C&I customer profile we developed, annual spending on energy bills is approximately $155,000/year for electricity and natural gas bills in 2020. Across all three scenarios, annual costs for small C&I Customers [1], [2], and [3] change as the following:

- Customer [1]: Keeping energy use constant at 2020 levels, annual energy cost increases by 12-27% relative to the 2020 Customer in real dollars.
- Customer [2]: Energy efficiency reduces annual energy cost by 5% compared to [1]. However, the total energy cost is still 5-20% higher compared to the 2020 Customer.
- Customer [3]: Electrification of heating reduces total energy costs by 30-40% compared to [2]. Total energy cost is approximately 30% lower compared to the 2020 Customer.

Natural gas and electricity bills change in a similar direction as those of small C&I customers. However, the average large C&I customer profile has a larger share of natural gas bills than the small C&I customer as illustrated in Figure 9. Therefore, this large C&I customer is affected more significantly by the changes in natural gas rates. For Customers [1] and [2], natural gas bills increase by 7-13% in the Current Policy Pathway, and by 20-30% in the EMP Achievement and Ambitious Pathways compared to the 2020 Customer. Natural gas rates increase across all scenarios as the increasing revenue requirements of utilities are spread over a decreasing volume of retail sales due to energy efficiency and electrification. Electricity bills increase only by ~5% for Customer [1], decreases by 2-5% for Customer [2], and doubles for Customer [3] due to electrification of heating for Customer [3]. Electricity rates experience both an upward pressure due to increasing costs and a downward pressure due to increasing sales, and increase by 4-8% from 2020 levels across all three scenarios.

FIGURE 9: ANNUAL ENERGY COSTS FOR LARGE C&I CUSTOMERS UNDER DIFFERENT SCENARIOS



IV. Conclusion

While the 2019 EMP evaluated a core set of policy strategies for achieving economy-wide GHG reduction outcomes in the most cost-effective manner and established a "Least Cost Pathway" to achieving targeted GHG outcomes, it did not evaluate the net cost of these incremental programs to customers. This Study set out to quantify the impact of the EMP on customers' energy costs through a comprehensive model of customer rate and energy cost impacts across the State of New Jersey as of 2030.

The key outcome of this Study is the "total energy cost" in 2030, which is calculated for average customers from each class and for each electric and gas utility combination studied.[47] Total energy cost by including customers' electricity, natural gas and transportation (for the residential customers) expenses, provides a comprehensive look at the customers' energy spending and captures the impacts of energy efficiency and electrification of heating and transportation on customers' overall energy use and resulting costs. We evaluate the total energy cost under three scenarios, and compare them to costs in 2020.

We find that the average **non-low-income residential customer's** total energy costs are expected to increase through 2030 if they do not change their energy consumption patterns by taking advantage of the energy efficiency programs proposed in the EMP, adopting electric vehicles, or switching to electric heating. However, if the customers can adopt these technologies and pair them with energy efficiency program participation, their 2030 energy costs are expected to be lower than their current costs, in real dollars. While the total energy cost impacts are higher under the EMP Achievement Pathway, they are only moderately higher relative to the Current Policy Pathway. For Customer [2], who implements EE consistent with the statewide EE targets and continues to drive an ICE vehicle, the total energy cost is higher by 15% relative to the 2020 Customer under the EMP. This is 5 percentage points higher than the impact under the Current Policy Pathway. For Customer [4], who adopts the same level of EE, switches to driving an EV and adopts electric heat pumps, the total energy cost decreases by 15% relative to the 2020 Customer. This is 1 percentage point lower than that achieved under the Current Policy Pathway.

Results are directionally similar for the average **low-income residential customer**. In 2030, Customer [2] total energy cost is 16% higher compared to the 2020 Customer; Customer [4] total energy cost is 16% lower compared to the 2020 Customer. The key difference is that the

47 Throughout this Study, we calculate the rates and energy costs for 2030, and not for the interim years.

low-income customer consumes less energy, which leads to lower costs. We find that low-income customers are currently experiencing a high energy burden in 2020 (7.3% excluding vehicle operating costs and 10.8% including vehicle operating costs). However, energy burden may fall or at least stay the same through 2030 despite increases in electricity and gas rates, if low-income customers adopt electric vehicles and heat pumps. For instance, under the EMP Achievement Pathway, Customer [4]’s energy burden is 6.7% excluding the vehicle operating costs and 9% including the vehicle operating costs. This implies that energy assistance programs targeting low-income customers may be key to reduce the upfront costs of electrification and energy efficiency improvements. These programs may range from providing rebate assistance for the purchase of efficient appliances and electric vehicles to on-bill financing for income qualifying customers to be able to undertake projects with high initial capital cost requirements.

We find that the direction of cost impacts for the average **non-residential customer** is similar to that for the residential customer. The same driving factors apply to C&I classes, although the specific rates and the magnitude of the costs are different.

The key focus of this study has been to evaluate the **impacts of the EMP on the ratepayers and their total energy burden**. However, Board Staff and Brattle acknowledge that the EMP will undoubtedly play a major role in reducing emissions and the adverse effects of climate change, including public health impacts and extreme weather events. While a rigorous analysis of these benefits is outside the scope of this Study, we calculated the avoided cost of greenhouse gas emissions in 2030 using the U.S. Environmental Protection Agency’s Social Cost of Carbon and found that the annual benefit of **reduced GHG emissions** is $1.75 billion/year in 2030 under the EMP Achievement Pathway. Annual greenhouse gas emissions decrease by 30% from 2020 levels by 2030 under the EMP Achievement Pathway, which is equivalent to avoided emissions from 3.4 million homes' energy use for one year, or 5.8 million gasoline vehicles driven for one year. Board Staff acknowledges the potential usefulness of conducting a rigorous study in the future of climate and health benefits.

As expected in a forward-looking study, there is uncertainty involved in the Study findings. While we undertook a sensitivity analysis to inform the impact of some of these uncertainties, there are other elements of uncertainty that were not captured in our analysis. In the meantime, these results should be useful in informing public policymaking in the State of New Jersey, highlighting the importance of pursuing transportation electrification and building decarbonization along with the EMP to mitigate adverse effects on ratepayer total energy costs. While the State has made a commitment to transportation electrification, a comprehensive building decarbonization pathway is still under development. Board Staff acknowledges the importance of advancing the building decarbonization pathway in the State of New Jersey and recommends a comprehensive study to further the State’s efforts in this area.

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Appendix A: EMP Program Costs

A.1 Statewide Cost of Serving Electricity Customers

In 2020, the total cost of the statewide electricity system was $11.6 billion (in 2022 U.S. dollars). This is the sum of commodity costs, distribution costs, and surcharges (Table 9). Commodity and distribution costs accounted for 92% of the system costs and surcharges accounted for the remainder. In 2020, surcharges recovered the costs of the following program funds: societal benefits charge (SBC), utility-run energy efficiency programs, SREC and TREC programs, ZEC programs and costs from other surcharges.[48] Table 9 presents a breakdown of electricity system costs in 2020.

TABLE 9: BREAKDOWN OF SYSTEM WIDE ELECTRICITY COSTS IN 2020 (2022$ MILLIONS)

Cost Category	Cost (2022$ Millions)
Commodity Costs	**$8,024**
RTO Charges	$7,199
SREC Costs	$733
Class I REC Costs	$92
Distribution Costs	**$2,659**
Surcharges	**$910**
System Benefits Charge	$488
Utility-Run Energy Efficiency	$10
SREC program	$50
TREC program	$38
ZEC program	$235
Other Surcharges	$89
Total	**$11,593**

Note: Numbers may not add up due to rounding.

We compute **commodity costs** in 2020 and 2030 based on the statewide consumption of electricity and the average commodity price of natural gas. Per our analysis, the statewide average price of electricity will decline from $0.116 per KWh in 2020 to $0.104 per kWh in 2030 (in 2022 dollars). (See Appendix B.7 for details on commodity price projections.) This price includes energy, capacity, ancillary services, and transmission charges, as well as Class I RECs

[48] Clean energy program costs include distribution surcharges, as well as the Class I RECS and SREC charges passed onto ratepayers as part of commodity costs.

and SREC charges. The "Regional Transmission Organization (RTO) charges" portion of the commodity costs include energy, capacity, ancillary services, and transmission charges.

We estimate total utility **distribution costs** in 2020 using the following equation for the electricity system:

$$\begin{aligned}(Total\ Distribution\ Costs) &= \big((Sales\ to\ Residential) * (Average\ Residential\ Distribution\ Rate)\big) \\ &+ \big((Sales\ to\ Small\ C\&I) * (Average\ Small\ C\&I\ Distribution\ Rate)\big) \\ &+ \big((Sales\ to\ Large\ C\&I) * (Average\ Large\ C\&I\ Distribution\ Rate)\big)\end{aligned}$$

We use the average distribution rates across each utility studied.[49] We first obtain the distribution charges collected by utilities for each class from EIA.[50] We then subtract the utility distribution surcharges (stated in utility tariffs) to obtain the portion that represent the "average distribution rate" which is only inclusive of base rates and fixed charges. Electricity sales to each class are obtained from EIA as well.[51]

We then derive the total utility distribution costs in 2030 using the 2020 distribution cost and an annual growth rate. This annual growth rate is 1% real YoY in the Current Policy Pathway and 2% in the EMP Achievement and Ambitious Pathways.

We take the average of **surcharge rates** across utilities and multiply it by statewide electricity consumption to ascertain the system wide surcharge costs in 2020. 2020 surcharges are obtained from the utility tariffs. 2030 surcharges are calculated in the model as described in Chapter II Step 3. One difference between 2020 and 2030 surcharges is the scope of the costs being considered. In addition to considering the costs recovered by the 2020 surcharge, the 2030 surcharge also covers the costs of new clean energy programs: costs from the SREC II program, costs from offshore wind, costs from storage and costs from EVs. Table 10 displays the total commodity costs, distribution costs and surcharges in 2030 under different scenarios.

49 The electricity distribution companies included in this Study are Atlantic City Electric (ACE), Jersey Central Power & Gas (JCPL), Public Service Electric & Gas (PSEG), and Rockland Electric Company (RECO).

50 Annual Electric Power Industry Report, Form EIA-861, U.S. Energy Information Administration. https://www.eia.gov/electricity/data/eia861/

51 Annual Electric Power Industry Report, Form EIA-861, U.S. Energy Information Administration. https://www.eia.gov/electricity/data/eia861/

TABLE 10: BREAKDOWN OF SYSTEM WIDE ELECTRICITY COSTS IN 2030 (2022$ MILLIONS)

Cost Category	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
Commodity Costs	**$7,921**	**$8,739**	**$8,861**
RTO Charges	$7,535	$8,320	$8,432
SREC Costs	$155	$165	$167
Class I REC Costs	$231	$253	$261
Distribution Costs	**$2,937**	**$3,241**	**$3,241**
Surcharges	**$2,822**	**$2,845**	**$2,845**
System Benefits Charge	$488	$488	$488
Utility-Run Energy Efficiency	$485	$485	$485
SREC program[52]	$50	$50	$50
TREC program	$244	$244	$244
SREC II program	$462	$313	$313
Offshore Wind	$664	$792	$792
Storage	$75	$93	$93
ZEC	$200	$200	$200
EV	$66	$91	$91
Other Surcharges	$89	$89	$89
Total	**$13,680**	**$14,825**	**$14,947**

Note: Numbers may not add up due to rounding.

In 2030, total statewide cost of serving electricity customers increases by 18% from 2020 levels in the Current Policy Pathway. The EMP Achievement and the Ambitious Pathways lead to a 28-29% increase over 2020 levels. The 2030 system wide electricity cost is $1 billion greater in the EMP Achievement Pathway than in the Current Policy Pathway.

As noted earlier, **clean energy program costs** include distribution surcharges as well as the Class I RECs and SREC charges, which are recovered from ratepayers as part of commodity costs. In 2030, these clean energy program costs are $3.21 billion in the Current Policy Pathway, $3.26 billion in the EMP Achievement Pathway, and $3.27 billion in the Ambitious Pathway. These represent an 85%, 88%, and 89% increase from 2020 levels for each scenario, respectively. In 2030, the aggregate spending on the SREC II program and offshore wind ($1.1 billion) is a major driver of surcharge costs. Another driver of the increase in the total surcharge

52 These represent utilities' costs to administer various solar programs. These are not inclusive of all the Solar Renewable Energy Certificate (SREC) costs. The majority of SREC costs are market-based costs passed through to ratepayers within commodity costs to cover the charges of Third Party Suppliers and Basic Generation Service Providers.

cost is the expansion of utility-run EE programs. In 2030, electric distribution companies in New Jersey will collectively spend over $400 million annually; in 2020, this figure was approximately $12 million.

Commodity costs decrease by 1% from 2020 levels in the Current Policy Pathway despite the increase in sales volume. This mainly stems from the lower electricity price due to declining SREC costs, which are recovered through generation charges. Due to 7 terawatt hours (TWh) of additional electricity consumption, commodity costs are $800 million higher in the EMP Achievement Pathway than in the Current Policy Pathway. In the Ambitious Pathway, commodity costs are $120 million higher than in the EMP Achievement Pathway due to higher sales.

SREC Program Evolution

New Jersey closed its SREC program for new applications in 2021. Since then, New Jersey provides incentives to solar energy producers through two new solar programs, namely the "Transition Incentive" (TI) Program and the "Successor Solar Incentive" (SuSI) Program. The TI program provided incentives through Transition Renewable Energy Certificates (TRECs) and the SuSI Program through Solar Renewable Energy Credits II (SREC IIs). Under the legacy SREC program, Third Party Electricity Suppliers (TPS) and Basic Generation Service (BGS) providers obtained and retired SRECs to comply with the solar electric generation portion of the RPS. SREC charges appeared in the generation portion of customers' bills. Under the TI and SuSI Programs, however, the costs of TREC and SREC II programs will be recovered directly by the electric utilities through the use of distribution surcharges. Legacy SREC costs decline over time as the SREC obligations under RPS decrease: the percentage of electricity that must be supplied from solar energy declines from 5.1% in Energy Year 2021 to 1.6% in Energy Year 2030. New Jersey's TI and SuSI programs each reduce the per-MWh cost of incentives for new solar generating facilities, therefore ensuring that new solar is provided at a lower cost to ratepayers.

A 1% YoY increased growth rate in distribution costs accounts for roughly $300 million (10%) increase in annual costs under the Current Policy Pathway in 2030, relative to 2020. In the EMP Achievement Pathway, real commodity costs in 2030 are 10% higher than in 2020 and real distribution costs in 2030 are 22% higher than in 2020. The Ambitious Pathway differs from the EMP Achievement Pathway only in commodity costs as mentioned above. Figure 10 and Figure 11 below provide a breakdown of system wide costs in 2030 versus 2020.

FIGURE 10: BREAKDOWN OF STATEWIDE ELECTRICITY COSTS, 2020 VS 2030

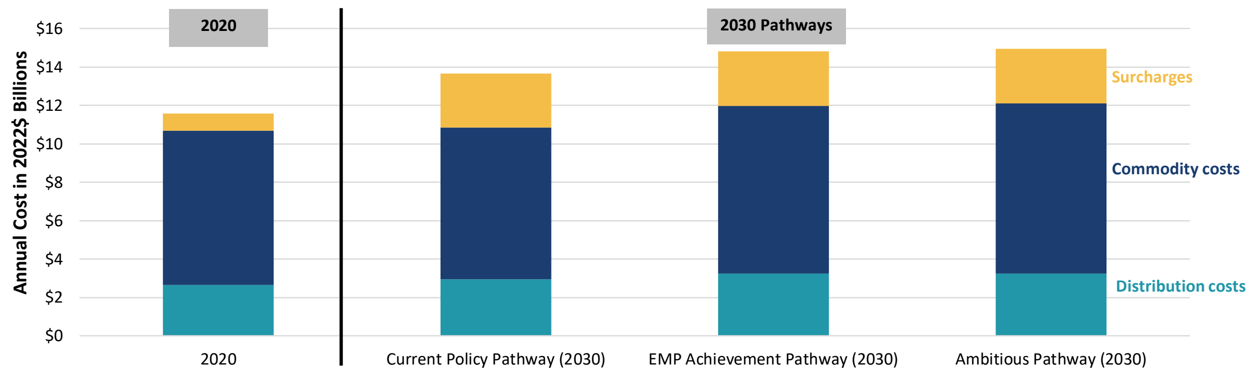
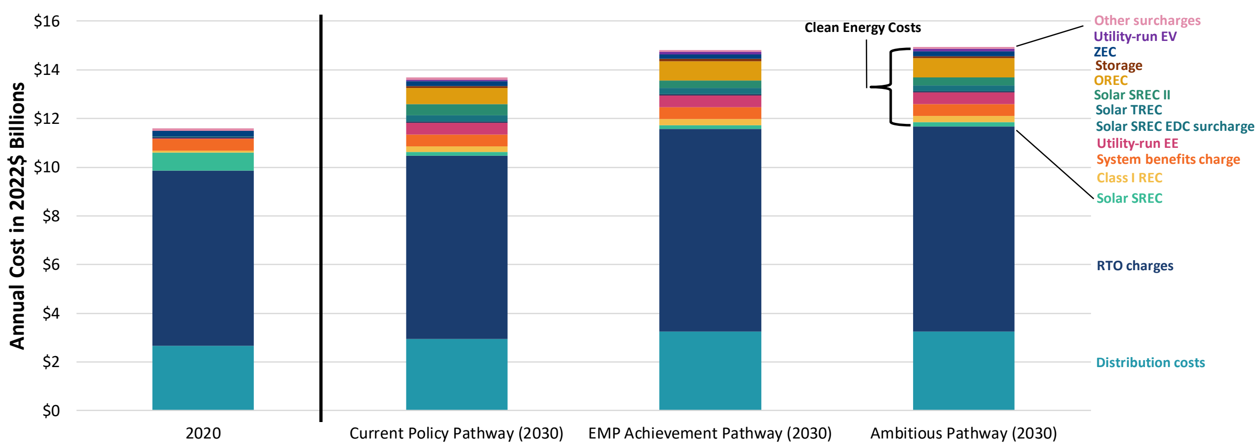


FIGURE 11: BREAKDOWN OF SYSTEM WIDE ELECTRICITY COSTS, 2020 VS 2030



Note: Clean energy program costs include all costs except for RTO charges and distribution costs.

In addition to the system wide electricity cost, the average unit cost of electricity (system wide cost divided by total load) also changes. Across all pathways, the unit cost of delivered electricity is at least 5% higher in 2030 than in 2020. The average cost of electricity is highest in the Current Policy Pathway because the approximately $2 billion increase in surcharges between 2020 and 2030 is spread over less load than in either the EMP Achievement or Ambitious Pathways. Table 11 below presents the system wide electricity cost, annual electricity consumption and unit cost of electricity.

TABLE 11: AVERAGE UNIT COST OF DELIVERED ELECTRICITY, 2020 AND 2030

Category	Units	2020	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
System-wide Cost	2022$	$11,593	$13,680	$14,825	$14,947
Annual Consumption	TWh	69	76	84	85
Unit Cost	**2022$/MWh**	**$168**	**$180**	**$177**	**$176**

A.2 Statewide Cost of Serving Natural Gas Customers

In 2020, the total cost of the statewide natural gas system was $4.03 billion (in 2022 U.S. dollars). This is the sum of commodity costs, distribution costs, and surcharges (Table 12). Ninety six percent of the statewide natural gas costs were commodity or distribution costs, whereas surcharges accounted for 4% of costs. There are three categories of **surcharge costs** in the natural gas system: costs from the SBC, costs from utility-run energy efficiency programs, and costs from other surcharges. **Clean energy program costs** include these distribution surcharges. Table 12 below displays the breakdown of costs of the natural gas system in 2020.

TABLE 12: BREAKDOWN OF SYSTEM-WIDE NATURAL GAS COSTS IN 2020 (2022$ MILLIONS)

Cost Category	Cost (2022$ Millions)
Commodity Costs	**$2,049**
Distribution Costs	**$1,822**
Surcharges	**$157**
System Benefits Charge	$253
Utility-Run Energy Efficiency	$49
Other Surcharges	-$145
Total	**$4,029**

Note: Numbers may not add up due to rounding.

For the natural gas system, total cost of serving customers is obtained by multiplying the sales for each class by the average residential, small and large C&I rates inclusive of commodity charges. The average rates by class are obtained from the American Gas Association (AGA)[53] based on total revenues and total sales reported.

[53] Annual Report of Volumes, Revenues, and Customers by Company (2002 – 2020), American Gas Association. Annual Report of Volumes, Revenues, and Customers by Company (2002-2020) | American Gas Association (aga.org).

Distribution costs in 2020 are estimated by subtracting the commodity costs and program costs recovered through surcharges from the total cost of serving customers. We compute **commodity costs** based on the statewide consumption of natural gas and the average price of natural gas obtained from utility tariffs. We compute total surcharge revenues in 2020 by multiplying the statewide gas consumption by the average of the surcharges stated in utility tariffs.[54]

2030 distribution costs are obtained by applying 1% real YoY growth in distribution revenues from 2020 levels across all scenarios. To obtain the commodity costs in 2020, we multiply the sales in each scenario by the commodity price. For the purposes of this Study, we keep the price of natural gas constant for each utility (at a statewide average of $4.70/MMBtu) in real terms between 2020 and 2030. (See Appendix B.7 for details on commodity price projections.) 2030 surcharges are calculated in the model as described in Chapter II Step 3. Table 13 presents the cost breakdown of natural gas system in 2030 for all three scenarios examined.

TABLE 13: BREAKDOWN OF SYSTEM WIDE NATURAL GAS COSTS IN 2030 (2022$ MILLIONS)

Cost Category	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
Commodity Costs	**$1,926**	**$1,545**	**$1,462**
Distribution Costs	**$2,013**	**$2,013**	**$2,013**
Surcharges	**$352**	**$352**	**$352**
System Benefits Charge	$253	$253	$253
Utility-Run Energy Efficiency	$245	$245	$245
Other Surcharges	-$145	-$145	-$145
Total	**$4,291**	**$3,910**	**$3,827**

Note: Numbers may not add up due to rounding.

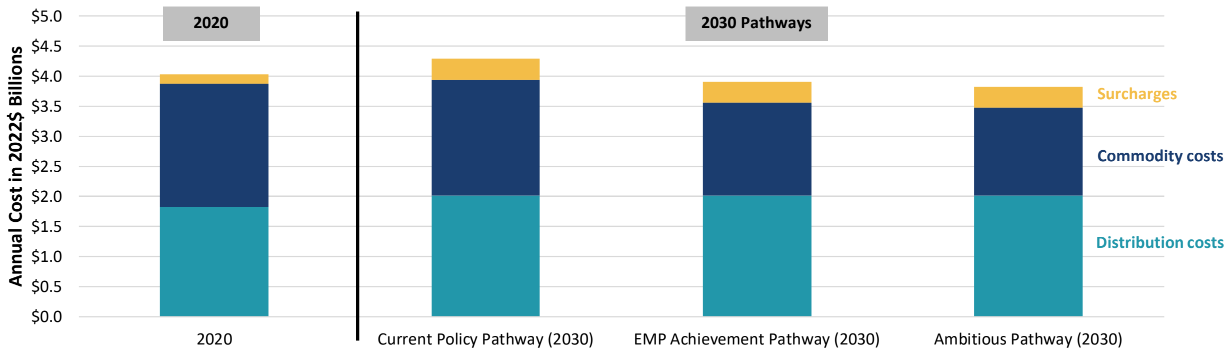
In real terms, system wide costs in 2030 are higher in the Current Policy Pathway than in 2020, despite a reduction in statewide energy consumption. The $123 million decline in real commodity costs is more than offset by a $195 million increase in surcharges and $191 million increase in distribution costs. An increase in spending on energy efficiency programs to meet the 2030 gas efficiency target drives the increase in overall surcharges.

The only difference between the Current Policy Pathway and the other two scenarios is the difference in commodity costs. Lower natural gas consumption because of building decarbonization explains the further decline in commodity costs under the EMP Achievement

[54] The natural gas distribution companies included in this Study are Elizabethtown Gas (ETG), South Jersey Gas (SJG), Public Service Electric & Gas (PSEG), and New Jersey Natural Gas (NJNG).

and Ambitious Pathways. New Jersey customers consume less MMBtus of natural gas in the EMP Achievement Pathway than the Current Policy Pathway (328 million vs. 410 million MMBtus). Due to reduced commodity costs, the total cost of the natural gas system is less in 2030 under the EMP Achievement and Ambitious Pathways compared to 2020. Figure 12 below demonstrates the breakdown of system wide costs in 2030 versus 2020.

FIGURE 12: BREAKDOWN OF SYSTEM WIDE NATURAL GAS COSTS, 2020 VS 2030



While the overall cost of the system is lower in the EMP Achievement and Ambitious Pathways, the unit cost of delivered natural gas (in 2022$/MMBtu) is higher in 2030 than in 2020 in all three scenarios. While commodity costs decline with overall consumption, surcharges and distribution costs increase between 2020 and 2030. With increased cost spread over decreasing consumption, the result is an increase in the delivered cost of natural gas. In 2020, the average cost of delivered natural gas was $9.25/MMBtu. This increases to $10.48/MMBtu in 2030 under the Current Policy Pathway. Under the EMP Achievement Pathway, the unit cost of delivered natural gas will be 29% higher in 2030 than in 2020.

Table 14 below displays the average unit cost of delivered natural gas in 2020 and 2030.

TABLE 14: AVERAGE UNIT COST OF DELIVERED NATURAL GAS, 2020 AND 2030

Category	Units	2020	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
System-wide Cost	2022$ Millions	$4,029	$4,291	$3,910	$3,827
Annual Consumption	MMBtu	436	410	328	311
Unit Cost	**2022$/MMBtu**	**$9**	**$10**	**$12**	**$12**

Appendix B: Modeling Assumptions

B.1 Scenario Assumptions and Inputs

Supply-side inputs are defined by the RPS targets and other clean energy targets under each scenario:

- **2030 RPS target** is 50% based on the Clean Energy Act in the Current Policy Pathway and EMP Achievement Pathway. The Ambitious Pathway achieves higher renewables deployment based on the NJBPU Resource Adequacy Investigation,[55] which identified new policy and market structures to accelerate clean energy deployment at competitive prices.
- **Nuclear capacity** is held constant through 2030 across all scenarios assuming existing nuclear power plants continue to operate as planned and no new nuclear power plants are built by 2030.
- **Solar capacity** in 2030 takes into account the solar quantities under the SREC Registration Program (SRP), Transition Incentive (TI) Program, and Successor Solar Incentive (SuSI) Program.[56] SuSI program capacities are the same across all scenarios until 2026 (450 MW/year under ADI and 300 MW/year under CSI).[57] After 2026, the Current Policy Pathway keeps the annual additions constant until 2030 within the SuSI program. The EMP Achievement Pathway assumes the same quantity of solar but adds generic PJM solar purchases after 2026 rather than procured through the SuSI program. The Ambitious Pathway assumes additional solar is procured through generic PJM solar purchases. The Ambitious Pathway assumes 58% of electricity consumption in 2030 will be met by renewable energy resources.[58] The Ambitious Pathway procures 8% additional renewables beyond the 50% RPS target from PJM generic solar purchases in 2030. To estimate the capacity of solar in 2030, Brattle leveraged data from a variety of sources. Brattle used data

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[55] New Jersey Board of Public Utilities, Alternative Resource Adequacy Structures for New Jersey, Docket No. EO20030203, June 2021.

[56] Existing solar quantities under each program are obtained from the New Jersey Board of Public Utilities, Solar Activity Reports, accessed on June 14, 2022.

[57] Successor Solar Incentive (SuSI) Program | NJ OCE Web Site (njcleanenergy.com).

[58] Based on New Jersey Board of Public Utilities, Alternative Resource Adequacy Structures for New Jersey, Docket No. EO20030203, June 2021.

from NJBPU's webpage on solar activity[59] to assess the capacity of solar buildout from the SREC program and the RPS carve out for SRECs in 2030.[60] We also utilized NJBPU's website, as well as correspondences with NJBPU staff, to estimate the cumulative solar capacity that will be added under the SuSI program by 2030, and how much of the capacity will be under each of SuSI's subcategories (Administratively Determined Incentive (ADI) Program and Competitive Solar Incentive (CSI) Program).[61]

- **Energy storage** quantity in the Current Policy Pathway is based on the Clean Energy Act target. The EMP Achievement Pathway and the Ambitious Pathway assumptions are based on the EMP Least Cost scenario.
- **Offshore wind** capacities and OREC prices are based on the Board orders for Solicitation #1[62] (Ocean Wind I) and #2[63] (Ocean Wind II and Atlantic Shores) for Current Policy Pathway. The EMP Achievement Pathway and the Ambitious Pathway assumptions also include capacities from Solicitation #3.[64] We used data from the Second Solicitation Evaluation Report prepared by Levitan & Associates[65] to develop assumptions for offshore wind capacity and OREC prices in 2030.
- **Prices of renewables** are a necessary input to determine the statewide costs in Step 4. Brattle forecasted the SREC, TREC, and SREC II incentive prices with NJBPU's input.[66] Brattle used the Board orders for the offshore wind solicitations to obtain the 2030 OREC purchase price.

59 Solar Activity Reports, Renewable Energy, New Jersey's Clean Energy Program. https://njcleanenergy.com/renewable-energy/project-activity-reports/project-activity-reports.

60 NJBPU Rule proposal 53 N.J.R. 1337(a), New Jersey's Clean Energy Program. https://njcleanenergy.com/files/file/Solar%20Transition/FY22/NEW%20JERSEY%20REGISTER%20_%20Successor%20Solar%20Incentive%20Program%20Rule%20Proposal%20August%2016.pdf.

61 Administratively Determined Incentive (ADI) Program. https://njcleanenergy.com/renewable-energy/programs/susi-program/adi-program; Competitive Solar Incentive (CSI) Program. Competitive Solar Incentive (CSI) Program | NJ OCE Web Site (njcleanenergy.com)

62 In the Matter of The Board of Public Utilities Offshore Wind Solicitation For 1,100 MW - Evaluation of the Offshore Wind Applications, State of New Jersey Board of Public Utilities Docket No. Q018121289.

63 In The Matter of the Board of Public Utilities Offshore Wind Solicitation 2 For 1,200 To 2,400 MW – Ocean Wind II, LLC, Docket Nos. QO20080555, QO21050825. In The Matter of the Board of Public Utilities Offshore Wind Solicitation 2 For 1,200 To 2,400 MW – Atlantic Shores Offshore Wind Project 1, LLC, Docket Nos. QO20080555, QO21050824.

64 New Jersey Offshore Wind Solicitations | NJ OCE Web Site (njcleanenergy.com).

65 Public Evaluation Report, New Jersey Offshore Wind Solicitation #2.

66 In the Matter of a Solar Successor Incentive Program. Board of Public Utilities, State of New Jersey. NJBPU (njcleanenergy.com), Docket No. QO20020184, July 2021

Demand-side inputs include baseline data from 2020, building decarbonization assumptions, transportation electrification assumptions, technology efficiencies, and energy efficiency targets. Brattle pulled statewide electricity use in 2020 by sector from EIA's Annual Electric Power Industry Report (released October 2021)[67] and statewide natural gas use in 2020 from the EIA.[68] Additionally, Brattle also acquired data from PJM's load forecast report on the forecasted electricity use by zone and year.[69] Brattle also developed a New Jersey-specific figure for the average annual vehicle miles traveled (VMT) using data from the Federal Highway Administration.[70] The VMT includes total annual miles driven in both rural and urban areas.

- **Energy efficiency assumptions** are based on Board orders,[71] which set energy savings targets for electric and gas utilities until 2026. Targets are represented as net energy use reduction as a percentage of annual energy usage. These targets are expressed as reductions in annual energy consumption as a percentage of the average annual usage in the prior three years. "For example, PY5 compliance would be evaluated based on the utility's performance related to the PY5 energy use reduction target (expressed as a percentage) based on the average of retail sales in PY2, PY3, and PY4."[72] We obtained these percentages from the Board orders and converted them to YoY percentages assuming that targets are met every year. The Current Policy Pathway keeps the annual targets constant after 2026. This leads to a cumulative reduction of 9% for electricity and 5% for natural gas use compared to 2020 levels in 2030. For the EMP Achievement and Ambitious Pathways, after 2026, we continue to increase the EE targets until 2030. This leads to a 12% reduction in electricity and 7% reduction in natural gas use compared to 2020 levels by 2030.
- **Transportation electrification** projections were developed based on a Brattle EV Adoption model[73] for the Current Policy Pathway. This Brattle model is a detailed bottom up

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67 Annual Electric Power Industry Report, Form EIA-861, U.S. Energy Information Administration. https://www.eia.gov/electricity/data/eia861/.

68 Energy Information Administration. New Jersey Natural Gas Consumption by End Use (eia.gov)

69 PJM Load Forecast Report (January 2022). https://pjm.com/-/media/library/reports-notices/load-forecast/2022-load-report.ashx.

70 Table VM-2: Functional System Travel – 2019, Highway Statistics 2019, Highway Statistics Series, Federal Highway Administration, U.S. Department of Transportation. https://www.fhwa.dot.gov/policyinformation/statistics/2019/vm2.cfm. The 'Total' column on the right-hand side of the table was used. This includes the total annual miles driven in both rural and urban areas.

71 New Jersey Board of Public Utilities, Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs, Docket No. QO19010040, Agenda Item 8D, June 10, 2020.

72 New Jersey Board of Public Utilities, Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs, Docket No. QO19010040, Agenda Item 8D, June 10, 2020.

73 Getting to 20 Million EVs by 2030: Opportunities for the Electricity Industry in Preparing for an EV Future, 2020.

econometric model, which forecasts an EV market share of 30% for light duty vehicles (LDV) in 2030. This assumption leads to 10% of vehicles on the road to be electric in 2030, or roughly 467,000 light duty EVs on the road. The EMP Achievement and Ambitious Pathway values are based on the EMP Least Cost scenario assumptions. Accordingly, 85% of LDV sales would be electric, corresponding to 1.3 M light duty electric vehicles on the road in 2030. EMP Least Cost scenario also models 65% market share for the medium-duty vehicles and 43% market share for the heavy-duty vehicles.

- **Building decarbonization** assumptions under the Current Policy Pathway are based on the current market adoption trends for building decarbonization. Accordingly, natural gas demand associated with heating declines at a -0.2% YoY rate, which is the expected value of the historical trend (-1.4%) and utility forecasts (1%). The EMP Achievement Pathway is consistent with the EMP Least Cost scenario (-2.4% YoY rate) and the Ambitious Pathway (-3% YoY rate) explores a more ambitious goal.
- **Technology efficiencies** do not change across scenarios. The technology efficiencies that were most relevant to our model were the average efficiencies of ICE and electric vehicles, the heating efficiency of natural gas furnaces and the heating efficiency of electric heat pumps. Brattle used data from the 2021 Annual Energy Outlook for the average gas mileage of light, medium and heavy vehicles.[74] For electric vehicles, Brattle relied upon a 2017 electrification futures study by National Renewable Energy Laboratory (NREL) to assess the efficiency of EVs in miles/kWh.[75] Brattle also relied on NREL's study for data on electric heat pump efficiency (expressed as Coefficient of Performance, or COP). For natural gas furnace efficiency, Brattle leveraged data on the average Annual Fuel Utilization Efficiency (AFUE) rating for a mid-efficiency furnace.[76]

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74 See Table 40 'Light-Duty Vehicle Miles per Gallon by Technology Type' and Table 49 'Freight Transportation Energy Use' from the EIA's 2021 Annual Energy Outlook.

75 Electrification Futures Study, National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy18osti/70485.pdf.

76 What Does AFUE Stand For? Trane. https://www.trane.com/residential/en/resources/glossary/what-is-afue/.

B.2 Statewide Energy Demand

Natural Gas Demand. Brattle's model first forecasts the statewide natural gas demand in 2030. Brattle's model takes the baseline demand in 2020 and computes the amount that will be electrified by multiplying the demand by the heating share of gas use and percentage reduction in use over the next 10 years. Brattle then derives the heating output (in BTUs) of this natural gas by multiplying the heating input by the average furnace efficiency. Our model then estimates the necessary heating input from electric heat pumps by dividing the original heating output by the assumed electric heat pump efficiency. We then convert this heating input to an electric load figure that we use for projecting the electricity demand. Our model then takes the non-electrified portion of the natural gas demand and applies the energy efficiency target for gas to get the 2030 natural gas use. The equation below summarizes our process for projecting 2030 natural gas demand by sector (residential, small commercial & industrial, and large commercial & industrial):

$$2030\ Demand = 2020\ Demand - Electrification - EE$$

$$Electrification = 2020\ Demand * Heating\ Share * Reduction\ in\ NG\ Use$$

$$EE = 2020\ Demand * \ Gas\ Efficiency\ Target$$

Electricity Demand. Brattle modifies PJM's 2030 energy forecast to project the statewide electricity demand for each scenario. Brattle incorporates the following factors when modifying the 2030 forecast: the impact of building and transportation electrification, energy efficiency and distributed solar. The following equation details how we build up our 2030 electricity forecast:

$$2030\ Demand = \ Statewide\ PJM\ Forecast + Added\ EV\ Load - Net\ EE - Electrification + Distributed\ Solar$$

$$Added\ EV\ Load = Brattle\ Forecast\ of\ EV\ Load - PJM\ Forecast\ of\ EV\ Load$$

$$Net\ EE = EE\ in\ Given\ Scenario - \ EE\ in\ CPP$$ [77]

$$Electrification = Electrification\ in\ Given\ Scenario - Electrification\ in\ CPP$$

[77] CPP is short hand for the Current Policy Pathway.

Based on our analysis, we have found that the PJM's energy efficiency, distributed solar, and building decarbonization assumptions are consistent with those in the Current Policy Pathway. However, we adjust PJM's EV forecast down to reflect the EV adoption assumption in the Current Policy Pathway.

From our projection of the statewide natural gas demand, we have the electric load associated with electrifying buildings for each scenario. We then treat the building decarbonization load in the Current Policy Pathway as a 'baseline' and compute the additional decarbonization that occurs in the EMP Achievement and Ambitious Pathways. Brattle then accounts for the impact of the 2030 energy efficiency target for electricity by multiplying the target by statewide electricity use in 2020 to estimate the total reduction in electricity from energy efficiency. Much like with building decarbonization, we treat the total electricity reduction in the Current Policy Pathway as a baseline and derive the additional decarbonization that occurs in the other two scenarios. The model forecasts load from electric vehicles by projecting number of EVs on the road in 2030, calculating the total VMT by those vehicles and dividing this VMT by the efficiency (in miles/kWh) to obtain the statewide load. We then subtract these load figures by PJM's forecast of load from electric vehicles in 2030 to make the incremental adjustments.

The statewide electricity and natural gas demand in 2030 is allocated to utilities and utility rate classes based on 2020 sales shares.

Electricity Supply Mix. Brattle constructs the 2030 electricity supply under the constraint that it must meet electric load from all sectors. Our generation mix must also meet the RPS standard that either 50% (Current Policy Pathway, EMP Achievement Pathway) or 58% (Ambitious Pathway) of the generation must be sourced from Class I renewables (offshore wind, out-of-state wind and solar).

Our model calculates the generation from offshore wind by summing the capacity of each facility, multiplying by the number of hours in a year (8760) and adjusting for the capacity factor (45%).

Brattle derives the total generation from solar by first calculating the generation from solar added under the SREC and TREC programs. We derive the total generation from 'SREC Solar' by multiplying the statewide load by the RPS carve-out for SRECs in 2030 (1.58%). Our model computes the total generation from 'TREC Solar' by multiplying the total TREC capacity in 2030, by the capacity factor for solar and the number of hours in a year. Our model then calculates the total generation from 'SREC II Solar' added under the ADI and CSI programs by multiplying the incremental capacity additions in each year for each program by the capacity factor for solar and the number of hours in a year. With solar from the various state programs accounted for, we then turn our attention to generic solar purchases from PJM (except in the Current Policy Pathway, where we do not assume any market solar). In the EMP Achievement Pathway, capacity additions from PJM market solar replace the capacity additions from the ADI and CSI programs between 2027 and 2030. The total generation from PJM market solar is equal to the cumulative capacity added by market solar, multiplied by the capacity factor for solar and the number of hours in a year. In the Ambitious Pathway, we mandate that 8% of all electric generation must come from PJM market solar based on the NJ Resource Adequacy Investigation.[78] We obtain the total solar generation by adding the generation from SREC, TREC, SREC II, and market solar programs.

After computing the generation from offshore wind and solar, the model deducts the combined generation from the total generation covered by the RPS standard to obtain the electric load that other Class I RECs has to cover. With Class I renewable sources covered, our model then seeks to satisfy the constraint that Class II renewable sources (hydropower and municipal solid waste) must cover 2.5% of electric load.[79] With the remainder of the statewide electric load, Brattle first seeks to meet this need using nuclear generation. The total electricity generation from nuclear power equals the current capacity of nuclear (3.5 GW) times the capacity factor (88%) and number of hours in a year. Once we account for nuclear in our model, it assumes that fossil fuel resources will meet the rest of electricity demand. Our model does not distinguish between fossil fuel resources.[80]

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[78] New Jersey Board of Public Utilities, Alternative Resource Adequacy Structures for New Jersey, Docket No. EO20030203, June 2021.

[79] NJ RPS Compliance History, RPS Summary Report EY 2005-2020.pdf (njcleanenergy.com).

[80] The two remaining coal plants in New Jersey are deactivated as of May 31, 2022, despite having contracts to sell power until 2024. Source: Board of Public Utilities | NJBPU Approves ACE Modified Power Purchase Agreements Ending the Use of Coal Generation in the State

TABLE 15: ELECTRICITY GENERATION BY RESOURCE TYPE AND SCENARIO (TWH)

Resource	2020	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
Class I Renewable	14.9	42.1	44.9	52.9
Offshore Wind	0.0	14.8	19.5	19.5
Solar	4.5	13.8	13.8	17.7
Other Class I REC	10.4	13.5	11.6	15.7
Class II Renewable	1.8	2.1	2.2	2.3
Nuclear	26.7	26.7	26.7	26.7
Fossil Fuel	29.0	13.3	16.0	9.3

TABLE 16: ELECTRICITY GENERATION MIX BY SCENARIO

Resource	2020	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
Class I Renewable	21%	50%	50%	58%
Offshore Wind	0%	18%	22%	21%
Solar	6%	16%	15%	19%
Other Class I REC	15%	16%	13%	17%
Class II Renewable	2.5%	2.5%	2.5%	2.5%
Nuclear	37%	32%	30%	30%
Fossil Fuel	40%	16%	18%	10%

Note: Numbers may not add up due to rounding.

Over the next decade, nuclear and fossil fuel generation will meet a smaller share of electricity demand. While the model keeps nuclear generation constant, the increase in statewide electric load means that nuclear generation will meet a smaller share of statewide load. In the Current Policy and EMP Achievement Pathways, aggregate fossil fuel use will decline by more than 50% over the next 10 years; in the Ambitious Pathway, it will decline by more than two-thirds. Fossil fuel use is higher in the EMP Achievement Pathway than in the Current Policy Pathway because the statewide electricity demand is higher and the RPS standard remains the same (50%).

Generation from offshore wind and solar substantially increases. In the EMP Achievement Pathway, combined generation from offshore wind and solar increases by 30 TWh (from 15 TWh to 45 TWh) over the next decade. A buildout of offshore wind and solar capacity drives this shift in the generation mix. Our model expects that 5 GW of offshore wind capacity will come online in 2030 in the EMP Achievement and Ambitious Pathways. Furthermore, the SREC II program and market solar are expected to add at least 7 GW of solar capacity in each scenario by 2030.

Transportation Fuel Demand (Gasoline and Diesel). This Study's core focus is on ratepayer costs associated with electricity and natural gas programs, and we only focus on the average transportation expenses of residential customers. However, we also estimate the statewide energy demand for vehicles to calculate the statewide greenhouse gas emissions. We project the number of EVs on the road and the number of total vehicles on the road. We obtain the number of ICE vehicles on the road in 2030 by subtracting the number of EVs from the number of total vehicles. We then compute the total VMT by vehicle type by multiplying the number of vehicles by type and the average VMT by vehicle type. We then divide the VMT by vehicle type by the average fuel efficiency by vehicle type to obtain the motor gasoline or diesel use by vehicle type. In New Jersey approximately 64 percent of the medium and heavy duty vehicles have diesel engines and 36 percent use gasoline in 2020.[81] For the purposes of this analysis, we assume that all light duty vehicles use gasoline. After combining the motor gasoline and diesel use by light, medium and heavy-duty vehicles, we obtain the statewide motor gasoline and diesel use by vehicles in 2030.

Fuel Oil Demand by Non-Transportation Uses. We obtain the statewide fuel oil consumption in 2020 from EIA.[82] From this, we subtract the fuel oil use by the "On-Highway" category, since we calculate diesel use by on-road vehicles in our model as explained above. The remaining amount represents the fuel oil use by categories other than light duty, medium duty and heavy duty vehicles. To obtain the 2030 demand, for the Current Policy Pathway we assume these uses of fuel oil will experience a 3% reduction between 2020 and 2030. This is based on the historical change in fuel oil consumption in end-uses other than vehicles in the last 10 years as presented in EIA data.[83] In the EMP Achievement and Ambitious Pathways, we assume these uses will experience a 15% reduction from 2020 levels. This is based on the change in non-transport uses of fuel oil in the EMP Least Cost scenario.

Propane Demand. We obtain the 2020 propane consumption in New Jersey from EIA statistics.[84] Propane is mainly used for space and water heating in the residential sector and for various equipment in commercial and industrial sectors.[85] Propane represents a small portion

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81 New Jersey Clean Trucks Program. An Analysis of the Impacts of Zero-Emission Medium- and Heavy-Duty Trucks on the Environment, Public Health, Industry, and the Economy, 2021.

82 Sales of Distillate Fuel Oil by End Use, Petroleum & Other Liquids, U.S. Energy Information Administration, New Jersey Adjusted Sales of Distillate Fuel Oil by End Use (eia.gov)

83 Sales of Distillate Fuel Oil by End Use, Petroleum & Other Liquids, U.S. Energy Information Administration, New Jersey Adjusted Sales of Distillate Fuel Oil by End Use (eia.gov)

84 2020 Propane total consumption, API Query Browser, State Energy Data System, https://www.eia.gov/opendata/qb.php?category=2804515&sdid=SEDS.PQTCP.NJ.A.

85 Uses of hydrocarbon gas liquids - propane in depth - U.S. Energy Information Administration (EIA)

of energy use (4% of fuel oil use) in New Jersey. To project the 2030 use, we use the same assumptions for reduction in fuel oil use. For the Current Policy Pathway we assume that propane use will experience a 3% reduction between 2020 and 2030. In the EMP Achievement and Ambitious Pathways, we assume these uses will experience a 15% reduction from 2020 levels.

B.3 Electricity Consumption by Class

In 2020, New Jersey consumed approximately 72.4 TWh of electricity. Net load (electricity consumed by residential, commercial and industrial customers of utilities) was 69.2 TWh after accounting for the contribution of distributed solar. Statewide electricity consumption will increase over the next decade due to building and transportation electrification. As noted in Appendix B.2, Brattle forecasted 2030 electricity consumption by scenario by modifying PJM's 2030 forecast to include the impact of electrification, energy efficiency, and distributed solar. Table 17 displays the 2030 statewide electricity consumption by scenario. Gross load refers to all electricity usage including that sourced from distributed solar, and net load refers to electricity usage from the grid connected generation and excludes the contribution of distributed solar.

TABLE 17: STATEWIDE ELECTRICITY CONSUMPTION (TWH)

Category	2020	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
Gross Load (TWh)	72.4	84.3	90.0	91.2
Difference From 2020		16%	24%	26%
Net Load (TWh)	69.2	76.0	83.9	85.0
Difference From 2020		10%	21%	23%

Across each scenario, statewide electricity consumption increases by at least 15%. In the Ambitious Pathway, we estimate that electricity consumption will increase by 19 TWh (26%). A growth in baseline load from PJM's forecast (which will add about 5 TWh), building electrification (~6 TWh) and transportation electrification (~7 TWh) are the primary drivers of the 19 TWh increase in the Ambitious Pathway.

Brattle projects electricity consumption by sector by calculating the share of the net electric load each sector consumed in 2020. Brattle then estimates 2030 load by sector by assuming that these shares remain constant and multiplying them by the projected statewide net electric load. Brattle forecasts load from distributed solar by combining the expected capacity buildout by year under the ADI program, multiplying it by the capacity factor for solar and number of hours in a year. Table 18 details the statewide electricity consumption by sector in 2030:

TABLE 18: STATEWIDE ELECTRICITY CONSUMPTION BY SECTOR (TWH)

Sector	2020	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
Residential	28.5	31.3	34.5	35.0
Commercial	34.4	37.8	41.7	42.3
Industrial	6.3	6.9	7.6	7.7
Distributed Solar	3.2	8.3	6.2	6.2

B.4 Natural Gas Consumption by Class

In 2020, New Jersey consumed approximately 436 million MMBTUs of natural gas. Our model projects that statewide consumption will decline over the next decade. Building electrification and energy efficiency targets of natural gas use will drive this decline. Brattle forecasted 2030 natural gas use by taking the baseline use from 2020, electrifying the portion used for space and water heating as shown in the scenario assumptions and applying an energy efficiency target specified by NJBPU. Table 19 displays the statewide natural gas consumption by scenario:

TABLE 19: STATEWIDE NATURAL GAS CONSUMPTION (MILLIONS OF MMBTU)

Category	2020	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
Consumption	435.7	409.5	328.4	310.8
Difference From 2020		-6%	-25%	-29%

Natural gas consumption declines by over 100 million MMBTUs in both the EMP Achievement Pathway and Ambitious Pathway. Building electrification in the residential sector alone reduces natural gas consumption by 45 million MMBTUs in the EMP Achievement Pathway and 55 million MMBTUs in the Ambitious Pathway. Statewide energy efficiency targets further reduce consumption by about 25 million MMBTUs across both scenarios.

Our model projects natural gas consumption by class. We first obtain the 2020 statewide natural gas use by class from EIA.[86] To allocate the statewide consumption to each utility, we obtain the shares of utilities' sales within each customer class by using confidential utility data.

[86] Energy Information Administration. New Jersey Natural Gas Consumption by End Use (eia.gov)

We allocate the total statewide sales to each utility within each class. After deriving the natural gas consumption by class in 2020, we then estimate the natural gas consumption in 2030 by incorporating the impact of electrification and energy efficiency. We incorporate the impact of electrification by focusing on the natural gas used for heating purposes and assuming that a portion[87] gets replaced by electricity (see Appendix B.2 above for a detailed description of natural gas demand calculation). Table 20 details the statewide electricity consumption by sector in 2030:

TABLE 20: STATEWIDE NATURAL GAS CONSUMPTION BY CLASS (MILLIONS OF MMBTU)

Class	2020	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
Residential	231.6	216.6	170.0	159.9
Commercial	143.2	135.4	111.1	105.9
Industrial	60.9	57.5	47.2	45.0

B.5 Greenhouse Gas Emissions

Brattle builds up statewide emissions by considering GHG emissions from four possible sources: (1) emissions from electric power generation, (2) emissions from natural gas use, (3) emissions from propane and fuel oil use and (4) emissions from the transportation sector. Brattle estimates emissions from natural gas use and the transportation sector by multiplying the statewide use of natural gas and motor gasoline in 2030 by the carbon dioxide emissions factors of natural gas and motor gasoline.[88] When gauging the emissions from fuel oil and propane, Brattle assumes that fuel oil and propane use decreases by 3% each between 2020 and 2030 in the Current Policy Pathway and by 15% each in the EMP Achievement and Ambitious Pathways.[89] Most of the reduction is due to electrification of transportation, i.e. specifically the replacement of diesel-powered vehicles with electric. Brattle then uses carbon

[87] In the Current Policy Pathway, this portion is 2%. In the EMP Achievement and Ambitious Pathways, the corresponding figures are 22% and 26%.

[88] Carbon Dioxide Emissions Coefficients, Environment, U.S. Energy Information Administration, https://www.eia.gov/environment/emissions/co2_vol_mass.php.

[89] Brattle obtained data on fuel oil use in 2020 from this source: Sales of Distillate Fuel Oil by End Use, Petroleum & Other Liquids, U.S. Energy Information Administration. https://www.eia.gov/dnav/pet/pet_cons_821dst_dcu_SNJ_a.htm. Brattle obtained data on propane use in 2020 from this source: Propane total consumption, API Query Browser, State Energy Data System, https://www.eia.gov/opendata/qb.php?category=2804515&sdid=SEDS.PQTCP.NJ.A.

dioxide emissions factors from EIA (see footnote 89) to estimate the total emissions from fuel oil and propane use in 2030.

To derive the total emissions from electric power generation in 2030, Brattle considers the emissions from each resource type. Brattle calculates the emissions from fossil fuel resources by multiplying the generation from fossil fuel resources by PJM-specific data on the average emissions intensity of fossil fuel resources.[90] Brattle assumes that electricity generation from nuclear, solar and wind resources does not produce any carbon emissions. Table 21 and Figure 13 below present the statewide emissions by source:

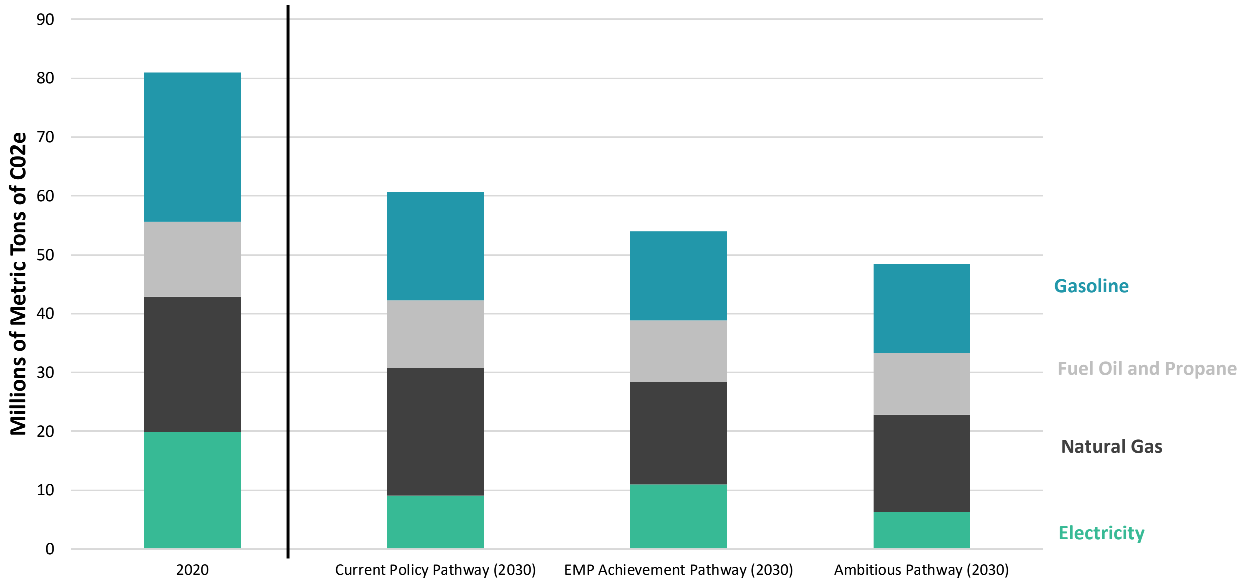
TABLE 21: GREENHOUSE GAS EMISSIONS BY SCENARIO (MILLION METRIC TONS OF CO2 EQUIVALENT)

Source	2020	Current Policy Pathway (2030)	EMP Achievement Pathway (2030)	Ambitious Pathway (2030)
Electric Power	19.9	9.1	11.0	6.4
Fuel Oil & Propane	12.7	11.5	10.5	10.5
Natural Gas	23.1	21.7	17.4	16.4
Transportation	25.4	18.5	15.0	15.0
Total	**81.0**	**60.7**	**53.9**	**48.4**

Across each scenario, emissions decline by at least 25% between 2020 and 2030. Reductions in emissions from the electric power sector and transportation sector primarily drive the decline in total statewide emissions. In the Ambitious Pathway, we forecast that emissions from the electric power sector will decline by 68% between 2020 and 2030. Drastically reduced fossil fuel use causes the reduction in emissions from electric power; a switch to electric cars drives the decline in emissions from transportation. Statewide emissions from the natural gas sector also decline as natural gas use decreases in all three scenarios.

90 Environmental and Renewable Energy Regulations, State of the Market Report, PJM Monitoring Analytics. https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2020/2020q1-som-pjm-sec8.pdf.

FIGURE 13: GREENHOUSE GAS EMISSIONS BY SCENARIO
(MILLION METRIC TONS OF CO2 EQUIVALENT)



EMP will lead to a plethora of other benefits ranging from climate impact mitigation to avoided health impacts. While we do not quantify these benefits in this Study, we calculate the avoided cost of greenhouse gas emissions in 2030 using Social Cost of Carbon (Figure 14).

- The annual benefit of reduced GHG emissions is $1.31 billion, $1.75 billion, and $2.11 billion/year in 2030 in the Current Policy Pathway, EMP Achievement Pathway, and Ambitious Pathway, respectively.[91]
- Annual greenhouse gas emissions decrease by 20-40% from 2020 levels by 2030. This is equivalent to avoided emissions from 4.4 – 7.1 million gasoline vehicles driven for one year,[92] or 2.5-4.1 million homes' energy use for one year.[93]

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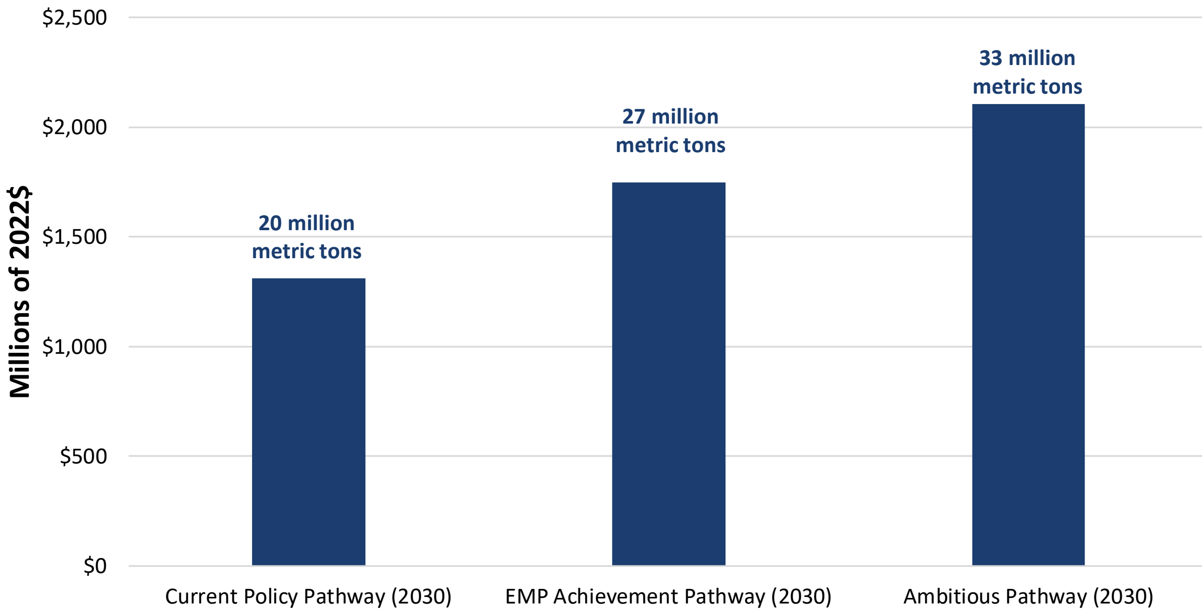
91 Social cost of carbon is estimated at $64.50/ton (2022$) for 2030 based on Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

92 Brattle obtains this figure by dividing the reduction in emissions in each scenario by the estimated annual emissions from a light-duty vehicle. We derive the annual emissions estimate for a light duty vehicle by multiplying the estimated motor gasoline consumption by the emissions intensity of motor gasoline. As we discuss in Appendix C, we estimate that the average light duty vehicle consumes 511 gallons of gasoline annually. Per the EIA, the average emissions intensity of motor gasoline is about 9 kg/gallon. Based on these two figures, we obtain that the average light-duty vehicle emits 4.6 metric tons of carbon dioxide annually. Source: Carbon Dioxide Emissions Coefficients, Environment, U.S. Energy Information Administration, U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.

93 US EPA's Greenhouse Gas Equivalencies Calculator was used to convert greenhouse gas emissions (20-33 million tons of CO2equivalent) to the equivalent emissions from average U.S. households.

This is only one component of broader benefits of EMP, which also include local air quality and health co-benefits, estimated to equal $3 billion/year in the EMP.

FIGURE 14: AVOIDED COST OF GREENHOUSE GAS EMISSIONS IN 2030 (2022$)



Note: The quantities of greenhouse gas emission reductions are shown above the bars.

Executive Order 274[94] mandates 50% reduction in GHG emissions from 2006 levels by 2030. All three scenarios achieve this target. Current Policy Pathway achieves approximately 50% reduction in GHG emissions from 2006 levels by 2030. EMP Achievement Pathway achieves 55% and Ambitious Pathway achieves 60% reduction. Greenhouse gas emissions of New Jersey was approximately 120 million metric CO2 equivalent in 2006.[95, 96]

B.6 Utility Rate Calculations

We calculate the rates for the New Jersey utilities shown in Table 22 and Table 23.

94 State of New Jersey, Executive Order No. 274, November 10, 2021.

95 New Jersey Department of Environmental Protection, Air Quality, Energy & Sustainability, Statewide Greenhouse Gas Inventory, 2017, accessed on June 26, 2022.

96 New Jersey Department of Environmental Protection New Jersey's Global Warming Response Act 80x50 Report, 2020.

TABLE 22: UTILITY CODES FOR ELECTRIC DISTRIBUTION COMPANIES

Utility Code	Electric Distribution Company
ACE	Atlantic City Electric
JCPL	Jersey Central Power & Light
PSEG Electric	Public Service Enterprise Group
RECO	Rockland Electric Company

TABLE 23: UTILITY CODES FOR GAS DISTRIBUTION COMPANIES

Utility Code	Gas Distribution Company
ETG	Elizabethtown Gas
NJNG	New Jersey Natural Gas
PSEG Gas	Public Service Enterprise Group
SJG	South Jersey Gas

We base our analysis on the following classes:

ACE

Residential Service

Monthly General Service Secondary

Annual General Service Secondary

JCPL

Residential Service

General Service Secondary

General Service Primary

RECO rates

Residential Service

SC2 Secondary Demand Billed

SC7 Large General Time-of-Day Primary

PSEG Electric

Residential Service

General Light and Power Service

Large Power Light Service - Secondary

ETG

Residential Service

General Delivery Service
Large Volume Demand Service

SJG
Residential Service
General Service
Large Volume Service

NJNG
Residential Service
General Service Small
General Service Large

PSEG Gas
Residential Service
General Service
Large Volume Service

Distribution Rates. We follow the approach below for each utility and each rate class of interest. We first calculate the distribution revenues collected in 2020. We make assumptions about the distribution revenue growth and customer charges through 2030, as shown below. We calculate the 2030 base rates after taking into account the changes in distribution revenue and the customer charges. To do this, we first calculate the revenue collected through customer charges in 2030. We subtract this amount from the estimated revenue requirement in 2030. For the residential class, we divide the remaining revenue by the 2030 sales to obtain the 2030 volumetric distribution base rates. For C&I classes, we assume that the ratio of volumetric and demand charges remains the same in 2030. We allocate the revenue to demand and volumetric base rates according to this ratio. We obtain the demand rates and volumetric rates using the 2030 sales and load factor estimates.[97]

- **Distribution Revenue Requirements.** For electric utilities, we assume that distribution revenue requirements increase 1% YoY in real terms for the Current Policy Pathway. For the EMP Achievement Pathway and the Ambitious Pathway, we assume 2% YoY real growth.

[97] Electricity load factors are estimated based on the following source: Load Factor and Commercial Demand Charges – How to Lower Your Business Electricity Bill. Load Factor & Commercial Demand - Lower Your Electricity Bills (electricityplans.com). Natural gas load factors are estimated based on the following source: Southern California Gas Company 2020 Triennial Cost Allocation Proceeding (TCAP). 09_Chapter_9_Schmidt-Pines_Workpapers.pdf (socalgas.com).

For natural gas utilities, we assume revenue requirements increase 1% YoY in real terms for all three scenarios. The best approach to inform this assumption would be to rely on utility "distribution system plans" for the next decade for the estimated costs of integrating the new load and generation associated with meeting EMP targets. In the absence of these plans, we reviewed utilities' historical revenue requirements and found that they have increased in the range of 1-2% YoY over the past 5 years. We also assume that there is some headroom for growth in the grid until 2030 and the use of load flexibility programs will keep the growth rate under check.

- **Customer Charges.** We assume 20% nominal growth rate from 2020 to 2030, which implies keeping the fixed monthly customer charge constant in real dollars based on a 2% average inflation rate. In developing this assumption, we reviewed the changes in customer charges for the New Jersey electric utilities over the past 10 years. We found that the customer charges increased by 1-6% YoY in nominal terms. Even though there is a basis for increasing the customer charges according to the historical data and leading to lower volumetric rates, we keep the customer charges 2% YoY in nominal terms (or constant in real terms) to ensure our results remain conservative for the bill impact analysis.
- **Customer Counts.** We relied on individual utilities' projections of customer counts for relevant classes. For the residential class, projections range from 0.35% to 1.5% YoY. For the small C&I class, projections range from -0.4% to 1.5% YoY. For the large C&I class, projections range from -1.5% to 1.2% YoY.

B.7 Commodity Price Projections

- **Electricity Price.** For 2020 prices, we use BGS charges from utilities. We develop 2030 estimates by adding energy, capacity, PJM surcharges, Class I REC and SREC charges. We obtain estimates for New Jersey load weighted wholesale energy price, capacity price, and Class I REC price from the Ocean Wind II Evaluation Report.[98] We obtain the SREC price estimates from the NJBPU Cost Cap tool.[99] We also obtain the PJM surcharge component based on PJM data on administration charges, ancillary services, and uplift charges. We develop a generation price estimate for each utility by preserving the difference between utilities observed in 2020 prices. We obtain the following prices for each utility: PSEG: $103 /MWh, JCPL: $72/MWh, ACE: $67/MWh, and RECO: $70/MWh. We use the same estimated

[98] Public Evaluation Report, New Jersey Offshore Wind Solicitation #2.

[99] New Jersey Board of Public Utilities, Cost Cap Tool Excel Spreadsheet, accessed on June 14, 2022.

electricity price for all customer classes in 2030. The sensitivity analysis (Appendix D) explores lower and higher energy and capacity prices on customers' energy costs.

- **Transmission.** We keep transmission charges constant at $26/MWh and apply the same 2030 charge to all utilities. Based on PJM's Phase 1 Results of the OSW Transmission Study,[100] we estimate that clean energy policies will have a small impact on transmission costs. We estimate that clean energy policies could increase transmission costs by ~$0.4/MWh in New Jersey. If the policy-driven amount is less or more (minus or plus 50%), it would change resulting transmission costs by anywhere from $0.2/MWh to $0.6/MWh. Transmission charge is currently ~$26/MWh on average. The impact of a relatively large 50% change to policy-driven transmission costs is small (<2.4% of transmission costs, or <0.3% of residential customer electricity bills). The direction of impact is uncertain. There are offsetting effects that could change the direction either way. The cost may increase if more solar is moved out of state, increasing net demand in New Jersey and thus exacerbating the need for transmission. The cost may also decrease, offering siting flexibility to sellers to make the best use of existing transmission to avoid network expansion.
- **Natural Gas Price.** Citygate price in New Jersey was $4.2/MMBtu in 2020 (~$0.42/th) (Figure 15). This is consistent with 2020 BGSS prices average across utilities. EIA Annual Energy Outlook (2022) forecasts indicate prices will stay constant in real terms in the long term in the majority of the scenarios, despite short-term fluctuations (Figure 16). Given these forecasts, we keep natural gas price constant in real terms for each utility: $0.49/th for ETG, $0.50/th for NJNG, $0.33/th for PSEG, and $0.56/therm for SJG. We apply the same 2030 charge to all customer classes. The sensitivity analysis (Appendix D) explores lower and higher prices on customers' energy costs.
- **Motor Gasoline Price.** We calculate the motor gasoline price in 2030 using the 2020 motor gasoline price and the forecasted changes in the price of Brent crude oil between 2020 and 2030. Gasoline prices have four components. Brent crude oil, refining costs and margins, retail and distribution costs, and taxes. We use the projections of Brent crude oil prices from EIA,[101] and keep the other three components constant. When translating the crude oil price projections to gasoline, we use EIA guideline: "A general guideline for how crude oil

[100] PJM 1st Phase of the OSW Transmission Study https://www.pjm.com/-/media/library/reports-notices/special-reports/2021/20211019-offshore-wind-transmission-study-phase-1-results.ashx

[101] Brent crude oil prices for 2020 and 2030 were obtained from EIA Annual Energy Outlook 2021 Appendix A. Table A1.

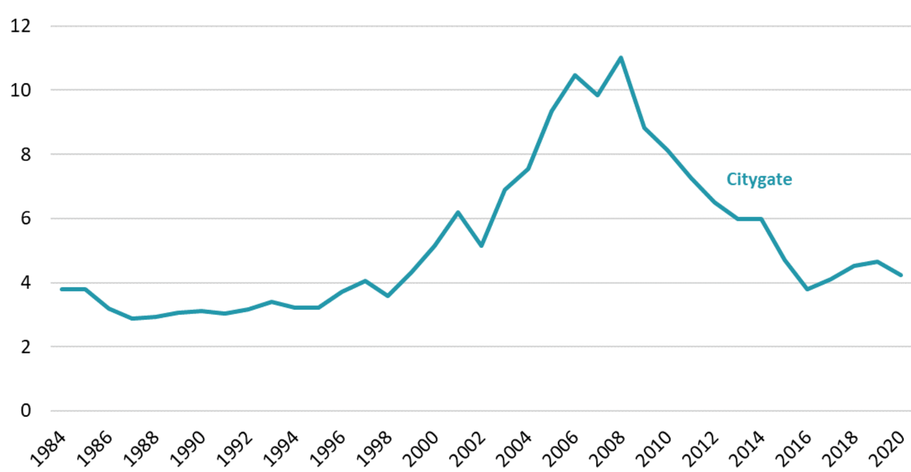
prices affect gasoline is that a $1/barrel change in the price of crude oil translates into a change of about 2.4 cents per gallon of gasoline. (There are 42 gallons in one barrel, and 2.4 cents is about 1/42 of $1)."[102] Table 24 shows the average motor gasoline prices[103] in 2020, Brent crude oil prices in 2020 and 2030,[104] and our projection of gasoline price in 2030 which is proportional to the changes in the Brent crude oil price. The sensitivity analysis (Appendix D) explores lower and higher prices on customers' energy costs.

TABLE 24: MOTOR GASOLINE PRICE: 2020 AND 2030

Year	Brent Crude Oil Price (2020$/Barrel)	Price of Gasoline (2022$/Gallon)
2020	$41	$2.35
2030	$73	$3.16

Notes: EIA's guide for how crude oil prices affect gasoline is that a $1-per-barrel change in the price of crude oil translates into a change of about 2.4 cents per gallon of gasoline as there are 42 gallons in one barrel, and 2.4 cents is about 1/42 of $1. [105]

FIGURE 15: NEW JERSEY HISTORICAL NATURAL GAS PRICES AT CITYGATE (NOMINAL $/MMBTU)[106]



[102] EIA, U.S. gasoline prices move with Brent rather than WTI crude oil, and What Drives U.S. Gasoline Prices?, 2014.

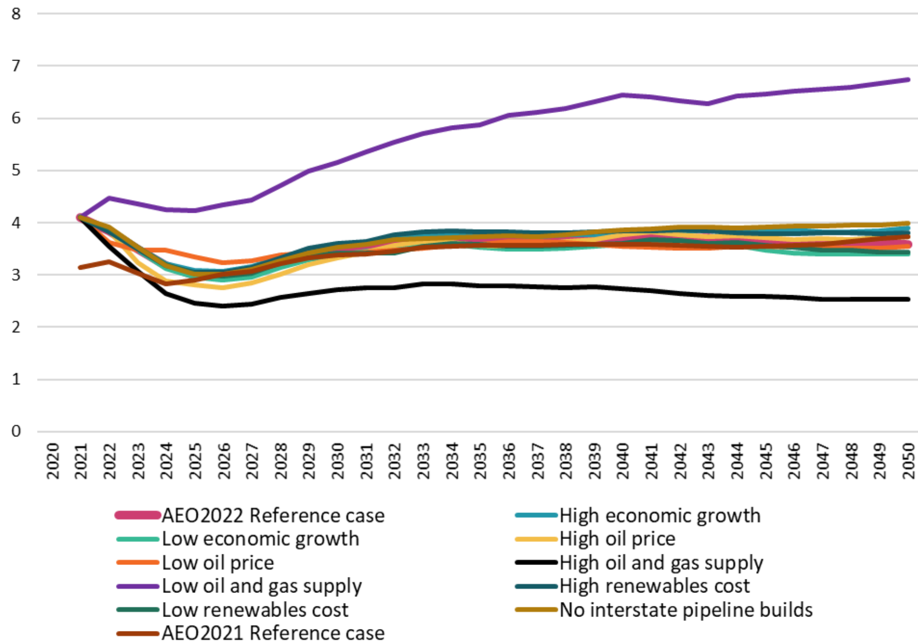
[103] U.S. All Grades All Formulations Retail Gasoline Prices, Petroleum & Other Liquids, U.S. Energy Information Administration. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPM0_PTE_NUS_DPG&f=A.

[104] Brent crude oil prices for 2020 and 2030 were obtained from EIA Annual Energy Outlook 2021 Appendix A. Table A1.

[105] EIA, U.S. gasoline prices move with Brent rather than WTI crude oil, and What Drives U.S. Gasoline Prices?, 2014.

[106] EIA, New Jersey Natural Gas Prices New Jersey Natural Gas Prices (eia.gov). EIA defines citygate as a point or measuring station at which a distributing gas utility receives gas from a natural gas pipeline company or transmission system.

FIGURE 16: HENRY HUB SPOT PRICE FORECASTS FROM EIA AEO (2021$/MMBTU)[107]



[107] EIA, Annual Energy Outlook (AEO) 2022. Table 13. Natural Gas Supply, Disposition, and Prices. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. The Henry Hub natural gas pipeline is where prices are set for natural gas futures traded on the New York Mercantile Exchange. Local market prices are set based on a differential to Henry Hub prices.

Appendix C: Customer Profiles

C.1 Residential Customer Load Profiles

To account for the relationship between energy consumption and income, Brattle developed two sets of load profiles for low-income and non-low-income customers. We define low-income customers as those with a household income less than 300% of the federal poverty line.[108] Assuming an average household size of four, this puts the cut-off between low-income and non-low-income customers approximately at $80,000 annually.[109] Each set of load profiles has four customer types to account for the plausible range of customer behaviors in 2030 (Table 3).

We assume that the typical customer in 2020 mirrors customer type [1]: they heat their homes using a natural gas furnace, drive an ICE vehicle and primarily use electricity for non-heating purposes. Our first step in developing the 2030 use profiles is to create a use profile for the typical customer in 2020. To ascertain annual electricity and natural gas use in 2020, we combined the total sales to residential customers and divided this figure by the total number of residential customers. We estimated motor gasoline use by computing the average annual VMT for a light duty vehicle in New Jersey and dividing it by the fleet-wide fuel efficiency of light duty vehicles.[110] We obtained a New Jersey-specific VMT figure using data from the Federal Highway

[108] Based on True Poverty report by Legal Services of New Jersey, 2021. This report found that that the average true poverty level for all New Jerseyans is 300% FPL (overall average for a nonelderly family without members with disability). New Jerseyans need at least 300% FPL to meet basic needs to avoid falling into True Poverty or deprivation.

[109] According to the U.S. Department of Health and Human Services, the 2021 poverty line for a family of four was $26,500. Source: U.S. Federal Poverty Guidelines Used to Determine Financial Eligibility for Certain Federal Programs, 2021 Poverty Guidelines, Department of Health and Human Services. https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines/prior-hhs-poverty-guidelines-federal-register-references/2021-poverty-guidelines.

[110] The average VMT for a light duty vehicle in New Jersey is 12,274 miles/year. The fleet wide fuel efficiency of light duty vehicles in 2020 is 24 miles per gallon. Based on these figures, we obtain an average annual motor gasoline use of 511 gallons. Source: See 'Functional System Travel – 2019, Annual Vehicle Miles. Table VM-2. Highway Statistics 2019. Highway Statistics Series. Federal Highway Administration.' https://www.fhwa.dot.gov/policyinformation/statistics/2019/vm2.cfm.

Administration.[111] We acquired data on fleet-wide fuel efficiency in 2020 from the 2021 Annual Energy Outlook.[112] Table 25 displays the use profile for the average customer in 2020.

TABLE 25: LOAD PROFILE FOR A TYPICAL CUSTOMER (2020)

Energy Use Category	Units	Typical Customer Use Profile (2020)
Electricity (non-EV) consumption	kWh	7,874
Natural gas consumption	Therms	808
Gasoline consumption	Gallons	511

We use data from the Residential Energy Consumption Survey (RECS) to adjust the use profile of the average customer to obtain estimated load profiles for low-income and non-low-income customers. According to the RECS data on fuel consumption in the Northeast, non-low-income households consume about 25% more electricity and natural gas than the average customer. By contrast, low-income households consume about 12% less electricity and natural gas on an annual basis.[113] By applying the 25% adjustment to the load profiles in Table 25, we find that non-low-income households consume 9,834 kWh of electricity annually and 1,010 therms of natural gas annually. The corresponding figures for low-income households are 6,949 kWh of electricity annually and 713 therms of natural gas annually.

The electricity and natural gas consumption figures we derived in the previous paragraph correspond to the 2030 consumption profile for customer type [1]. When it comes to projecting gasoline consumption, we assume that low-income and non-low-income customers travel the same amount each year and have the same gasoline needs. Therefore, we estimate that both type [1] low-income and non-low-income customers consume about 511 gallons of motor gasoline each year.

We derive the energy consumption for customer type [2] using the consumption of customer type [1]. Type [2] customers resemble their type [1] contemporaries in every respected except they implement energy efficiency and therefore reduce their electricity and natural gas consumption. We assume that the efficiency improvements that type [2] customers make are in line with statewide efficiency trends. Thus, type [2] customers use 9% less electricity and 5%

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[111] We computed the New Jersey-specific VMT figure for LDVs by dividing the estimated VMT for all LDVs in New Jersey by the number of LDVs in New Jersey. We estimate the number of LDVs in New Jersey using this source: https://www.fhwa.dot.gov/policyinformation/statistics/2019/pdf/mv1.pdf. We estimate the VMT for all LDVs in New Jersey using this source: https://www.fhwa.dot.gov/policyinformation/statistics/2019/vm2.cfm.

[112] EIA Annual Energy Outlook 2021. Table 40. Light Duty Vehicles Miles per Gallon by Technology Type.

[113] EIA 2015 RECS Survey Data, Residential Energy Consumption Survey (RECS). Table CE 2.2. Fuel consumption in the Northeast.

less natural gas than type [1] customers. In terms of vehicle efficiency, we keep the fuel efficiency constant through 2030 at 24 miles per gallon.

Customer type [3] keeps the energy efficiency improvements from customer type [2] but swaps their ICE vehicle for an electric vehicle. We compute the electricity demand from their electric vehicle by dividing the average annual VMT by the average fuel efficiency of EVs (in miles/kWh). NREL's electrification futures study projects that light duty EVs will have an average fuel efficiency of 3.1 miles/kWh.[114] Using this fuel efficiency assumption and the established annual VMT for New Jersey vehicles, we find that these customers will use about 3.9 MWh of electricity to charge their vehicles in 2030.

Customer [4] uses electricity almost exclusively to meet their energy needs. Unlike the other three customer types, they have electrified heating. Since their natural gas heating load is electrified, their annual natural gas consumption falls by 93%.[115] To forecast the new residential electricity consumption for these customers, Brattle estimates the amount of heating input an electric heat pump needs to replace heating output of their natural gas furnace. We derive the total heating input into the natural gas furnace by converting the heating natural gas use from therms to BTUs. To account for energy losses that occur with furnace heating, we assume that the average natural gas furnace converts 73% of the energy input into heating output.[116] We then divide this heating output by the projected heat pump efficiency in 2030 to obtain the necessary electric heating input in BTUs.[117] After converting this figure to kWh, we find that non-low-income customers need 5 MWh of electricity to heat their homes and low-income customers need 3.6 MWh of electricity. Per our analysis, non-low-income customers with electric heating consume 14 MWh of electricity annually and low-income customers with electric heating consume 10 MWh of electricity annually.

[114] Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050. National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy18osti/70485.pdf, 2017

[115] EIA 2015 RECS Survey Data, Residential Energy Consumption Survey (RECS). Table CE 4.1 'End-use consumption by fuel in the US', https://www.eia.gov/consumption/residential/data/2015/index.php?view=consumption#by%20fuel.

[116] Furnaces and Boilers, Energy Saver, Energy.Gov. Furnaces and Boilers | Department of Energy.

[117] Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050, Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050 (nrel.gov).

C.2 C&I Customer Load Profiles

We obtain the statewide average electricity and natural gas consumption of small and large C&I classes from the EIA.[118] For both electricity and natural gas, we divide the statewide small C&I consumption by the statewide small C&I customer numbers to obtain the *average* small C&I customer profile. Similarly, we divide the statewide large C&I consumption by the statewide large C&I customer numbers to obtain the *average* large C&I customer profile.

Energy use reduction due to energy efficiency is consistent with the statewide assumptions of the Current Policy Pathway. This leads to a 9% reduction in electricity use and 5% reduction in gas use compared to 2020 levels for Customer [2]. For Customer [3], electrified heating load is calculated by converting the heating load (82% of the total natural gas use[119]) from gas furnaces to electric heat pumps. In this calculation, replaced gas furnace efficiency is 80%[120] and the C&I electric heat pump COP is 3.4. [121]

For C&I profiles, electricity peak demand is defined as the peak demand in a year based on an average C&I load factor. The average C&I load factor is assumed to be 48%. Note that load factors vary for different subcategories within small and large C&I classes, and this value is a representative value.[122] We obtain the electricity peak demand by dividing the annual kWh consumption by the product of the load factor and the number of hours in a year. This way we obtain the *annual* peak; however, we use the annual peak value as the monthly billable demand for monthly demand charge calculations. To obtain the annual demand charges, we sum the monthly demand charges and apply a 10% reduction to account for the fact that monthly peaks can be lower than the annual peak. See the figure below for an illustrative load shape for C&I classes.

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[118] Natural gas statewide consumption by class: New Jersey Natural Gas Consumption by End Use (eia.gov). Natural gas customer counts by class: Number of Natural Gas Commercial Consumers (eia.gov). Electricity statewide consumption and customer counts by class: Annual Electric Power Industry Report, Form EIA-861, U.S. Energy Information Administration. https://www.eia.gov/electricity/data/eia861/

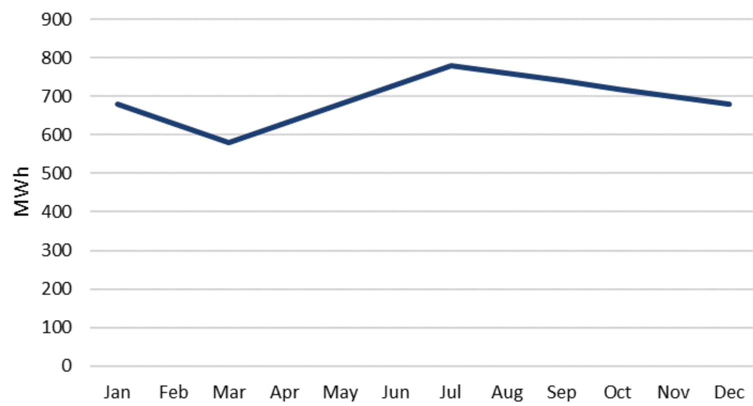
[119] EIA CBECS Survey Data, Table E7. Energy Information Administration (EIA)- About the Commercial Buildings Energy Consumption Survey (CBECS).

[120] Furnaces and Boilers, Energy Saver. Furnaces and Boilers | Department of Energy.

[121] Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050, National Renewable Energy Laboratory (NREL), 2017. Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050 (nrel.gov).

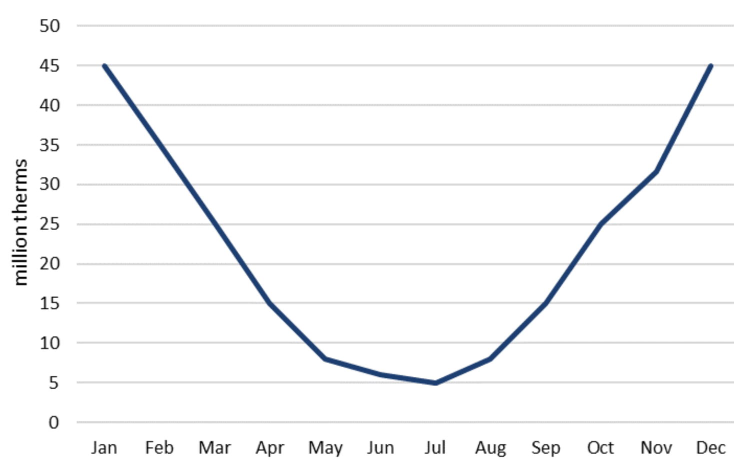
[122] Load Factor and Commercial Demand Charges – How to Lower Your Business Electricity Bill, Load Factor & Commercial Demand - Lower Your Electricity Bills (electricityplans.com).

FIGURE 17: ILLUSTRATIVE C&I CLASS ANNUAL ELECTRICITY LOAD PROFILE



Natural gas peak demand is defined as the average daily usage in the month with the highest usage in a year. Starting from the annual consumption of a customer, we first estimate the usage in the month with the highest demand. We estimate that the highest monthly consumption is 15% of the annual consumption. See the figure below for an illustrative load shape for C&I classes. Then we divide this monthly consumption by 30 to get the average daily demand. This is the billable demand for the month. To obtain the monthly demand charges, we multiply the monthly billable demand by the demand rate to get the monthly demand charges. The same monthly charge applies every month in a year.

FIGURE 18: ILLUSTRATIVE C&I CLASS ANNUAL NATURAL GAS LOAD PROFILE



Appendix D: Sensitivity Analysis

Sensitivity analysis is conducted by varying the eight factors listed below. The central value for each factor is based on the EMP Achievement Pathway. Lower and upper values for each factor are presented; the sources and the reasoning underlying the values are explained in (Table 26). In this sensitivity analysis, factors are varied one at a time, while keeping all other factors and scenario inputs at their original values in the EMP Achievement Pathway.

Sensitivity analysis is performed for the core result of the Study: Residential customer annual energy cost ($/year) for ACE-SJG combination for two customer types

- Customer 2: non-electrified customer with EE (non-low-income)
- Customer 4: electrified customer with EE (non-low-income)

This sensitivity analysis is helpful in evaluating the impact of each of the key drivers of the model on the model results, one variable at a time. In other words, the bars in Figure 19 and Figure 20 are not additive; therefore, it is not an appropriate use of this information to construct a new case consisting of all the lower end values. Each of the lower end and upper end case assumptions is plausible but represent an extreme value that has small likelihood of occurring. To assume that all of these small probabilities would materialize together, in a single case, is improbable.

The results are shown in Figure 19 for Customer [2] and Figure 20 for Customer [4].

TABLE 26: SENSITIVITY ANALYSIS RANGES

	Factor	Unit	Lower end value	Upper end value	EMP Achievement Pathway - Central value
1	Gasoline price	$/gal	2.5	5.5	3.2
2	Natural gas commodity price	$/MMBtu	2.5	7	5.6 for SJG
3	Wholesale energy price	$/MWh	30	60	32.4
4	Wholesale capacity price	$/MW-day	50	250	149.4
2&3	Natural gas price & wholesale energy price	$/MMBtu	2.5	7	see Factor 2
		$/MWh	30	60	see Factor 3
5	Building decarbonization	% YoY	-3% YoY	+1% YoY	-2.4% YoY
6	Gas EE	% cumulative reduction in use	-9%	-5%	-7%
		$/year of EE program cost	$351,354,135	$210,812,481	$281,083,308
7	Electricity EE	% cumulative reduction in use	-15%	-9%	-12%
		$/year of EE program cost	$606,045,714	$363,627,428	$484,836,571
8	EV	number of cars on the road	233K	1.3M	1.3M
		$/year of EV program cost	$65,916,762	$197,750,286	$91,289,235

	Sources and Notes	
1	Gasoline price	Gasoline prices have four components. Brent crude oil, refining costs and margins, retail and distribution costs, and taxes. We use the projections of Brent crude oil prices from the EIA, and keep the other three components constant. Brent oil price projections are obtained from EIA Annual Energy Outlook 2022 Table 1. Total Energy Supply, Disposition, and Price Summary.[123]
2	Natural gas commodity price	Lower and upper end values are based on the Henry Hub price scenario projections from EIA Annual Energy Outlook 2022 Table 13. Natural Gas Supply, Disposition, and Prices.[124]
3	Wholesale energy price	Lower end value is selected based on the 2021 value in the Levitan Associates report for New Jersey Offshore Wind Solicitation #2 **FIGURE 12**.[125] Upper value is not a projection; it is based on the historical values that were observed in PJM in the last ten years.[126]
4	Wholesale capacity price	Lower end value is based on the past PJM capacity auction results.[127] Upper end value is based on prices in market design scenarios in the NJ Resource Adequacy study Table 4.[128]
5	Building decarbonization	Lower end value is the value used to represent the change in natural gas use for heating in the Ambitious Pathway. Upper end value is obtained from the natural gas sales projections in the London Economics International report prepared for New Jersey Board of Public Utilities.[129] Upper end value indicates a bookend case where there is no building decarbonization and the total natural gas use increases.
6	Gas EE	Lower and upper end values are selected to explore the sensitivity of the results to lower and higher reduction in energy use due to EE (-/+25% compared to the EMP Achievement Pathway). Program costs are scaled proportionately.
7	Electricity EE	
8	EV	Lower end vehicle quantities are based on 50% of the light duty EV stock in the Current Policy Pathway. Lower end program cost is kept at the Current Policy Pathway level. Upper end vehicle quantity is the same as the quantity in the EMP Achievement Pathway. Upper end program cost is set as three times the cost in the Current Policy Pathway and approximately twice the cost in the EMP Achievement Pathway to explore a more costly path.

123 EIA Annual Energy Outlook (AEO) 2022 Table 1. Total Energy Supply, Disposition, and Price Summary

124 EIA Annual Energy Outlook (AEO) 2022 Table 13. Natural Gas Supply, Disposition, and Prices. See **Figure 16** in this report for a plot of Henry Hub prices in EIA AEO 2022 scenarios.

125 Public Evaluation Report, New Jersey Offshore Wind Solicitation #2. New Jersey Offshore Wind Solicitation #2 (njoffshorewind.com)

126 Components of PJM Price, Monitoring Analytics. Monitoring Analytics - Components of PJM Price.

127 PJM - Capacity Market (RPM); 2019 State of the Market Report for PJM (monitoringanalytics.com); 2022 Quarterly State of the Market Report for PJM: January through March (monitoringanalytics.com)

128 New Jersey Board of Public Utilities, Alternative Resource Adequacy Structures for New Jersey, Docket No. EO20030203, June 2021.

129 Analysis of Natural Gas Capacity To Serve New Jersey Firm Customers Prepared for New Jersey Board of Public Utilities By London Economics International, 2021

FIGURE 19: SENSITIVITY ANALYSIS FOR CUSTOMER [2]'S ANNUAL ENERGY COSTS IN 2030

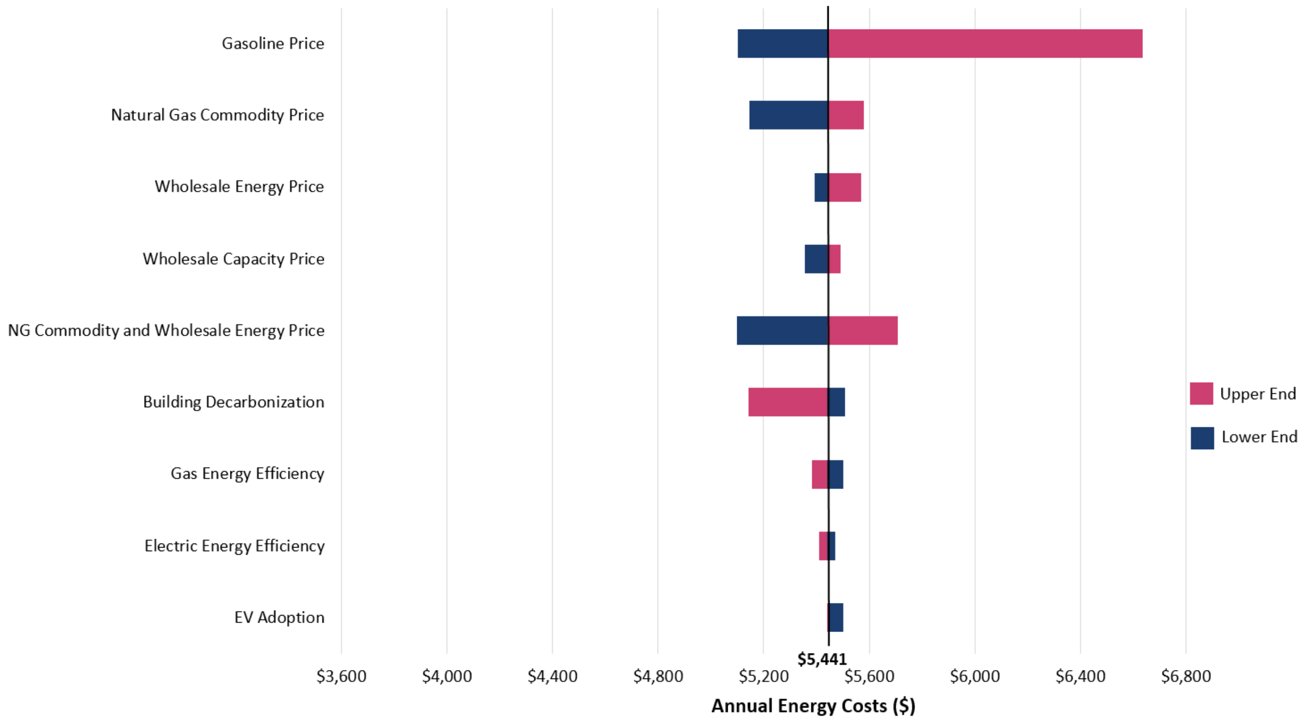
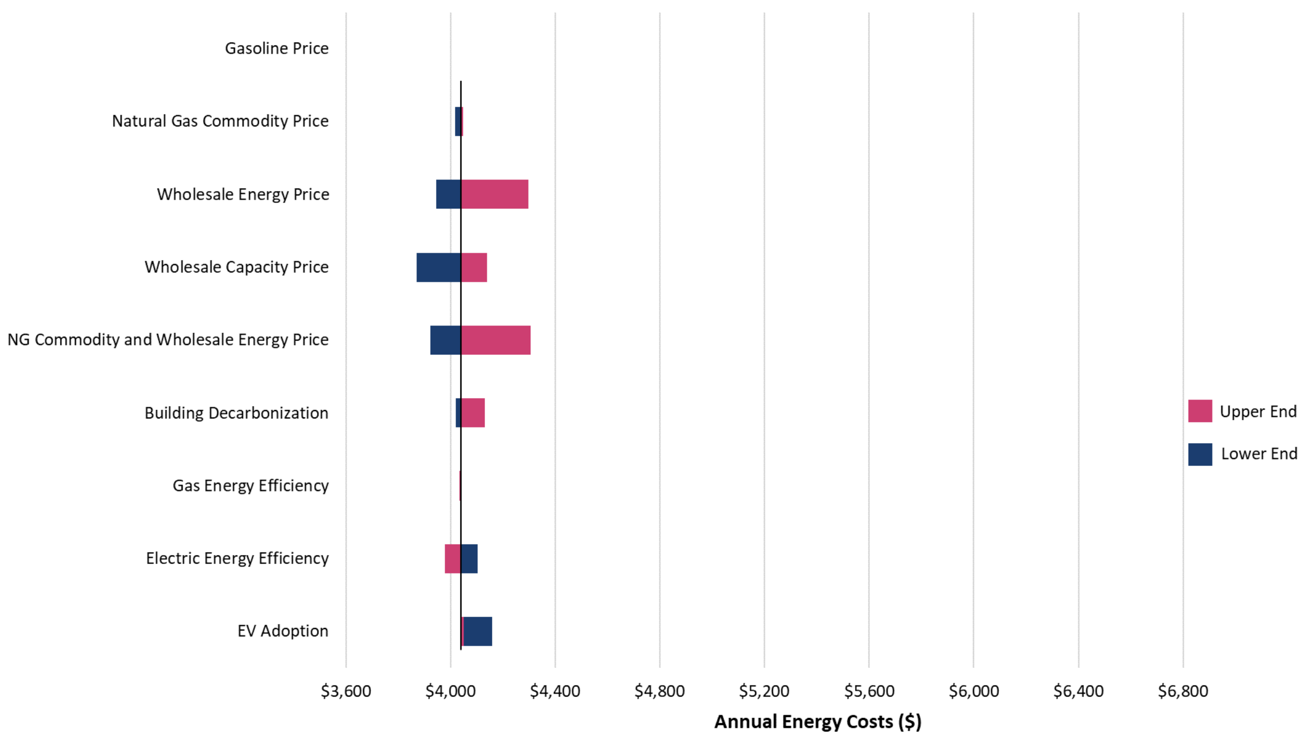


FIGURE 20: SENSITIVITY ANALYSIS FOR CUSTOMER [4]'S ANNUAL ENERGY COSTS IN 2030



Gasoline price. The lower end leads to a 21% reduction in price, while the upper end leads to a 74% increase in price. Changes in gasoline price the annual costs of Customer [2] who drives a gasoline vehicle. The lower end decreases the annual cost by 6%, while the upper end increases the cost by 22%. Customer [4] remains unaffected since this customer drives an electric vehicle instead.

Natural gas commodity price. The lower end leads to a 55% reduction in price, while the upper end leads to a 25% increase in price. The lower end decreases costs and the upper end increases costs for both customers. The annual cost of Customer [2] is affected more than that of Customer [4], since Customer [2] uses a larger amount of natural gas: the lower end decreases costs by 5% for Customer [2] vs 1% for Customer [4]; the upper end increases costs by 3% for Customer [2] vs 0.2% for Customer [4].

Wholesale energy and wholesale capacity prices. These two factors enter into the electricity commodity price calculation. The lower end values decrease customers' costs and the upper end values increase customers' annual costs for both customers. Changes in electricity commodity prices affect Customer [4] more, since Customer [4] has a higher electricity usage. Electricity commodity price affects customers' costs in two ways. (1) They affect costs directly through the generation portion of the electricity rates. An increase in energy and capacity prices *increase* the generation rates. (2) Energy and capacity prices also affect surcharges related with offshore wind and energy storage. The energy and capacity market revenues of offshore wind and energy storage projects are returned to customers in our model. Therefore, an increase in energy and capacity prices *reduce* surcharges associated with these projects. Effect (1) is more dominant than (2).

Building decarbonization. The lower end value indicates a scenario where only heating uses are electrified, and there is a 3% YoY (or 26% reduction from 2020 levels) in natural gas use in heating. The lower end leads to a smaller volume of gas sales leading to higher gas rates, and a larger volume of electricity sales leading to lower electricity rates. This increases costs for Customer [2] who is more reliant on natural gas. This decreases costs for Customer [4] who is more reliant on electricity. On the other hand, the upper end value explores a bookend case where total natural gas sales increases by 1% YoY (34% increase from 2020 levels) and there is no switch to electricity from natural gas in buildings. The effect is the opposite of what we observe for the lower end. The upper end leads to a larger volume of gas sales leading to lower gas rates, and a smaller volume of electricity sales leading to higher electricity rates. This decreases costs for Customer [2] who is more reliant on natural gas. This increases costs for Customer [4] who is more reliant on electricity.

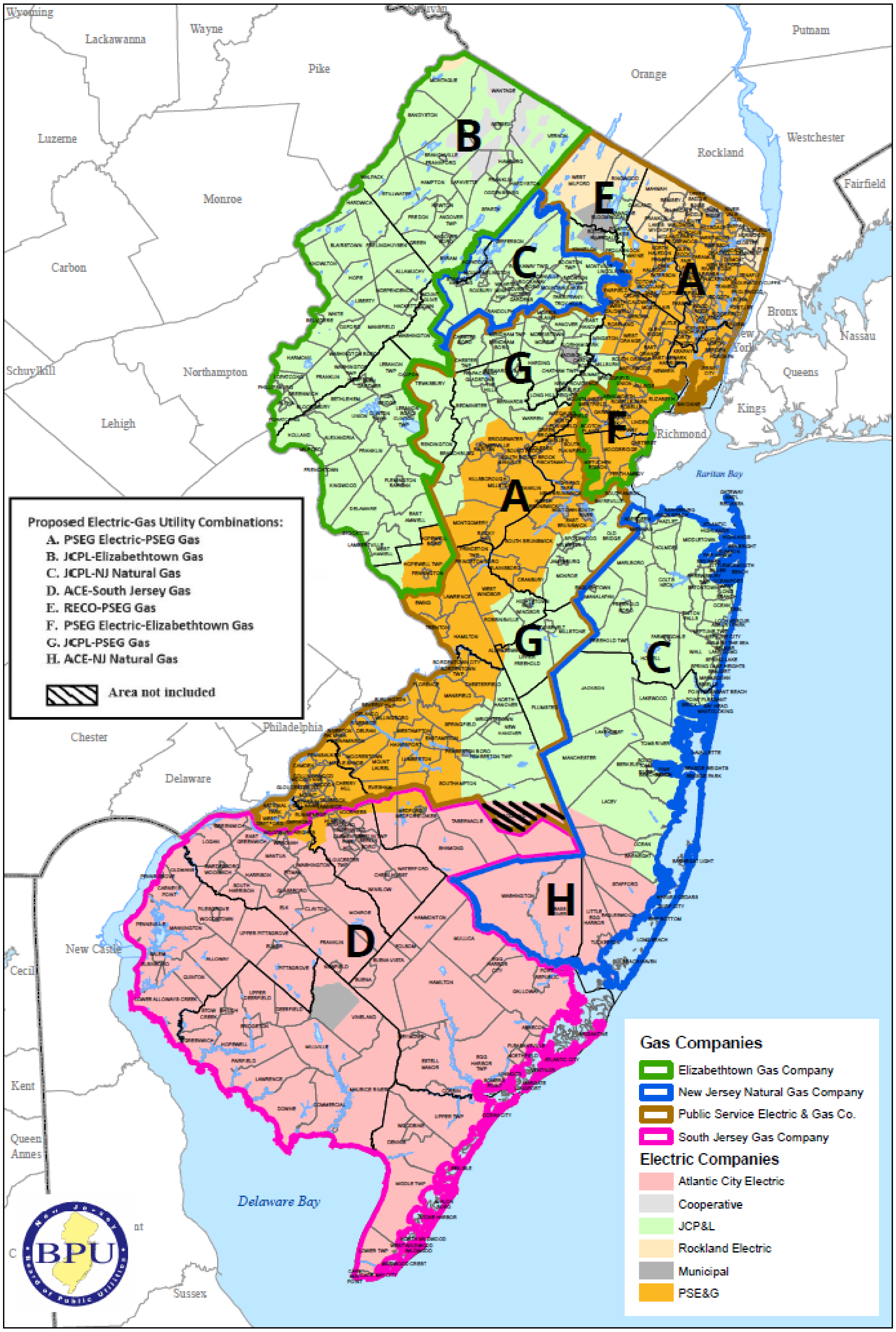
Gas EE. The lower and upper end values are selected to explore the sensitivity of the results to lower and higher reduction in energy use due to EE (-/+25% compared to the EMP Achievement

Pathway). Program costs are scaled proportionately. The lower end values lead to lower sales and higher EE program costs, which lead to higher rates and increase customers' costs. Upper end values the other way around. Customer [2] is affected more than Customer [4], since Customer [2] uses more natural gas. The effect on Customer [4] is minimal due to the small natural gas use.

Electricity EE. The lower and upper end values are selected to explore the sensitivity of the results to lower and higher reduction in energy use due to EE (-/+25% compared to the EMP Achievement Pathway). Program costs are scaled proportionately. The lower end values lead to lower sales and higher EE program costs, which lead to higher rates and increase customers' costs. Upper end values the other way around. Customer [4] is affected more than Customer [2], since Customer [4] uses more electricity.

EV. The lower end values indicate lower EV adoption, which decreases statewide electricity sales. The lower end values also decrease EV program costs. However, the effect of decreasing electricity sales is stronger on electricity rates. Overall, electricity rates increase and increase customers' annual costs. The upper end values keep the EV adoption same as that in the EMP Achievement Pathway, however increase the EV program costs. This has an increasing effect on electricity rates, albeit lower than the effect of lower end values. Customer [4] is affected more than Customer [2] by these changes, since Customer [4] uses more electricity.

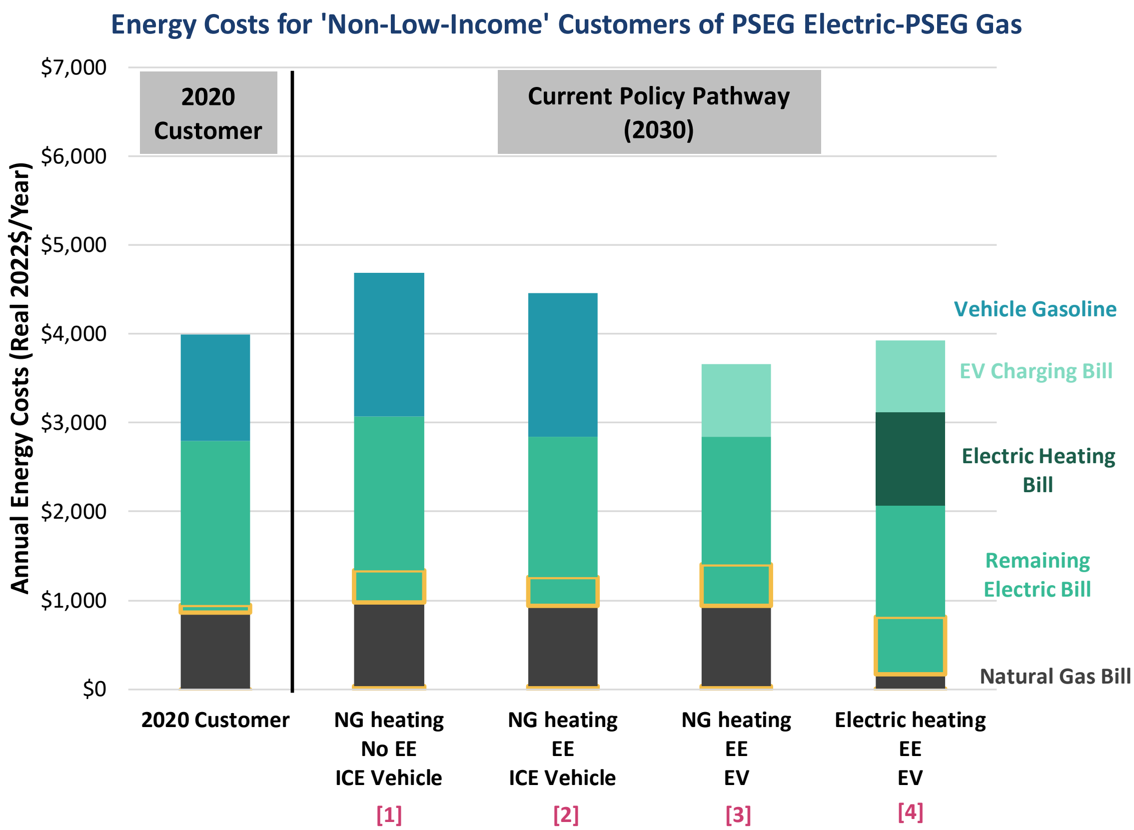
Appendix E: Electric/Gas Utility Combinations

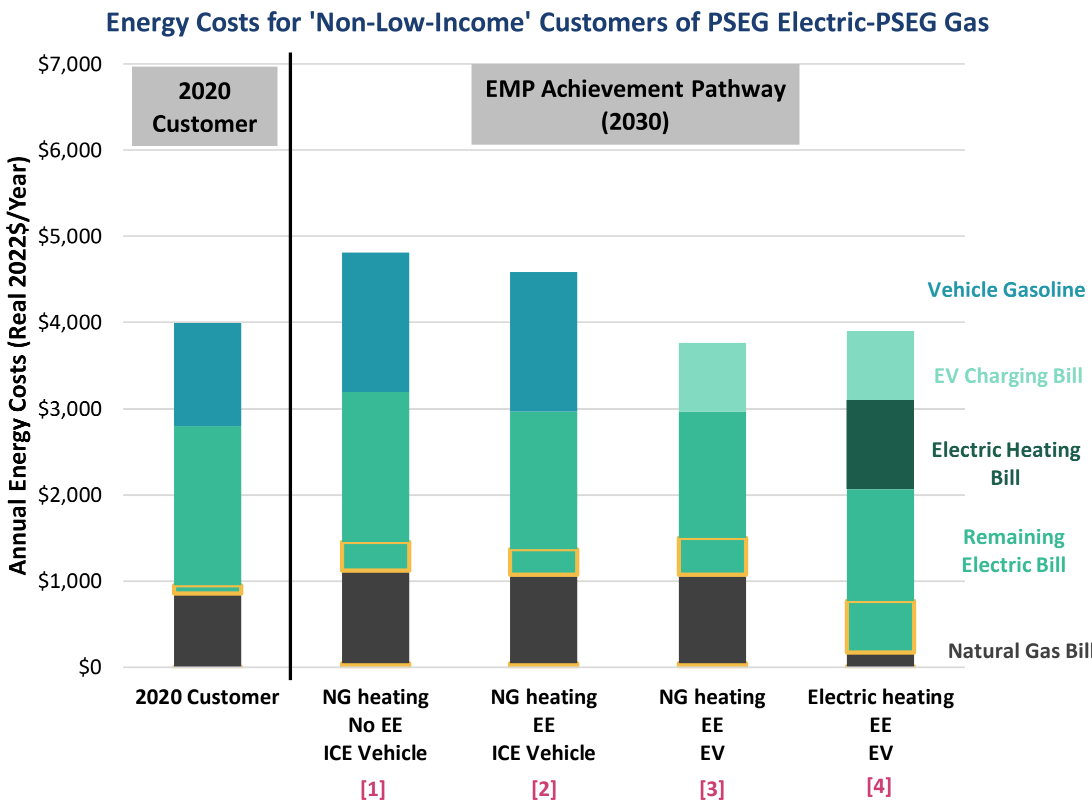


Appendix F: Total Energy Cost Impacts by Electric-Gas Utility Combinations

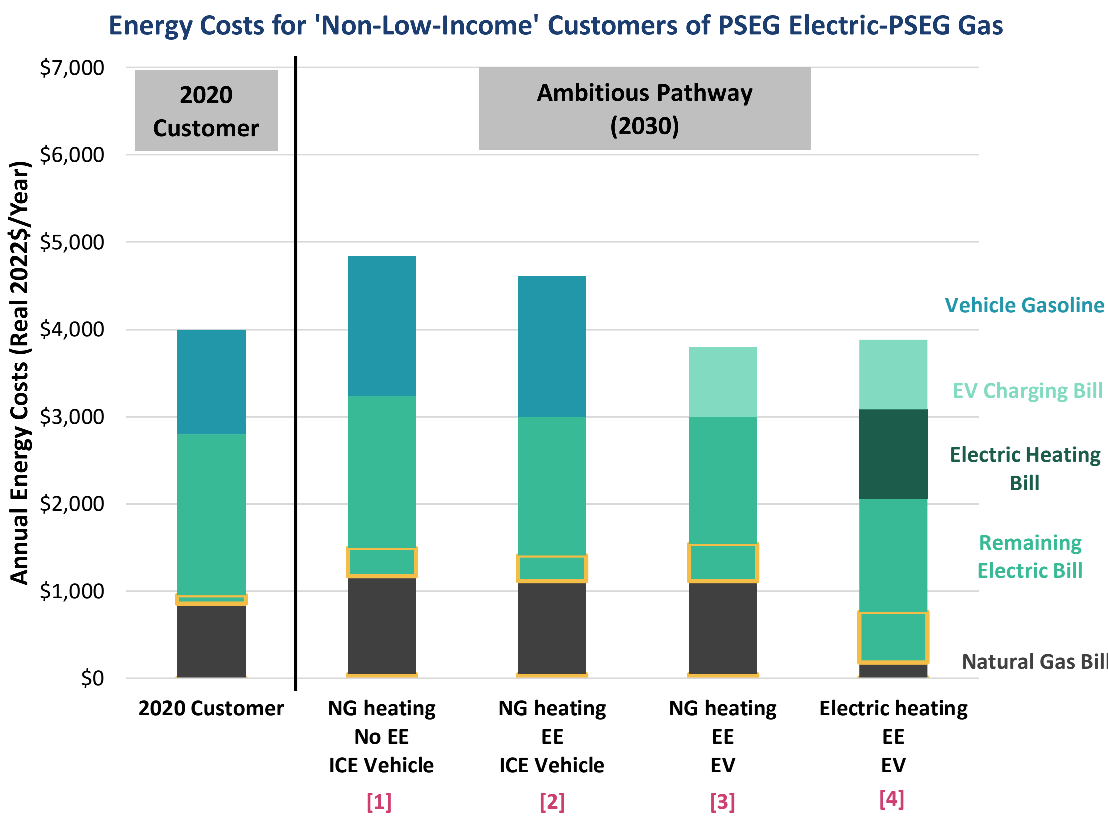
F.1 Residential Customers

PSEG ELECTRIC – PSEG GAS

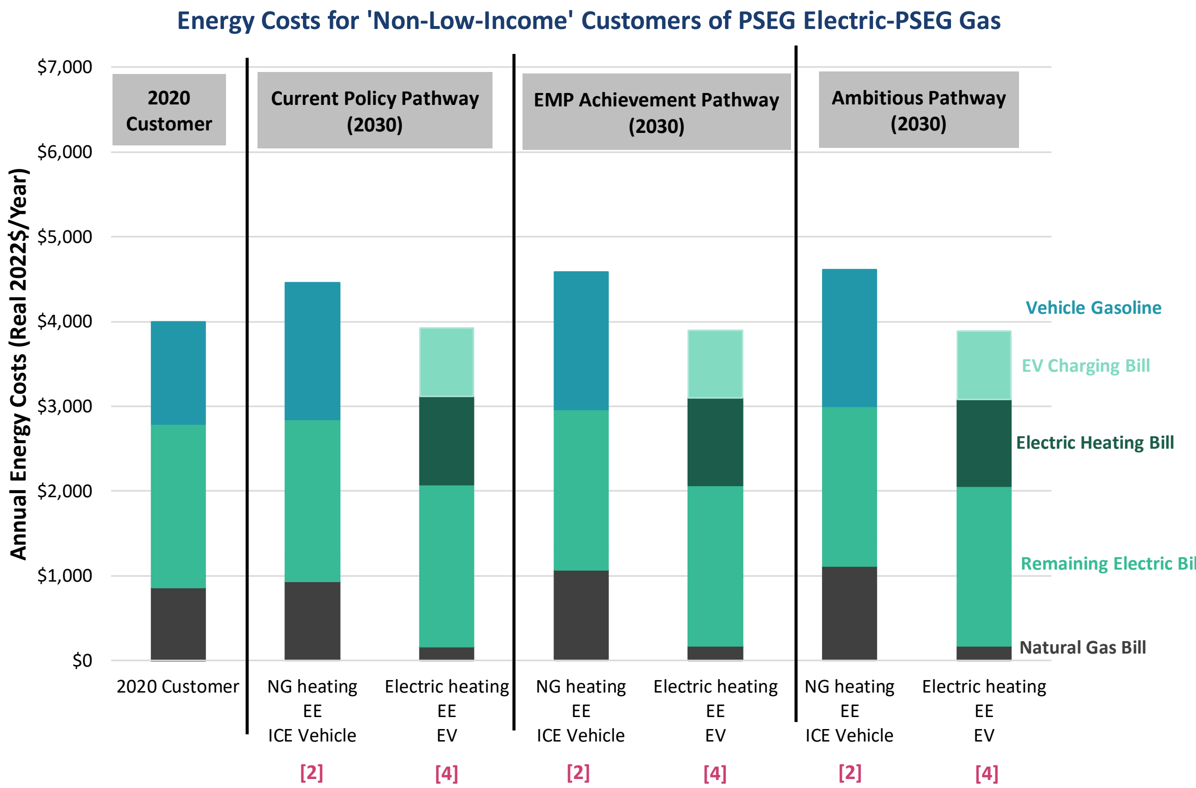


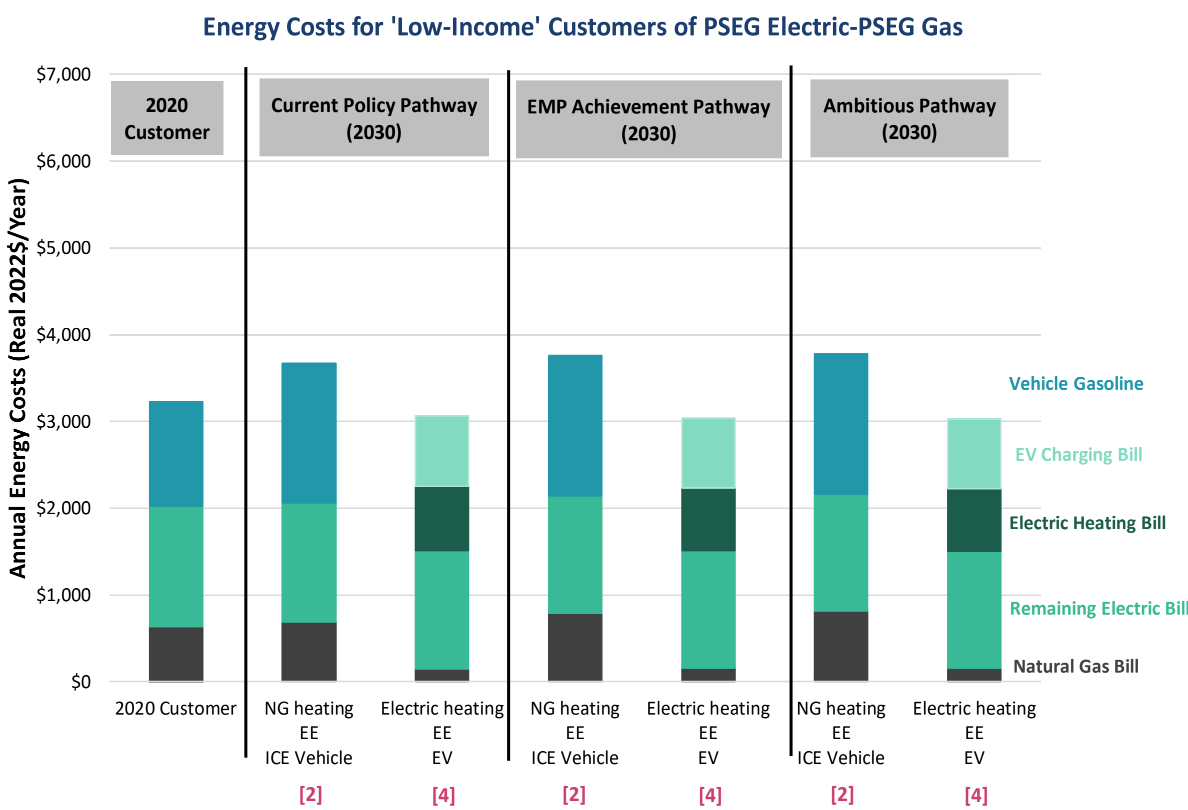


Energy Costs for 'Non-Low-Income' Customers of PSEG Electric-PSEG Gas
2020 Customer
EMP Achievement Pathway (2030)
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
NG heating No EE ICE Vehicle [1]
NG heating EE ICE Vehicle [2]
NG heating EE EV [3]
Electric heating EE EV [4]

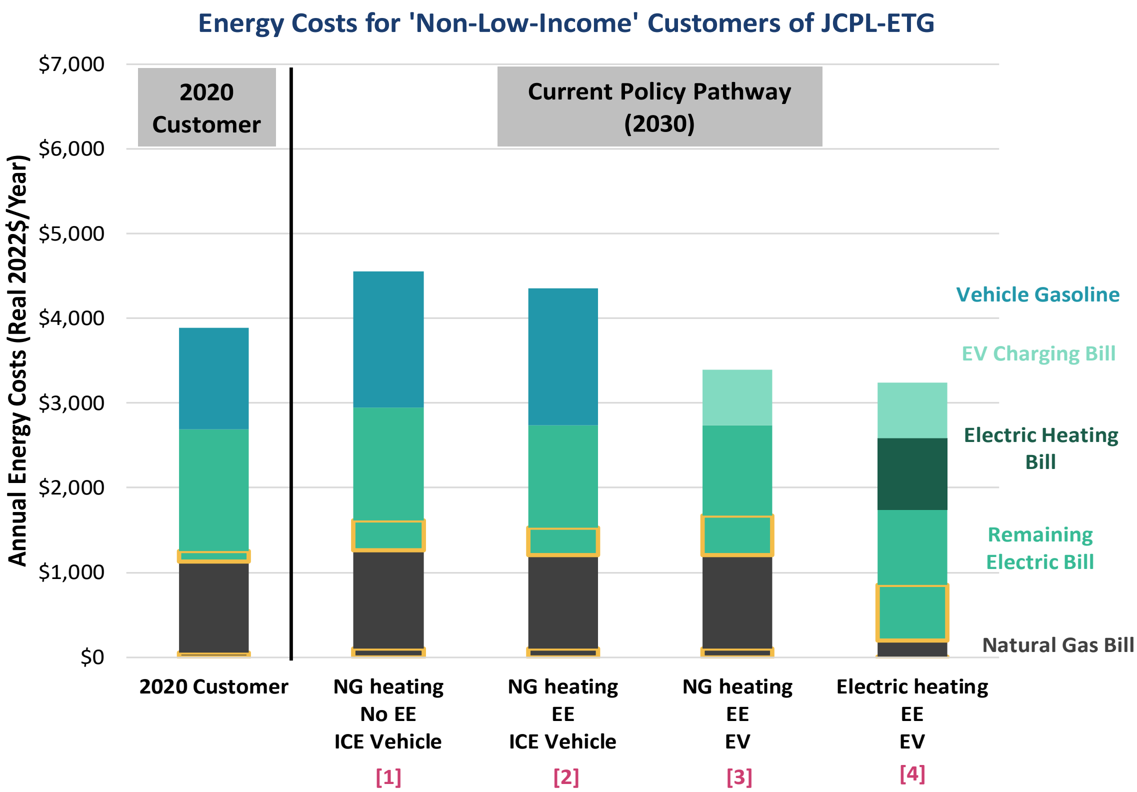


Energy Costs for 'Non-Low-Income' Customers of PSEG Electric-PSEG Gas
2020 Customer
Ambitious Pathway (2030)
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
NG heating No EE ICE Vehicle [1]
NG heating EE ICE Vehicle [2]
NG heating EE EV [3]
Electric heating EE EV [4]


Energy Costs for 'Non-Low-Income' Customers of PSEG Electric-PSEG Gas
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Annual Energy Costs (Real 2022$/Year)
2020 Customer
Current Policy Pathway (2030)
EMP Achievement Pathway (2030)
Ambitious Pathway (2030)
2020 Customer
NG heating EE ICE Vehicle [2]
Electric heating EE EV [4]
NG heating EE ICE Vehicle [2]
Electric heating EE EV [4]
NG heating EE ICE Vehicle [2]
Electric heating EE EV [4]
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill


Energy Costs for 'Low-Income' Customers of PSEG Electric-PSEG Gas
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Annual Energy Costs (Real 2022$/Year)
2020 Customer
Current Policy Pathway (2030)
EMP Achievement Pathway (2030)
Ambitious Pathway (2030)
2020 Customer
NG heating EE ICE Vehicle [2]
Electric heating EE EV [4]
NG heating EE ICE Vehicle [2]
Electric heating EE EV [4]
NG heating EE ICE Vehicle [2]
Electric heating EE EV [4]
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill

JCPL – ETG



Energy Costs for 'Non-Low-Income' Customers of JCPL-ETG
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
2020 Customer
Current Policy Pathway (2030)
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
NG heating No EE ICE Vehicle [1]
NG heating EE ICE Vehicle [2]
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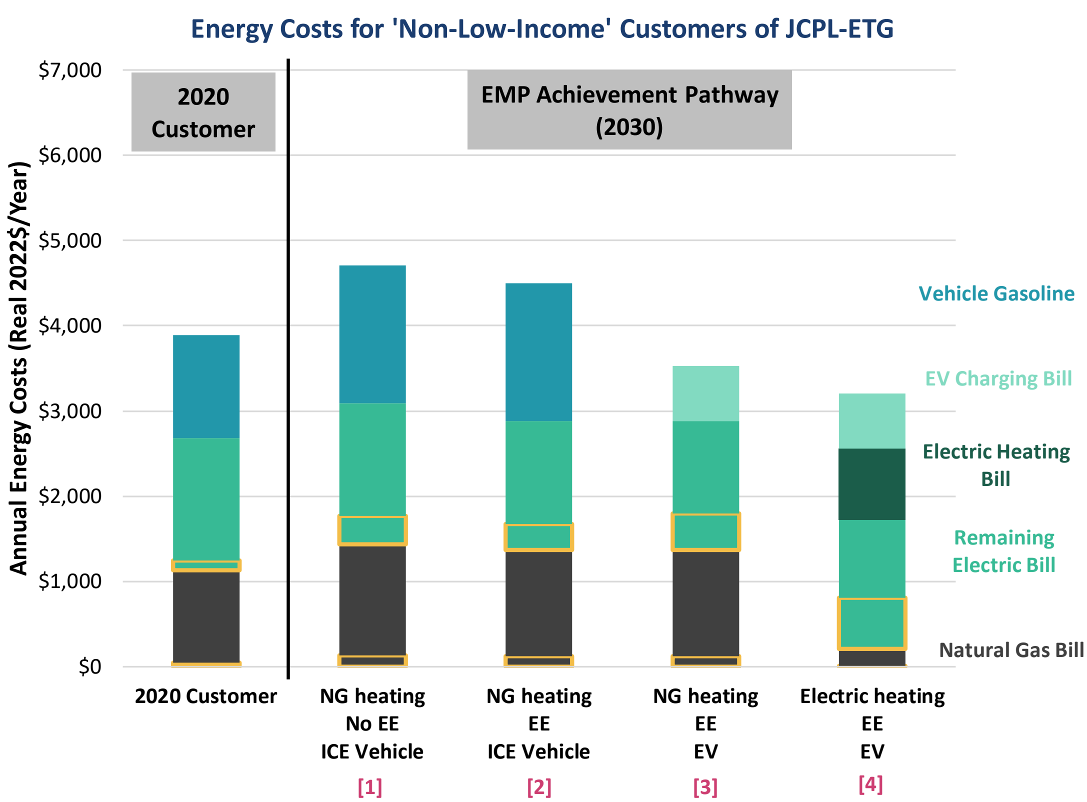

Energy Costs for 'Non-Low-Income' Customers of JCPL-ETG
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
2020 Customer
EMP Achievement Pathway (2030)
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
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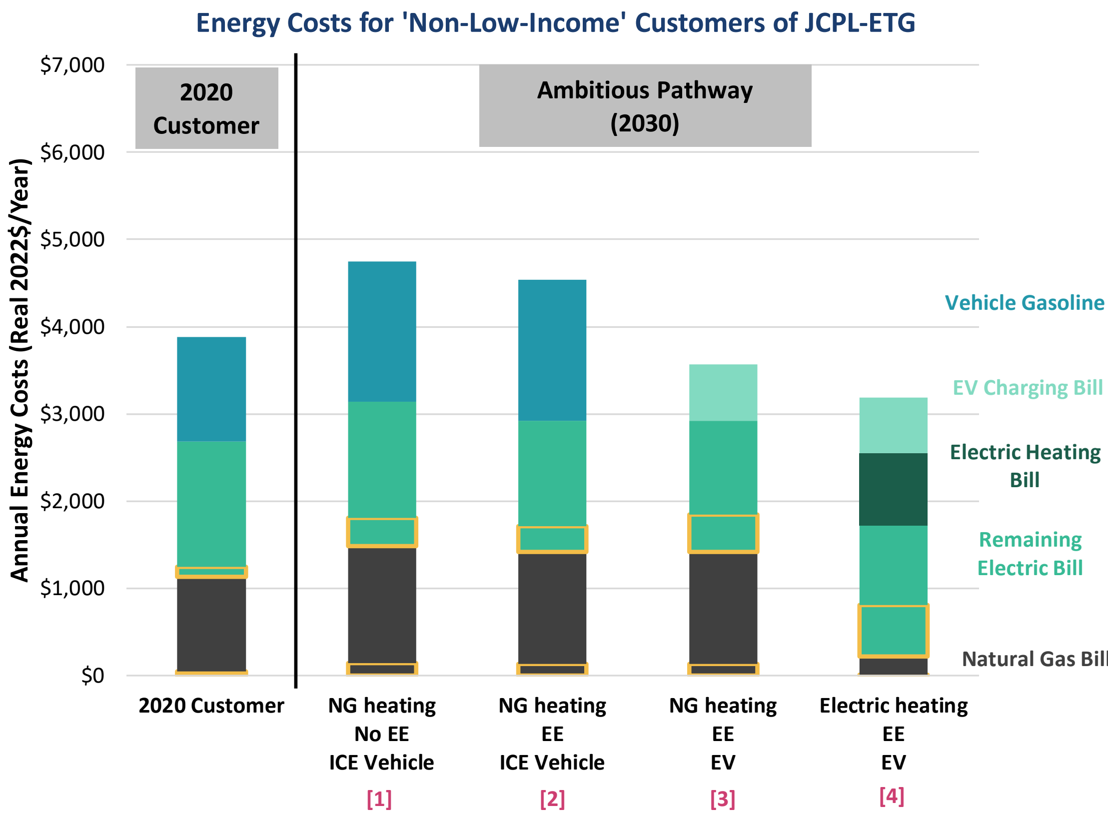
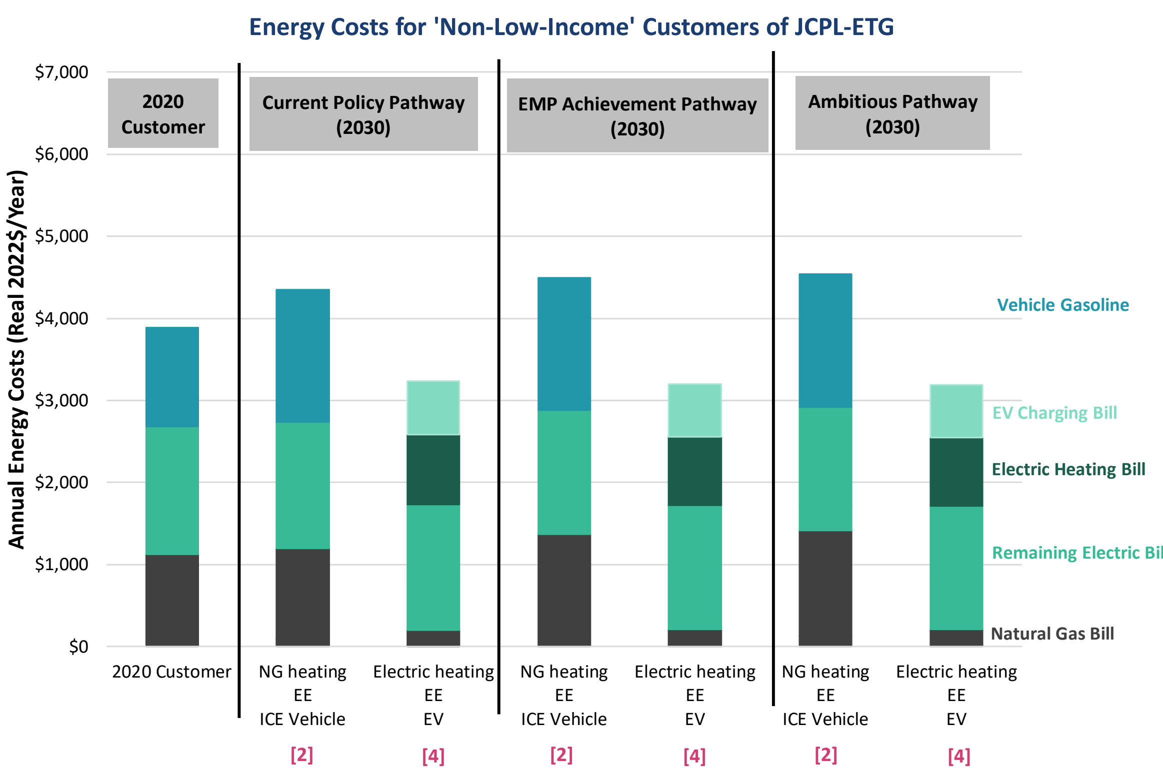
NG heating EE ICE Vehicle [2]
NG heating EE EV [3]
Electric heating EE EV [4]


Energy Costs for 'Non-Low-Income' Customers of JCPL-ETG
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
2020 Customer
Ambitious Pathway (2030)
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
NG heating
No EE
ICE Vehicle
[1]
NG heating
EE
ICE Vehicle
[2]
NG heating
EE
EV
[3]
Electric heating
EE
EV
[4]


Energy Costs for 'Non-Low-Income' Customers of JCPL-ETG
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
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$0
2020 Customer
Current Policy Pathway (2030)
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Vehicle Gasoline
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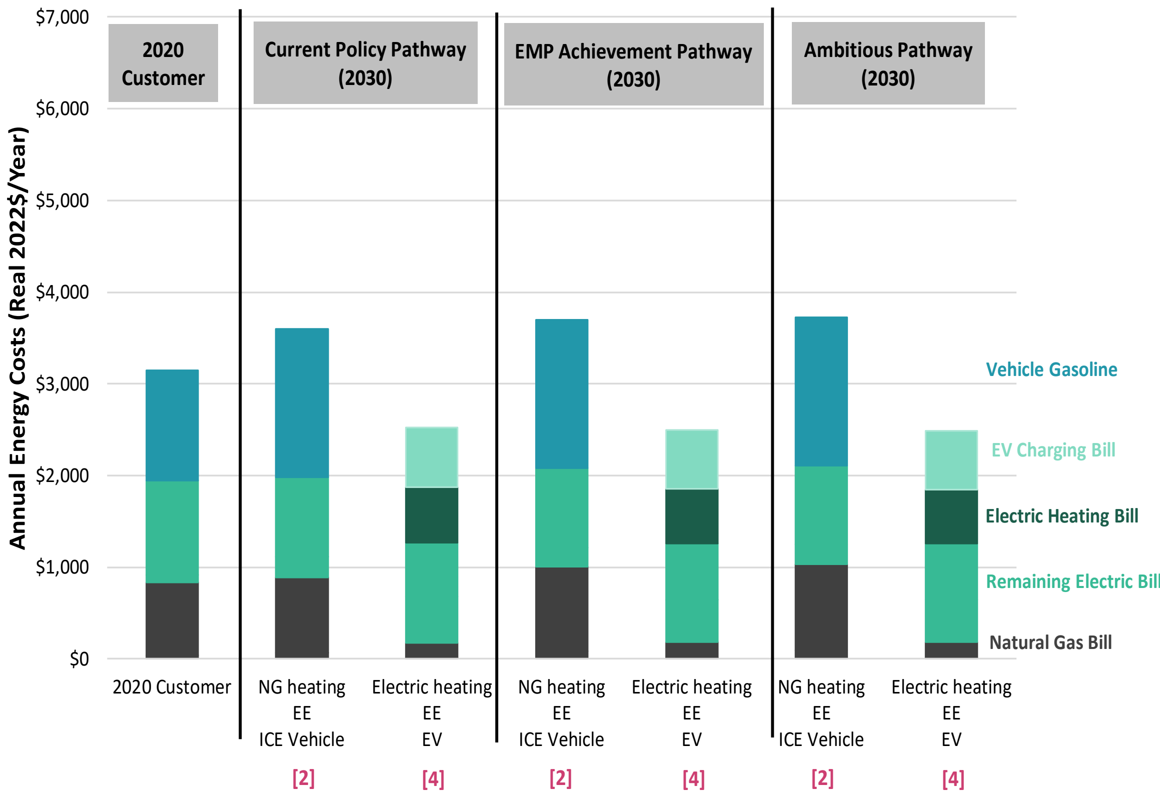
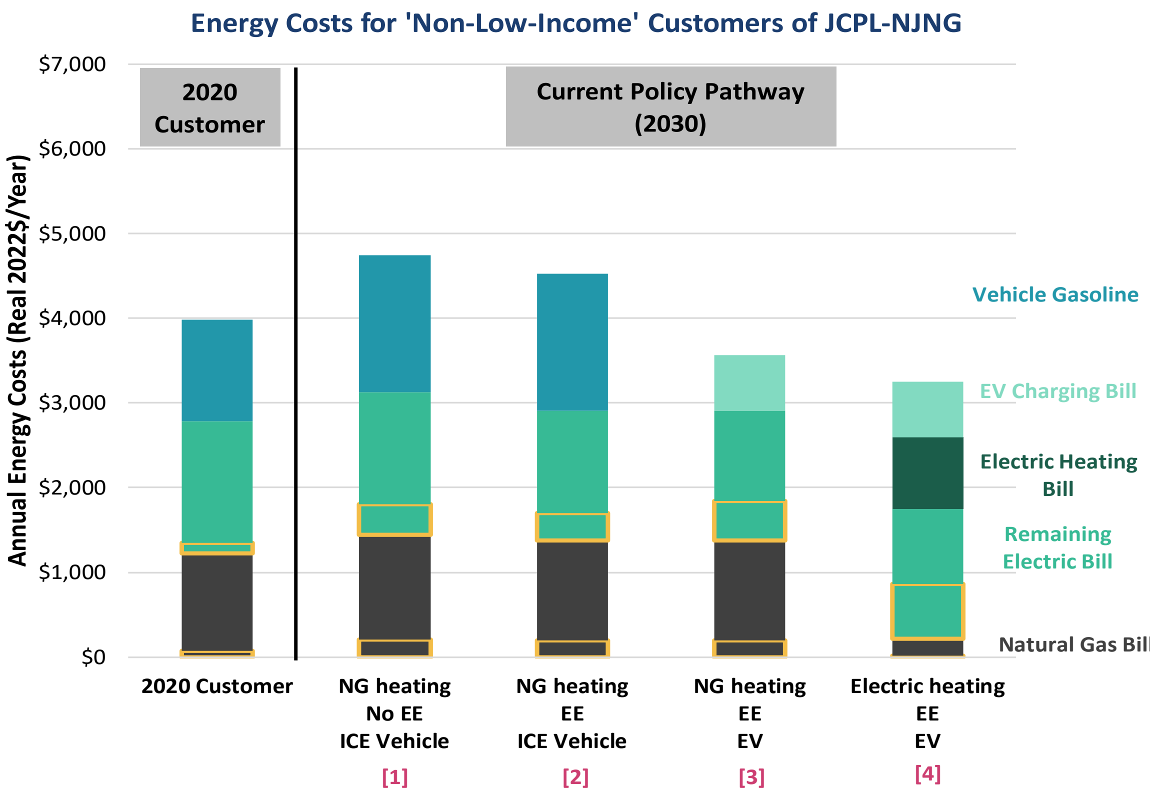
Natural Gas Bill
2020 Customer
NG heating
EE
ICE Vehicle
[2]
Electric heating
EE
EV
[4]
NG heating
EE
ICE Vehicle
[2]
Electric heating
EE
EV
[4]
NG heating
EE
ICE Vehicle
[2]
Electric heating
EE
EV
[4]

Energy Costs for 'Low-Income' Customers of JCPL-ETG



JCPL – NJNG



Energy Costs for 'Non-Low-Income' Customers of JCPL-NJNG
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Annual Energy Costs (Real 2022$/Year)
2020 Customer
Current Policy Pathway (2030)
Vehicle Gasoline
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2020 Customer
NG heating No EE ICE Vehicle [1]
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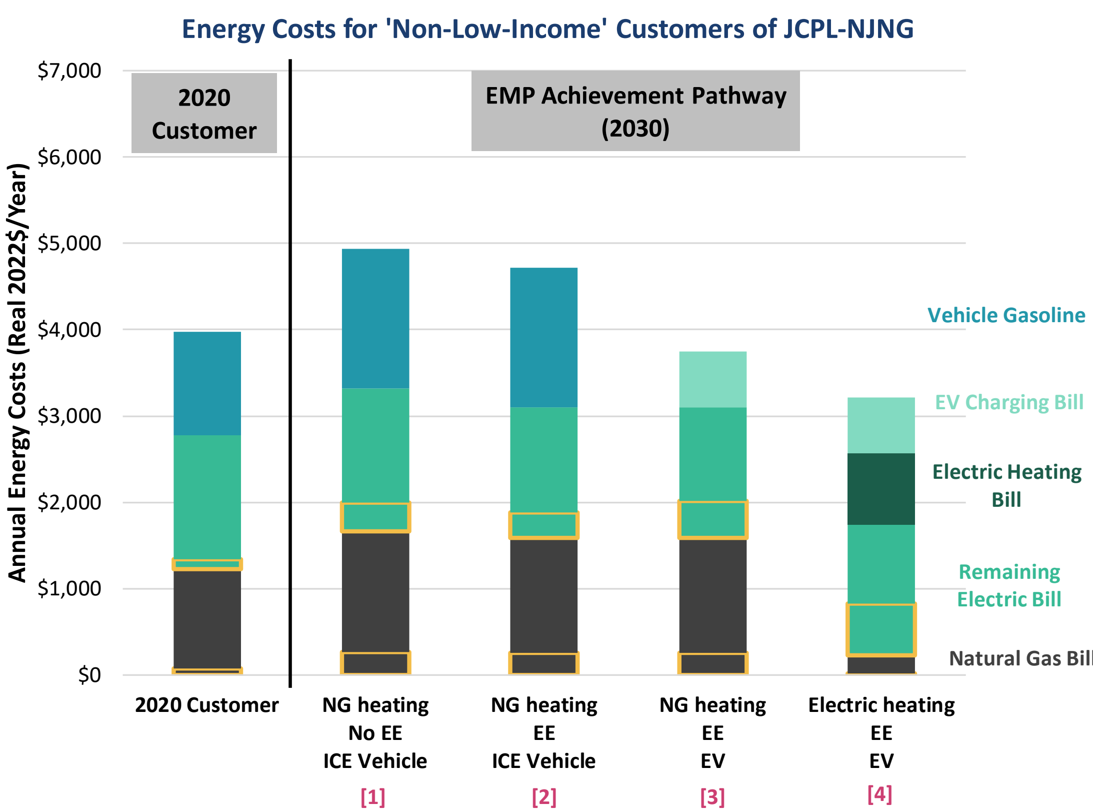

Energy Costs for 'Non-Low-Income' Customers of JCPL-NJNG
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Annual Energy Costs (Real 2022$/Year)
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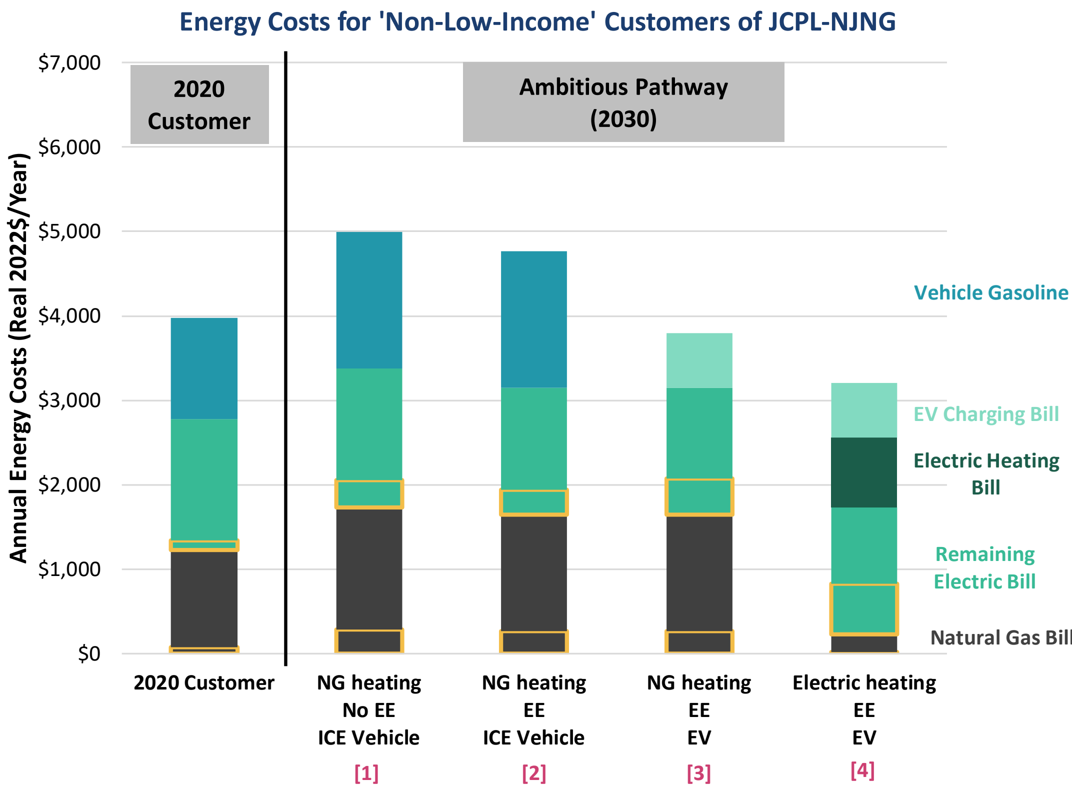

Energy Costs for 'Non-Low-Income' Customers of JCPL-NJNG
Annual Energy Costs (Real 2022$/Year)
$7,000
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$3,000
$2,000
$1,000
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2020 Customer
Ambitious Pathway (2030)
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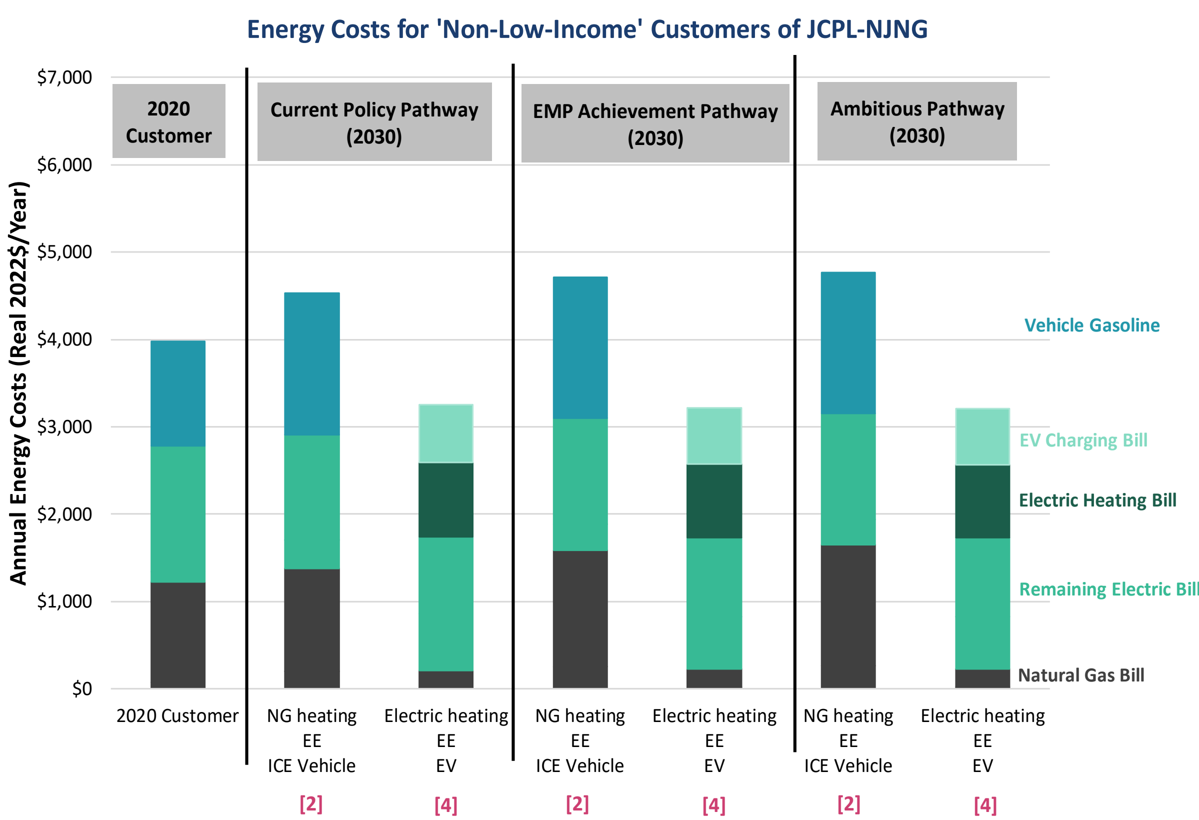

Energy Costs for 'Non-Low-Income' Customers of JCPL-NJNG
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
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$3,000
$2,000
$1,000
$0
2020 Customer
Current Policy Pathway (2030)
EMP Achievement Pathway (2030)
Ambitious Pathway (2030)
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Natural Gas Bill
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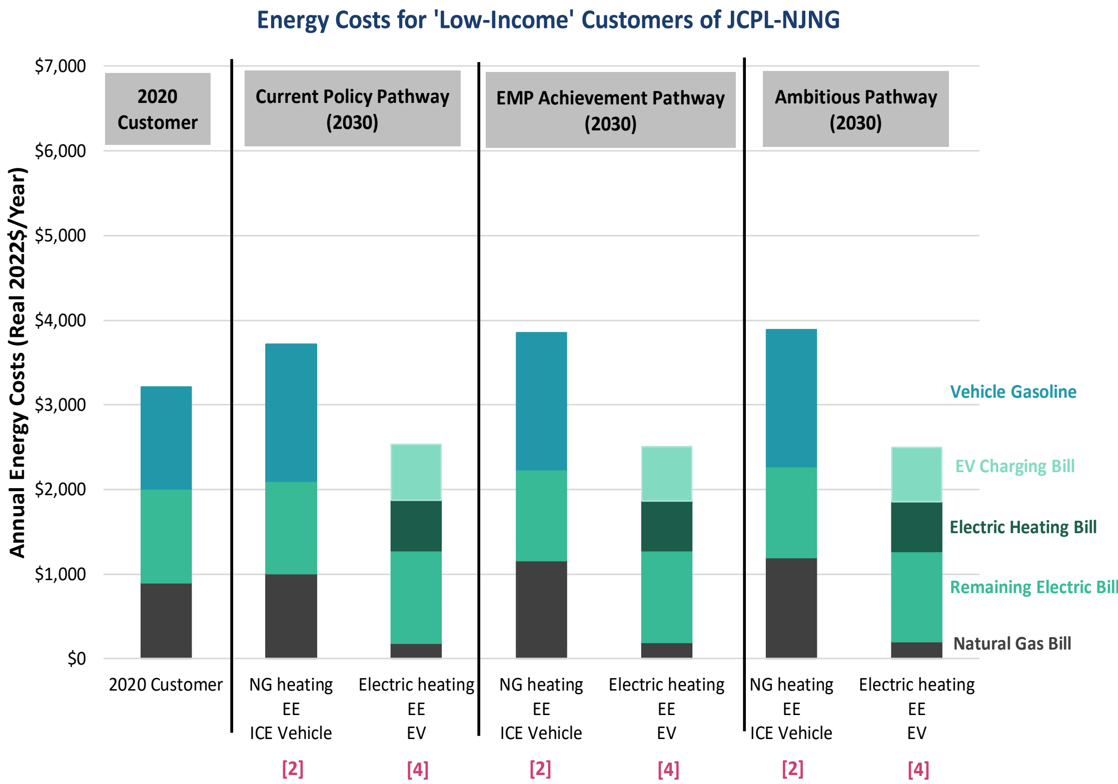
Energy Costs for 'Low-Income' Customers of JCPL-NJNG
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
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$3,000
$2,000
$1,000
$0
2020 Customer
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EMP Achievement Pathway (2030)
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Natural Gas Bill
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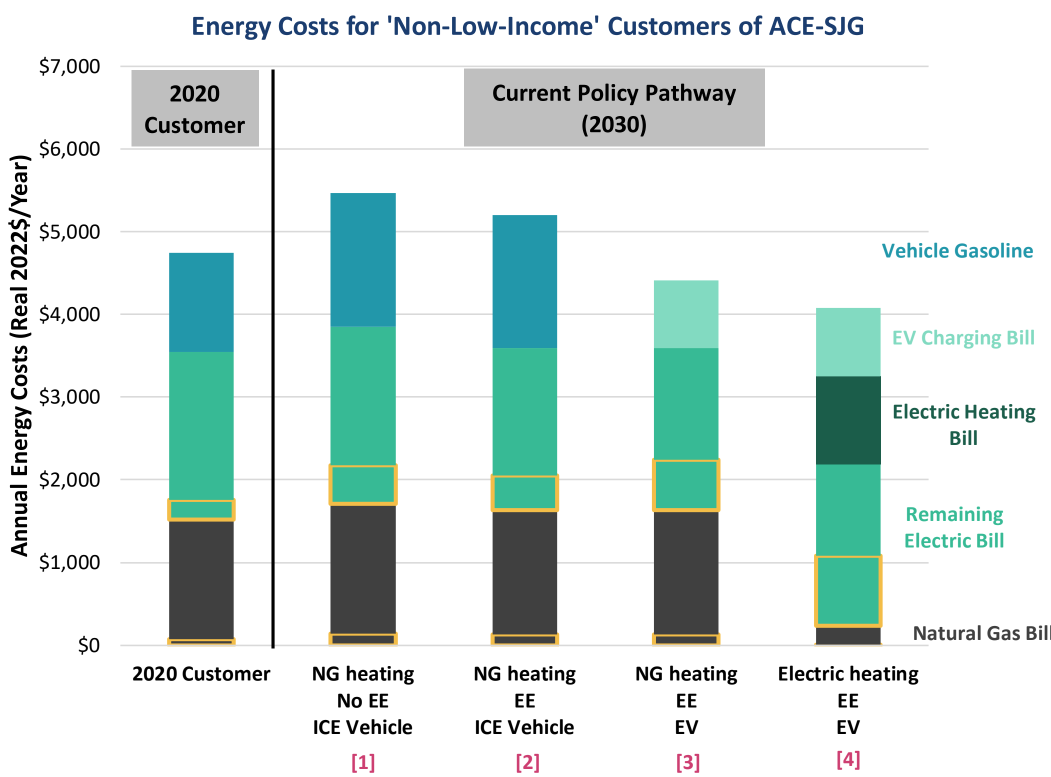
Electric heating EE EV [4]
NG heating EE ICE Vehicle [2]
Electric heating EE EV [4]
NG heating EE ICE Vehicle [2]
Electric heating EE EV [4]

ACE – SJG


Energy Costs for 'Non-Low-Income' Customers of ACE-SJG
Annual Energy Costs (Real 2022$/Year)
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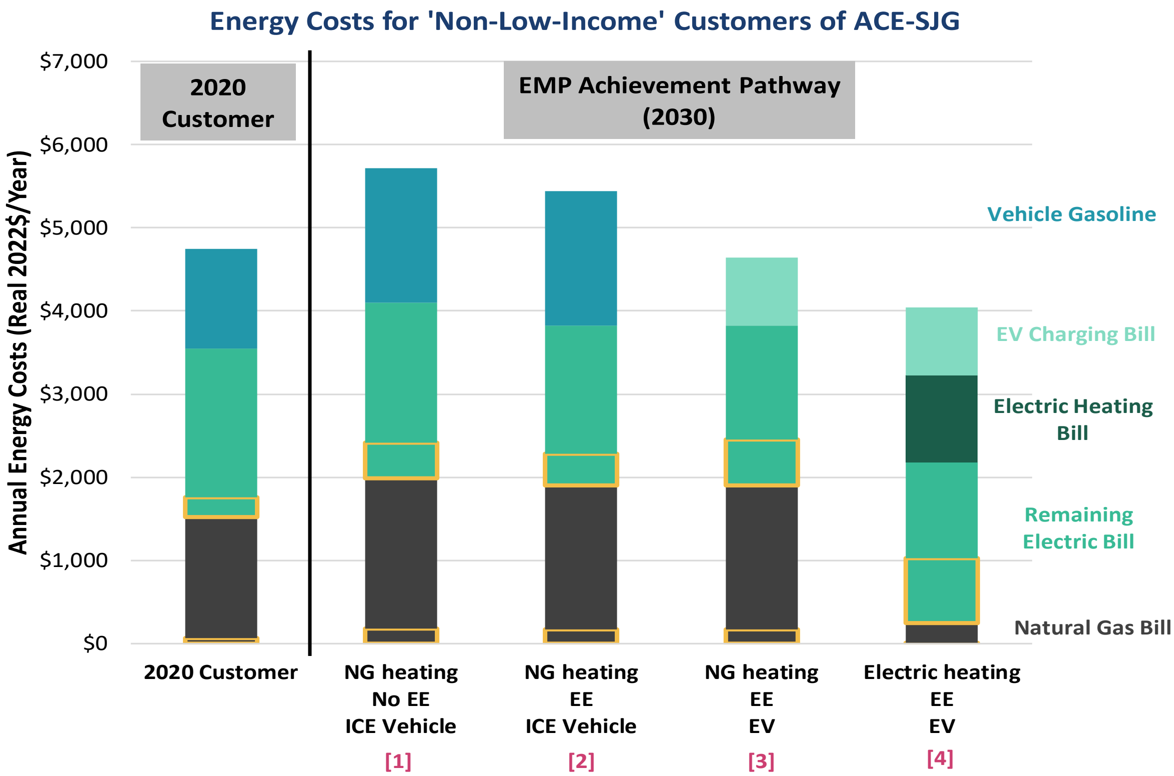
$5,000
$4,000
$3,000
$2,000
$1,000
$0
2020 Customer
Current Policy Pathway (2030)
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
NG heating No EE ICE Vehicle [1]
NG heating EE ICE Vehicle [2]
NG heating EE EV [3]
Electric heating EE EV [4]


Energy Costs for 'Non-Low-Income' Customers of ACE-SJG
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$4,000
$3,000
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$1,000
$0
Annual Energy Costs (Real 2022$/Year)
2020 Customer
EMP Achievement Pathway (2030)
Vehicle Gasoline
EV Charging Bill
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Remaining Electric Bill
Natural Gas Bill
2020 Customer
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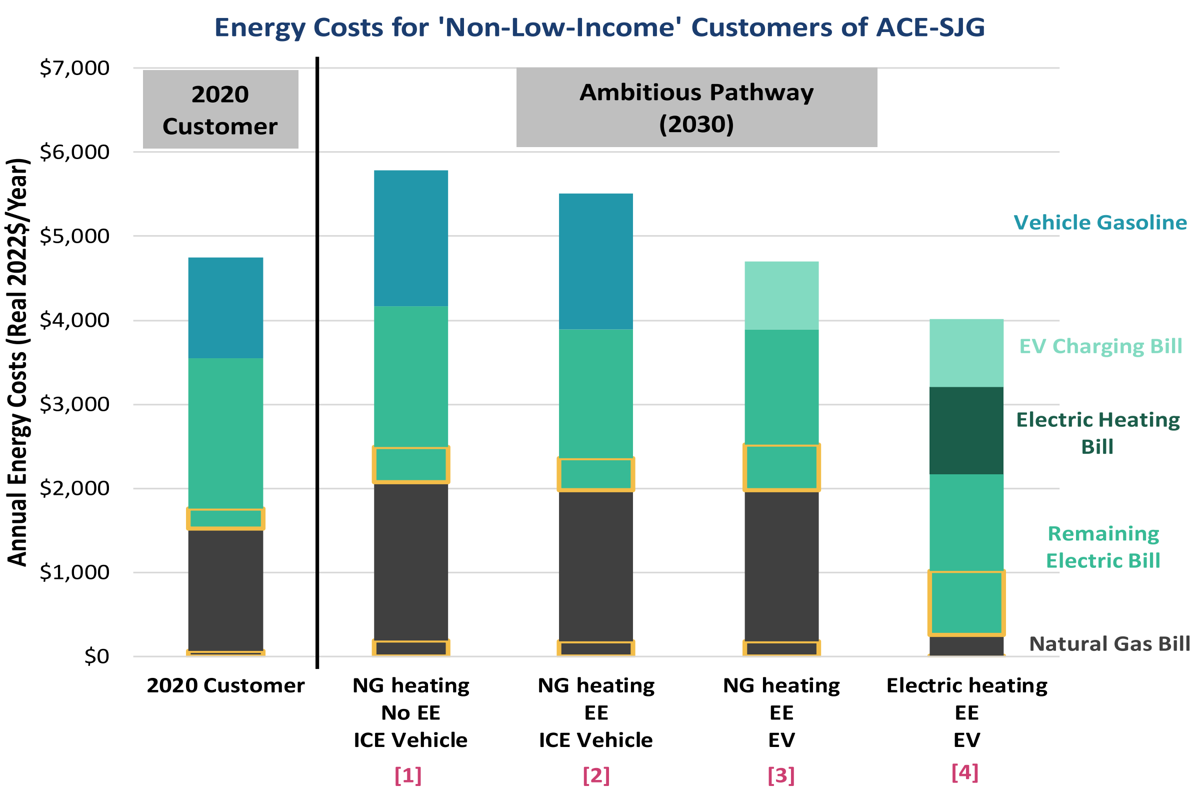
Electric heating EE EV [4]


Energy Costs for 'Non-Low-Income' Customers of ACE-SJG
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$4,000
$3,000
$2,000
$1,000
$0
Annual Energy Costs (Real 2022$/Year)
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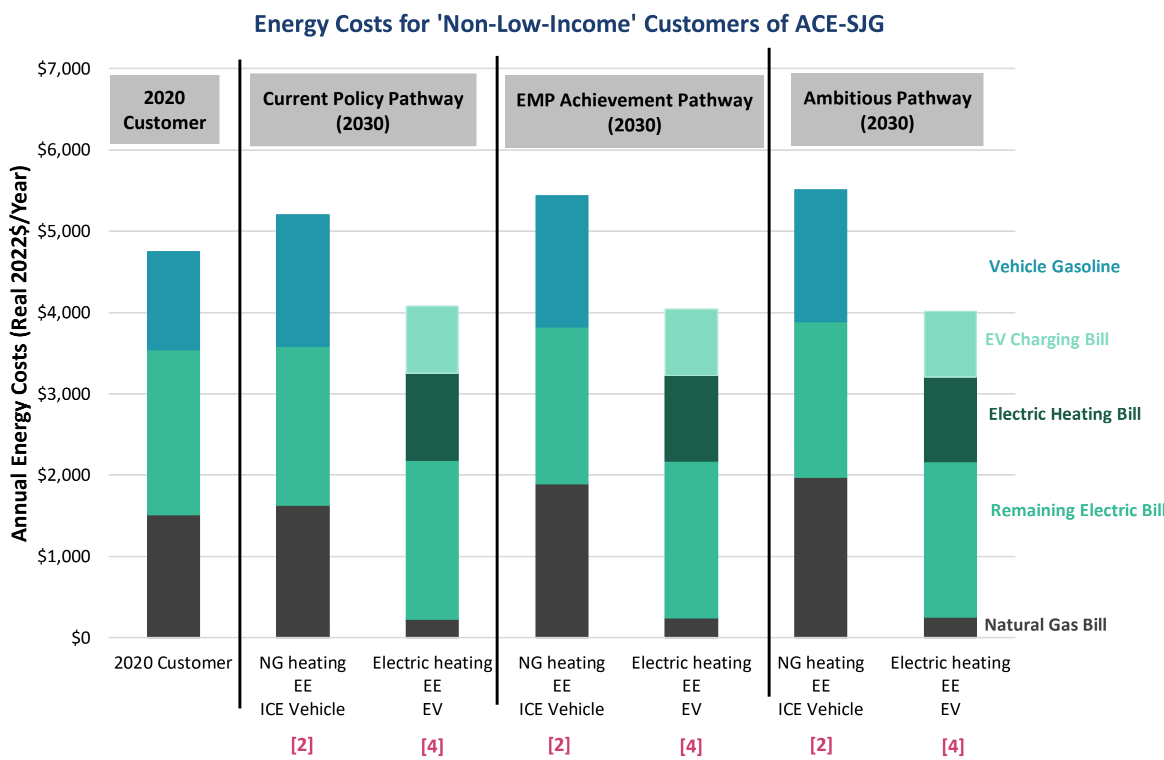
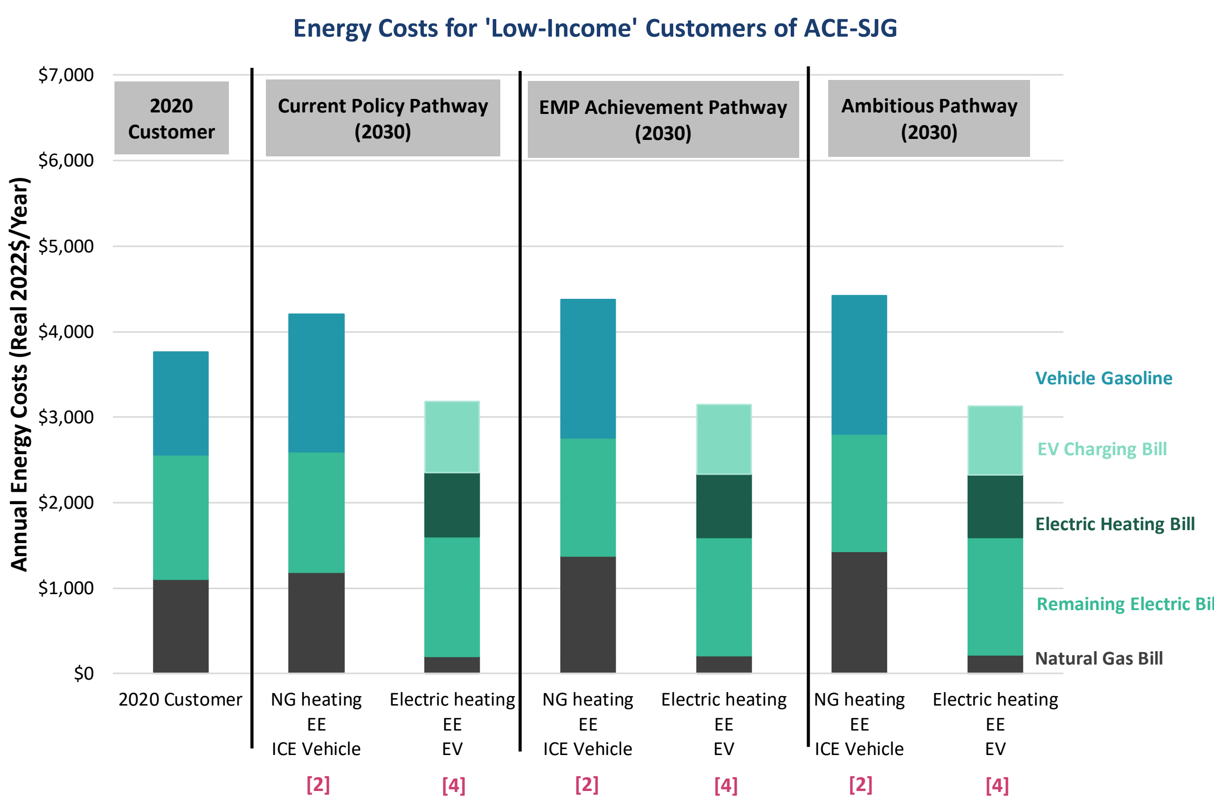
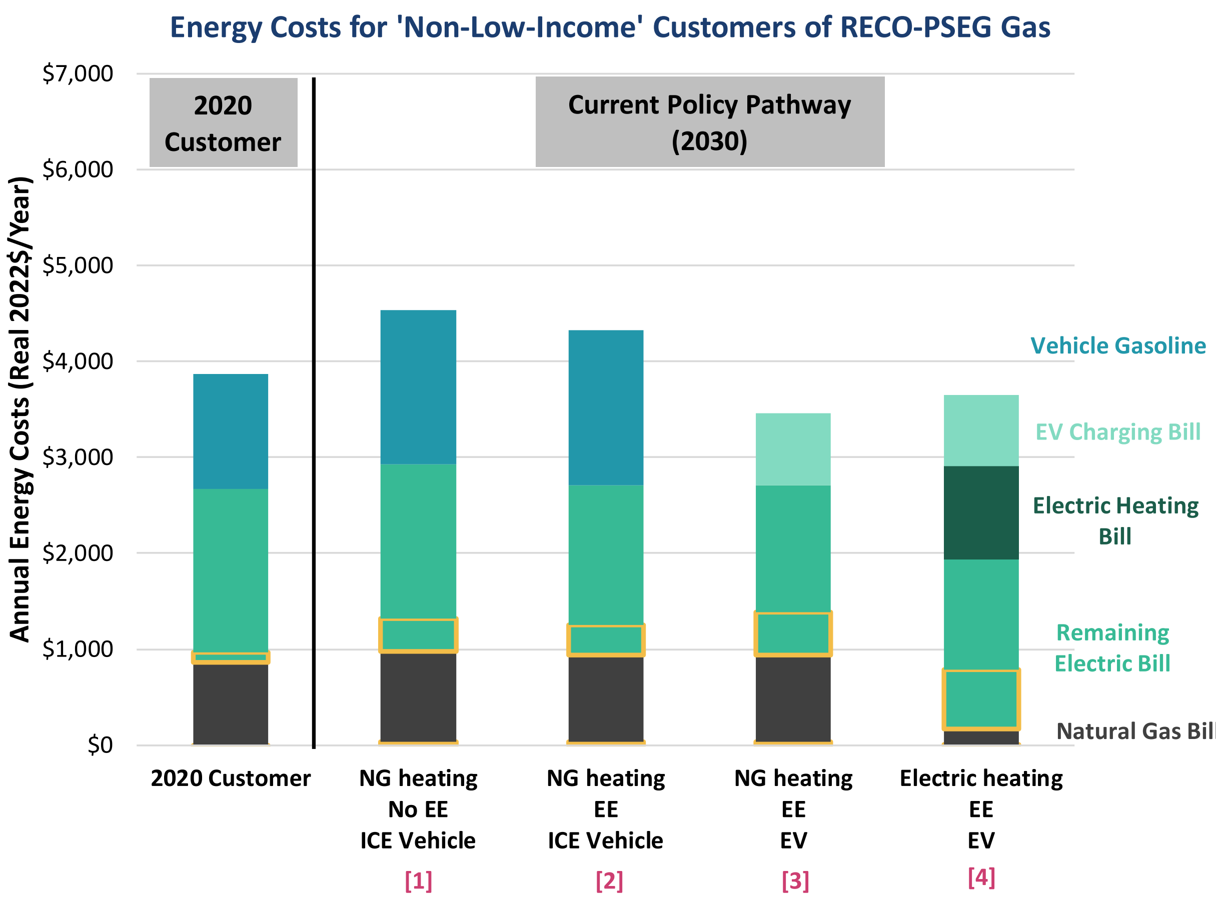
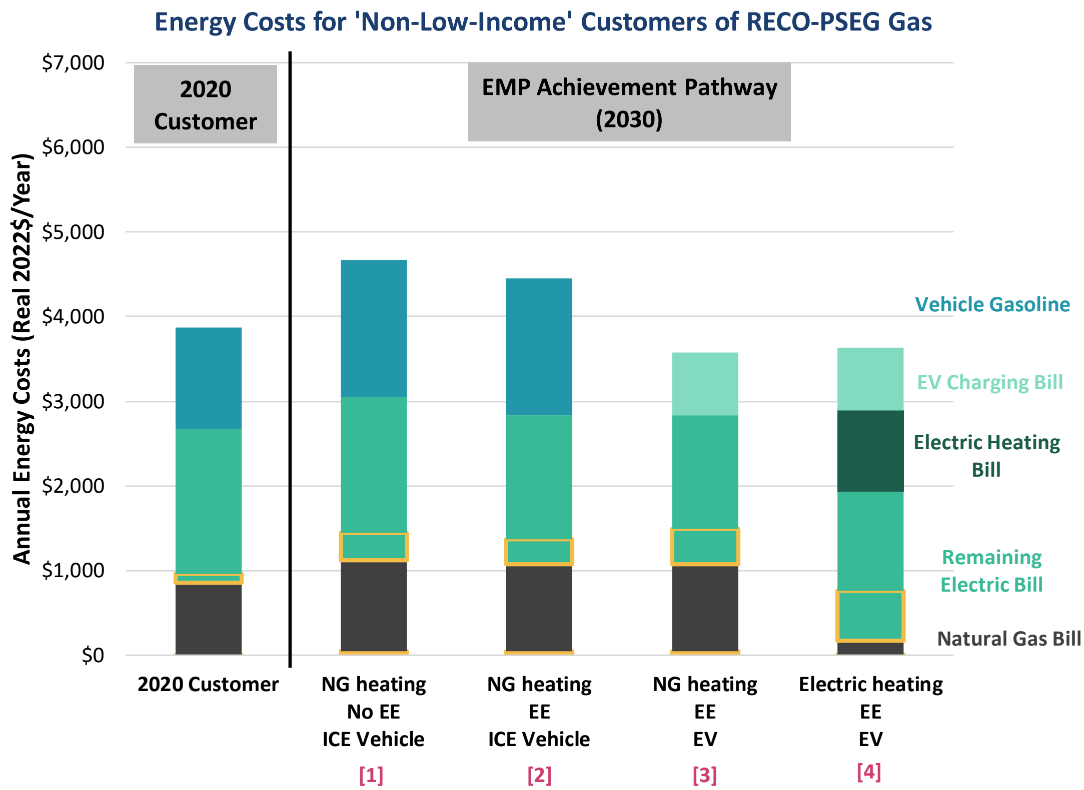


Energy Costs for 'Non-Low-Income' Customers of ACE-SJG
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
2020 Customer
Current Policy Pathway (2030)
EMP Achievement Pathway (2030)
Ambitious Pathway (2030)
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
NG heating EE ICE Vehicle
Electric heating EE EV
[2]
[4]



Energy Costs for 'Low-Income' Customers of ACE-SJG
Annual Energy Costs (Real 2022$/Year)
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
2020 Customer
Current Policy Pathway (2030)
EMP Achievement Pathway (2030)
Ambitious Pathway (2030)
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
NG heating EE ICE Vehicle
Electric heating EE EV
[2]
[4]


Energy Costs for 'Non-Low-Income' Customers of RECO-PSEG Gas
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Annual Energy Costs (Real 2022$/Year)
2020 Customer
Current Policy Pathway (2030)
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
NG heating
No EE
ICE Vehicle
[1]
NG heating
EE
ICE Vehicle
[2]
NG heating
EE
EV
[3]
Electric heating
EE
EV
[4]


Energy Costs for 'Non-Low-Income' Customers of RECO-PSEG Gas
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Annual Energy Costs (Real 2022$/Year)
2020 Customer
EMP Achievement Pathway (2030)
Vehicle Gasoline
EV Charging Bill
Electric Heating Bill
Remaining Electric Bill
Natural Gas Bill
2020 Customer
NG heating No EE ICE Vehicle [1]
NG heating EE ICE Vehicle [2]
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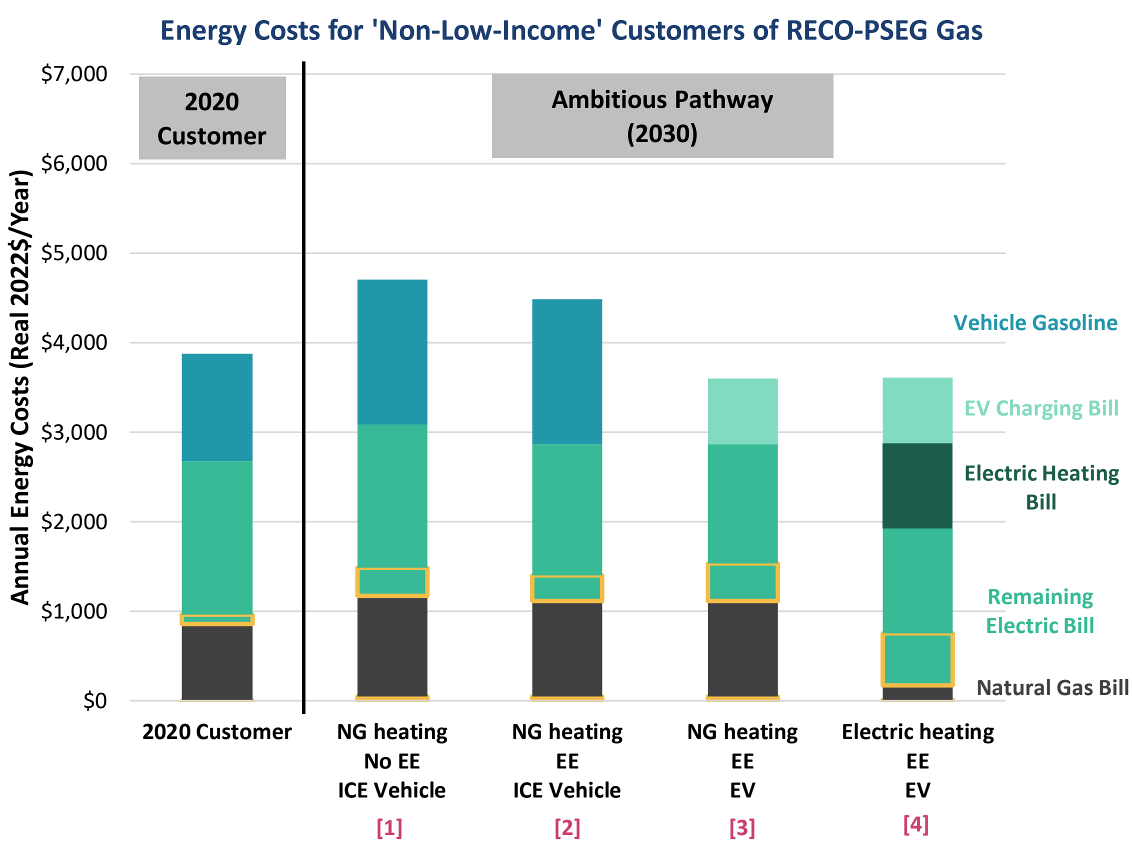
Energy Costs for 'Non-Low-Income' Customers of RECO-PSEG Gas
$7,000
$6,000
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$2,000
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NG heating EE EV [3]
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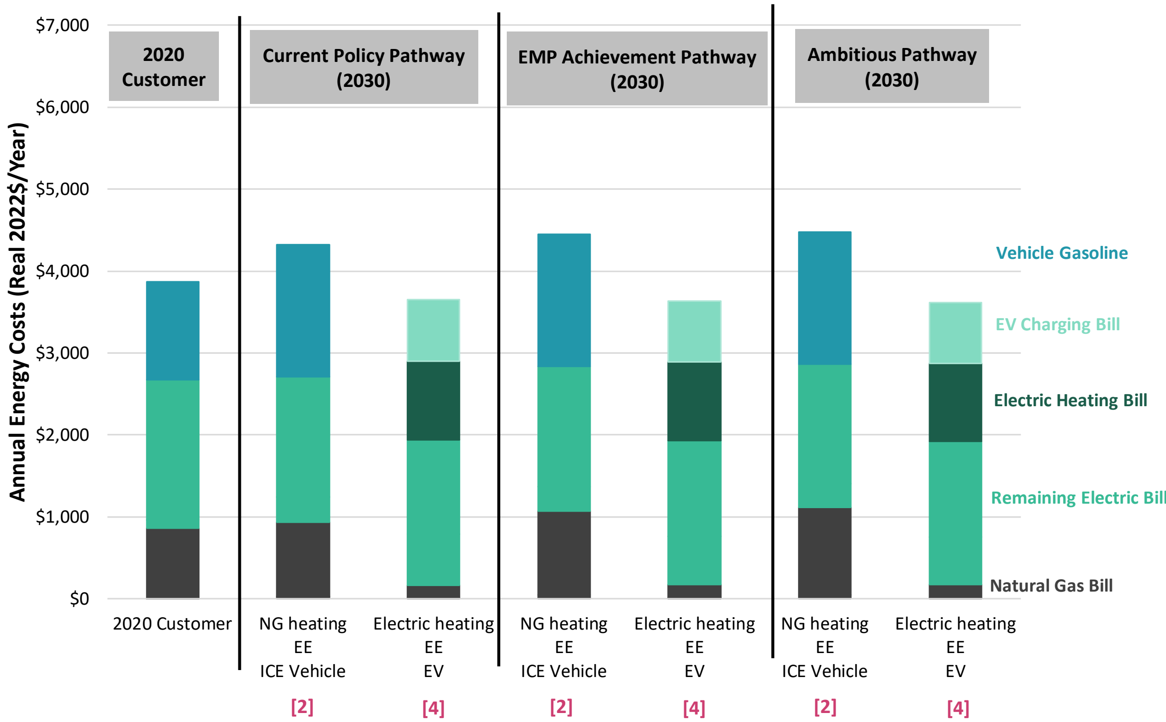
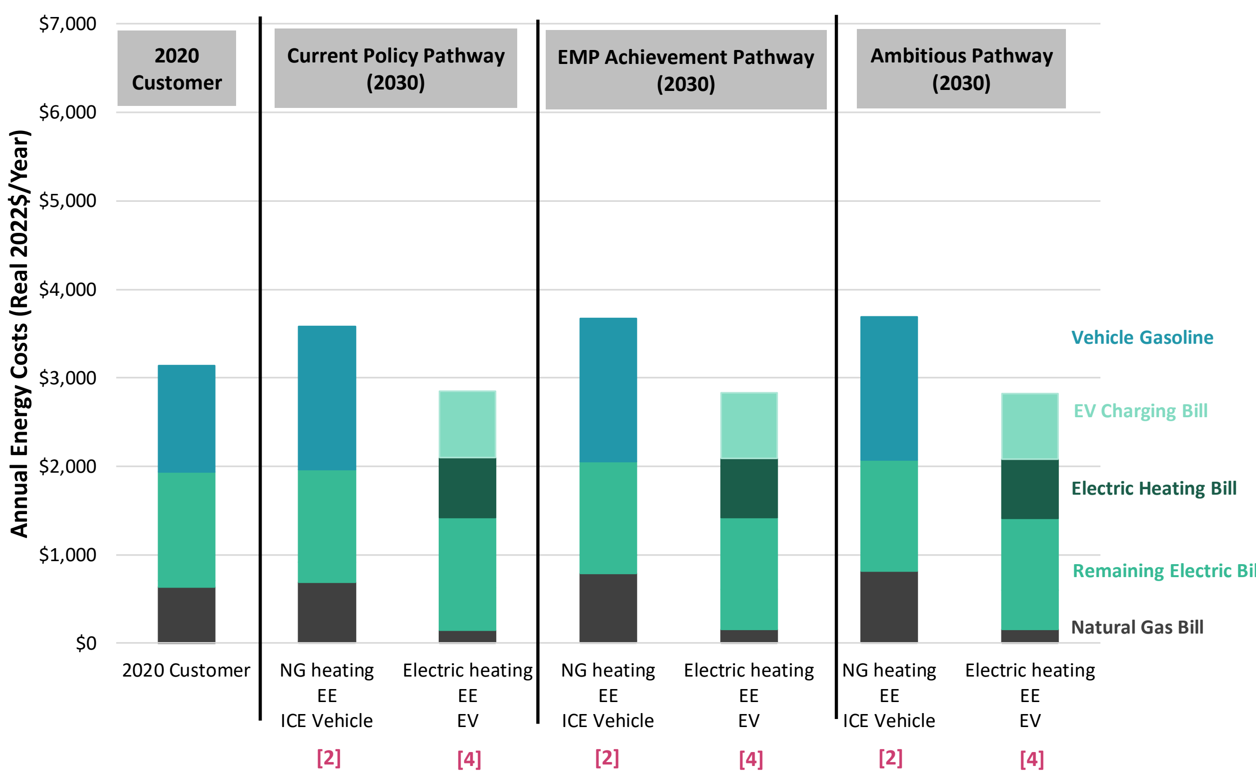
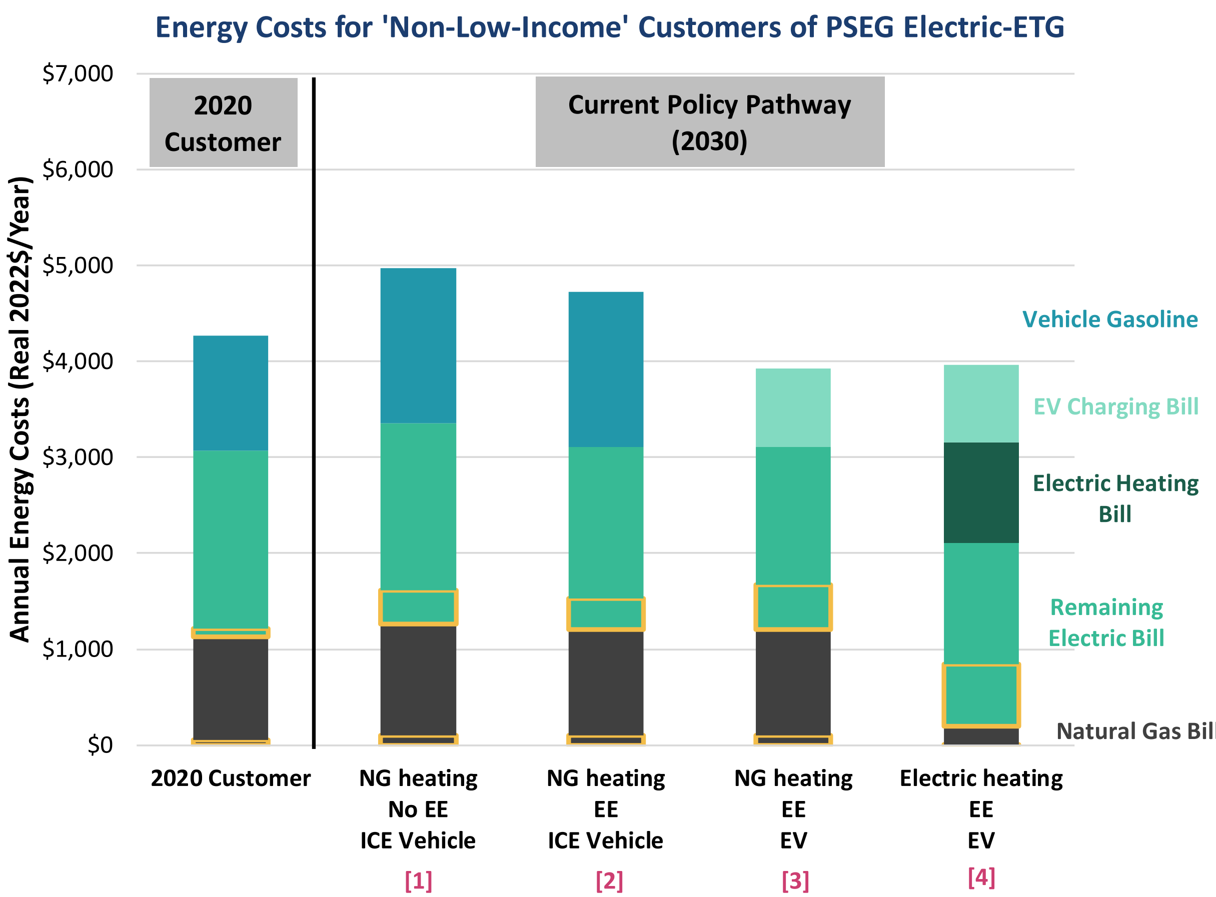
Energy Costs for 'Non-Low-Income' Customers of RECO-PSEG Gas



Energy Costs for 'Low-Income' Customers of RECO-PSEG Gas




Energy Costs for 'Non-Low-Income' Customers of PSEG Electric-ETG
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$6,000
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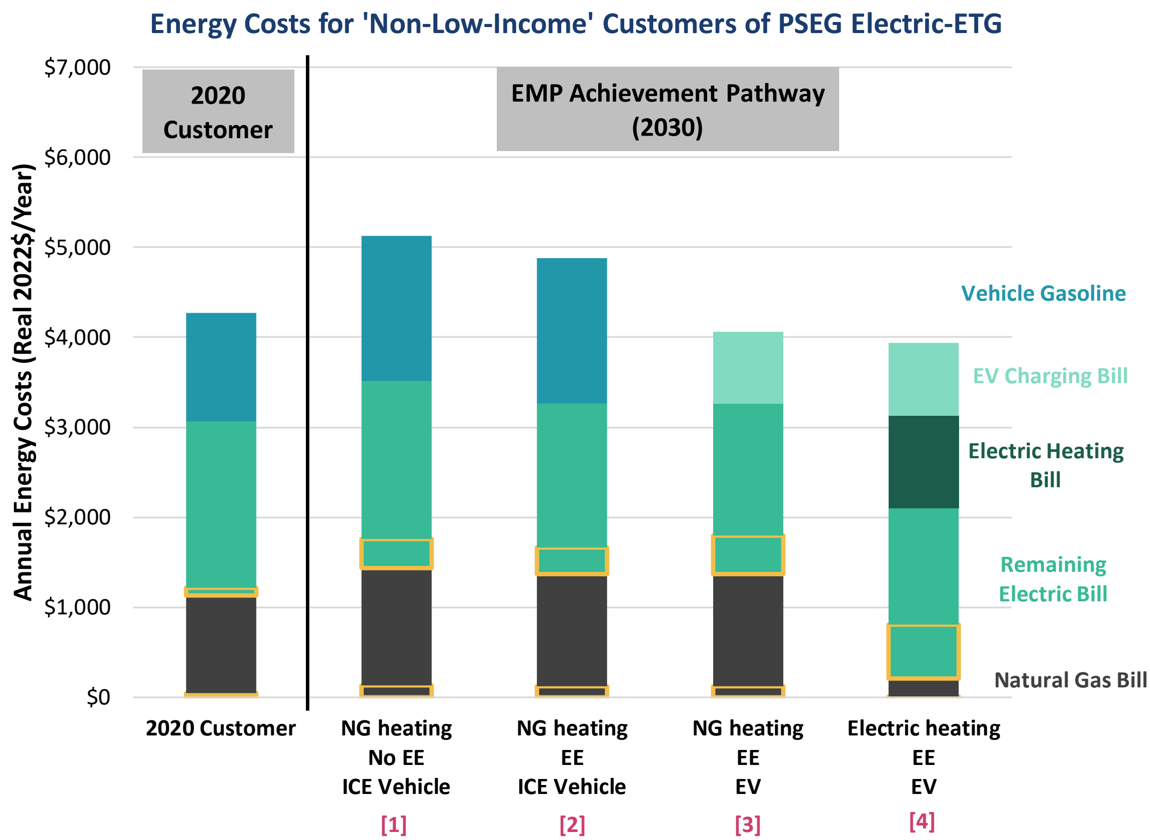

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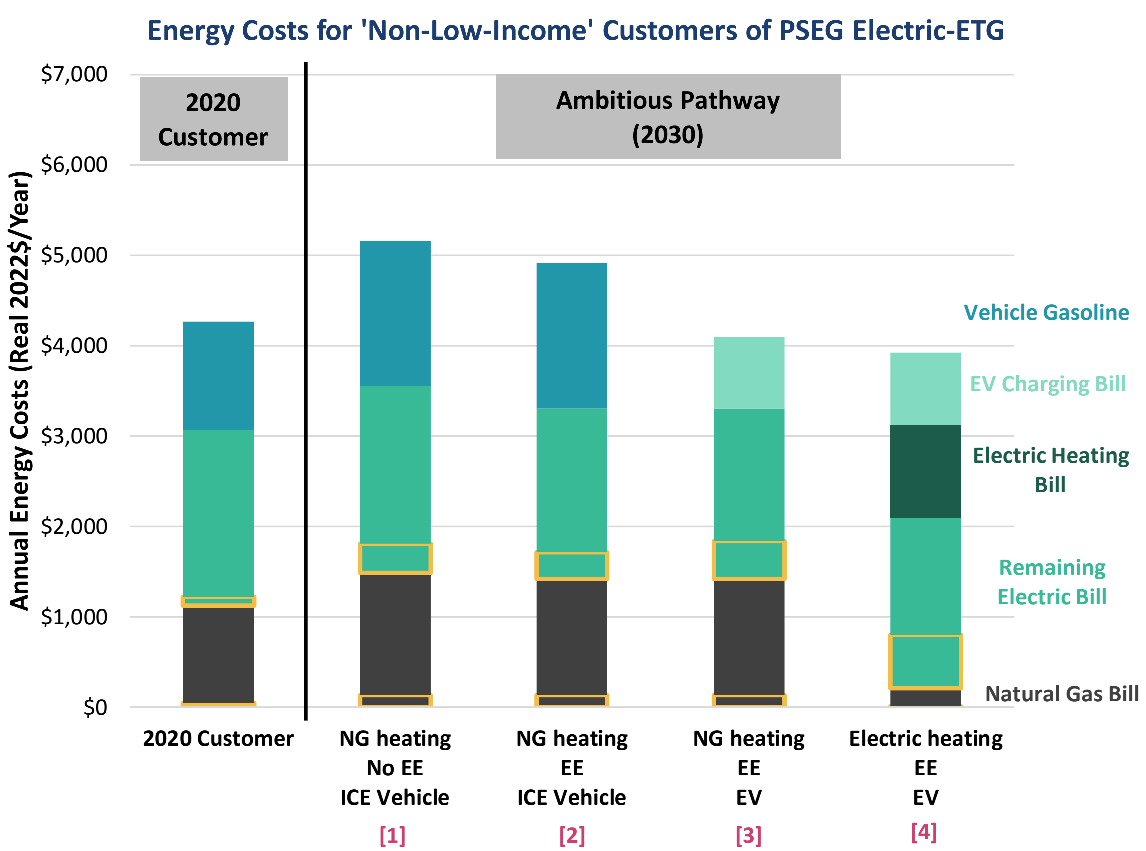

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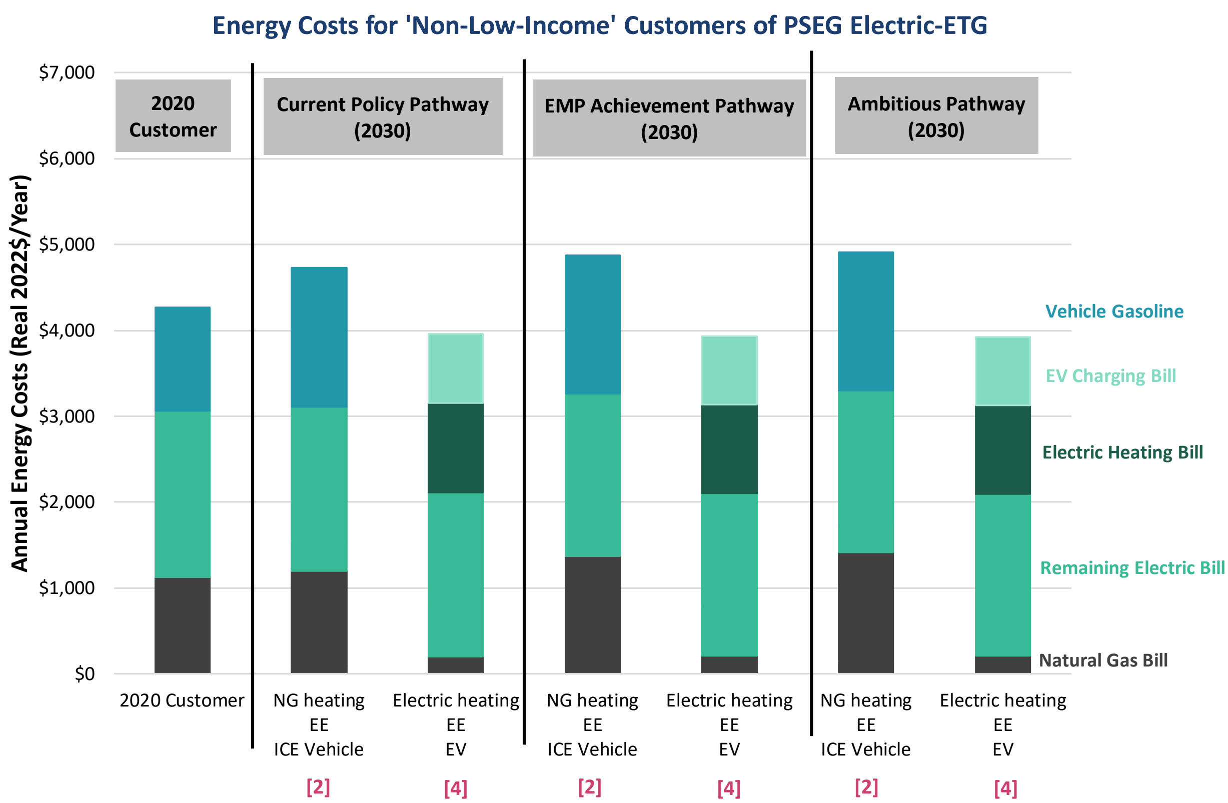

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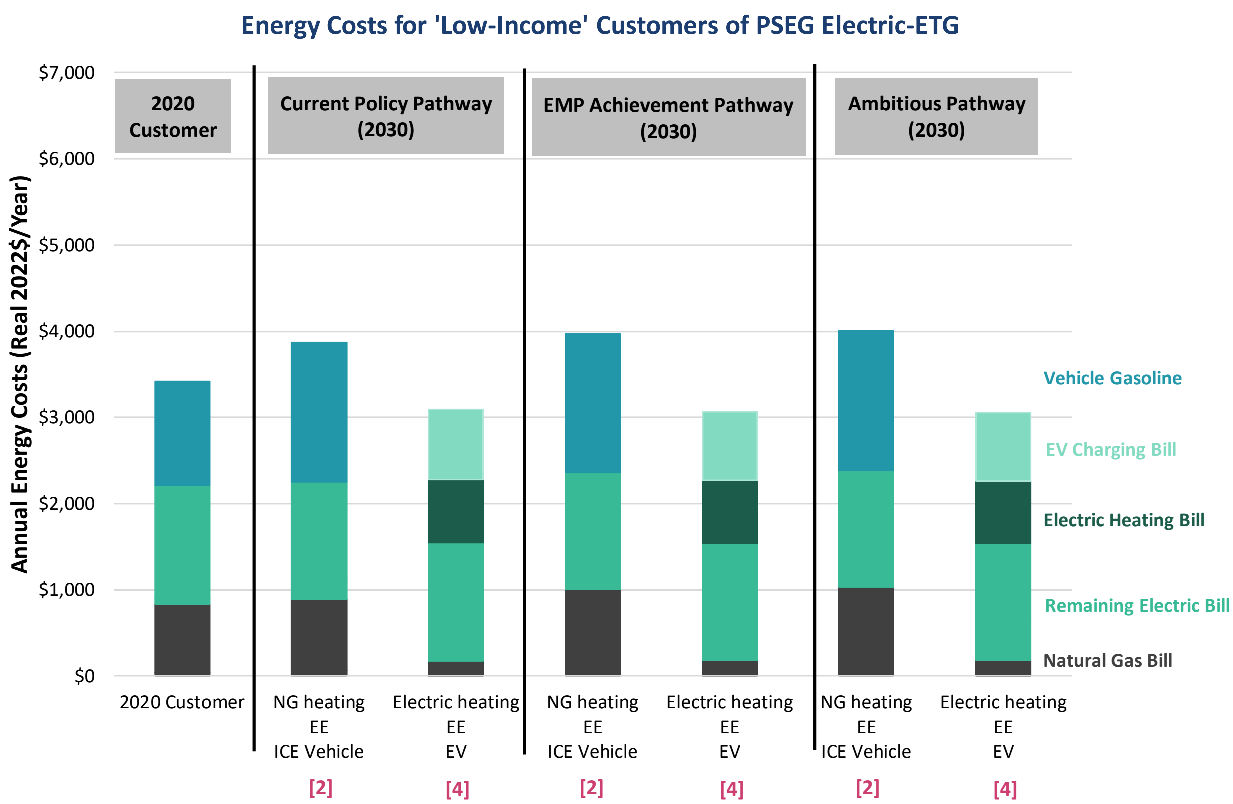

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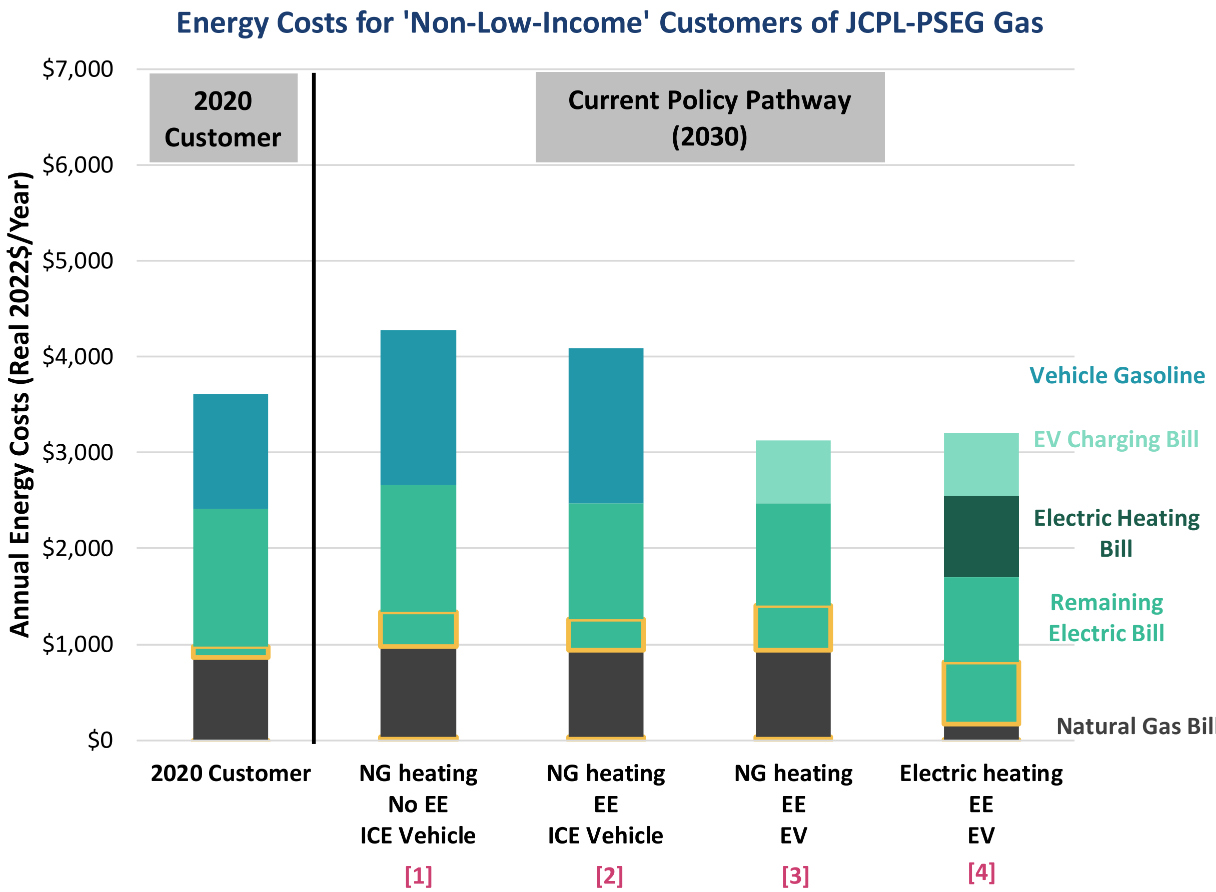
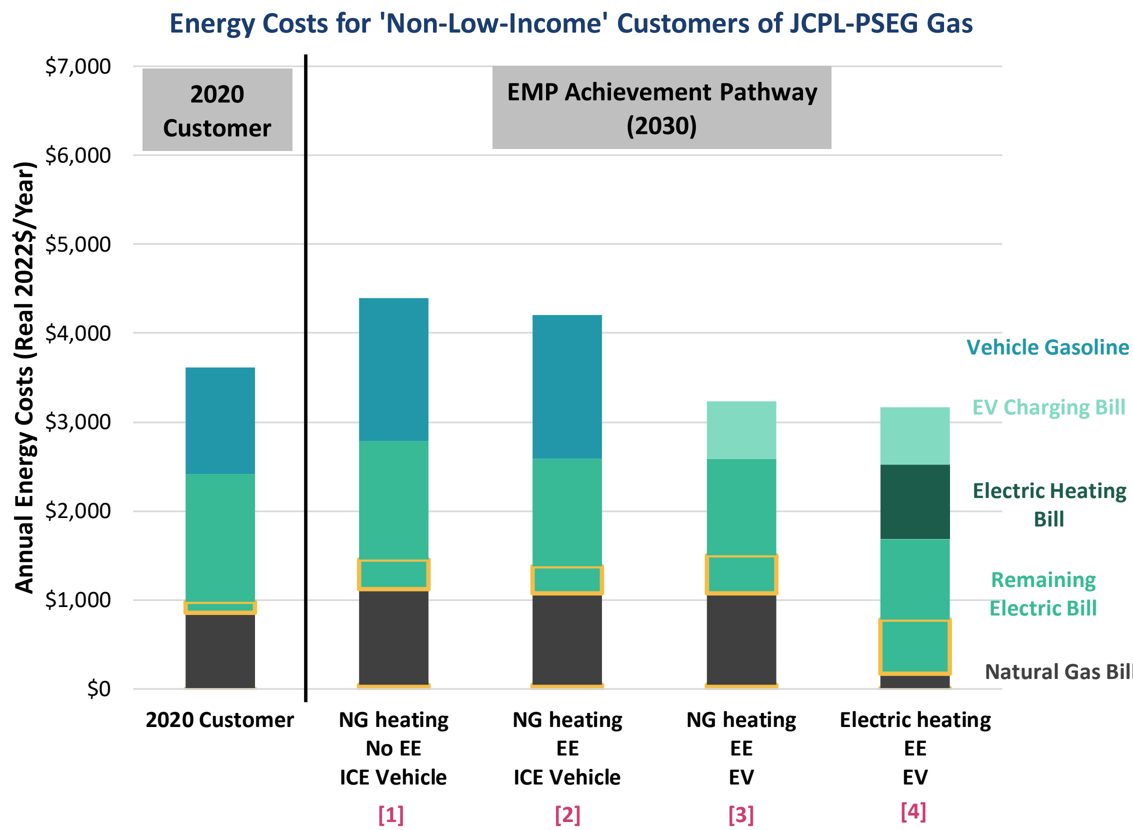
JCPL – PSEG GAS





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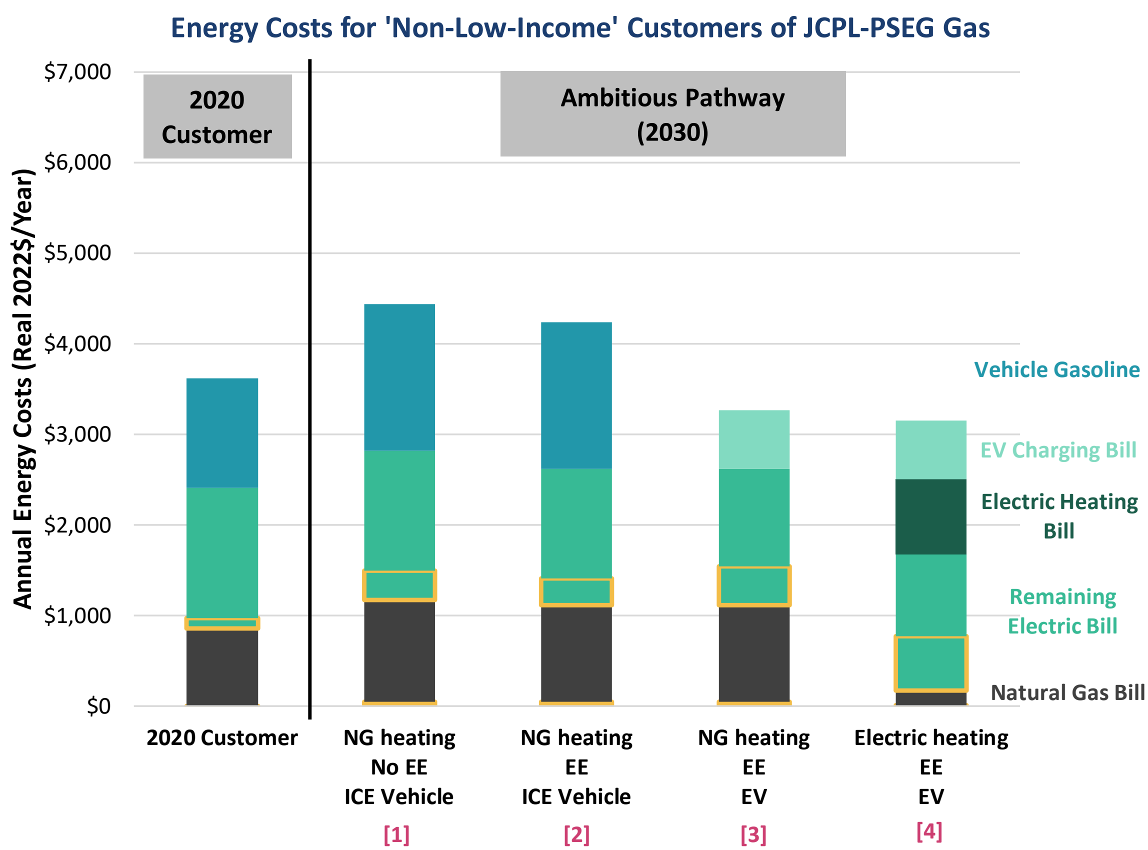

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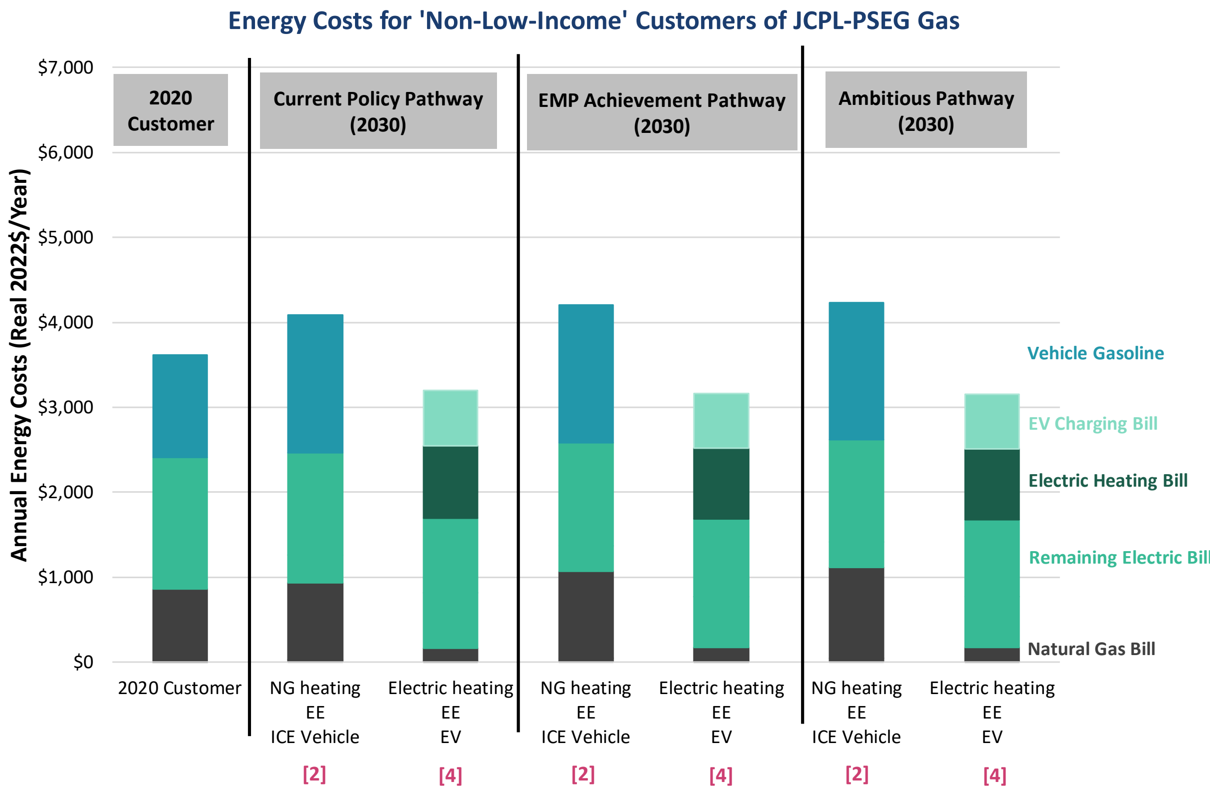
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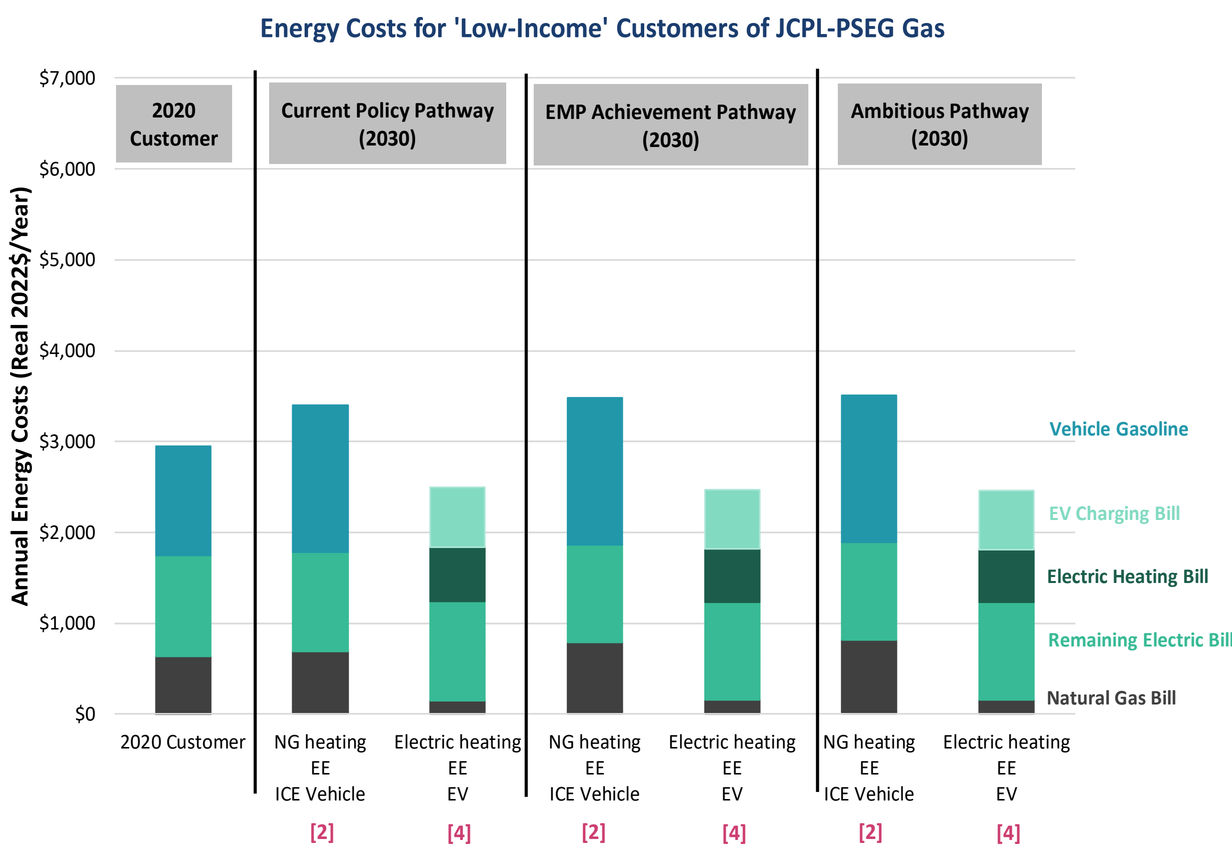
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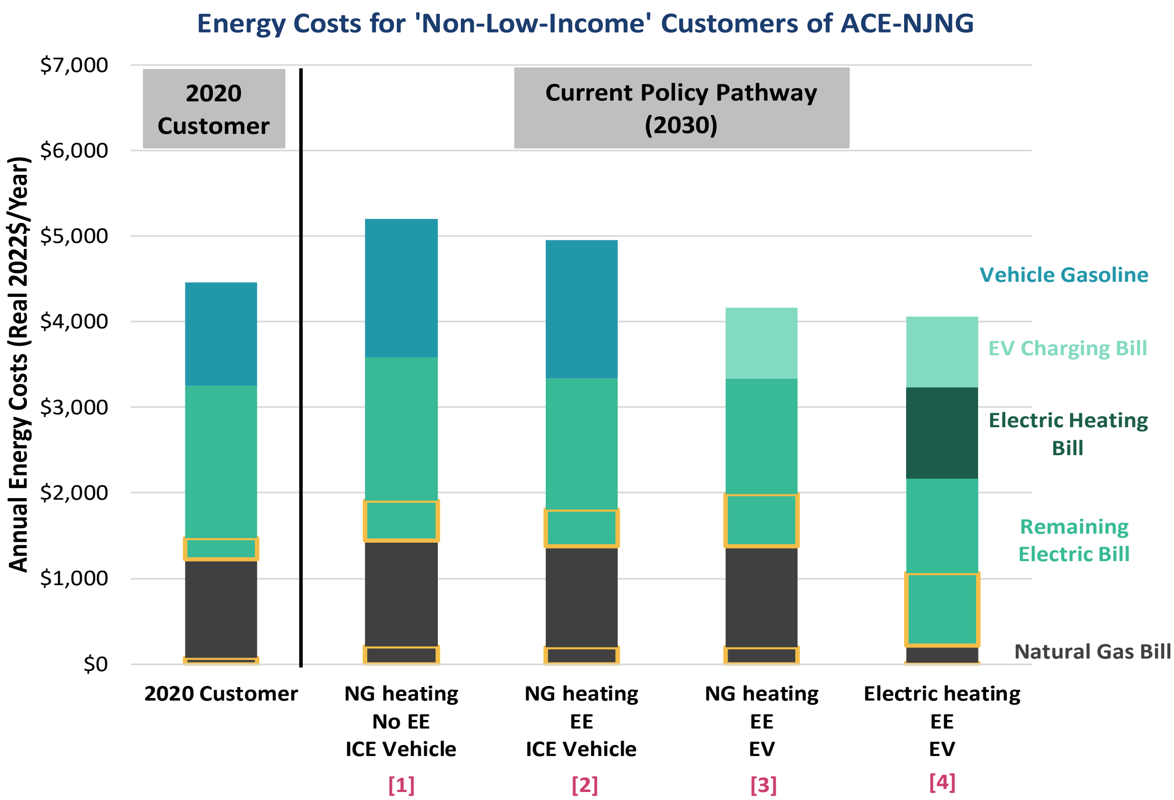
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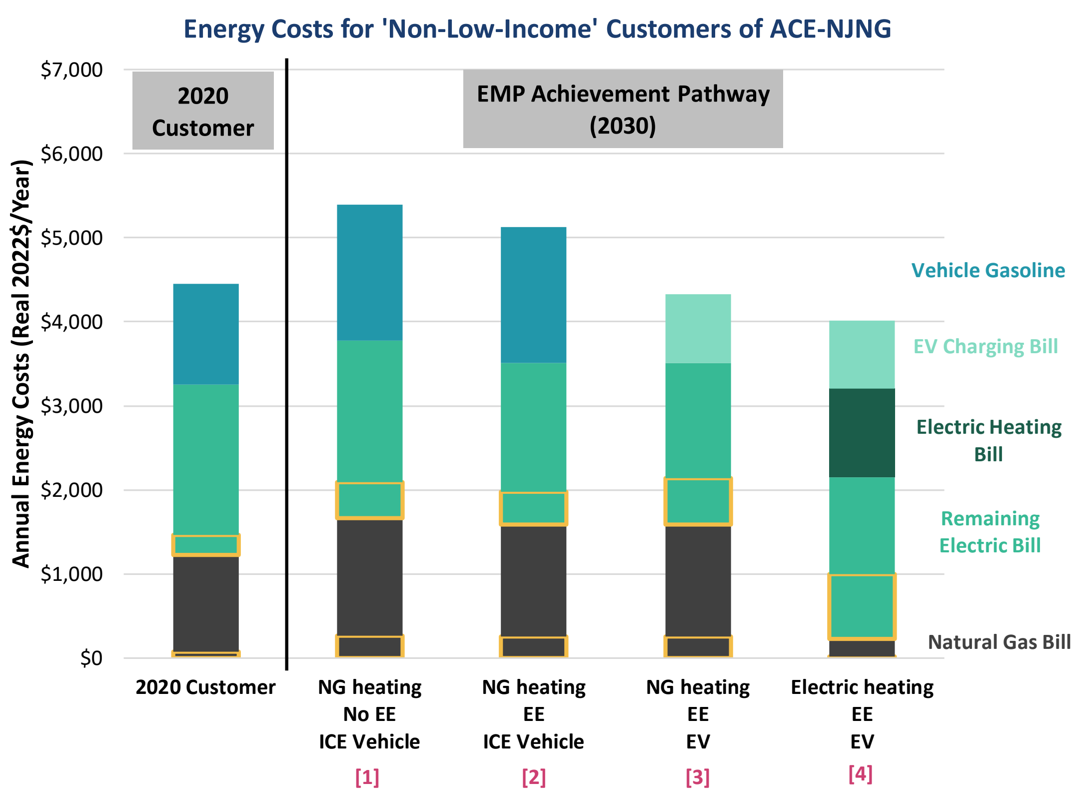
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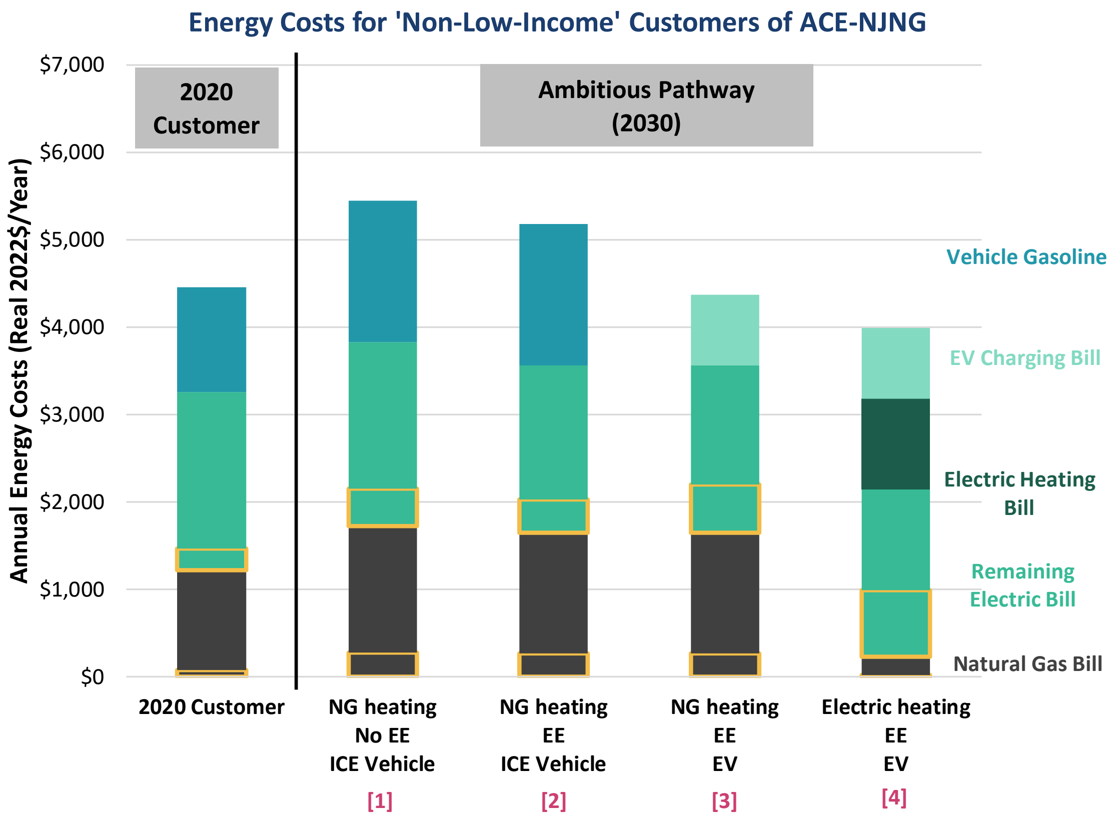
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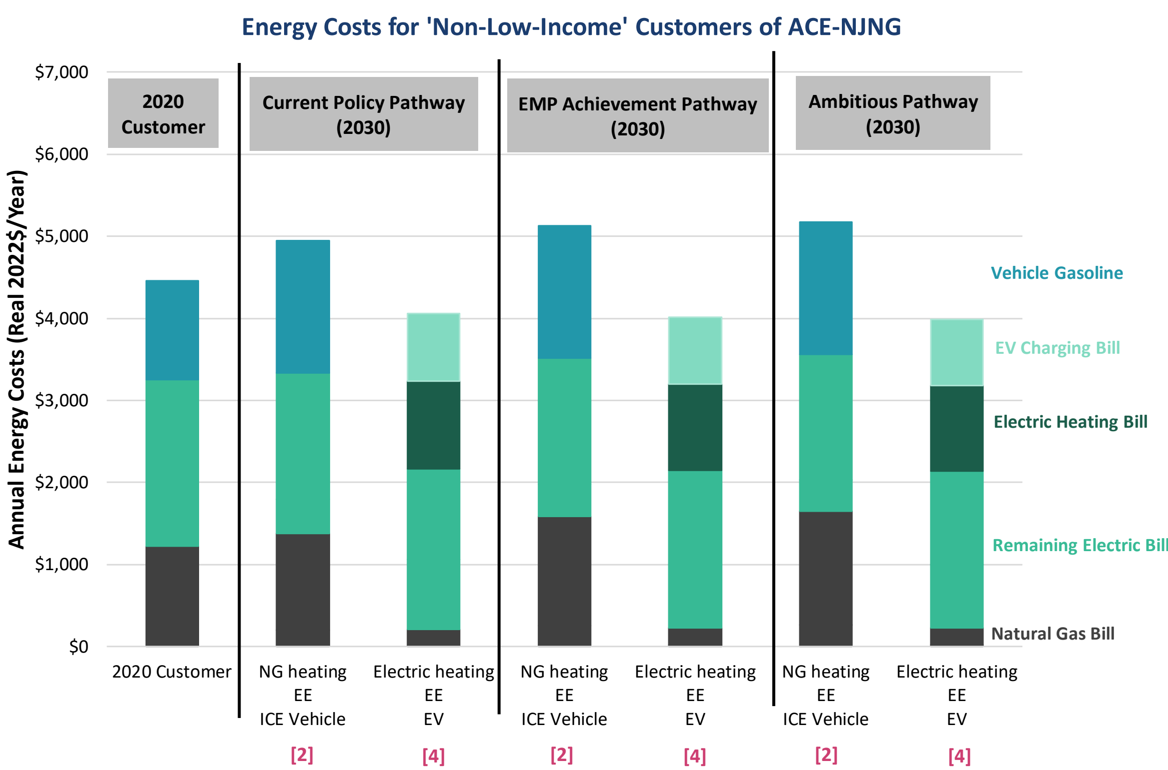
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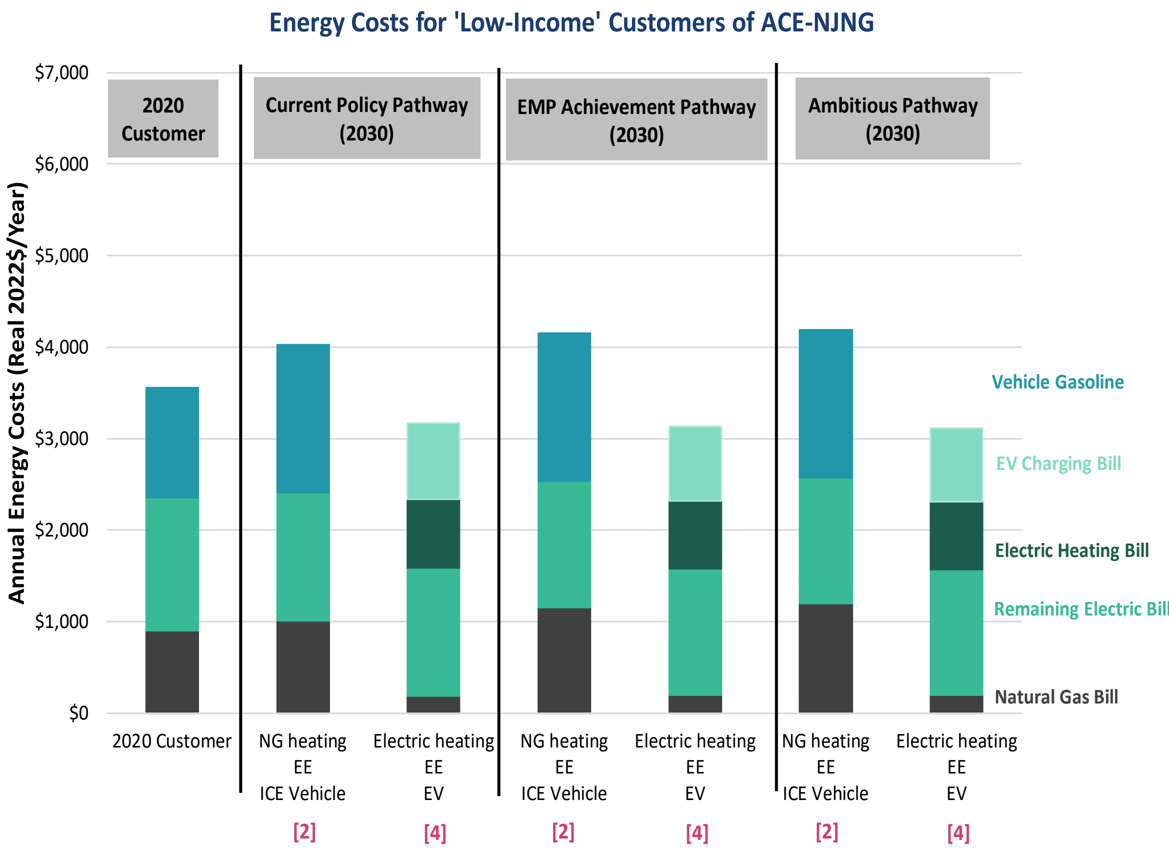


F.2 Annual Energy Costs for Residential Customers Using Fuel Oil

The purpose of this analysis is to quantify the annual energy costs of representative delivered fuel customers as of 2020. For this analysis, we estimated the annual energy bills faced by residential customers in 2020 who used fuel oil for heating purposes instead of natural gas or electricity.

We find that the total annual energy bills of customers who used fuel oil were almost 20% *higher* than customers who used natural gas for heating in 2020. Fuel oil customers will have more to gain than natural gas customers (i.e. [Customer 2020]) by electrifying their end uses since their starting cost is higher than natural gas customers. Given the key findings of this Study, this analysis indicates that fuel oil customers would experience savings in operating costs if they switched to natural gas for heating and even higher savings if they switch to electric heat pumps in 2030. Note that this Study does not include costs due to equipment purchases or operation and maintenance.

Below, we explain how we created a 'fuel oil' customer profile, computed their annual bills and compared their total energy bills against their counterparts who used natural gas heating.

Per the U.S. Energy Information Administration, 7.4% of New Jersey households used fuel oil to heat their homes in 2020.[130] Given that there were 3.3 million households[131] in New Jersey in 2020, we estimate that roughly 240,000 households used fuel oil for heating purposes. To estimate the average fuel oil use per household, we assumed that only these 240,000 households use fuel oil in New Jersey. We the obtained the fuel oil use for low-income and non-low-income households based on the natural gas consumption patterns for low-income and non-low-income households. According the 2015 Residential Energy Consumption Survey (RECS), low-income households consumed 12% less natural gas than average whereas non-low-income households consumed 25% more natural gas than average.[132] Table 27 shows the fuel oil consumption by low-income and non-low-income households.

TABLE 27: AVERAGE ANNUAL FUEL OIL CONSUMPTION[133]

Customer Type	Units	Annual Consumption (2020)
Low-Income	Gallons	535
Non-Low-Income	Gallons	757

We assume that the fuel oil that these households use replaces the natural gas they would otherwise use to heat their homes. According to the RECS, residential customers in the Middle Atlantic Census Region (which includes New Jersey) used 93% of their natural gas for heating purposes.[134] Customers who use fuel oil for heating would use about 7% as much natural gas as their counterparts. Table 28 displays the estimated natural gas consumption by customers who use fuel oil for heating.

[130] Consumption & Expenditures, New Jersey State Energy Profile, New Jersey Quick Facts. New Jersey Profile (eia.gov).

[131] Table S1901: Income in the Past 12 Months, American Community Survey, United States Census Bureau. S1901: INCOME IN THE PAST 12 MONTHS... - Census Bureau Table.

[132] Table CE2.2 'Annual household site fuel consumption in the Northeast – totals and averages, 2015', Consumption & Expenditures (C&E) Tables, 2015 RECS Survey Data, Residential Energy Consumption Survey (RECS). U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.

[133] These figures are based on data that residential customers in New Jersey used 147 million gallons of fuel oil in 2020. Source: Sales of Distillate Fuel Oil by End Use – New Jersey, Petroleum & Other Liquids, New Jersey Sales of Distillate Fuel Oil by End Use (eia.gov).

[134] Table CE4.1 'End-use consumption by fuel in the U.S. – totals', Consumption & Expenditures (C&E) Tables, 2015 RECS Survey Data, Residential Energy Consumption Survey (RECS). U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.

TABLE 28: NATURAL GAS CONSUMPTION BY HOUSEHOLDS WHICH USE FUEL OIL

Customer Type	Units	Annual Consumption (2020)
Low-Income	Therms	49
Non-Low-Income	Therms	70

With the new natural gas and fuel oil consumption estimates, we are able to derive the annual natural gas and fuel oil bills for low-income and non-low-income customers. We compute annual fuel oil bills by multiplying the consumption figures from Table 27 with the average residential heating oil price in 2020. Per the EIA, the average heating oil price in New Jersey was $2.81/gallon in 2020.[135] Based on this average price, we estimate that low-income customers paid about $1,504 annually for their fuel oil needs and non-low-income customers paid about $2,128.[136]

Brattle obtained the natural gas bills for these households by assuming the received gas service from South Jersey Gas Company. Based on South Jersey Gas' customer charge and volumetric rate in 2020, we estimate that low-income customers faced an annual natural gas bill of $194 and non-low-income customers faced an annual bill of $223.[137] Table 29 compares the annual energy bills for non-low-income customers with fuel oil heating and non-low-income customers with natural gas heating.

135 Weekly New Jersey No.2 Heating Oil Residential Price, Petroleum & Other Liquids, U.S. Energy Information Administration. Weekly New Jersey No. 2 Heating Oil Residential Price (Dollars per Gallon) (eia.gov).

136 For non-low-income customers, the calculation was as follows: 757 gallons x $2.81/gallon = $2,128.

137 South Jersey Gas customers faced an annual customer charge of about $126 and an average volumetric rate of $1.38/therm. For non-low-income customers who used fuel oil for heating, we computed their natural gas bills in the following manner: $126 + ($1.38/Therm) x (70 Therms) = $223.

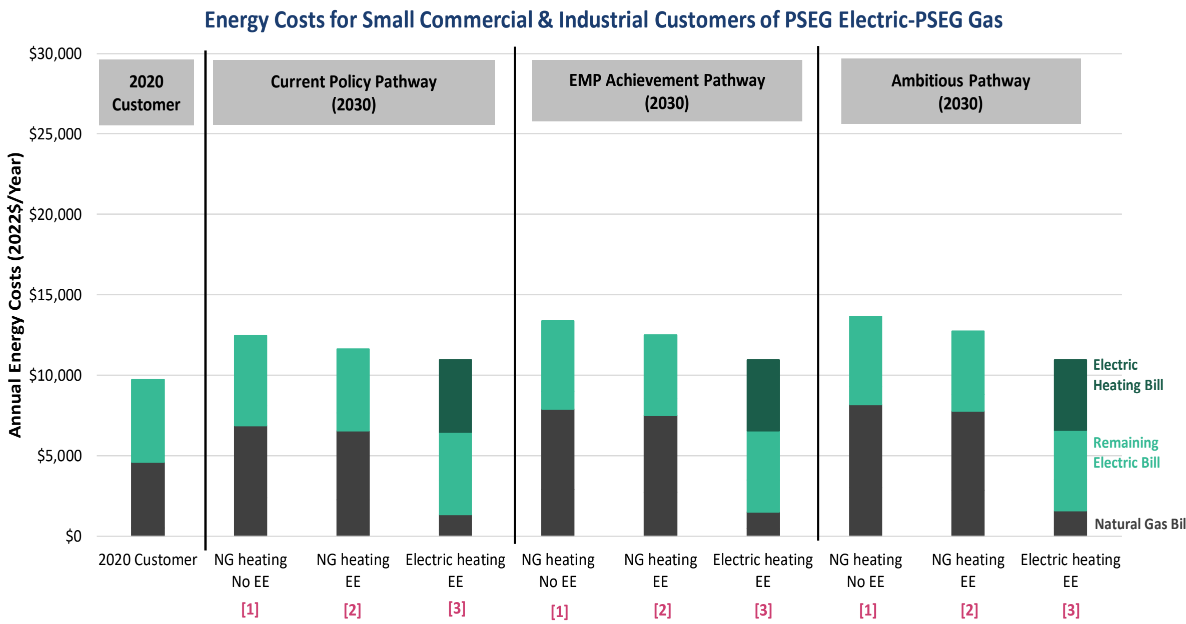
TABLE 29: ENERGY BILLS FOR FUEL OIL HEATING AND NATURAL GAS HEATING CUSTOMERS

Bill Component	Units	2020 Customer with NG Heating	2020 Customer with Fuel Oil Heating
Electricity customer charge	2022$/Year	$72	$72
Electricity rate	2022$/KWh	$0.20	$0.20
Electricity consumption	KWh/Year	9,834	9,834
Electricity Cost	**2022$Year**	**$2,028**	**$2,028**
Natural Gas customer charge	2022$/Year	$126	$126
Natural Gas rate	2022$/Therm	$1.38	$1.38
Natural Gas consumption	Therms/Year	1,010	70
Natural Gas Cost	**2022$/Year**	**$1,517**	**$223**
Fuel Oil rate	2022$/Gallon	$2.81	$2.81
Fuel Oil consumption	Gallons/Year	0	757
Fuel Oil Cost	**2022$/Year**	**$0**	**$2,128**
Gasoline price	2022$/Gallon	$2.35	$2.35
Gasoline consumption	Gallons/Year	511	511
Vehicle Fuel Cost	**2022$/Year**	**$1,201**	**$1,201**
ANNUAL ENERGY COST	**2022$/Year**	**$4,747**	**$5,580**

By using fuel oil to heat their homes, non-low-income customers spend $834 more annually to cover their annual energy needs than customers with natural gas heating.

F.3 Small C&I Customers

PSEG ELECTRIC – PSEG GAS



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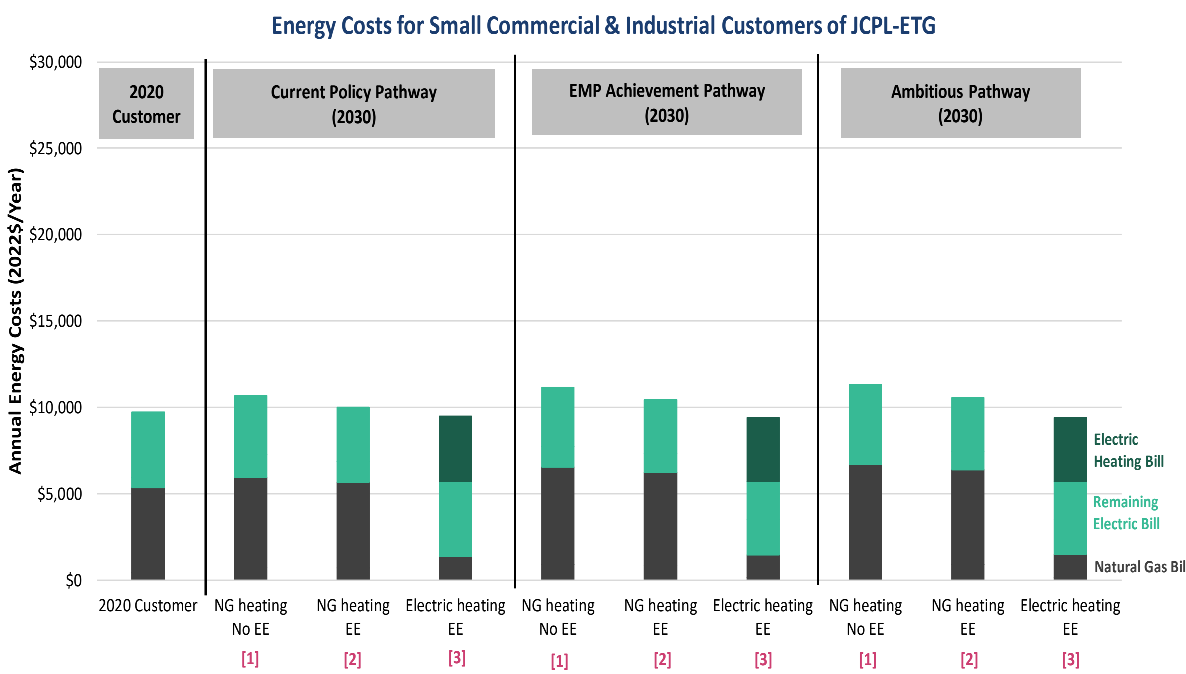
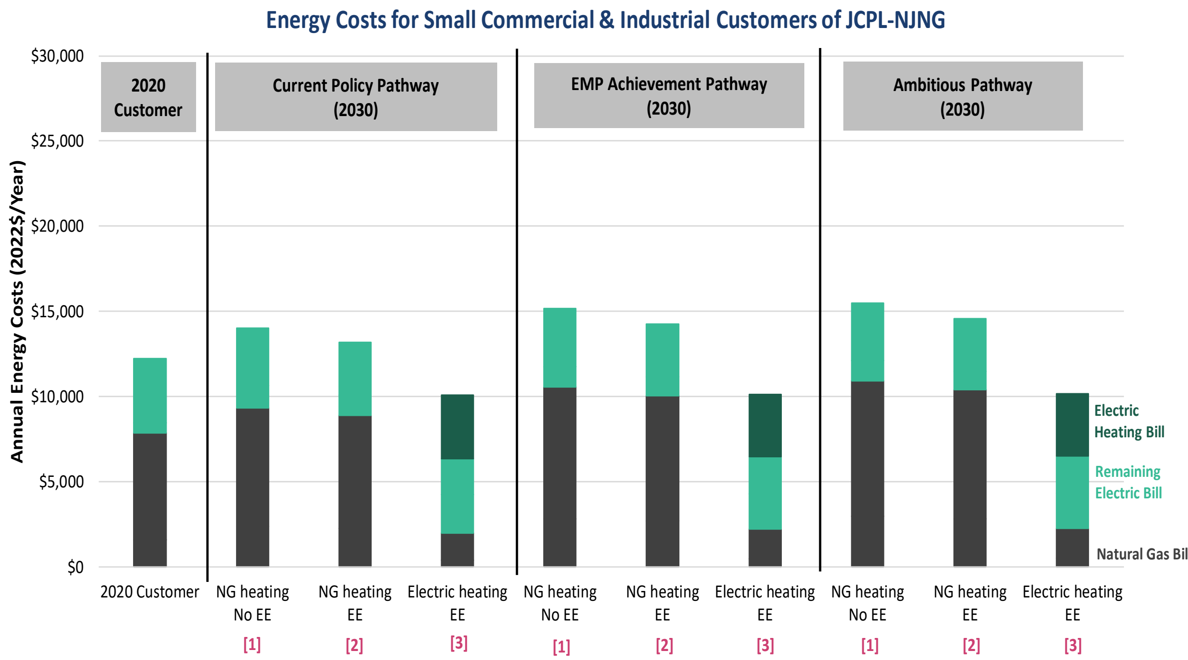
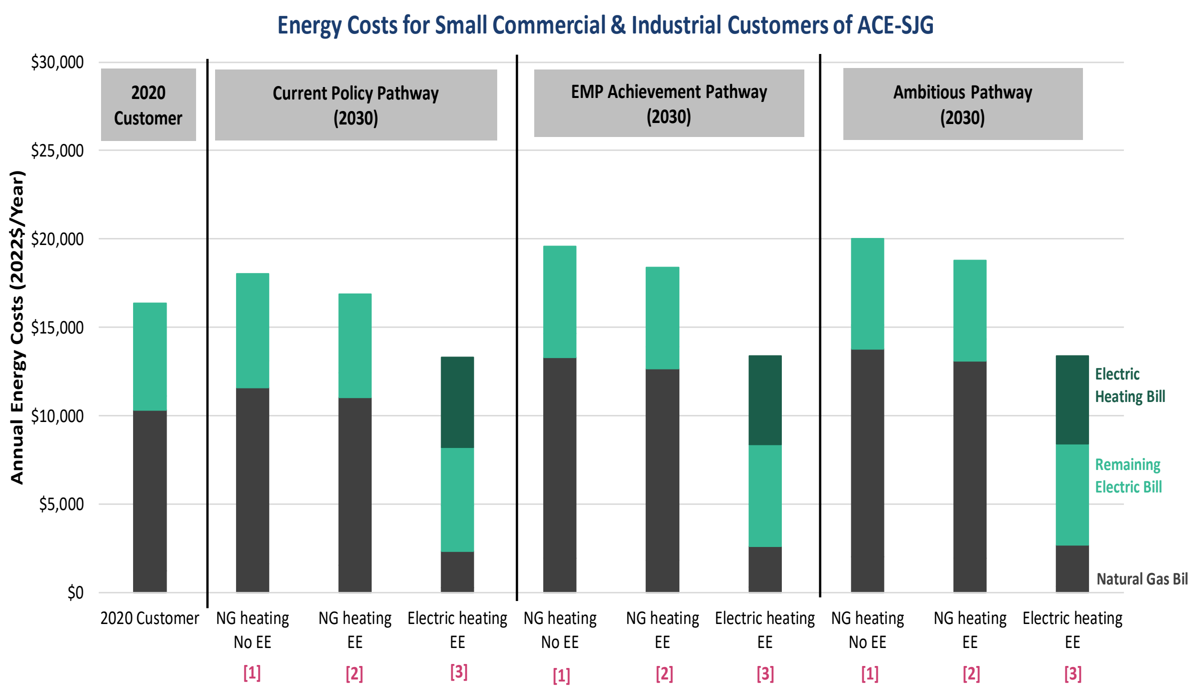


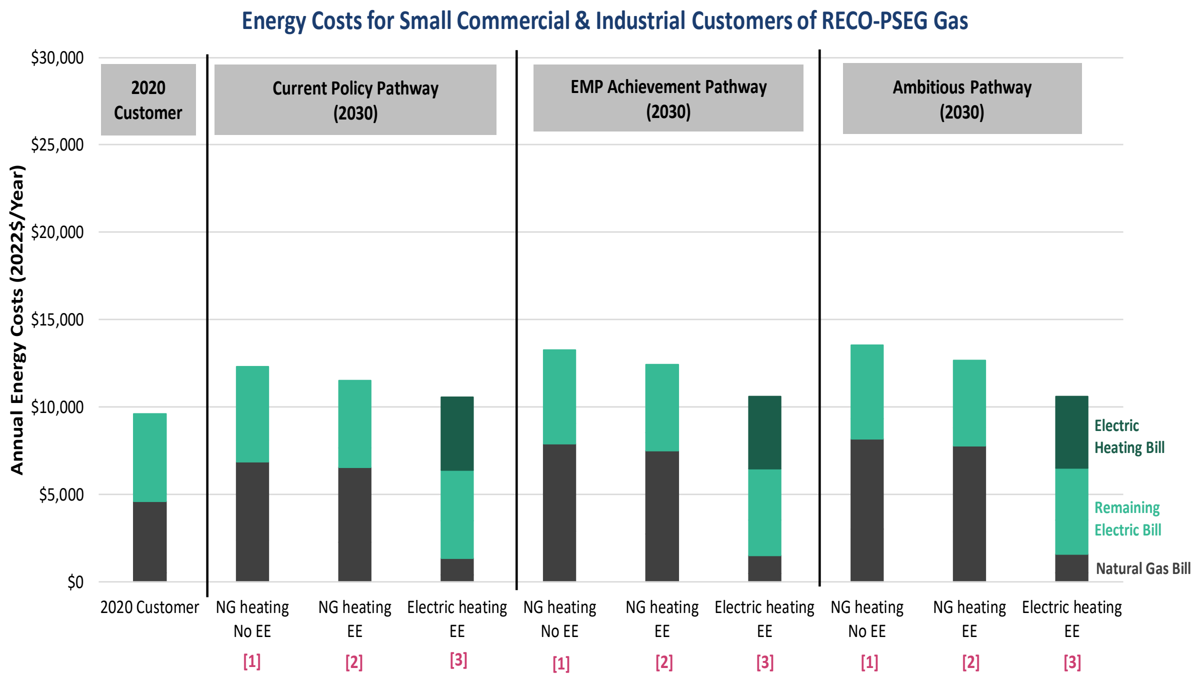
JCPL – NJNG



ACE – SJG



RECO – PSEG GAS



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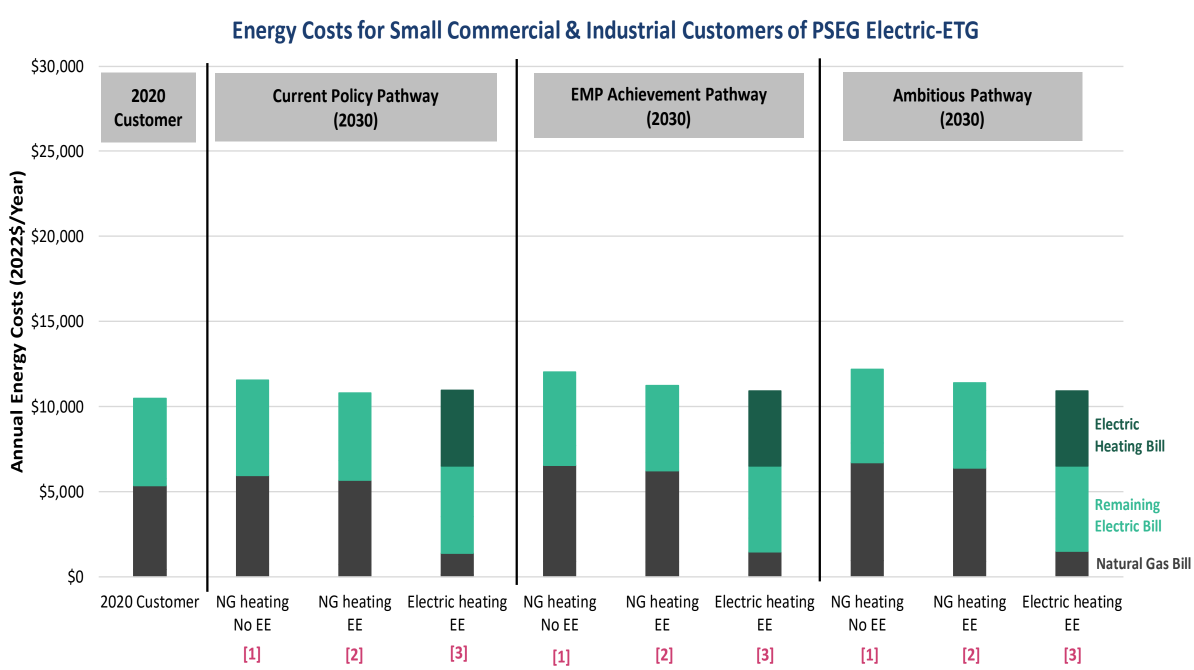

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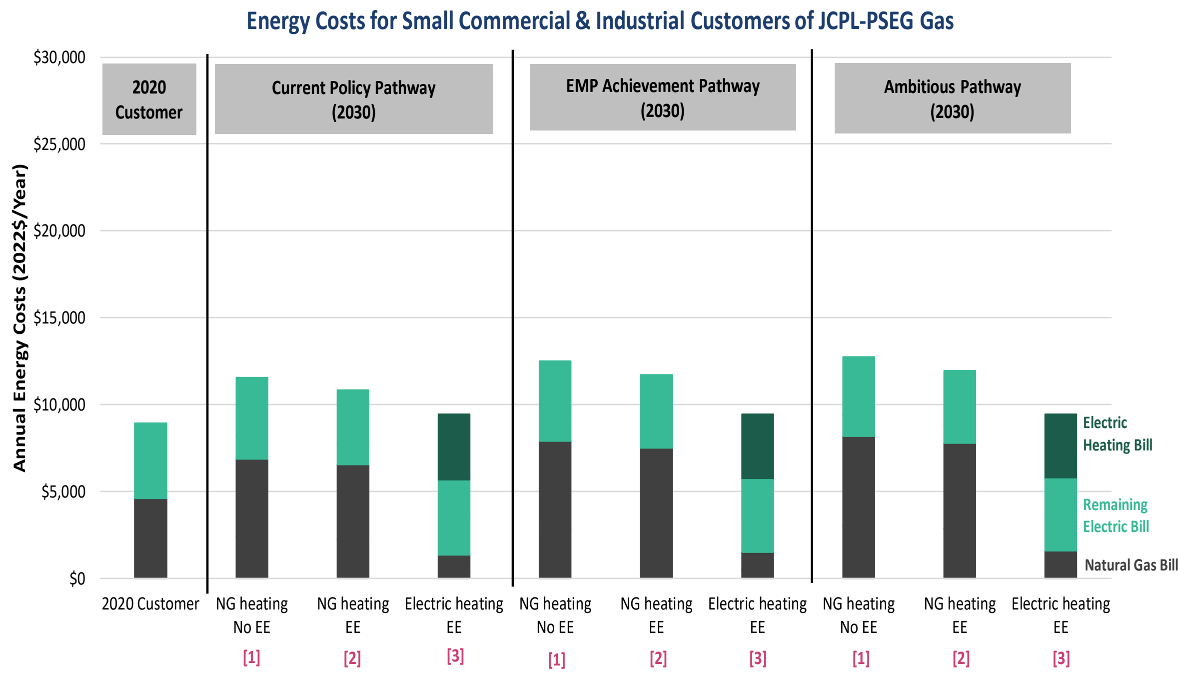

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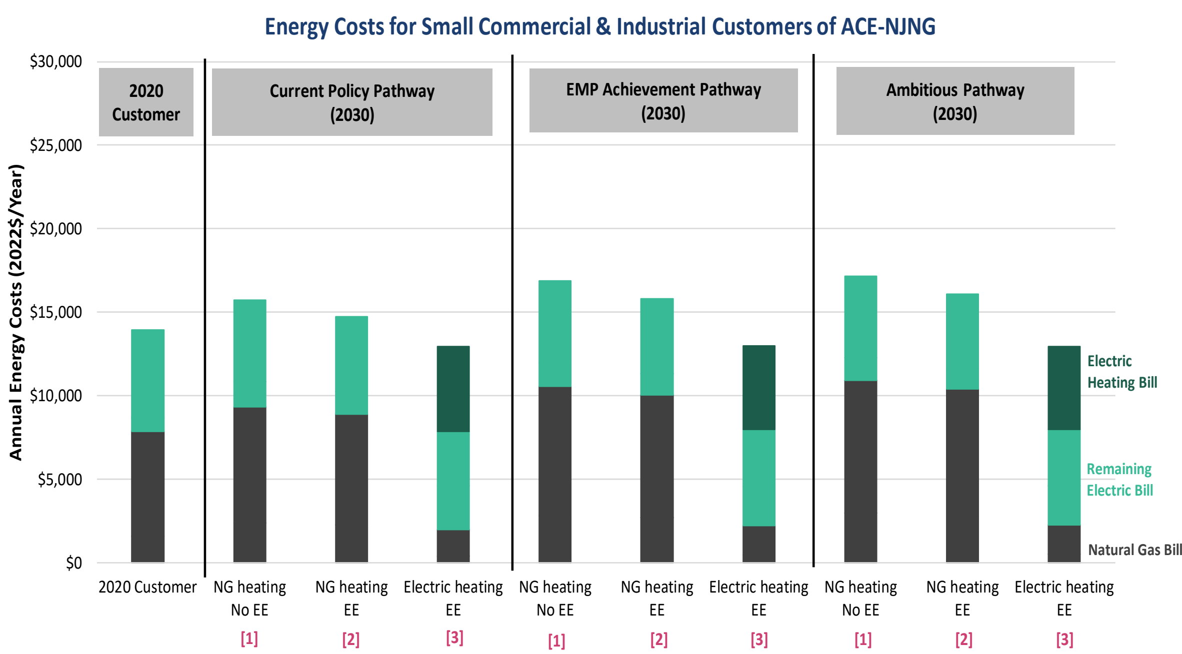
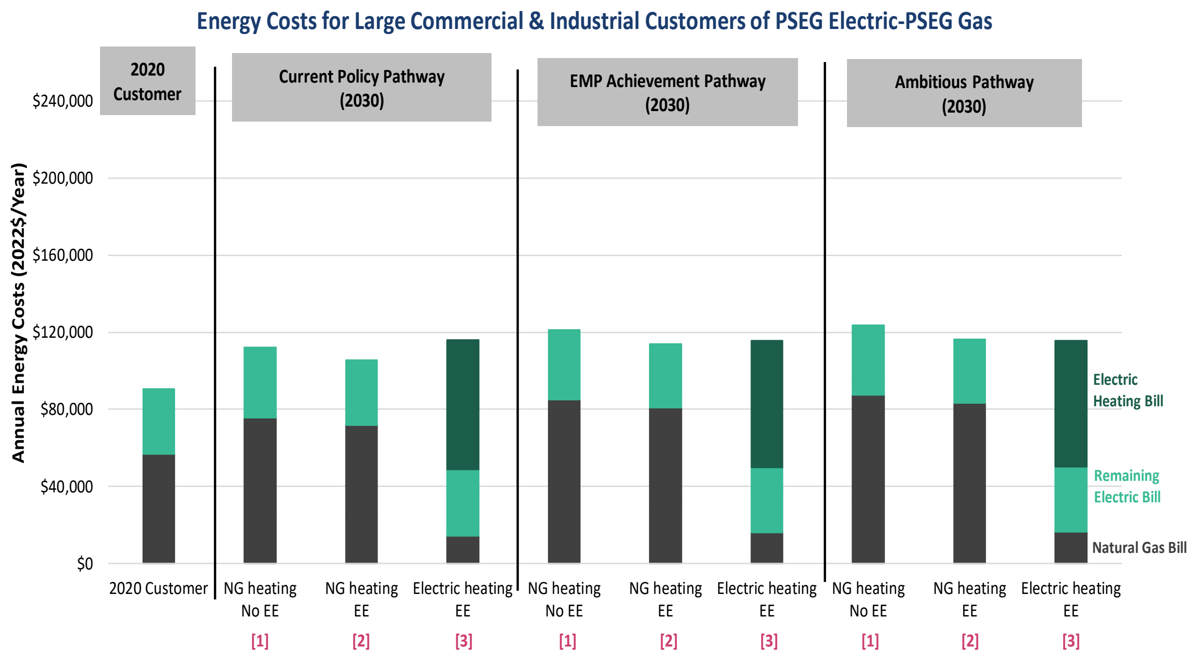


F.4 Large C&I Customers

PSEG ELECTRIC – PSEG GAS



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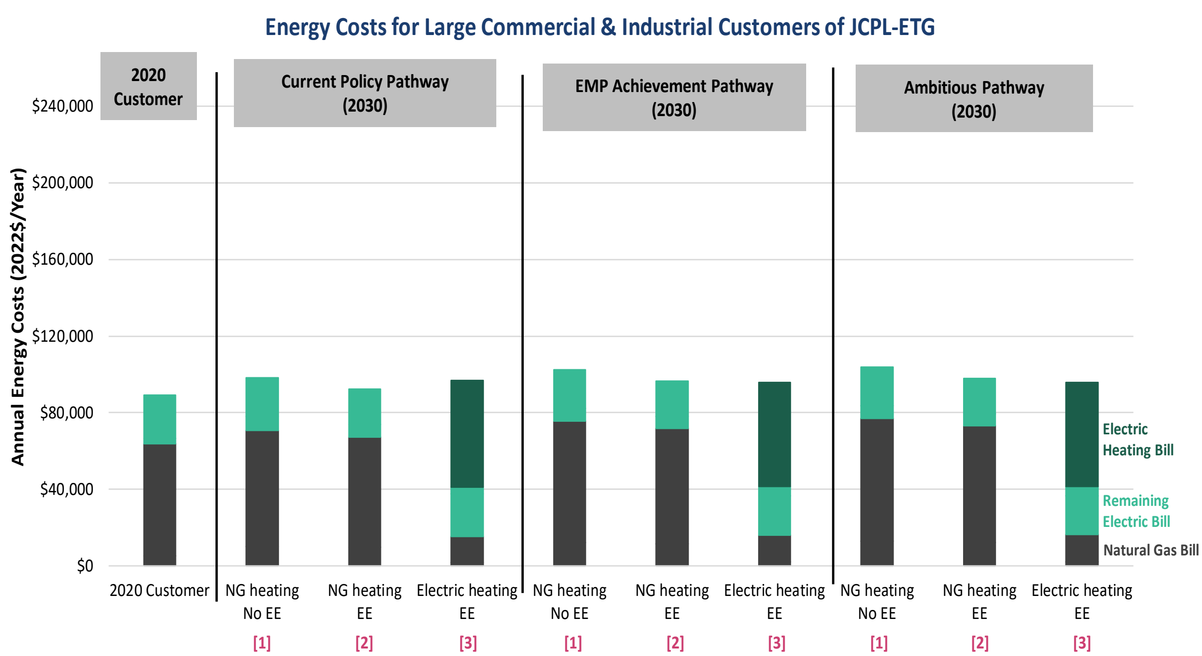

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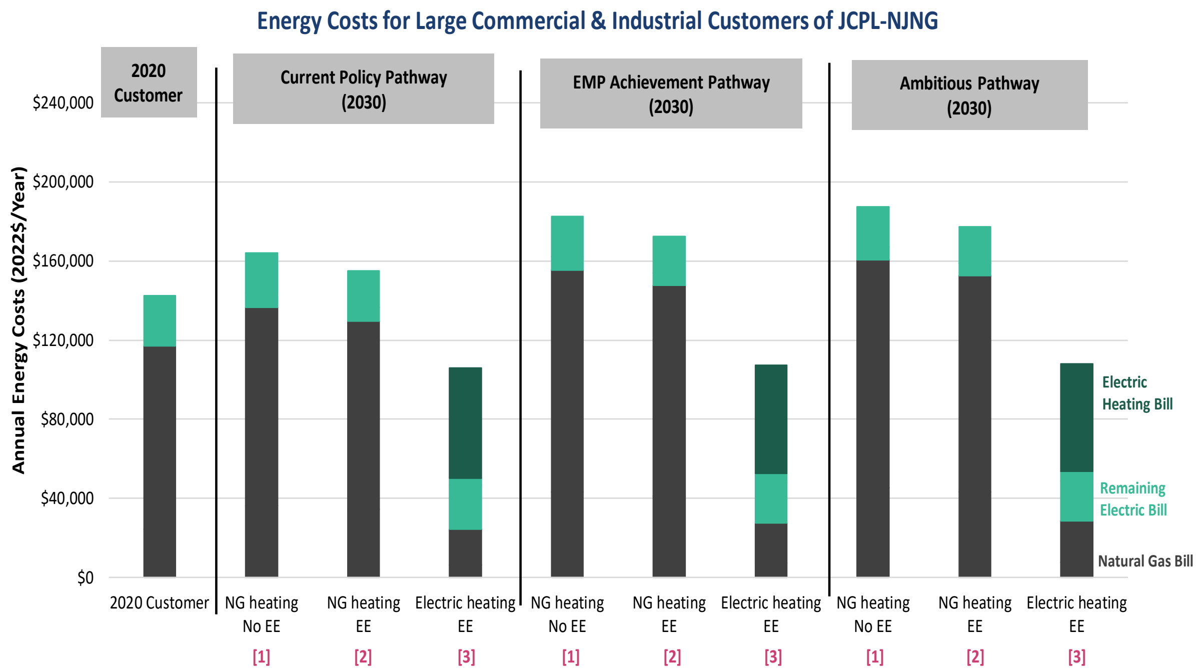

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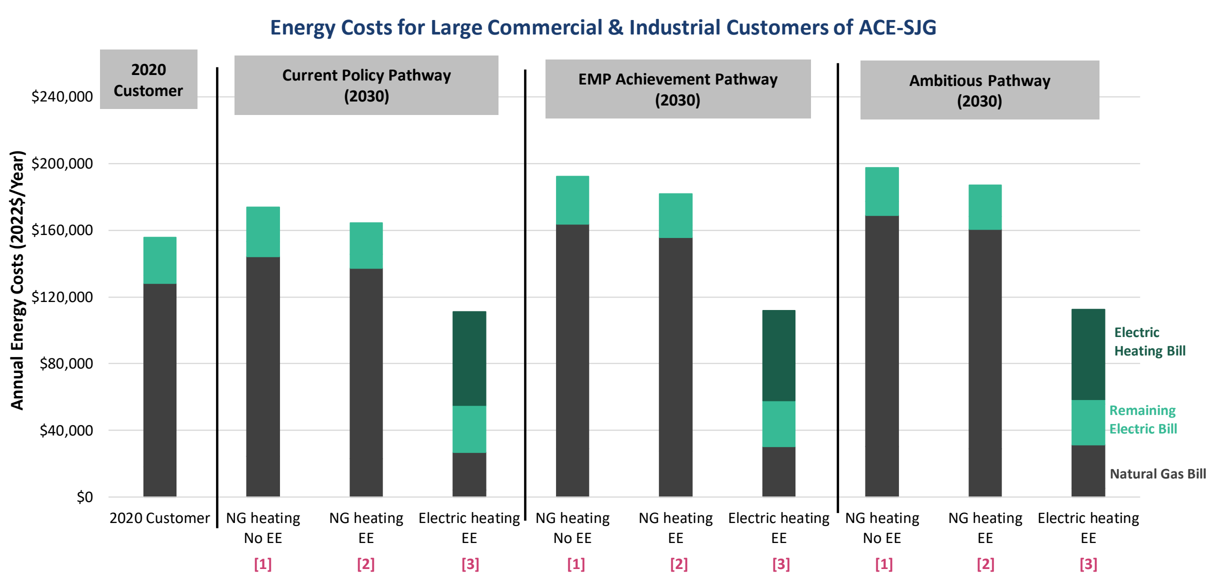

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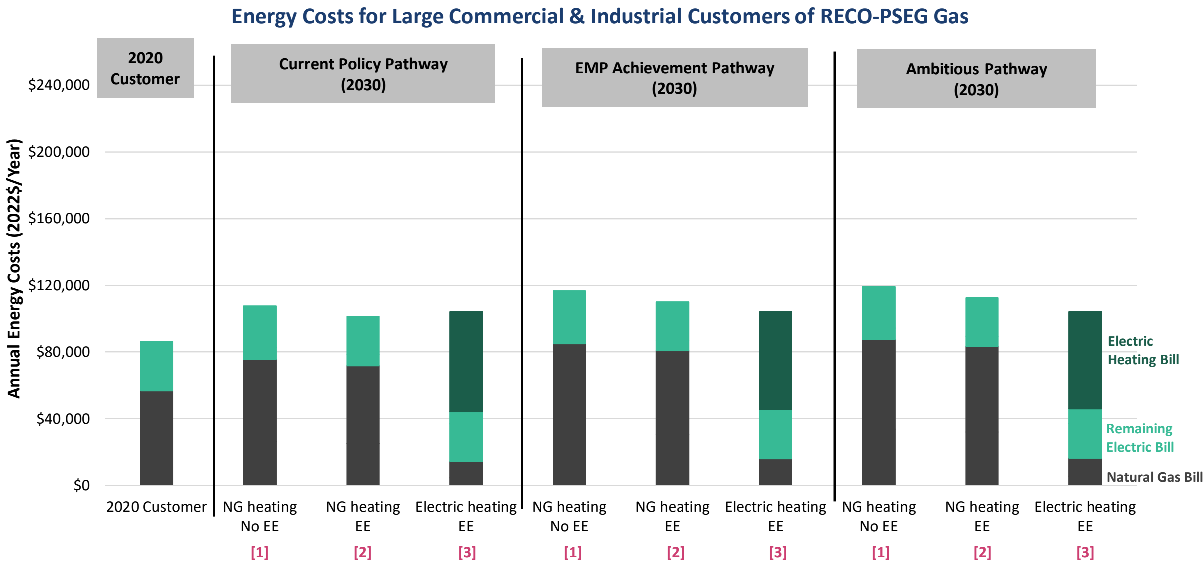

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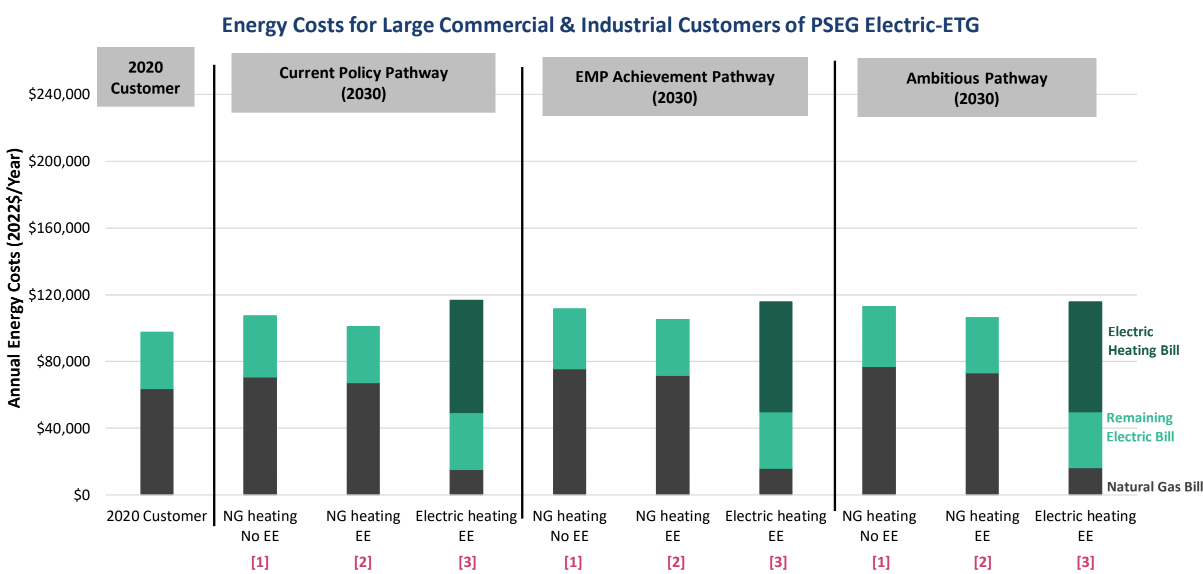

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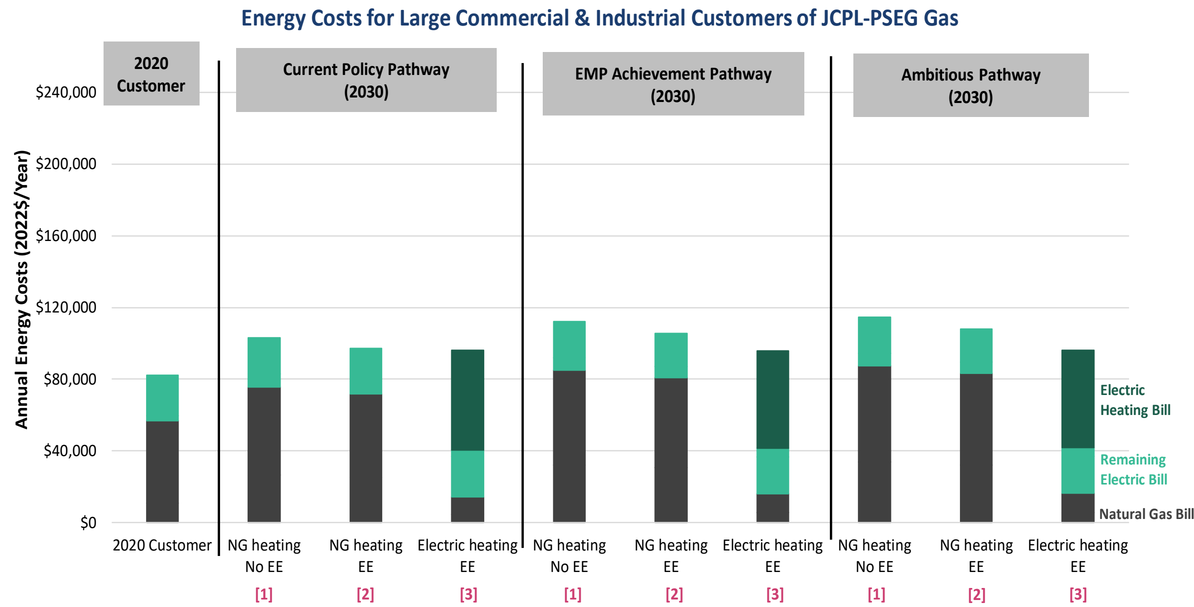

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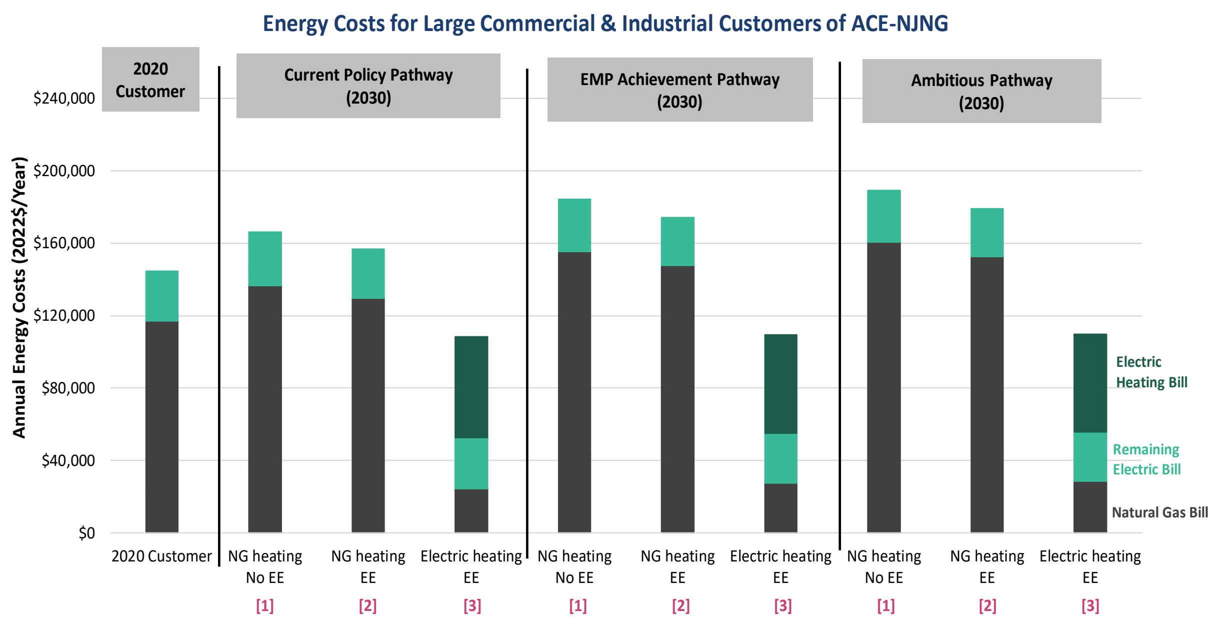

Appendix G: References

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