NEW JERSEY
INTEGRATED ENERGY PLAN

PUBLIC WEBINAR

NOVEMBER 1, 2019

Webinar agenda

- About the New Jersey Integrated Energy Plan
- High level findings
- Questions and Answer
- Detailed findings
- Question and Answer

<u>To ask questions</u>

- Use the Questions feature of GotoWebinar (you must use your computer or the GotoWebinar app on your mobile device to ask questions)
- We will do our best to answer all clarifying questions about the Integrated Energy Plan process, modeling assumptions or methodology, and modeling results.

NEW JERSEY INTEGRATED ENERGY PLAN

- The Integrated Energy Plan (IEP) will inform New Jersey's Energy Master Plan (EMP) by modeling least-cost pathways that meet both the energy needs of NJ's growing economy and the state's emissions reduction targets.
- Modeling and interpretation has been informed by two workshops, in June and October. The Board of Public Utilities invited stakeholders that represent NJ's diverse interests.

The Board of Public Utilities contracted with Rocky Mountain Institute for the IEP analysis

Rocky Mountain Institute (RMI) is an independent, nonprofit organization with 35 years of experience in energy analysis. RMI's mission is to transform energy use to create a clean, prosperous, and secure low-carbon future. From RMI, Chaz Teplin and Mark Dyson are helping with this webinar today.

RMI subcontracted with Evolved Energy Research to help with modeling. Evolved has deep industry knowledge and extensive consulting experience focused on the questions posed by energy transformation. EER's mission is to provide decision makers the analytical tools and insights they need to manage energy system transformation. From Evolved, Jeremy Hargreaves is helping with this webinar.

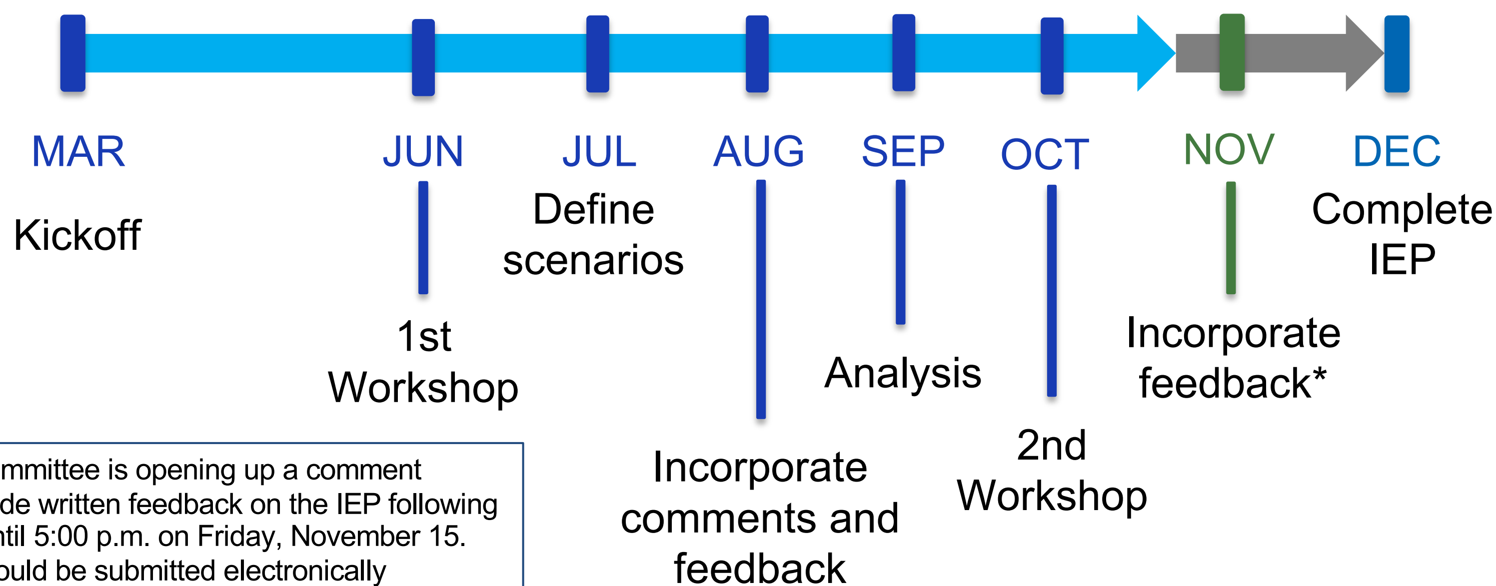
Project status: IEP modeling is complete. We are working to hear and incorporate feedback into the final IEP report and Energy Master Plan

The IEP effort set out to address three overarching questions

Where are we now?
What is the current state of New Jersey's energy system?

Where are we going?
What resource mixes and pathways meet 2050 emissions goals?

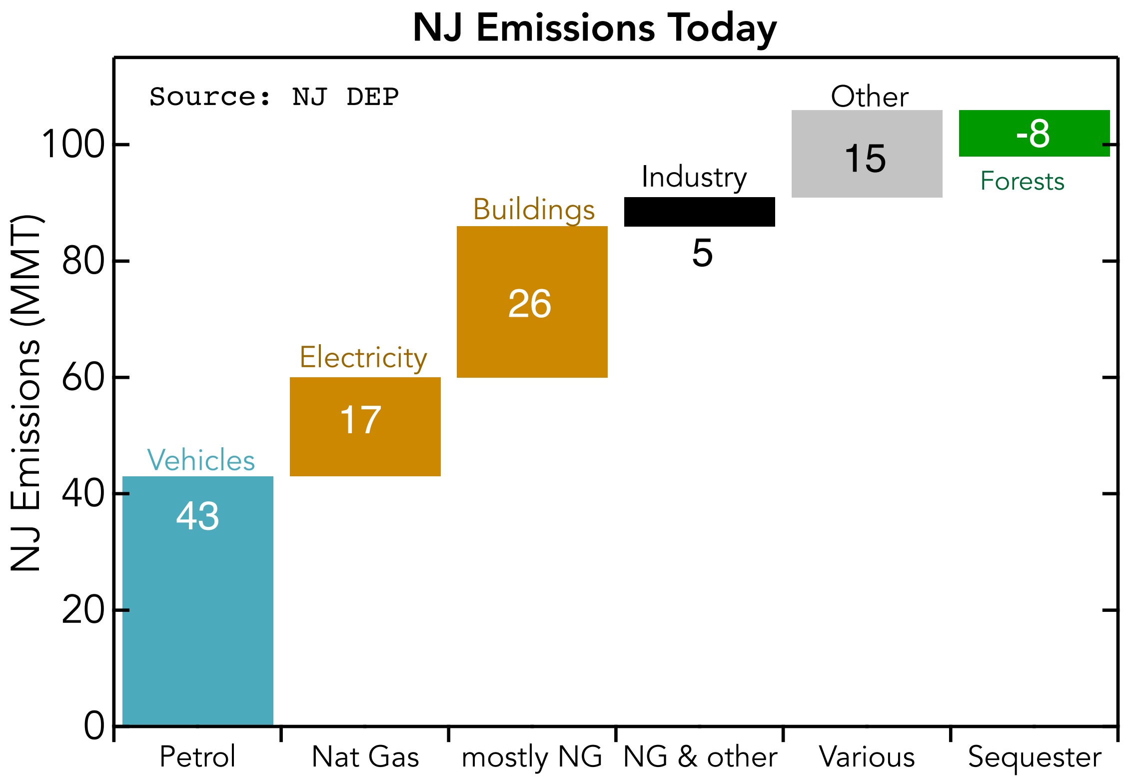
How should we get there?
What strategies are common to least-cost pathways?



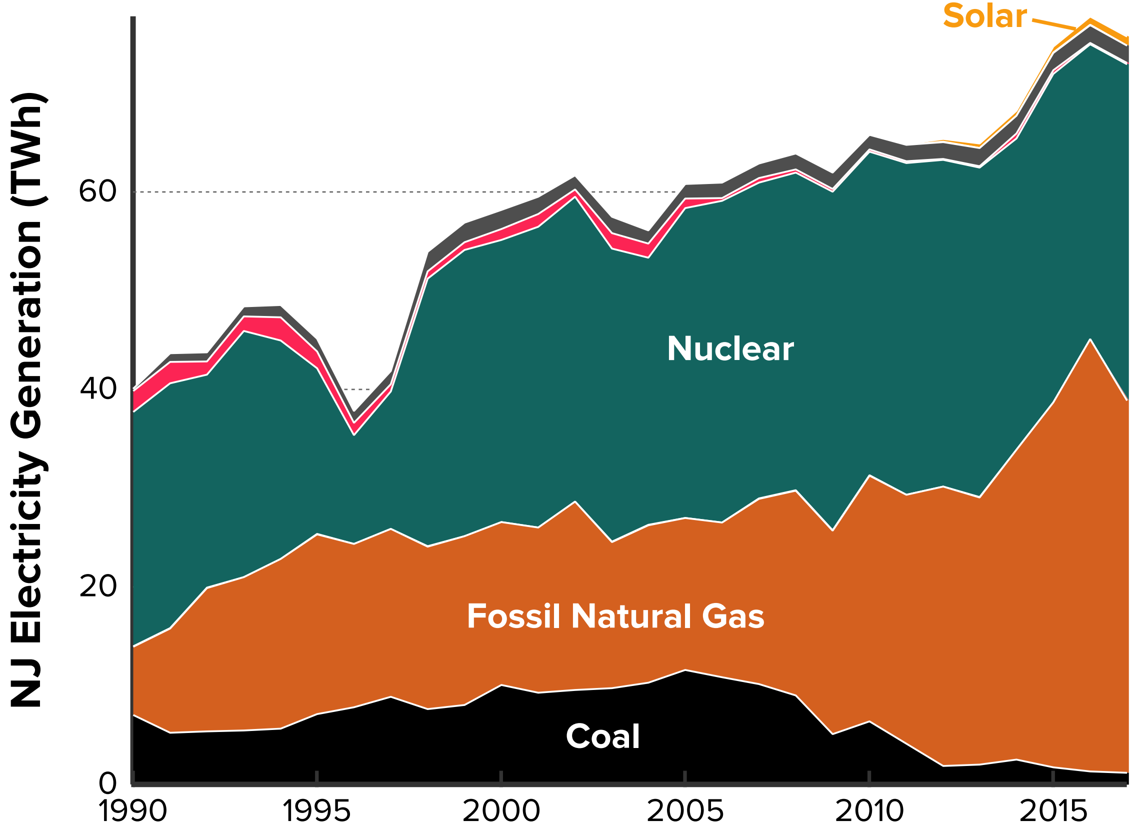
*The EMP Committee is opening up a comment period to provide written feedback on the IEP following the webinar until 5:00 p.m. on Friday, November 15. Comments should be submitted electronically to emp.comments@bpu.nj.gov, using the subject line "IEP feedback"

NEW JERSEY'S EMISSIONS AND ENERGY SYSTEM TODAY

Transportation, buildings, and electricity generation dominate NJ's emissions in 2019

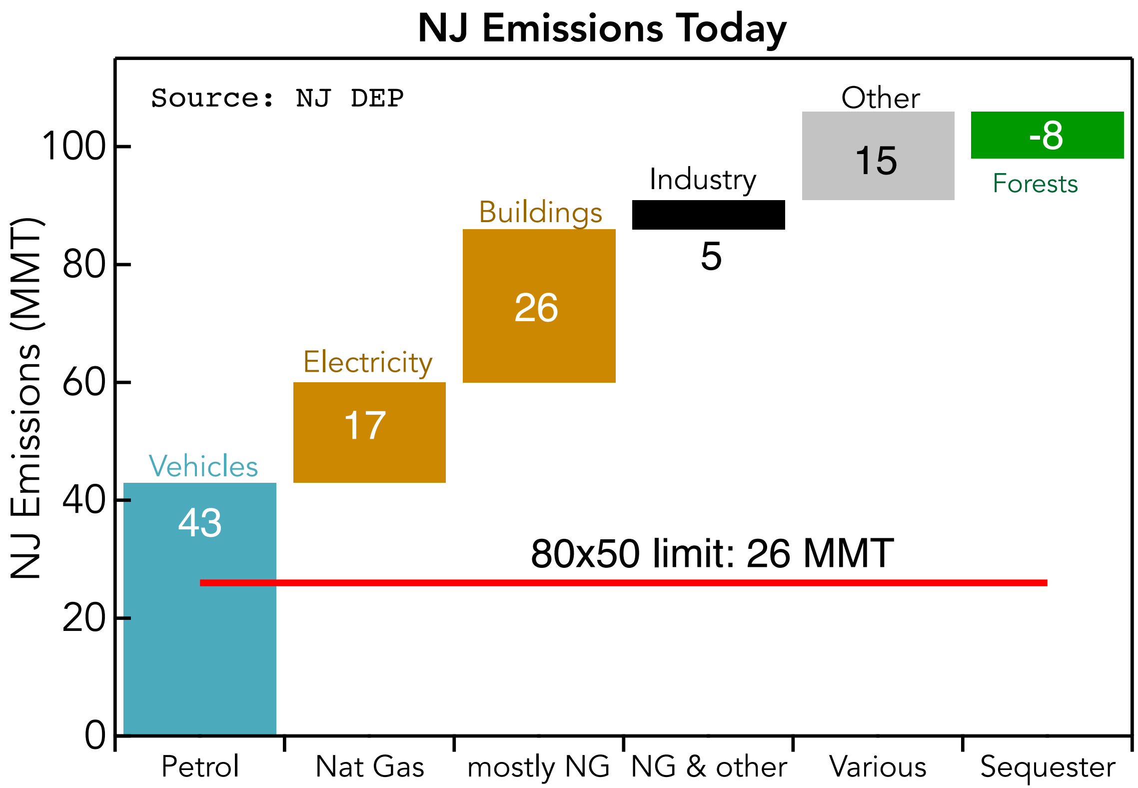


Today, New Jersey produces most of its electricity with nuclear and natural gas



Source: US Energy Information Agency

New Jersey's Global Warming Response Act (GWRA) and Governor Murphy's Executive Order set emissions reduction targets



80x50 goal

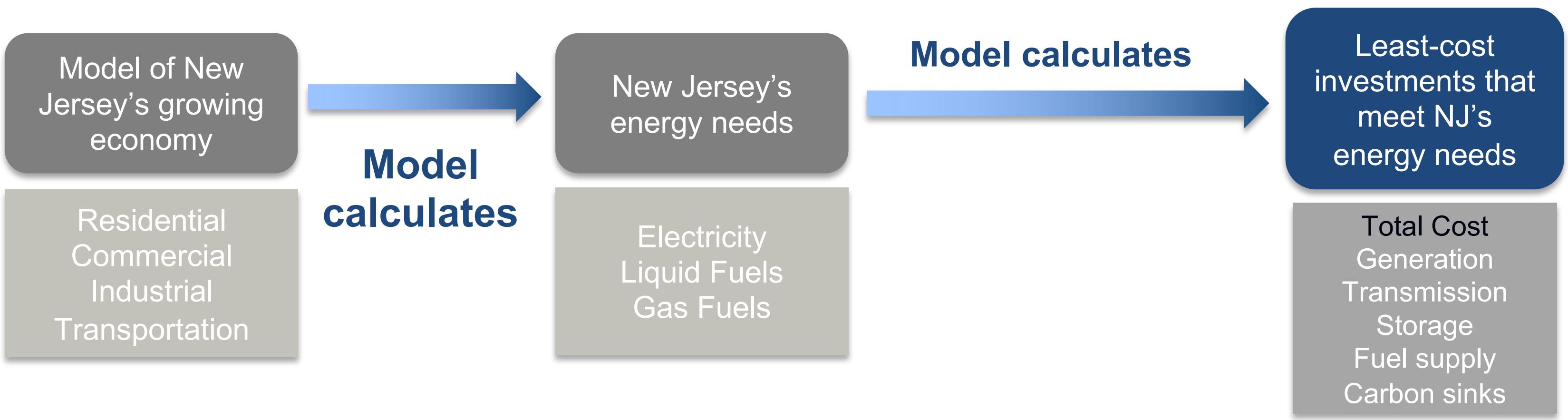
By 2050, reduce economy-wide emissions to 80% below 2006 levels

100% Clean Energy

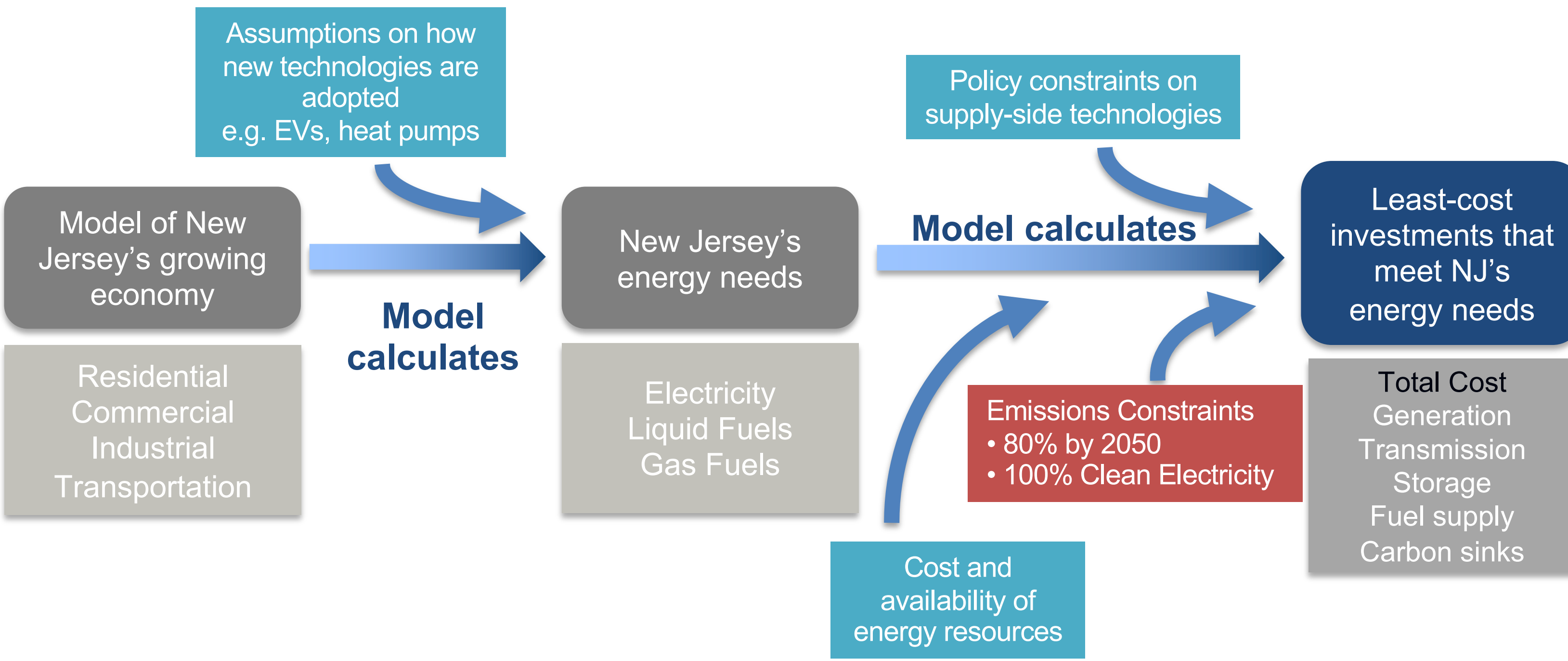
NJ electricity sector is carbon-neutral by 2050.

Integrated Energy Plan modeling reveals least-cost pathways that meet these emissions targets and the energy needs of New Jersey's growing economy.

IEP modeling approach



Review of IEP modeling approach



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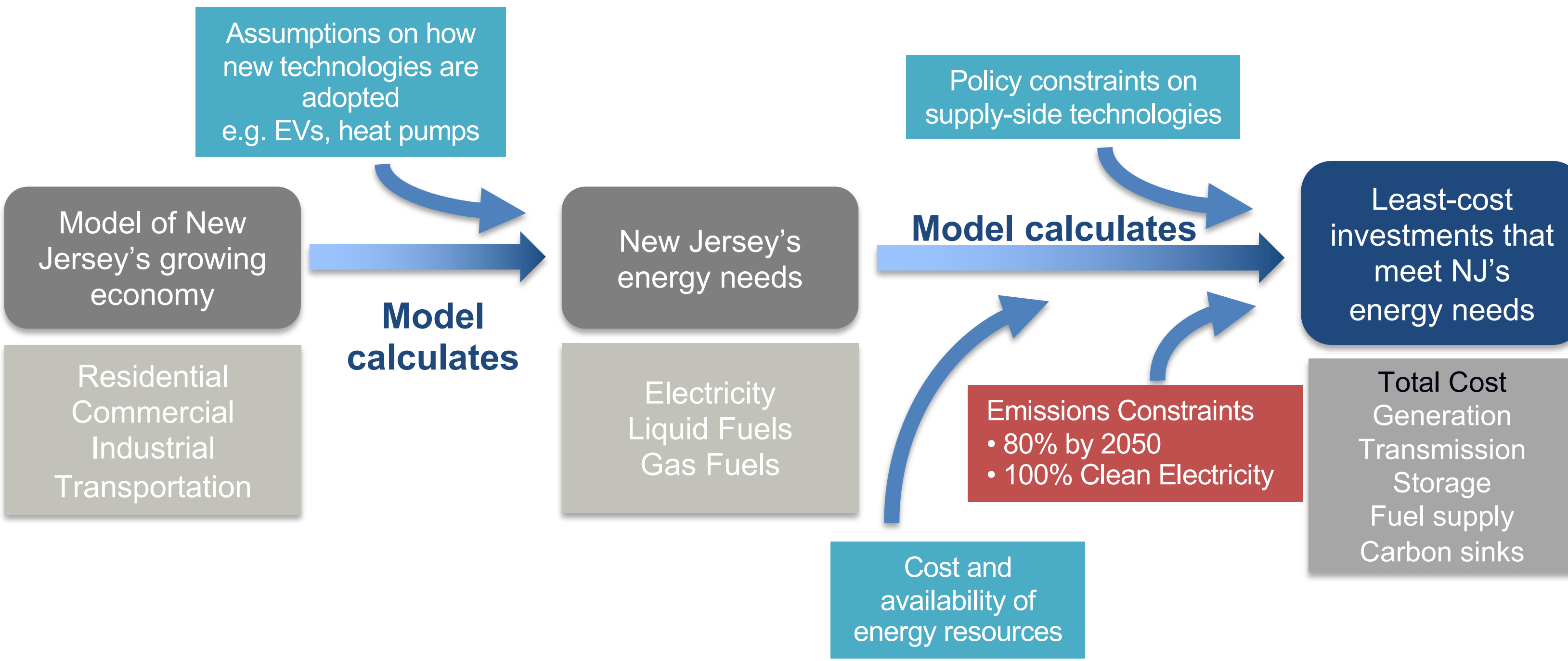


We modeled 7 scenarios that meet the emissions targets with different assumptions.
We modeled 2 references cases that did not meet the emissions constraints.

The IEP team worked with stakeholders to define nine scenarios to explore tradeoffs and implications of different external factors and policy decisions

Name	Summary	Key question
Reference 1	No current or prospective energy policies	What are cost and emissions outcomes of "business as usual?"
Reference 2	Existing policy except GWRA & 100% Clean	What cost and emissions impact do existing policies have?
Least Cost	Fewest constraints. Meets emissions goals	If all options are open to New Jersey, what is the least cost pathway to meet goals?
Variation 1	Regional deep decarbonization	How does regional climate action affect New Jersey's cost to meet goals?
Variation 2	Reduced regional cooperation	How can NJ meet its goals internally?
Variation 3	Retain fuel use in buildings	How would NJ meet its goals if it kept gas in buildings, and at what cost?
Variation 4	Faster renewables & storage cost declines	How would cheaper clean energy affect costs and resource mix?
Variation 5	Nuclear retires and no new gas plants	How does minimizing thermal generation affect decarbonization costs?
Variation 6	Reduced transportation electrification	How would NJ meet its goals if it kept fossil fuels in vehicles, and at what cost?

Final scenarios reflected a range of input assumptions across sectors

		Reference 1	Reference 2	Least Cost	Variation 1	Variation 2	Variation 3	Variation 4	Variation 5	Variation 6
		BAU – No Clean Energy Act	Existing carve-outs. No emissions goals	All Options to meet Goals	Region achieves 80 by 50 goals	Reduced regional cooperation	Retain gas use in buildings	Fast clean tech cost declines	No new gas generation. Nuclear retires	Reduced transport electrification
		Provides fossil-fuel based reference case	What is the cost of existing programs?	Least-cost 'base' route to NJ goals consistent w/ EMP.	How does regional cooperation reduce costs?	How can NJ meet its goals internally?	Impact of retaining gas use in buildings.	What are savings if technology continues its rapid advance?	Assess cost of 2020 NG moratorium and nuclear retirement	Impact of reduced EV adoption
	Emissions									
C1	**Economy-wide Emissions Constraint**	none	none	80% below 2006 in 2050	80% by 2050 applied PJM-wide	80% below 2006 in 2050	80% below 2006 in 2050	80% below 2006 in 2050	80% below 2006 in 2050	80% below 2006 in 2050
C2	**Electricity Emissions Constraint**	none	none	C-neutral by 2050	C-neutral by 2050	C-neutral by 2050	C-neutral by 2050	C-neutral by 2050	C-neutral by 2050	C-neutral by 2050
C3	**Renewable Portfolio Standard**	22.5% by 2021	50% by 2030	50% by 2030	50% by 2030	50% by 2030	50% by 2030	50% by 2030	50% by 2030	50% by 2030
	Transportation									
T1	**Light Duty Vehicles**	Only choose EVs if less expensive than ICE	330k EVs by 2025	330k EVs by 2025. ICE sales decrease to 0 in 2035	330k EVs by 2025. ICE sales decrease to 0 in 2035	330k EVs by 2025. ICE sales decrease to 0 in 2035	330k EVs by 2025. ICE sales decrease to 0 in 2035	330k EVs by 2025. ICE sales decrease to 0 in 2035	330k EVs by 2025. ICE sales decrease to 0 in 2035	200k EVs by 2025. EV's 50% in 2050
T2	**Medium Duty Vehicles**	No EVs	Continue business-as-usual	75% Electric in 2050	75% Electric in 2050	75% Electric in 2050	75% Electric in 2050	75% Electric in 2050	75% Electric in 2050	Continue business as usual
T3	**Heavy Duty Vehicles**	No EVs	Continue business-as-usual	50% EV by 2050: residual fuel mix optimized to meet 80x50	50% EV by 2050: residual fuel mix optimized to meet 80x50	50% EV by 2050: residual fuel mix optimized to meet 80x50	50% EV by 2050: residual fuel mix optimized to meet 80x50	50% EV by 2050: residual fuel mix optimized to meet 80x50	50% EV by 2050: residual fuel mix optimized to meet 80x50	Continue business as usual
T4	**Aviation**	Continue business-as-usual	Continue business-as-usual	Jet fuel: fuel mix optimized to meet 80x50	Jet fuel: fuel mix optimized to meet 80x50	Jet fuel: fuel mix optimized to meet 80x50	Jet fuel: fuel mix optimized to meet 80x50	Jet fuel: fuel mix optimized to meet 80x50	Jet fuel: fuel mix optimized to meet 80x50	Jet fuel: fuel mix optimized to meet 80x50
	Building electrification									
B1	**Building retrofits**	No electrification target	No electrification target	90% electric by 2050. Rapid adoption in 2030	90% electric by 2050. Rapid adoption in 2030	90% electric by 2050. Rapid adoption in 2030	No electrification retrofits	90% electric by 2050. Rapid adoption in 2030	90% electric by 2050. Rapid adoption in 2030	90% electric by 2050. Rapid adoption in 2030
B2	**Delivered Fuels**	No electrification target	No electrification target	Transition to electric starting in 2030	Transition to electric starting in 2030	Transition to electric starting in 2030	No electrification target	Transition to electric starting in 2030	Transition to electric starting in 2030	Transition to electric starting in 2030
	Electricity									
E1	**PJM Carbon content**	PJM meets state RPS & chooses least-cost tech	PJM meets state RPS & chooses least-cost tech	PJM meets state RPS & chooses least-cost tech	Eastern Interconnect C-neutral in 2050	PJM meets state RPS & chooses least-cost tech	PJM meets state RPS & chooses least-cost tech	PJM meets state RPS & chooses least-cost tech	PJM meets state RPS & chooses least-cost tech	PJM meets state RPS & chooses least-cost tech
E2	**NJ able to purchase out-of-state renewable generation?**	No	No	Yes – up to transmission limit	Yes – up to transmission limit	No	Yes – up to transmission limit	Yes – up to transmission limit	Yes – up to transmission limit	Yes – up to transmission limit
E3	**Expanded transmission**	None	None	Allowed to expanded from 7 to 14 GW if least cost	Allowed to expanded from 7 to 14 GW if least cost	Kept at 7 GW	Allowed to expanded from 7 to 14 GW if least cost	Allowed to expanded from 7 to 14 GW if least cost	Allowed to expanded from 7 to 14 GW if least cost	Allowed to expanded from 7 to 14 GW if least cost
E4	**Efficiency**	No efficiency programs	Existing -2% electric, -0.75% gas	Accelerated Efficiency. Best available tech by 2025	Accelerated Efficiency. Best available tech by 2025	Accelerated Efficiency. Best available tech by 2025	Accelerated Efficiency. Best available tech by 2025	Accelerated Efficiency. Best available tech by 2025	Accelerated Efficiency. Best available tech by 2025	Accelerated Efficiency. Best available tech by 2025
E5	**Nuclear**	Kept through permit. Then keep if least-cost	Kept through permit. Then keep if least-cost	Kept through permit. Then optimized to meet energy & emissions at least cost.	Kept through permit. Then optimized to meet energy & emissions at least cost.	Kept through permit. Then optimized to meet energy & emissions at least cost.	Kept through permit. Then optimized to meet energy & emissions at least cost.	Kept through permit. Then optimized to meet energy & emissions at least cost.	Kept through permit. Then retire	Kept through permit. Then optimized to meet energy & emissions at least cost.
E6	**Natural Gas Electricity Generation**	No restrictions. Chooses if least cost	No restrictions. Chooses if least cost	Optimize to meet emissions at least cost.	Optimize to meet emissions at least cost.	Optimize to meet emissions at least cost.	Optimize to meet emissions at least cost.	Optimize to meet emissions at least cost.	No new gas. Exisitng retires after 50 year life	Optimize to meet emissions at least cost.
E7	**PV**	Add 400+ MW/year through 2030	Add 400+ MW/year through 2030	Add 400+ MW/year in NJ to 2030. More if economic.	Add 400+ MW/year in NJ to 2030. More if economic.	Add 400+ MW/year in NJ to 2030. More if economic.	Add 400+ MW/year in NJ to 2030. More if economic.	Add 400+ MW/year in NJ to 2030. Lower cost.	Add 400+ MW/year in NJ to 2030. More if economic.	Add 400+ MW/year in NJ to 2030. More if economic.
E8	**Storage**	No restrictions. Chooses if least cost	2 GW by 2030	≥2 GW by 2030, then optimized to meet emissions at least cost.	≥2 GW by 2030, then optimized to meet emissions at least cost.	≥2 GW by 2030, then optimized to meet emissions at least cost.	≥2 GW by 2030, then optimized to meet emissions at least cost.	≥2 GW by 2030, then optimized to meet emissions at least cost. Lower cost.	≥2 GW by 2030, then optimized to meet emissions at least cost.	≥2 GW by 2030, then optimized to meet emissions at least cost.
E9	**Off-shore Wind**	No restrictions. Chooses if least cost	3.5 GW by 2030	≥3.5 GW by 2030, the optimized to meet emissions at least cost	≥3.5 GW by 2030, the optimized to meet emissions at least cost	≥3.5 GW by 2030, the optimized to meet emissions at least cost	≥3.5 GW by 2030, the optimized to meet emissions at least cost	≥3.5 GW by 2030, the optimized to meet emissions at least cost. Lower cost.	≥3.5 GW by 2030, the optimized to meet emissions at least cost	≥3.5 GW by 2030, the optimized to meet emissions at least cost

MODELING RESULTS

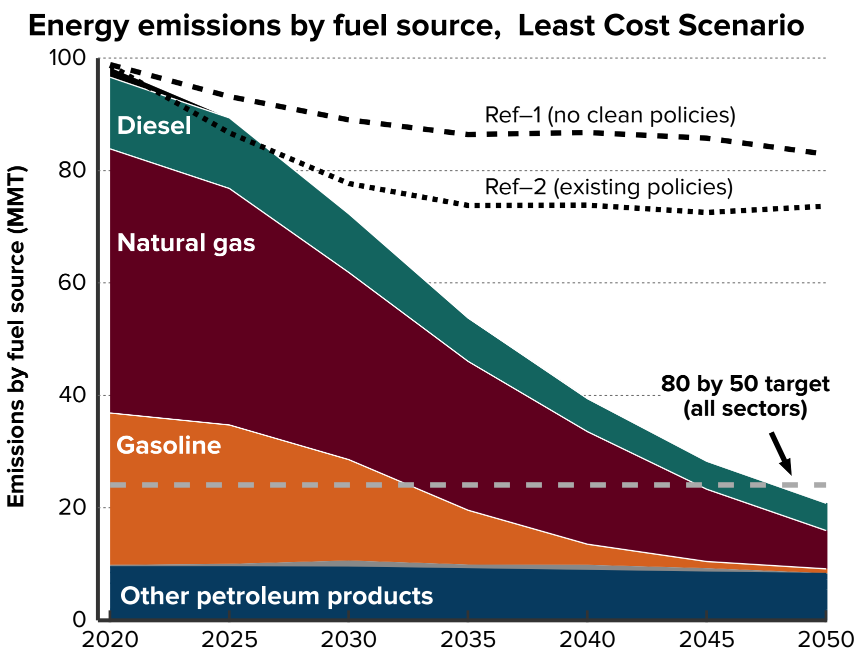
Key findings

Summary of key findings presented today

1. New Jersey can meet Global Warming Response Act and 100% Clean Energy with existing technologies
2. Costs to meet NJ emissions targets are small compared to total energy system spending and offset by clean air benefits
3. Existing policies reduce emissions, but are not sufficient to meet GWRA and 100% Clean Energy targets
4. A least-cost energy system that meets New Jersey's goals is substantively different in a number of ways from today's

New Jersey can meet Global Warming Response Act and 100% Clean Energy goals with existing technologies

Economy-wide emissions fall to meet 80% by 2050 emissions target



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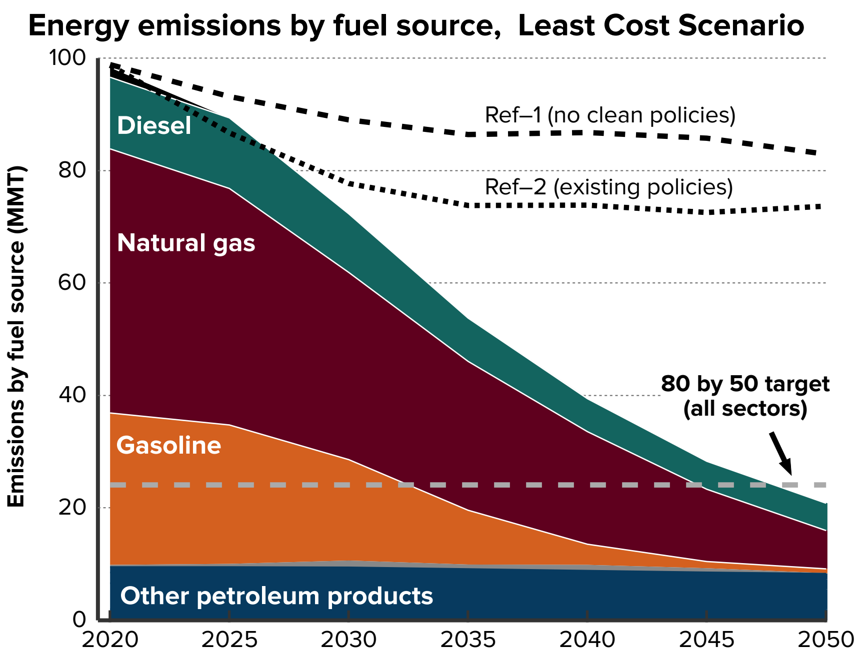
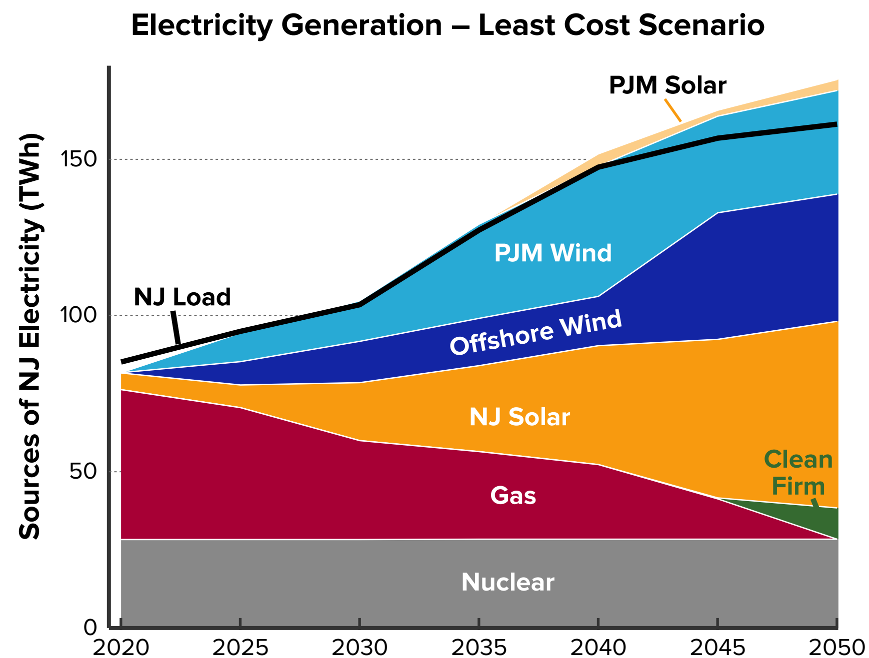


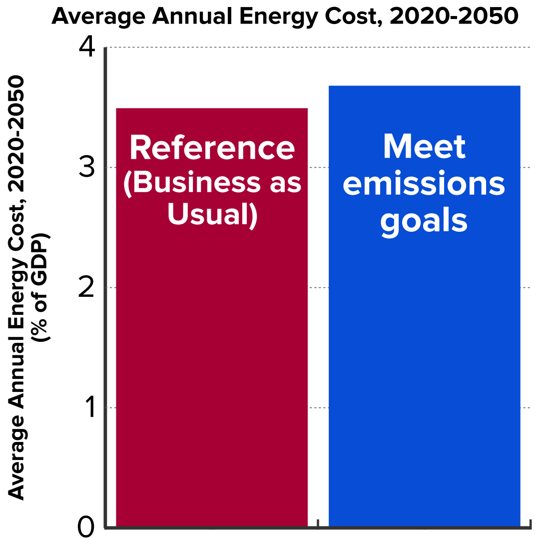
Carbon-neutral electricity grows and transitions to meet 100% Clean Energy



Storage capacity not shown on graph. Clean firm generation currently modeled as biogas but could be substituted with long-term storage or other technologies; discussed in coming slides.

Costs to meet NJ emission targets are small compared to total energy system spending, and offset by clean air benefits

Meeting emissions targets increases the average costs of New Jersey's total annual energy system from 3.5% to 3.7% of GDP



Modeled costs include annualized supply-side capital costs, incremental demand-side equipment, fuel costs, and O&M.

Total 2050 energy system spending (not ratepayer cost or impact):

- Reference: $32.6B/year (2018 dollars)
- Meet emissions goals: $34.7B/year (2018 dollars)

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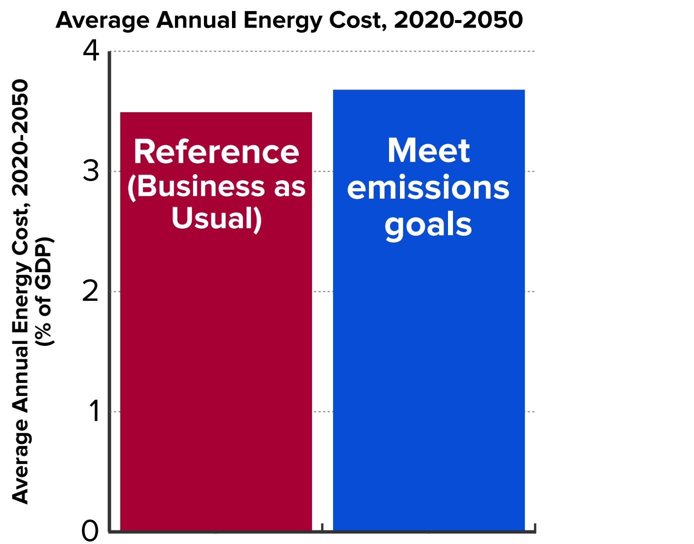

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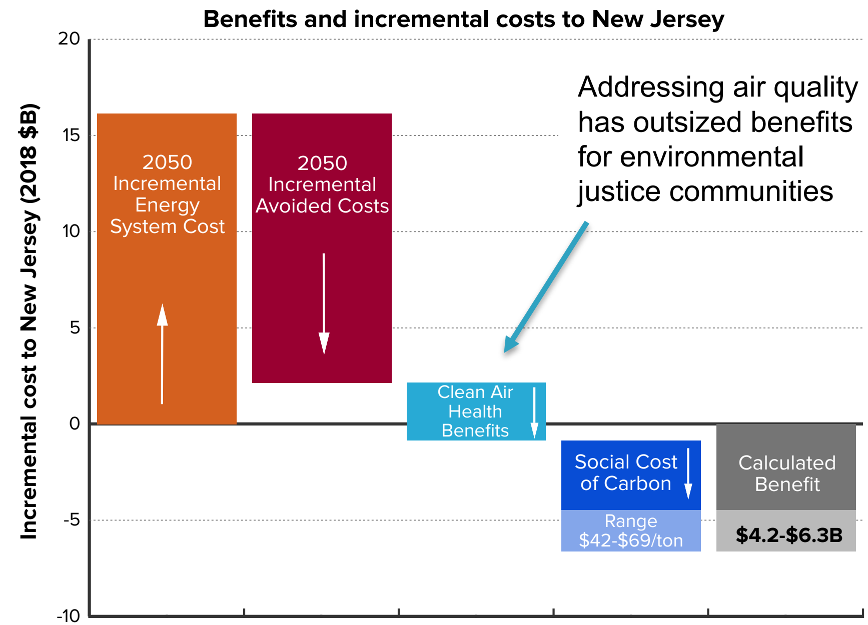
- Reference: $32.6B/year (2018 dollars)
- Meet emissions goals: $34.7B/year (2018 dollars)

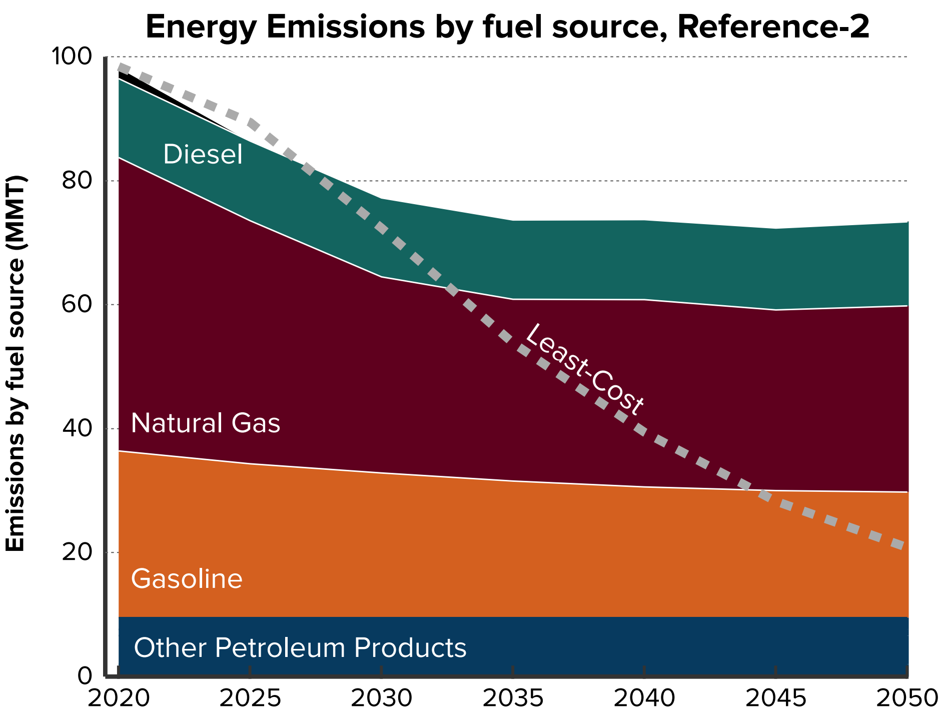
Incremental costs of meeting emissions targets are offset by fossil fuel cost savings and cost savings associated with reduced pollution



Clean air benefits estimated from American Lung Association. Social cost of carbon from U.S. Environmental Protection Agency (3% discount rate)

Existing policies reduce emissions, but are not sufficient to meet GWRA and 100% Clean Energy targets

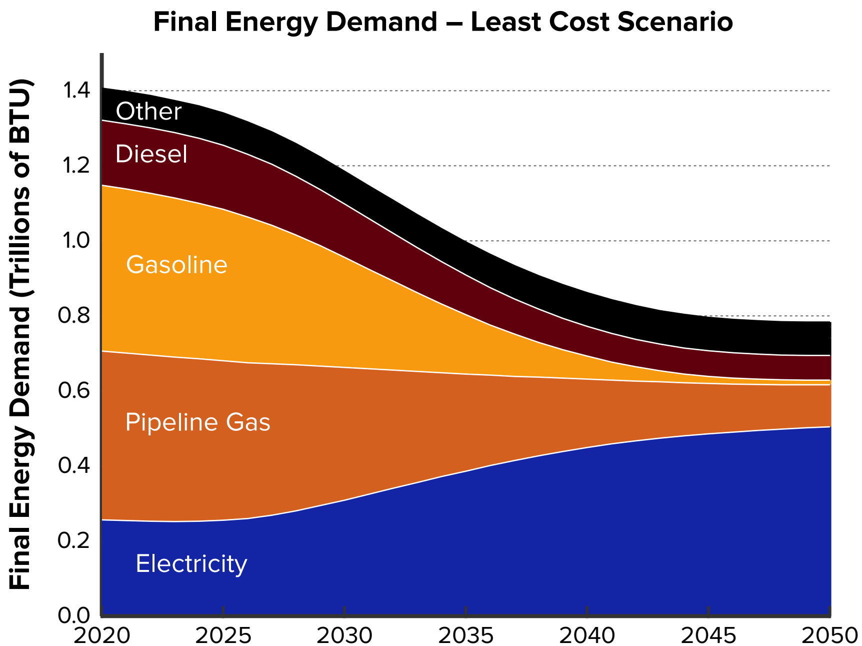
Emissions decline through 2035 but then flatten under current energy policies



- Electricity sector reduces emissions through 2035 as offshore wind and out-of-state wind reduce gas use.
- Existing transportation and building sector policies reduce diesel, gasoline, and natural gas use in 2020s, but do not lead to significant additional emissions reductions after 2035.
- Further action starting in 2020s is necessary to enable NJ to meet 2050 goals.

Electrification reduces fuel use and costs of meeting policy targets but increases electricity demand

Near-term EV adoption reduces gasoline use through 2035. Building electrification reduces gas use starting in late 2020s.



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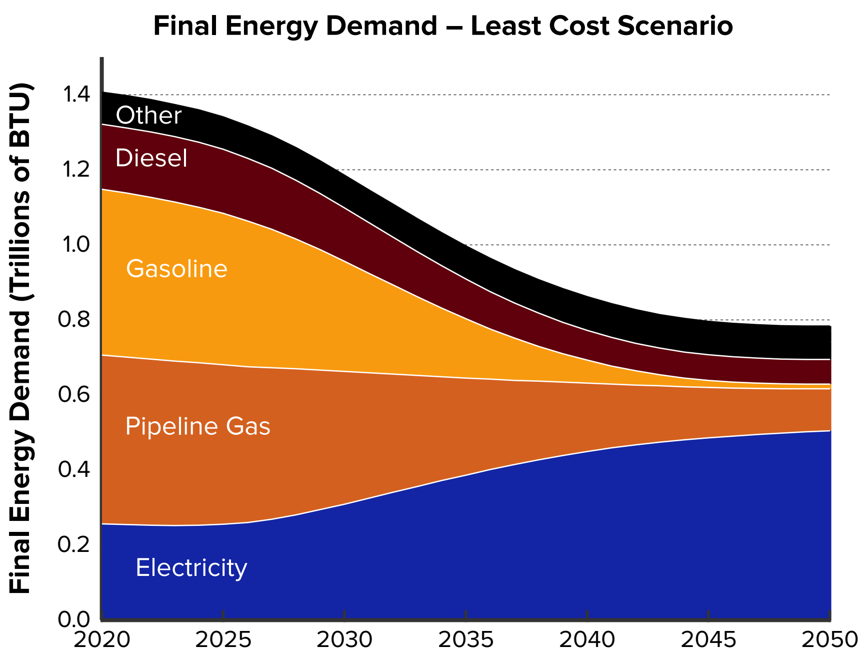
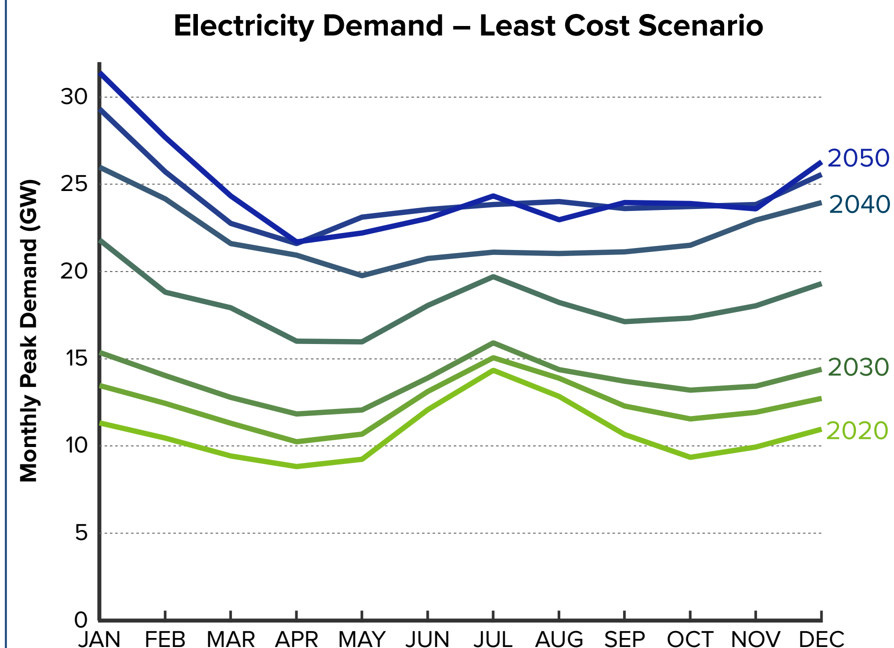
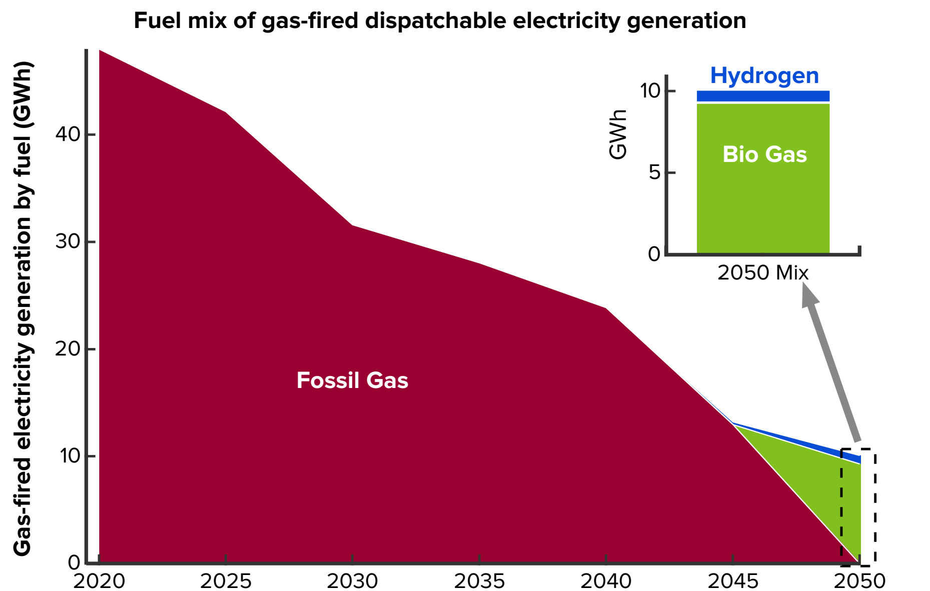


Electric vehicles and electrified heating steadily increase electricity demand, and shift peak periods to winter months



In-state gas generation falls as NJ deploys renewables. Existing and new dispatchable resources provide reliability.

Electricity generation from gas capacity falls steadily due to adoption of in- and out-of-state renewable energy resources.



- In the 2040s, options for clean firm energy include
  - long duration storage
  - turbines fueled using biogas and/or synthetic gas
  - H_2-powered generators.
- Least Cost scenario selects biofuel and hydrogen burned in conventional turbines

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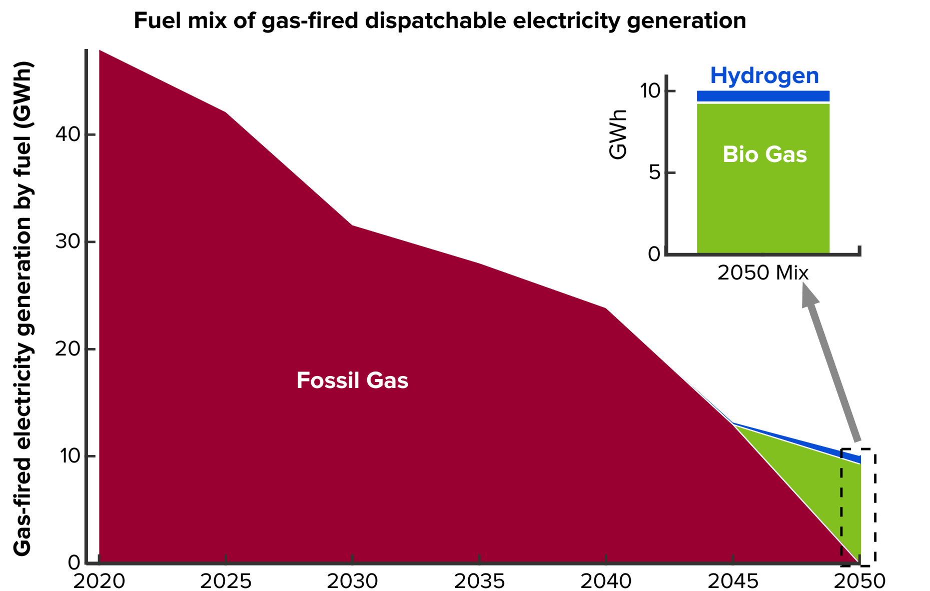

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  - long duration storage
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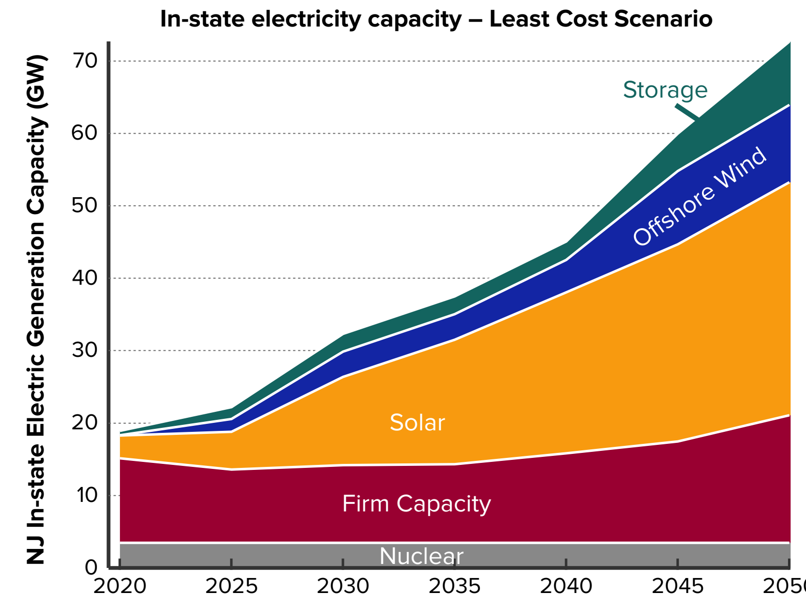
Renewable and storage capacity increases. To reliably meet growing demand, additional firm generation capacity is needed in 2040s.



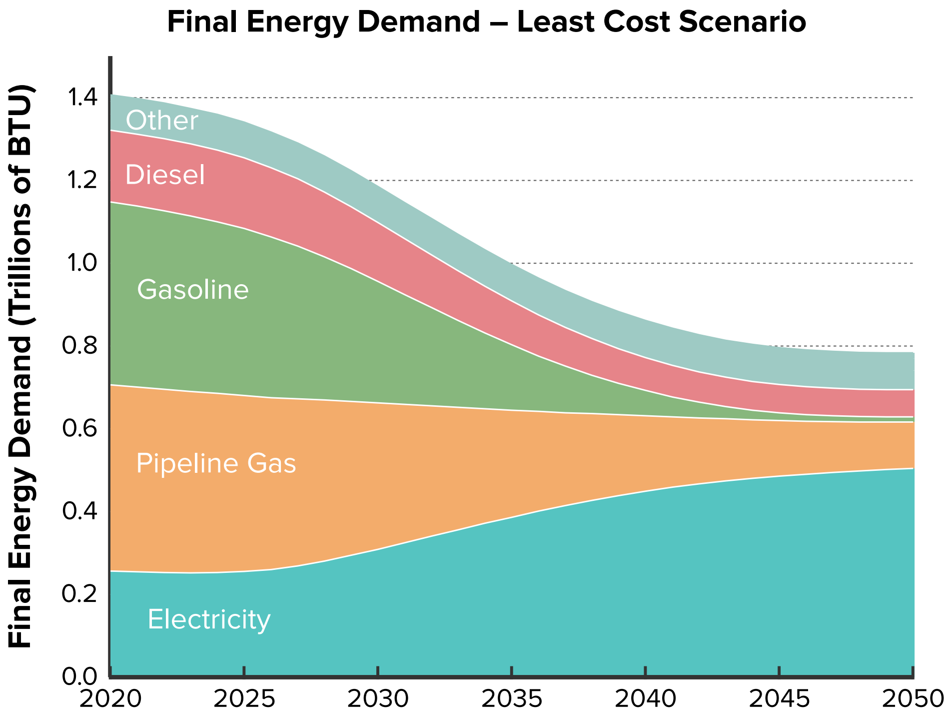
- 2020 dispatchable generation from gas generators.
- 100% clean electricity requires dispatchable generation transition away from fossil gas
- Dispatchable technology choice can be delayed to 2035

MODELING RESULTS

Least Cost scenario

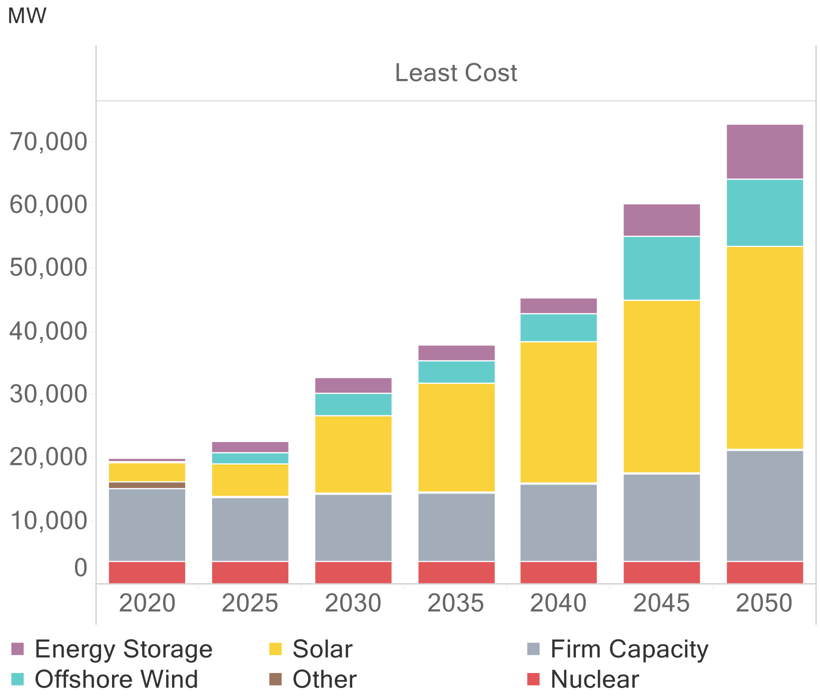
Model overview: The model sums ~30 end uses across the economy to define New Jersey's total energy needs and finds least cost supply

1. Model New Jersey's energy needs by sector across the economy
   - Stock rollover model
   - Fuel switching and transition to more efficient demand-side technologies
2. Aggregate final energy demands
   - Determine how economy-wide fuel and electricity consumption evolves over time
3. Determine most economic way of serving energy demands
   - Constrained by energy policy that varies by scenario
   - Determines cross-sectoral allocations of resources



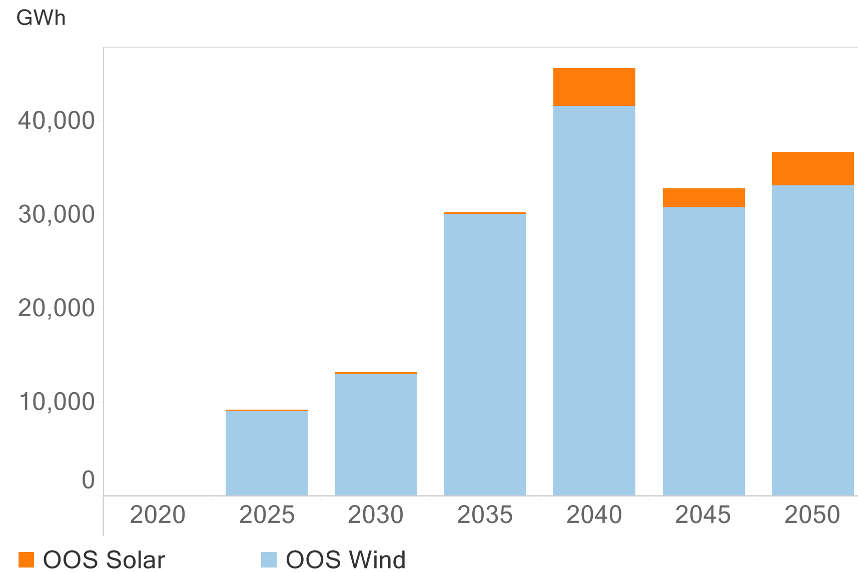
Least Cost Scenario: Installed Capacity of In-state Resources

- Installed generating capacity is 3.5x today's fleet
  - Doubling of load, but more capacity needed due to intermittency of renewables
- Nuclear fleet is extended
- Firm capacity increases from 12 GW to 17.5 GW by 2050
  - Needed for reliability when renewable output is low
  - Used infrequently in later years
  - Fossil gas through 2045
  - Fully powered by clean biogas in 2050
  - Technology choice and investment can be delayed until >2030
- Offshore wind and energy storage above current mandates
  - Offshore wind: 11 GW in 2050
  - Storage: 9 GW in 2050



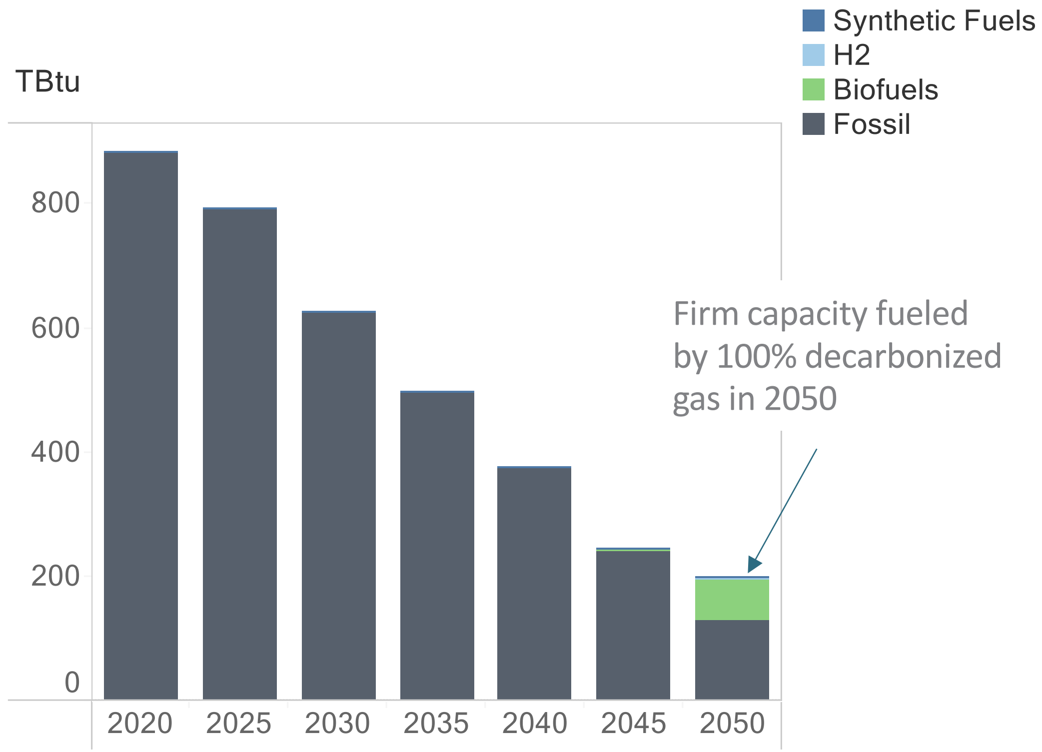
Least Cost Scenario: Out-of-state Renewables and Transmission

- NJ also imports energy from new out-of-state (OOS) wind and solar plants in PJM
- PJM-to-NJ transmission increased from 7 GW to 9 GW
  - Model had the flexibility to add up to 14GW of PJM-to-NJ transmission
  - More cost effective to add in-state resources than expand transmission capacity



Least Cost Scenario: Gas Consumption and Supply

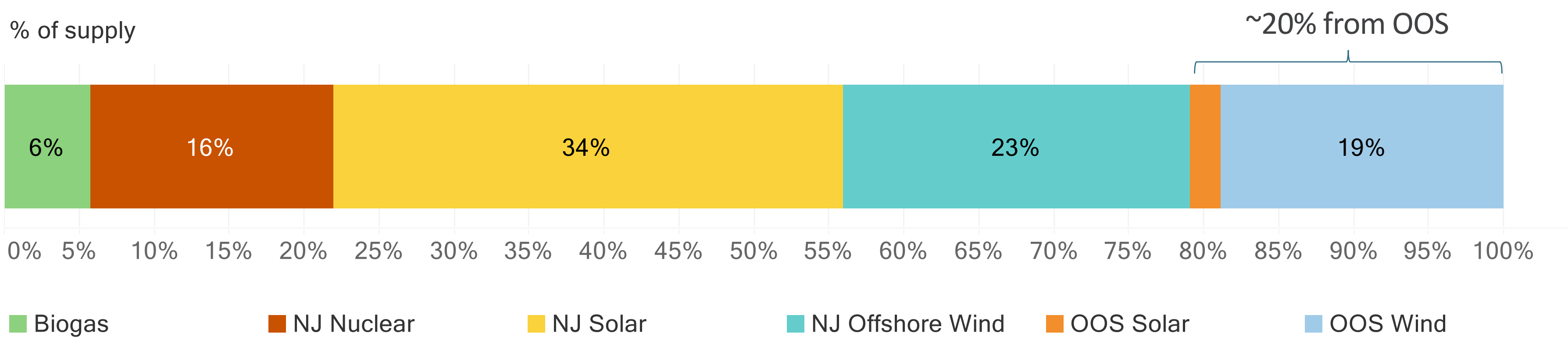
- Overall consumption declines by approximately 75 percent from 2020 to 2050
- One-third of supply is from biofuels in 2050 to provide firm capacity with fuel that qualifies for 100% Clean
- Remaining natural gas delivered to:
  - Non electrified space and water heating loads
  - Industrial processes



Least Cost Scenario: Diverse resources contribute to 100% Clean Requirement

2050

- Load in the Least Cost Case is 165 TWh in 2050



Least Cost Scenario: Cost Overview

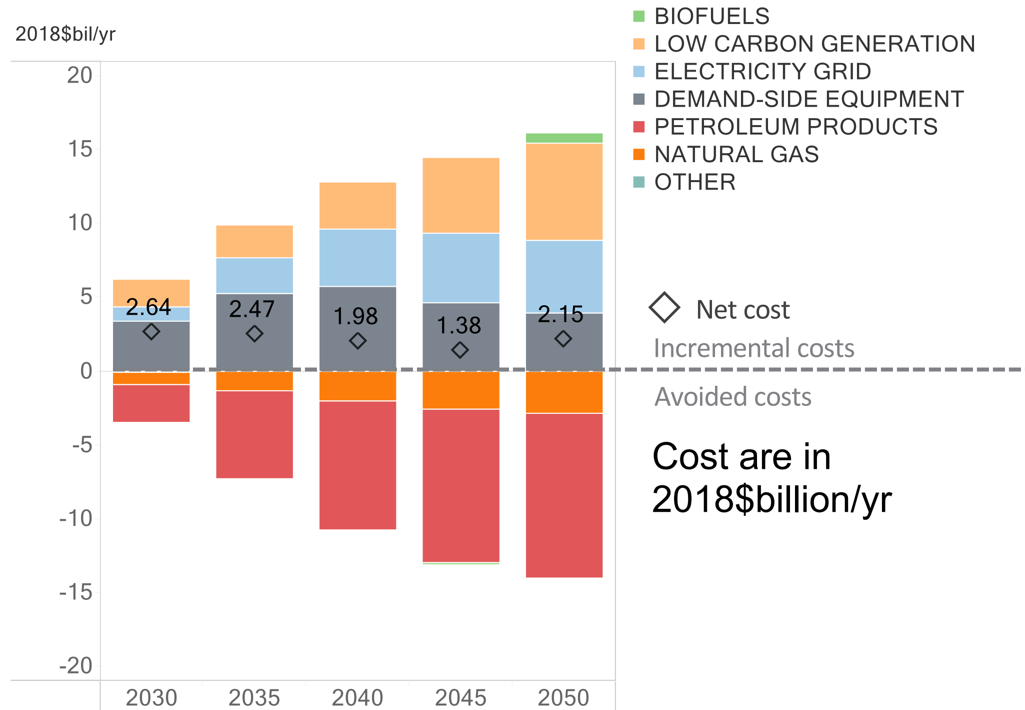
- Costs include demand-side equipment, such as vehicles and appliances, supply-side equipment, such as wind turbines and power plants, and their fuel and operating costs:
  - Annualized capital costs of demand- and supply-side energy equipment
  - Variable fuel costs
  - Fixed and variable operations and maintenance costs
- Equivalent to an "energy system revenue requirement"
  - Annual cost of producing, distributing and consuming energy in New Jersey
- Our analysis does not include costs outside of the energy system or benefits from avoiding climate change and air pollution
- All costs are in 2018 dollars
- Costs are not indicative of rate impacts

Least Cost Scenario: Decomposing Net Costs

- Reduced spending on natural gas and refined oil products (gasoline, diesel)
- New investments in low-carbon generation, the electricity grid, demand-side equipment, and biofuels

Net System Cost =

Least Cost Energy System Cost – Reference 1* Energy System Cost



Cost are in 2018$billion/yr

* Reference 1 is the business-as-usual case that does not include GWRA or Clean Energy policies through 2030

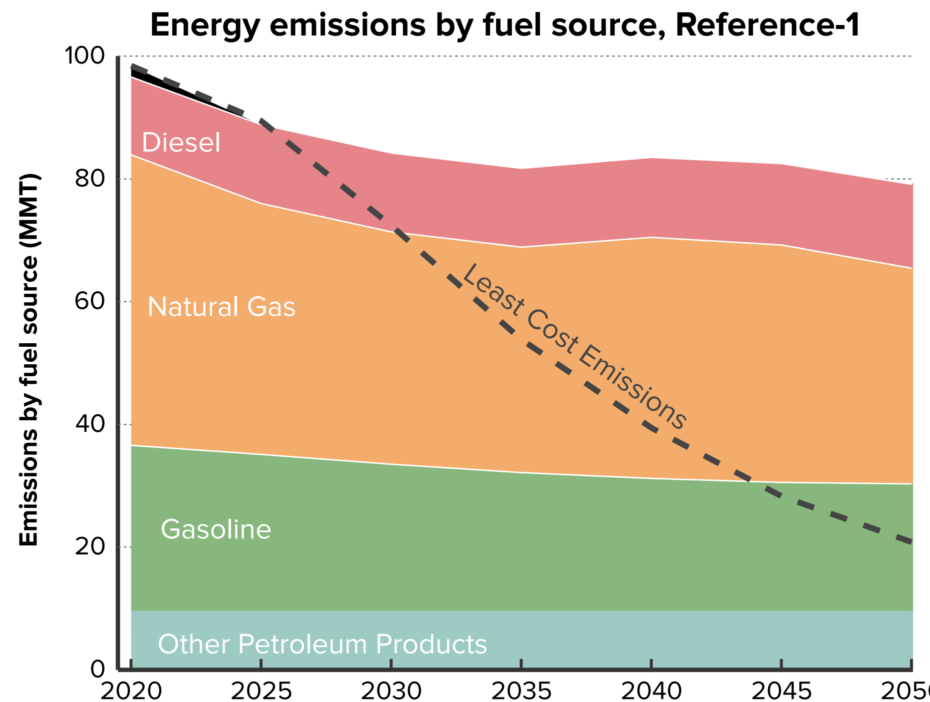
MODELING RESULTS

Alternative Scenarios

Reference 1: Business-As-Usual

What are cost and emissions outcomes of “business as usual?”

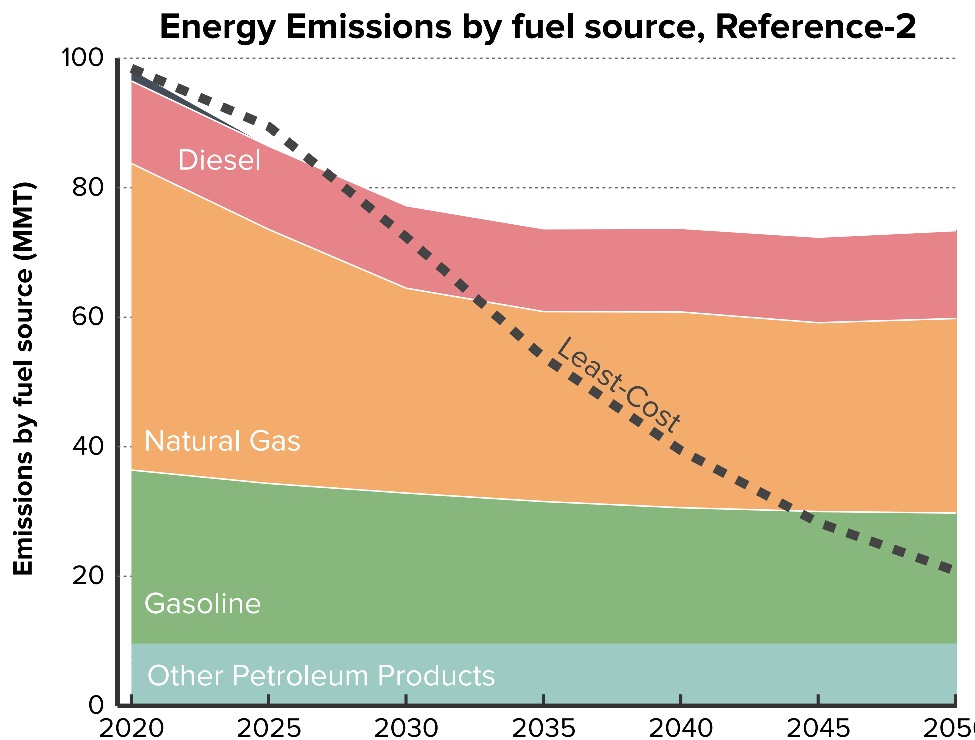
- Implementation
  - No clean energy policy action taken going forward from 2020
  - RPS constant at 22.5% going forward
- Major impacts
  - Emissions decline only 15%, driven by efficiency gains and limited fuel-switching to clean electricity
  - Electricity load increases slightly but far less than in the Least Cost Case
  - In-state gas and nuclear dominate electricity supply



Reference 2: Existing Energy Policy

What cost and emissions impact do existing policies have?

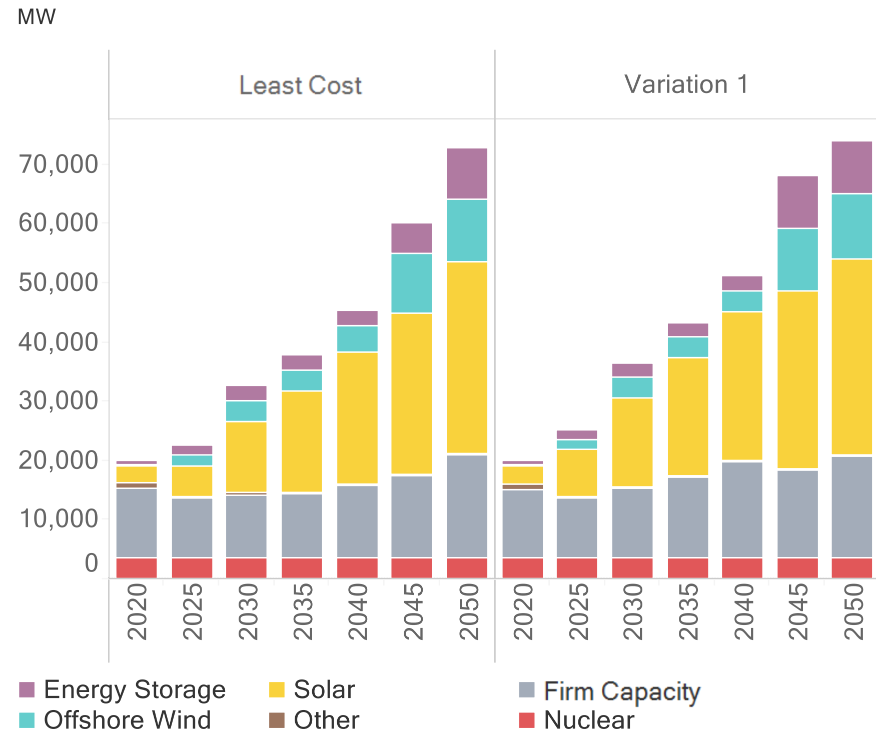
- Implementation
  - Existing policy included
    - 3.5 GW of wind by 2030
    - 2 GW of storage by 2030
    - 330k EVs on the road by 2025
    - 50% RPS by 2030
    - Improvements in EE
- Major impacts
  - Electricity emissions fall through 2035 as offshore and PJM wind reduce gas use
  - Transportation and building emissions reductions plateau after 2030
  - Electricity load increases but still less than Least Cost Case
  - In-state gas generation offset by offshore and PJM wind



Variation 1: Regional Deep Decarbonization

How does regional climate action affect New Jersey's cost to meet goals?

- Implementation
  - Eastern Interconnection pursues 100% clean electricity and 80x50 GHG target
- Major impacts
  - Decarbonization policies across the Eastern Interconnection increases demand for renewable generation
  - Increased competition results in NJ importing higher-cost / lower-quality renewables and developing additional in-state resources
  - Greater benefits of region-wide decarbonization not captured

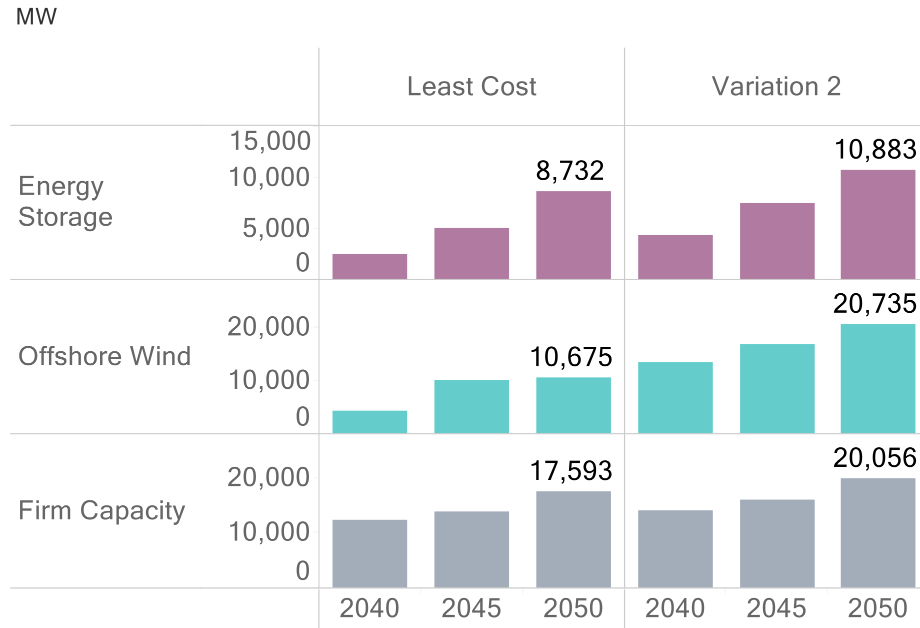


EVOLVED ENERGY RESEARCH

Variation 2: Reduced Regional Cooperation

How can New Jersey meet its goals internally?

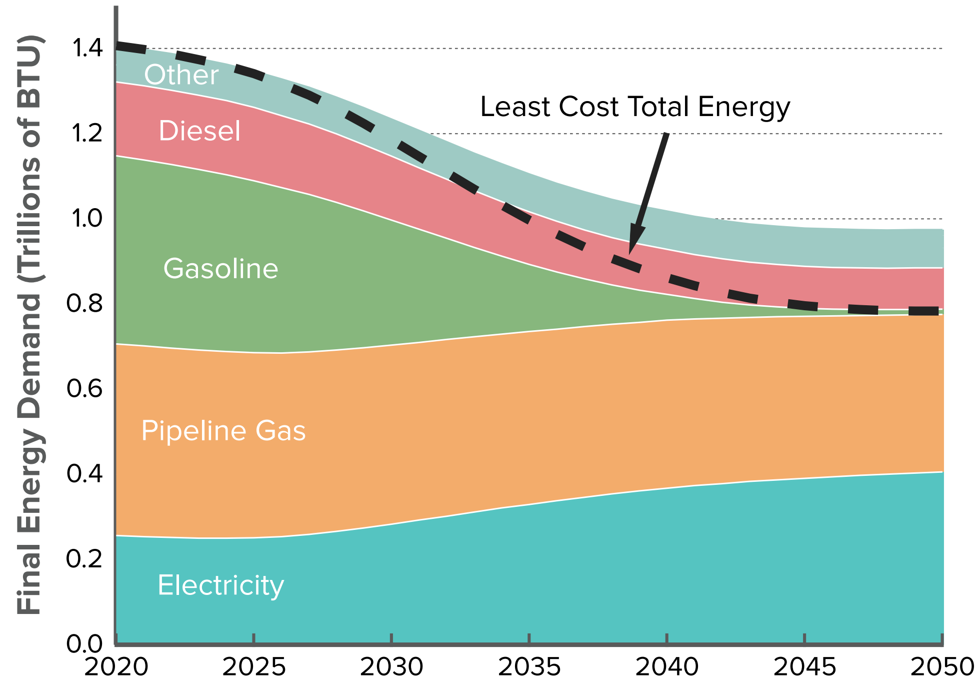
- Implementation:
  - Disallow new transmission and OOS resource procurement
- Major impacts:
  - Losing access to OOS resources and transmission requires additional in-state resources
  - Firm capacity resources require additional biogas (2x Least Cost consumption)
    - Lower resource diversity increases balancing requirements



Variation 3: Retain Gas in Buildings

How would New Jersey meet its goals if it kept gas in buildings, and at what cost?

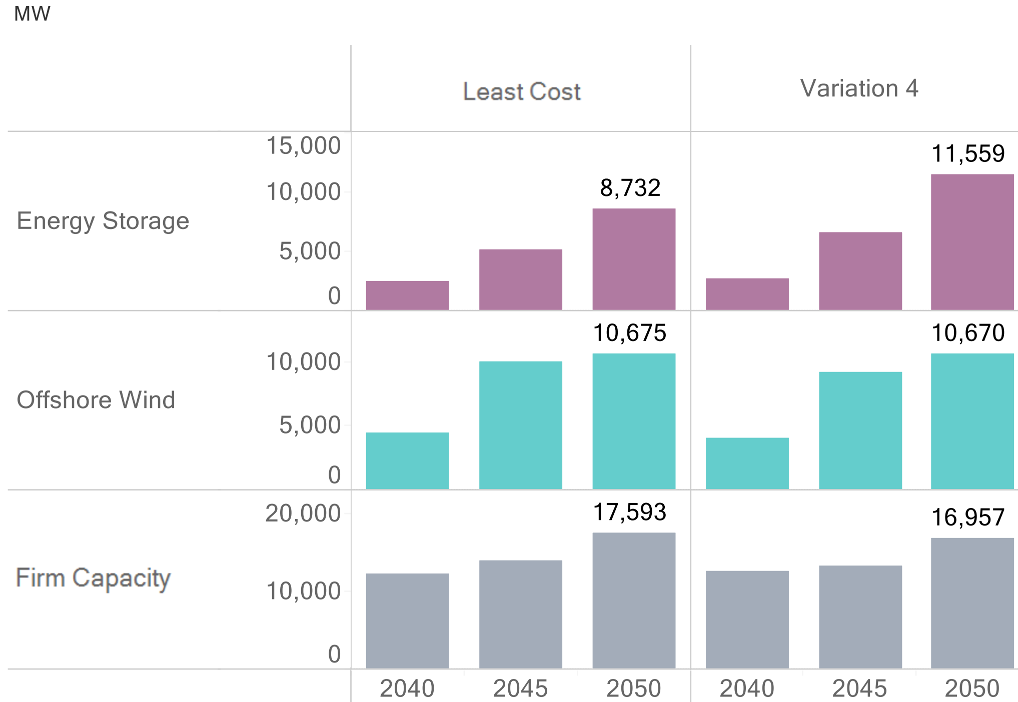
- Implementation
  - Zero electrification of residential and commercial buildings
- Major impacts
  - The total energy required increases compared to least cost scenario.
  - Higher gas emissions offset by increased use of biofuels in transportation.
  - Gas use in buildings makes it expensive to further reduce emissions or accommodate failures in other sectors



Variation 4: Technology Cost Reductions

How would cheaper clean energy affect costs and resource mix?

- Implementation
  - Past technology cost forecasts have often been high relative to actual realized costs
    - Investigating the impact of optimistic forecasts
  - Low renewable and storage costs*
- Major impacts
  - Increased storage build due to relatively more favorable storage pricing
  - Increased OOS solar imports relative to OOS wind
  - Reduction in biogas burn due to lower cost renewable energy

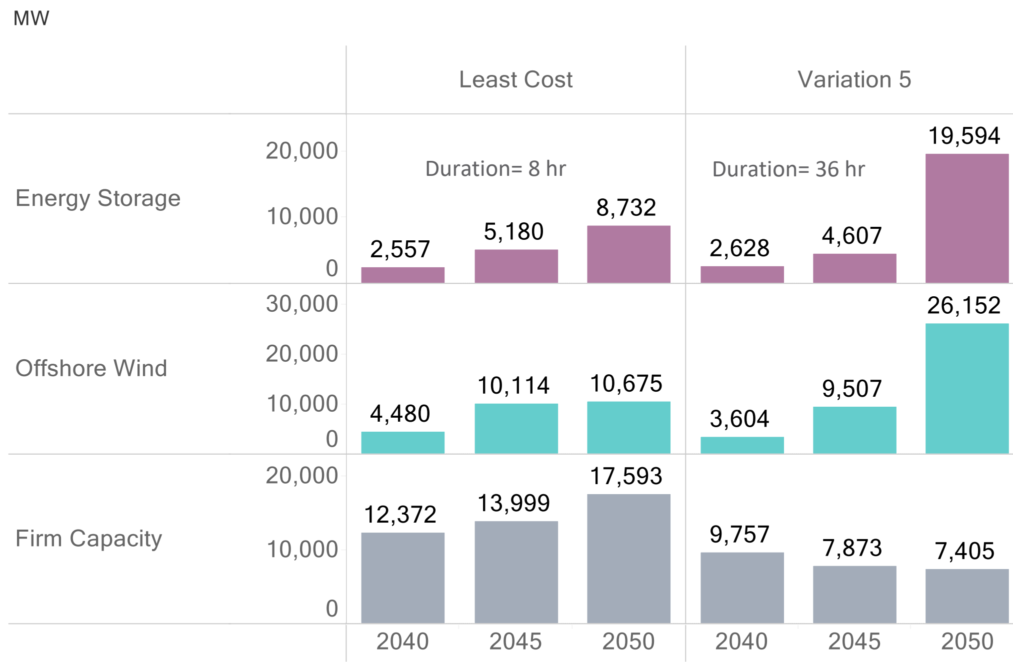


*Technology prices from NREL ATB 2019 Low forecasts. Storage prices from International Renewable Energy Agency (IRENA) Low forecasts

Variation 5: Nuclear Retirement and No New Gas Power Plants

How does minimizing thermal generation affect decarbonization costs?

- Implementation
  - Look at impact of a renewable only future
    - No new gas plants allowed
    - Nuclear cannot extend
- Major impacts
  - Significant increase in offshore wind and energy storage build
  - Average storage duration increases to address lack of gas resource flexibility
    - Least Cost: 8 hours in 2050
    - Variation 5: 36 hours in 2050
  - Increased intertie capacity
    - Gas imports for reliability prior to 2050
    - Replace nuclear energy with additional OOS renewables

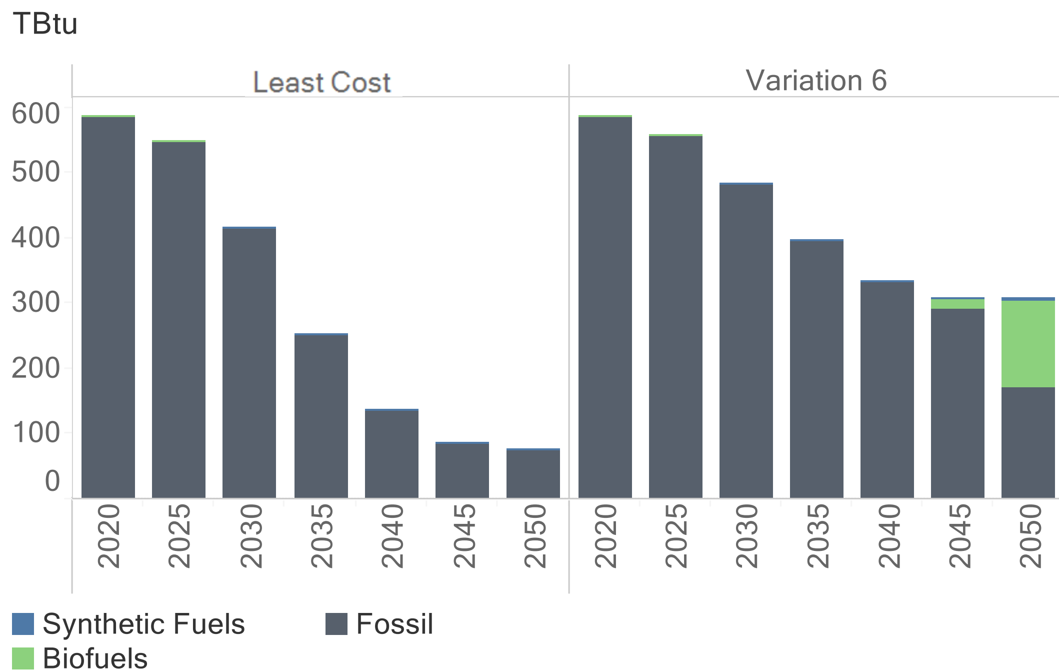


EVOLVED ENERGY RESEARCH

Variation 6: Reduced Transportation Electrification

How would New Jersey meet its goals if it kept fossil fuels in vehicles, and at what cost?

- Implementation
  - Light duty vehicle electrification cut in half
  - Medium duty and heavy duty vehicle electrification is zero
- Major impacts
  - Additional biofuels used primarily to decarbonize liquid fuel consumption from freight trucks

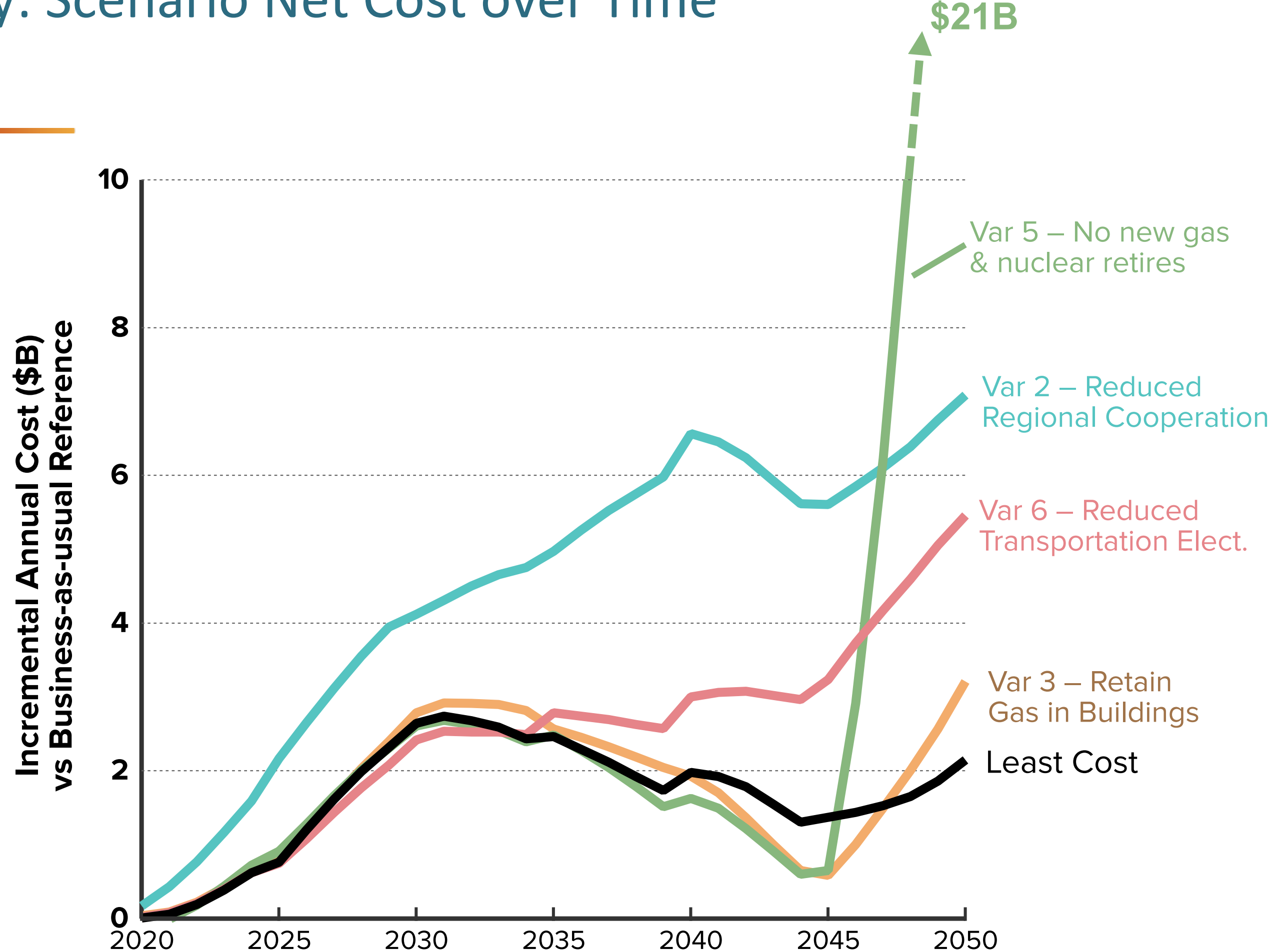


EVOLVED ENERGY RESEARCH

MODELING RESULTS

Cost comparison

Summary: Scenario Net Cost over Time



Drivers of Variation Cost Results

	Net Cost (2018$bil/yr) Relative to Least Cost Case*: 2030	2050	Cost Drivers
New Jersey controls variation changes			
Variation 2: reduced regional cooperation	$1.5	$4.9	Lost access to low-cost out-of-state renewables requires procurement of offshore wind higher up the supply curve.
Variation 3: retain fuel use in buildings	$0.1	$1.1	Not pursuing building electrification avoids some electric T&D incremental costs but relies on higher consumption of expensive biofuels. Poor foundation for carbon reductions beyond 80x50.
Variation 5: nuclear retires and no new gas plants	$0.0	$19.0	Incremental costs are largely driven by energy storage (average duration increases from 7 → 36 hours). Batteries are ill-suited for long-duration storage required under 100% Clean electricity policy.
Variation 6: reduced transport electrification	-$0.2	$3.3	Lower electrification requires higher consumption of expensive biofuels. Poor foundation for carbon reductions beyond 80x50.
Changes outside of New Jersey's control			
Variation 4: faster renewables & storage cost declines	-$0.5	-$1.4	Accelerated cost reductions for wind, solar and energy storage reduce cost of deep decarbonization.

*Reflects changes in investments in demand and supply side equipment, operations costs, and avoided fuel costs versus the Least Cost Case. Not reflective of ratepayer costs.

Putting the Costs in Context

Least Cost Case compared to GSP

- Increased costs in Least Cost Case are small relative to:
  - Projected gross state product: 0.2% of GSP in 2050
  - Projected total energy spending in Reference 1: 6% in 2050

Gross State Product	2018	2030	2050
Gross state product (2018$bil/yr)*	$625	$787	$1,138
Least Cost Net costs (2018$bil/yr)	$0	$2.6	$2.1
Percent of GDP	**0%**	**0.3%**	**0.2%**

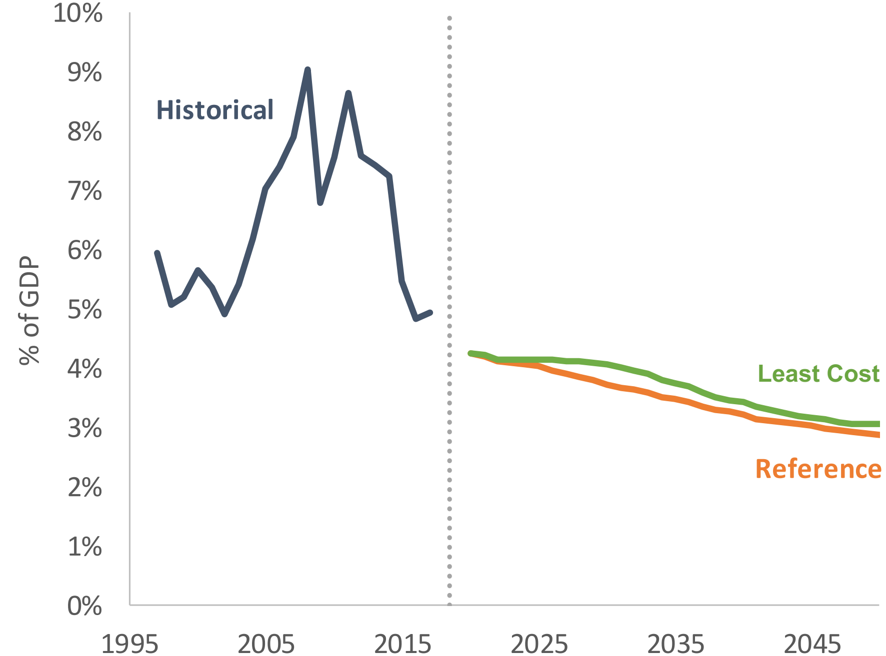
Total Energy Spending	2030	2050
Reference 1: BAU (2018$bil/yr)	$29.4	$32.6
Least Cost Case (2018$bil/yr)	$32.0	$34.7
Percentage Increase over Ref1	**9%**	**6%**

*GSP projections based on growth rates from EIA's *Annual Energy Outlook*

Total Spending on the Energy System as Share of GDP

- Historically, spending on the energy system has represented 5-9% of GDP
  - Fossil fuel prices play a large role
- Share of spending on energy is projected to decrease
  - State GDP continues to increase, less dependent on increased energy use
  - Energy intensity declines with business-as-usual efficiency, notably from light-duty vehicle fuel economy
- Least Cost spending on energy as a share of GDP is marginally higher than Reference 1

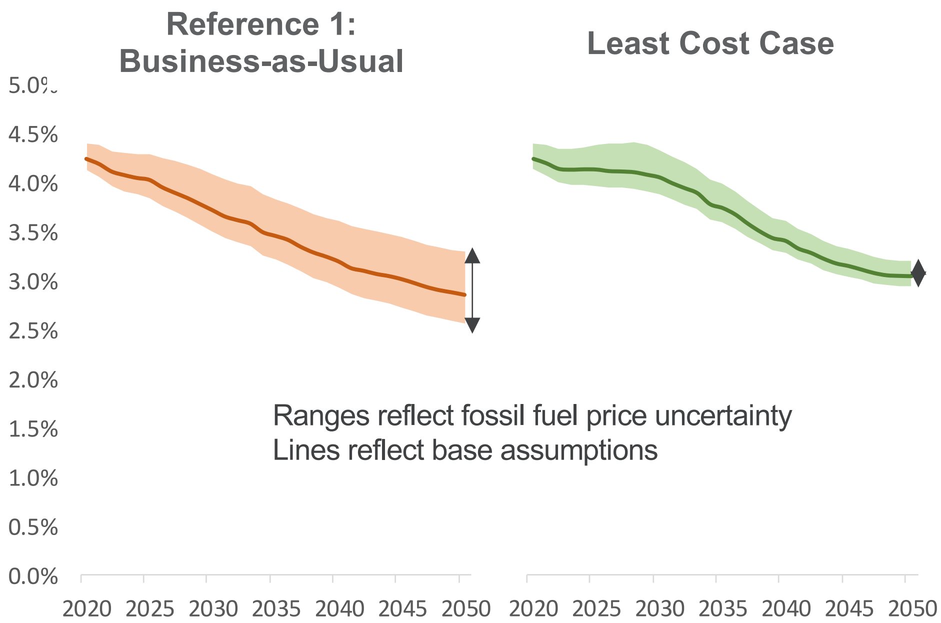
Total Energy System Costs as Percentage of GDP



Sources and notes: historical state GDP from the U.S. Bureau of Economy Analysis; historical energy spending from U.S. Energy Information Administration.

Total Spending on the Energy System as Share of GDP: Fossil Fuel Price Uncertainty

- Deep decarbonization reduces New Jersey's exposure to volatile fossil fuel prices
  - Hedge against fuel prices dictated by international markets, increasing energy security
- Least Cost reduces cost uncertainty due to fuel prices
  - Investment in clean energy infrastructure that reduces fuel consumption
- Reference 1 is still exposed to volatile fossil fuel prices and the uncertainty increases over time
  - Underestimating risk since geopolitical impact on prices not considered
- Range of fossil fuel price projections are from EIA's *AEO 2019*
  - *Oil price +10%/-12% in 2050*
  - *Gas price +70%/-30% in 2050*

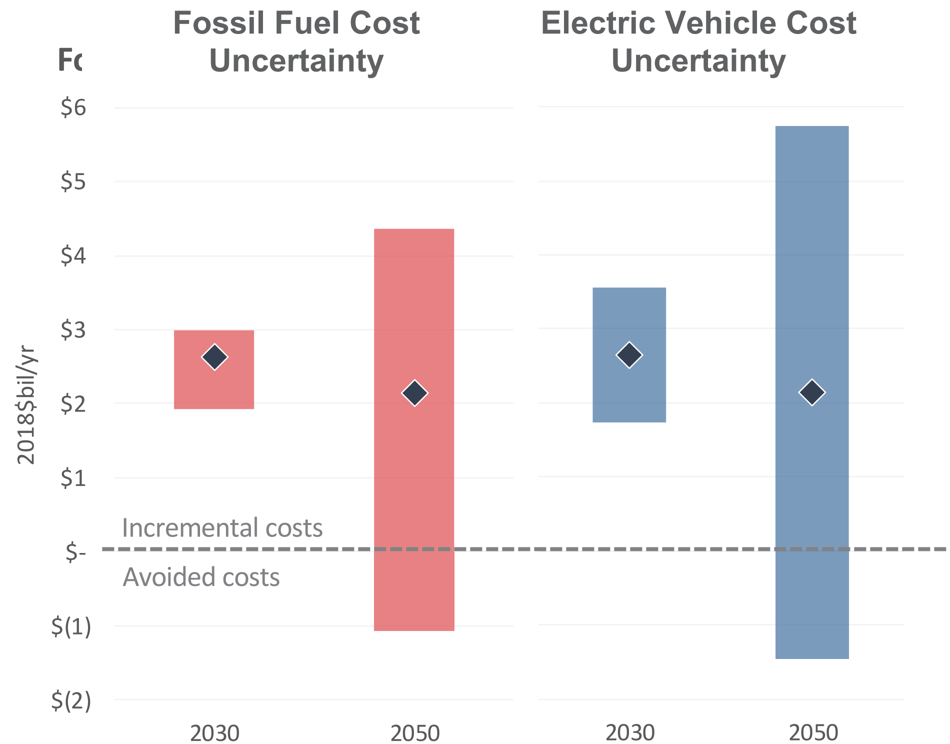


Sources and notes: fossil fuel price projections from U.S. EIA Annual Energy Outlook 2019. Base assumption utilizes "Reference Case" prices. Fossil fuel price sensitivities based on "Low oil and gas resource and technology" and "High oil and gas resource and technology" scenarios".

Uncertainty in Cost Inputs

Sensitivity to fuel prices in 2050

- Cost of deeply decarbonizing New Jersey's energy system is highly uncertain, and this uncertainty increases with time
- Particularly sensitive to fuel and vehicle costs
- Uncertainty is illustrated through ranges in net cost for the Least Cost case with alternative fossil fuel prices and battery electric vehicle costs
  - Range of fossil fuel price projections are from EIA's *AEO 2019**
    - *Oil price +10%/-12% in 2050*
    - *Gas price +70%/-30% in 2050*
  - Range of electric vehicle cost projections is +/-10% of the baseline assumption



*High and Low Oil and Gas Resource and Technology Cases – US oil and gas reserves are assumed to be larger or smaller than current forecasts, and recovery technology is assumed to develop faster or more slowly than forecast. Global and geopolitical price fluctuations may be substantially higher

THANK YOU