Exploring Climate Solutions Webinar Series

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Rocky Mountain Institute Decarbonization Study for New Jersey Integrated Energy Plan

April 15, 2020

Modeling decarbonization pathways that meet New Jersey’s energy needs and emissions targets

April 15, 2020

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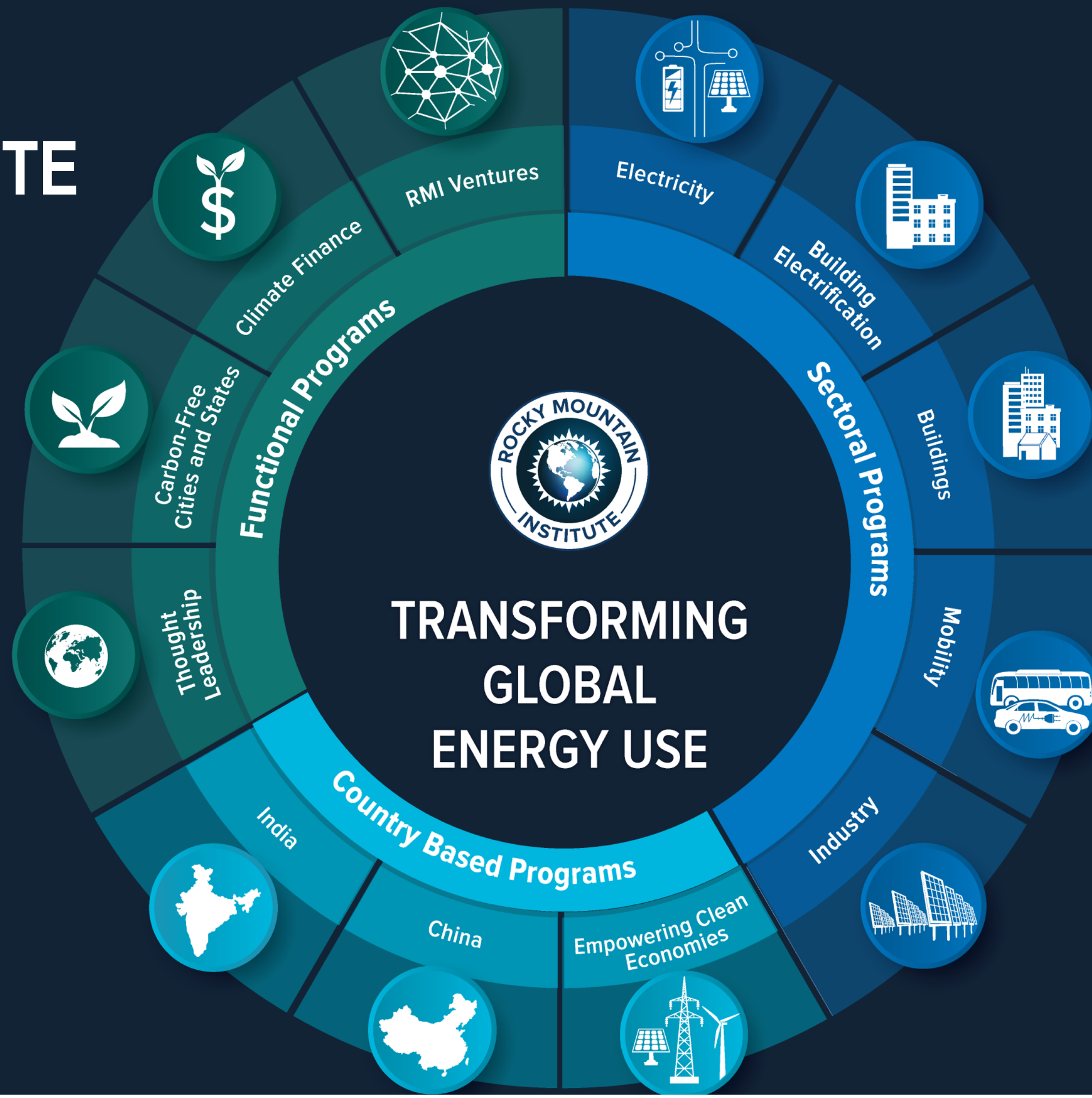
rmi.org/NJEMP

ROCKY MOUNTAIN INSTITUTE

ABOUT
ROCKY MOUNTAIN INSTITUTE

- Nonprofit, nonpartisan, independent, research & collaboration firm
- Founded 1982 in Old Snowmass, Colorado
- Offices in Basalt and Boulder CO, Washington DC, New York, Oakland, Beijing
- ~225 staff
- Focus: Market-based approaches to clean energy



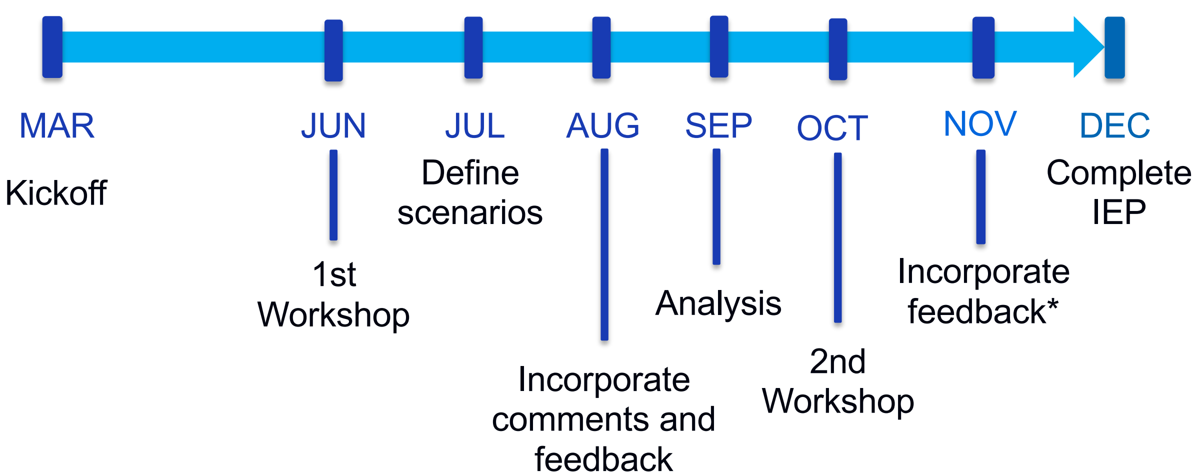
AGENDA

- Context & the value of decarbonization analysis
- Key findings
- Deeper Dive
- Q&A

NJ.gov/EMP

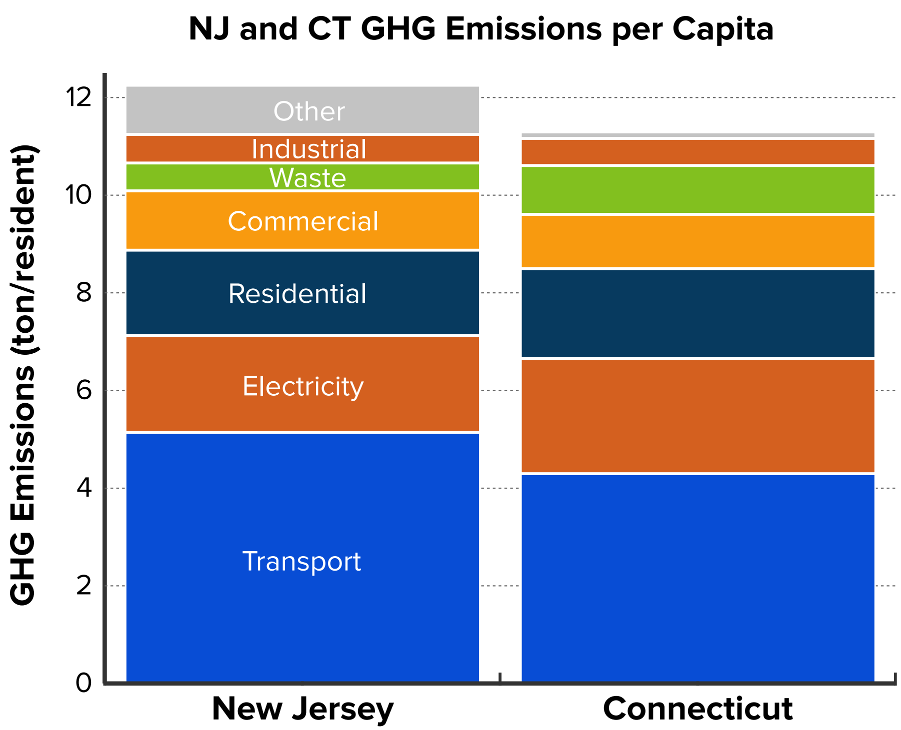
THE NJ BOARD OF PUBLIC UTILITIES HAD RMI MODEL LEAST-COST PATHS TO DECARBONIZE

- Year-long project that took most of 2019
- Analysis requested by Governor Murphy
- RMI led analysis, stakeholder engagement, and authored “Integrated Energy Plan”
- RMI subcontracted with Evolved Energy Research who brings decarbonization modeling tool
- Modeling informed NJ’s Energy Master Plan (EMP), released in January



EMP published in January 2020 nj.gov/EMP

Connecticut and New Jersey have similar energy profiles and similar decarbonization targets



	New Jersey	Connecticut
Emissions Profile	Similar	
Economy-wide targets	"80 by 50"	"80 by 50"
Electricity target	100% net-zero in 2050	100% Clean grid in 2040

Both NJ and CT are aggressively procuring **offshore wind** and **electric vehicles** (EVs)

Deep decarbonization studies show cross-sector impacts and the implications of today's investments.

Deep Decarbonization Studies show the big picture, providing context for 2020.

- What investments are 'least regrets'?
- Which of today's investments are risky for a low-carbon future?
- How do investments in transportation, industry, buildings, and electricity influence one another?

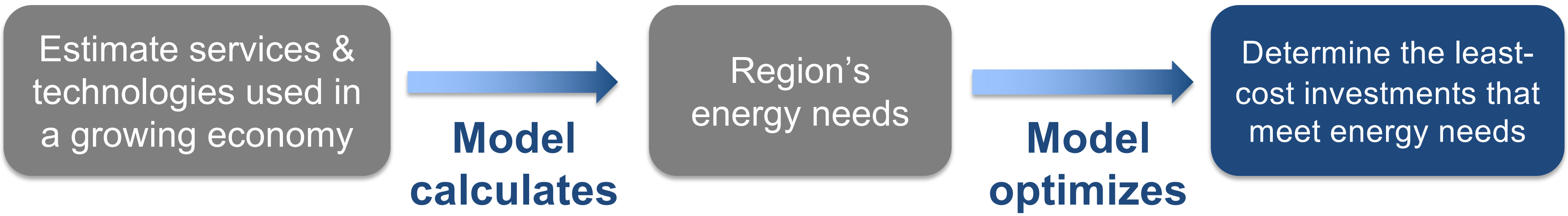
Assumptions and scenarios matter. State the questions you want the analysis to answer

- Results are sensitive to predicted technology costs & capabilities
- The regional and national context matter
- Scenario selection define the questions being asked

Least-cost modeling doesn't value equity. Results should provide data that informs policy, not dictate it.

- Direct health costs are not valued
- Local community impacts are not easily captured
- 'Least cost' policy is not necessarily equitable
- Costs are state-wide, energy system costs

<u>Deep Decarbonization Studies</u> find the least-cost investments in electricity, transportation, buildings, & industry to meet the needs of a growing economy.



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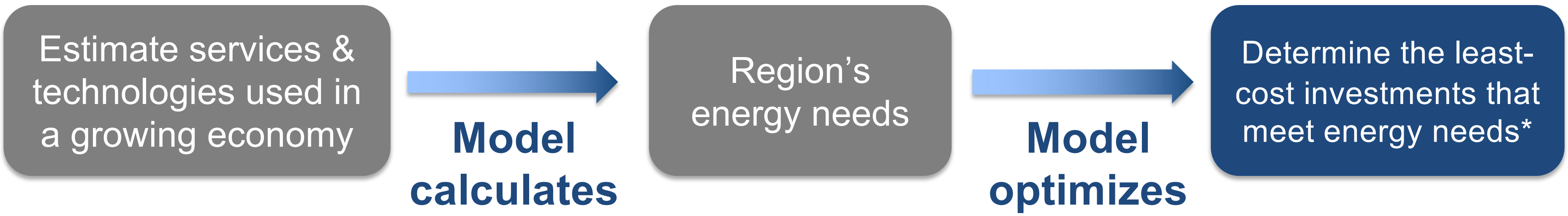


Key Assumptions

- Consumer technology adoption
- Future technology and fuel costs
- Regional cooperation and resources

Constraints

- Start with today's system
- Decarbonization goals
- Additional policy requirements

*The model carefully addresses and <u>requires</u> reliability

With stakeholders and the state, we analyzed nine scenarios to explore 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 cooperatiorn	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

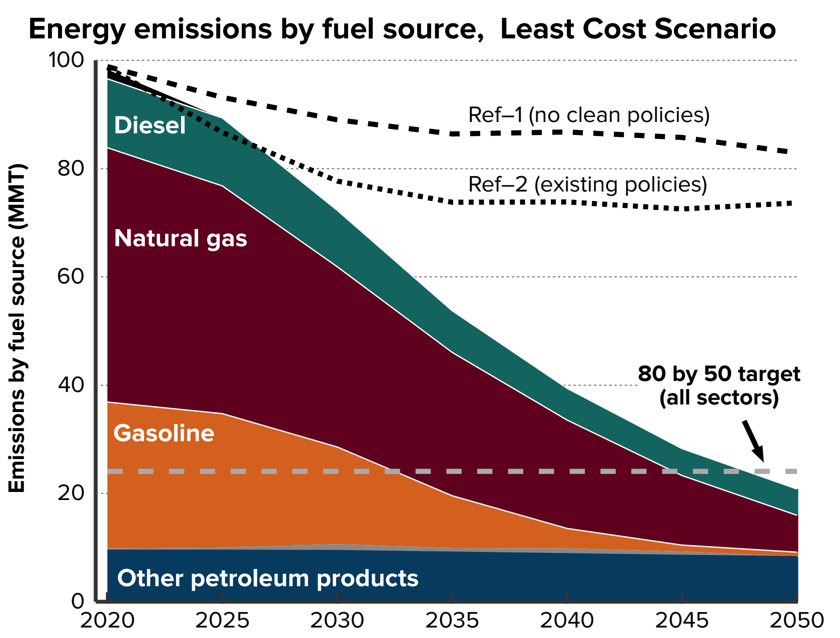
Key findings

Summary of key findings

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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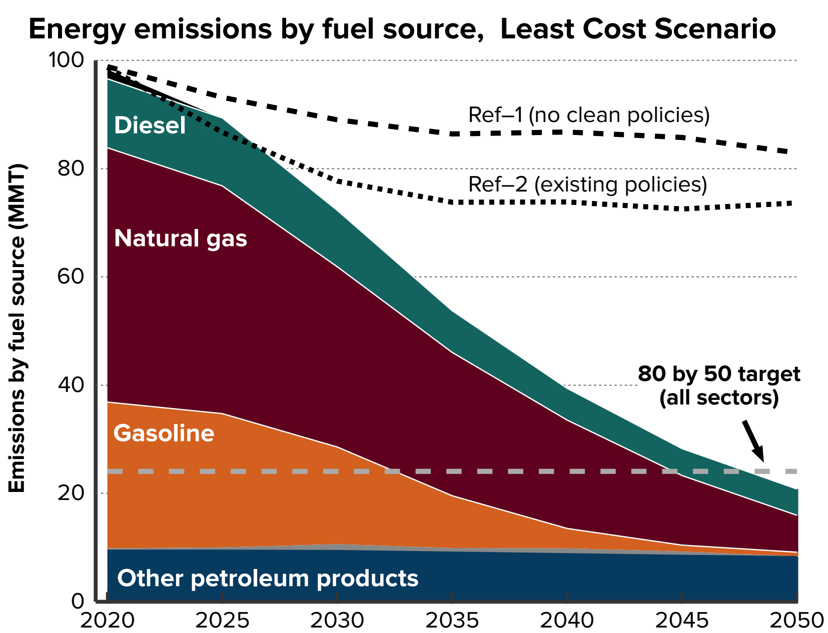
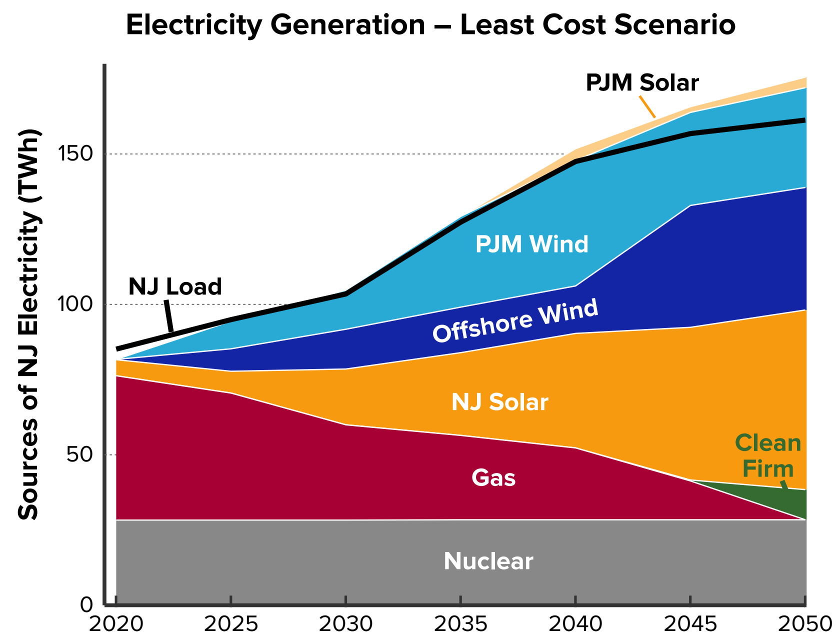


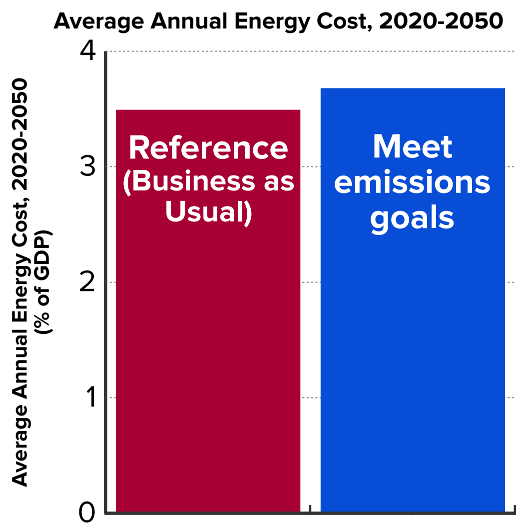
Carbon-neutral electricity grows and transitions to meet 100% Clean Energy



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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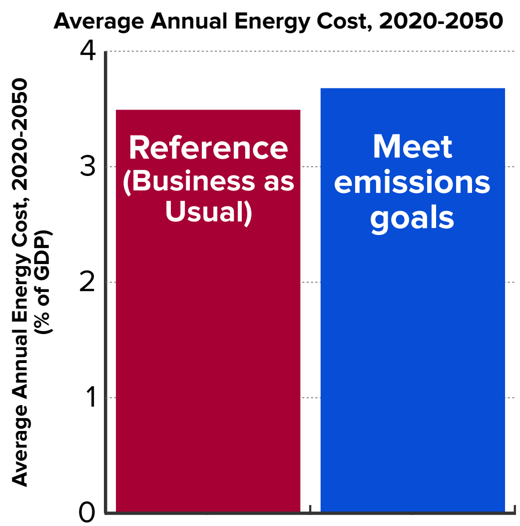

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Total 2050 energy system spending (not ratepayer cost or impact):

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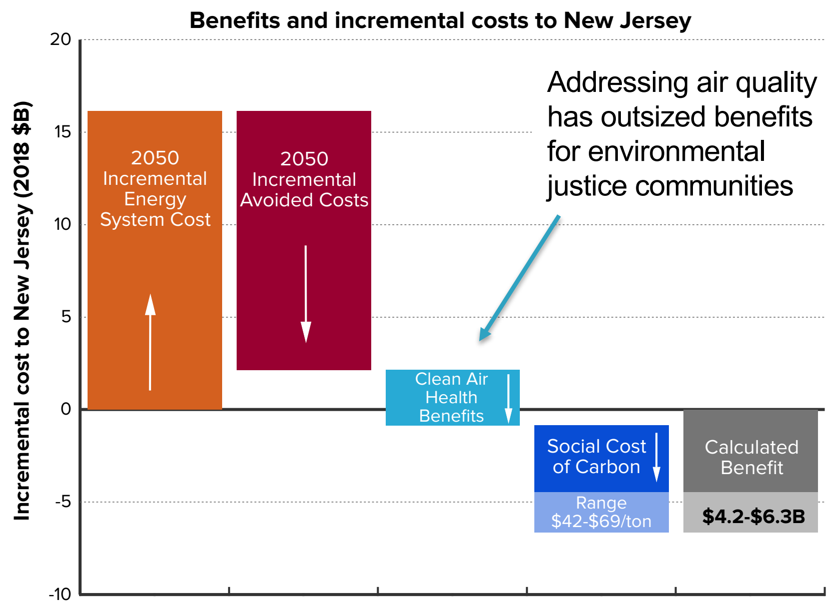
- Meet emissions goals: $34.7B/year (2018 dollars)

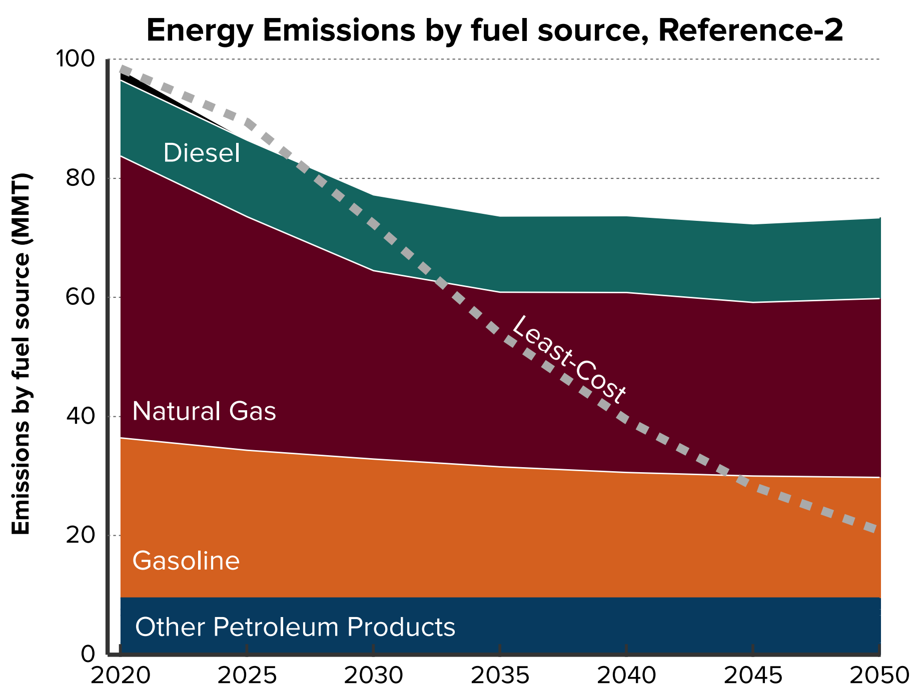
Incremental costs of meeting emissions targets are offset by fossil fuel cost savings and cost savings associated with reduced pollution



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

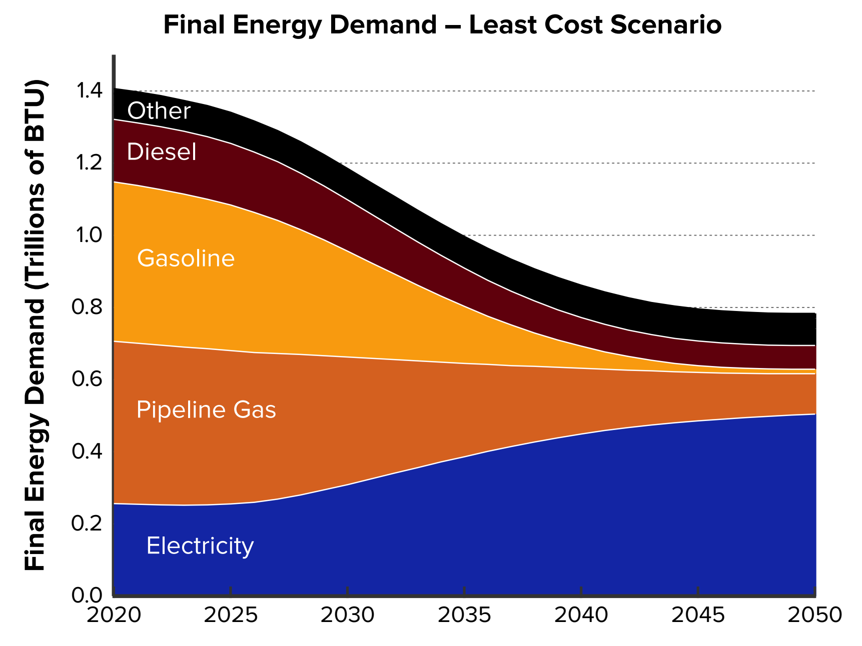
Emissions decline through 2035 but then flatten under current energy policies



- 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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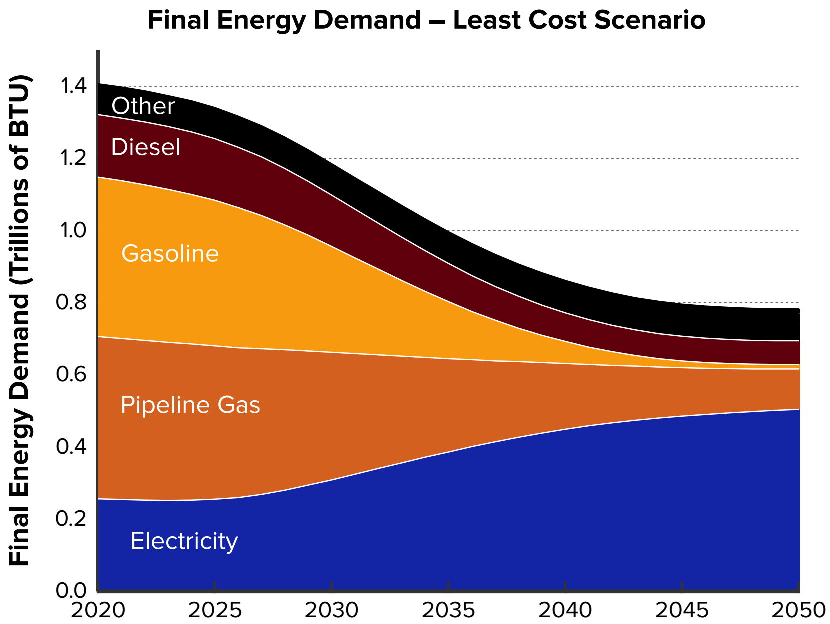
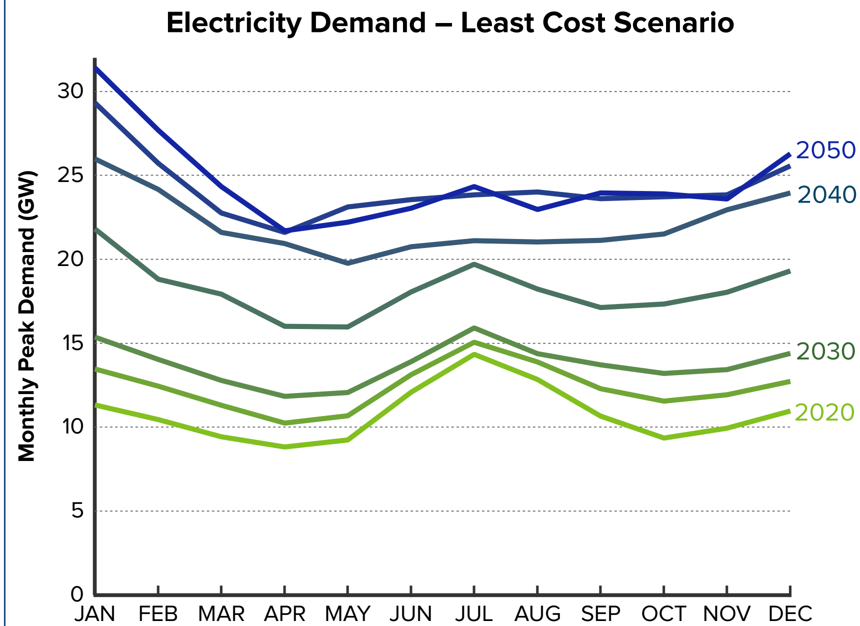
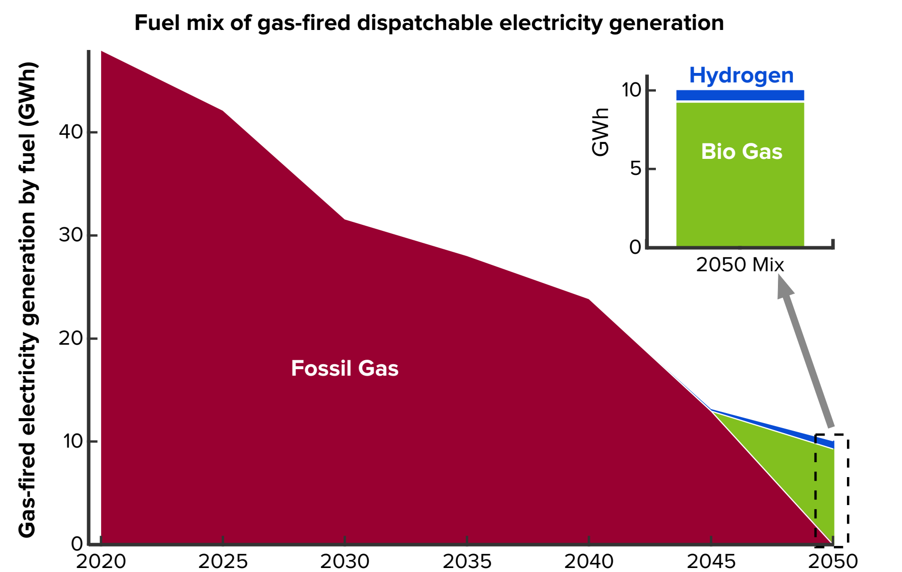


Electric vehicles and electrified heating steadily increase electricity demand, and shift peak periods to winter months



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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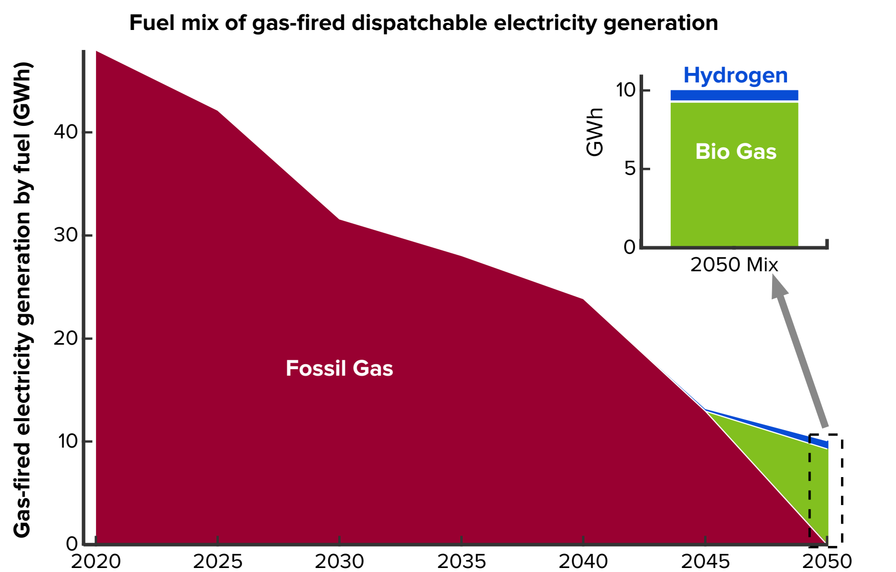

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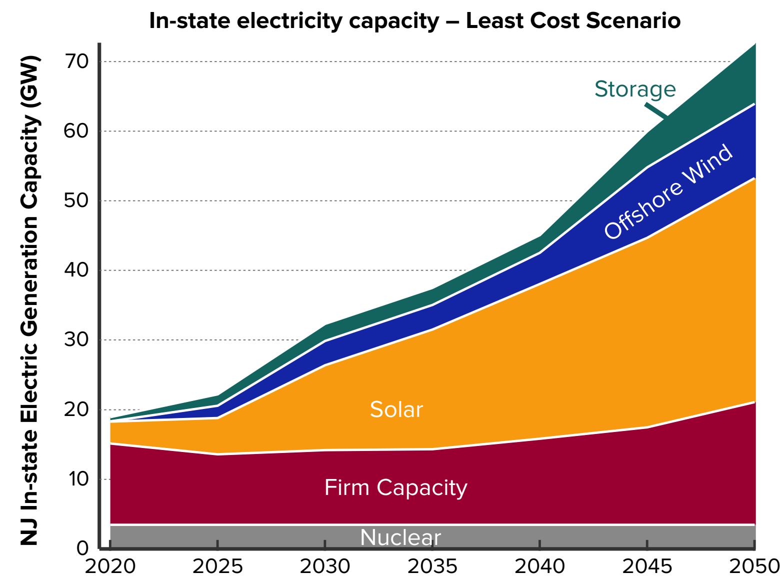
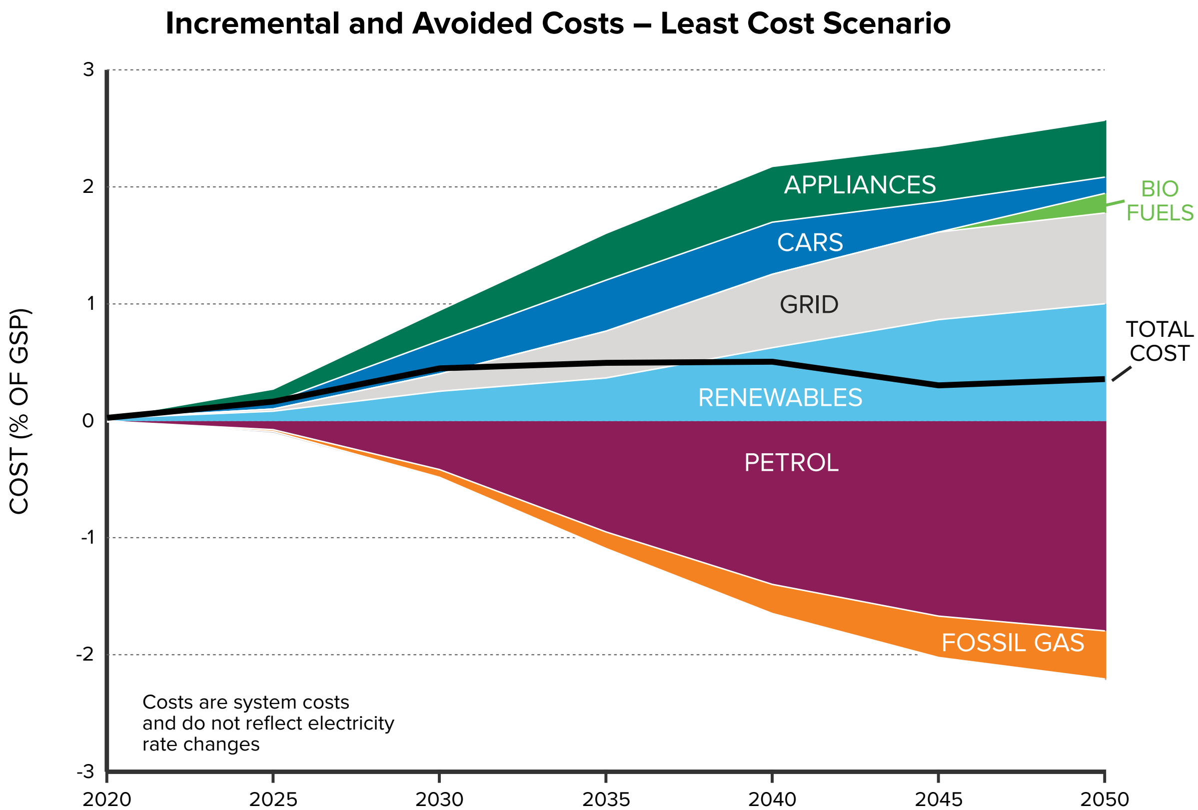
Renewable and storage capacity increases. To reliably meet growing demand, additional firm generation capacity is needed in 2040s.



- 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

DEEPER DIVES ON COST AND SCENARIO IMPLICATIONS

Cost is difficult to assess and communicate because there are both new and avoided costs

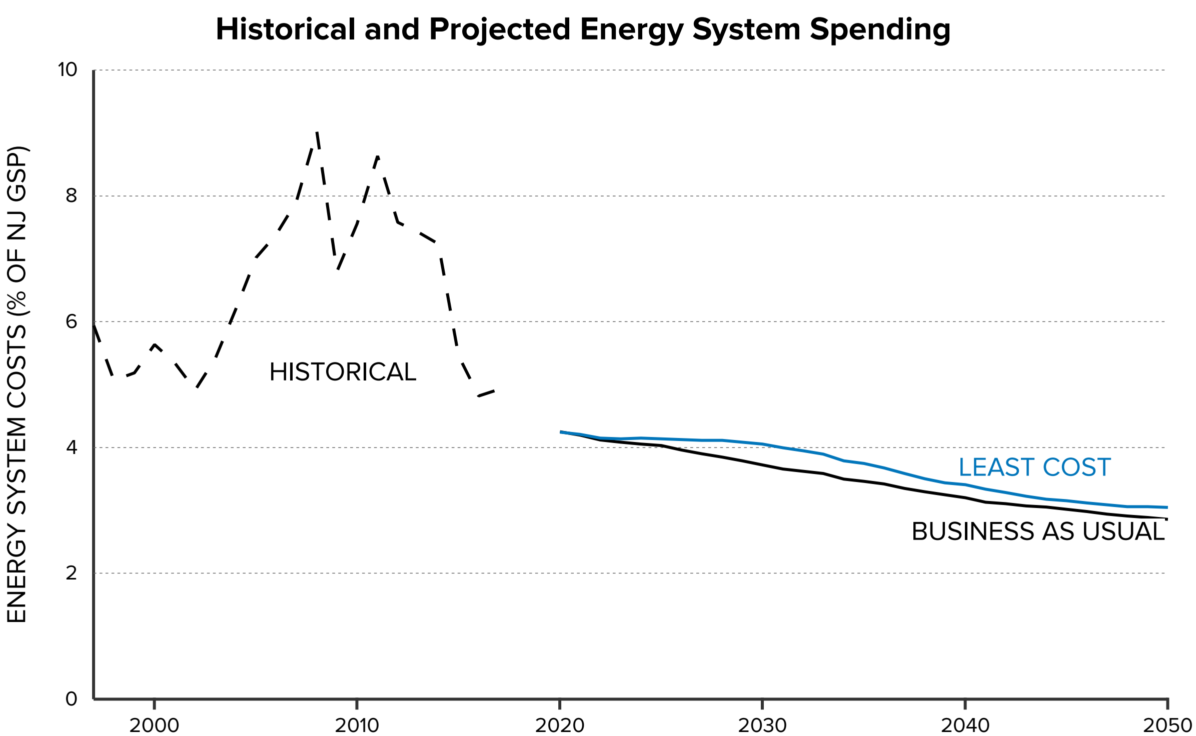


Key Cost Assumptions*

- The cost of EVs
- Fossil fuel costs
- Costs to increase grid capacity
- Whether we retain gas distribution system
- Dispatchable electricity technology
- (Whether to include health and cost of carbon benefits)

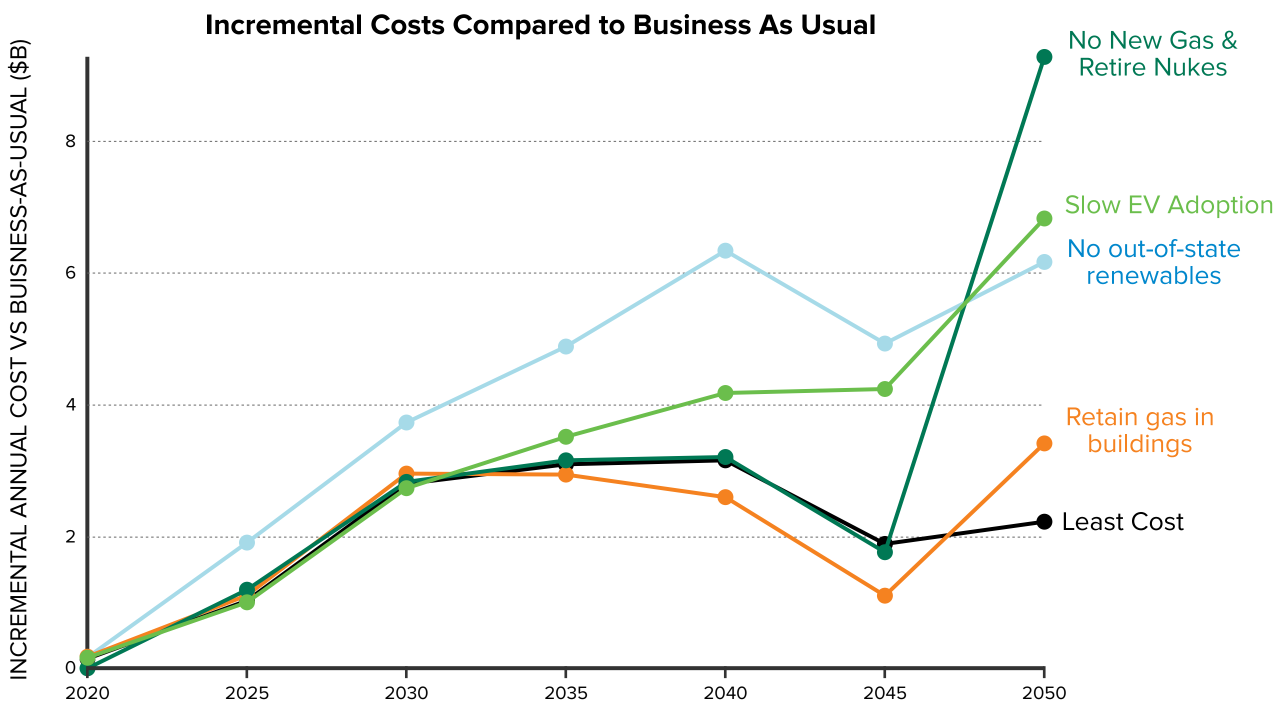
*All cost predictions are uncertain, especially future ones

Cost Differences in the 'Big Picture' are minimal



- In all scenarios, energy costs are a decreasing fraction of US economic spending
- Sensitivity and risks to fossil fuel prices decrease in decarbonized scenarios

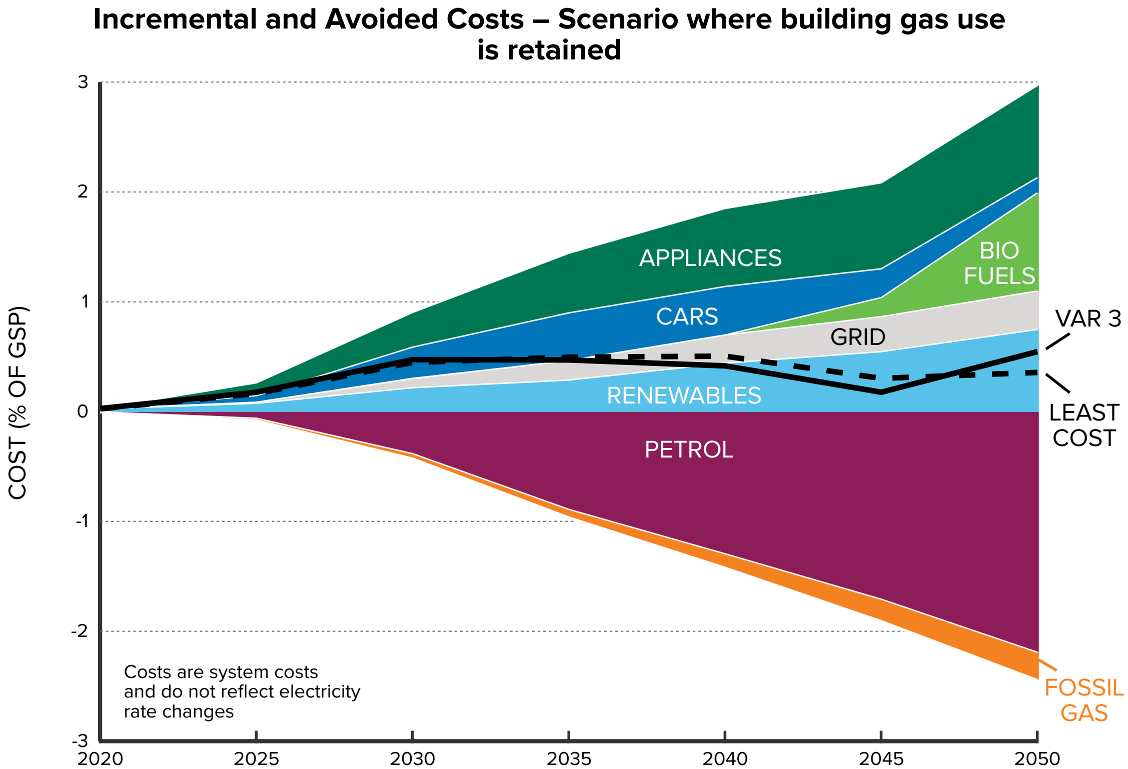
Choices in the 2020s will impact long term costs



It is critical to invest in technologies that enable deep decarbonization. Some options are cheaper in the near-term – but add cost in the long run.

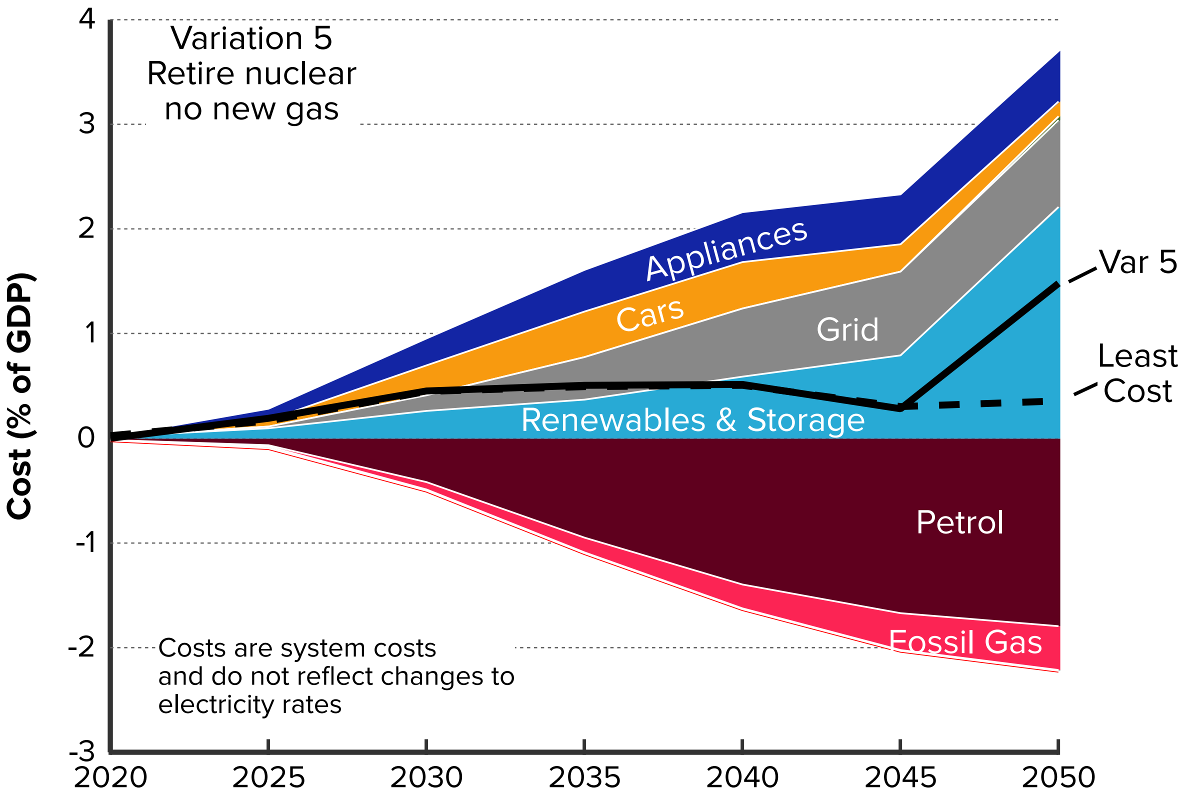
- Retaining gas in buildings
- Not transitioning to EVs
- Disallowing any firm generation

Retain Gas in Buildings



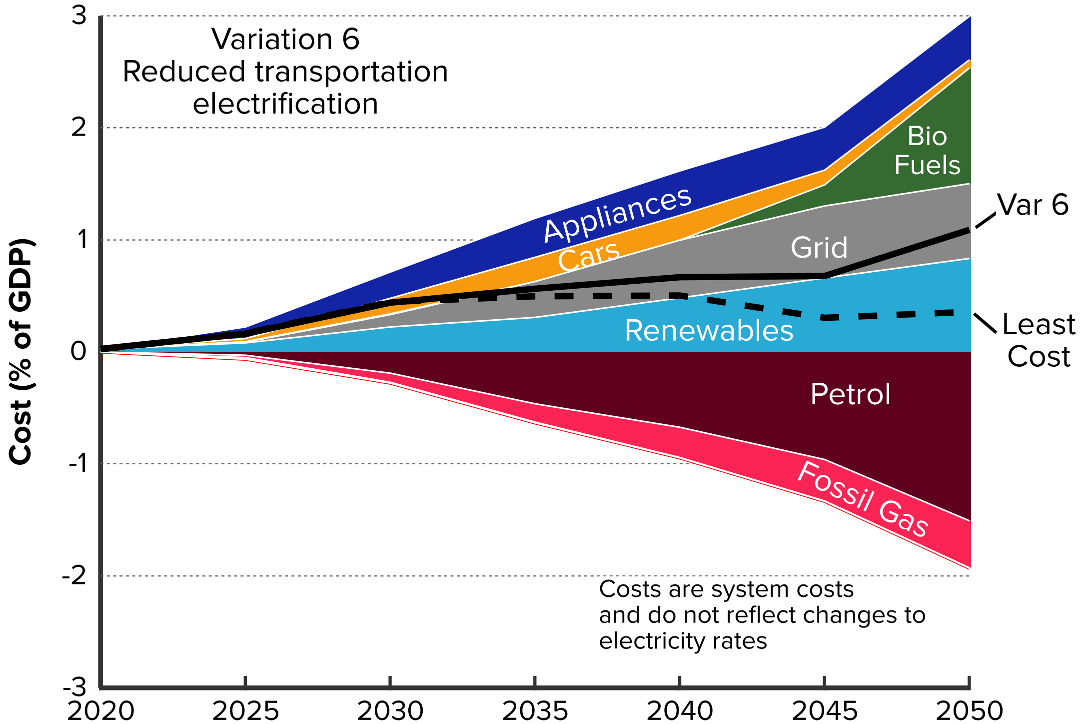
- Costs are lower in the short term
- But much higher in the long term
- Continuing to >80% decarbonization would be VERY expensive
- Key cost assumptions:
  - Electric distribution upgrades
  - Continued upkeep of gas distribution
  - Fossil gas costs

Close nuclear plants and prohibit new gas



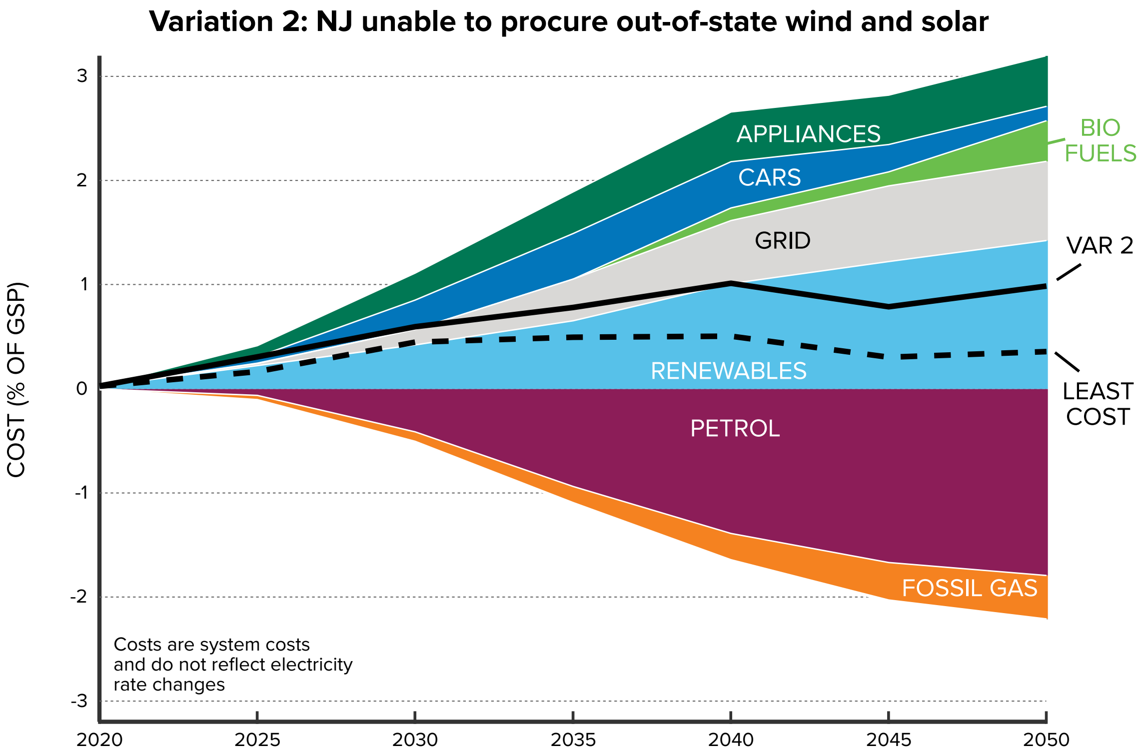
- Firm capacity plays a critical role for full electricity decarbonization
- Without gas or nuclear available, reliability requires very long duration battery storage that is prohibitively expensive
- This scenario depends strongly on assumptions for long duration storage, H_2-based technologies, and the availability of synthetic C-free fuels.

Slowing EV adoption increases cost and makes continued decarbonization difficult



- Nearly impossible to decarbonize without EVs. This scenario still includes 50% EVs in 2050
- Pathway forced to use biofuels for transportation

New Jersey "goes it alone" is expensive because out-of-state renewables add diverse clean energy



- Scenario limited out-of-state wind and solar procurement
- Biggest difference from least-cost is that more NJ solar and off-shore wind is required

Summary and key takeaways

New Jersey can affordably meet its emissions targets

- Modeling shows that decarbonization is similar in cost to business-as usual
- The technologies needed today are viable. Numerous reliability options are likely in the 2030s and 2040s.

Least-regret actions in 2020
"Electrify Everything and decarbonize electricity"

- Accelerate electrification of transportation and buildings
- Deploy renewables at scale
- Keep reliability options open

Don't let uncertainties after 2030 prevent 2020 action

- Many decarbonization models show similar results: the next 10 years are the "easy part"
- The earlier we get started, the easier decarbonization will be!

THANK YOU !