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Weaning NE Buildings Off Fossil Gas; and
Market (Redesign) Pathways to a Decarbonized NE Grid (#174)

Friday, June 10, 2022 - 9:00 am-12:30 pm

Convener/Moderator: Dr. Jonathan Raab, Raab Associates, Ltd.
Host: Foley Hoag, Seaport West, 155 Seaport Blvd, Boston, MA 02210
Twitter: **#RaabRT** Website: www.RaabAssociates.org

Agenda

9:00 **Welcome and Introductions—Dr. Jonathan Raab**

9:05 **Weaning NE Buildings Off Fossil Gas**

- **Rebecca Tepper,** Chief Energy & Environment Bureau, MA Attorney General's Office
- **Judith Judson,** VP & Head of US Strategy, National Grid
- **William Akley,** President/COO Gas Companies, Eversource Energy
- **Amy Boyd,** Director of Policy, Acadia Center

10:30 **Break**

11:00 **Market (Redesign) Pathways to a Decarbonized NE Grid**

- **Katie Dykes,** Commissioner, Connecticut DEEP
- **Gordon van Welie,** President & CEO, ISO New England
- **Todd Schatzki,** Principal, Analysis Group
- **Peter Fuller**, Principal, Autumn Lane Consulting

12:30 **Adjourn**

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NE Electricity Restructuring Roundtable:

E3 MA DPU 20-80 Decarbonization Report

June 2022

nationalgrid

E3’s scenarios

E3 worked with stakeholders and the MA LDCs to design 8 scenarios to evaluate different strategies to achieve decarbonization in the buildings sector in alignment with the state’s net zero emissions target.

Inspired by the Massachusetts Roadmap and interim 2030 CECP, modified to meet goals of 2021 climate legislation

Alternative 2050 decarbonization scenarios, reflecting stakeholder input

Scenario:

- Low Electrification (inspired by “Pipeline Gas”)
- High electrification (inspired by “All Options”)
- Interim 2030 CECP
- Hybrid Electrification
- Networked Geothermal
- Targeted & Optimized Electrification
- Efficient Gas Equipment
- 100% Gas Decom-missioning

 Source: Decarbonization Pathways Report at 48, Figure 13, 11.16.21 DRAFT Scenario Analysis at Slide 9

E3's Overall Assessment

Higher gas system utilization ⟵⟶ Lower gas system utilization

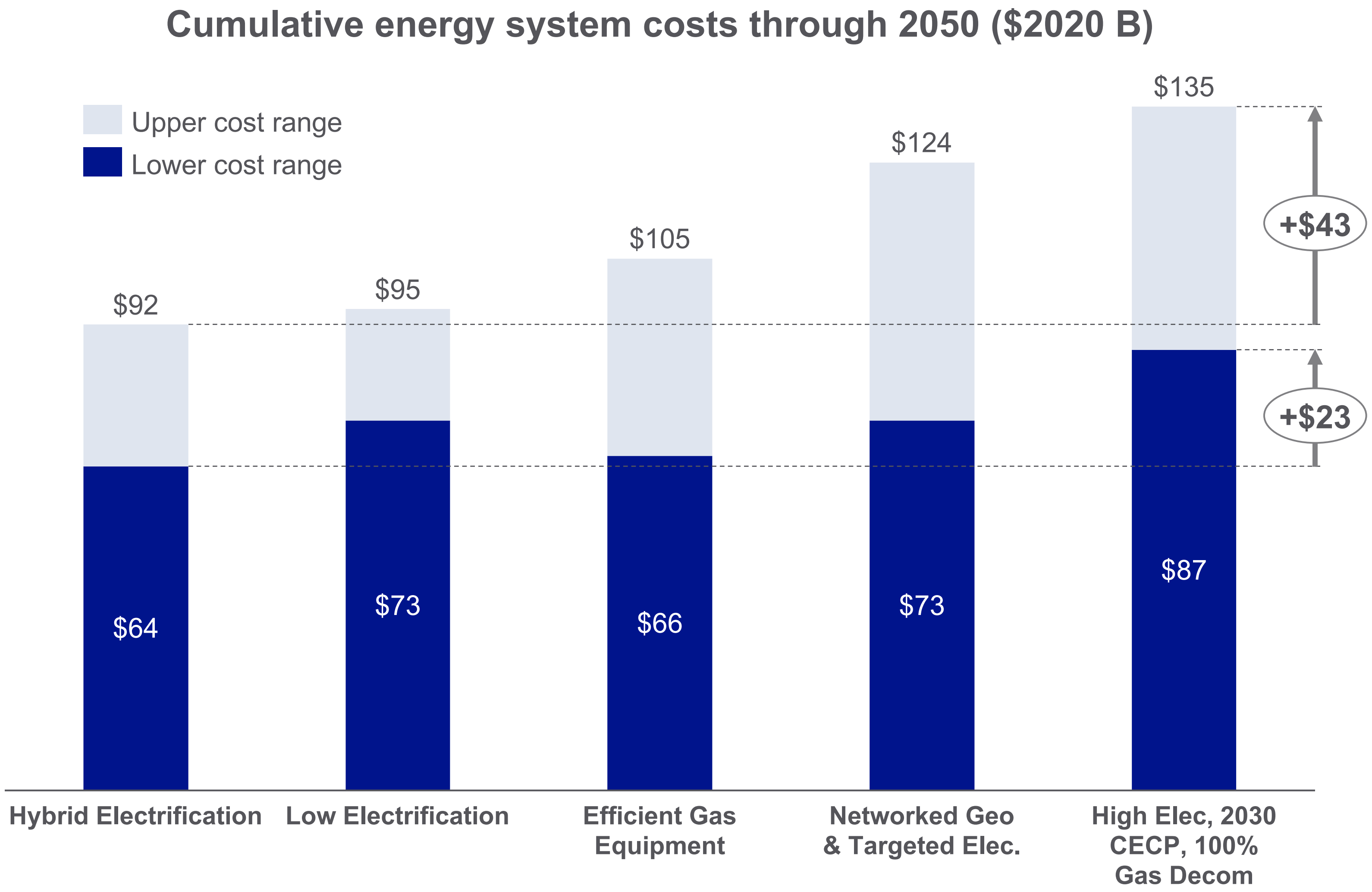
Level of challenge: *Lower* ▯▯▯ *Higher*

	Efficient Gas Equipment	Low Electrification	Hybrid Electrification	Networked Geo & Targeted Elec.	High Elec, 2030 CECP, 100% Gas Decom
Cumulative Energy System Costs ($2020)	$ 66-105 bln	$73-95 bln	$64-92 bln	$73-124 bln	$87-135 bln
Infrastructure Requirements					
Technology Readiness					
Air Quality					
Workforce Transition					
Customer Practicality					
Near-term Customer Affordability (2020s)					
Long-term Customer Affordability (2040s)					
Customer Equity (2040s)					
Safety & Reliability	*All pathways are assumed to comply with D.P.U. and industry safety and reliability standards*				

Source: Decarbonization Pathways Report at 12

E3 Scenarios Economywide Cost Comparison

“The **Hybrid Electrification** scenario that envisions an ongoing, though reduced, role for the gas system carries the **lowest cumulative costs**.”

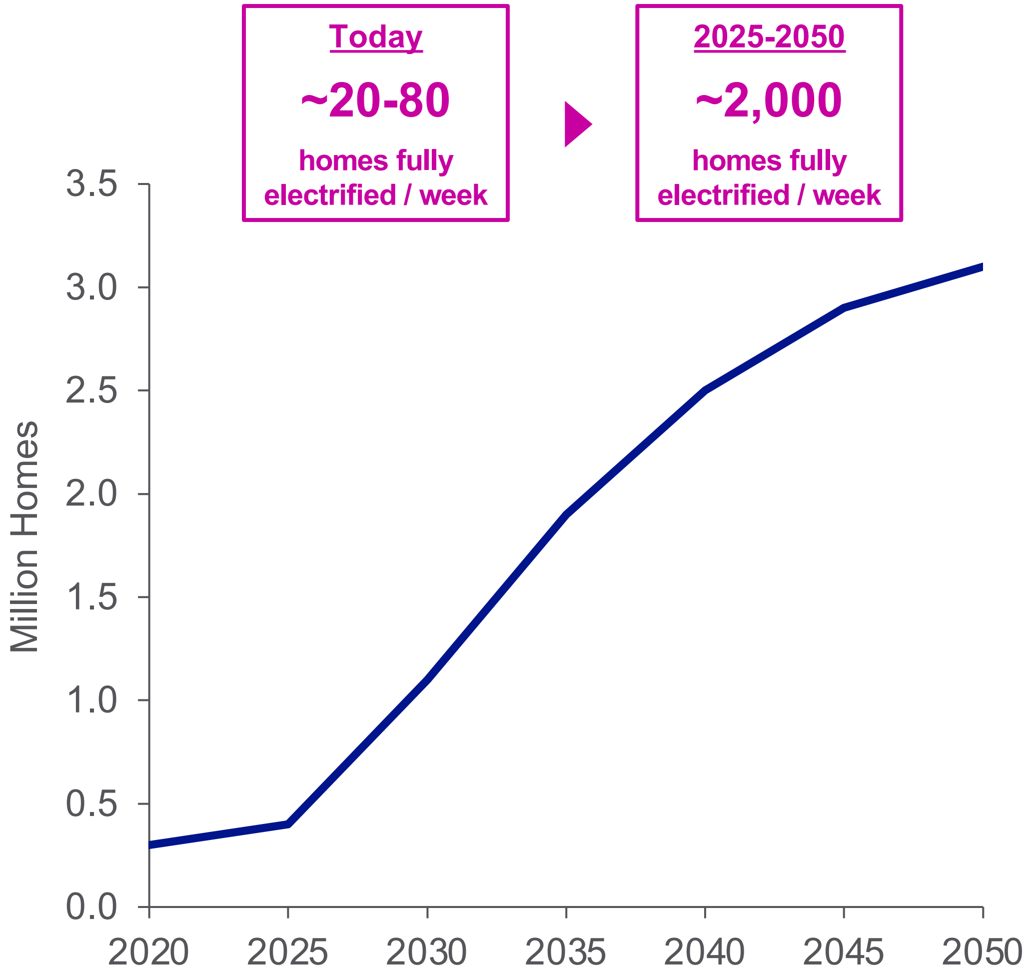


 Source: Decarbonization Pathways Report at 78. National Grid figure using data from Decarbonization Pathways Report at 11, Figure 1

Customer Practicality

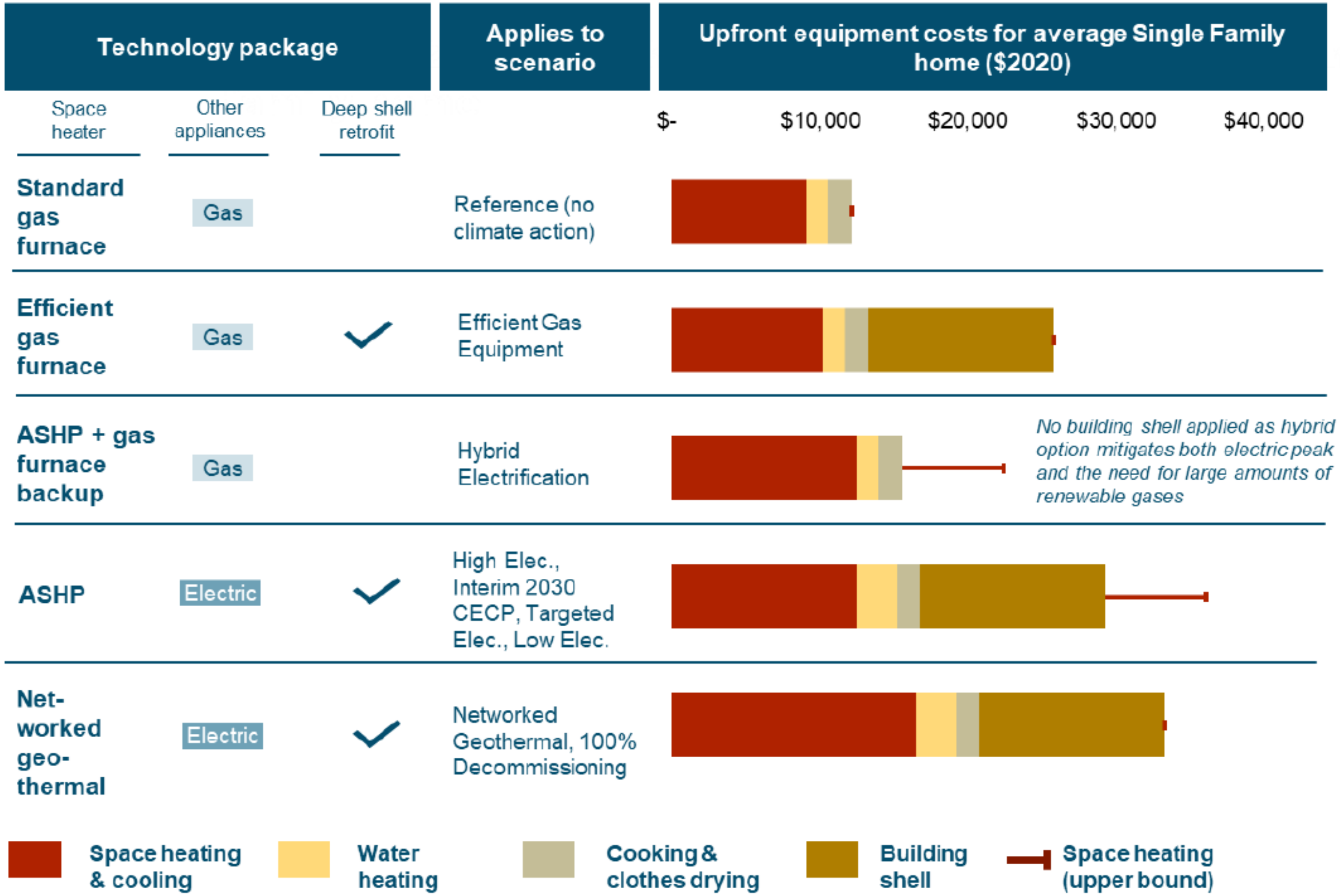
"Pathways that require the **most rapid conversion** of natural gas customers to **electric energy solutions** present **significant challenges for customers, regulators, and LDCs** to change current customer behavior at an unprecedented pace and scale."

Pace of Change to Achieve Full Electrification



 Source: Decarbonization Pathways Report at 79. National Grid figure using data from Decarbonization Pathways Report at 98, Table 15.

Customer Affordability and Equity

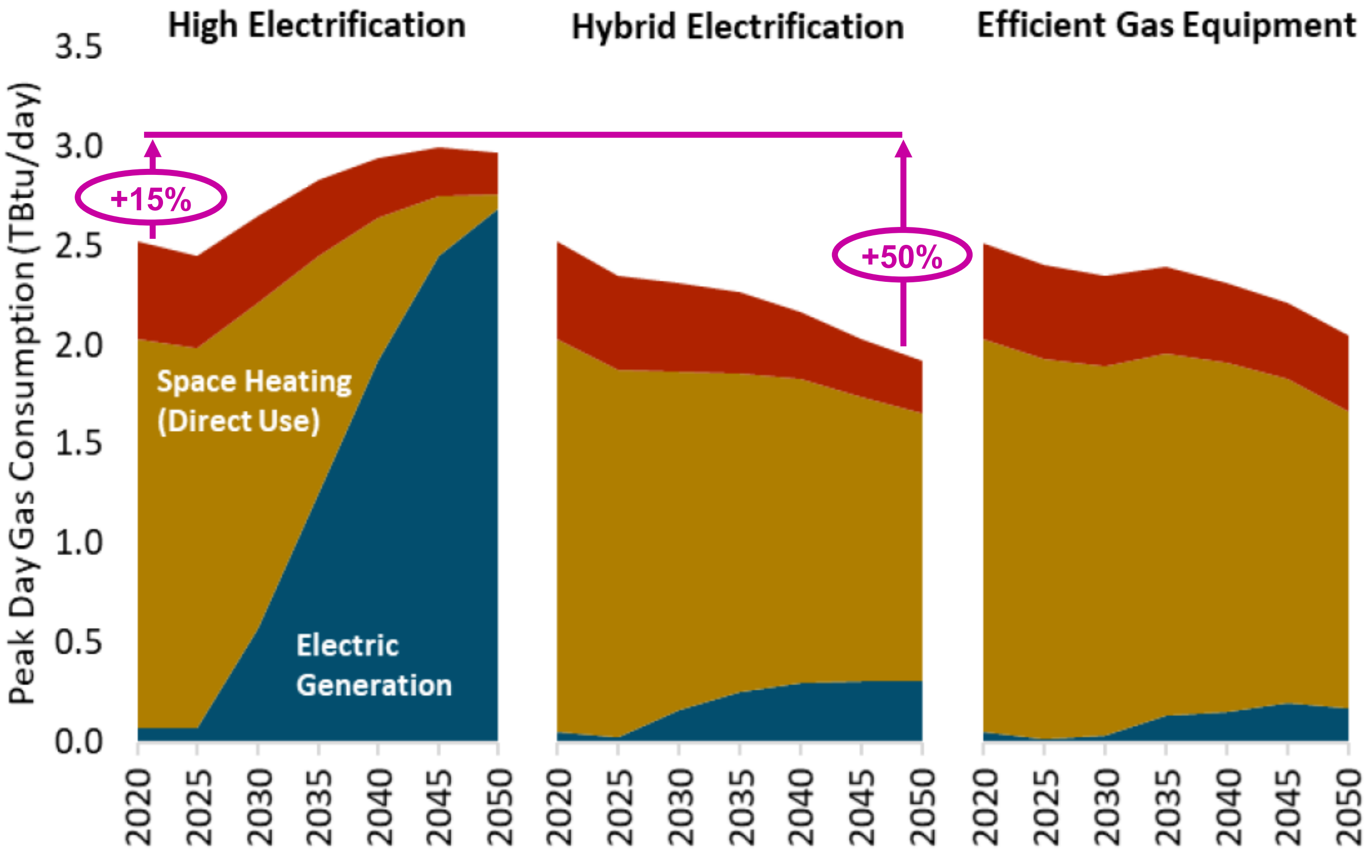


"Affordability results are **particularly concerning for lower-income customers** given that the upfront cost challenges associated with fully electrifying a building makes it more likely they will experience increasing gas system costs."

 Decarbonization Pathways Report at 79 and 105, Figure 39

High Electrification Requires More Renewable Gas on Peak Day

Changes in peak winter day gas volumes for three decarbonization pathways. Total gas volumes include zero-carbon pipeline gas, including hydrogen.



"This figure implies that the **gas infrastructure associated with meeting peak demands may increase** in those pathways with **higher levels of electrification** (e.g., High Electrification)."

 Source: Decarbonization Pathways Report at 65, Figure 24. National Grid added features in pink.

Conclusions and Recommendations from E3's Report

1. "Despite long-term uncertainty on the direction of decarbonization, there are several **low-regret** decarbonization technologies used across scenarios":
   - Energy Efficiency, Building electrification, Biomethane, Renewable electricity

2. "Balancing across many considerations, decarbonization pathways that strategically use the state's **gas infrastructure alongside and in support of electrification** are likely to carry lower levels of challenge.

3. "In addition to these common strategies, several decarbonization technologies are worth **further research and development** to better understand their costs and resource potential":
   - Targeted electrification, Networked geothermal systems, Hybrid system operation, Renewable hydrogen

4. "The Consultants recommend that the LDCs, together with the D.P.U., begin implementing **decarbonization strategies and regulatory reforms** to support the Massachusetts climate goals."

Source: Decarbonization Pathways Report at 18 and 19

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NE Electricity Restructuring Roundtable:

National Grid Fossil-free Vision

June 2022

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Our Plan Borrows Heavily from the Consultants' Hybrid Electrification

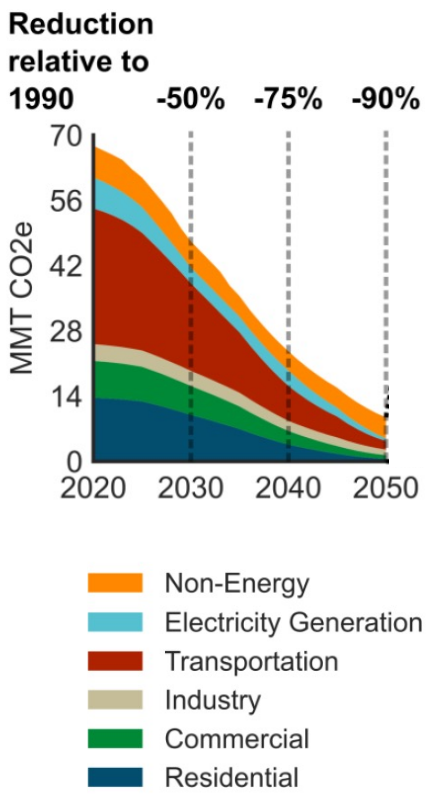
Our plan relies on key features of Hybrid Electrification…

- ✓ Roughly **60% gas demand reduction**
- ✓ **Similar gas customer count**
- ✓ 100% **renewable gas for Residential and Commercial** customers
- ✓ Significant customer adoption of **hybrid heating** systems

…but also allows for inclusion of features from other pathways, where safe and cost-effective to implement.

- \+ **Targeted electrification** and **networked geothermal**
- \+ 100% **renewable gas for Industrial** customers
- \+ Deep **energy efficiency** measures

Emissions trajectory for all scenarios modeled by the Consultants*



 *Decarbonization Pathways Report at 48, Figure 13

Four Pillars of Our Plan

Pillar one
Energy efficiency in buildings

We will continue to provide programs for our customers to accelerate energy efficiency improvements to buildings, including deep retrofits and measures that reduce peak gas and electric demand; and support more rigorous building codes for new buildings.

Pillar two
Hybrid electric-gas heating systems

We will support our customers by providing them strategies and tools to capture and maximize the benefits of pairing electric heat pumps with their gas appliance.

Pillar three
Targeted electrification and networked geothermal

We will support cost-effective targeted electrification on our gas network, including piloting new solutions like networked geothermal. We will support customers who heat with oil and propane with strategies and tools to convert to heat pumps.

Pillar four
100% fossil-free gas network

We will eliminate fossil fuels from our existing gas network no later than 2050 by delivering renewable natural gas and green hydrogen to our customers.

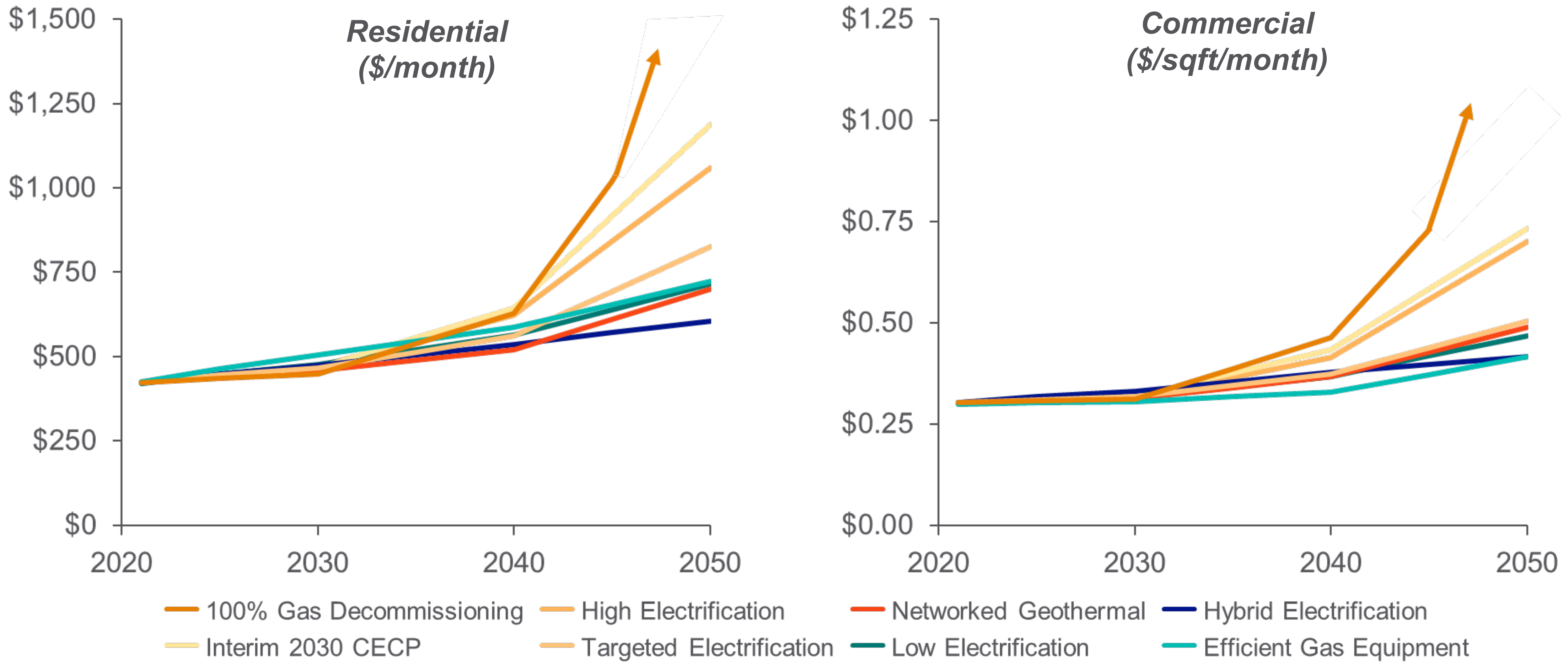
National Grid's Plan for a Net Zero Gas Network in Massachusetts

Our plan presents a **practical and achievable** pathway to net zero for the Commonwealth.

- ✓ **Lowest cost:** Saves $23-43 Billion compared to other net zero pathways.
- ✓ **Leverages existing infrastructure:** Requires significantly less electric generation, transmission, and distribution infrastructure.
- ✓ **Leaves no customer behind:** Supports equitable outcomes for environmental justice communities. By avoiding large upfront costs, our vision enables all customers to have access to clean energy.
- ✓ **Preserves customer choice:** Keeps heating and cooking options open.
- ✓ **More resilient and reliable:** Not all eggs in one basket.
- ✓ **Less gas on a winter peak day**: Our plan uses less gas than high electrification during peak times.
- ✓ **Utilizes skill set of our existing workforce:** Empowers gas workers to use skill set to achieve our shared net zero goals.
- ✓ **More likely to reach net zero by 2050:** Practical and achievable.

A Hybrid Approach Results in More Affordable and Equitable Outcomes for Our Customers

Estimated average total monthly gas and electric energy costs for customers that utilize the gas system



 National Grid Net Zero Enablement Plan at 15, Figure 6; National Grid figures based on E3 customer affordability modeling data

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September 30th Roundtable
The Connective Tissue:
Transmission in Support of Decarbonization

FERC Transmission NOPR(s) and Joint Federal-State Task Force on Electric Transmission

- **Chairman Richard Glick**, FERC
- **Chairman Mathew Nelson**, MA DPU

Key Innovations in Transmission Planning, Procurement, and Cost Allocation

- **Doreen Harris**, President & CEO, NYSERDA [terrestrial transmission N/S; and OSW transmission plans]
- **Abe Silverman**, General Counsel, NJ BPU [OSW Transmission RFP]
- **Aubrey Johnson**, VP System Planning MISO [Long-Range Transmission Plan]
- **Robert Ethier**, VP System Planning, ISO New England New England [2050 Transmission Study]

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Pathways Study: Evaluation of Pathways to a Future Grid for New England

Restructuring Roundtable

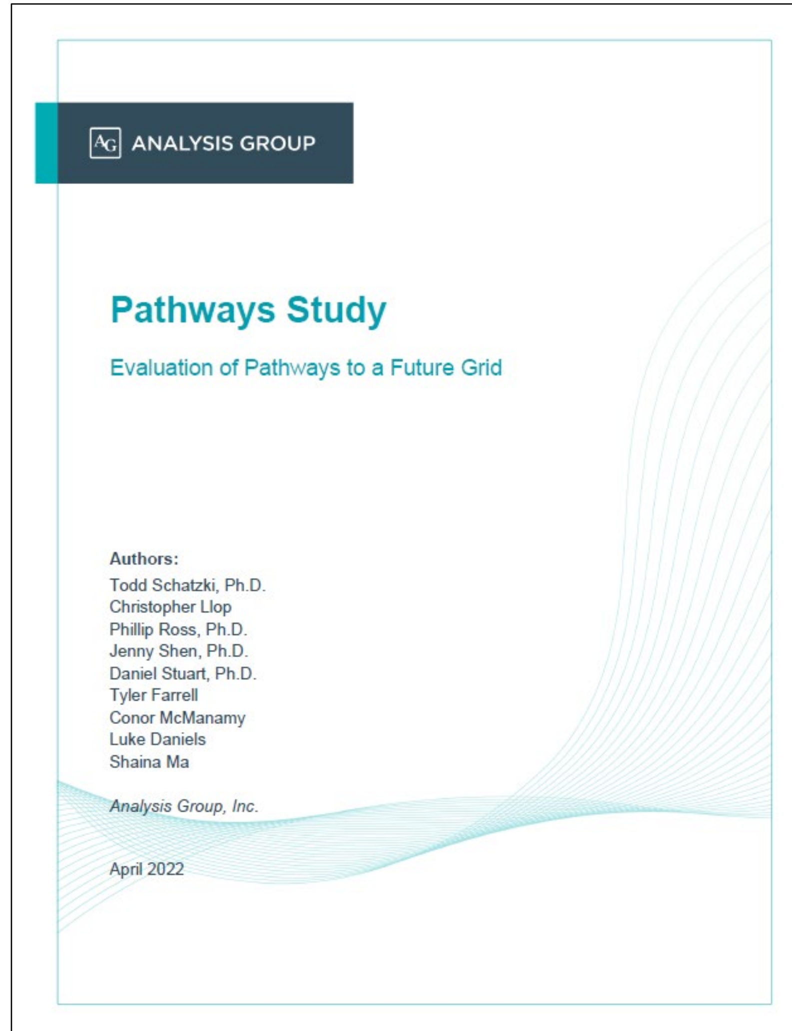
Todd Schatzki

June 10, 2022

Pathways Process – A Brief History

- **Multi-stakeholder effort**
  - Prepare for transition to a decarbonized gird, including NEPOOL, ISO-NE and New England States Committee on Electricity (NESCOE)

- ***The Pathways Process***
  - Explore and evaluate potential centralized, market frameworks for the transition to a decarbonized future grid
  - Initial "pathways" evaluation considers broad scope of market-based options (NEPOOL final report: January 2021)
  - *Pathways Study* (April 2022) provides thorough qualitative and quantitative evaluation of four potential pathways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Pathways Study

Evaluation of Pathways to a Future Grid

Authors:
Todd Schatzki, Ph.D.
Christopher Llop
Phillip Ross, Ph.D.
Jenny Shen, Ph.D.
Daniel Stuart, Ph.D.
Tyler Farrell
Conor McManamy
Luke Daniels
Shaina Ma

Analysis Group, Inc.

April 2022

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Development of Economically Efficient, Reliable Future Grid Requires Study of Many Dimensions

- ***Pathways Study***
  - Evaluates choice among policy approaches given economic, market and regulatory tradeoffs
  - Does not address all relevant policy considerations or all relevant system, operational and market issues
- Other on-going study processes are addressing some outstanding issues, while some remain unaddressed

Issue	Study	Issue Description
Legal and Regulatory	--	Certain policy approaches may raise issues of jurisdiction (e.g., *which* institutions can administer various policies) and compliance with existing federal and state statues and policies (e.g., requirements not to create undue discrimination in competitive markets)
Reliability	*Future Grid Reliability Study*	Variable renewable integration, capacity market uncertainty, and other dimensions of reliability
Transmission	*ISO-NE 2050 Transmission Study*	Analysis of transmission needs of a decarbonized system

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Four Policy Approaches Evaluated

Policy Approach	Description
Status Quo	• Continuation of recent unilateral policies by each of the six New England states • Reliance on procurement of clean energy supplies through bilateral multi-year contracts
Forward Clean Energy Market	• Forward market for clean energy certificates ("CECs") awarded to all "clean" energy, akin to RPS with RECs • Forward centralized auction with settlement against forward commitment • CEC demand created by state-imposed utility CEC requirements
Net Carbon Pricing	• Cost on carbon emissions from generators – cap-and-trade or fixed carbon price • Carbon revenues credited to customers
Hybrid Approach	• Carbon price set to provide sufficient revenues for the region's largest clean energy plant to remain financially viable (while also making other existing resources viable); carbon revenues credited to customers • An FCEM with CEC awards limited to "new" resources

- ***Four approaches studies are not the full scope of potential options*** – in particular, other "hybrid" options mixing carbon pricing and FCEM are feasible and may provide different balance tradeoffs

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Incentives: Subsidize "Goods" or Impose Costs on "Bads"

Technology	Eligible for CECs?	Subject to Carbon Price?
Onshore wind	✓	✗
Offshore wind	✓	✗
Utility-scale solar	✓	✗
BTM solar	✓	✗
Canadian hydro	✓	✗
Run-of-river hydro	✓	✗
Pondage hydro	✓	✗
Pumped storage	✗	✗
Nuclear	✓	✗
Battery storage	✗	✗
Municipal solid waste	✓	✗
Other biomass	✓	✗
Natural gas combined cycle	✗	✓
Fuel cells	✗	✓
Coal	✗	✓
Steam Turbine	✗	✓
Gas Turbine	✗	✓

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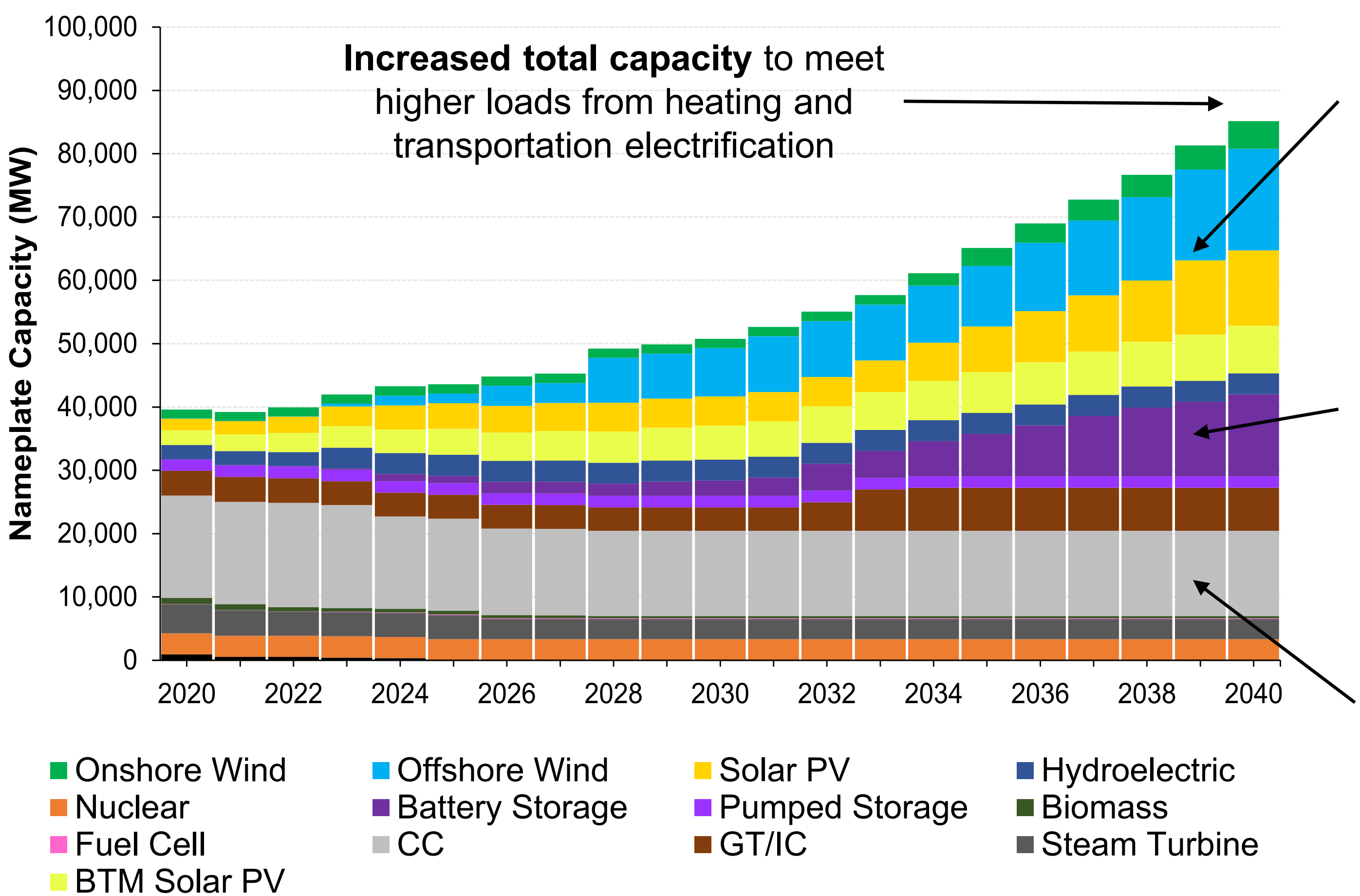
Evolution of System Resources to Lower Economy-Wide Emissions

Resource Mix, Status Quo Policy Approach, 2020-2040 (MW)



Increased variable renewable capacity (solar PV, onshore and offshore wind) to increase clean energy share

Increase in battery storage capacity to shift excess variable renewable supplies to displace carbon emissions

Reduced fossil capacity, but large fraction retained to maintain resource adequacy

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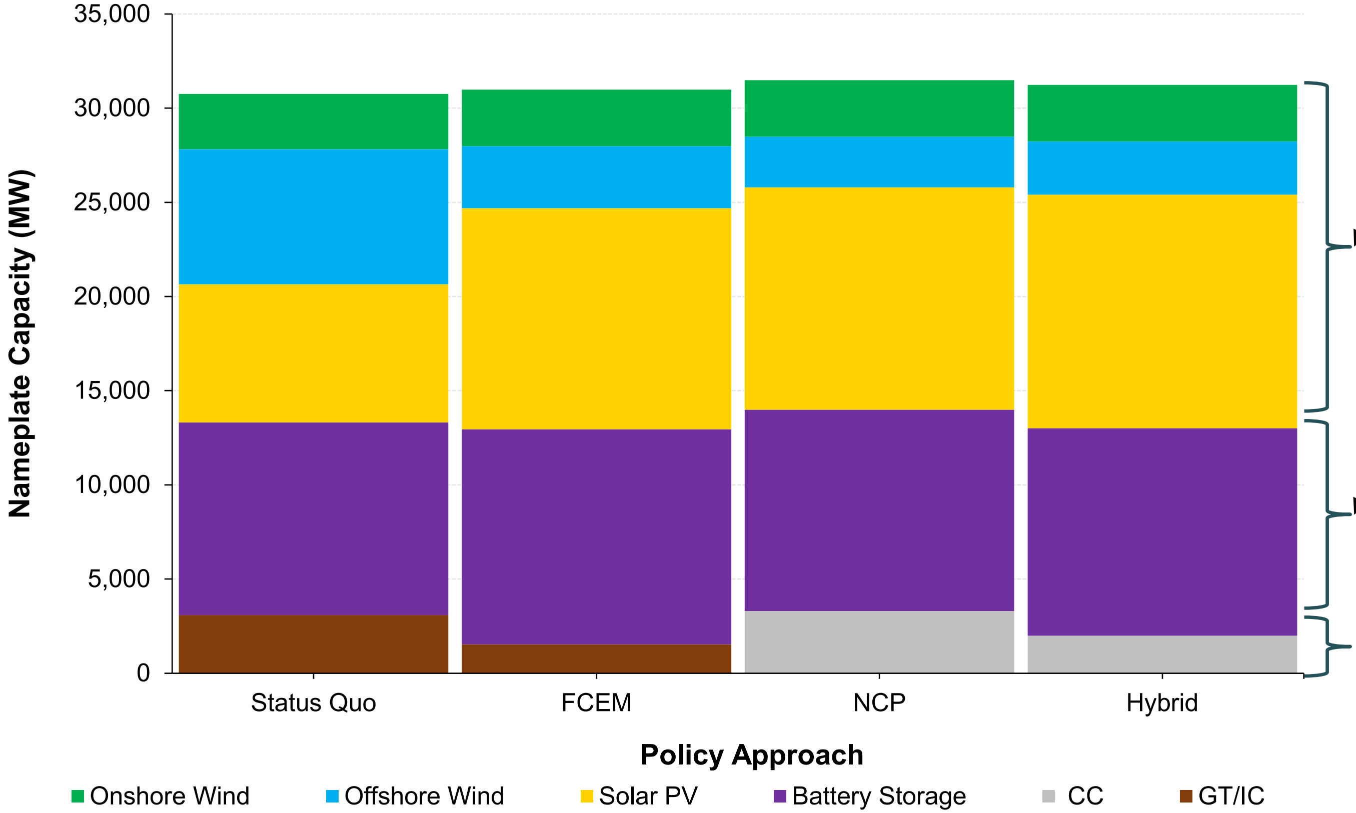
Incented New Resources Vary by Policy Approaches

New Resources (Incr. to Baseline State Policies) by Policy Approach, 2040 (MW)



Mix of new renewable resources varies by across policy approaches

Quantity of battery storage capacity relatively similar across approaches

New gas-fired resource technology (given fossil retirements) **differs across policy approaches**

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Cost-Effectiveness

Centralized approaches can increase cost-effectiveness through transparent market-based price signals

- Net Carbon pricing incents most cost-effective emission reductions – *when*, *where*, and *how* reductions are achieved
- Other centralized approaches differ in which types of emission reductions are incented
- Status Quo lacks price signals to incent reductions – relies on procurements to select least-cost resources

Cost-Effectiveness of Key Resource Decisions	***Status Quo***	***FCEM***	***FCEM w/ Dynamic CECs***	***Net Carbon Pricing***	***Hybrid Approach***
Substitution of Clean for Fossil-Fuel Resources	*NA*	High	High	High	High
Choice Among Clean Energy Resources	*NA*	Low-Medium	Medium	High	Medium
Choice Among Fossil-Fuel Resources	Low	Low	Low	High	Medium

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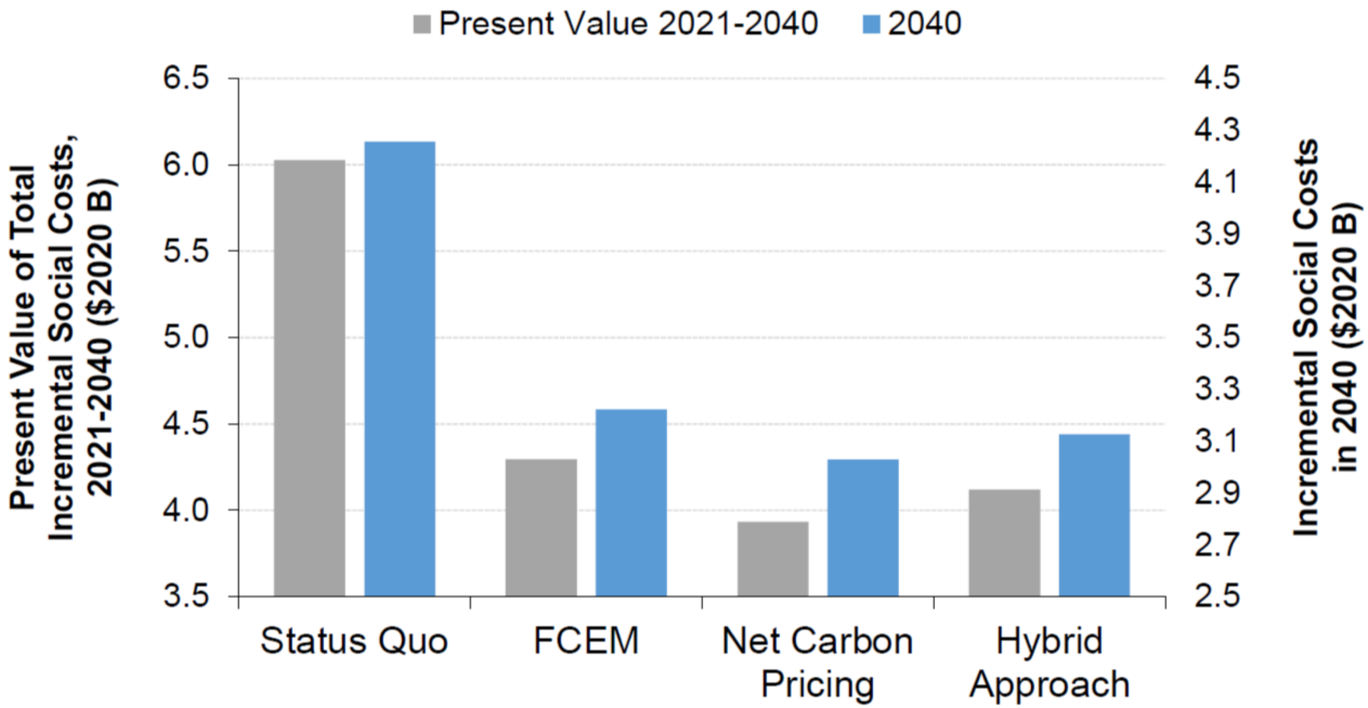
Differences in Cost-Effectiveness Reflected in Social Costs

Estimated Social Costs of Incremental Emission Reductions



- Differences in social costs between centralized approaches reflects differences in cost-effectiveness
- Higher cost of Status Quo reflects a combination of factors, including cost-effectiveness differences and assumed resource mix given current state studies and roadmaps

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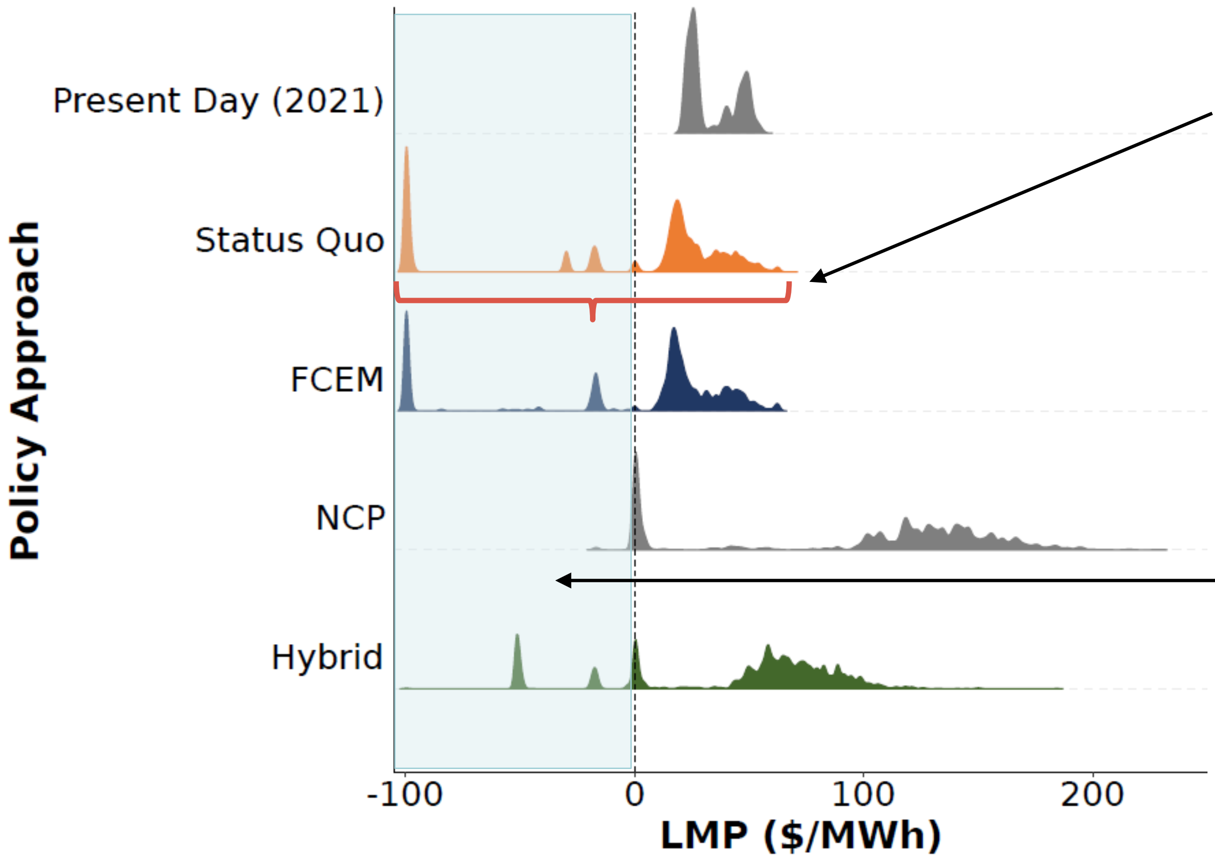
Negative Pricing Varies Across Policy Approaches

LMP Distribution by Policy Approach, 2040 ($2020/MWh)



Larger LMP spreads under all policy approaches

- Incents battery storage, which can arbitrage large price spreads

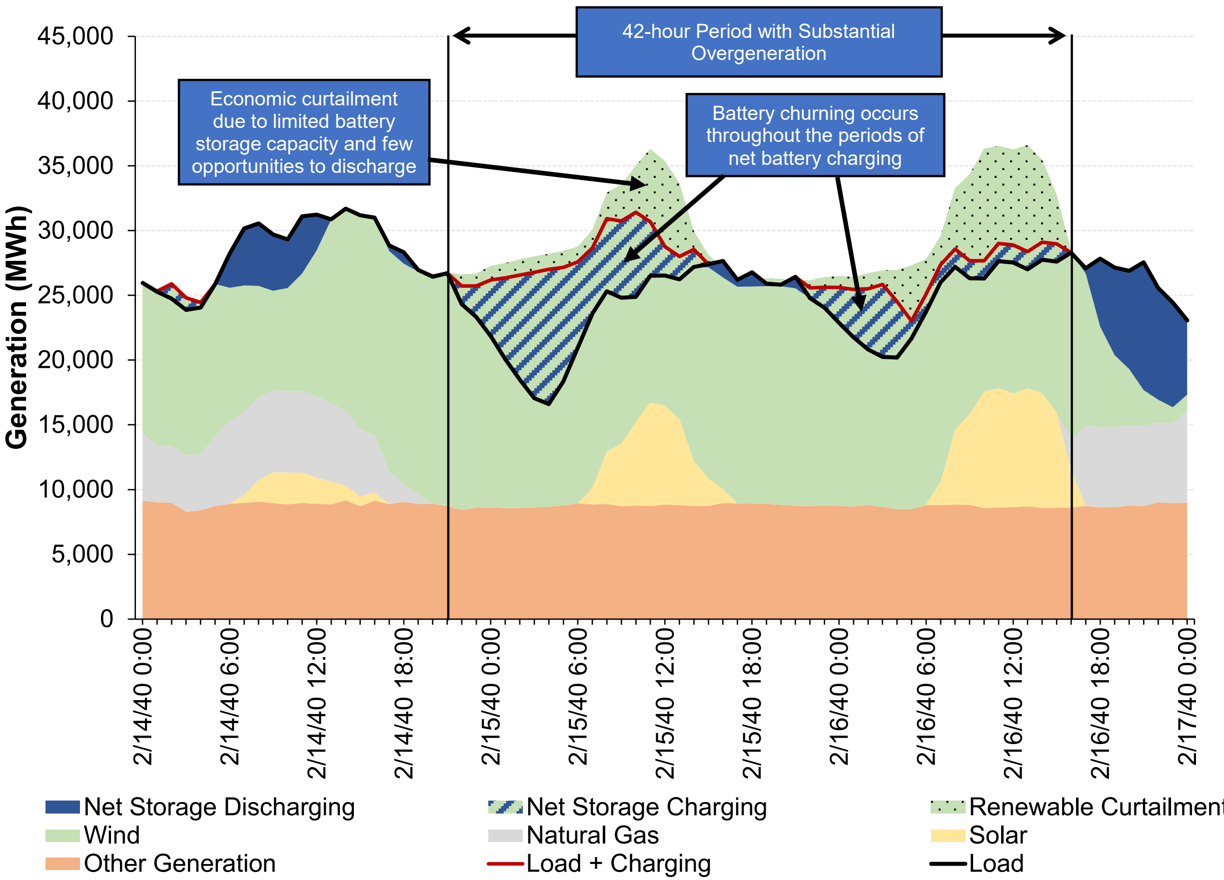
Negative LMPs

- Out of market revenues lead to negative offers from variable renewables with Status Quo, FCEM and Hybrid Approach
- Variable renewables curtailments and smaller margins – increases development risk

Consequences of negative pricing not fully understood and requires more research

Potential Consequences of Negative Prices

Example: Storage (Battery) "Churning"



- **"Churning"** occurs when batteries "consume" otherwise-curtailed variable renewable energy and earn net revenues for energy losses
  - With negative prices, the battery receives a positive net payment for energy losses
  - Churning leads to inefficient battery use and investment
- Many factors will affect whether churning occurs in practice, particularly development of other advanced technologies that can take advantage of negative LMPs

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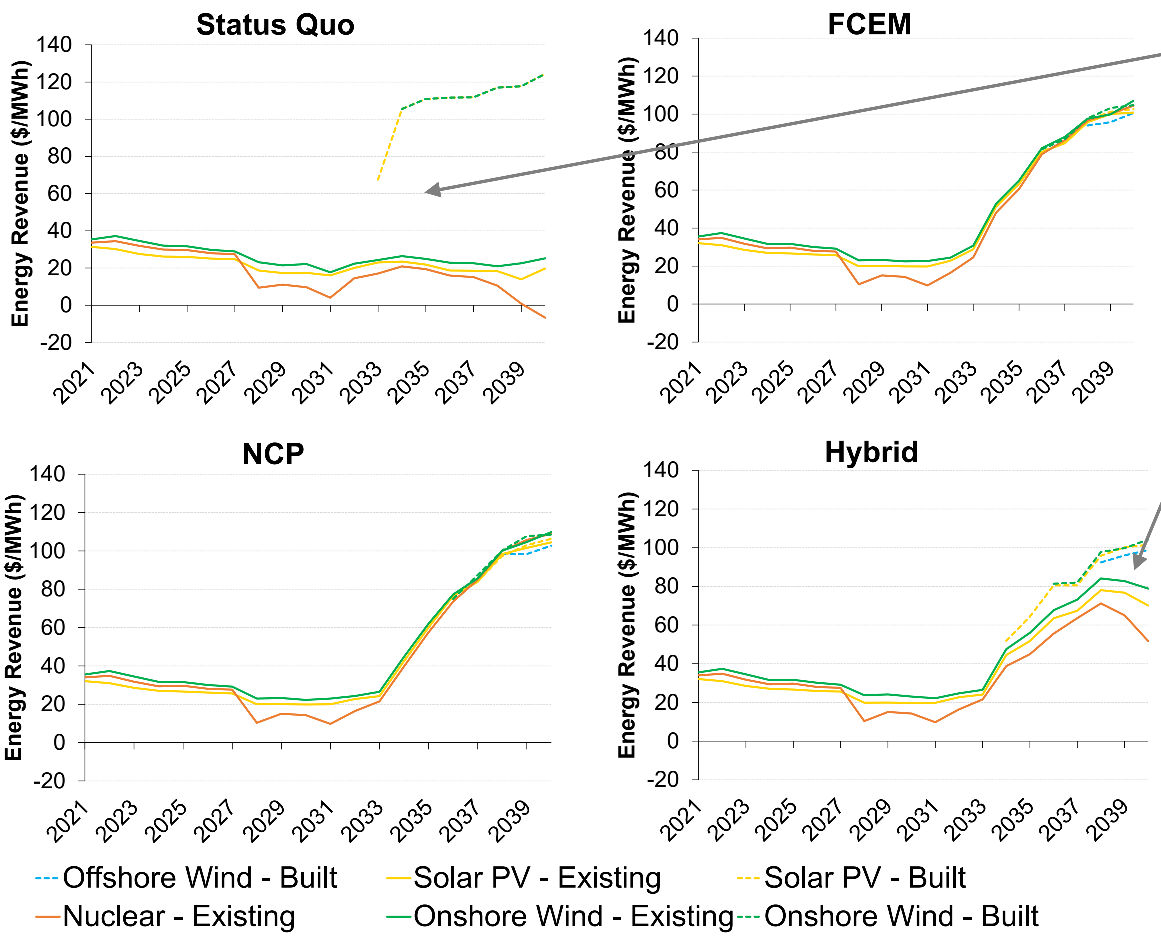
Price Discrimination

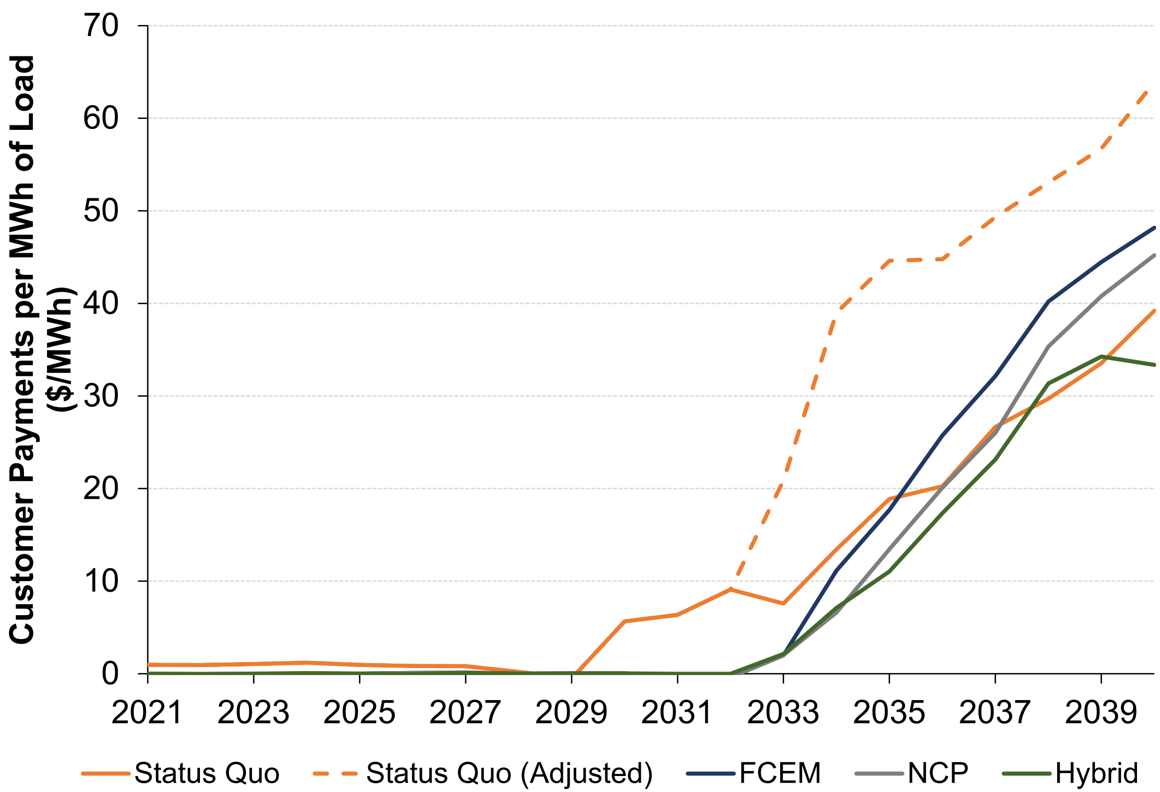
Comparison of Energy Revenues for Clean Energy Resources



- **Status Quo.** Existing resource revenues substantially below new resources (absent other support)
- **Hybrid Approach.** In-market compensation for clean energy from existing resources is below in-market compensation for clean energy from new resources.
- **FCEM, Net Carbon Pricing.** Same compensation for all clean energy.

Customer Payments Reflect Multiple Factors

Average Incremental Customer Payments by Policy Approach, 2021-2040, $2020/MWh



- **Incremental payments vary reflecting multiple factors:**
  - **Cost of emission reductions**
  - **Price discrimination**
  - **Treatment of existing clean energy resources**
  - **Market interactions**, particularly between energy and environmental market outcomes and capacity market outcomes, reflecting multi-year revenue recovery

Other Important Economic and Implementation Issues

- ***Economic Consequences of Multi-Year Contracts Under Status Quo***
  - Potentially lower financing costs for renewable projects
  - Potentially large impacts on utility balance sheets and transfers of financial risk
- ***Consequences for ISO-NE Resource Adequacy Framework***
  - Viability of dispatchable technologies under alternative frameworks
- ***Challenges for Policy Implementation***
  - All approaches will require substantial effort to address legal/regulatory issues and market design, particularly in light of multi-state preferences
  - Some approaches face challenges that may affect feasibility – for example:
    - Certain FCEM designs, such as integration of FCEM with Forward Capacity Market
    - Hybrid Approach, as it may not resolve uncertainty over resource retention

Policy Approaches Differ in Accommodation of New England's Unique Political Circumstances

- ***Approaches differ in the degree to which they can accommodate differences in commitments and consensus regarding centralized solutions***
  - All centralized solutions require clear, forward-looking commitment to the solutions adopted to provide investor certainty

Policy Factor	Status Quo	FCEM	Net Carbon Pricing	Hybrid Approach
Reliance on Regional Coordination and Consensus	Low (unilateral state policies)	Can coordinate state clean energy goals Requires consensus on CEC product	Requires carbon price or target consensus	Requires consensus on carbon price and CEC product
Cost Allocation Flexibility	Low (bound by unilateral policies)	High (through assignment of CEC obligations)	Moderate (through allocation of carbon revenues)	Moderate/High (through assignment of CEC obligations and allocation of carbon revenues)

Conclusion

- **Centralized approaches offer opportunity to lower costs through market mechanisms while still achieving environmental objectives**
  - By contrast, Status Quo costs depend on administrative processes
- **Centralized approaches differ in many important ways independent of impact on costs**
  - Negative prices, price discrimination, policy complexity, etc.
  - Impacts on ISO-NE markets – negative pricing, resource adequacy
- **Multi-state market complicates policy challenges, but there are precedents (e.g., RGGI)**
  - Approaches differ in accommodation of differences in state preferences and desire for consensus

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