MARCH 24, 2023

ISO New England Regional Update & Control Room Tour

Maine Legislature: Committee on Energy, Utilities and Technology (EUT)

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ISO NEW ENGLAND OVERVIEW

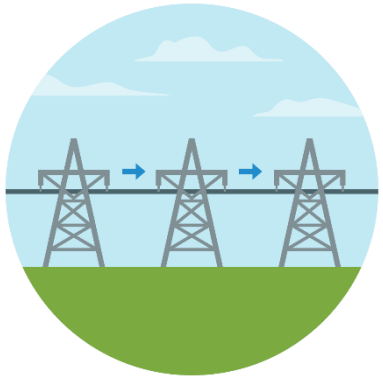
ISO New England (ISO) Has More Than Two Decades of Experience Overseeing the Region's Restructured Electric Power System

- **Regulated** by the Federal Energy Regulatory Commission
- **Reliability Coordinator** for New England under the North American Electric Reliability Corporation
- **Independent** of companies in the marketplace and **neutral** on technology

ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

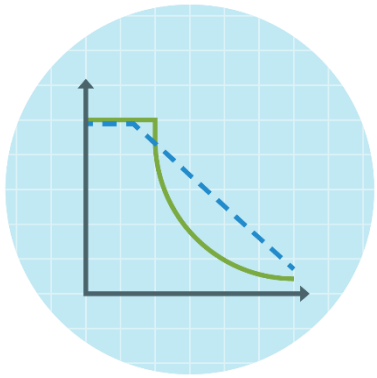
Grid Operation

Coordinate and direct the flow of electricity over the region's high-voltage transmission system



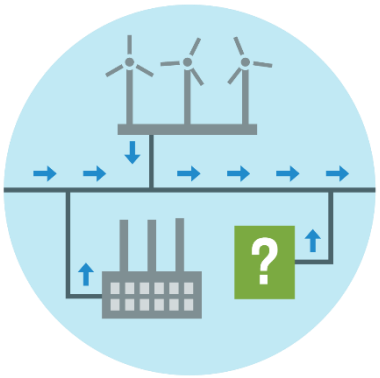
Market Administration

Design, run, and oversee the markets where wholesale electricity is bought and sold



Power System Planning

Study, analyze, and plan to make sure New England's electricity needs will be met over the next 10 years



Things We Don't Do

Handle retail electricity—the power you buy from your local utility or electric supplier

Own, maintain, or repair power grid infrastructure, such as power plants, power lines, and substations

Plan or control the resource mix, or have a financial interest in the companies that own energy infrastructure

Have jurisdiction over fuel infrastructure

ISO New England's *Mission and Vision*

Mission: *What we do*

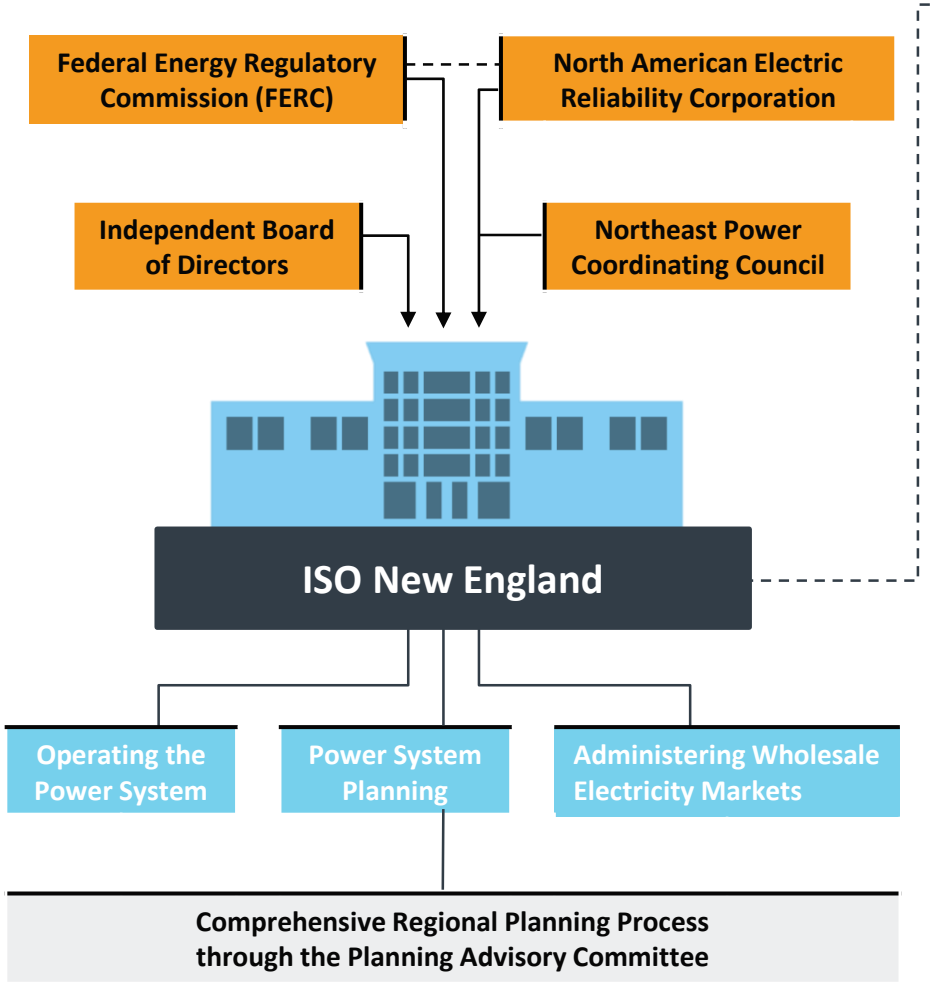
Through collaboration and innovation,
ISO New England plans the transmission system, administers the region's wholesale markets, and operates the power system to ensure reliable and competitively priced wholesale electricity

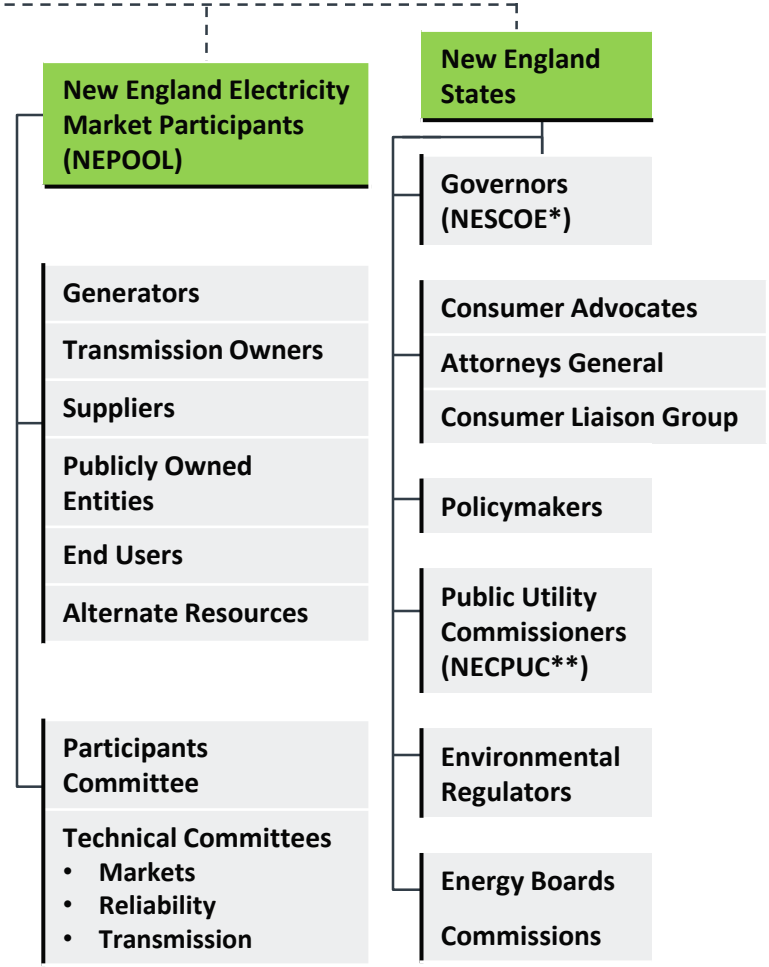
Vision: *Where we're going*

To harness the power of competition and advanced technologies to reliably plan and operate the grid as the region transitions to clean energy

*The ISO's new **Vision** for the future represents our long-term intent and guides the formulation of our Strategic Goals*

Numerous Entities Including an Independent Board Provide Oversight of and Input on ISO's Responsibilities

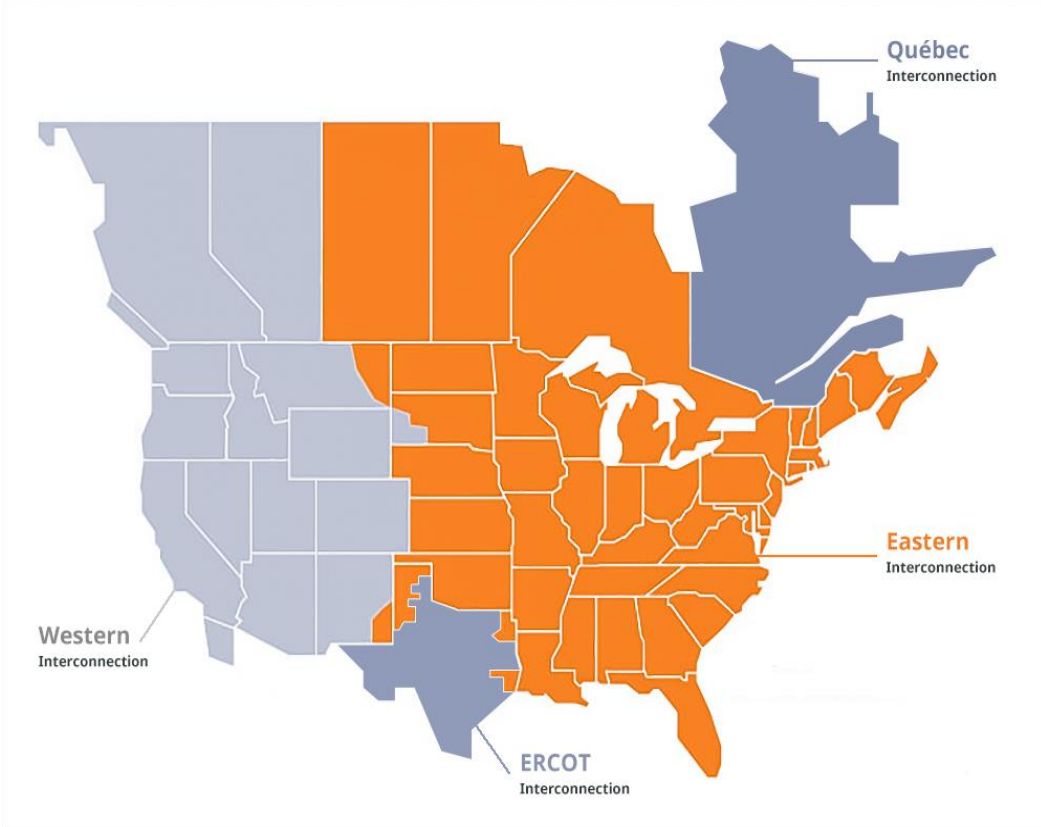




*New England States Committee on Electricity
**New England Conference of Public Utilities Commissioners

New England's Power Grid Is Part of a Larger Electric Power System

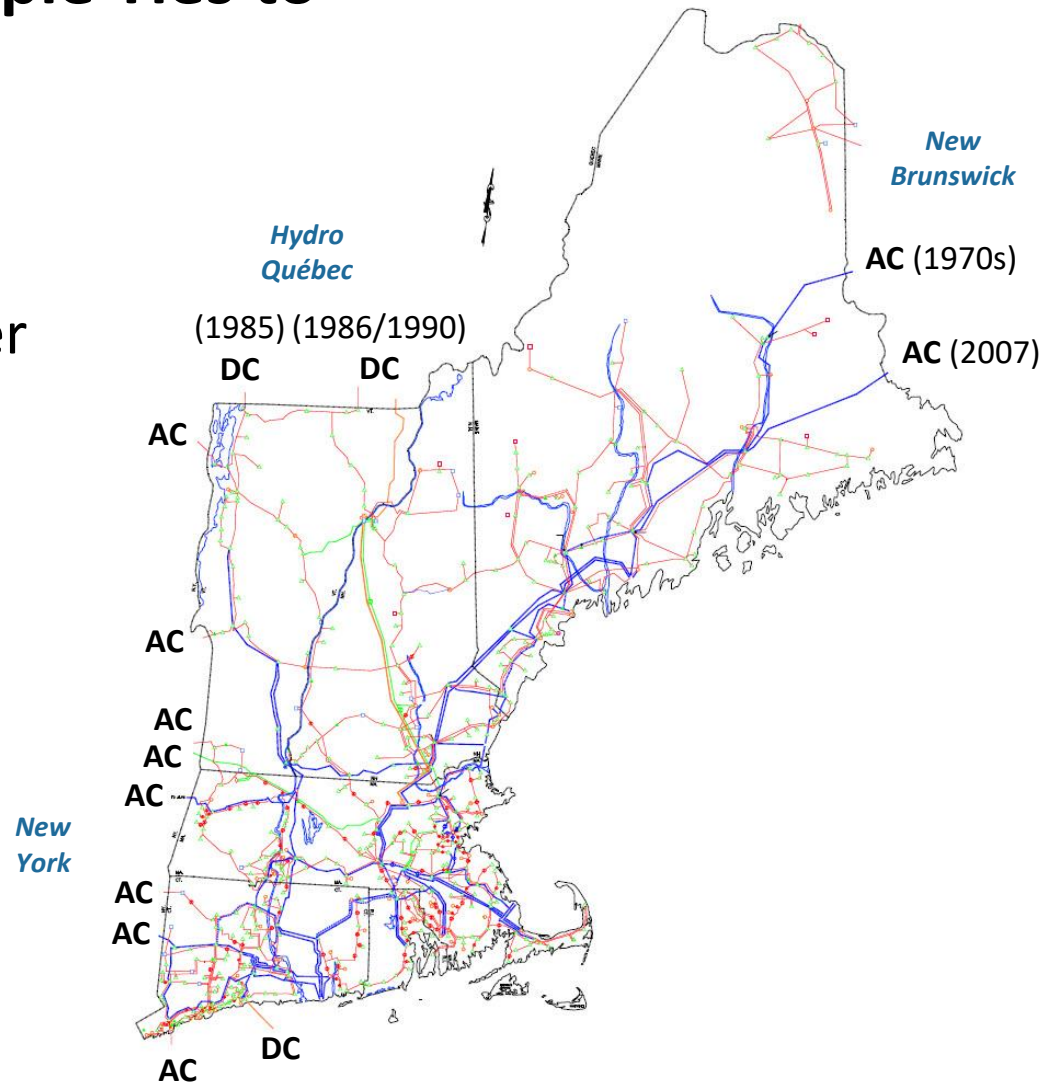
- Part of the **Eastern Interconnection**, one of four large power grids in North America
  - Interconnected through primarily alternating current (AC) transmission
- Tied to **Québec** only through direct current (DC) transmission
- 2003 blackout ushered in wide-area monitoring and **mandatory** reliability standards
- Subject to reliability standards set by **NERC** and **NPCC***



* North American Electric Reliability Corporation (NERC) and Northeast Power Coordinating Council (NPCC)

New England Has Multiple Ties to Neighboring Regions

- Transmission system is tied to neighboring power systems in the U.S. and Eastern Canada:
  - New York (8 AC ties, 1 DC tie)
  - Hydro Québec (2 DC ties)
  - New Brunswick (2 AC ties)
- **14%** of the region's energy needs were met by imports in 2022



Note: AC stands for Alternating Current and DC stands for Direct Current

NEW ENGLAND POWER SYSTEM & MARKETS

Generation and Demand Resources Are Used to Meet New England's Energy Needs

- **350** dispatchable generators in the region
- **31,500 MW** of generating capacity
- Almost **34,000 MW** of proposed generation in the ISO Queue
  - Mostly wind, solar, and storage proposals
- Roughly **7,000 MW** of generation have retired or will retire in the next few years
- **765 MW** of active demand response and **2,032 MW** of energy efficiency with obligations in the Forward Capacity Market*
  - Demand resources have had further opportunities in the wholesale markets since 2018

* In the Forward Capacity Market, demand-reduction resources are treated as capacity resources.

ISO-NE Is a Summer-Peaking System

New England shifted from a winter-peaking system to a **summer-peaking** system in the early 1990s, largely because of the growth of air conditioning and a decline in electric heating

- Peak demand on a normal summer day has typically ranged from 17,500 MW to 22,000 MW
- Summer demand usually peaks on the hottest and **most humid** days and averaged roughly 25,600 MW since 2000

- Region's all-time summer peak demand was **28,130 MW** on **August 2, 2006**

The region could shift back to a **winter-peaking system** with the electrification of heating demand

- Region's all-time **winter** peak demand was **22,818 MW** on **January 15, 2004**

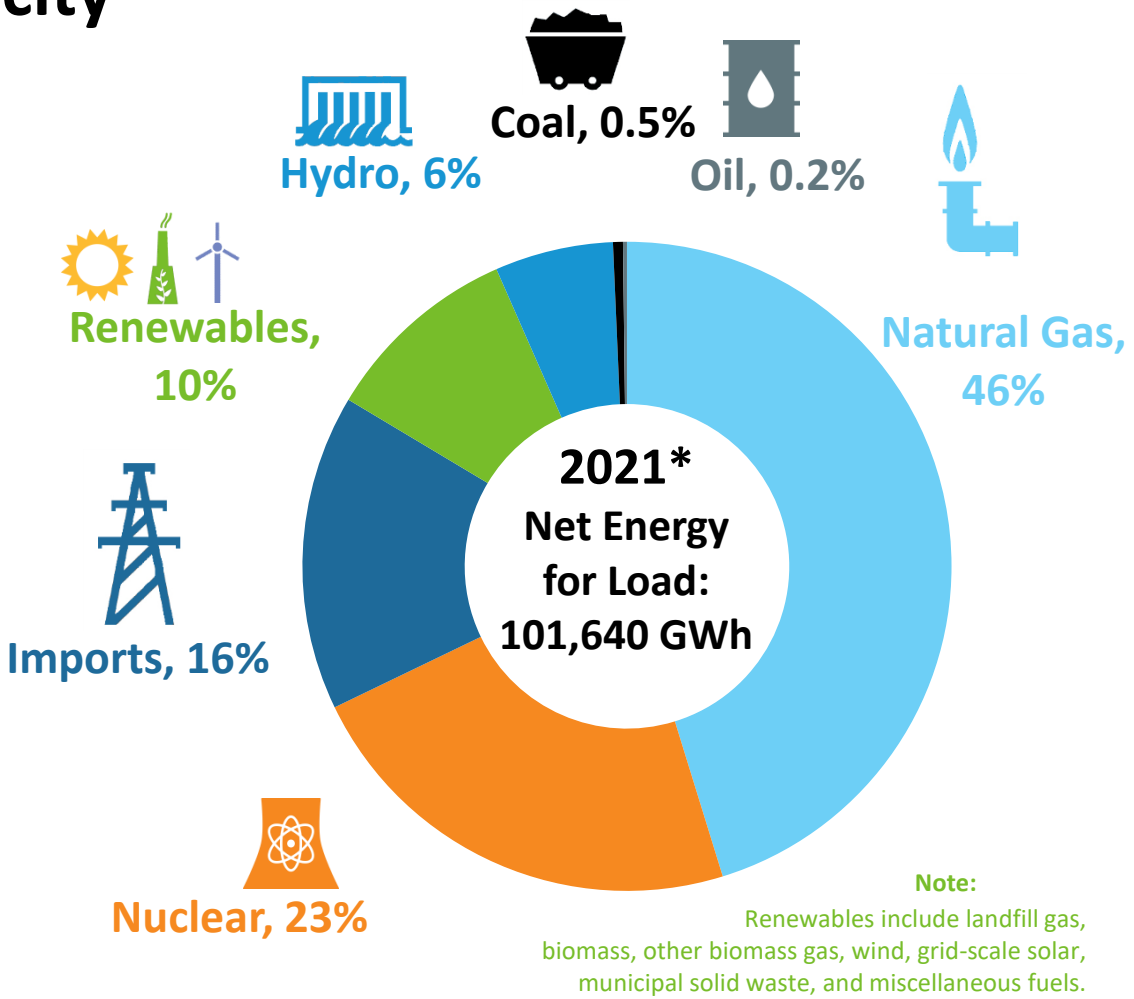
Source: ISO New England Status of Non-Price Retirement Requests and Retirement De-list Bids (January 2022)

Since 2013, Roughly 7,000 MW of Generation Have Retired or Announced Plans for Retirement in the Coming Years

- Include predominantly coal, oil, and nuclear resources
- Another **5,000 MW** of remaining coal and oil are at risk of retirement
- These resources have played an **important** role in recent winters when natural gas supplies are constrained in New England

Lower-Emitting Sources of Energy Supply Most of New England's Electricity

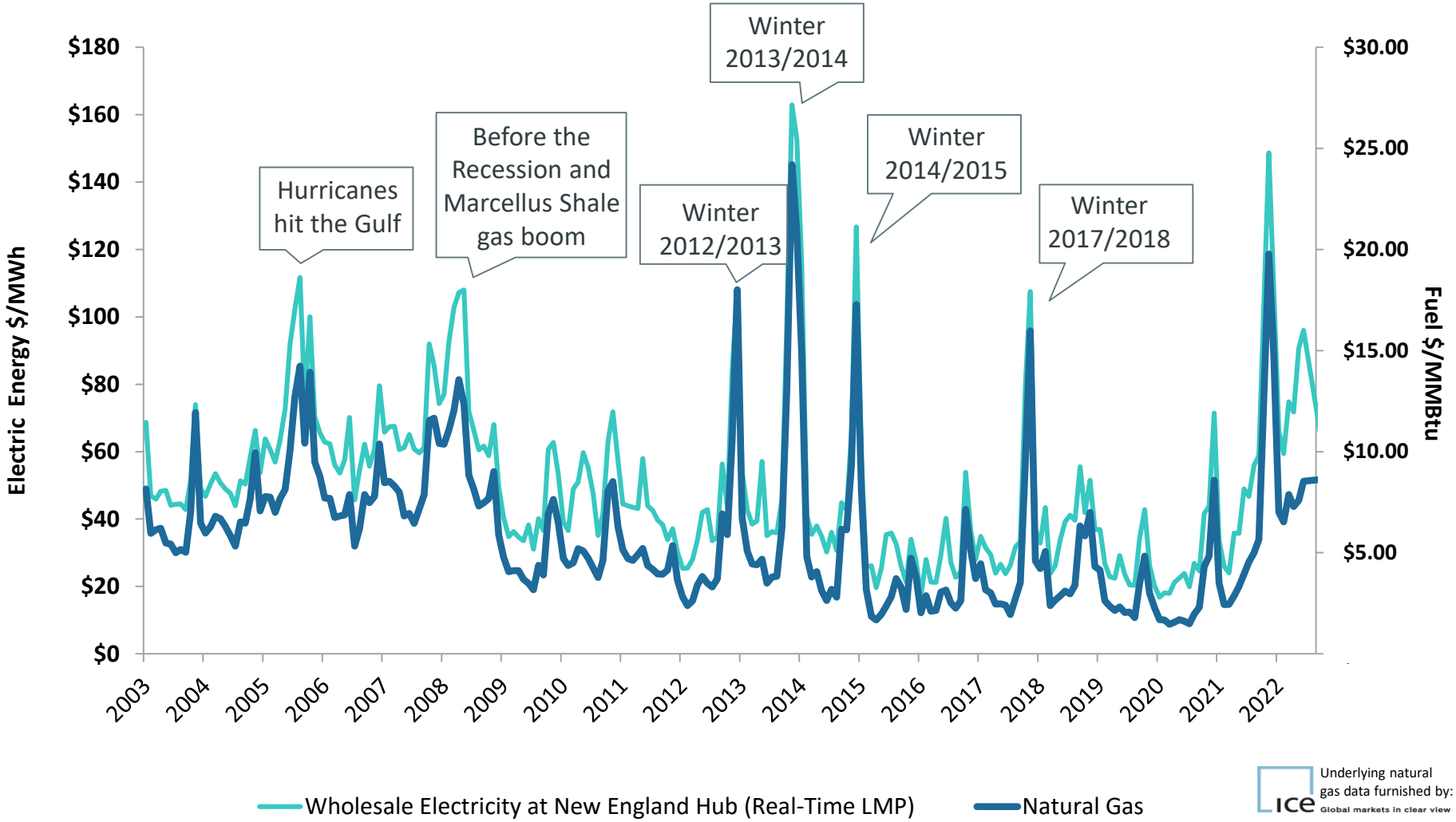
- In 2021, most of the region's energy needs were met by natural gas, nuclear, imported electricity (mostly hydropower from Eastern Canada), renewables, and other low- or non-carbon-emitting resources
- Region is transitioning away from older coal and oil resources



*Data is subject to adjustment. Source: 2021 Net Energy and Peak Load by Source
https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/net-ener-peak-load

Natural Gas and Wholesale Electricity Prices Are Linked

Monthly average natural gas and wholesale electricity prices at the New England hub



Underlying natural gas data furnished by: ICE Global markets in clear view

Markets Select the Most Cost-Efficient Resources to Meet Current and Future Electricity Needs

Energy Market

Electric Energy: The Day-Ahead and Real-Time Energy Markets are forward and spot markets for trading **electric energy**. Energy prices **fluctuate** throughout the day and at different locations in New England, reflecting the amount of consumer demand, constraints on the system, and the price of fuel that resources use to generate electricity.

Ancillary Services

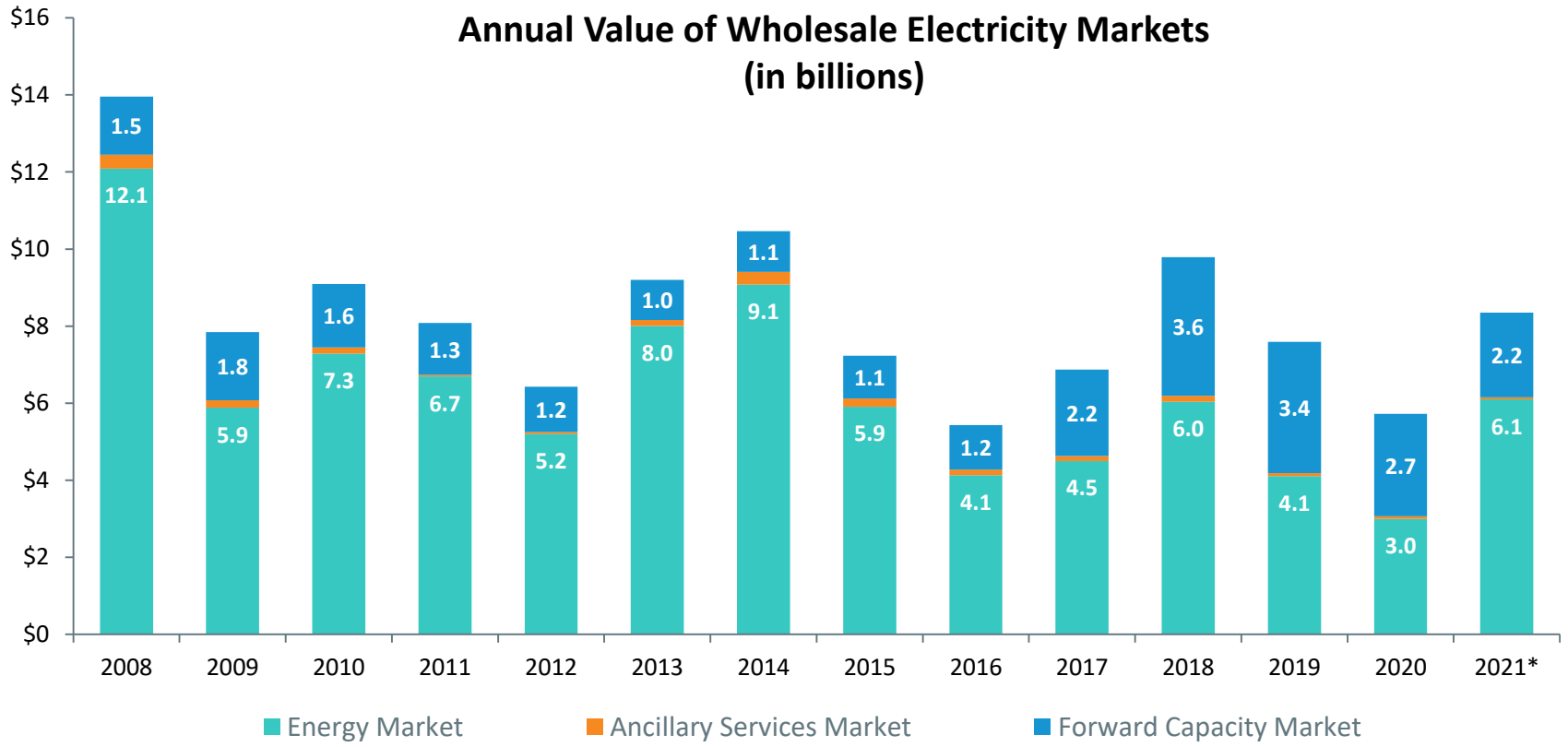
Short-Term Reliability Services: Resources compete in the ancillary markets to provide backup electricity as well as services needed to support the physical operation of the system, such as frequency regulation and voltage support. These services are **critical** during periods of heavy demand or system emergencies.

Forward Capacity Market

Long-Term Reliability Services: Resources compete to sell **capacity** to the system in three years' time through annual Forward Capacity Auctions. The Forward Capacity Market works in tandem with the Energy Markets to **attract** and **sustain** needed power resources today and into the future.

Markets Select the Most Cost-Efficient Resources to Meet Current and Future Electricity Needs

Energy Market Values Vary with Fuel Prices, While Capacity Market Values Vary with Changes in Supply



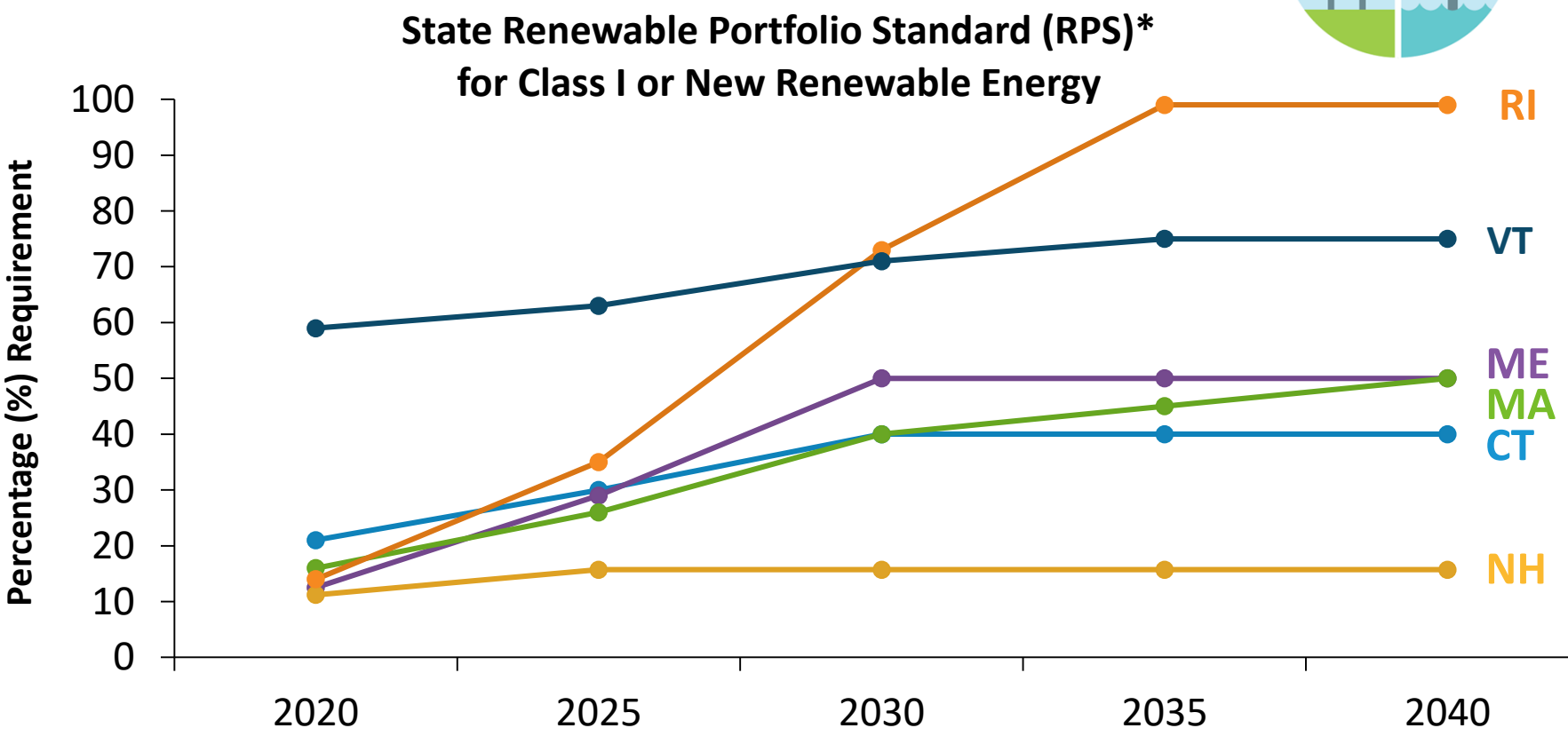
Source: *2021 Report of the Consumer Liaison Group*; *2021 data is preliminary and subject to resettlement

State Laws Target Deep Reductions in CO_2 Emissions and Increases in Renewable and Clean Energy

≥80% by 2050	Five states mandate greenhouse gas reductions economy wide: MA, CT, ME, RI, and VT (mostly below 1990 levels)
Net-Zero by 2050 80% by 2050	MA emissions requirement MA clean energy standard
90% by 2050	VT renewable energy requirement
100% by 2050 Carbon-Neutral by 2045	ME renewable energy goal ME emissions requirement
100% by 2040	CT zero-carbon electricity requirement
100% by 2030	RI renewable energy requirement

Renewable Energy Is on the Rise

State policy requirements are a major driver

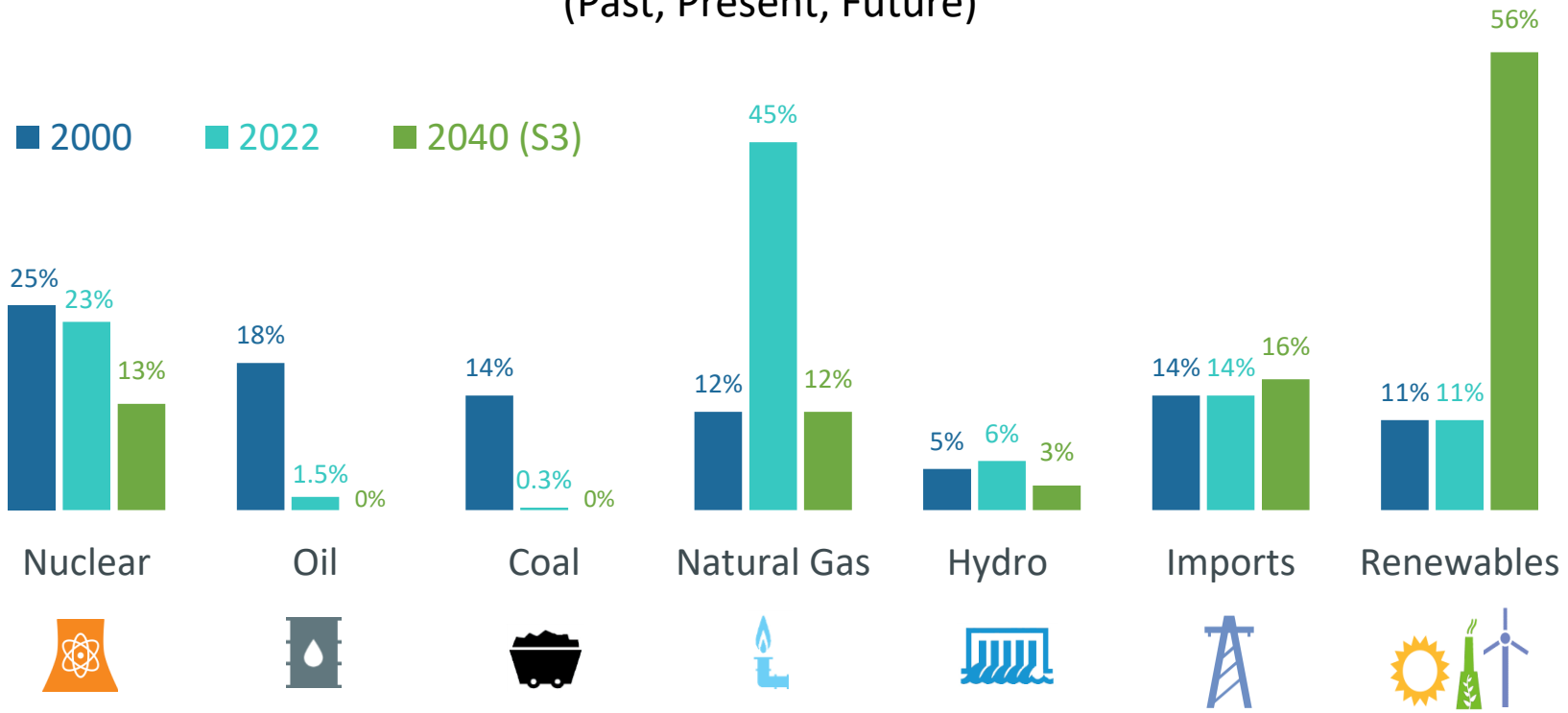


Notes: State RPS requirements promote the development of renewable energy resources by requiring electricity providers (electric distribution companies and competitive suppliers) to serve a minimum percentage of their retail load using renewable energy. Connecticut's Class I RPS requirement plateaus at 40% in 2030. Maine's Class I/IA RPS requirement increases to 50% in 2030 and remains at that level each year thereafter. Massachusetts' Class I RPS requirement increases by 2% each year between 2020 and 2024, 3% each year between 2025 and 2029, reverting back to 1% each year thereafter, with no stated expiration date. New Hampshire's percentages include the requirements for both Class I and Class II resources (Class II resources are new solar technologies beginning operation after January 1, 2006). New Hampshire's Class I and Class II RPS requirements plateau at 15.7% in 2025. Rhode Island's requirement for 'new' renewable energy reaches 100% in 2033. Vermont's 'total renewable energy' requirement plateaus at 75% in 2032; it recognizes all forms of new and existing renewable energy and is unique in classifying large-scale hydropower as renewable.

Dramatic Changes in the Energy Mix

New England made a major shift from coal and oil to natural gas over the past two decades, and is shifting to renewable energy in the coming decades

Percent of Total **Electric Energy** Production by Source
(Past, Present, Future)



Source: ISO New England Net Energy and Peak Load by Source; data for 2022 is preliminary and subject to resettlement; data for 2040 is based on Scenario 3 of the ISO New England 2021 Economic Study: Future Grid Reliability Study Phase 1.
Renewables include landfill gas, biomass, other biomass gas, wind, grid-scale solar, behind-the-meter solar, municipal solid waste, and miscellaneous fuels.

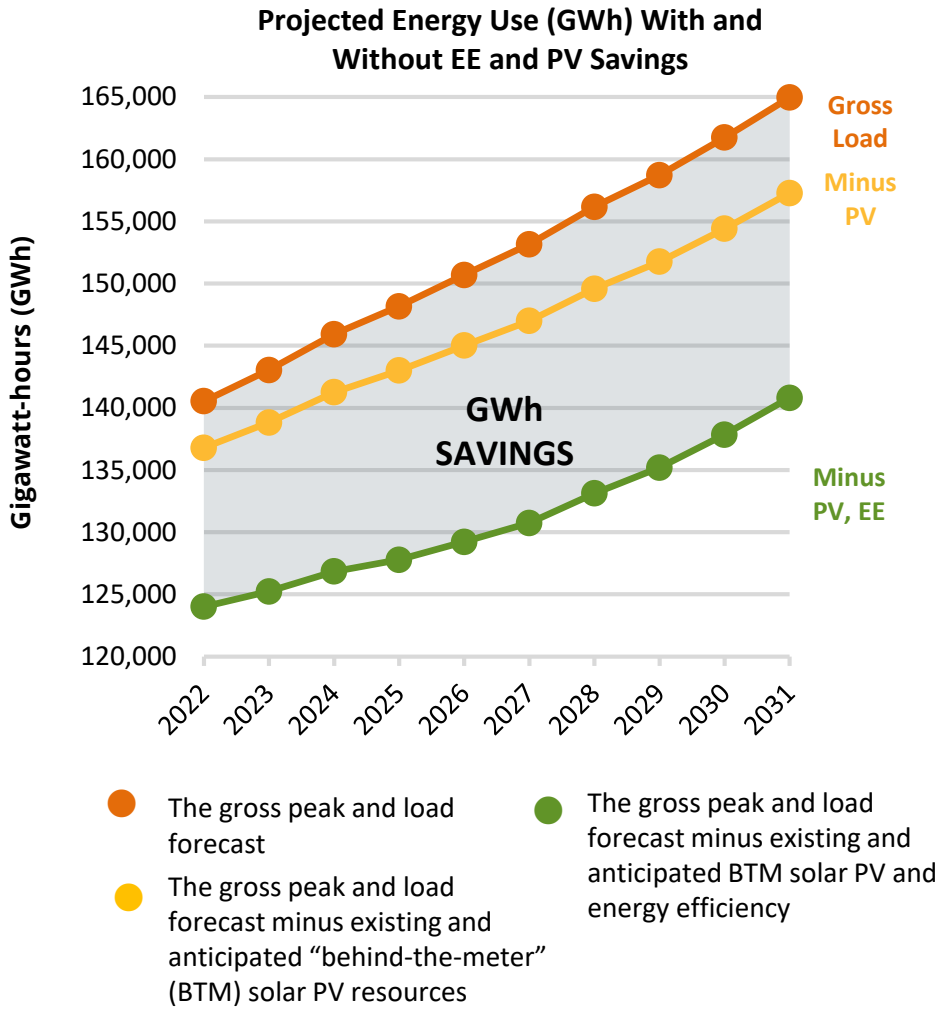
Energy Efficiency and Behind-the-Meter Solar Resources Are Reducing Annual Energy Use

- **136,355 GWh:** all-time highest total annual energy served, set in 2005
- Energy efficiency (EE) and behind-the-meter (BTM) solar are **reducing annual growth** in energy use
- Annual growth rates for 2022–2031:

  +1.8% without EE and BTM solar

  +1.4% with EE and BTM solar

- Electrification of heating and transportation will increase load



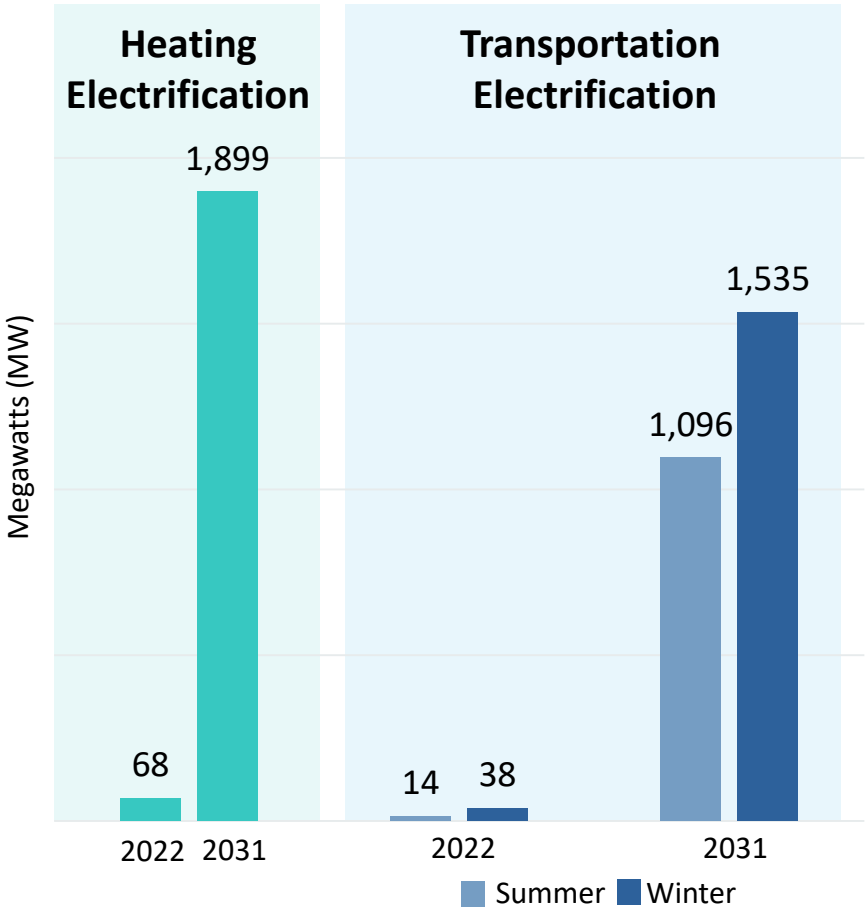
Source: ISO New England 2022-2031 Forecast Report of Capacity, Energy, Loads, and Transmission (2022 CELT Report) (May 2022)

ISO's Electrification Forecast Shows Demand Growth

- The ISO began including **forecasted impacts** of heating and transportation electrification on state and regional electric energy and demand in the 2020 CELT report
- In New England by **2031**, the ISO forecasts that there will be:

  > 1.1 million air-source heat pumps

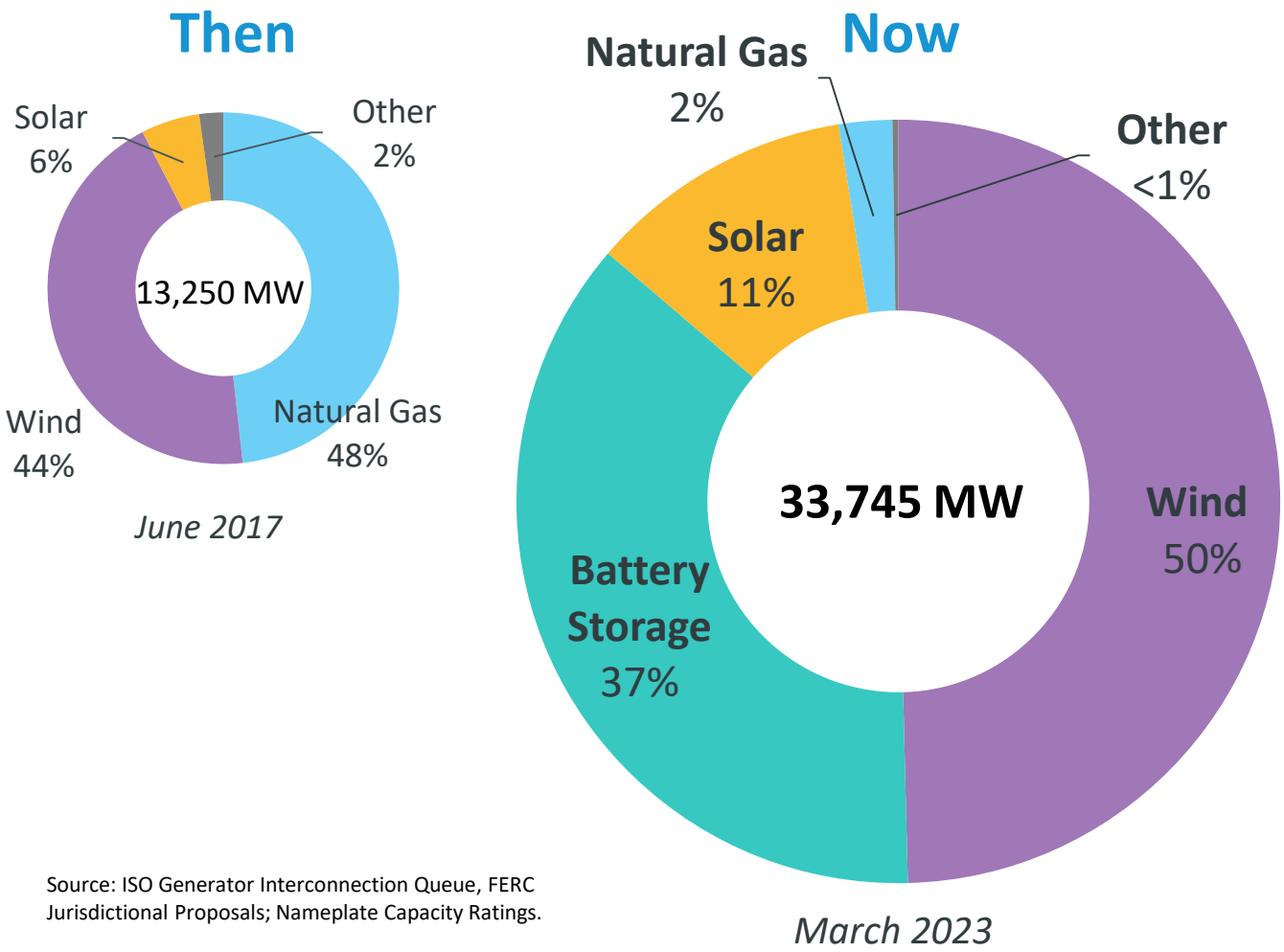
  > 1.5 million electric vehicles



Sources: : ISO New England 2022-2031 Forecast Report of Capacity, Energy, Loads, and Transmission (2022 CELT Report) (May 2022), Final 2022 Transportation Electrification Forecast, and Final 2022 Heating Electrification Forecast

The ISO Generator Interconnection Queue Provides Snapshots of the Future Resource Mix

Dramatic shift in proposed resources from natural gas to battery storage and renewables



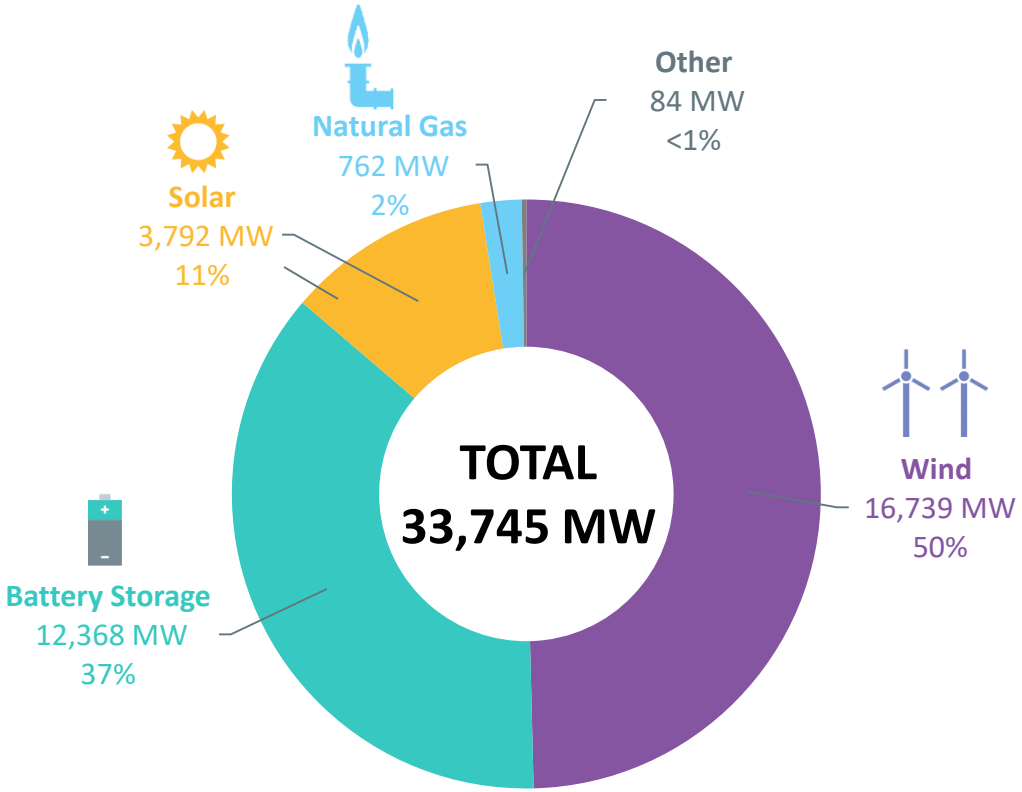
Offshore Wind	
CT	2,400 MW
MA	11,514 MW
ME	12 MW
RI	704 MW

Onshore Wind	
ME	2,110 MW

Source: ISO Generator Interconnection Queue, FERC Jurisdictional Proposals; Nameplate Capacity Ratings.

Wind Power Comprises Half of New Resource Proposals in the ISO Interconnection Queue

All Proposed Resources



Source: ISO Generator Interconnection Queue (March 2023)
FERC Jurisdictional Proposals; Nameplate Capacity Ratings
Note: Some natural gas proposals include dual-fuel units (with oil backup). Some natural gas, wind, and solar proposals include battery storage. Other includes hydro, biomass, fuel cells and nuclear uprate.

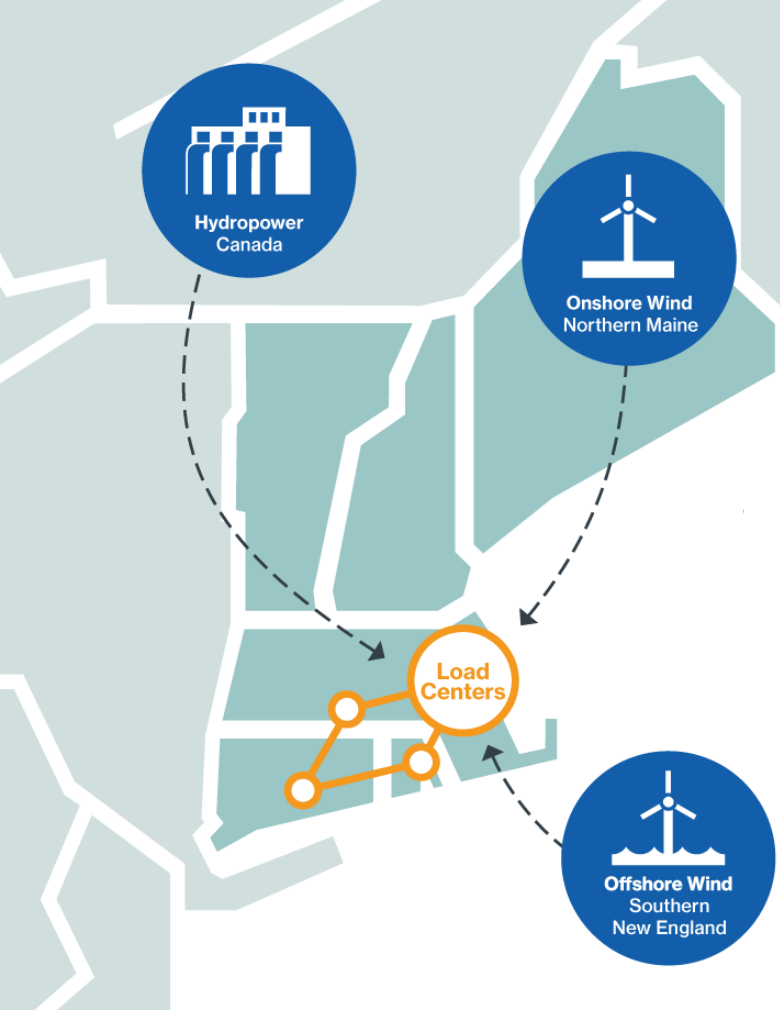
Proposals by State

(all proposed resources)

State	Megawatts (MW)
Massachusetts	19,190
Connecticut	6,796
Maine	5,051
Rhode Island	1,472
New Hampshire	1,145
Vermont	90
Total	**33,745**

Source: ISO Generator Interconnection Queue (March 2023)
FERC Jurisdictional Proposals

Developers Are Proposing Large-Scale Transmission Projects to Deliver Clean Energy to Load Centers



Lines represent types of ETUs private developers have proposed in recent years

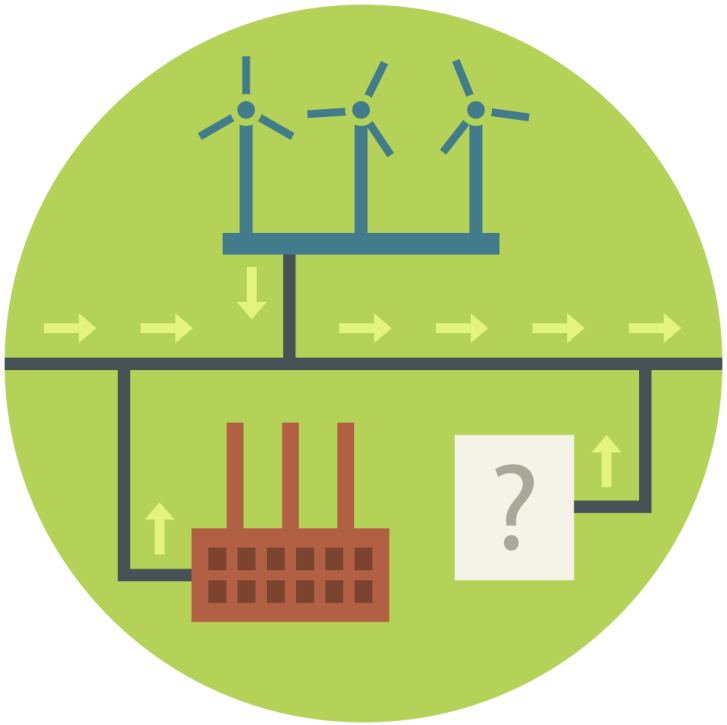
Source: ISO Interconnection Queue (March 2023)

- Developers are proposing 8 elective transmission upgrades (ETUs) to help deliver over **14,000 MW** of clean energy to New England load centers
- Wind projects make up **50%** of new resource proposals in the ISO Queue
  - Most are offshore wind proposals in southern New England, but some are onshore wind proposals in northern New England and **would require transmission** to deliver the energy to load centers

ISO NEW ENGLAND SYSTEM PLANNING

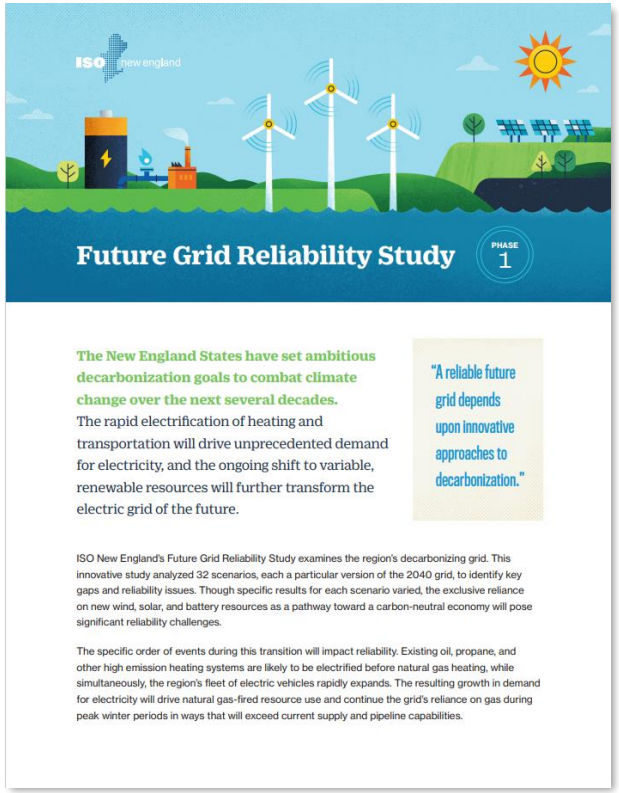
ISO New England Manages Regional Power System Planning to Meet Future Electricity Needs

- Manage regional power system planning in accordance with mandatory reliability standards
- Administer requests for interconnection of generation and regional transmission system access
- Conduct transmission system needs assessments
- Plan regional transmission system to provide regional network service
- Develop Regional System Plan (RSP) with a ten-year planning horizon



2021 Economic Study: Future Grid Reliability Study Phase 1

- On July 29, the ISO released the 2021 Economic Study: Future Grid Reliability Study Phase 1
- The study, requested by NEPOOL stakeholders, evaluates how a 2040 grid could perform when the system has significantly more renewables and a greater amount of electrification of the transportation and heating sectors
- The ISO hosted a webinar on **October 21** to discuss the findings of the Study
  - The webinar recording is available on the ISO website.

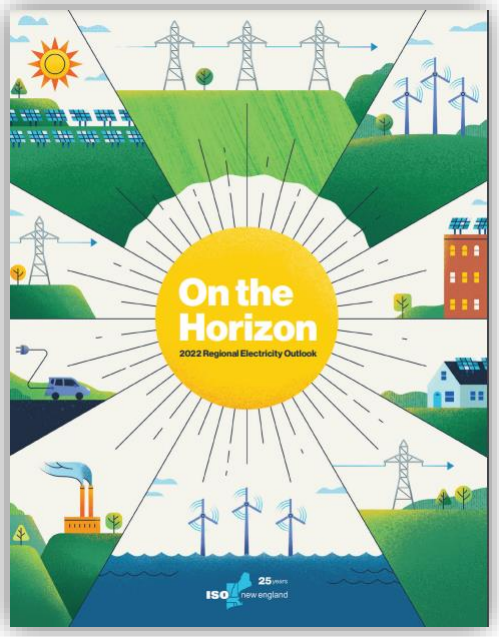


Overview of Studies Supporting Future Grid

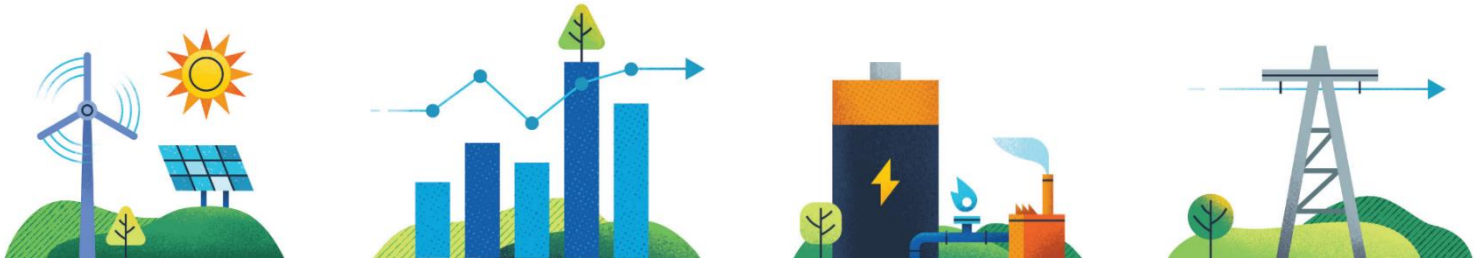
- **Weather**: Operational Impacts of Extreme Weather Events
  - Rigorously model likelihood and impact of extreme weather events
- **Transmission**: 2050 Transmission Study
  - Determine transmission needs to support renewable/high load future
- **Operations**: Future Grid Reliability Study (Phase 1)
  - Examine operational effects of renewable-heavy grid
- **Markets**: Pathways to the Future Grid
  - Evaluate different market options to support a renewable-heavy grid
- **Reliability**: Transmission Planning for the Clean Energy Transition
  - Explore how near-term needs assessments should evolve with renewables

There Are Four Pillars Necessary to Support a Successful Clean Energy Transition

1. **Significant amounts of clean energy** to power the economy with a greener grid
2. **Balancing resources** that keep electricity supply and demand in equilibrium
3. **Energy adequacy**—a dependable energy supply chain and/or a robust energy reserve to manage through extended periods of severe weather or energy supply constraints
4. **Robust transmission** to integrate renewable resources and move clean electricity to consumers across New England

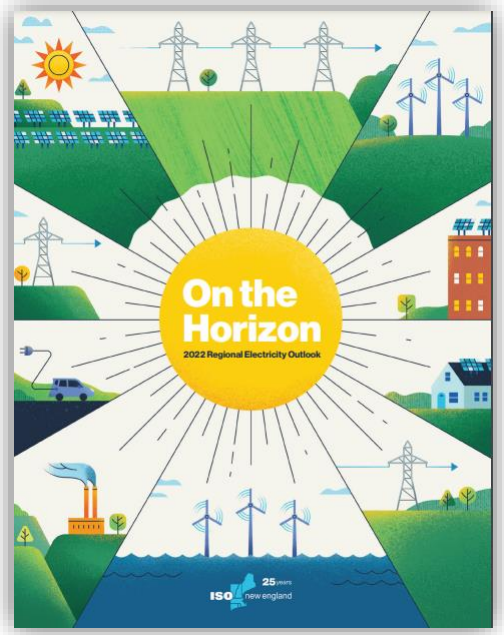


2022 Regional Electricity Outlook



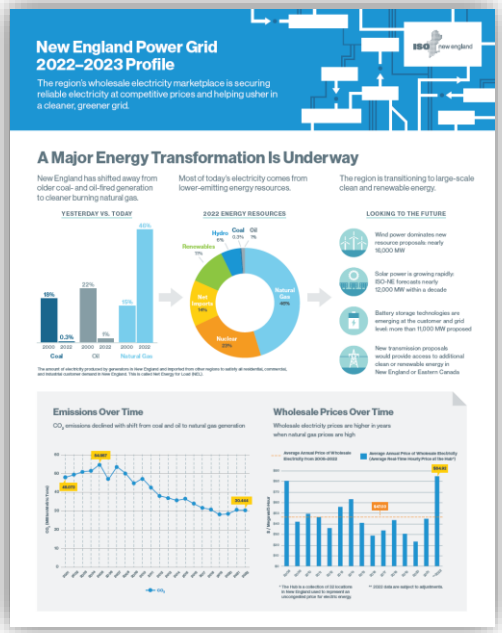
ISO NEW ENGLAND PUBLICATIONS AND RESOURCES

ISO New England Releases Several Publications



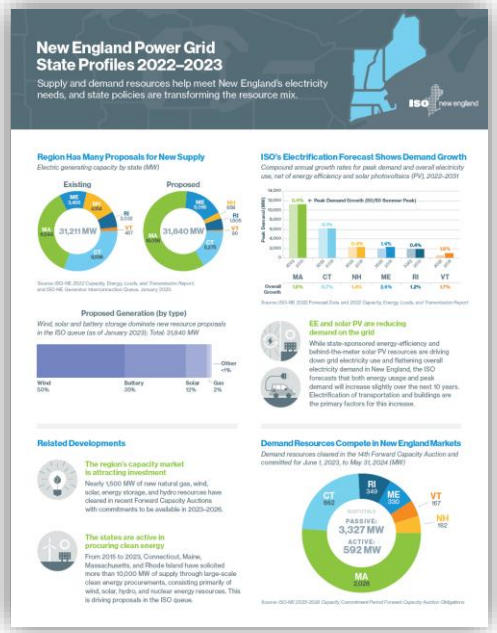
2022 Regional Electricity Outlook

Provides an in-depth look at New England's biggest challenges to power system reliability, the solutions the region is pursuing, and other ISO New England efforts to improve services and performance



New England Power Grid Profile

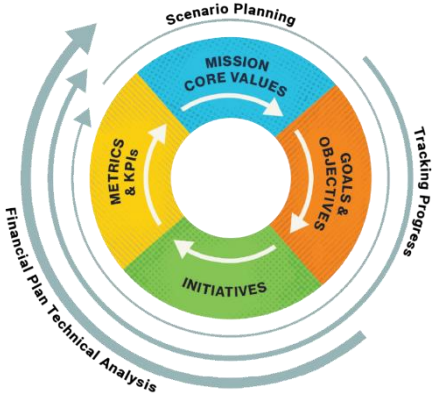
Provides key grid and market stats on how New England's wholesale electricity markets are securing reliable electricity at competitive prices and helping usher in a cleaner, greener grid



New England State Profiles

Provides state-specific facts and figures relating to supply and demand resources tied into the New England electric grid and state policies transforming the resource mix in the region

ISO New England's Strategic Plan



- On **October 26**, the ISO released Vision in Action: ISO New England's Strategic Plan
- The plan provides insight into how the ISO intends to fulfill its three critical roles during the clean energy transition
- In addition to discussing the ISO's key goals and initiatives, the plan offers perspectives on trends shaping the power industry
- ISO CEO Gordon van Welie presented an overview of the plan at the Nov 1 Open Board Meeting

Consumer Liaison Group Provides a Forum for Consumers to Learn about Regional Electricity Issues

- A forum for sharing information between the ISO and electricity consumers in New England
- The CLG Coordinating Committee consists of 12 members who represent various stakeholder groups
- Quarterly meetings are free and open to the public, with in-person and virtual options to participate
- 2023 Meetings
  - Thursday, March 30
  - Thursday, June 8
  - Thursday, September 21
  - Wednesday, December 6

2021 CLG Annual Report is posted at: https://www.iso-ne.com/static-assets/documents/2022/03/2021_report_of_the_consumer_liaison_group_final.pdf

More information on the CLG is available at: https://www.iso-ne.com/committees/industry-collaborations/consumer-liaison/

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ISO Newswire is your source for regular news about ISO New England and the wholesale electricity industry within the six-state region

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ISO Express provides real-time data on New England's wholesale electricity markets and power system operations

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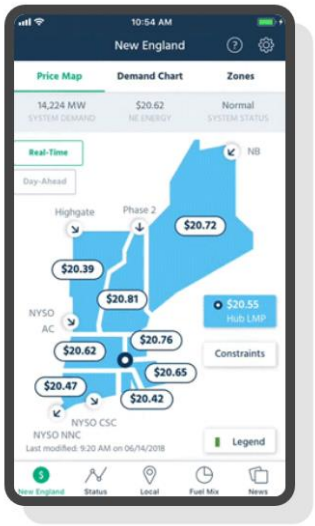
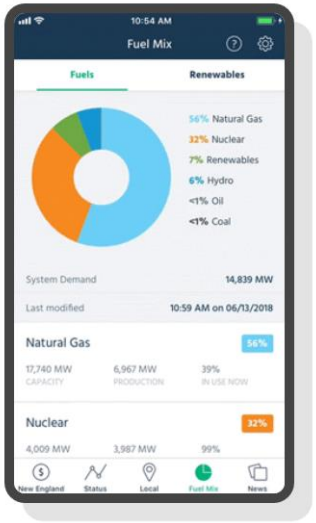
Download the ISO to Go App

ISO to Go is a free mobile application that puts real-time wholesale electricity pricing and power grid information in the palm of your hand





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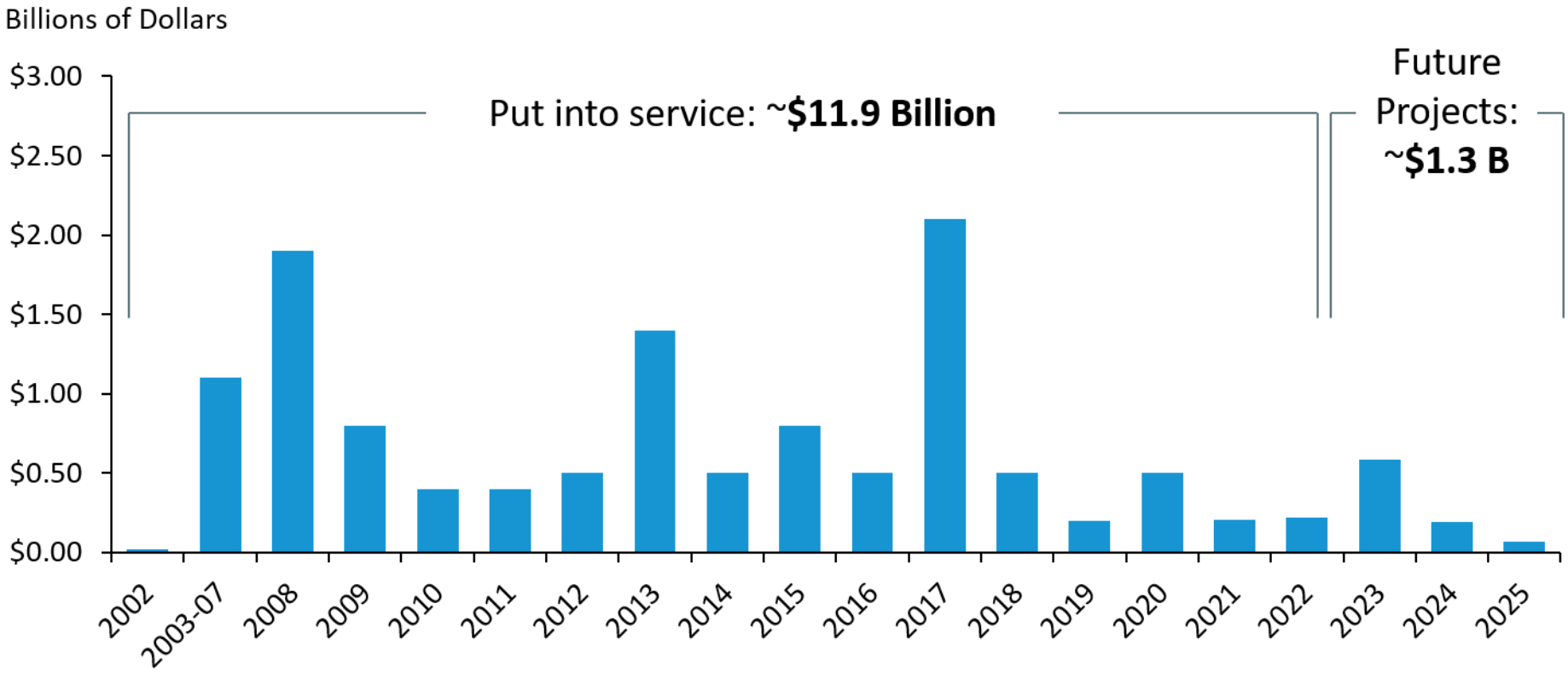
Questions

APPENDIX

Additional resources regarding transmission development and ongoing studies at ISO New England

New England Has Made Major Investments in Transmission to Ensure a Reliable Electric Grid

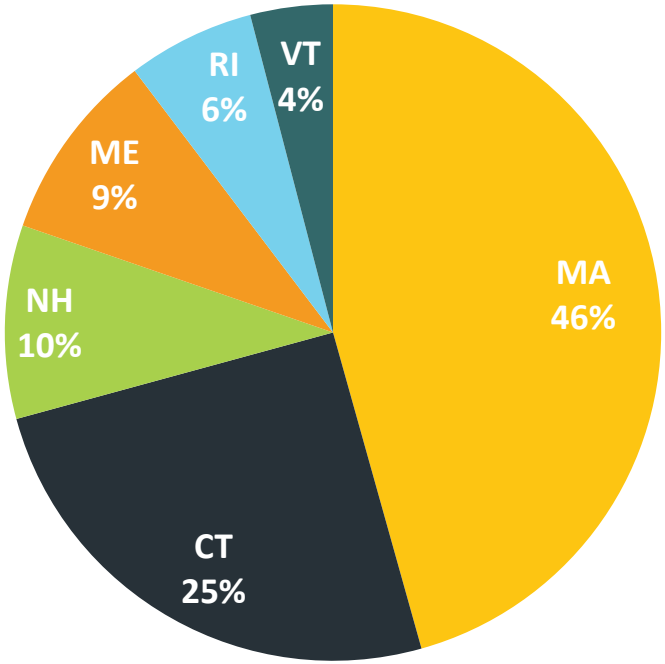
Transmission investment by year that projects are put into service (capital costs)



Source: ISO New England RSP Transmission Project Listing, October 2022
Estimated future investment includes projects under construction, planned and proposed.

How Are Transmission Costs Allocated?

- The New England electric grid is a **tightly interconnected** system; each state shares in the benefits of reliability and market efficiency upgrades
- The amount of electricity demand in an area determines its **share** of the cost of new or upgraded transmission facilities needed for reliability or market efficiency

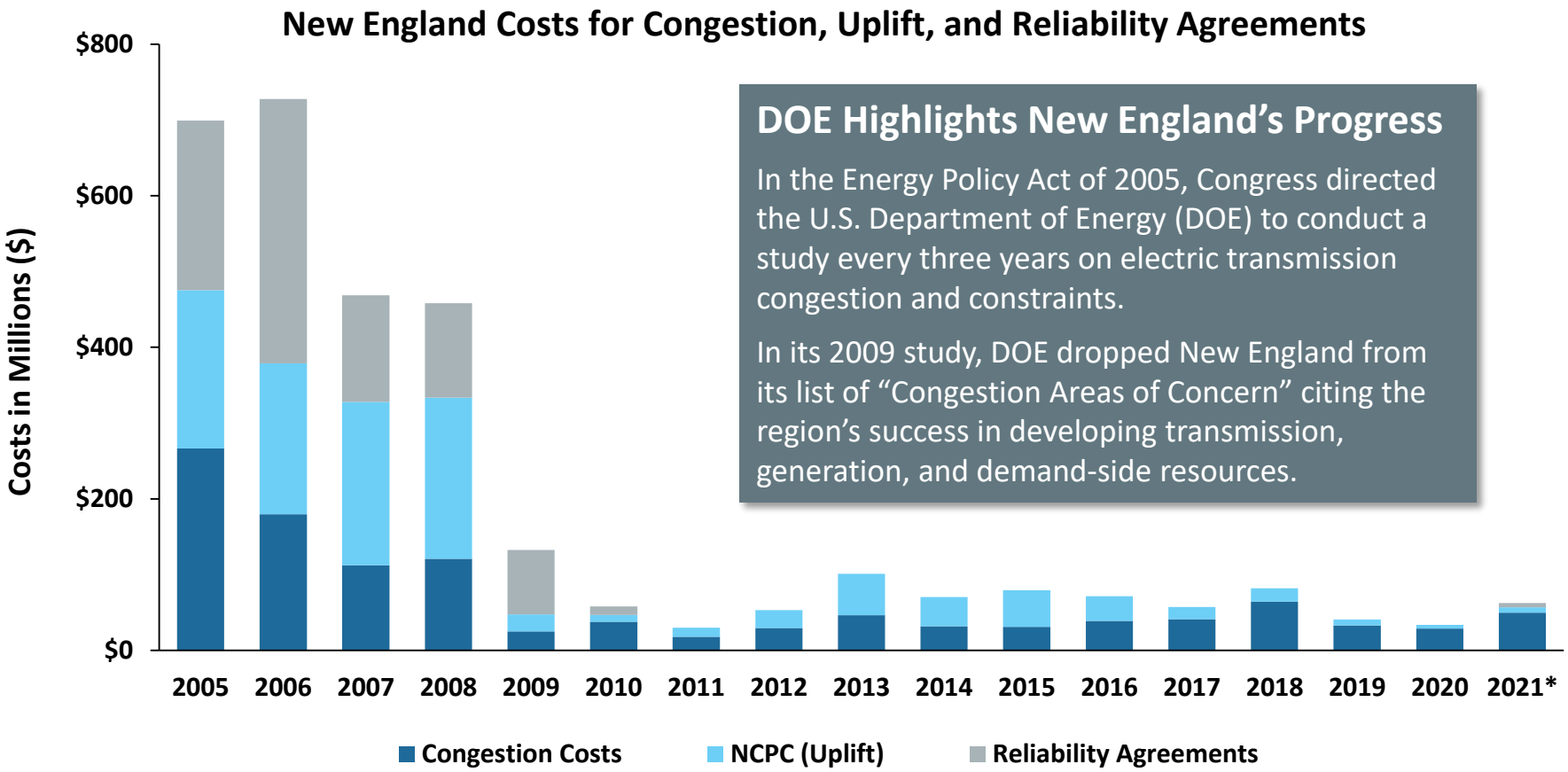


2022 Network Load by State

Transmission Provides Benefits Beyond Reliability

- **Transmission has reduced or eliminated out-of-market costs:**
  - Reliability agreements with certain generators that were needed to provide transmission support in weak areas of the electric grid
    - These often were older, less-efficient generating resources
  - Uplift charges to run specific generators to meet local reliability needs
- **The markets are increasingly competitive:** Easing transmission constraints into import-constrained areas has enabled the ISO to dispatch the most economic resources throughout the region to meet customer demands for electricity
- **Transmission congestion has been nearly eliminated**
- **Transmission facilitates resource transformation:** Transmission upgrades have allowed older, less efficient resources to retire, which helps the states achieve their environmental objectives

Transmission and Resource Developments Have Reduced Energy and Reliability Costs



DOE Highlights New England's Progress

In the Energy Policy Act of 2005, Congress directed the U.S. Department of Energy (DOE) to conduct a study every three years on electric transmission congestion and constraints.

In its 2009 study, DOE dropped New England from its list of "Congestion Areas of Concern" citing the region's success in developing transmission, generation, and demand-side resources.

Note: Congestion is a condition that arises on the transmission system when one or more restrictions prevents the economic dispatch of electric energy from serving load. Net Commitment-Period Compensation is a payment to an eligible resource that operated out of merit and did not fully recover its costs in the energy market. Reliability Agreements are special reliability contracts between the ISO and an approved generator whereby the generator continues to operate, even when it is not economical to do so, to ensure transmission system reliability. Sources: Regional System Plans, ISO-NE Annual Markets Reports. *2021 data subject to adjustment.

2050 Transmission Study

A High-Level Study for the Years 2035, 2040, and 2050

- Initial study scope and assumptions developed **in conjunction with the states**
- Aims to **inform the region** of the amount, type, and high-level cost estimates of transmission infrastructure that would be needed to cost-effectively:
  - Incorporate clean-energy and distributed-energy resources and;
  - Meet state energy policy requirements and goals, including economy-wide decarbonization

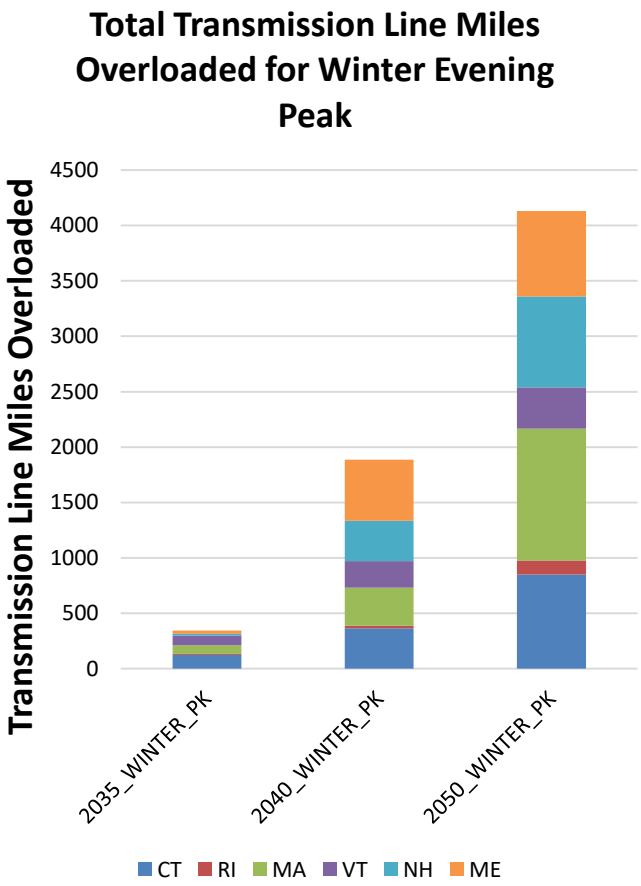
- Looks **well beyond** the ISO's 10-year horizon for transmission planning
- It is ***not*** a plan to build specific projects
- Solution development work will be ongoing throughout 2023

The most up-to-date information on the 2050 study is available at the Planning Advisory Committee

2050 Transmission Study

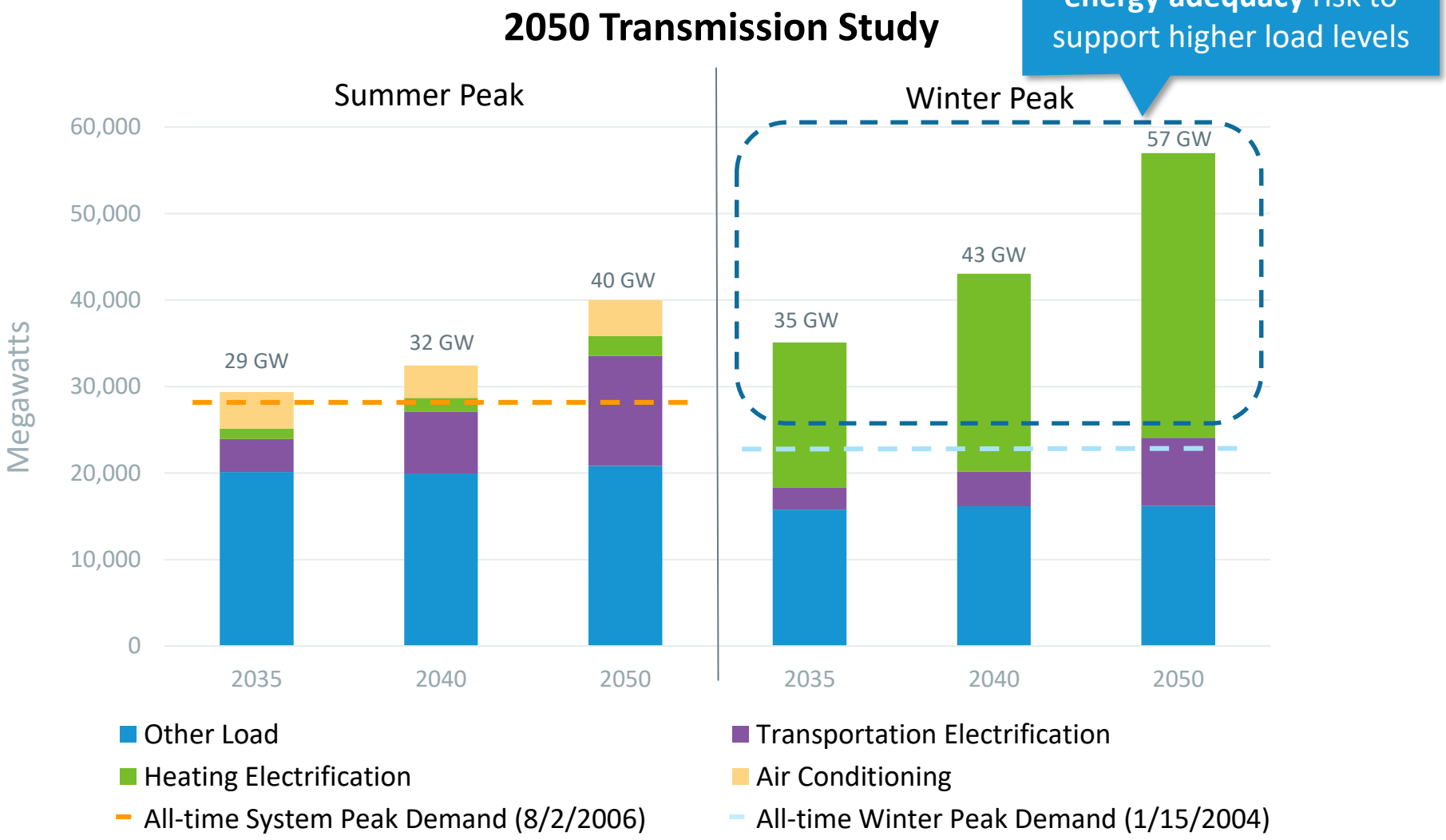
Key Takeaways

- The assumptions used for the 2050 Transmission Study represent numerous **paradigm shifts** for New England
  - Shift from a *summer-peaking* area to a *winter-peaking* area
  - Rapid growth in the development of *renewable* resources
  - Electrification of *heating* and *transportation* more than doubles the amount of peak power consumption by 2050
- Achieving a **load-generation balance** with the input assumptions requires:
  - The dispatch of *some fossil units* for energy balance in all snapshots
  - Additional resources beyond the input assumptions to meet the load in the Summer Evening and Winter snapshots
- Significant **new transmission** may be needed to reliably serve load under the assumptions analyzed in this study
  - With the current resource location assumptions, the *paths between North and South* would need significant upgrades to transfer surplus generation in Northern New England to generation-deficient Southern New England



New England System Peak Grows Substantially and Shifts to Winter-Peaking

Region needs to address **energy adequacy** risk to support higher load levels



Modeling and Assessing Operational Impacts of Extreme Weather Events

Considering how to study New England's reliability risks from severe weather events

- The ISO is working with Electric Power Research Institute (EPRI) to conduct a probabilistic energy security study for the New England region in the operational timeframe (10 years) under extreme weather events
  - The project is collaborative opportunity for industry leaders and regional stakeholders to learn how extreme weather events in the future may affect the evolving power system and to prompt thinking about how best to prepare
  - **Step 1 (Extreme Weather Modeling)** analysis was completed in May
  - **Step 2 (Risk Model Development and Scenario)** preliminary results were presented at the January Reliability Committee meeting
  - **Step 3 (Perform Energy Adequacy Assessment)** initial results expected in March
  - The results of the study will help inform the region's larger energy security/energy adequacy discussion
- The ISO expects final Study results in 2023

FGRS HIGHLIGHTS

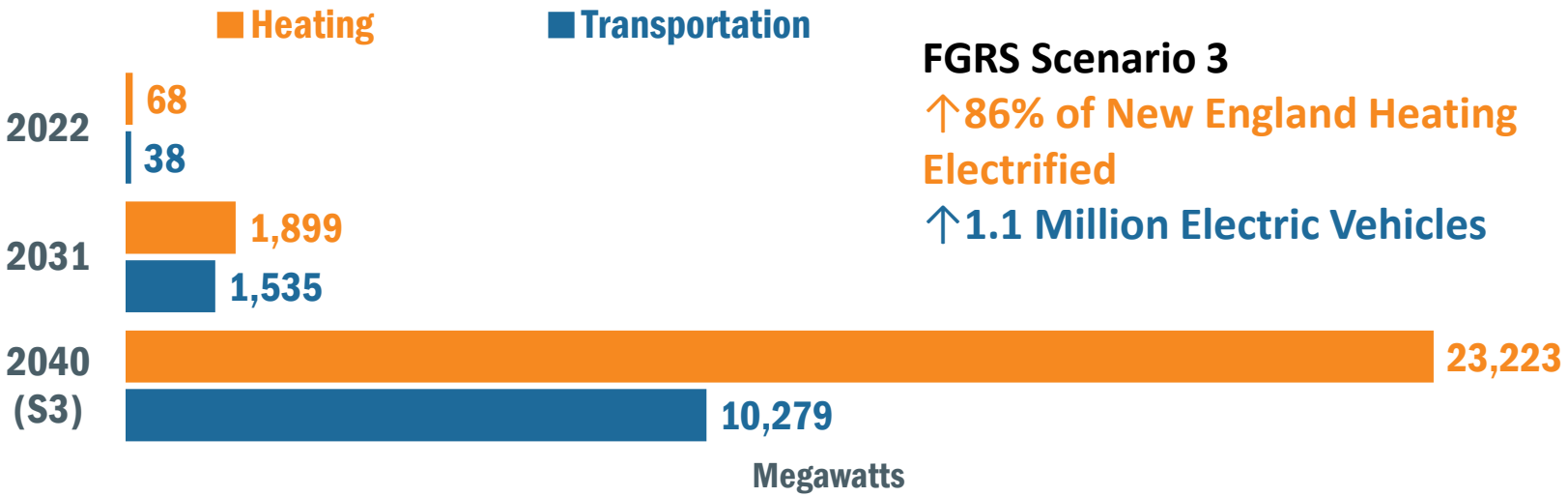
Development and Origin of the FGRS

- In order to assess and evaluate a transformed future grid, the New England Future Grid Initiative was proposed by the New England Power Pool (NEPOOL) at the March 2020 NEPOOL Participants Committee
  - The objective was to assess and discuss the future state of the regional power system in light of current state energy and environmental policies
- Starting in April 2020 and culminating in March 2021, the joint Markets & Reliability Committees met to discuss and define a scope of work for the initiative
- A Future Grid Reliability Study (FGRS) framework document was created from those discussions that defined two phases
  - Phase I would use stakeholder-defined scenarios to identify operational and reliability challenges in light of current state energy and environmental policies
  - Phase II would contemplate whether revenues from the existing market could be sufficient to attract and retain the new and existing resources necessary to continue operating the system reliably under stakeholder-defined scenarios

A Focus on Scenario 3

- Scenario 3 assumptions were derived from the "All Options Pathway" of the Massachusetts 2050 Deep Decarbonization Roadmap Study and imagined heavy renewable penetration and electrification loads to achieve net-zero economy-wide emissions
- Scenario 3 modeled all known retirements and then also retired all remaining coal, oil, and refuse-burning plants. Renewable additions were large: 16 GW of offshore wind (a doubling from Scenario 2), 28 GW of solar nameplate (a 38% increase from Scenario 2), 600 MW of Battery Energy Storage System (BESS), the NECEC tie-line, plus an additional new tie-line with Hydro Québec
- Both heating and transportation electrification load additions were large: heating load comprising 20% of the total load and transportation comprising 18.6%
- Over the course of the study and interaction with stakeholders *Scenario 3 took prominence,* and is the focus of the results in this presentation. Scenario 3 illustrates the sea change in power grid planning and operation that is required to support emission reduction goals

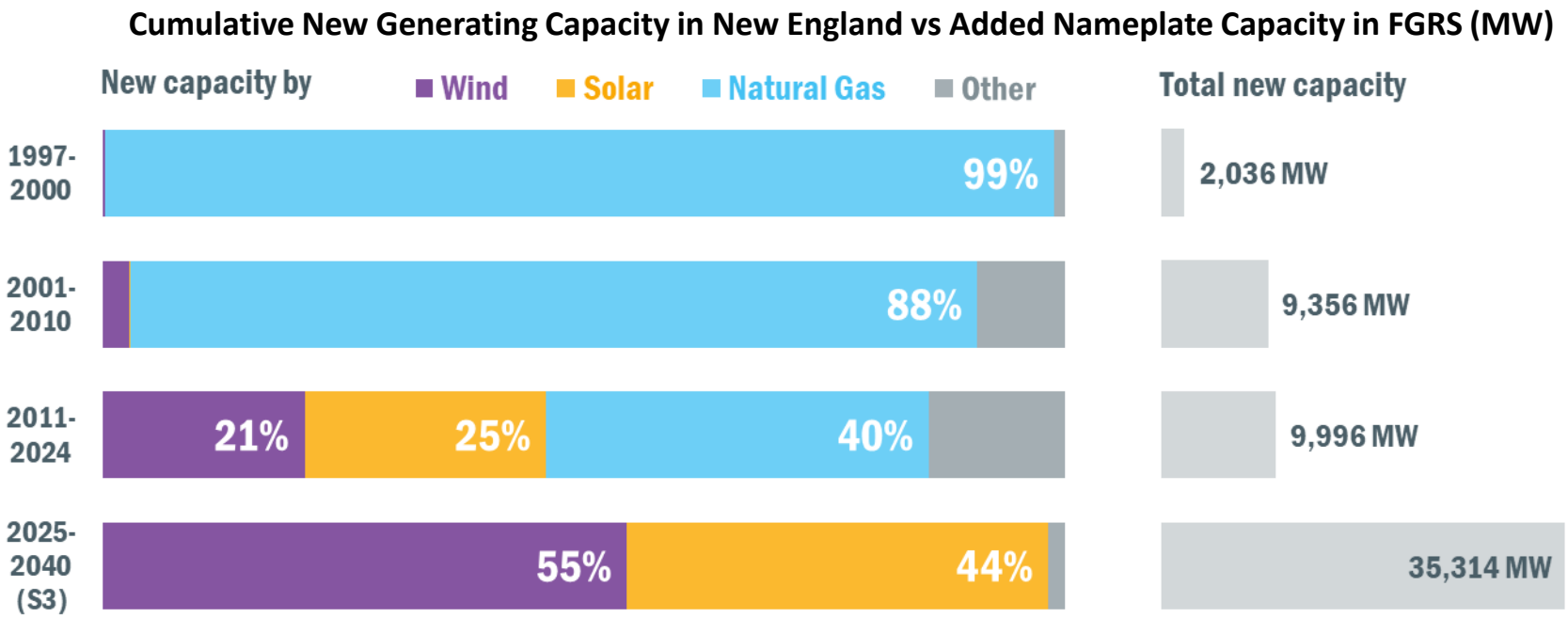
Electrification of Heating and Transportation Will Further Drive the Increasing Demand on the Grid



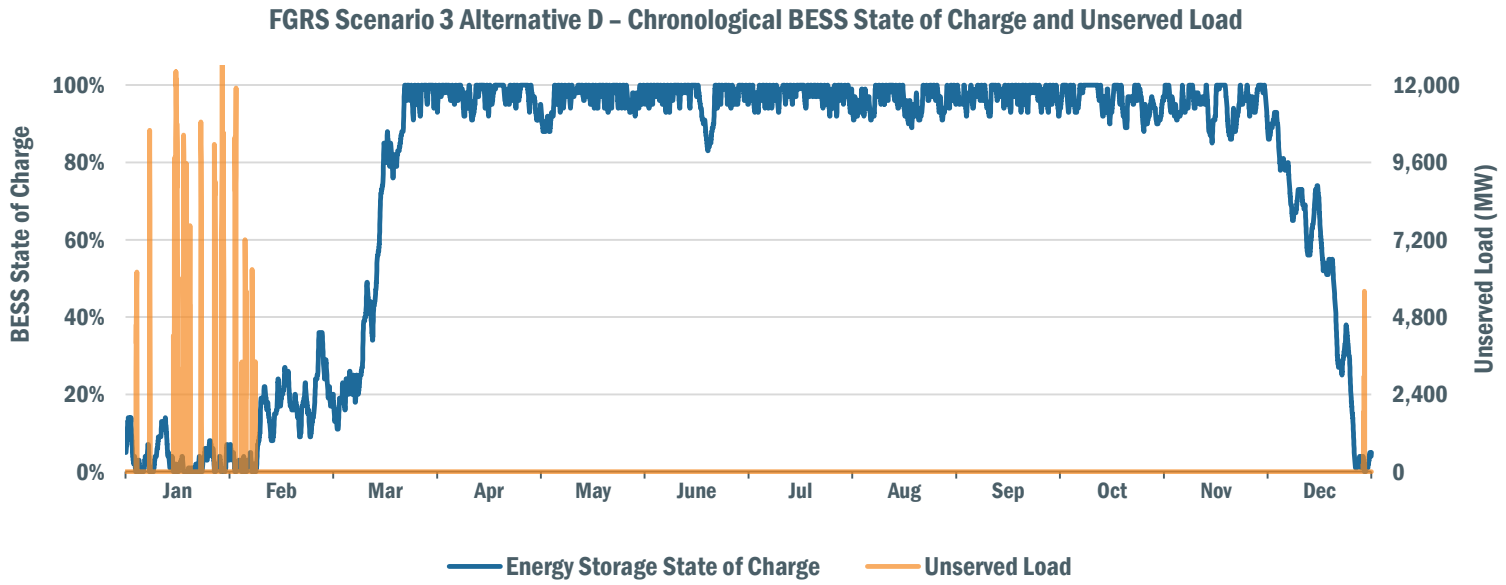
- As part of decarbonization efforts, state goals include extensive electrification of transportation and heating
- While transitioning to clean energy resources, New England must be ready to provide energy to these new loads

Source: ISO New England 2022-2031 Forecast Report of Capacity, Energy, Loads, and Transmission (2022 CELT Report) (May 2022)

Wind and Solar Replace Natural Gas as the Dominant Fuel Source for New Generating Capacity in the FGRS



System Need for Seasonal Storage Will Require Large Penetrations of Energy Storage



- During the periods of the year when storage is needed, the storage does not have enough time to charge, and becomes depleted
  - Even with over 2 TWh of storage capability in this scenario, there is insufficient storage to store seasonal variable generation for use during the heating season

Dispatchable Generation Can Greatly Decrease the Amount of Variable Energy Resources Needed for Reliability

- Substituting relatively small, targeted amounts of dispatchable units significantly reduced the necessary new units of wind, solar, and storage to attain resource adequacy
  - In a proxy mix alternative of S3 that referenced the Pathways Status Quo Case, substituting 3,000 MW of additional units reduced the necessary new units of wind, solar, and storage by 19% (17,000 MW), illustrating the importance of dispatchable resources to the future grid