Resource Mix

Over the past 20 years, New England's wholesale electricity markets have attracted billions of dollars in private investment in some of the most efficient, lowest-emitting power resources in the country—providing reliable electricity every second of every day, lowering wholesale prices, shifting costly investment risk away from consumers, and reducing carbon emissions. Because private firms make this investment and not public utilities, consumers are shielded from the investment risks they had been exposed to before the introduction of competitive markets.

Sources of Electricity Used in 2019

Here's the breakdown of the amount of electricity produced by generators in New England and imported from other regions to satisfy all residential, commercial, and industrial customer demand during 2019. This is called net energy for load (NEL).

Note: **Data is preliminary, pending a 90-day resettlement period.** (Last update: 1/20/20.) For the most current information, download the Net Energy and Peak Load by Source spreadsheet in ISO Express.

Fast Stats

- **350** dispatchable generators
- **About 31,000 MW** of generating capability (seasonal claimed capability)
- **99.5%** of the region's electricity in 2019 was provided by natural gas, nuclear, imported electricity (mostly hydropower from Eastern Canada), renewables, and other low- or non-carbon-emitting resources
- **About 21,000 MW** of new generating capacity, mostly wind, proposed to be built, though many projects ultimately withdraw (source: January 2020, ISO Interconnection Queue)
- **Roughly 7,000 MW** of generation have retired since 2013 or will retire in the next few years, with another 5,000 MW from coal- and oil-fired plants at risk of retirement in the coming years
- **Over 3,400 MW** of active demand response (DR) and energy efficiency and other passive demand resources are registered in New England (February 2020 DRWG monthly statistics)
- **About 1,500 MW** in summer and **1,000 MW** winter of imported electricity are obligated to be available for the region—mostly hydropower from Eastern Canada
- **Over 180,000** solar power installations totaling about **3,400 MW** (nameplate), with most connected "behind the meter"

	GWH (a)	% OF GENERATION	% OF NEL
Total Generation (b)	97,853	100.0%	82%
Gas	47,447	48.5%	39.9%
Nuclear	29,818	30.5%	25%
Renewables	11,149	11.4%	9.4%
Wind	3,527	3.6%	3%
Refuse	3,027	3.1%	2.5%
Wood	2,476	2.5%	2.1%
Solar	1,644	1.7%	1.4%
Landfill Gas	431	0.4%	0.4%
Methane	44	0.04%	0.04%
Steam	0	0.0%	0.0%
Hydro (c)	8,788	8.9%	7.4%
Coal	442	0.5%	0.4%

(a) GWh stands for gigawatt-hour.

(b) As of January 2016, this chart approximates the amount of generation by individual fuels used by dual-fuel units, such as natural-gas-fired generators that can switch to run on oil and vice versa. Previously, the report attributed generation from such units only to the primary fuel type registered for the unit. The new reporting flows from changes related to the Energy Market Offer Flexibility Project implemented December 2014. See the notes in the Net Energy and Peak Load by Source Report for more details.

(c) Hydro is not included in the renewables category primarily because the various sources that make up hydroelectric generation (i.e., conventional hydroelectric, run-of-river, pumped

Oil	161	0.2%	0.1%
Price-Responsive Demand	26	0.03%	0.02%
Other (d)	21	0.02%	0.02%
Net Flow over External Ties (e)	22,985		19%
Québec	14,010		
New Brunswick	3,287		
New York	7,343		
Pumping Load (f)	-1,717		-1.4%
Net Energy for Load (g)	119,122		100.00%

storage) are not universally defined as renewable in the six New England states.

(d) "Other" represents resources using a fuel type that does not fall into any of the existing categories. Other may include new technologies or new fuel types that come onto the system but are not yet of sufficient quantity to have their own category.

(e) Tie lines are transmission lines that connect two balancing authority areas. A positive value indicates a net import; a negative value represents a net export.

(f) The energy used to operate pumped storage plants.

(g) Generation
+ net interchange
- pumping load.

Lower-Emitting Resources Supply Most of the Region's Electricity

In 2019, natural-gas-fired generation, nuclear, other low- or no-emission sources, and imported electricity (mostly hydropower from Eastern Canada) provided roughly 99.5% of the region's electricity.

When the wholesale markets opened to competition, private companies invested billions of dollars in the development of natural-gas-fired power plants because they used advanced technology that made them run efficiently; were relatively inexpensive to build, site, and interconnect; and their lower carbon emissions compared to coal and oil helped the region meet state environmental policies. As nearby shale gas emerged as an inexpensive and plentiful fuel resource in the 2008 timeframe, natural gas generators became the go-to resource for New England, clearing as the largest resource type in the market year after year. Nearly half of the region's electric generating capacity uses natural gas as its primary fuel (about 15,000 MW), and natural-gas-fired power plants produce about 40% of the grid electricity consumed in a year.

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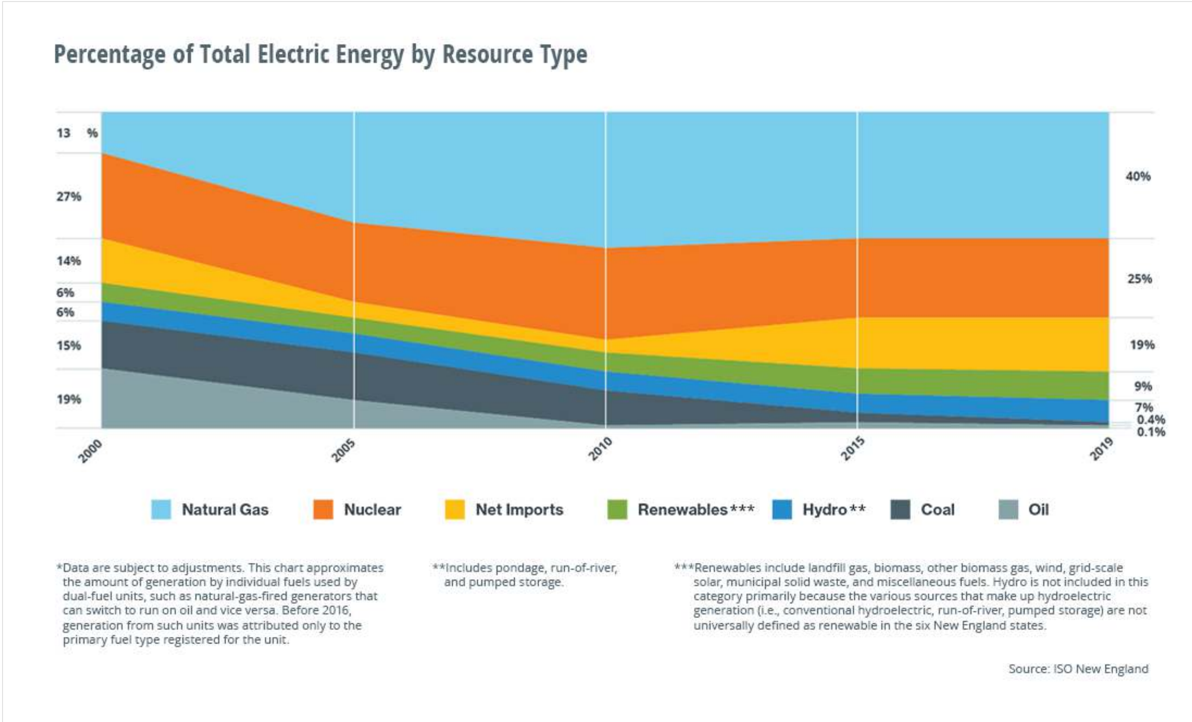


Markets Respond to Changing Times: Resources on the Way OUT

In contrast, aging coal-fired, oil-fired, and nuclear power plants have been closing largely because their operating, fuel, and environmental-compliance costs make them too expensive to compete against lower-cost resources. Since 2013, roughly 7,000 MW of mostly coal, oil, and nuclear generation have retired or have announced plans for retirement in the coming years. Another 5,000 MW of oil and coal, which now run only during peak demand or periods of gas pipeline constraints, are likely to retire soon. (The region’s remaining two zero-carbon-emitting nuclear facilities, Millstone and Seabrook, supply a quarter of the electricity New England consumes in a year and will be critical components of a reliable clean-energy grid because they are carbon free and have a dependable, on-site fuel supply). Competition in the markets brought about this change at a faster pace than under the traditional industry model. Under wholesale markets, private companies have carried the risks of uneconomic investments, not utilities and their customers. Consumers have benefited from this least-cost resource mix created through competitive markets.

Notable exits include:

- Brayton Point Station (1,535 MW from oil and coal)
- Salem Harbor Station (749 MW from oil and coal)
- Pilgrim Nuclear Station (677 MW from nuclear power)
- Vermont Yankee (604 MW from nuclear power)
- Bridgeport Harbor Station (564 MW from coal)
- Norwalk Harbor Station (342 MW from oil)
- Mount Tom Station (143 MW from coal)

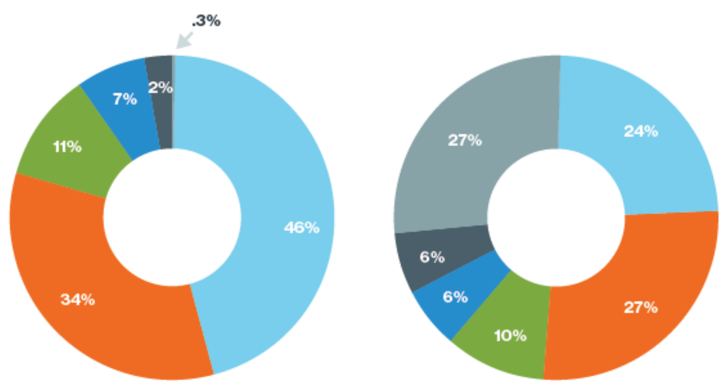
Nuclear, oil, and coal generators are critical on the coldest winter days when natural gas supply is constrained (as shown below). Coal- and oil-fired resources also make valuable contributions on the hottest days of summer when demand is very high or major resources are unavailable. As more and more conventional, thermal generation that store fuel on site retire, the system is increasingly made up of generating facilities that run on just-in-time energy sources: natural gas (from pipelines and LNG deliveries), wind, and solar energy.

With limited options for storing natural gas, most natural-gas-fired plants rely on just-in-time fuel delivered to New England through interstate pipelines. However, interstate pipeline infrastructure has only expanded incrementally over the last several decades, even as reliance on natural gas for home heating and for power generation has grown significantly. During cold weather, most natural gas is committed to local utilities for residential, commercial, and industrial heating. As a result, we are finding that during severe winter weather, many power plants in New England cannot obtain fuel to generate electricity. Liquefied natural gas (LNG), brought to New England by ship from overseas, can help fill the gap—but regional LNG storage and sendout capability is limited, and its timely arrival depends on long-term weather forecasts, global market prices, and other logistical challenges.

Winter also imposes the most challenges for solar output in New England due to snow, clouds, and shortened daylight hours. In addition, shortened winter days means consumers use the most electricity after sunset, and therefore solar doesn't reduce winter peak demand. While offshore wind experiences its highest production during winter, winter storms that limit solar power can also significantly limit the output of wind generation. This type of variability is an understandable challenge in meeting the states' decarbonization goals through greater renewable, weather-dependent technologies, and it poses new technical challenges to the grid's reliability.

Oil Generation is High During Extreme Winter Cold

Oil generation was 27% of the regional fuel mix during the cold spell of winter of 2017/2018 compared with 0.3% for most of the month of December.



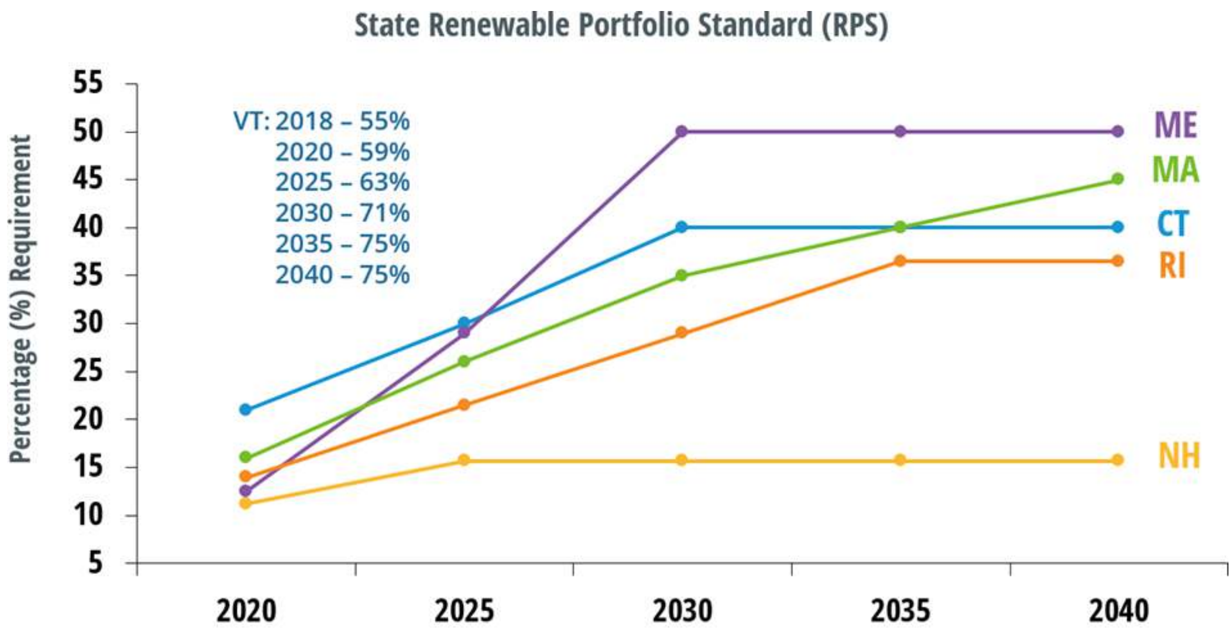
- Natural Gas
- Nuclear
- Renewables
- Hydro
- Coal
- Oil

Average Fuel Mix for Most of December 2017 (Dec. 1–26, 2017)

Average Fuel Mix for Extreme Cold Spell (Dec. 26, 2017 to Jan. 9, 2018)

Tomorrow's Energy Mix: Resources on the Way IN

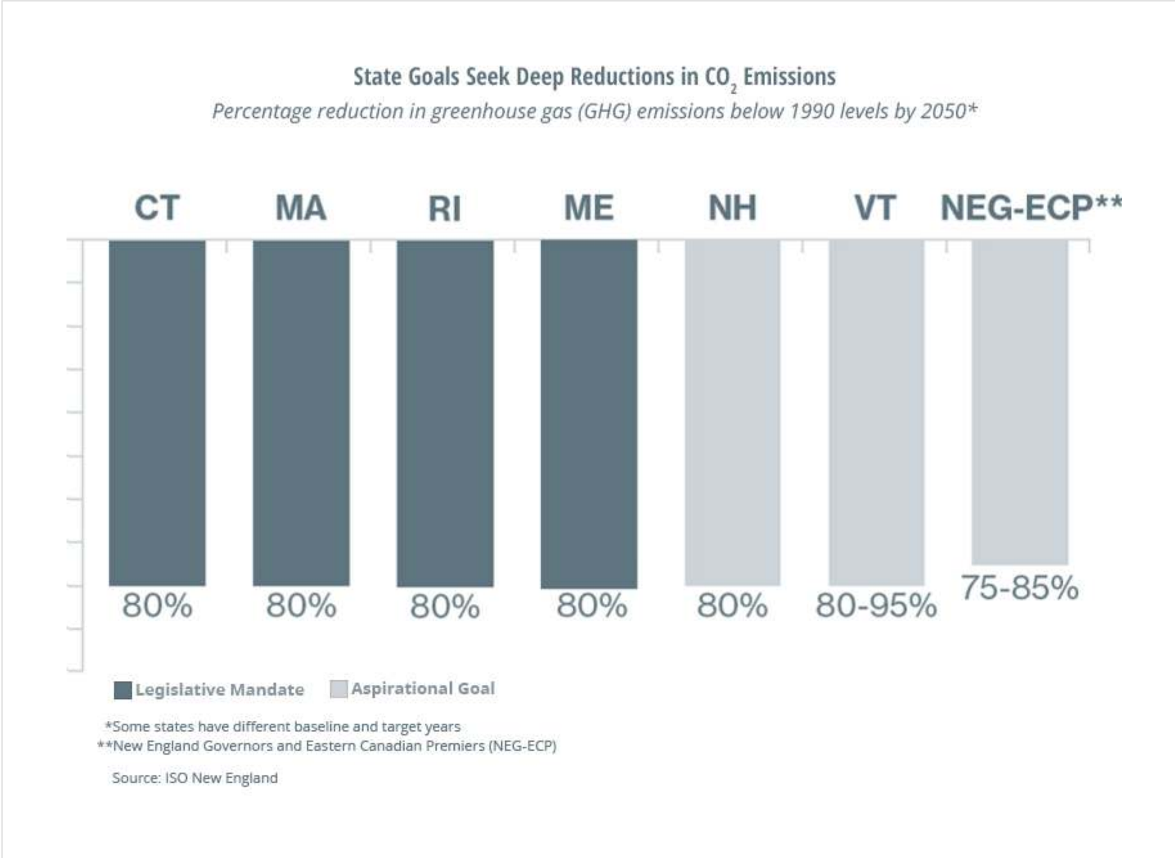
All six New England states have renewable energy standards, which require electricity suppliers to provide customers with increasing percentages of renewable energy to meet state requirements.



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 2030, 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 plateaus at 36.5% in 2035. 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.

Source: ISO New England

The New England states are also promoting greenhouse gas (GHG) reductions on a state-by-state basis and at the regional level, through a combination of legislative mandates and aspirational goals.



With deadlines looming, the states are eager for the quicker transformation of the power grid to renewables and for electrification of the broader economy. Because large-scale renewable resources typically have higher up-front capital costs and different financing opportunities than more conventional resources, they have had difficulty competing in the wholesale markets. Therefore, the New England states are promoting, at varying levels and speed, the development of specific clean-energy resources to meet their public policy goals.

Several states have established public policies that direct electric power companies to enter into rate-payer-funded, long-term contracts for large-scale carbon-free energy that would cover most, if not all, of the resource's costs. Long-term contracts carry risk given the rapid development and falling costs of new technologies—and this risk of stranded costs is placed back on consumers. As policymakers seek to convert the transportation and heating sectors to carbon-free electricity to fully meet climate goals, this public policy trend is expected to continue.

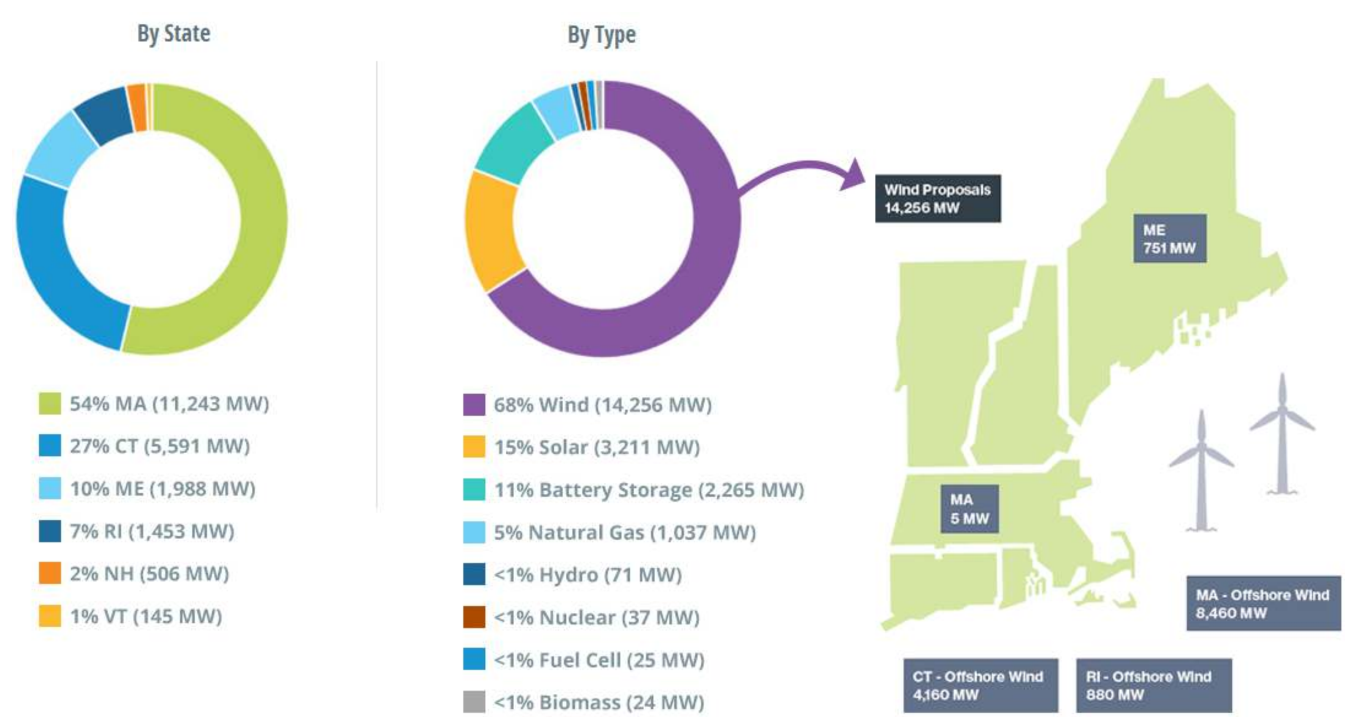
States Accelerate Procurement of Renewable Energy

State(s)	State Procurement Initiatives for Large-Scale Clean Energy Resources	Resources Eligible/Procured	Target MW (nameplate)
CT	**2019**: Offshore Wind RFP	Offshore Wind	400—2,000 MW
MA	**2019**: Section 83C II Offshore Wind RFP	Offshore Wind	800 MW

RI	**2018**: Renewable Energy RFP	Solar, Wind, Biomass, Small Hydro, Fuel Cells and Other Eligible Resources	400 MW
CT	**2018**: Zero-Carbon Resources RFP	Nuclear, Hydro, Class I Renewables, Energy Storage	Approx. 1,400 MW (11,658,080 MWh)
CT	**2018**: Clean-Energy RFP	Offshore Wind, Fuel Cells, Anaerobic Digestion	252 MW
MA, RI	**2017**: Section 83C I Offshore Wind RFP	Offshore Wind	800 MW (MA) 400 MW (RI)
MA	**2017**: Section 83D Clean-Energy RFP	Hydro Import	Approx. 1,200 MW (9,554,000 MWh)
MA, CT,RI	**2015**: Multi-State Clean-Energy RFP	Solar, Wind,	390 MW

Note: Nameplate MW may be higher than qualified Forward Capacity Market capacity MW.

Developers of clean-energy resources are taking advantage of state incentives, declining technology costs, and revenues from the wholesale markets. About 95% of resources currently proposed for the region are grid-scale wind, solar, and battery projects. As of January 2020, about 20,100 MW have been proposed in the ISO Generator Interconnection Queue.

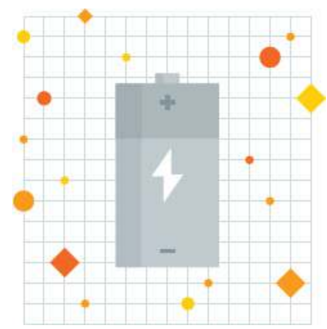


Source: ISO Generator Interconnection Queue (January 2020); FERC and Non-FERC Jurisdictional Proposals; Nameplate Capacity Ratings

Note: Some natural gas proposals include dual-fuel units (with oil backup). Some natural gas, wind, and solar proposals include battery storage.

Wind power dominates new resource proposals. ISO New England has more than 14,000 MW of wind interconnections under study, which is by far the largest group of resources seeking to connect to the region's electricity grid (as of January 2020). The New England coast offers prime conditions for offshore wind, and about 13,500 MW of proposed wind is located offshore of Massachusetts, Rhode Island, and Connecticut, with most of the remaining located onshore in Maine. In 2016, the wind turbines at the Block Island Wind Farm began putting power onto the electricity grid, making the 30 MW project the first offshore wind farm in the United States. Learn more about transmission needed to support a hybrid grid.

Solar power now ranks second in the ISO Interconnection Request Queue, surpassing natural gas. Most solar power in New England is connected to local distribution utilities or "behind the meter" directly at retail customer sites. Because such projects do not follow the ISO interconnection process, they aren't reflected in the ISO Queue numbers above. The ISO must still track solar power's growth in the region for forecasting and planning purposes, however, since it reduces demand on the grid; the region had over 180,000 solar power installations at the end of 2019 with a combined nameplate generating capability of more than 3,400 MW. Read more about solar power in New England—its growth, locations, and effects on the system, as well as how the ISO is handling related challenges.



Energy storage is "charging" ahead and now ranks third in the ISO Interconnection Request Queue, also surpassing natural gas. For more than 40 years, New England has enjoyed the benefits of two large-scale pumped-hydro energy- storage facilities that can supply almost 2,000 MW of capacity within 10 minutes. Now, new storage technologies are emerging, driven by technological advances, falling costs, support from the states, and changes to the markets that enable storage participation. About 20 MW of grid-scale battery-storage projects have come on line since 2015; nearly 2,300 MW of grid-scale stand-alone energy-storage projects are requesting interconnection. Grid-scale and behind-the-meter energy storage can contribute a number of benefits:

- Provide grid operators with short-term reliability services
- Maximize the output from wind and solar resources by storing their excess energy
- Defer transmission and distribution system upgrades when strategically placed
- Shave the peak during times of high system demand
- Provide backup power during localized power outages
- Enable the development of microgrids

Region will need investment in the superhighway for moving clean energy

Even with substantial investment made to modernize the transmission system and enable the free flow of low-cost power, additional transmission (and distribution) system upgrades will be needed to accommodate large amounts of diverse clean-energy sources—from large-scale offshore wind, remote Canadian hydropower, and hundreds of thousands of distributed solar and storage sources. Think of the grid as the superhighway for moving the clean energy that ultimately will be fundamental to reliably converting millions of vehicles and heating systems in buildings to electricity.

ISO New England has no authority over siting processes or permits, and because of local opposition and other factors, transmission investments can take a long time to come to fruition in New England. To achieve decarbonization goals, the region must be proactive in developing infrastructure that aligns with supply growth and is available when needed. Regional coordination may not alleviate local opposition but may help make the siting process more successful.

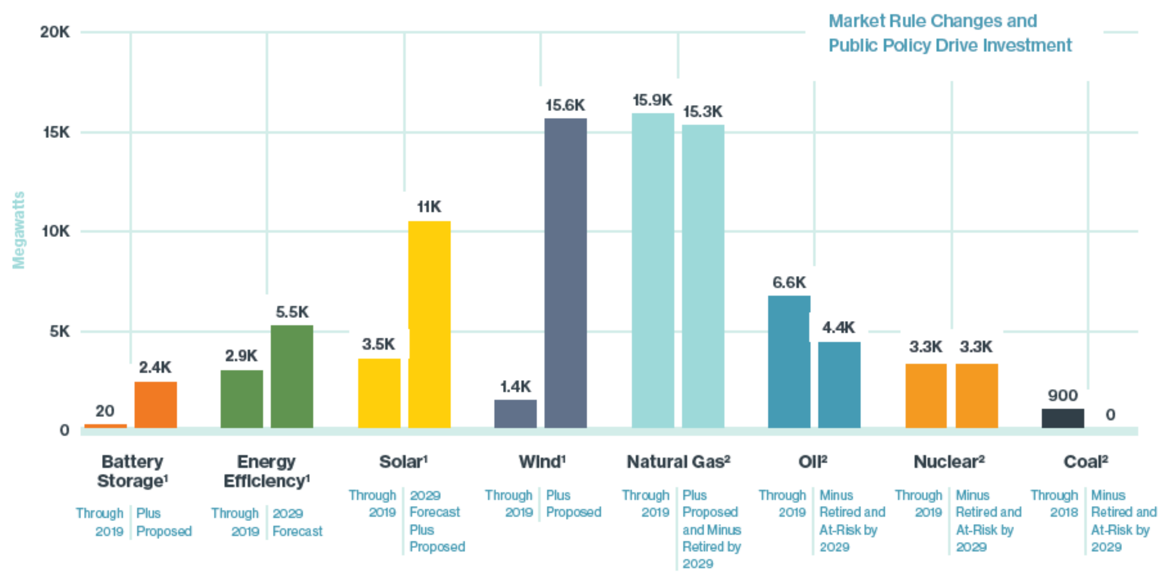
Storage also consumes energy and may not provide assistance once depleted. Energy-storage resources draw electricity from the power system or directly from a generating resource (such as a colocated solar or wind facility) as they “stockpile” energy and then send electricity to the grid at a later time. Overall, they consume more energy than they supply, as operations and losses during energy conversion consume some of their “inventory” of stored energy. If these resources are already depleted during a system emergency, they would not be able to provide help but would instead sit idle, making their “inventory management” and optimization a key technical challenge for the grid’s reliability.

In addition, 2,600 MW of **energy efficiency** (EE) measures can reduce electricity demand from New England’s power grid. New England states invest billions of dollars on EE programs that promote the use of energy-efficient appliances and lighting and advanced cooling and heating technologies (nearly $5.4 billion on EE programs from 2013–2018 and another $10.7 billion between 2021 and 2029). Massachusetts, Rhode Island, Connecticut and Vermont rank among the top 10 states in energy efficiency in the US, according to the American Council for an Energy-Efficient Economy's 2018 rankings.

Unlike EE and behind-the-meter PV, which are *passive demand resources*, *active demand resources* (also known as demand-response resources) can be dispatched by the ISO. Demand-response resources can reduce their electricity consumption from the regional grid “on demand,” by powering down machines (load management), by switching to an on-site generator (distributed generation), or by switching to a storage device (batteries). Demand-response resources provided about 500 MW of the region’s total capacity needs in 2019. And, after a multi-year development effort, on June 1, 2018, ISO New England became the first US grid operator to deploy demand-response resources as part of the energy dispatch and reserve-designation process along with generating resources. Integrating demand-response resources directly into the wholesale market for energy and reserves was a long sought after but complex goal. Active demand response accounted for 26 GWh of reduced system demand in 2019.

Battery Storage, Energy Efficiency, and Renewables Are Trending Up in New England

Projected Changes in Key New England Power Resources and EE



Notes: Numbers are rounded. Not all proposed new projects are built; historically, almost 70% of proposed new megawatts in the ISO Interconnection Request Queue have ultimately withdrawn.

1. Nameplate capacity. Battery storage includes existing and proposed grid-connected resources; some wind and solar projects also include batteries. Solar includes existing and proposed grid-connected resources, as well as existing and forecasted BTM resources. EE includes resources in the capacity market, as well as forecasted future capacity.

2. Nameplate capacity for proposed projects; summer seasonal claimed capability for existing units based on primary fuel type. Some oil units can also burn natural gas and vice versa. The 2029 at-risk values are hypothetical, reflecting retirement delist bids, plus the possible loss of nearly 2,100 MW of generation.

Source: ISO New England, *ISO Interconnection Request Queue* (January 2020), *2019 CELT Report*, *Draft 2020 Solar PV Forecast* (February 2020), *2020 Draft Energy-Efficiency Forecast* (February 2020), *Seasonal Claimed Capability Monthly Report* (January 2020), *Status of Nonprice Retirement Requests and Retirement Delist Bids* (August 2019), and *2016 Economic Studies Phase I Assumptions* (2016)

Read about solar power in New England—its growth, locations, and effects on the system, as well as how the ISO is handling related challenges.

Learn about how ISO New England is actively pursuing innovations to help create a more efficient, responsive, reliable system that can handle expanded renewable generation and smart grid technology.

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