2019 Regional Electricity Outlook

ISO new england

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About Us

ISO New England is the not-for-profit corporation responsible for keeping electricity flowing across the six-state New England region: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. The company's power system engineers, economists, computer scientists, and other professionals ensure that the region has reliable, competitively priced wholesale electricity today and into the future. The ISO is independent – none of the ISO's board members, officers, or employees has a financial interest in any company doing business in the region's wholesale electricity marketplace. The Federal Energy Regulatory Commission (FERC) regulates the ISO.

About This Report

ISO New England's unique role gives it an objective, bird's-eye view of trends that could affect the region's power system. The *Regional Electricity Outlook* is one of the many ways the ISO keeps stakeholders informed about the current state of the grid, issues affecting its future, and ISO initiatives to ensure a modern, reliable power system for New England. Please also see our Annual Work Plan at www.iso-ne.com/work-plan for information on the ISO's major projects for the year to improve our services and performance. Contact ISO New England's Corporate Communications and External Affairs teams at (413) 535-4309 for copies of this report.

Please note: The facts and figures in this report were current as of January 2019. However, the ISO continually generates and updates data and analyses.

Our Mission

ISO New England's mission includes three interconnected responsibilities:

- Overseeing the day-to-day operation of New England's electric power generation and transmission system
- Managing comprehensive regional power system planning
- Developing and administering the region's competitive wholesale electricity markets

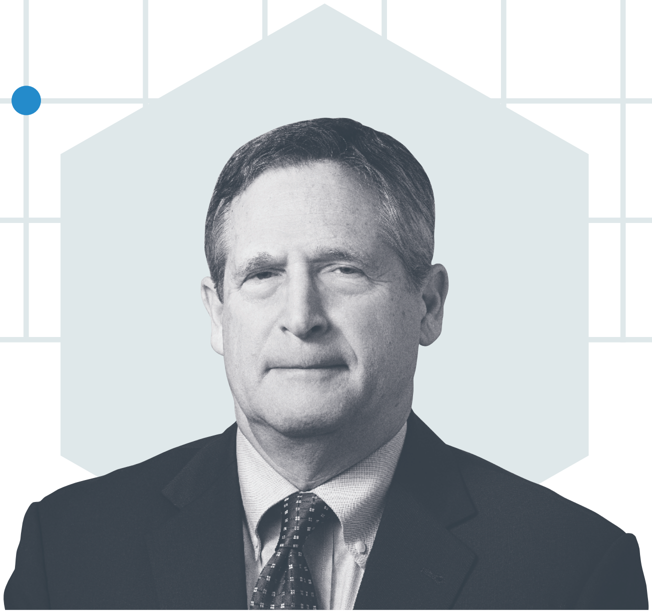
Visit www.iso-ne.com/reo for data updates, background information, and in-depth discussions of many of the topics covered in this report.

From the Board Chair and CEO

Philip Shapiro joined the ISO Board in 2010 and was named chair in 2014. He has extensive experience in finance and infrastructure.

Gordon van Welie has been president and chief executive officer of ISO New England since 2001.

Read their full bios at www.iso-ne.com/about.



Philip Shapiro
Board Chair

Gordon van Welie
President and CEO

Nearly a decade ago, the theme of ISO New England's Regional Electricity Outlook (REO) was, *Bringing Possibilities into Focus*. Over the years, ISO New England has enthusiastically emphasized the opportunities ahead in the electric power industry. Today, it is remarkable to see that grid transformation is no longer a hypothetical vision but a certain reality.

Wholesale markets have changed the electric power industry in New England. Competition has stimulated technological advancement in the electric generation sector, giving rise to a more efficient generating fleet and competitive wholesale prices. As a result, carbon emissions from the grid have fallen by roughly a third. Overlay New England's policy drive toward carbon reduction in the power sector, and the region is on its way from having an electric grid dominated by fossil-fuel and nuclear generation to one that includes large amounts of wind and hydro generation and hundreds of thousands of small solar and storage systems spanning the six states. The states' next step in their decarbonization journey is to transition the emissions-heavy heating and transportation sectors to low-carbon electricity. This will be a massive undertaking for the region, and we need a stable market construct and a reliable grid to enable the transition and ensure that it occurs in a cost-effective and reliable fashion.

Using our data and experience, the ISO strives to provide a consistent, forward look at the changing industry landscape—and with that we must also be realistic about the region's risks. From our point of view, the transition to a clean-energy economy is exciting because it offers opportunities for new technologies and innovation in electricity production, cost, and reliability. But for the foreseeable future, the region will remain vulnerable to energy shortfalls and wholesale price volatility as more and more resources with limited-energy "inventories" (natural gas generation, wind, solar, battery storage) displace resources with on-site fuel that can sustain operation for extended periods (oil, coal, nuclear, dual-fuel generation).

It's not that the region's resource mix is changing, but *the way this change is happening* that's challenging reliable system operations and competitive wholesale electricity markets.

Conventional generators that can sustain energy production continuously for days or weeks throughout severe winter weather are retiring because they can no longer financially compete in the markets. Yet these resources are needed to perform when natural gas generators and renewable resources cannot. While battery storage is promising, current technology is limited by the quantity of energy stored and, therefore, is useful only for shortage events that last a few hours. Severe winter weather conditions can also hamper resupplies of oil and LNG, and increasingly strict emissions regulations limit how often generators run on oil. These energy constraints mean the ISO has to operate the grid on a thin margin. To date, our operators have been able to manage through periods of energy constraints, but we are concerned that in the future, this may not always be possible, and we'll have to rely on costly measures to stabilize the power system and avoid blackouts.

When restructuring was introduced more than two decades ago, the policymakers and the industry did not foresee a world where the majority of generators would have limited fuel supply. Competitive markets were designed to incentivize the private development of the least-expensive resources to reliably provide electricity, under the assumption that resources would have access to adequate fuel supplies. They were not designed to telegraph future energy-scarcity conditions, compensate resources for their ability to maintain fuel inventories over extended periods, optimize the logistics of fuel use or fuel resupply during times of system stress, or drive investments in fuel infrastructure.

In parallel to the retirements, Connecticut, Massachusetts, and Rhode Island are signing up large quantities of renewable energy resources through long-term contracts outside of the ISO's wholesale marketplace. In addition to the original goal of using competitive markets to achieve efficiencies and cost savings, the states now also have an imperative to eliminate air emissions. And like the energy-security issue, the markets were not designed to achieve carbon-reduction goals or to specifically bring forth the development of renewable resources. In lieu of having carbon priced in the markets, the states are using above-market contracts to provide a guaranteed source of revenue to specific renewable resources, which is the boost they need to reach financial viability.

However, when resources with guaranteed revenue enter the wholesale market, competitive prices become suppressed. This not only stresses the markets' ability to work as designed, it also places additional economic pressure on all other nonsponsored resources needed to maintain reliability and cost control. On the other hand, keeping these resources outside of the wholesale markets and not counting them as regional system capacity would lead to expensive overbuild of resources.

Establishing a realistic price on carbon remains a more seamless and simpler way to achieve clean-energy goals through markets without distorting competition, but this is not in the ISO's jurisdiction. State or federal policymakers could pursue this direction but have not done so to date. In the meantime, the ISO launched a new substitution auction in the Forward Capacity Market in early 2019 to accommodate the entry of these resources, while maintaining competitive pricing in the primary auction.

The region's two remaining nuclear plants fall under both scenarios described here because they are carbon free and have a dependable, on-site fuel supply, but they are not compensated for these attributes in the markets. Nuclear power currently supplies a quarter of the grid electricity New Englanders use each year, and our analyses show that we would be more vulnerable to blackouts, higher prices, and increased emissions should we lose these two resources. Regional emissions rose when Vermont Yankee closed, for example. Nuclear resources will prove critical to meeting both decarbonization and energy-security goals for years to come, but how they can remain financially viable is still unclear.

As you will read in this report, the ISO has been continuously adapting both our markets and operations to reflect these new realities and create a framework for successful resource transition. We have leveled the playing field for wind, solar, and advanced storage devices by adapting market rules and updating operating procedures. We've implemented measures to protect and enhance price formation during scarcity and surplus conditions. And we've also strengthened financial consequences for resources that do not perform as committed.

This year, the ISO is pioneering new ways to change the wholesale market structure to appropriately compensate resources able to ensure a secure energy supply during long periods of system stress. These economic incentives should help keep some resources from retiring prematurely; ensure that existing resources procure fuel and make investments to provide operational flexibility across all system conditions; and stimulate the development of new resources and technologies that can provide energy-secure attributes.

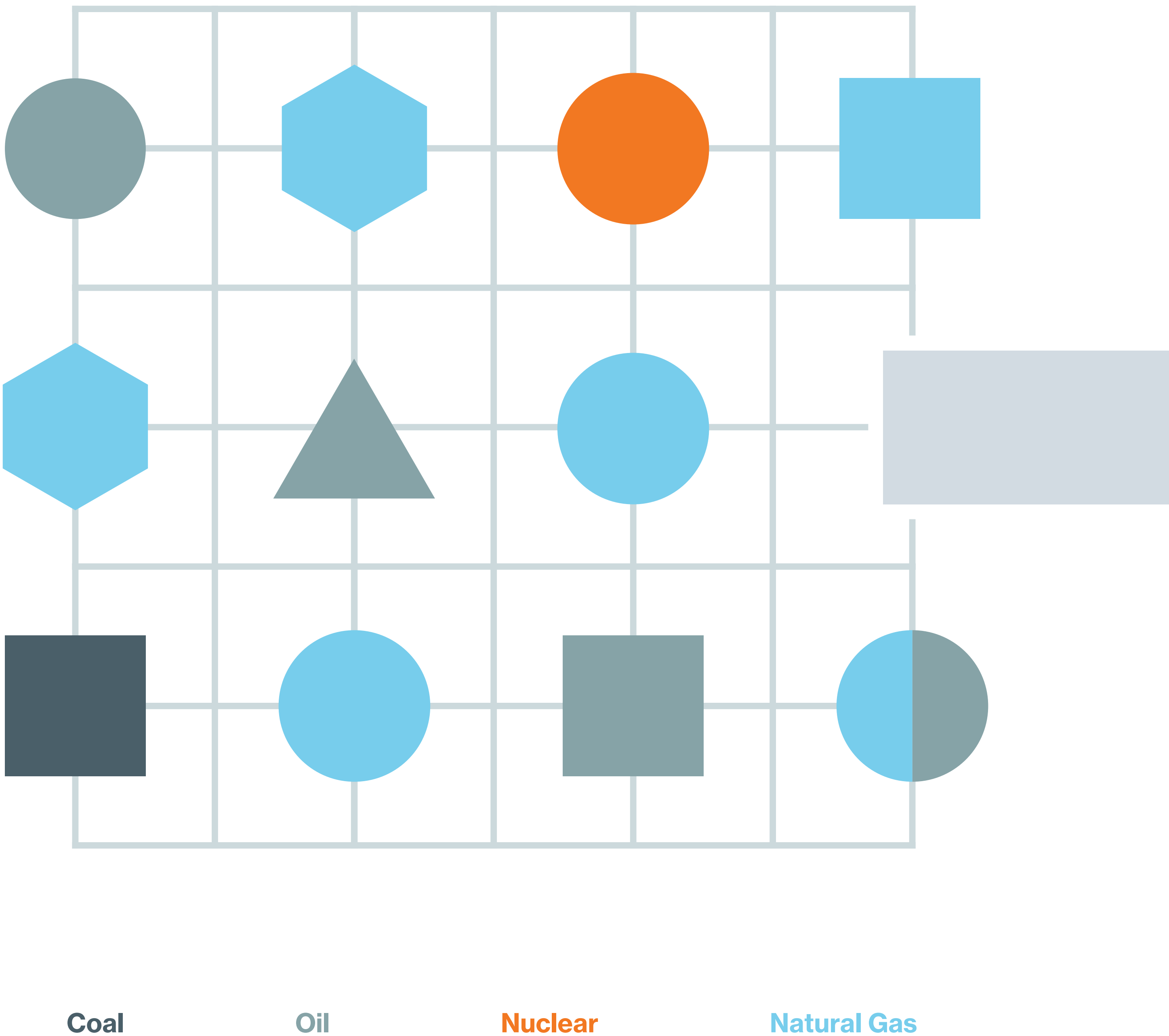
Through this new market construct, the pricing signals will have to motivate resources to alleviate the energy-security problem and may result in periodic higher prices and volatility. Showing accurate price signals is especially important given that energy security is mostly a wintertime risk for now and some of the scenarios are low-probability events—but with potentially catastrophic outcomes. These market solutions will still require years of development, and until these changes take effect, the ISO has to make difficult decisions about resource retirements—and in some cases retain resources to maintain reliability.

Importantly, ISO New England does not have the authority to dictate investments in energy infrastructure that can help ensure that the region's energy needs can be met in all seasons, under all conditions. Our toolkit is to create financial stimuli through the wholesale electricity markets that will drive action. Opposition or impediments to infrastructure decisions will only exacerbate the region's energy-security constraints.

As we've been saying for the past two decades, the evolution of our power system and wholesale markets hold tremendous promise. By executing on our mission to achieve reliability through wholesale markets, and by fulfilling our planning and operational obligations to integrate new renewable energy resources, we can help speed decarbonization. We thank you for your ongoing support and contributions as we work together to manage complexity and maintain reliability. New England's capacity for innovation and collaboration will be essential during the months and years ahead.

Sincerely,

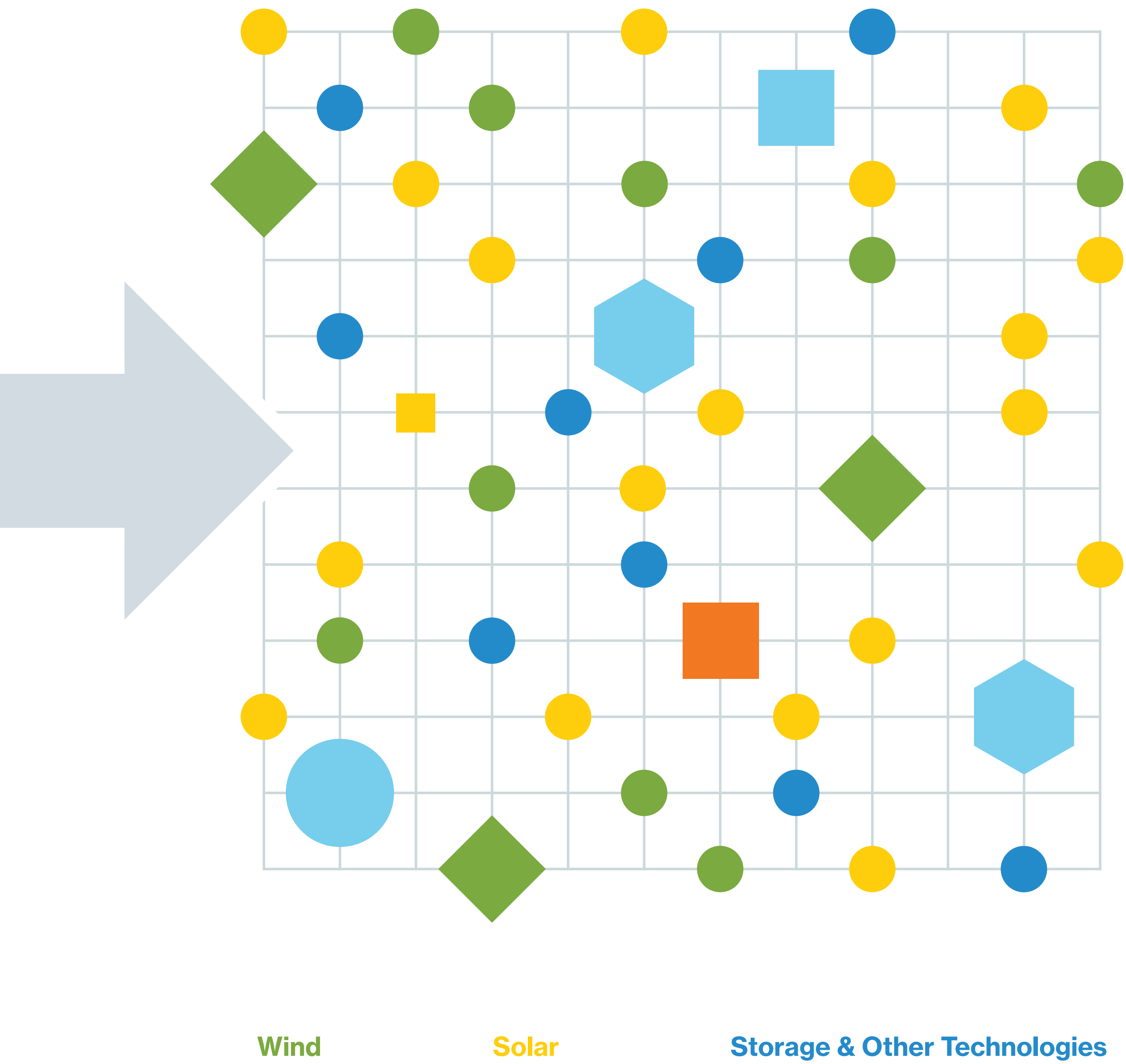
New England's Electricity Journey



A hybrid grid is emerging in New England.
There are two dimensions to this transition, happening simultaneously:

1. A shift from conventional generation to renewable energy

2. A shift from centrally dispatched generation to distributed energy resources



From achieving reliability and innovation through competitive markets

The electric power grid in New England has evolved over recent decades, guided by the principle that a reliable supply of competitively priced electricity is the foundation of a thriving society and economy. New England restructured its wholesale power industry in the late 1990s, moving away from vertically integrated, rate-payer funded utilities that controlled how the grid developed, and introduced open, wholesale electricity markets.

Markets provide an open, level playing field for developers to build resources that compete with one another to generate electricity for New Englanders. Over the past 20 years, the transparent, competitive wholesale electricity markets have driven 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.

To a growing focus on carbon reduction

Today, New England is focused on combatting climate change. A top policy priority for many of the states is to move the electric power industry toward the goal of supplying electricity from resources that do not emit greenhouse gases. But because large-scale renewable resources typically have higher up-front capital costs than more conventional resources, they have difficulty competing against less costly resources in the markets. And consumer-owned resources such as rooftop solar, battery storage, electric vehicles, and even energy-efficiency measures are cost-prohibitive to most households and businesses. The states are spending billions of dollars through tax-payer- and rate-payer-funded financial programs to make carbon-free renewable and distributed resources more affordable and stimulate their proliferation.

And it's having an impact. New England's *traditional* power system is rapidly becoming a *hybrid* system where electricity needs will be met by conventional resources and significant amounts of large-scale renewable resources connected to the regional transmission system, in combination with thousands of small resources connected directly to retail customers or local distribution utilities.

In the decades to come, the states will work to aggressively convert the transportation and heating sectors to carbon-free electricity to fully meet climate goals, likely reversing the downward trend in demand for electricity from the grid. The technological advancements needed to fully "electrify everything" will ultimately lead to a highly sophisticated and digitally interconnected power system responsive to consumer use. The moment-to-moment balancing of supply and demand will be optimized and orchestrated through dynamic pricing signals that originate at the ISO but will also be transmitted down to smart appliances (including vehicles) in households and businesses. Given the digital nature of this new grid, the region's policymakers, regulators, and utilities will have to take care to ensure that this system is designed, built, and operated with the appropriate cybersecurity safeguards.

The rate of policy and technological change occurring has a profound and complex impact on ***how grid resources operate and participate in the markets, how the ISO plans and runs the grid, and how consumers use and even pay for grid services.*** The interaction between consumers and the electric grid will continue to evolve as consumers become more dependent on, and gain more control over, their electricity supply, but the importance of reliable, affordable electricity to society's safety, comfort, and prosperity remains unchanged.

ISO New England's unique mission

ISO New England has the unique responsibility to identify and minimize risk to the reliable operation of the power system and to ensure that the markets can continuously provide cost-effective outcomes for the region as a whole. From its inception over 20 years ago to today, the ISO's mission is the same: solve the operational and market challenges that emerge as the industry evolves. **The ISO is focused on three elements essential to a reliable transition to the hybrid grid.**

1

Support the rapid transformation of the region's electricity supply and demand mix: Continue to innovate market, operational, and planning enhancements and products needed to facilitate and integrate high levels of renewable and distributed resources, while upholding the markets' ability to attract investment in existing and new resources needed to plan and operate the grid reliably.

2

Maintain a robust transmission system: The transmission grid is New England's interstate highway system for moving large amounts of clean energy, and additional investment in transmission infrastructure will be fundamental to reliably decarbonizing millions of vehicles, households, and businesses.

3

Ensure energy security: As more limited-energy resources are developed and traditional generating resources retire, there is a risk that resources at times will not have the fuel (be it natural gas, wind, sun, or even stored energy in batteries) needed to generate enough electricity to meet system demand. Improvements to the wholesale markets are required to appropriately compensate resources able to ensure a secure energy supply is available to support electricity demand across all kinds of system conditions. These improvements will incentivize optimal forward arrangements for fuel and investments in all forms of energy storage within the region.

Connecting the dots

As the independent grid operator, regional planner, and market administrator, ISO New England not only coordinates the moment-to-moment operation of resources on the power system, it also serves as a clearinghouse for data and information and identifies the trends affecting the region's power system. The ISO shares its data and analysis widely with industry stakeholders, regulators, and consumers and facilitates regional discussions on the future of New England's electric grid. ISO New England may call attention to challenges beyond its authority to solve, but at the same time it continues to adapt and innovate to meet the needs of the region.

Supporting the Rapid Transformation of New England's Electricity Demand and Supply Mix

Electricity demand from the regional power grid is trending downward over the next decade, but may trend upward in the long term

Energy efficiency and solar power are driving down annual energy use

Electricity consumers in New England used over 121,000 gigawatt-hours (GWh) of electricity from the grid in 2018, down from the record 136,355 GWh consumed in 2005. Nearly 3,000 megawatts (MW) of energy-efficiency (EE) measures can reduce electricity demand from New England's power grid. And more than 150,000 behind-the-meter (BTM) solar photovoltaic (PV) installations span the six states, with a combined nameplate generating capability of nearly 2,900 MW (they typically don't generate at maximum capacity at the same time). Almost all solar installations are connected to local distribution utilities or provide power directly to homes and businesses. The ISO doesn't dispatch the electricity these resources produce but has to manage their impact as a reduction in demand on the grid.

14.8 million people in 7.2 million households and businesses rely on New England's power system.

New England states continue to invest billions of dollars on making solar energy affordable for consumers and on EE programs (projected $10.5 billion on EE between 2019 and 2027) that promote the use of energy-efficient appliances and lighting, and advanced cooling and heating technologies. Massachusetts, Rhode Island, Connecticut, and Vermont rank among the top five states in energy efficiency in the US, according to the American Council for an Energy-Efficient Economy's 2018 rankings.

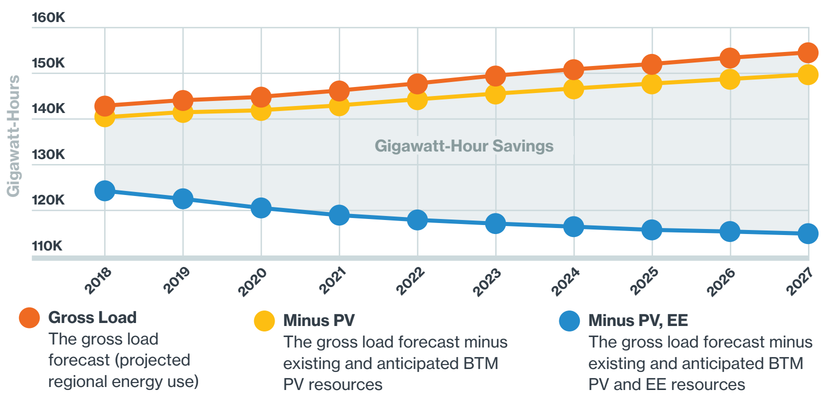
Future demand-reducing effects of EE and BTM PV are projected in the graph below. To enhance its planning for the future grid, the ISO improved its innovative EE forecast methodology in 2018 to more accurately forecast the amount of EE installed on the distribution systems operated by local utilities across the region. EE measures are estimated to save an average of 2,059 GWh each year and will reduce peak demand by 281 MW annually.

Installed Solar PV Capacity by State

State	Installed Capacity (MWAC)	Number of Installations
MA	1,871.27	90,720
CT	464.34	35,889
VT	306.30	11,864
NH	83.84	8,231
RI	116.66	5,993
ME	41.40	4,309
NE	2,883.81	157,006

Source: Data provided by regional distribution owners; values represent installed nameplate as of December 31, 2018.

Projected Annual Energy Use With and Without EE and PV Saving

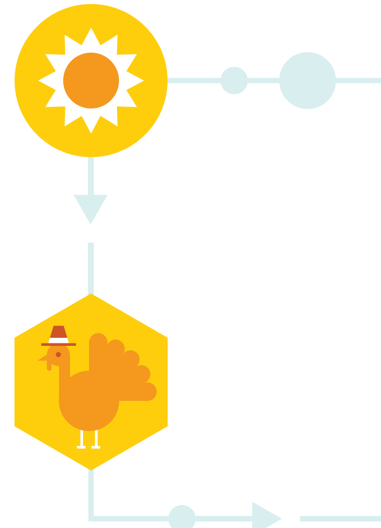


Source: ISO New England *2018 CELT Report* (April 30, 2018)

Solar power is changing historical grid demand patterns

When conditions are right, the ISO sees a significant reduction in regional electricity demand from BTM PV. During a heatwave in July 2018, BTM solar generation peaked each day at around 1:00 p.m., reducing demand from the regional power system by approximately 2,000 MW.

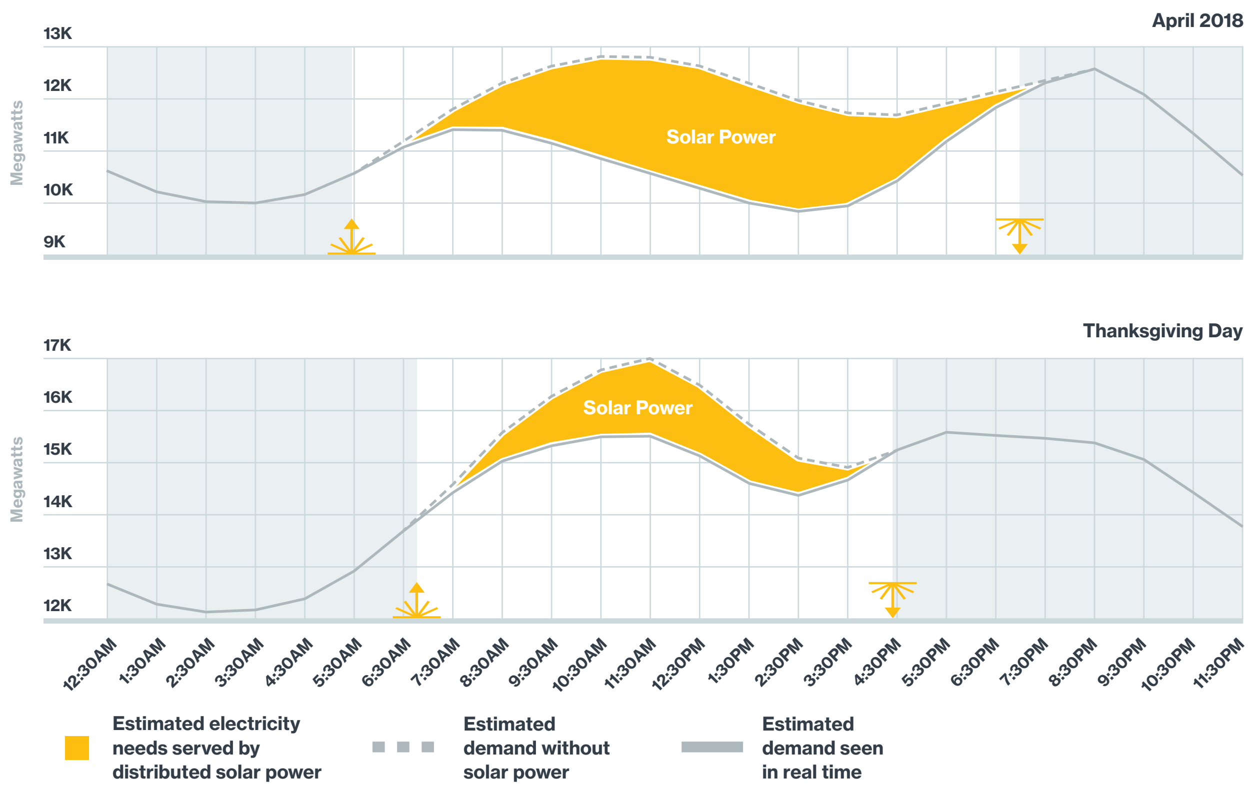
Springtime conditions are ripe for high solar output. On a cool, sunny day in April 2018, BTM solar output reached an estimated record high at 1:00 p.m. and drove down electricity demand on the regional power system by 2,300 MW. The result was a regional first: New Englanders used more grid electricity while they slept that night than during the middle of the day.



For the first time since at least 2000, and possibly ever, grid electricity demand on Thanksgiving Day did not peak in the morning as New Englanders turned on their ovens; solar pushed the peak to after sunset.

The ISO's grid operators traditionally rely on historical patterns of electricity use to accurately predict how much electricity must be generated to meet second-to-second demand. But as distributed solar resources dramatically change electricity demand patterns, producing accurate forecasts becomes more challenging.

Historic Dips in Demand



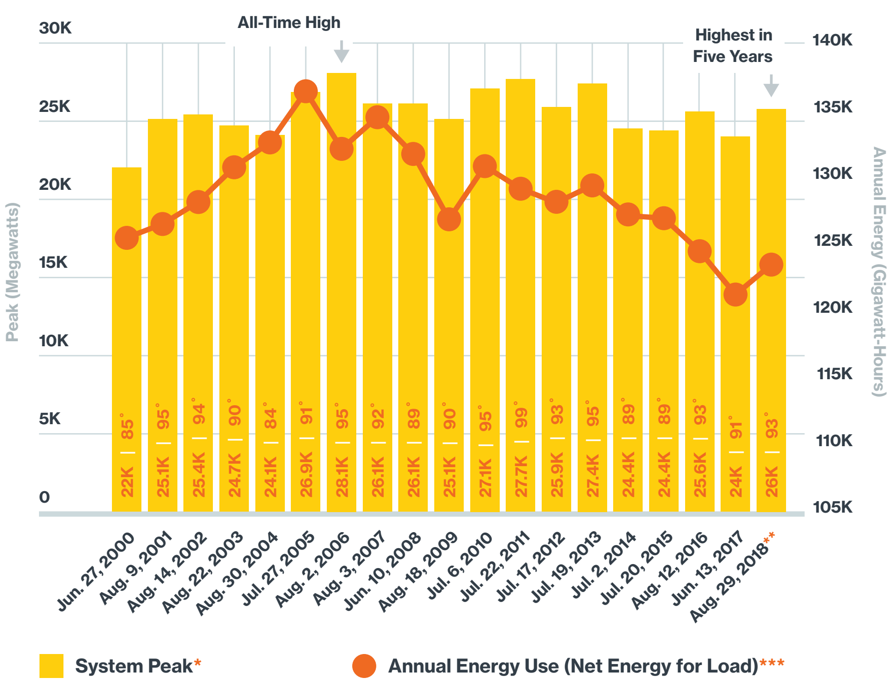
Weather still drives spikes in demand

Weather has always been the biggest factor in determining how much electricity New England consumers will use every hour of every day. For example, when the dew point is above 70°◦ Fahrenheit, every *one-degree increase* can cause demand to rise by about *500 MW*—the amount produced by a medium-sized power plant.

With an increasing amount of electricity produced by resources that use sun or wind, ISO grid operators can no longer rely exclusively on traditional weather forecasts. The actual output from solar power installations can vary widely depending on a number of weather variables that vary widely across the six New England states. These include the amount and location of cloud cover, haze, humidity, and rain and snow. New England has erratic weather conditions, and New Englander know how hit or miss weather forecasts can be—even from town to town.

Summer 2018 was marked by spells of hot and humid weather that drove electricity demand on the power grid to peaks not seen in five years. Despite significant declines in grid energy use on an annual basis, spikes in electricity demand on the power grid still occur, and the region's power system must remain prepared to meet these peaks even if they aren't historically high. New England also reached its highest Labor Day peak ever recorded as people cranked up air conditioning to deal with the swampy air blanketing the region. Overall, consumer demand for grid electricity was up 5.3% in summer 2018 compared with the previous summer.

Peak Demand vs. Annual Energy Use on New England Power System



*The sum of metered generation and metered net interchange, minus demand from pumped storage units. Starting with full market integration of demand response on June 1, 2018, this total also includes the grossed up demand-response value.

**Annual peak, as of January 2019. Values are preliminary and subject to adjustment.

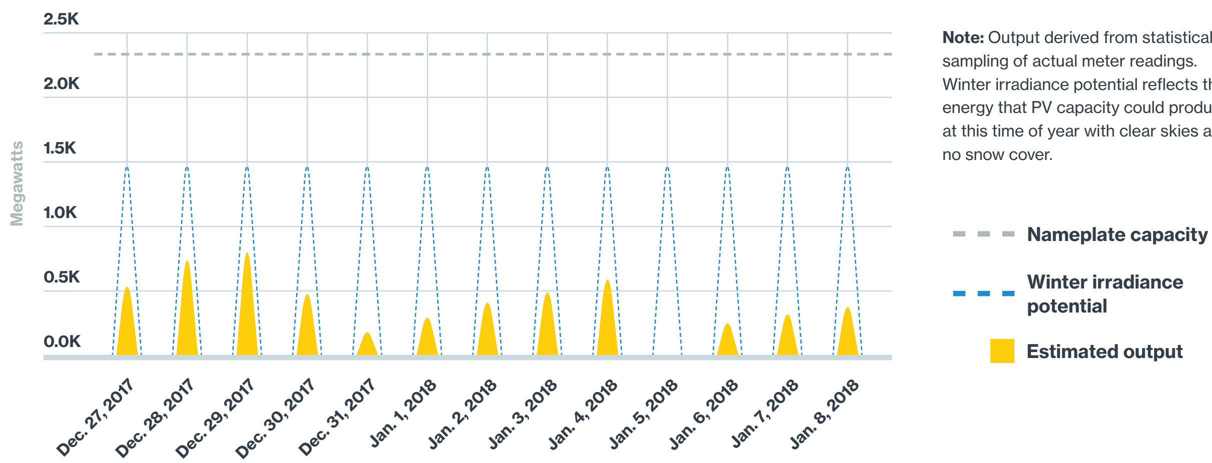
***Net energy for load (NEL) is the total amount of grid electricity produced by generators in New England and imported from other regions during the year to satisfy all residential, commercial, and industrial customer demand.

Source: ISO New England, *Seasonal Peaks since 1980 Report*, *Hourly Real-Time System Demand Report*, and *Annual Generation and Load Data for ISO NE and the Six New England States Report*.

Solar output is especially variable in winter

In New England, winter imposes the most variation in solar output because of snow, clouds, and shortened daylight hours. Cloud and snow cover prevented solar panels from reaching their seasonal potential during last year's historic 16-day cold spell (December 24, 2017, through January 8, 2018) and particularly during Winter Storm Grayson, which occurred during that period. In time, battery storage systems will be able to help manage through day-to-day variation but may not help when unfavorable solar conditions last for multiple days. In addition, shortened winter days means consumers use the most electricity after sunset. So whereas solar helps reduce grid demand during sunny days without significant snow cover and can help conserve other fuels for use later in the day, it doesn't reduce winter peak demand.

Potential vs. Actual Estimated Output from Behind-the-Meter Solar Power During 2017-2018 Cold Spell



Note: Output derived from statistical sampling of actual meter readings. Winter irradiance potential reflects the energy that PV capacity could produce at this time of year with clear skies and no snow cover.

Predicting the unpredictable: continuous forecasting enhancements

The ISO is working with industry experts to build a method of predicting PV output regionally that will be integrated into its existing day-ahead and seven-day operational load forecasts beginning in early 2019. Given that it's infeasible for the ISO to collect performance data directly from all 150,000 individual PV systems, these efforts will enhance visibility and help the ISO grid operators forecast variations in system demand with the higher degree of accuracy needed to operate the grid reliably and efficiently. The ISO also now has a full-time meteorologist on staff to help with more precise weather forecasting. Looking out longer term, the ISO has incorporated improved modeling of BTM solar power in the calculations that help determine the amount of capacity to procure through the Forward Capacity Market.

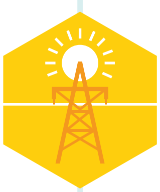
Operating the grid reliably with volatile changes in electricity demand

Solar shuts off quickly as the sun sets or clouds roll in: Ensuring enough fast-start resources

The ISO launched improved real-time fast-start pricing in 2017 to help incentivize power resources that can quickly ramp up their output to bridge the steep increase in grid demand that occurs when the sun sets.

More solar will mean more extreme dips in demand: Preventing excess energy

In 2014, the ISO began allowing negative pricing in the energy market to create a disincentive for grid resources to operate when there's surplus power. Negative pricing also provides a market-based way to manage resources such as wind that may choose to continue producing electricity at prices below zero because they receive other sources of income, such as the federal production tax credit.

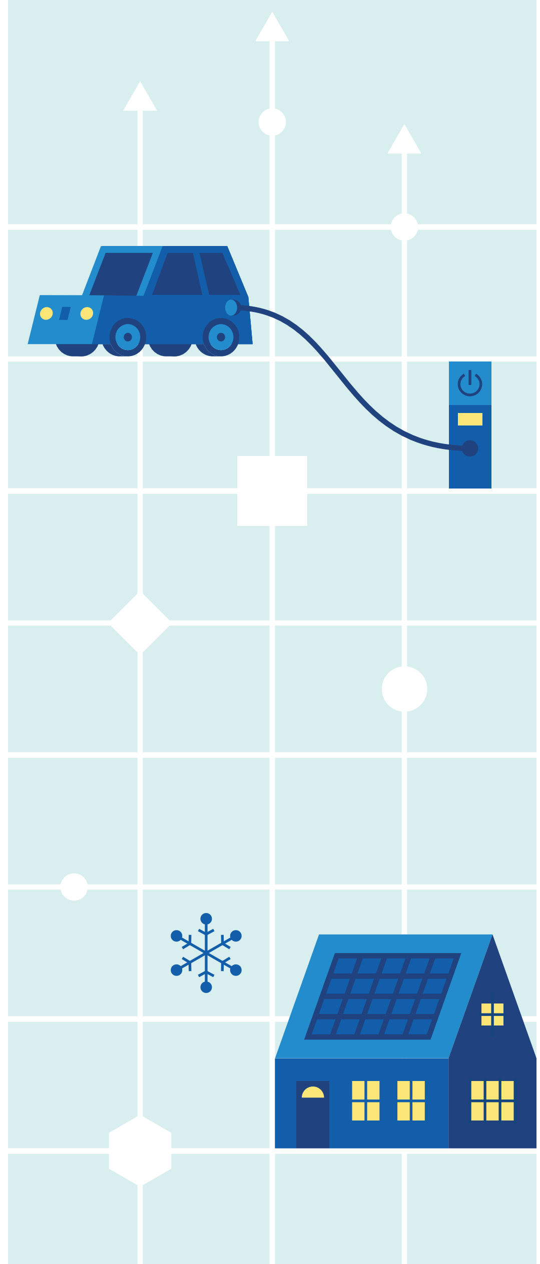


Solar needs to ride through voltage or frequency changes: Strengthening interconnection standards

If a large amount of solar power were to shut down suddenly when a transmission line or generator trips off line, net demand on the regional grid would spike, potentially introducing instability. Four states so far—including Massachusetts, with over 60% of the region's solar power—have agreed to adopt the ISO's interim ride-through requirements for future solar interconnections.

Decarbonization = Electrification

The ISO has begun working with regional stakeholders to quantify the impact of potential decarbonization efforts in the transportation and heating sectors on long-term grid electricity demand and will discuss these effects in future Regional System Plans.

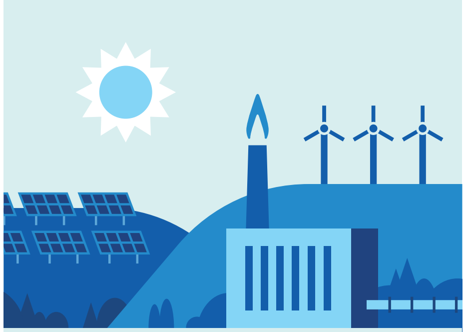


Today's grid electricity supply is cleaner and cheaper, except during extreme cold weather

Lower-emitting resources supply most of the region's electricity

The region's energy, capacity, and ancillary (regulation and reserves) markets have attracted more than 500 companies that compete to sell, buy, and transport wholesale electricity and other grid-related services. In 2018, natural-gas-fired generation, nuclear, other low- or no-emission sources, and imported electricity (mostly hydropower) provided roughly 99% of the region's electricity.

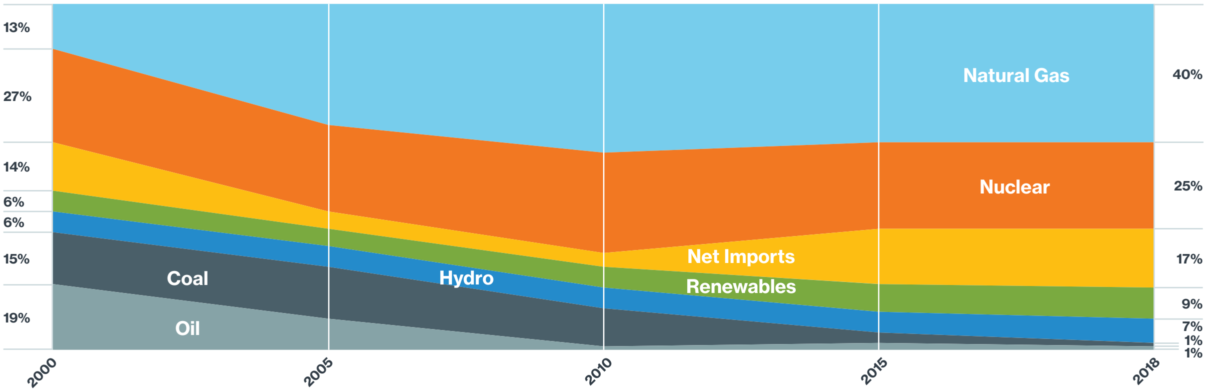
With low-cost fuel from domestic shale deposits, advances in technology, and smaller generators that are easier to site, natural gas-fueled power plants have proliferated in New England over the past two decades. Market participants have invested billions into new, efficient (meaning they use less fuel), relatively low-emitting natural-gas-fired generation. 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.



New England has about 350 dispatchable generators able to supply roughly 31,000 MW of electric power. Up to 1,500 MW of electricity can be imported to meet New England's power needs.

Until electric storage or other technologies have the ability to supply quick energy for longer periods and in greater quantities, flexible natural-gas resources are a necessary element of the hybrid grid, not only to help supply the "missing energy" when the weather is uncooperative for wind and solar resources, but also to provide the precise grid-stability and reliability services that renewables generally cannot. However, natural gas delivery constraints in winter caused by high demand for this fuel from both the heating and electric power sectors can prevent these resources from filling this need during cold weather. The need to meet environmental requirements can also restrict the amount of time natural gas plants that use oil as backup can run.

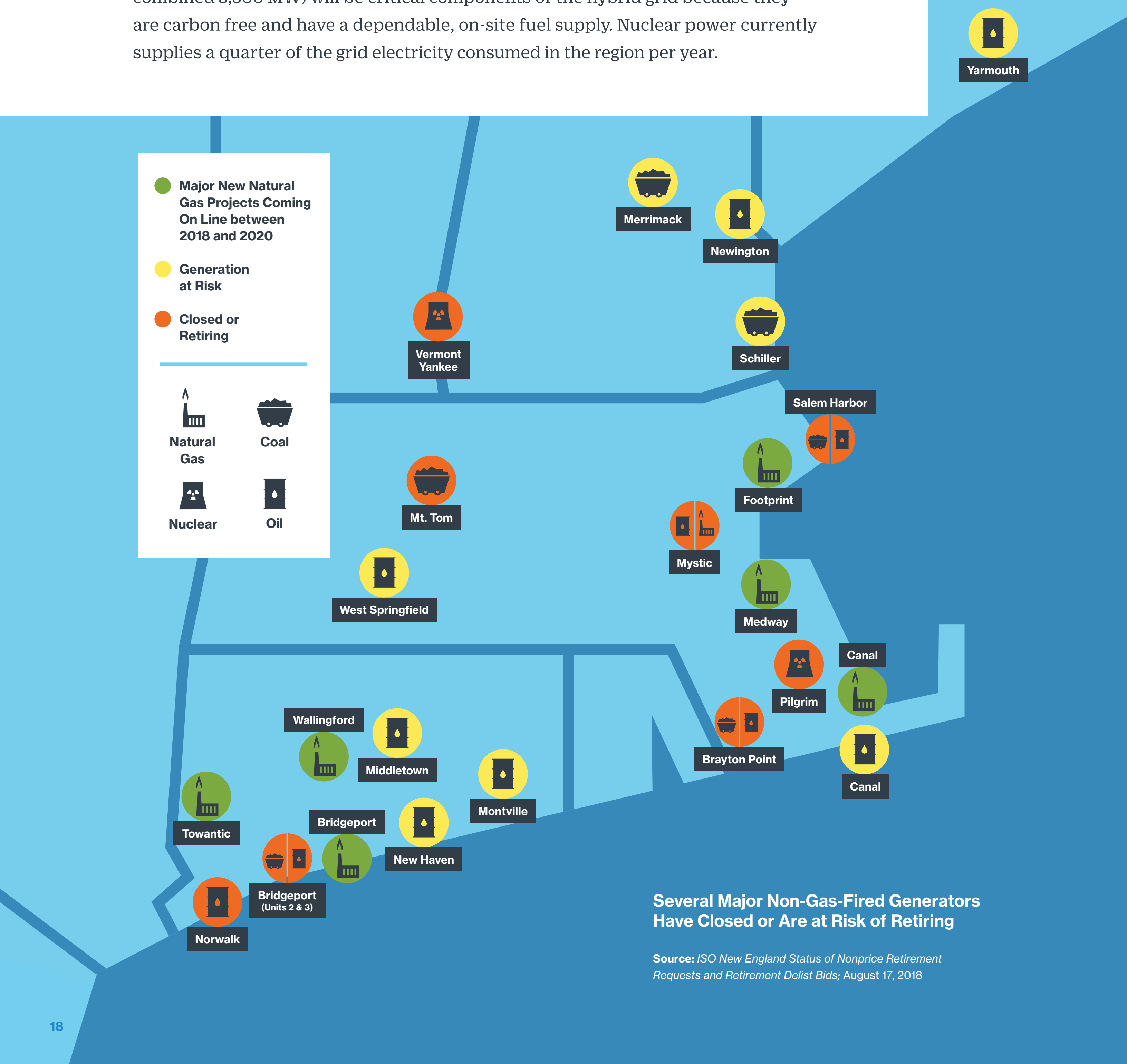
Sources of Grid Electricity in New England (Annual Net Energy for Load)



Source: ISO New England, generation data, and *Net Energy and Peak Load by Source Report*

Markets respond to changing times: Less efficient resources retire

In contrast, aging coal-fired, oil-fired, and nuclear power plants are closing largely because their fuel and environmental-mitigation costs make them too expensive to effectively compete against natural-gas-fired generators and growing levels of renewable-energy resources that have no fuel costs, low operational costs, and incentives designed to lower their initial capital investments. More than 5,200 MW of oil, coal, and nuclear power plants will have retired from 2013 to 2022, and another 5,000 MW of coal- and oil-fired generation could be retiring in coming years. The region's remaining two nuclear facilities (Millstone and Seabrook, which produce a combined 3,300 MW) will be critical components of the hybrid grid because they are carbon free and have a dependable, on-site fuel supply. Nuclear power currently supplies a quarter of the grid electricity consumed in the region per year.



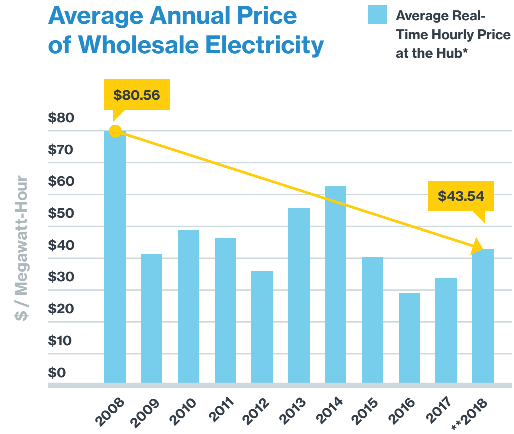
Several Major Non-Gas-Fired Generators Have Closed or Are at Risk of Retiring

Source: *ISO New England Status of Nonprice Retirement Requests and Retirement Delist Bids;* August 17, 2018

Wholesale electricity prices are historically low; constrained fuel supplies drive price spikes

With about 50% of the region's generators able to run on natural gas, the price of this single fuel sets the energy price most of the time. The high efficiency of natural-gas-fired generators and the generally low cost of nearby domestic shale gas (which emerged as a resource in 2008) are largely responsible for a 46% decrease in the average annual price of New England's wholesale electricity over the past 10 years. Lower wholesale prices translate into lower power-supply charges for consumers.

Average Annual Price of Wholesale Electricity

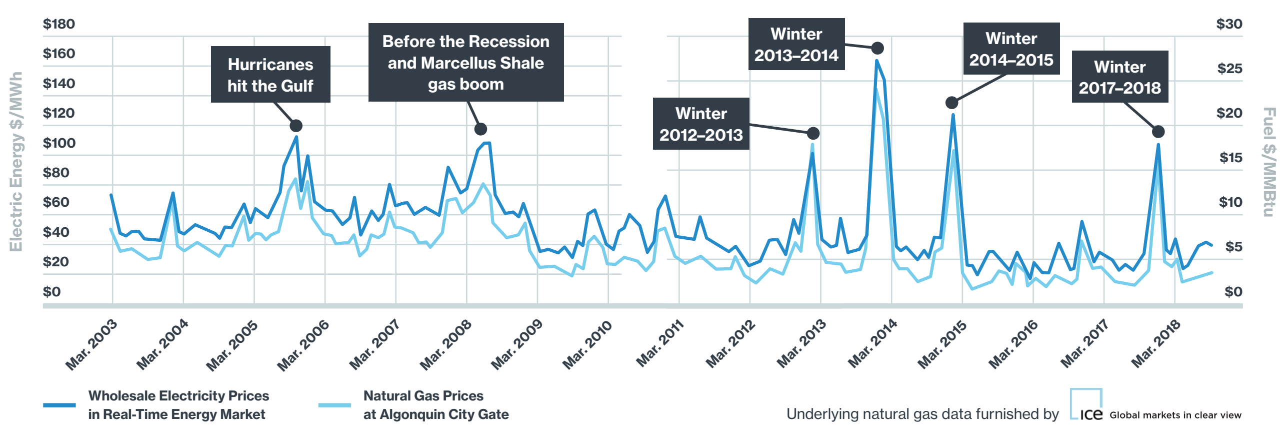


* The Hub is a collection of 32 locations in New England used to represent an uncongested price for electric energy.

** 2018 data are subject to adjustments.

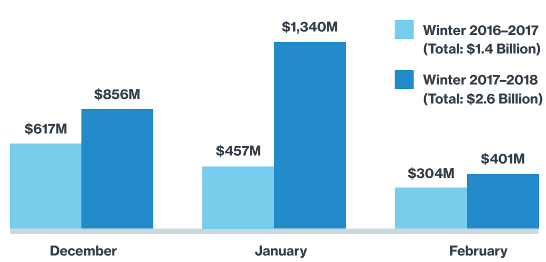
Higher real-time power prices in 2013, 2014, and 2018 were largely due to spikes in natural gas prices during wintertime natural gas delivery constraints. When natural gas is constrained and at a premium, oil generation becomes more economic. High prices are an expected and efficient market outcome when system conditions are tight—signaling a system need. Price volatility becomes more acute as constraints on energy supply become more severe.

The Largest Driver of Wholesale Energy Costs is the Price of Fuel Used to Generate Electricity



Natural gas delivery constraints during the cold spell that spanned the end of 2017 and beginning of 2018 significantly affected energy-market prices. The region's wholesale energy market was valued at $992 million for the two-week period from December 26 to January 8, compared with $243 million during the same time the prior year. Over the course of the entire winter, the energy market was valued at $2.6 billion, with approximately 38% of that coming during the cold snap.

Wholesale Energy Costs during Winter 2017–2018 Compared to Winter 2016–2017 (in millions)*

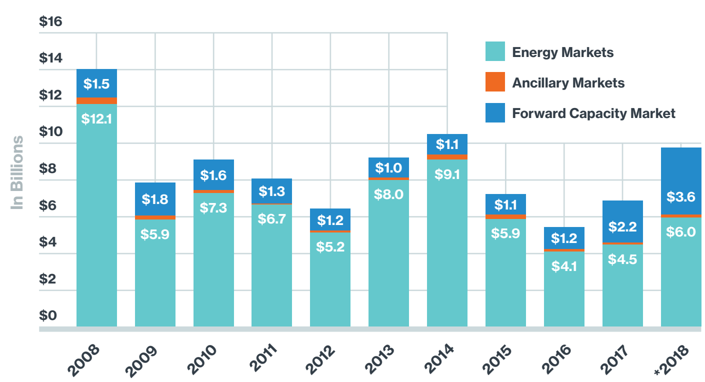


*Includes Day-Ahead and Real-Time Energy Markets

Annual value of wholesale energy markets declined 50% over the past decade; may rise with changing resource mix

Despite December price spikes, 2017 ultimately had the second-lowest average annual energy-market prices in over a decade because prices and demand were lower for most of the year. The region should expect to see the annual energy-market value continue to decline over time as renewable resources drive down energy-market prices. Nevertheless, winter will continue to exhibit price volatility reflective of the fuel and weather constraints that limit the ability of power resources to produce electricity during extended cold conditions.

Annual Value of Wholesale Electricity Markets



*Data are subject to adjustments.

While the energy-market value varies with fuel prices, the capacity market value varies with changes in amounts of supply competing to provide capacity. (The FCM compensates resources for taking on an obligation to meet the region's electricity needs approximately three-years after the annual auction is held.) The capacity market value over the past two years was higher, reflecting a rash of generation retirements that led to a smaller amount of competing supply and thus higher prices. Strong competition has generally kept capacity market auction prices low for most years. However, as energy-market revenues decrease over time, the prices in the capacity and ancillary markets will likely rise to cover the costs for resources that rely solely on market revenue (i.e., without state- and federal-based incentives) needed to balance renewable resources and provide energy security, particularly in winter.

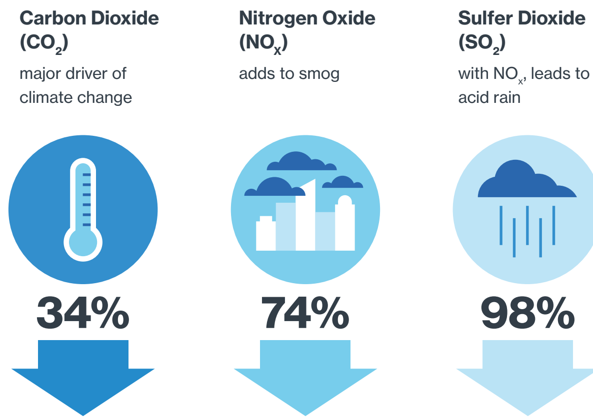
Retail electricity rates reflect different policy choices of the individual states

Wholesale costs and retail rates can vary dramatically among the New England states and from year to year, mainly because wholesale and retail electricity markets are used to obtain different products. Wholesale market costs reflect the short-term market for electric energy and wholesale production capacity; whereas, retail prices reflect the longer-term, fixed-price contracts for energy, the recovery of the costs to pay for the distribution system, and various policy-driven adders. Wholesale market costs are relatively consistent across the New England states (ranging from 5.36 cents/kilowatt-hour (kWh) to 5.68 cents/kWh in 2017), due in large part to the region's robust transmission system and its ability to move the lowest-cost power across the region. Retail power supply rates on the other hand vary significantly across the New England states (ranging from 7.83 cents/kWh to 12.61 cents/kWh in effect on January 1, 2018), due in large part to the vastly different power procurement practices of each state and the utilities within each state.

Air emissions from power plants have fallen dramatically but rise during cold spells when oil- and coal-fired generation surges

The shift to cleaner, more efficient natural-gas-fired generation and strong regional investment in transmission improvements to move that power has resulted in a striking decrease in annual generator air emissions, compared here between 2001 and 2017. Conversely, during the 16-day cold spell of 2017–2018, New England's power system relied heavily on oil generation, and daily carbon dioxide emissions rose to an average of over 220,000 short tons, up from 100,000 short tons per day leading up to the cold snap.

New England Generator Air Emissions, 2001 vs. 2017



The **70 million short tons of carbon dioxide emissions avoided** regionally between 2001 and 2017 is like taking more than **13.5 million passenger vehicles off of the road** for a year. For comparison, in 2016, roughly 5.1 million vehicles were registered in New England.

Source: ISO New England and the US Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator

Tomorrow's resources will be even cleaner

With laws mandating a steep reduction in greenhouse gas emissions, some New England states began offering additional incentives to bring more solar, hydro, and wind power on line over the past few years. More recently, several New England states have established public policies that direct electric power companies to enter into long-term contracts for carbon-free energy that would cover most, if not all, of the resource's costs. Massachusetts for example directed its utilities to sign 20-year contracts committing the state's electricity customers to pay for the development of large-scale offshore wind and hydroelectricity import projects. In all, three of the six states are seeking to develop or retain approximately 5,600 MW of clean energy and storage resources. In addition, the federal Bureau of Ocean Energy Management recently auctioned leases in

States Accelerate Procurement of Renewable Energy

State(s)	State Procurement Initiatives for Large-Scale Clean Energy Resources	Resources Eligible/ Procured	Target MW (nameplate)
MA, CT, RI	2015 Multi-State Clean Energy RFP	Solar, Wind	390 MW
MA	2017 Section 83D Clean Energy RFP	Hydro Import	Approx. 1,200 MW (9,554,000 MWh)
MA, RI	2017 Section 83C Offshore Wind RFP	Offshore Wind	1,600 MW (MA) 400 MW
CT	2018 Renewable Energy RFP	Offshore Wind, Fuel Cells, Anaerobic Digestion	254 MW
CT	2018 Zero-Carbon Resources RFP	Nuclear, Hydro, Class I Renewables Energy Storage	Approx. 1,400 MW (12,000,000 MWh)
RI	2018 Renewable Energy RFP	Solar, Wind, Biomass, Small Hydro, Fuel Cells and other Renewables	400 MW

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

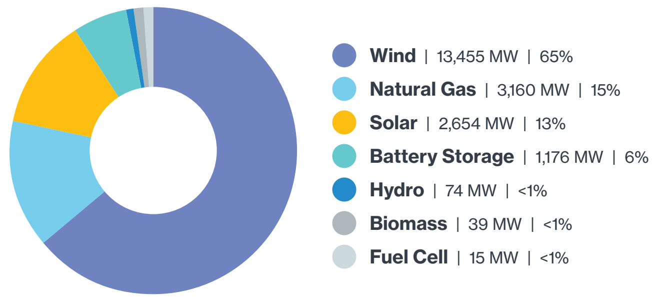
offshore Massachusetts for additional wind development. This public policy trend is expected to grow as legislators seek to accelerate the transition to a clean-energy economy. Developers of renewable resources are taking note, and this interest is reflected in the ISO interconnection queue for new generation.

Wind power dominates new resource proposals

In 2018, the amount of new wind power seeking interconnection in New England was for the first time more than double the amount of natural gas-fired generation proposed—and today, there are four times more wind power proposals than natural gas. Of the roughly 13,500 MW (nameplate) of wind power being proposed regionally (as of January 2019), about 9,500 MW would be offshore of Massachusetts, Rhode Island, and Connecticut, with most of the remaining 4,000 MW located onshore in Maine. Massachusetts utilities have executed contracts (subject to regulatory approval) for 800 MW of offshore wind to be on line by 2023, with plans for an additional 800 MW of offshore wind by 2027. Connecticut and Rhode Island utilities have also negotiated contracts for offshore wind to be on line by 2023.

Currently about 1,400 MW of wind power are installed in New England, producing over 350 GWh of energy during some months.

Proposals by Type



Total: 20,573 MW

Proposals by State

Massachusetts	10,426 MW	Rhode Island	1,366 MW
Maine	4,578 MW	New Hampshire	302 MW
Connecticut	3,682 MW	Vermont	218 MW

Source: ISO Generator Interconnection Queue (January 2019)

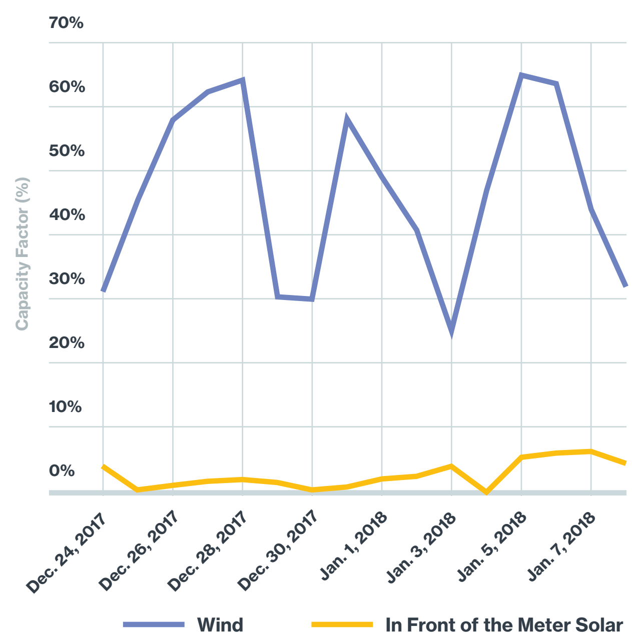
Note: Not all proposed new projects are built; historically, 70% of megawatts have ultimately withdrawn.

Wind output is especially variable in winter

During the 2017–2018 cold spell, ISO system operators observed variable generation from wind turbines, as wind speeds fluctuated throughout the 16-day period. At times, transmission congestion also required curtailments of some wind farms.

Daily Capacity Factor for Intermittent Resources during 2017–2018 Cold Spell

Based on nameplate capacity



Battery storage is "charging" ahead

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, and support from the states. Today, the region has about 20 MW of grid-scale battery storage capacity; currently proposed new projects could add more than 1,300 MW of battery storage capacity by 2022.

Grid-scale and behind-the-meter energy storage can contribute a number of benefits:

- Help grid operators with balancing, frequency control, and contingency response
- Maximize the output from wind and solar resources by storing their excess energy
- Defer transmission and distribution system upgrades when strategically placed in locations with transmission constraints
- Shave the peak during times of high system demand to help utilities and their consumers reduce capacity charges and/or RNS charges
- Provide backup power during storms or other localized power outages
- Enable the development of microgrids, which typically include some combination of local generation and storage

Storage is also a negative-energy resource

Energy-storage resources draw electricity from the power system or directly from a generating resource (such as a co-located solar or wind facility) as they "stockpile" energy, then they add electricity back to the grid when that stored energy is released. Overall, they consume more energy than they provide as operation and inefficiencies consume some electricity. Current battery technologies run for short periods and may not help during tight system conditions that may occur over longer periods like days or weeks. If these resources need to be charged during a system contingency, they would not be able to provide help but would instead sit idle or drain energy needed for grid reliability.

Battery Projects in New England

Connecticut: 2018 Comprehensive Energy Strategy identified energy storage as an approach to help manage peak demand. Allowed energy storage to compete in recent clean energy and grid-modernization RFPs.

Maine: Hosts two, utility-scale battery storage projects.

Massachusetts: Set an energy-storage target of 1,000 MWh to be achieved by December 31, 2025. $20 million in grants awarded to 26 energy-storage demonstration projects across the state.

New Hampshire: Regulators approved a utility battery pilot program, which will deploy up to 200 customer-sited batteries in phase one and up to 800 batteries in phase two.

Rhode Island: 2017 Power Sector Transformation (PST) Report contemplates using energy storage to shave peak demand. Regulators approved utility PST plan that includes two energy-storage demonstration projects.

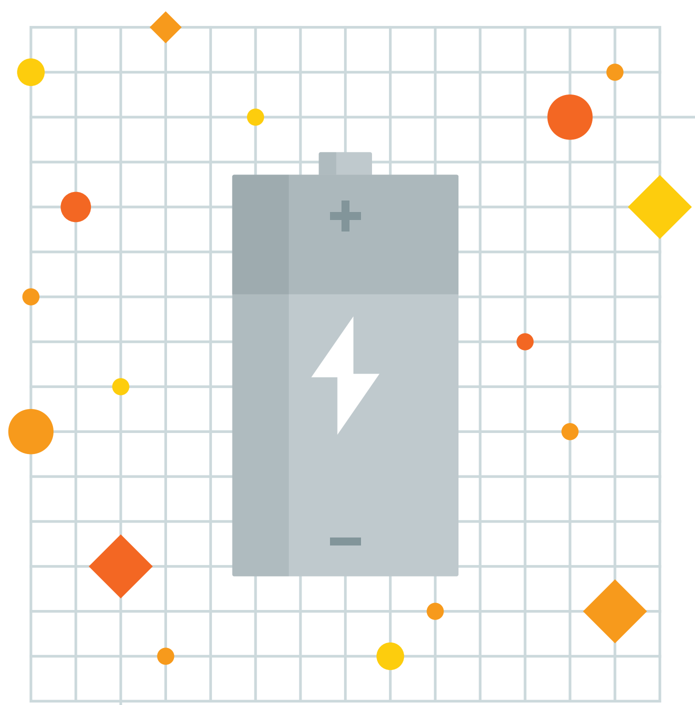
Vermont: Allows its Clean Energy Development Fund to support energy-storage projects. Hosts a utility-scale storage facility.

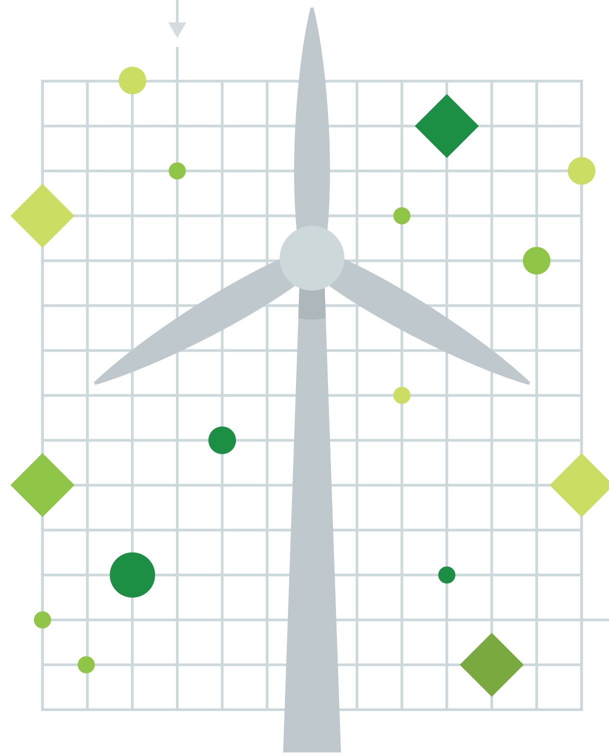
Wholesale markets provide a platform to integrate renewable and distributed resources

Demand-response resources: 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 by shifting the time of their demand (such as changing the operating times of machines, adjusting times of water use, or modifying temperatures), by switching to an on-site generator (distributed generation), or by switching to a storage device such as a battery. After a multiyear development effort, on June 1, 2018, ISO New England became the first US grid operator to price 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. During the first three months, active demand response accounted for 10.4 GWh of reduced system demand.

Battery storage and microgrids: ISO New England continues to remove barriers and expand market access for new energy-storage technologies. Since 2015, the ISO has been preparing for the arrival of *grid-scale* (in-front-of-the-meter) battery storage resources, which have the physical capability to act as generators, demand, or both. The ISO has implemented and planned for a number of market enhancements ahead of federal requirements mandated by FERC Order No. 841 in 2018. In spring 2019, market changes take effect that enable grid-scale batteries and other emerging storage technologies to be dispatched and priced in the Real-Time Energy Market in a manner that more fully recognizes their ability to transition continuously and rapidly between a charging state (as demand) and a discharging state (as generation).

Operational coordination between the wholesale market and *retail-level* distributed resources and microgrids is complex, and it will remain important for all resources that provide wholesale grid reliability services to have the same obligations and performance incentives. For the most part, the ISO will rely on aggregators to integrate small-scale distributed resources into the wholesale market, much as the ISO does with demand-response providers. In fact, the ISO's integration of demand response paved the way for the full integration of storage and microgrids.





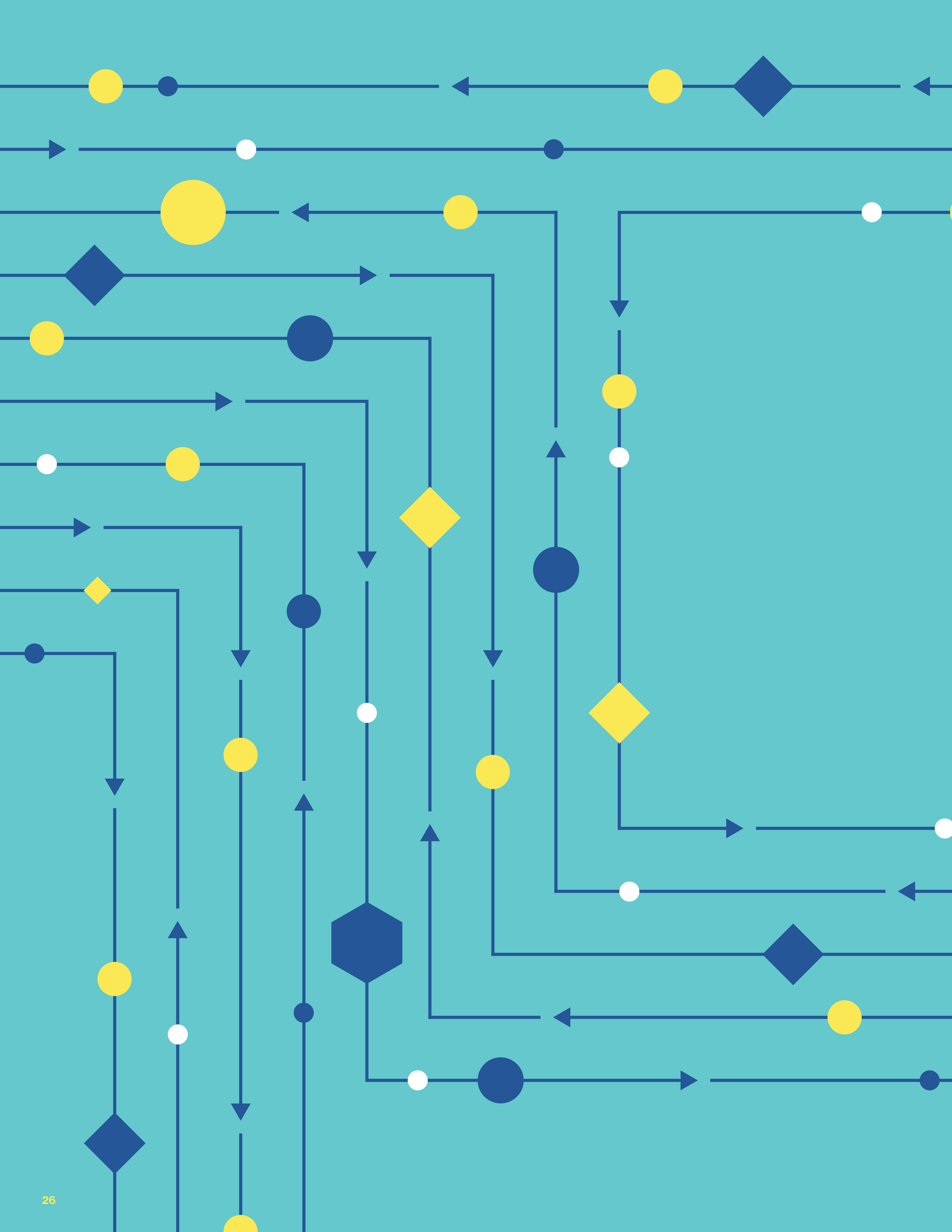
Wind power: For more than a decade, ISO New England has been preparing for the interconnection of large-scale wind resources. Since 2010, the ISO has been studying the potential impacts of integrating large amounts of wind resources into the New England system. And since 2014, the ISO has been implementing market enhancements and operational tools to efficiently manage the grid with an increasing amount of this variable resource. Enhancements include negative pricing, do-not-exceed dispatch, and an advanced wind power forecasting tool, among other improvements.

In 2017, the ISO implemented a new "clustering" methodology that enables interconnection requests from multiple generators and elective transmission upgrades (ETUs) in the same area to be studied together. This is helping to advance the requests in northern and western Maine where thousands of megawatts of proposed new resources, mostly wind, are seeking to interconnect to the regional grid. It may also help generators save on interconnection costs. The first cluster of resources is proceeding through the interconnection study process on the basis of these new rules.

Accommodating publicly-funded resources while maintaining competitive markets: For the ISO's capacity market to function as designed and incentivize competitive resource development in New England, prices need to accurately and transparently reflect the true costs of building and operating resources. However, sponsored resources with contracts that guarantee revenues can bid into the market at below market prices and thereby suppress prices for all other resources. Depressed prices can drive resources with higher costs out of business or discourage the development of the nonsponsored resources and new technologies needed to satisfy New England's electricity needs, balance intermittent renewable generation, and provide grid-stability services.

The ISO has implemented an enhancement to the capacity auction called Competitive Auctions for Sponsored Policy Resources (CASPR) to ensure that the capacity market continues to reflect accurate resource costs. CASPR establishes a competitive market mechanism through which sponsored resources can compete to buy out the capacity supply obligations held by older, higher-emitting generators.

CASPR provides a path into the capacity market for sponsored resources, maintains competitive pricing, and reduces the likelihood of expensive procurement of more power resources than the region needs. By ensuring a level playing field for power resources that don't receive state incentives, CASPR also minimizes the potential for one state's consumers to bear the costs of other states' subsidies. The ISO ran the first substitution auction in Forward Capacity Auction #13 in February 2019, covering the capacity commitment period of June 1, 2022, through May 31, 2023.



Maintaining a Robust Transmission System to Move Clean Energy

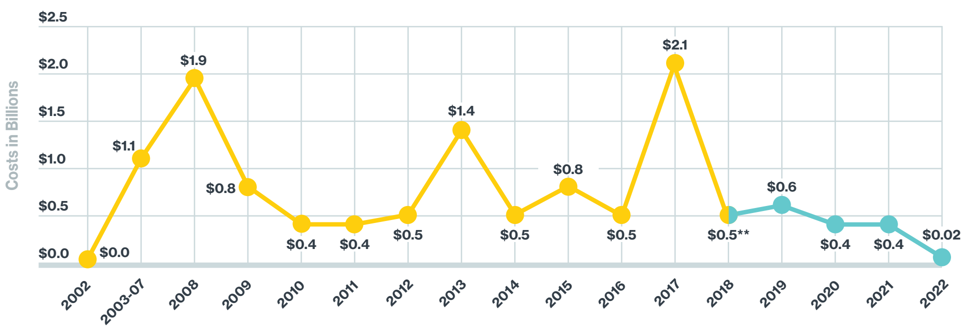
Transmission projects provide benefits beyond reliability: Lower prices and cleaner energy

Before industry restructuring, New England saw little investment in transmission infrastructure. Over the past 20 years, the ISO's continuous study and analysis of the transmission system has helped guide cooperative regional investment to fix weak spots and bottlenecks on the system that greatly improved its economic performance and maintained reliability of service. This investment has also enabled the interconnection of power plants with lower emissions, as well as the more efficient flow of low-cost power across the region.

The regional transmission system includes about 9,000 miles of high-voltage transmission lines and 13 interconnections to electricity systems in New York and Canada.

Today, New England's electricity consumers, who share transmission project costs, benefit from reduced risk of blackouts, lower wholesale energy costs, and less air pollution, all while the grid is being positioned to become greener and more flexible. Because of this investment, fewer projects for reliability purposes are expected going forward; transmission development will largely shift to projects needed to integrate renewable energy being procured by the states.

Transmission Investment in New England to Maintain Reliability



Cumulative Investment through October 2018: $10.7 billion

Estimated Investment November 2018 through 2022: $1.6 billion*

* Estimated future investment includes projects under construction, planned, and proposed. Totals may not add up due to rounding.

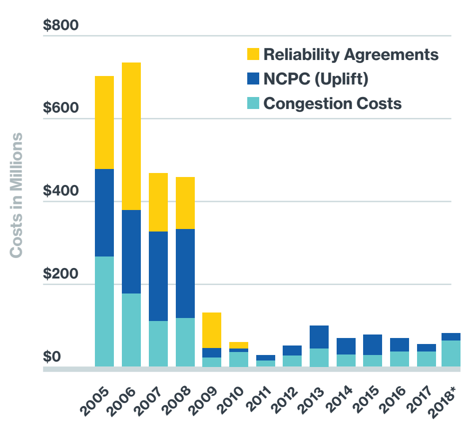
**$0.3 billion was in service through October, and $0.2 billion was estimated for the remainder of 2018, for a total of $0.5 billion for the year.

Source: ISO New England, *RSP Transmission Project List* (October 2018)

Helping lower costs for congestion, uplift, and reliability agreements

Transmission system upgrades have contributed to striking decreases in congestion costs in the New England energy market and have, with the aid of low natural gas prices and other factors, helped drive down and mitigate "uplift" payments to run specific generators to meet local reliability needs. Additionally, since 2010, the ISO has not had to rely on special reliability contracts with older, less efficient generating resources in weak areas of the transmission system. (These costs are included in the market values shown on page 20.)

Costs for Congestion, Uplift, and Reliability Agreements

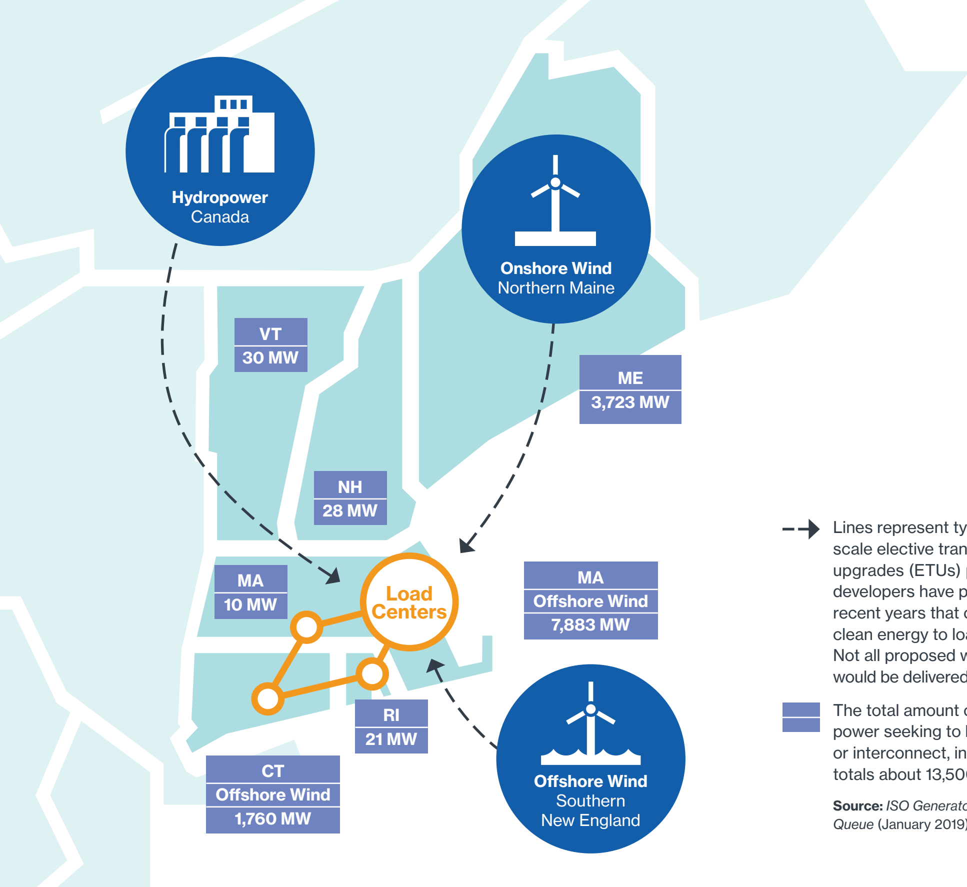


Note: Reliability agreements have not been used in the region since 2010.

NPCP is Net Commitment-Period Compensation

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.

Source: *Regional System Plans, Annual Markets Reports*

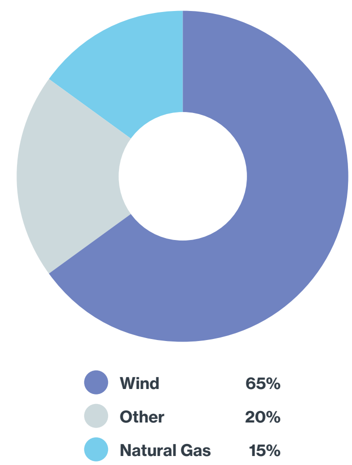


Lines represent types of large-scale elective transmission upgrades (ETUs) private developers have proposed in recent years that could deliver clean energy to load centers. Not all proposed wind projects would be delivered through ETUs.

The total amount of wind power seeking to be built, or interconnect, in the states totals about 13,500 MW.

Source: *ISO Generator Interconnection Queue* (January 2019)

Wind Generation Comprises Two-Thirds of New Resource Proposals



Positioning for a hybrid grid: More wind and hydro power means more wires

Investments in the regional transmission grid will facilitate the states' policy directives for renewable energy and enable the transportation and heating sectors to be powered by low-carbon electricity. Because of the long distances from some of the proposed onshore wind power projects to the existing grid, major transmission system upgrades will be needed to deliver more of this power from these remote, weaker areas of the system to far-away consumers. Proposed offshore wind projects closer to New England load centers may require fewer upgrades to the existing grid, but building wind turbines offshore is typically more costly than placing them on land.

In 2015, the ISO improved its interconnection study process for *elective* transmission upgrades (i.e. not reliability-driven upgrades) and introduced new rules that ensure that renewable resources are able to deliver capacity and energy into the wholesale electricity markets. Today, private developers are competing in state procurements to build transmission projects that would enable the delivery of thousands of megawatts of clean energy, mostly from wind resources in northern Maine and hydro resources in Canada (Not all proposed wind projects in New England would be delivered through ETUs). As of January 2019, more than 15 ETUs were proposed to be built over the next four to eight years. State procurement programs will be major deciders of which projects will move forward. Coordination of energy policy among multiple states is challenging, particularly when infrastructure needs to be built across multiple states.

Boston area transmission needs assessment

In 2019, the ISO will assess the transmission system in the Boston area with the anticipated retirement of the Mystic Generating Station. This study, which will identify any needs and the time-sensitivity of those needs, is the first step in the process to ensure that this area continues meets applicable national and regional reliability criteria. The siting and construction of transmission in Boston is likely to be challenging, and hence the overall project schedule will be an area of focus for both the ISO and potential developers.

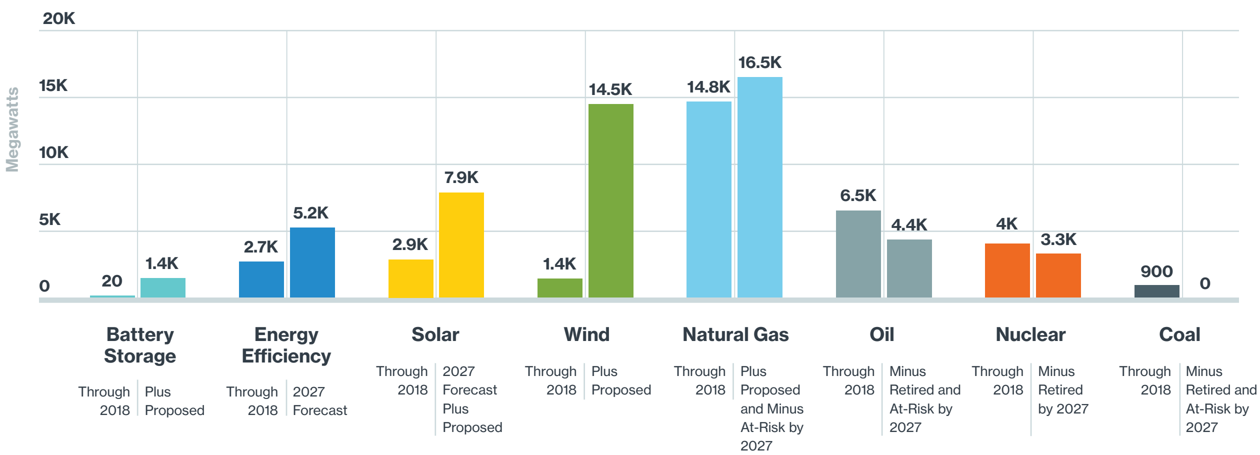
Ensuring Energy Security as Grid Resources Change

Energy security is an energy supply problem, not a capacity shortfall problem

The dependable performance of New England's fleet of generators is the cornerstone of a reliable supply of electricity, and this performance hinges on their access and willingness to procure fuel. The transition to a hybrid grid is changing the makeup of New England's power system where nearly all resources will have *limited fuel/energy inventories* (oil, pumped-storage hydro, batteries), will *use just-in time fuel* from limited sources (natural gas via pipeline or liquefied natural gas storage injections), *or will not have control of their "fuel"* (wind, solar).

New England has adequate capacity resources to meet projected demand. However, as more limited-energy resources are developed and traditional generating resources retire, the grid may not be able to supply enough energy to meet electricity demand. The ISO first identified this issue as a wintertime fuel-security problem, but the broader issue of year-round energy security will need to be addressed as the operational dynamics of the hybrid grid take hold.

Projected Changes in Key New England Power Resources and Energy Efficiency

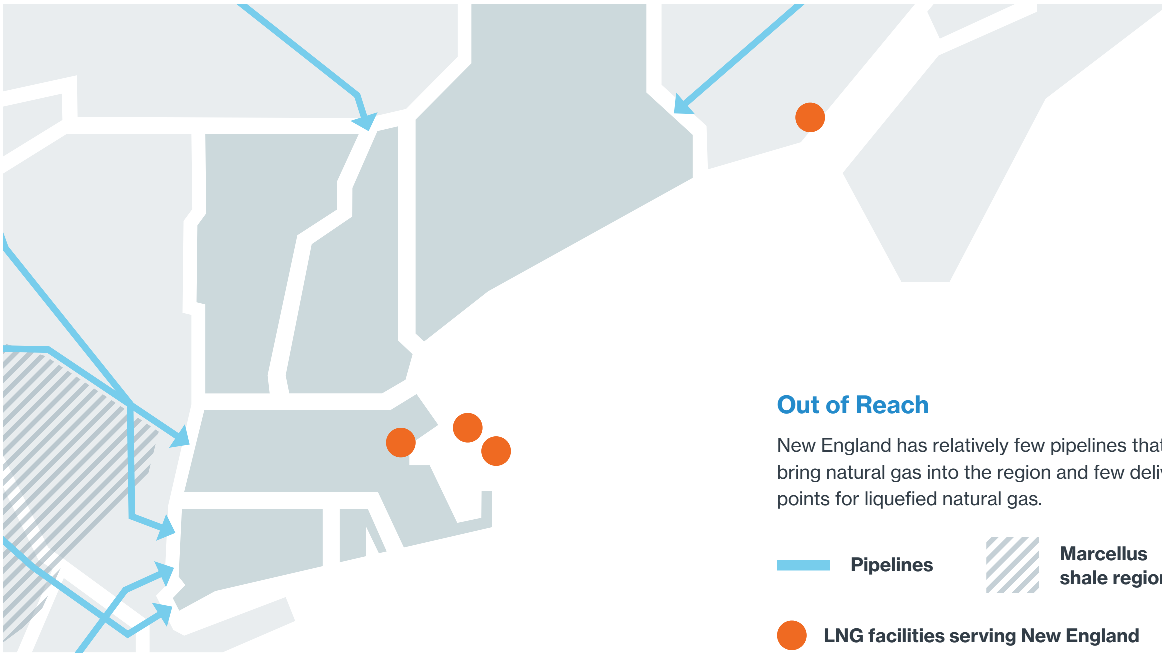


See chart footnotes and source information at www.iso-ne.com/resource-mix.

Fuel delivery challenges and emissions restrictions

New England has few natural gas pipeline and liquefied natural gas (LNG) delivery points, and gas infrastructure has expanded only incrementally even as reliance on this fuel for both power generation and heating continues to grow. With limited options for storing natural gas, most natural-gas-fired plants rely on just-in-time fuel delivery, which helps them keep their costs as low as possible during most of the year. However, during extremely cold weather, most gas pipeline capacity is committed to home heating and other customers of the gas utilities—thus fuel available to natural-gas-fired power plants can be constrained.

The use of LNG can help fill the gap, but regional LNG storage is limited, and the timely arrival of LNG cargoes to replenish depleting supplies—all of which is from foreign sources due to the Jones Act—varies based on contractual commitments, global market prices, and other logistical challenges, such as severe weather conditions.



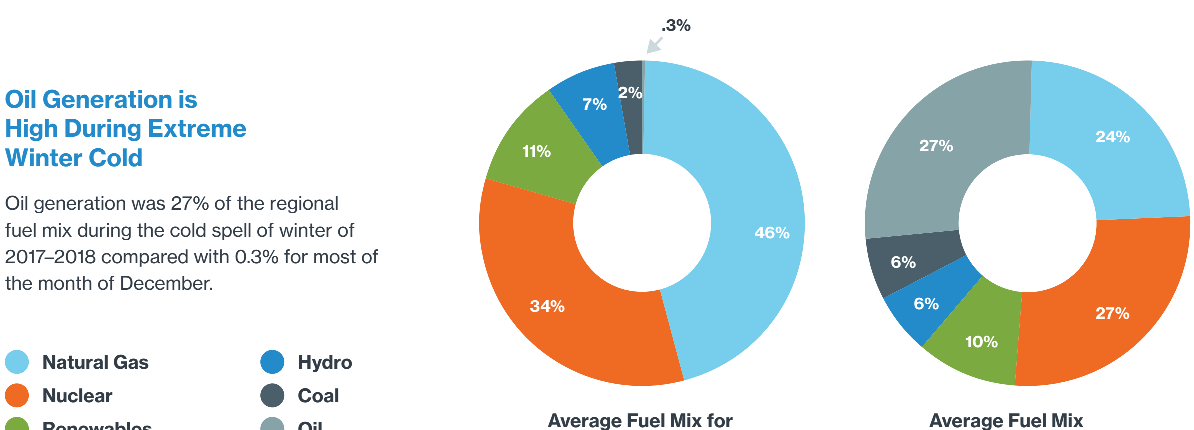
Out of Reach

New England has relatively few pipelines that can bring natural gas into the region and few delivery points for liquefied natural gas.

Oil-fired plants, which typically don't run often, become critical on cold winter days when the fuel for natural-gas-fired generators is limited and expensive. But during cold weather, oil and dual-fuel (natural gas/oil) plants can rapidly deplete their on-site oil supply or reach environmental limits on their run times. Extreme cold weather creates a number of obstacles to restocking oil supplies, as was illustrated during the winter 2017–2018 cold spell: severe maritime weather and sea and river ice hampered resupply by oil barges, Winter Storm Grayson delayed oil trucks, and truck drivers quickly reached driving time limits—which had to be lifted by emergency governmental actions. With extended days of burning oil, several resources either had concerns about hitting federal and state emissions limitations or were impacted by emissions limitations. Over two cold weeks in winter 2017–2018, New England power providers used 2 million barrels of oil—twice the average yearly amount.

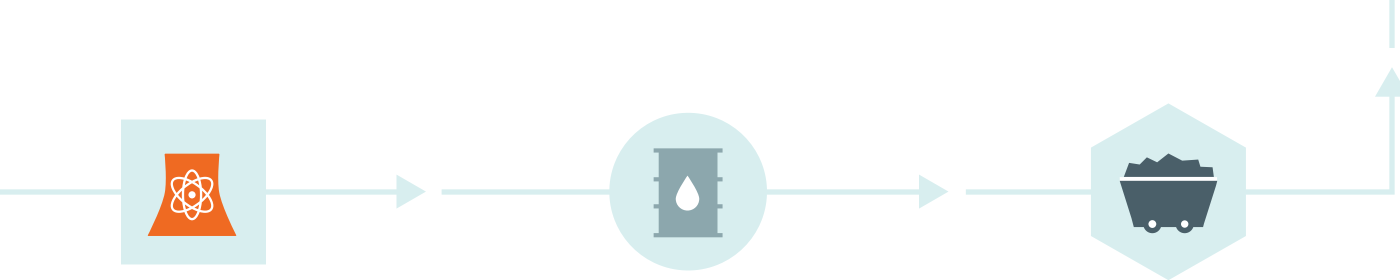
Oil Generation is High During Extreme Winter Cold

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.



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

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



Retirement of resources with on-site fuel that can sustain operation during cold weather

With the transition to a limited-energy system, the region is losing traditional generators that have substantial on-site fuels (nuclear, oil, or coal) and can sustain extended operations during cold weather conditions for days and even weeks on end. Without these resources, it becomes even more critical for the ISO to be able to effectively preserve energy supplies for forecasted cold weather conditions.

This issue accelerated in March 2018 when Exelon Corporation announced its intention to retire the Mystic Generating Station in 2022, which is located in the region's largest load center. Most of the Mystic station's generators are fueled solely by the nearby Distrigas LNG import facility, and these generators are the LNG facility's largest customers, creating concern that the LNG facility may retire as well. Though most of the Mystic station is fueled by natural gas, its use of stored LNG instead of pipeline-delivered gas makes it more akin to a coal, oil, or nuclear resource in terms of sustained operations during cold winter weather. The loss of one of New England's few LNG facilities would further constrain regional fuel logistics.

Wholesale market design gap

The wholesale energy markets were designed when most power plants had adequate and secure fuel supplies. The energy markets are run daily, giving ISO system operators the tools to manage energy supplies over the course of the operating day, reliably and at least cost. The markets were not designed to reflect future fuel scarcity conditions, compensate resources for their ability to maintain fuel inventories and resupply arrangements over extended periods, or optimize fuel use for potential contingencies that are many days away. The current markets do not help operators manage the use of limited-energy situations over multiple days or weeks or preserve for forecasted cold weather the limited on-site fuel supplies that remain in the system. In addition, in today's one-day-at-a-time energy market, suppliers provide information on their operating costs for that day only, not their *future* costs, and yet the ISO needs that future cost information to manage the region's limited-energy system cost effectively.

Therefore, during events that last for extended periods, ISO operators must manually optimize energy supplies, out of market, creating price distortions. This gap between the wholesale market design and a limited-energy system leaves the region vulnerable to both higher costs than necessary and serious reliability risks.

Addressing energy security

Through accurate pricing signals, the region's wholesale electricity markets incentivize power suppliers to take actions and make investments to operate efficiently, competitively, and to meet consumer demand at least cost. As the industry continues to evolve toward a limited-energy system, the region must enhance the markets so that they provide the economic incentives for existing resources to procure fuel and make investments to provide a secure energy supply across all system conditions (and keep them from retiring prematurely). Economic incentives must also stimulate the development of new resources and technologies that have the ability to maintain a reserve bank of energy that can be converted into electricity when needed.

The ISO has been working since 2004, and more intensively since 2010, to address generator performance and fuel-security issues. Many successful market and operational changes have been made to boost power plant performance and to improve gas-electric coordination and situational awareness. ISO New England and stakeholders are now specifically focused on improving energy security through several technology-neutral solutions to be put in place over the near-, mid-, and long-term.

Beginning winter 2018/2019

Improved awareness about energy availability so resources can take action

The ISO has begun forecasting and publishing to its website a 21-day energy assessment of New England generators' fuel inventories, emissions limitations, and other factors that could restrict their availability. Resources are informed of actual or anticipated energy-supply deficiencies, giving them advance notice to take action as needed—including scheduling fuel deliveries—to increase their availability and help ensure sufficient supplies.

Recouping cost of preserving fuel for when it's most needed

The ISO has begun providing generators with an opportunity cost amount that they can incorporate into their next-day energy-market offers. The opportunity cost reflects the estimated cost of preserving fuel when energy supplies are limited. Incorporating this opportunity cost into a generator's energy-supply offer reduces the likelihood that a generator with limited fuel will be dispatched and consume that fuel prematurely. This market enhancement thus provides an incentive for resources to preserve fuel for later periods, when it would have greater market value and greater benefit to system reliability.

Providing revenue to help motivate power plants to prepare to perform during periods of system stress

In the Forward Capacity Market, two components determine the payment each capacity resource receives. The first is a base capacity payment set in the annual Forward Capacity Auction. The second is a new performance payment that either rewards or penalizes the capacity resource based on the energy or the reserves it supplies during periods of system stress. Resources that don't perform to their obligations forfeit a portion of their capacity payments to resources that perform above their obligations. This system, known as pay for performance (PFP), took effect June 1, 2018, and winter 2018/2019 is the first under these performance-based capacity market rules.

Although PFP provides an efficient market mechanism to boost performance, it may not address all aspects of the region's energy-security challenges that emerged after PFP was developed. PFP's scarcity pricing provides a strong real-time signal for resources to prepare for tight operating conditions and to perform when the system is in an "at-risk" situation, but it is not a forecasting tool—it does not signal that risk in advance. Given that the region's fuel infrastructure can become tightly constrained and fuel logistics complex during harsh winter conditions, resource owners need advance notice of energy constraints so that they have time to make fuel delivery or other preparations. This will become more critical as fuel constraints continue to tighten with resource retirements and progressively stricter emission limitations on the power industry.

For winters 2022/2023, 2023/2024, and 2024/2025

Temporary, performance-based financial measures to help prevent resources with stored energy from retiring prematurely

ISO New England has been given federal approval to retain resources seeking retirement on the basis of a fuel-security reliability need. Mystic Generation Station's two gas-fired units, #8 and #9, will be retained under these new provisions for the 2022/2023 capacity commitment period and potentially for the 2023/2024 period (after additional studies in 2019). Other resources seeking to retire will be evaluated under these new provisions to determine whether a fuel-security reliability need exists. The ISO's ability to retain resources for fuel security will expire after the 2024/2025 period.

The ISO is also developing a *Seasonal Interim Settlement Mechanism* to be in place for the winters of 2023/2024 and 2024/2025. This mechanism provides revenues to resources with inventoried energy that contribute to reliable operations during tight winter conditions, which should reduce the potential for these resources to retire prematurely for uneconomic reasons. The ISO will file the proposal with FERC in March 2019 so that changes can take effect in time for the 2020 Forward Capacity Auction.

By winter 2025/26 and beyond

Market-based approach to optimize use of limited energy over extended periods and at least cost

Because New England's energy-security issues are fundamentally an energy-supply problem, not a generation capacity shortfall problem, the ISO is proposing a set of three interrelated changes to the energy markets:

1. Change the current Day-Ahead Energy Market to a **multi-day-ahead market** that procures resources over a rolling, multi-day-ahead horizon. By looking multiple days into the future, the new market will provide a forward price signal for resources to replenish fuel inventories when prospective supplies are tight and to avoid prematurely depleting limited energy.
2. Introduce a **new ancillary service** integrated into the multi-day-ahead market that would provide a price signal for technologies capable of maintaining a "buffer stock" of replacement energy that can be used on demand and compensates for the cost of ensuring that these replacement energy options are available when needed.
3. The ISO is also studying the benefits of a **new voluntary auction ahead of the winter** to procure replacement energy commitments, which would provide an incentive for resources to arrange firm energy-inventory logistics and a means to recover the costs of doing so.

New England is the first in the nation to bring forward a market design that will directly compensate energy-security attributes through markets. The changes maintain core principles of competition and a familiar framework for resources. The ISO is adhering to three central market design objectives:

- **Risk Reduction.** Minimize the heightened risk of unserved electricity demand during New England's cold winter conditions and other stressed situations , as the regional resource mix transforms into an increasingly limited-energy hybrid grid.
- **Cost Effectiveness.** Efficiently use the region's existing assets and infrastructure to achieve this risk reduction in the most cost-effective way possible.
- **Innovation.** Provide clear incentives for new resources and innovative technologies that can reduce this risk effectively over the long-term.

Designing and implementing long-term winter energy-security improvements will be a large, complex, multiyear project. The design will continue to evolve throughout 2019 as the ISO develops the rules, launches a formal quantitative and qualitative analysis on its proposal, and reviews it with stakeholders. It will take another four to five years to implement market administration processes, develop new software and IT infrastructure, and address computational implications associated with a multi-day- ahead market.

Action is also required by industry and policymakers

Once the energy-security revisions are implemented, New England's markets will value and better secure a reliable supply of energy during constrained periods. Yet these are just a stimulus to resolve the long-term causes of the region's energy-supply constraints. It will be up to market participants and state representatives to take actions to bolster the infrastructure that helps energy security. This includes investments in and supporting more LNG storage and battery storage; adding dual-fuel capability; further investments in efficiency, distributed generation, and reliable sources of renewable energy; and transmission infrastructure to move clean energy. Opposition to infrastructure, coupled with the rapid transformation of the energy-resource mix, will only exacerbate the region's energy-security constraints.

ISO Metrics

Measuring ISO New England's performance, accountability, and transparency

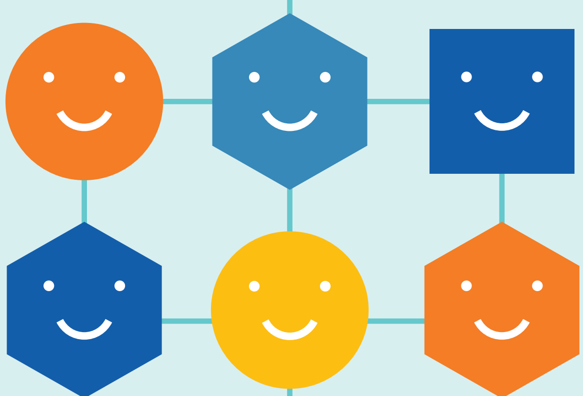
Accountability and Transparency

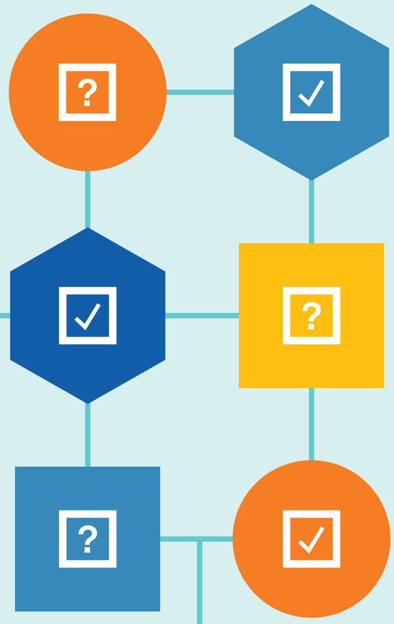
$0.98 per Month

The services and benefits the ISO provides to keep competitively priced power flowing will cost the average New England residential electricity consumer $0.98 per month in 2019, based on 750 kilowatt-hours per month usage. The ISO's 2019 operating budget is $198 million, a 1.5% increase over 2018; the 2019 revenue requirement filed reflects a decrease of 3.5%, as a result of previous years' underspend. Two major drivers of increase are cybersecurity and a mandatory update of the ISO's Energy Management System. The budget is the result of a robust stakeholder discussion to set priorities and is FERC-approved. Full financial statements are available at www.iso-ne.com/about.

95% Satisfaction

The latest survey of market participants (2018) revealed high overall satisfaction levels with the information and services the ISO provides. Positive satisfaction among respondents with an opinion was 95%. Responses help the ISO identify and prioritize improvements in system operations, market administration, the website, and other information products.





8,500 Issues Resolved

The ISO has a strong culture of responsiveness and outreach to keep market participants and other stakeholders well informed. In 2018:

- ISO Customer Support resolved over 8,500 issues submitted via phone call, email, and Ask ISO self-service.
- We held classroom or web-conference trainings for over 900 stakeholders and made over 66 elearning modules and 183 presentations available on the ISO website for stakeholders.
- Our extensive website was accessed over 1.2 million times by more than 355,000 unique visitors.
- ISO senior management, subject matter experts, and other staff met well over 500 requests from stakeholders and the media for presentations, panel discussions, technical answers, and interviews.

65+ Stakeholder Meetings

The ISO's stakeholders are a wide-ranging group, from **market participants** to **regulators** to **policymakers** to **environmental advocates** and **retail consumers.** Their diverse perspectives help inform discussion and generate solutions to regional challenges. Stakeholders are an integral part of the ISO's budget processes, regional system planning, market development, and ISO board nominations. They also interact regularly with ISO staff and participate in committees and working groups. In 2018, the ISO coordinated or participated in 65 meetings of the Markets, Reliability, Transmission, and Participants Committees and the Planning Advisory Committee (PAC). The Consumer Liaison Group (CLG) also met quarterly to share information about the power system and wholesale electricity markets' impacts on consumers. The PAC and CLG are open to the public, while the rules governing the New England Power Pool, the association of regional market participants, determines attendance for the other committees.

2018 Improvements for a Better Stakeholder Experience

New cloud-based Ask ISO tool

The ISO upgraded Ask ISO, its customer-issue management platform, to provide a more streamlined, user-friendly experience. It will help the ISO effectively and expeditiously to handle customer queries and can be operated from multiple locations simultaneously, thereby helping ensure that ISO Customer Support can quickly recover operations in the event of a disruptive emergency.

Flexibility added to Enhanced Energy Scheduling (EES) application

In response to market participant feedback, the ISO improved the functionality of its Enhanced Energy Scheduling (EES) application, which is used to submit external transactions in the energy markets. Market participants are now able to submit day-ahead external transactions with prices that vary by hour, consistent with the functionality available for the Real-Time Energy Market.

Revamped mobile app

The ISO launched ISO to Go 2.0, introducing a variety of features, such as customizable push notifications on grid conditions and pricing thresholds. Equipped with past, present, and future details about the regional power grid, its energy resources, and wholesale electricity prices, ISO to Go 2.0 provides all the facts and figures necessary for keeping up with New England's ever-changing power grid.

Successful 2018 Audits

Energy industry audits are always intensive and usually include site visits; interviews; reviews of vast amounts of data and documentation; and evaluation of processes, procedures, systems, and controls. In 2018, ISO New England successfully met compliance with four audits:

- **NERC CIP Compliance** audit measured cyber and physical compliance with NERC CIP Version 5, with the ISO receiving only five minor recommendations and positive observations on the ISO's strong culture of compliance, including its breadth of knowledge, thoroughness, and responsiveness.
- **FERC Division of Audits and Accounting** audit evaluated compliance over a four-year period with the ISO *Open Access Transmission Tariff*; FERC Order No. 1000, which established new electric transmission planning and cost allocation requirements; and FERC's accounting, reporting, and record-retention requirements.
- **Service Organization Controls (SOC) 1 Type 2** audit assessed the controls surrounding the market administration and settlements system for administering the wholesale electricity markets.
- **NERC Operations and Planning Compliance Audit** measured the ISO's compliance with a broad range of NERC standards governing real-time operations and the maintenance of situational awareness, emergency operations, and personnel training. The audit team identified areas of excellence and many positive observations about the ISO's operations and culture of compliance, and offered a couple of suggested recommendations.

Cybersecurity to Protect the Grid and Marketplace

The energy sector faces significant risk of attempted cyberintrusion. This year and for the foreseeable future, the ISO will build on our already extensive system of process controls, advanced detection and response systems, and redundancy in systems and control centers. These help us detect, respond to, and recover from any cyberattacks, as well as to comply with mandatory standards. For example:

- Our 24/7 Security Operations Center provides round-the-clock monitoring of the ISO technology network, and in the past few years we have tightened access to networked services and systems.
- We've tightened security controls for cyberassets and visitors to ISO facilities, in compliance with North American Electric Reliability Corporation (NERC) revised critical infrastructure protection (CIP) cybersecurity standards.
- A CIP and Systems Compliance Operations Group was formed to, among other things, provide day-to-day support of highly complex infrastructure and cybersecurity compliance functions required by NERC CIP Version 5. Compliance requires complex activities to be performed continually, even daily. One of the largest subrequirements requires around 125,000 items to be checked for CIP Version 5 compliance every 35 calendar days. A number of new CIP standards are expected in the coming years.
- FERC Order No. 848 requires NERC to update the CIP standard for cybersecurity incident reporting, which will require the ISO to update practices and procedures associated with cybersecurity event investigations and incident investigation and reporting.
- We participate in NERC GridEx exercises on cybersecurity and physical security and conduct annual training for all ISO employees. In 2017, more than 70 employees participated in GridEx IV, and we will take part in GridEx V in 2019.
- During 2019, we will be developing and implementing a third-party cybersecurity risk- management program that will include compliance with the new CIP standard addressing supply chain cybersecurity risk.
- During 2019–2020, we will be replacing our 14-year-old system for modeling and tracking physical and electronic access to systems and applications. The new Identity and Access Management system will add cloud-service access tracking, privileged access management, automated implementation of accounts, and enhanced reporting to address NERC CIP compliance objectives.
- A prominent corporate objective requires all ISO employees to participate in annual cybersecurity training.

Learn more about what we do at www.iso-ne.com.

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One Sullivan Road
Holyoke, MA 01040

ISO new england

iso-ne.com

iso-ne.com/isotogo

isoexpress.iso-ne.com

isonewswire.com

@isonewengland