ISO new england

ISO New England

2016 Regional Electricity Outlook

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 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.

Our Mission

Reliability is the core of ISO New England's mission, fulfilled by three interconnected and interdependent 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

About This Report

ISO New England's unique role gives it an objective, bird's-eye view of trends that could impact the region's power system. This report provides an update on ISO actions to address grid challenges, as well as other ISO efforts to improve its services and performance. 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 actions to address these issues. Contact ISO New England's Corporate Communications and External Affairs teams at (413) 535-4309 for copies.

Please note: The facts and figures in this report were current at publication in January 2016. However, the ISO is continually generating data and analyses. For the most current information, please visit www.iso-ne.com/reo.

2016 Regional Electricity Outlook

Learn More Online
www.iso-ne.com

From the Board Chair

Philip Shapiro joined the ISO Board in 2010 and was named chair in 2014. He has extensive experience in finance and infrastructure. Read his full bio at www.iso-ne.com/about.

These are exciting times in the electricity industry. Here in New England, we're spearheading the effort to build a bridge between the power system of yesterday and the promise – and complexity – of tomorrow's renewable, smart grid.

Strong cooperation between ISO New England and its stakeholders is helping the region modernize its electricity infrastructure, build a world-class marketplace for wholesale electricity, and develop one of the most efficient power systems in the country. As a testament to that stand the hundreds of formal and informal meetings and discussions held in 2015 between ISO New England and state and federal policymakers and regulators, attorneys general, market participants, electricity consumers, and consumer advocates. That spirit of cooperation will help the ISO ensure a reliable supply of electricity as the region manages both the opportunities and challenges associated with the grid's ongoing evolution. This year's *Regional Electricity Outlook* (REO) highlights related ISO efforts in each of its three areas of responsibility: grid operations, marketplace design and operation, and long-term system planning.

ISO New England has led the regional power system through industry change and innovation while meeting requirements set by the Federal Energy Regulatory Commission. This, along with satisfying the priorities of stakeholders, has increased the volume and complexity of our work. We have undertaken these efforts while seeking efficiency and cost savings wherever possible. However, we have also invested in critical resources. That's why we launched a new ISO cybersecurity control center in late 2015, which will be staffed around the clock for better protection against cyber threats to ISO systems that could affect the operation of the grid or marketplace. It's also why the Board of Directors approved additional employees for the Internal Market Monitor to help safeguard the open, competitive marketplace that has helped attract new investment in the region.

I am confident that together we will successfully keep New England's power system finely tuned to the needs of the region and on the leading edge of industry changes. I thank all regional stakeholders for their contributions and support.

Sincerely,

Philip Shapiro
Board Chair

From the CEO

ISO New England finds itself in the vanguard of a major transformation in how electricity is produced and delivered in the US.

Gordon van Welie has been president and chief executive officer of ISO New England since 2001. Read his full bio at www.iso-ne.com/about.

The region's fleet of power resources is changing: Natural-gas-fired generation has displaced older coal, oil, and nuclear plants. Weather-dependent renewable power resources and energy-efficiency measures are multiplying. On the horizon comes a "hybrid grid" – a combination of large power resources supplying the regional system while smaller ones directly supply consumer sites.

These three waves of change are not unique to New England, but the transformation began early here and is quickening, putting the ISO and its stakeholders at the forefront of nationwide efforts to rethink nearly every aspect of grid operations, markets, and system planning.

Now comprising the majority of New England's generating capacity, natural-gas-fired resources produce more electricity in a year than any other single type of power resource – and only slightly less than all other resource types *combined*. Our region's natural-gas-fired power resources are among the newest, most efficient, and lowest-emitting plants in the country. When their access to low-priced gas from the Marcellus shale is unrestricted, New England has reliable, low-priced electricity.

However, wintertime access to natural gas has grown tight over recent years because the regional fuel transportation network has not kept up with demand from both generation and heating sectors. These natural gas constraints have led to grid reliability challenges, emission increases during winter, and spikes in wholesale electricity prices. The situation is exacerbated by other market dynamics: low gas prices during most of the year except winter are putting economic pressure on coal, oil, and nuclear resources. By 2020, resources representing about 30% of regional capacity have committed to cease operation or are at risk of retirement. Taking their place are even more natural-gas-fired units – currently, more than 60% of new generation being proposed by private investors across the six states will be primarily or exclusively fueled by natural gas.

ISO New England has pioneered a number of tactics for managing the reliability risks associated with the region's growing dependence on natural gas. We've provided more flexibility in energy market offers to better reflect changing fuel costs and shifted market timelines to better align with the natural gas markets. We've developed new tools and processes for our system operators and increased communication with pipeline operators.

Most significantly, we've strengthened the financial incentives for power resources to perform as required. These incentives will drive generators to invest in maintenance and capital improvements and, importantly, to assure that they have fuel to operate when needed. Our analyses and experience to date indicate that gas-fired generators will tend to select the most economic option available to them: installing "dual-fuel" capability, which allows them to switch from gas to oil when the gas pipelines become constrained. Various ISO studies indicate that, ultimately,

improving the natural-gas-delivery infrastructure in New England – through added pipeline capacity, increased supplies of liquefied natural gas (LNG), improved gas storage solutions, or some combination – will have the most impact on addressing the reliability, price volatility, *and* negative emission impacts during winter.

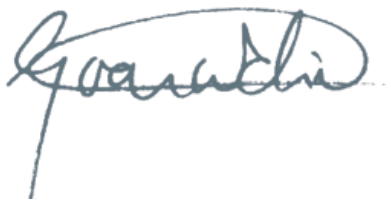
To be sure, alternatives to burning more fossil fuels exist. Energy-efficiency measures and other demand resources are helping New Englanders cut their electricity use, while renewable resources hold potential for serving a sizable portion of regional power needs. The ISO has been evolving its systems and processes to facilitate the expansion of these resources. However, displacing large amounts of gas use with renewable resources will take time and sizeable investments in transmission infrastructure. Connecting and delivering more wind power from northern New England, for example, as well as more hydropower from Canada, will first require the region to cooperate on substantial transmission upgrades. Also, adding more wind- and solar-powered resources in New England will paradoxically increase the region's need for fast-response, flexible resources – which in many cases will be natural-gas-fired generators. Until grid-scale energy-storage technologies become economic and widespread, the region will be calling on natural-gas resources to counter fluctuations in output from renewables. Adequate gas infrastructure is clearly important for ensuring reliability as the region transitions to a renewable power future.

Natural-gas-fired resources and other merchant resources, including carbon-free nuclear and pumped-hydro storage resources are not immune to economic pressures during these waves of change. Renewables have low to no fuel costs and receive policy-based financial incentives outside the ISO markets, enabling them to profitably produce electricity when prices are below their actual operating costs. Therefore, major additions of renewable energy should be expected to further reduce already low annual energy market revenues for traditional generating resources. To remain viable, conventional plants and the new technologies needed to complete the transition to carbon-free electricity production will become more dependent on capacity market revenues. Appropriate price formation in the capacity market becomes essential to maintaining adequate capital investment for all types of competitive resources and to achieving a graceful transition from high- to low-carbon emitting energy resources.

As this report describes, ISO New England has worked to optimize the energy and capacity markets so that together they will continue to attract and sustain the power resources New England needs. But that balance needs to be maintained. Mechanisms such as carbon cap-and-trade programs work relatively seamlessly within a competitive wholesale electricity market framework. Other mechanisms may disrupt price formation in the capacity market and result in inadequate revenues in the marketplace, dampening enthusiasm for private investment. To continue to attract private investment and maintain the resource base needed to ensure reliability, the region must find ways to harmonize the two energy policy objectives of competitive wholesale markets and reduced carbon emissions. This is critical to fulfilling the original goals and benefits of a wholesale marketplace: securing needed reliability services at the most competitive price, incentivizing innovation, and transferring the investment and technology risk from consumers to the marketplace.

The evolution of our power system and wholesale market construct holds tremendous promise. Making that promise a reality is going to take innovation, investment, hard work, and cooperation. I look forward to continued collaboration with state policymakers, our market participants, and other regional stakeholders in managing the waves of change affecting the region today, as well as those that the future is sure to bring.

Sincerely,



Gordon van Welie
President and Chief Executive Officer

“These three waves of change are not unique to New England, but the transformation began early here and is quickening, putting the ISO and its stakeholders at the forefront of nationwide efforts to rethink nearly every aspect of grid operations, markets, and system planning.”

GORDON VAN WELIE

Weathering Waves of Change

Ongoing industry transformation is redefining electricity production – and the very nature of the regional power system.

We're keeping the grid a step ahead.

Three Waves of New Resources

WAVE ONE: NATURAL GAS

The late 1990s ushered in a steady shift to natural-gas-fired generation in New England. These resources are easier to site, cheaper to build, and generally more efficient to operate than oil-fired, coal-fired, and nuclear power plants. About 80% of new capacity built in the region since 1997 runs on natural gas. Gas-fired units remain the top choice for developers, representing more than 60% – about 8,200 megawatts (MW) – of all new generation currently proposed.

WAVE TWO: RENEWABLE ENERGY AND DEMAND RESOURCES

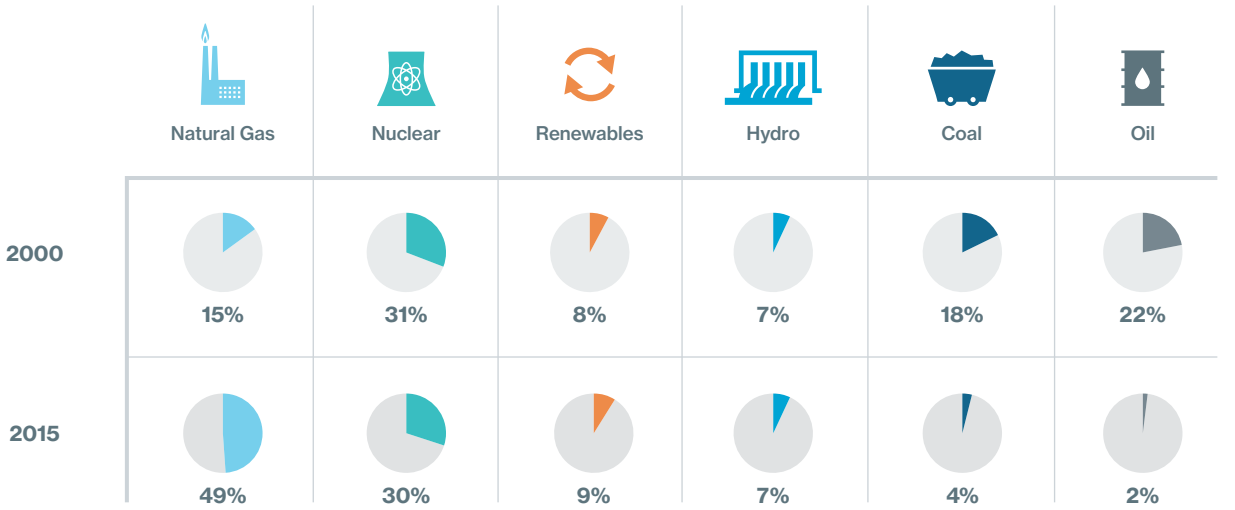
In the 2000s, wind power, solar power, and demand resources began to make up a growing share of New England's resource mix. The region's capacity market includes about 600 MW of active demand response, which relieve grid demand by reducing power consumption in real time, and 1,700 MW of energy-efficiency (EE) measures, which have essentially flattened demand growth over the next decade. Although renewable and demand resources comprise a small share of the power system's total capacity today, over 30% (about 4,200 MW) of all proposed new regional generation is wind-powered, and small-scale solar arrays are multiplying rapidly. While still many years off, renewable resources could in time satisfy a significant portion of New England's electricity needs.

WAVE THREE: DISTRIBUTED GENERATION (DG)

In the next decade or so, New England could have a "hybrid grid." Up to 20% of power resources in New England could be connected directly to retail customers or to local distribution utilities – and not to the transmission system. Widespread residential solar power and storage systems, electric vehicles, and smart meters will change not only how much electricity people draw from the grid, but when they draw it.

Dramatic shift

The mix of fuels used to produce New England's electricity have changed markedly in a relatively short period of time.



Drivers of Change

INNOVATION

New England's highly competitive wholesale electricity marketplace incentivizes the development and adoption of new technologies. These technologies succeed by providing the energy services the region needs in a more efficient way. Advances in many power production technologies – including natural gas, solar, and wind – have been major catalysts to change. Storage technologies are also advancing and will assist in managing the power system as the region's resource mix evolves.

PUBLIC POLICIES AND PROGRAMS

Federal and state efforts to reduce air emissions are the primary impetus behind the expansion of renewable energy and EE programs and are pushing the region toward a hybrid grid. These efforts have included emission limits, the mandated use of green power, and tax credits and incentives for EE measures and renewable resources.

ECONOMICS

Fuel cost is the biggest portion of a power plant's operating cost, particularly for New England's natural-gas-, oil-, and coal-fired generators. However, the region has no indigenous source of fossil fuels. As natural gas production from the Marcellus shale began to boom around 2010, the low cost of this nearby fuel source enabled natural-gas-fired generators to out-compete other generation resources. Other factors affecting regional power resources' profitability and long-term viability include falling technology costs, state-sponsored renewable policies, aging equipment, and investments to ensure environmental compliance.

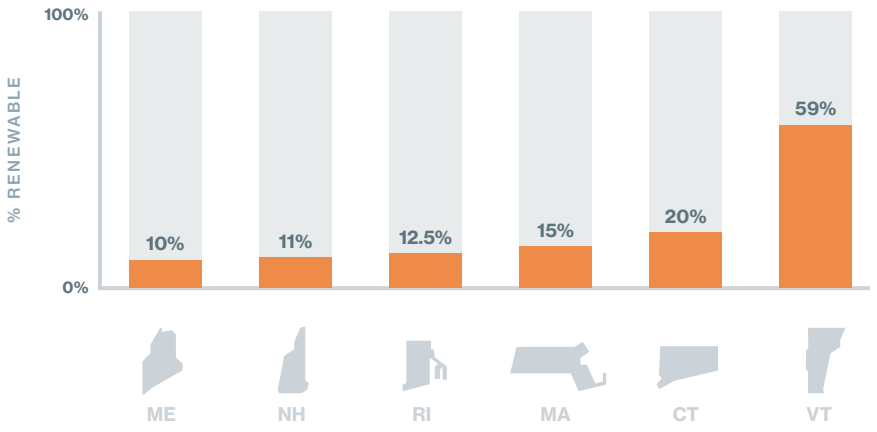
CONSUMER CHOICES

Electricity users are helping to shape the mix of regional power resources through their adoption of EE measures and DG resources.

Ambitious goals

State Renewable Portfolio Standards require electricity providers to serve a minimum percentage of their retail customer load using renewable energy. (Unlike the other New England states, Vermont's Renewable Energy Standard passed in 2015 counts electricity from large-scale hydro toward its total renewable energy requirement.)

State Renewable Portfolio Standards for Class I or New Renewable Energy by 2020



Opportunities

- Natural gas resources and renewables are displacing less economic and higher-emitting resources in New England.
- The ability of many natural-gas-fired plants to change output quickly helps to balance an increasing amount of generation from intermittent power resources that rely on the wind and sun.
- Overall regional air emissions are down significantly. Between 1999 and 2014, nitrogen oxides fell by 66%, sulfur dioxide by 94%, and carbon dioxide by 26%.
- Wholesale electricity prices are being driven down – except when natural gas prices spike.
- Distributed generation may be able to help lessen the impact of local power outages.
- Smart grid technology and retail rate design changes will empower consumers to use electricity more efficiently and reduce their energy bills.

Clear results

State policies, as well as state and federal support and tax credits, are having a clear effect on the growth of renewable resources and energy efficiency in New England.

Wind

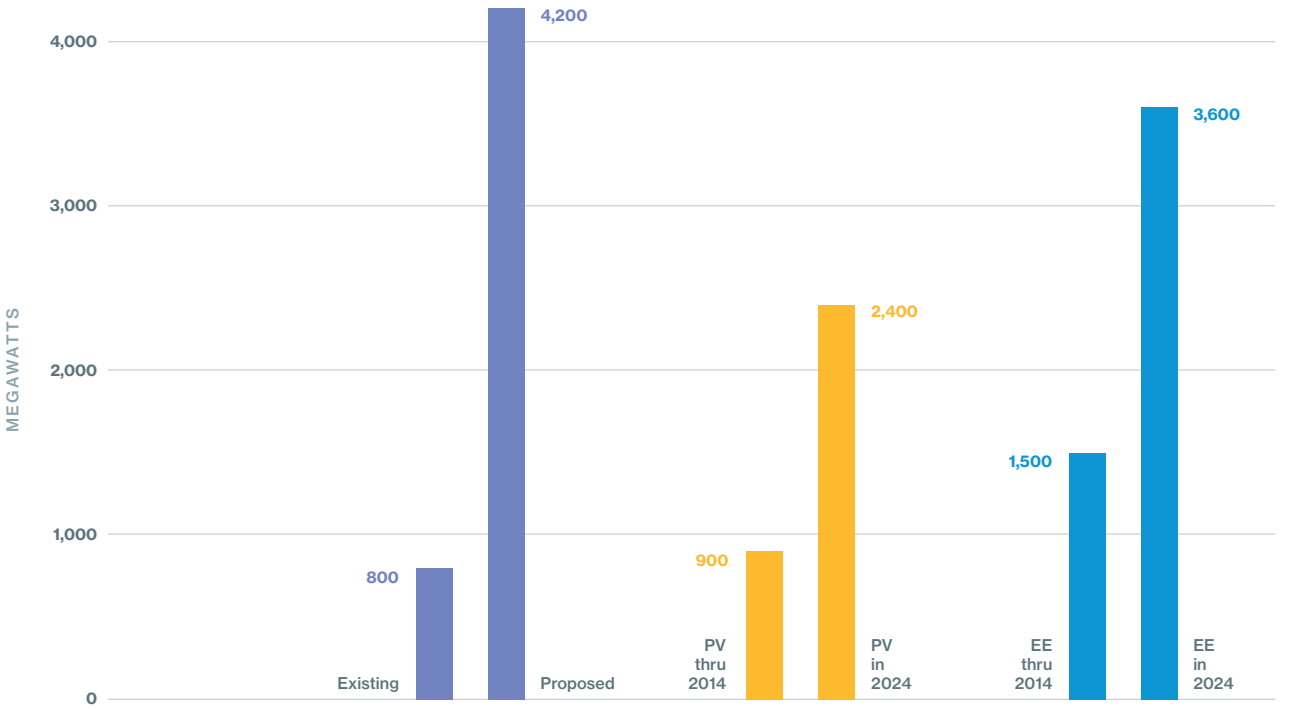
Nameplate capacity of existing wind resources and proposals in the ISO Generator Interconnection Queue.

Solar

2015 ISO-NE Solar PV Forecast, nameplate capacity, based on state policies.

Energy Efficiency

2015 CELT Report, EE through 2014, which includes EE resources participating in the Forward Capacity Market (FCM). EE in 2024 includes an ISO-NE forecast of incremental EE beyond the FCM.



Challenges

- Inadequate natural gas pipeline infrastructure is at times limiting the availability of gas-fired resources or causing them to switch to oil, which is creating reliability concerns and price volatility, and contributing to air emission increases in winter.
- Substantial nongas generating capacity is retiring, limiting the options for reliable grid operation when natural gas infrastructure is constrained.
- The weather-dependent output from wind and solar resources and the increase in DG adds complexity to how the ISO must operate the power system to maintain reliability.
- Expensive transmission infrastructure upgrades are needed to connect more wind and hydro resources.
- Efforts to meet state policy goals to inject more clean energy into the system through long-term contracts may undermine confidence in the markets and inhibit future investment in competitive power resources.

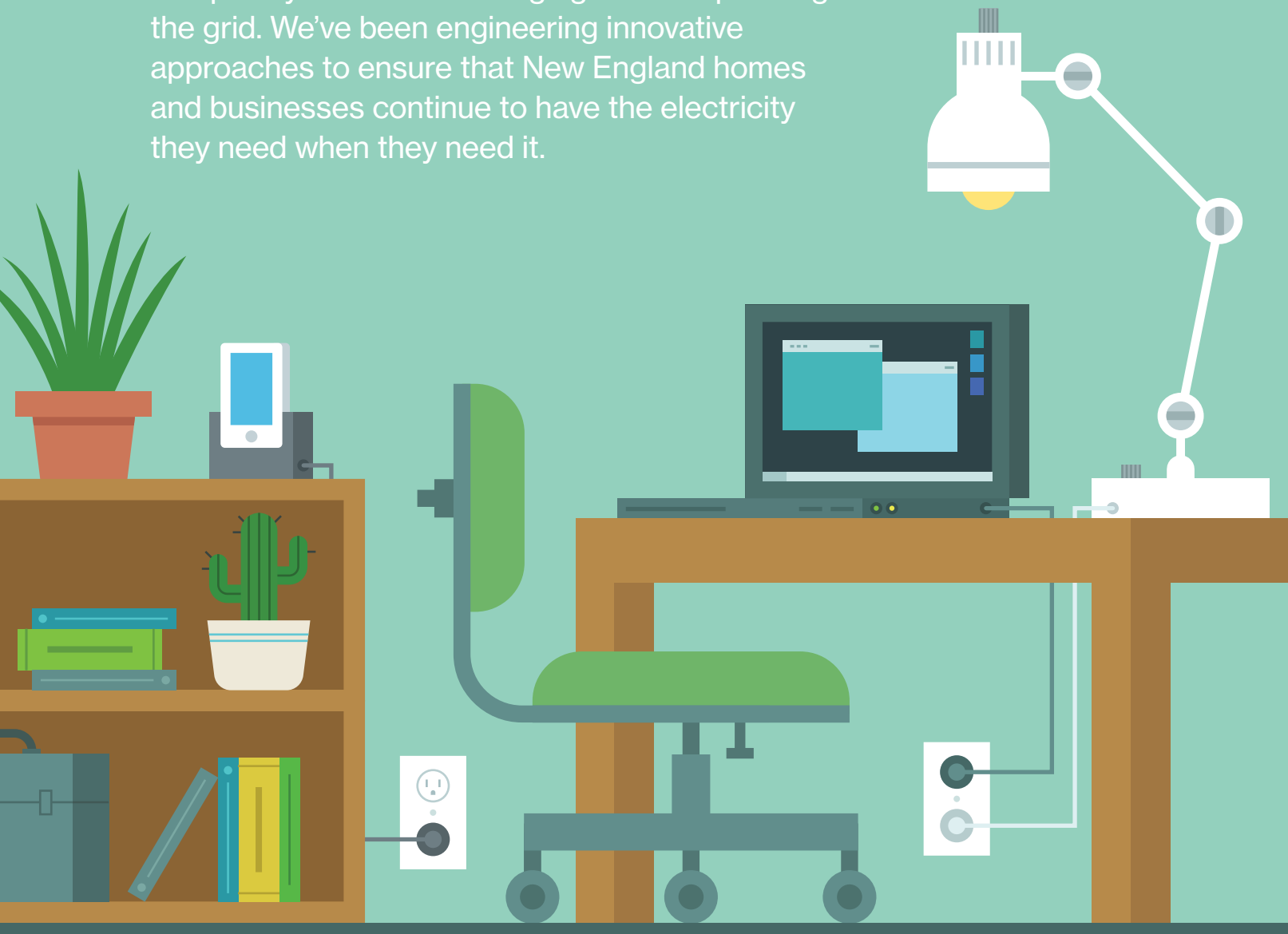
On the way out

More than 4,200 MW of the region's nongas generating capacity has retired or plans to retire soon. This includes several oil- and coal-fired units, as well as two nuclear plants that were part of the region's baseload generation. "At risk" for closing are another 6,000 MW from additional coal- and oil-fired generators, which are displaced from the electric energy market on most days by gas-fired units. But they are still critical for meeting the region's demand in winter, particularly when natural gas supplies are limited. In total, about 30% of the region's generating capacity could be gone by 2020. These retiring resources are likely to be replaced by more natural-gas-fired resources.

With each wave of change, the ISO reviews – and if necessary adapts – grid operations, market rules, and system planning to accommodate new entry in the marketplace while preserving reliability.

Seeking Excellence and Innovation in Grid Operations

The waves of change transforming the region's generation fleet are adding additional layers of complexity onto the challenging task of operating the grid. We've been engineering innovative approaches to ensure that New England homes and businesses continue to have the electricity they need when they need it.



Ensuring Supply and Demand Remain in Balance

A fundamental part of the ISO's job is to keep the energy that power resources supply to the grid in near-perfect balance with consumers' energy demand. Imbalances can happen, however – sometimes, with serious consequences for system reliability, as well as added wholesale electricity costs, unless ISO system operators take quick, corrective action. In 2015, ISO New England:

- Experienced zero violations of the power balance control standards set by the North American Electric Reliability Corporation (NERC), despite challenging operational conditions
- Accurately forecasted hourly regional load an average of over 98% of the time
- Used our time-tested Operating Procedure No. 4, *Action During a Capacity Deficiency*, to quickly return the power system to normal status after a sudden transmission outage blocked 500 MW of electricity from flowing into the region
- Coordinated close to 12,000 transmission and generator outage applications to maintain reliability and minimize the network congestion that adds to the price of wholesale electricity

Leveraging State-of-the-Art Technology for New England

The ISO is pioneering the use of cloud computing to save time and money when creating large-scale power system simulations to satisfy new NERC requirements. In early results, the ISO was able to reduce computing time for one class of reliability studies from eight hours to within 30 minutes.

We're also exploring how cloud computing can improve our use of the "high-resolution" data being generated by the region's new phasor measurement units (PMUs). The PMUs were installed in 2013 as part of a major smart grid initiative in collaboration with regional transmission owners and with a grant from the US Department of Energy. PMUs measure key elements of power system dynamics at 30 times per second. The ISO wrapped up a two-year observation phase of the project in June 2015 and has already used the data to detect – and work with a power resource to correct – potentially dangerous abnormal power system oscillations.

Learn more about the innovations we're pursuing to help facilitate grid modernization.

www.iso-ne.com/smart-grid

Inadequate Natural Gas Infrastructure Creates Tight Operating Conditions and Reliability Risks

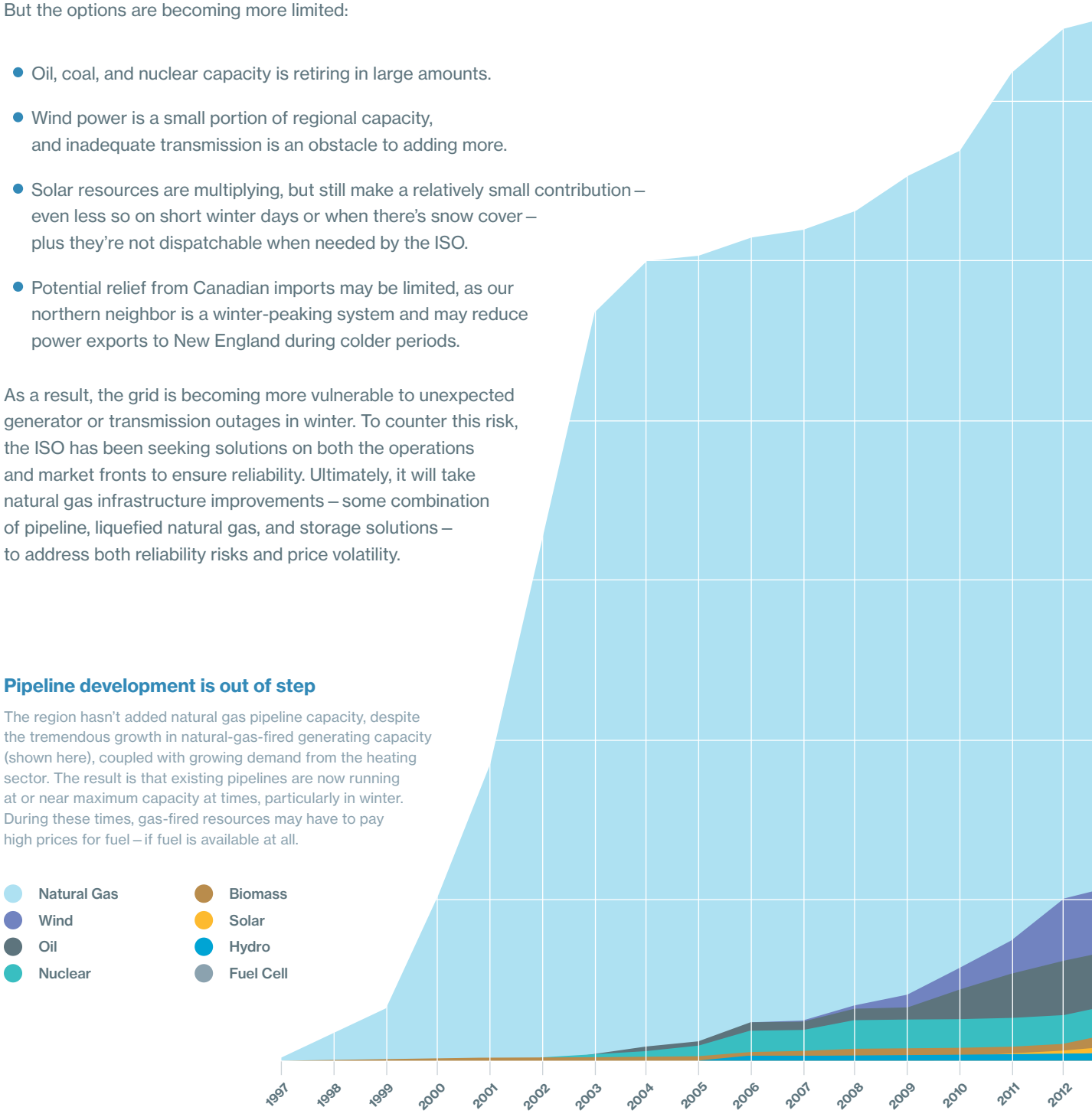
Satisfying consumer electricity demand has become more challenging as New England's supply of natural gas has tightened. Almost half the region's generating capacity now runs on natural gas – and this amount is growing. When natural-gas-fired resources can't get fuel or high fuel costs make them too expensive to run, ISO system operators must call on nongas power resources, which are often higher-emitting. But the options are becoming more limited:

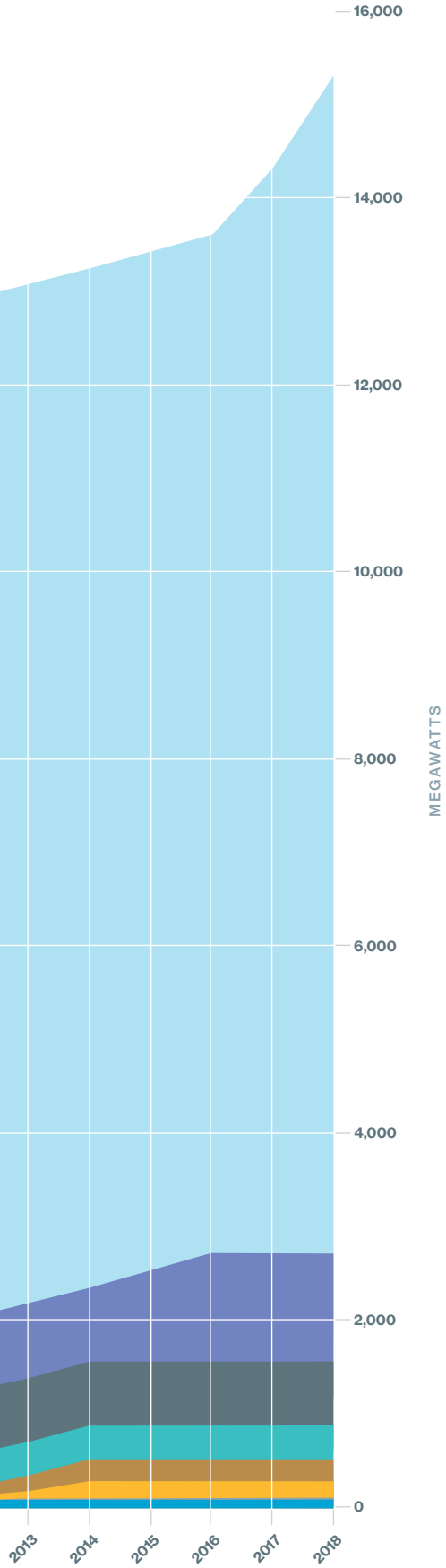
- Oil, coal, and nuclear capacity is retiring in large amounts.
- Wind power is a small portion of regional capacity, and inadequate transmission is an obstacle to adding more.
- Solar resources are multiplying, but still make a relatively small contribution – even less so on short winter days or when there's snow cover – plus they're not dispatchable when needed by the ISO.
- Potential relief from Canadian imports may be limited, as our northern neighbor is a winter-peaking system and may reduce power exports to New England during colder periods.

As a result, the grid is becoming more vulnerable to unexpected generator or transmission outages in winter. To counter this risk, the ISO has been seeking solutions on both the operations and market fronts to ensure reliability. Ultimately, it will take natural gas infrastructure improvements – some combination of pipeline, liquefied natural gas, and storage solutions – to address both reliability risks and price volatility.

Pipeline development is out of step

The region hasn't added natural gas pipeline capacity, despite the tremendous growth in natural-gas-fired generating capacity (shown here), coupled with growing demand from the heating sector. The result is that existing pipelines are now running at or near maximum capacity at times, particularly in winter. During these times, gas-fired resources may have to pay high prices for fuel – if fuel is available at all.

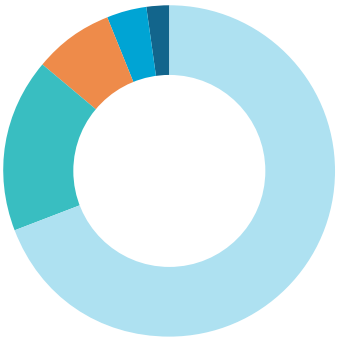




Nongas power resources are critical during winter

On days when natural-gas-fired generators have unconstrained access to low-cost Marcellus shale gas, they often produce the majority of New England's electricity. This is in stark comparison to winter, when heating needs claim most of the regional natural gas supply and the region must rely on its nongas resources, such as oil- and coal-fired plants. At the same time, the region's oil- and coal-fired plants – resources that operate infrequently, mainly to help meet peak demand and when gas-fired units can't get fuel or natural gas prices spike – are getting older. Their age and lack of regular run time can sometimes lead to operating problems.

SYSTEM FUEL MIX



	October 21, 2015 11:30 AM	February 25, 2015 12:21 PM
Natural Gas	**70%**	**24%**
Nuclear	17%	30%
Renewables	8%	8%
Hydro	4%	4%
Coal	**2%**	**11%**
Oil	**0%**	**22%**

Improving Short-Term Fuel Adequacy with Winter Reliability Programs

Since 2013, we've rolled out short-term programs that incentivize regional generation owners to boost winter fuel inventories. These programs, developed in collaboration with stakeholders, have been critical for keeping the lights on during the recent cold winters – particularly when the region's natural gas pipelines were operating at their maximum capacity and the power system had to rely on more expensive, oil-fueled generating units.

Managing Fuel-Adequacy Challenges

To manage the reliability risks related to inadequate fuel supplies, the ISO has taken on the additional work of confirming fuel availability for natural-gas-fired units scheduled to run – as well as the fuel inventory for oil-fired units that can serve as substitutes – and adjusting operating plans, as necessary. We do this through:

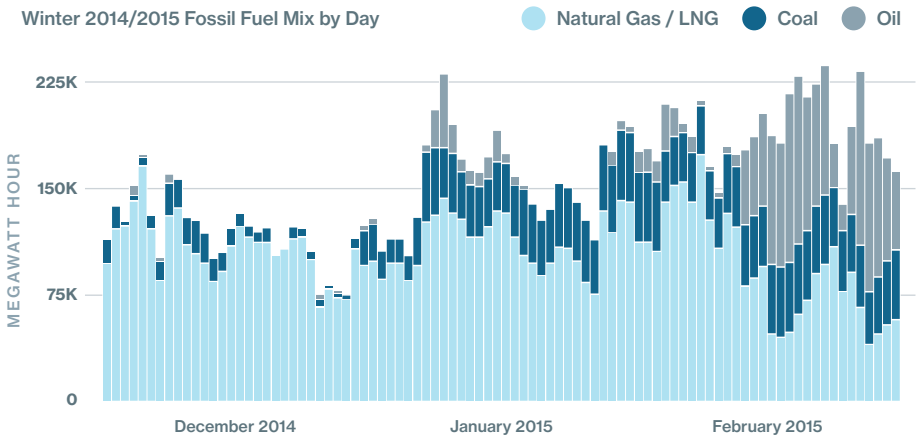
- Regular surveys of generator fuel supplies
- Frequent communications with gas pipelines, which share information that could affect fuel delivery
- New decision-support tools for system operators, such as the Gas Usage Tool, which can calculate, by pipeline or delivery point, the estimated amount of natural gas and LNG available to the region's gas-fired generators
- Routine reviews of fuel purchases by generators scheduled to operate on natural gas

The ISO also holds winter preparedness seminars for power resource operators and stakeholders and has regular conference calls with neighboring grid operators to confirm scheduled exchanges of energy.

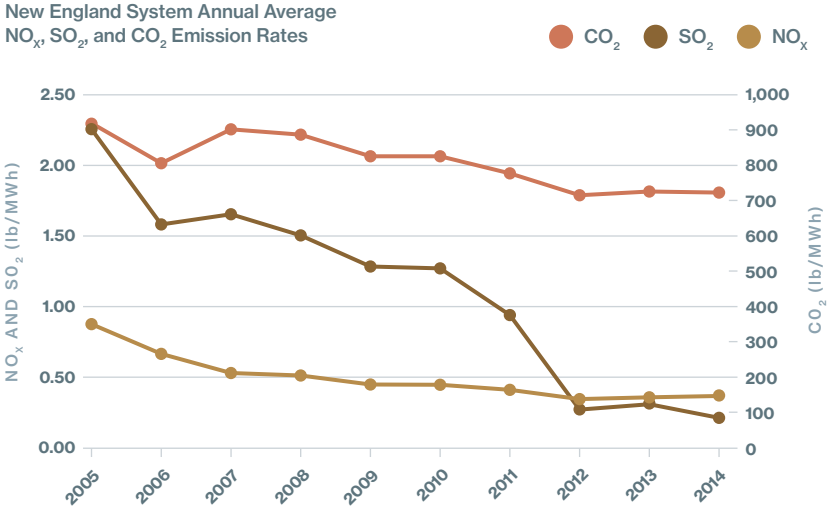
Pipeline constraints are affecting the winter fuel mix – and regional emissions

Increasingly during winter, ISO system operators must call on oil- and coal-fired units, as well as dual-fuel units that can switch to oil, to serve the region. Increased generation from these higher-emitting fuel types has a measurable effect on regional air emissions.

Winter 2014/2015 Fossil Fuel Mix by Day



New England System Annual Average NO_x, SO_2, and CO_2 Emission Rates



Long term, annual emissions have fallen significantly. But recent trends in emission rates – the pounds of emissions given off, on average, with every megawatt-hour of electricity produced (lb/MWh) – reflect the impact of the winter fuel mix, among other factors. A slowdown in declines and even some upticks have resulted.

Resource retirements are affecting emissions, too. The SO_2 drop between 2013 and 2014, for example, largely reflects the exit of over 1,000 MW of coal capacity from New England, with a corresponding 19% decrease in coal-fired generation.

Source: *2014 ISO New England Electric Generator Air Emissions Report*

Adjusting Operations to the New Normal

INTEGRATING WIND RESOURCES

With more than 800 MW of wind resources already installed in the region and significantly more new projects already proposed, the ISO has been modifying its systems and processes to better integrate these resources.

- ***Advanced operator displays*** – In addition to incorporating a new wind power forecast into scheduling and dispatch services in 2014, the ISO developed special displays and system functions to enhance ISO operators' situational awareness of wind power. The ISO continues improving on real-time wind dashboard displays for operators.
- ***Improved real-time dispatch*** – New in mid-2016 will be a modified electronic dispatch method that incorporates wind and hydro resources into real-time dispatch. This change will improve the ISO's ability to manage the system during rapidly shifting weather conditions and will improve price formation and the system's use of low-cost renewable resources in areas with limited transmission capacity.
- ***Cutting-edge analysis*** – The improved real-time dispatch will include the ISO's pioneering application of a powerful risk-management modeling tool in the electricity industry, developed in collaboration with university researchers. The computational strategy better quantifies and solves for today's unprecedented levels of uncertainty in real-time operations related to how much power will be available to supply the grid or demanded from it as more weather-dependent wind and solar resources come on line, as well as more demand resources. The new model yields both increased power system reliability and minimized dispatch costs, for a sizable savings, and remains effective as uncertainty levels increase.

Alternate Fuel Sources for Gas-Fired Generators: Oil and Liquefied Natural Gas

Winter operations have demonstrated that the use of alternate fuel sources for the natural-gas-fired fleet can help temper the reliability risks and price effects of pipeline congestion to some extent.

- ***Dual-fuel capability*** – Just over 30% of the region's gas-fired capacity can be switched to run on oil during winter when natural gas is hard to get or oil is cheaper. And many of the new gas-fired resources being proposed in the region are seeking dual-fuel capability. However, burning oil drives up emissions and may be limited by environmental use permits.
- ***Liquefied natural gas*** (LNG) – The increased use of existing LNG facilities and the addition of regional LNG storage can help fill the gap when the pipelines shipping Marcellus shale gas to the region are congested. However, regional LNG storage is limited, and because it is sourced internationally, LNG pricing varies and can be expensive.

ENHANCING UNIT COMMITMENT

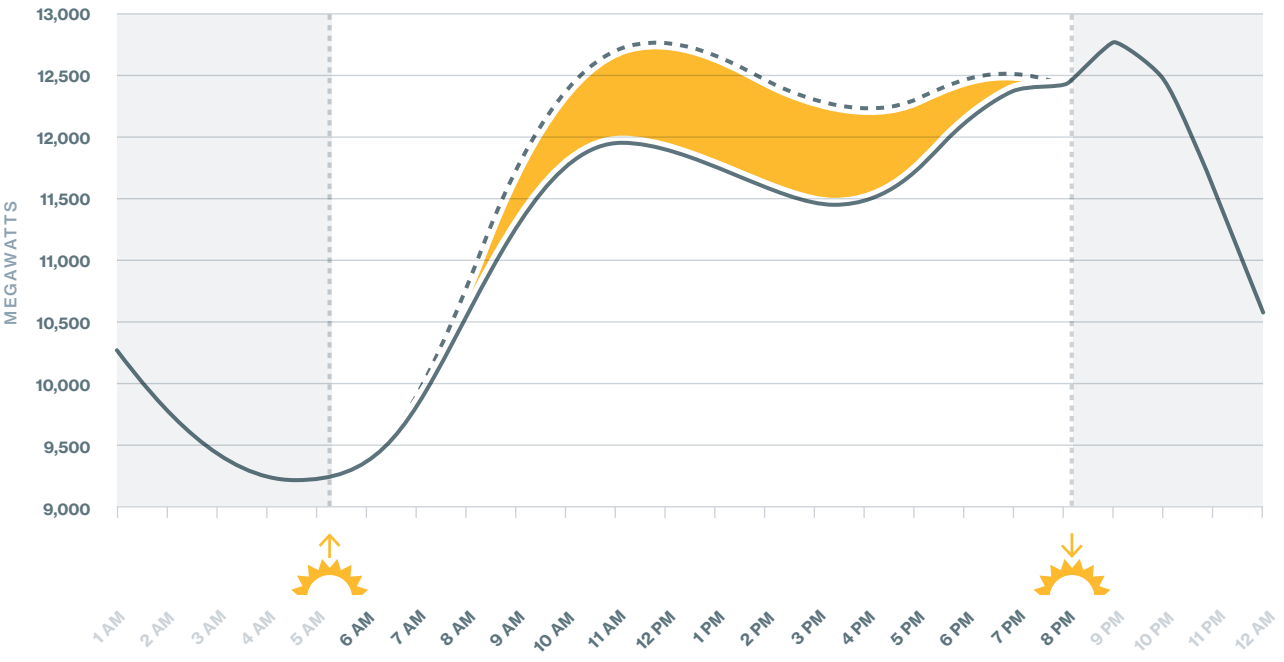
Several efforts have been underway to improve unit dispatch, particularly for fast-start units. These types of resources are likely to become more valuable to the region because of their ability to ramp up or down quickly to balance fluctuations in output from wind- and solar-powered resources.

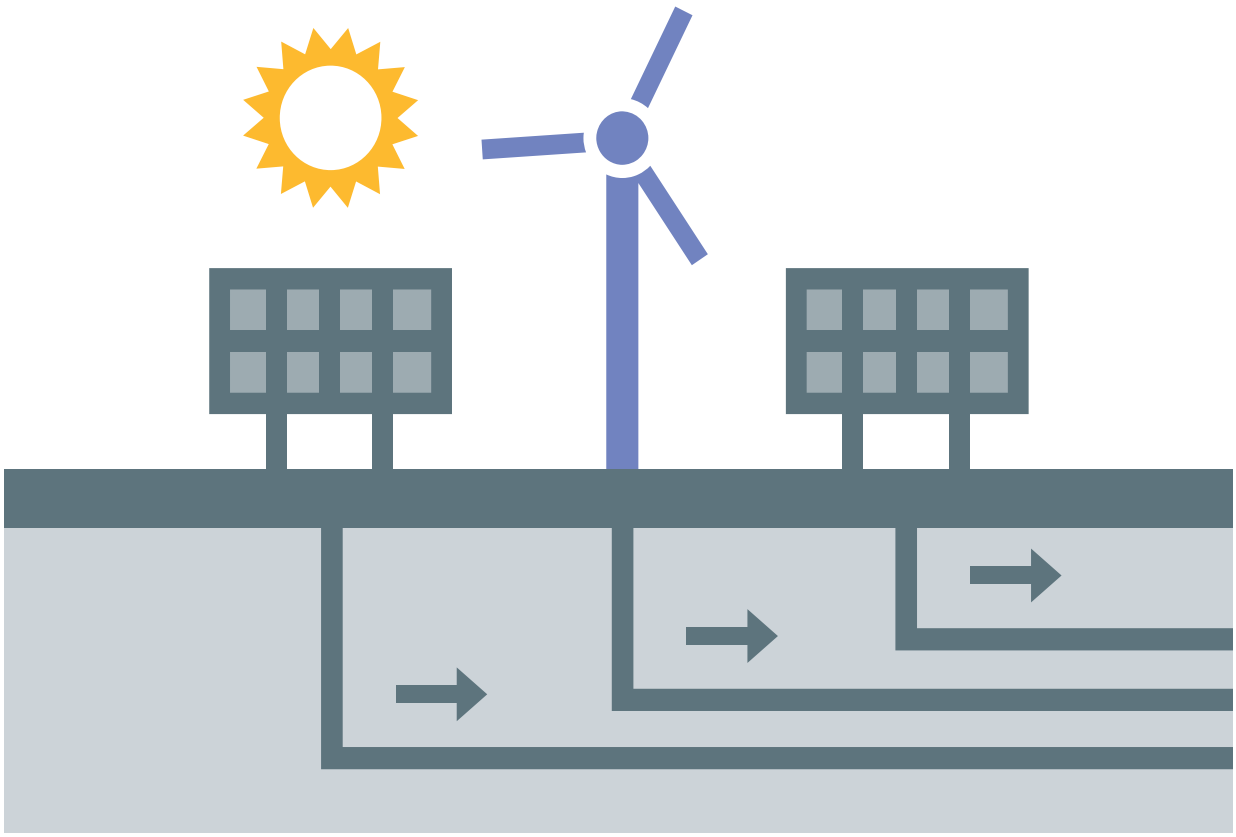
- Implemented November 2015, the **Generation Control Application (GCA) Project** created an enhanced version of the optimization engine for the commitment and shutdown of fast-start units, among other things.
- Also in November, the **GCA: Fast-Start Generator Reserve Change Project** refined the way reserves are designated on fast-start generators. This allows those capable of it to provide reserves more quickly after shutdown.
- A new **Dynamics Data Management System** is being implemented to house generator and transmission dynamics data and to automate the equipment-owner certification process.

Solar power is having a real impact on New England's electricity demand – and making it more challenging to forecast

On clear, sunny days, more and more electricity demand is being offset from the regional power system by solar-powered resources. The amount of demand that will be served by PV is hard to predict because solar power is so weather-dependent, plus most of the region's solar power is connected "behind-the-meter." The example below also shows the increased evening ramping being caused as PV output falls with the setting sun. Based on available data (through August 31), May 23 had New England's highest total PV output through spring and summer 2015, with ideal conditions for PV production: a clear, relatively cool day near the summer solstice.

Solar Power's Effect on Regional Electricity Demand
May 23, 2015





CREATING BETTER FORECASTS FOR RENEWABLE RESOURCES

Highly accurate forecasting is critical for being able to precisely dispatch power resources to serve electricity demand. The ISO continues to improve on its methods for forecasting electricity demand and is developing a new seven-day hourly forecast for the eight regional load zones. We are also developing new methods to anticipate the intermittent output of renewable resources.

Predicting wind power

Our seven-day hourly forecast of power generated by regional wind resources is exceeding accuracy expectations. The ISO began offering this forecast in 2013. Along with being an important tool for ISO operations, asset owners can use their resource's individual forecast to assist in bidding the resource's output in the energy market.

The ISO is now maintaining historical wind data for future use by the forecast service and in auditing and other analyses. We're also working on refining the forecast, automating publishing of the public aggregate version, and publishing medium- and long-term wind power forecasts.

Predicting solar power's effect on the grid

Another ongoing project is exploring the integration of irradiance data (a measurement of the sun's power) into our daily operational forecast. This will allow the ISO control room to better anticipate the level of solar generation in real time. The ISO has also contributed to research into predicting cloud cover, which can dampen PV output within seconds. Other variables that affect output and make PV power difficult to forecast include haze, temperature, humidity, wind speeds, and snow cover.

Putting Markets to Work for New England

Under the ISO's watch, the region's world-class wholesale electricity marketplace is not only securing reliable electricity at competitive prices, it's helping usher in a cleaner, greener grid.

Market Signals Are Attracting New Resources

The ongoing transformation of New England's power system wouldn't be possible without the open, competitive marketplace designed and administered by the ISO.

- Since 1997, the region has attracted investment in over 15,000 MW of new, mostly lower-emission generation, giving New England some of the most efficient combined-cycle gas plants in the country, along with growing numbers of wind- and solar-powered resources.
- About 2,300 MW of demand resources, such as EE, have entered the marketplace since the ISO enabled their participation. By reducing grid demand, these resources can help minimize the region's need for new power plants and transmission lines.
- The ISO's strong coordination with neighboring grids enables electricity from outside the region – much of it Canadian hydropower – to compete in our markets. Imports supplied 16% of regional electricity demand in 2015.

Markets Ensure Reliability at the Lowest Cost

The ISO's markets are designed to achieve reliability and long-term efficiency at the lowest costs and on a fuel- and technology-neutral basis. Resources offering to produce electricity or provide other specialized ancillary services (reserves and system regulation services) at the lowest prices in the markets are selected to operate, and all suppliers, regardless of technology, are compensated similarly for similar performance.

- The energy market and ancillary services markets ensure day-to-day reliability.
- The capacity market ensures long-term reliability.

Competitive Markets Are Delivering Competitive Prices

The region's wholesale electricity markets attract hundreds of buyers and sellers. Strong competition between them yields offers to sell electricity at prices that are typically close to each power resource's hour-by-hour operating cost. A competitive price isn't always cheap, though: a resource's operating cost will rise and fall with the price of its fuel.

A full list of market projects can be found on our website.

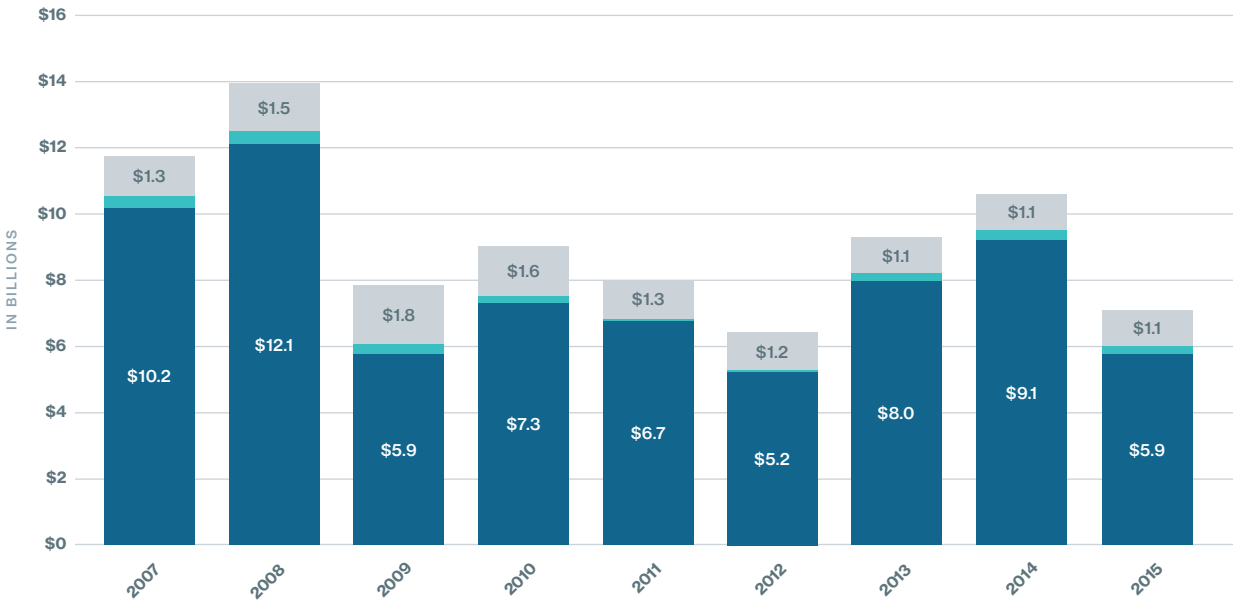
www.iso-ne.com/reo

Annual market values reflect prices

The region's energy market, where buyers and sellers trade electricity daily, is by far the biggest component of the region's wholesale electricity marketplace. The market's value has been rising and falling due to changes in both electricity demand and fuel costs for the region's generating fleet. (The 2015 values are preliminary.)

Capacity Market
Ancillary Markets
Energy Market

Annual Value of Wholesale Electricity Markets

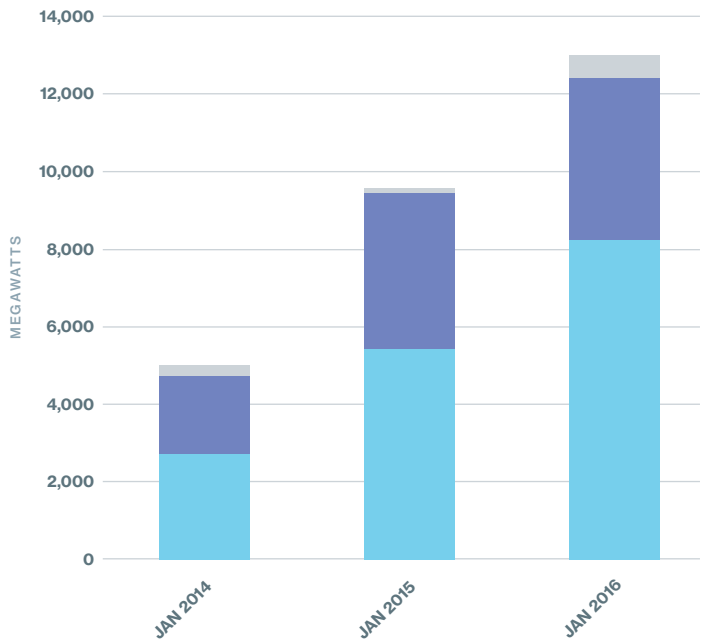


Encouraging new resource development

Prices in the region's capacity market auction have risen in recent years, properly signaling the need for new investment in resources to serve New England's future electricity demand. Higher prices are successfully attracting many competing proposals for new power resources. A look at the projects being proposed in the ISO's Interconnection Queue shows that low- and non-emitting resources dominate. And as of January 2016, 94 MW of battery storage were being proposed – a first for the region.

Other
Wind
Natural Gas
(including dual-fuel units)

Proposed Capacity in ISO's Generator Interconnection Queue

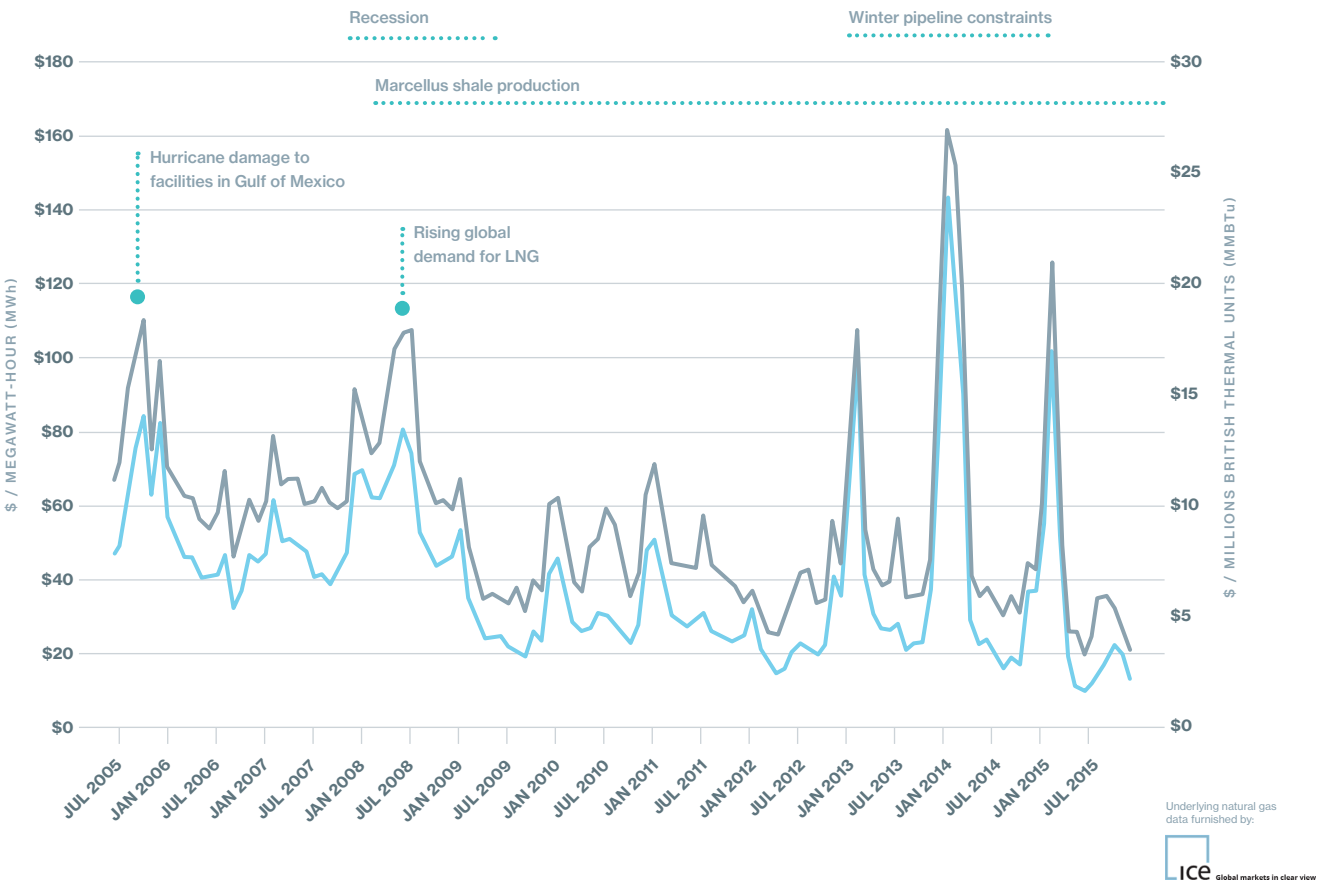


Natural Gas Infrastructure Constraints Lead to Price Volatility

Because so much of the region's generating capacity runs on natural gas, the price of this single fuel source sets the price for wholesale electricity about 70% of the time. Both electricity and gas prices have seen dramatic swings in recent years. Between February and June 2015, for example, the region's average monthly wholesale electricity price plummeted from the third-highest price to the lowest price since 2003, the year that competitive markets in their current form were introduced in New England. Behind these ups and down is the region's inadequate natural gas delivery infrastructure, which can cause price spikes.

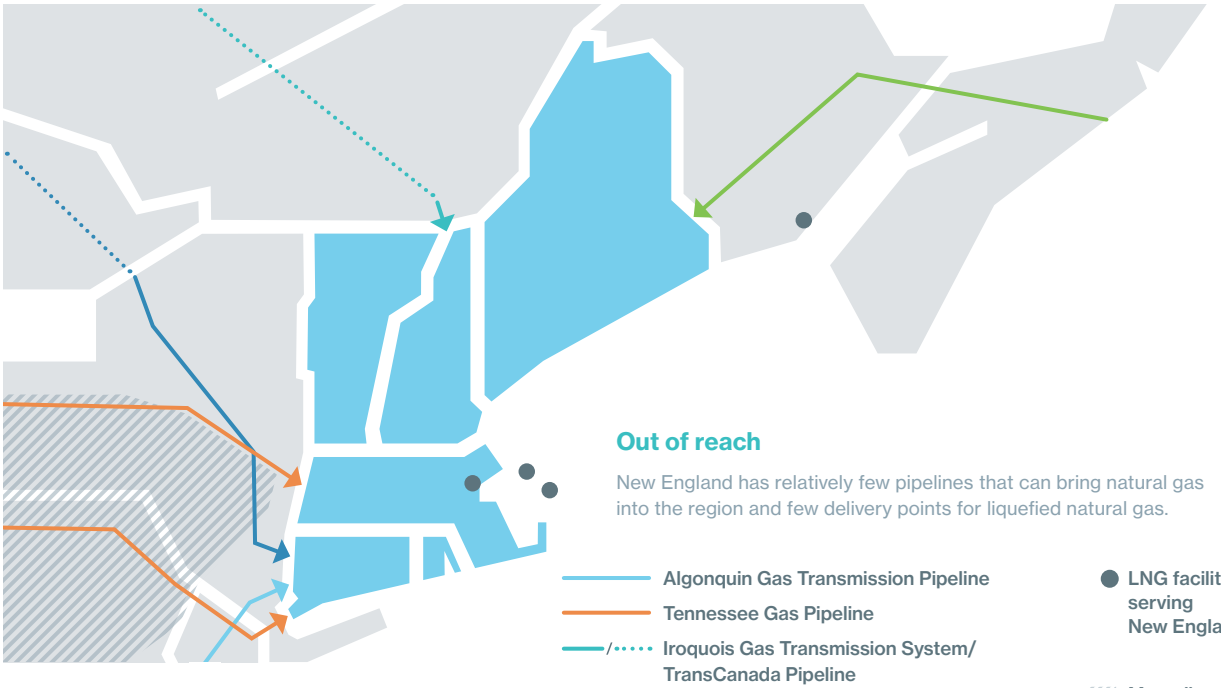
Regional prices for natural gas and wholesale electricity are linked

This close link is a sign that the wholesale electricity marketplace is efficient and competitive: generators' prices appropriately reflect their direct fuel costs. In recent winters, the region has experienced price spikes driven by strong demand from the electricity and heating sectors for limited supplies of low-cost fuel deliverable from the nearby Marcellus shale regions in Pennsylvania, Ohio, and other mid-Atlantic states.



Underlying natural gas data furnished by:

ICE Global markets in clear view



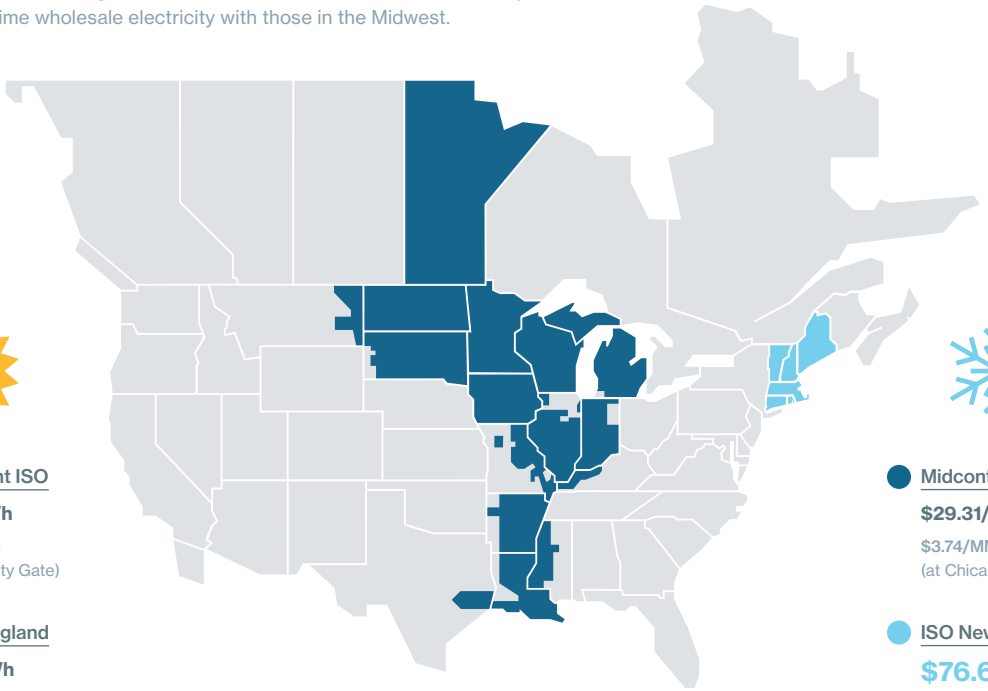
Out of reach

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

- Algonquin Gas Transmission Pipeline
- Tennessee Gas Pipeline
- Iroquois Gas Transmission System/ TransCanada Pipeline
- Portland Natural Gas Transmission System/ Gazoduc Trans Québec & Maritimes Pipeline
- Maritimes and Northeast (M&N Pipeline)
- LNG facilities serving New England
- Marcellus shale region

A tale of two seasons

When the region's gas-fired generators have unconstrained access to natural gas, wholesale electricity prices are competitive nationally. Compare New England's average summer (June–August 2015) and winter (December 2014–February 2015) prices for real-time wholesale electricity with those in the Midwest.



Midcontinent ISO
$28.78/MWh
$2.80/MMBtu
(at Chicago City Gate)

ISO New England
$26.86/MWh
$2/MMBtu
(at Algonquin City Gate)

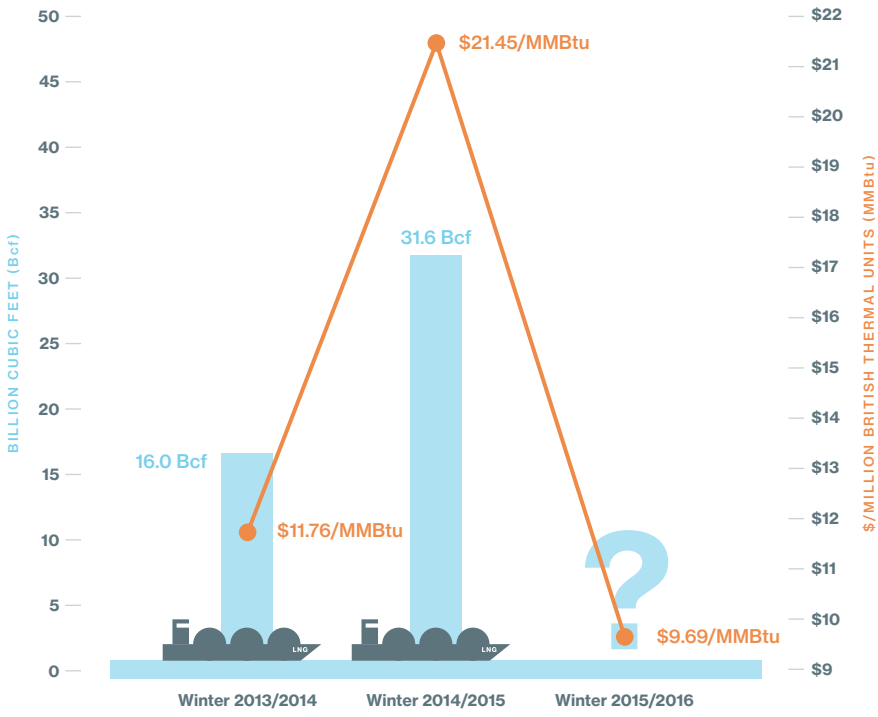
Midcontinent ISO
$29.31/MWh
$3.74/MMBtu
(at Chicago City Gate)

ISO New England
$76.64/MWh
$10.70/MMBtu
(at Algonquin City Gate)

LNG deliveries into New England are highly variable

In October 2014, natural gas futures-market prices for delivery into New England during the winter of 2014/2015 were among the highest prices in the world, attracting many LNG tanker ships to the region and roughly doubling LNG deliveries from prior years. As of October 2015, New England futures prices for winter 2015/2016 had fallen by half, but with global LNG prices below $8/MMbtu, LNG cargoes were still expected to be attracted to the region. However, the exact amount of LNG available in New England in this and future winters remains uncertain.

- Winter LNG Deliveries to New England
- Algonquin Natural Gas Futures Prices as of Previous October 1



Source: Data from NatGas Analyst Tool by Genscape, a part of DMG Information (DMGI); www.genscape.com

Continual Industry Evolution Requires Continual Market Refinements

At any given time, the ISO is evaluating, discussing with regional stakeholders, and implementing many different projects to refine the region's marketplace to ensure power system reliability and efficiency. In 2016, we'll continue our focus on enhancing market signals and incentives to ensure the region gets reliable performance from today's power resources and can attract resources for future needs. Many of these market improvements are intensive, technical projects. They must be sequenced sensibly and, as a result, take time to bring to fruition.

POWER RESOURCE PERFORMANCE

For more than a decade, the ISO has been highlighting issues that affect the operation of power resources, thereby posing risks to the reliable supply of electricity. Along with operational initiatives to address these risks, we've been fine-tuning the wholesale electricity markets to strengthen incentives for performance, particularly during times of system stress. Of biggest concern is the region's natural-gas-fired plants' vulnerability to inadequate fuel supplies. At the same time, the age and infrequent use of the region's typically more costly oil- and coal-fired power plants can sometimes lead to operating problems.

Examples of recent and upcoming market efforts to ensure reliable resource performance:

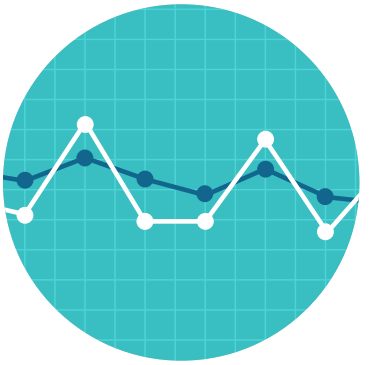
- A **tightening of the shortage-event trigger** in the Forward Capacity Market (FCM) and increased payments to resources providing essential operating reserves during scarcity conditions
- Off-line **reserve auditing provisions** and more robust ISO-initiated parameter auditing rules to provide greater accuracy in assessments of the 10- and 30-minute capability of reserve resources

- **Increasing the 10-minute nonspinning reserve (TMNSR) requirement** to account for recent fleet performance when dispatched during stressed operating conditions
- FCM enhancements known as **"pay for performance" (PFP)**, a two-settlement capacity market design that, starting in 2018, will reward resources that make investments to successfully boost performance during periods of system stress – for example, by adding dual-fuel technology – while resources that don't perform will forfeit capacity payments
- **Winter reliability programs** established for winters 2013/2014 through 2017/2018 to incentivize sufficient fuel supplies for nongas generators until PFP takes effect

PRICE FORMATION

Accurate, transparent pricing motivates and compensates resources to make cost-effective investments – at the right times, in the right amounts, and in the right locations – for delivering the energy consumers demand and the reserves that assure power system reliability. Examples of recent and upcoming changes to improve price formation:

- An **acceleration of the Day-Ahead Energy Market timeline** better aligned it with the daily natural-gas market, so generators have more opportunities to procure the gas they need to run the next day.
- **Energy market offer-flexibility enhancements** now allow participants to update their offers in real time to reflect changing fuel costs during the operating day.
- **Negative energy offer prices** as low as -$150/MWh are now allowed so that suppliers can indicate their willingness to, in effect, pay to operate if they do not wish to shut down. This helps avoid mandatory generation curtailments using noneconomic procedures during periods when energy demand is low.
- Various upcoming **FCM refinements**, such as instituting zonal demand curves starting with FCA #11 and reforming the process by which resources retire, will further strengthen the FCM's price signals as indicators of the true cost of meeting the system's long-term reliability requirements.
- Changes to **pricing for fast-start resources** are in the works to more accurately compensate these types of power resources, which are taking on greater significance as more renewables enter the marketplace.
- The upcoming switch to **subhourly real-time settlement** will make compensation for resources more consistent with their performance on a five-minute basis, especially for resources able to respond quickly. (The real-time energy, reserves, and regulation markets are all currently settled hourly, but resources are dispatched every five minutes.)
- Procuring and pricing operating reserves in **co-optimized Day-Ahead Energy and Reserves Markets** is planned as a future project to enable transparent market prices to signal the costs suppliers must incur to provide reliable operating reserves in the Day-Ahead Energy Market.



ENABLING INCREASED MARKET OPPORTUNITIES FOR STORAGE AND DEMAND RESOURCES

Opening the Regulation Market to Alternative Resources: After conducting a multiyear pilot program to encourage alternative technologies to participate in wholesale electricity markets, in 2015 the ISO opened the door for more advanced storage technologies to compete to provide frequency regulation services for New England. (Frequency regulation is the capability of specially equipped resources to increase or decrease their energy output every four seconds in response to ISO signals. This fine-tuning balances supply levels against small second-to-second variations in electricity use and helps maintain the power system's frequency.) We accomplished this with a redesigned Regulation Market in 2015 that includes a new type of "energy-neutral" dispatch signal that can be followed by resources using a storage technology, such as batteries and flywheels.

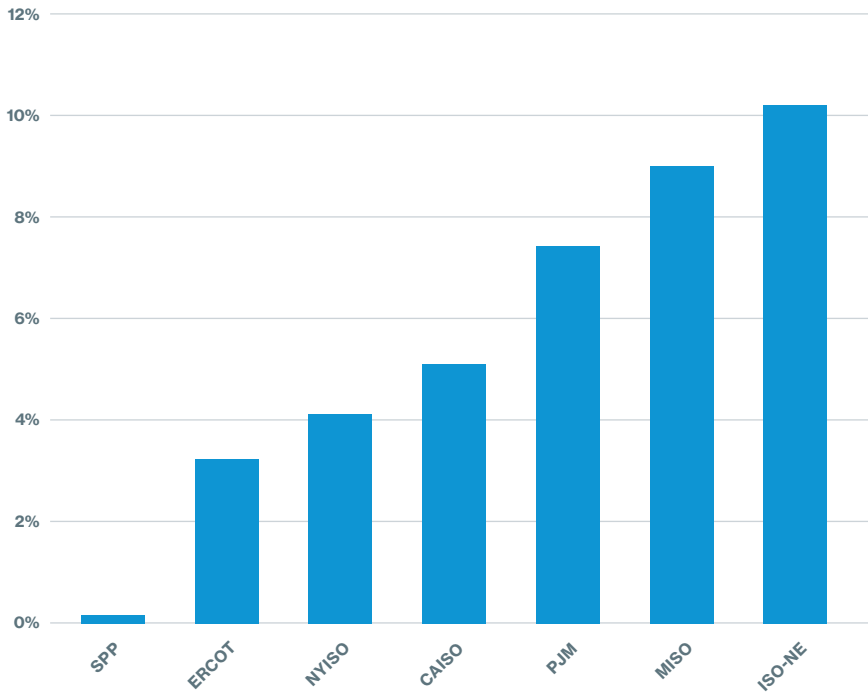
Fully Integrating Demand Response Participation in Markets: Both active demand resources (like the practice of powering down machines or switching to an on-site generator) and passive demand resources (like energy-efficiency measures) have been participating in the Forward Capacity Market since the market began in 2010. On May 23, 2014, the DC Circuit of the US Court of Appeals found that the Federal Energy Regulatory Commission (FERC) lacked jurisdiction to establish rules for demand response. On January 25, 2016, however, the US Supreme Court disagreed with the lower court's decision, and reaffirmed FERC's jurisdiction over demand response. This means that the ISO can complete the full integration of demand response in the wholesale electricity marketplace. This will take about two years, with completion expected by June 1, 2018. (The legal challenges to FERC jurisdiction led to a one-year delay from the original goal of full integration by 2017.)

Demand response in New England

ISO New England has the most demand resources as a percentage of peak demand compared with other ISOs/RTOs in the country.

Source: *Assessment of Demand Response and Advanced Metering Staff Report*, FERC, December 2015

Demand Response's Potential Reduction of Peak Demand by ISO/RTO



In Focus: The Effects of Renewable Resources on Wholesale Electricity Markets

The region's capacity market – and the importance of accurate price formation – are taking on greater significance as New England's power fleet transforms itself.

Energy and Capacity Markets Operate in Tandem to Accommodate the Influx of Renewables

Renewable resources, with low to no fuel costs and out-of-market financial incentives, can offer to produce energy at lower prices than conventional resources. Currently, renewables make up a small percentage of the region's power generation fleet, thus energy market prices still tend to be set by conventional resources. However, as the penetration of renewables in New England increases, these resources will put downward pressure on energy market prices, and the already low average energy price will drop further.

Reduced energy-market revenues will add to existing financial pressure on conventional generation – the resources needed to maintain reliability when weather hinders output from renewables. This is already happening in Europe and regions of the US that have high amounts of wind generation. To remain economically viable, these conventional resources will increasingly rely on Forward Capacity Market revenue and will require higher capacity prices. Over the long term, commercially developed resources of all types – even renewables and other new and emerging technologies – will likely have to turn to the FCM to recover increasing shares of their capital investments.

The ISO has been actively refining the FCM to be responsive to these evolving market conditions. The FCM is designed to dynamically complement the incentives in the energy market, providing price signals sufficient to attract and retain the right amount of reliable generating capacity needed to serve the region, as well as the types of resources needed to balance the operating characteristics of renewable resources. See the 2015 ISO discussion paper, *The Importance of a Performance-Based Capacity Market to Ensure Reliability as the Grid Adapts to a Renewable Energy Future.*

Achieving Environmental Objectives in a Way that Maintains a Competitive Wholesale Electricity Marketplace

In the late 1990s, the region adopted wholesale electricity markets based on broad principles of competition, transparency, and resource-neutrality. The marketplace would select whichever power resources offered energy services at the lowest cost, regardless of the fuel or technology employed; and investors, rather than consumers, would assume the risk for new power resources and technologies. Simultaneously, the region began setting aggressive policy goals to lower carbon emissions and increase the amount of renewable energy. To that end, many of today's state and federal public policy initiatives seek to promote specific resource types, even if they are not the lowest-cost technologies. A delicate balance exists between these two regional objectives.

Even with low to no fuel costs, most renewable resources are relatively expensive to build and are, therefore, not competitive in the wholesale marketplace. Policymakers have put in place policies that provide financial incentives beyond those offered by the market for adding more resources with low or zero carbon emissions. Additional incentives are still being considered.

Renewable energy policies that are effected through emissions- or attribute-based incentive programs – which, in turn, affect the operating costs of all power resources in proportion to their environmental impact – best complement competitive electricity markets. One example is the Northeast's Regional Greenhouse Gas Initiative (RGGI) carbon cap-and-trade program. RGGI causes high-emitting generators to incur higher costs, which are then factored into their market offers. The market then naturally shifts energy production toward less expensive – and lower emitting – resources. As a result, the competitive energy market accurately and transparently signals the cost of both providing energy and fulfilling the region's environmental goals – while promoting the lowest-cost means of meeting both objectives simultaneously.

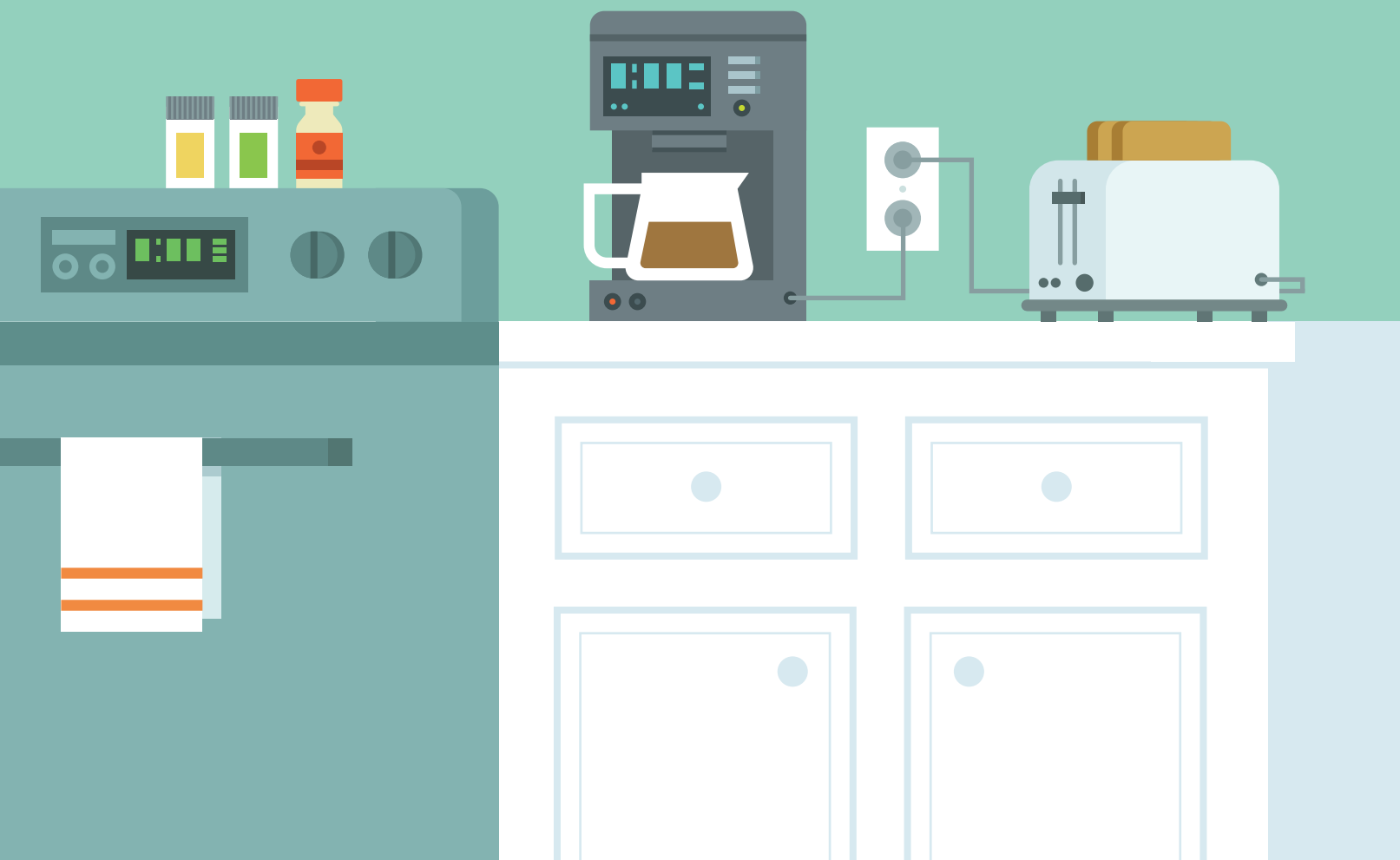
As long as price formation is protected, the capacity market will continue to sustain and attract the private investment needed to meet reliability standards.

Renewables receiving direct support in the form of long-term contracts or other specific incentives can offer energy supplies at lower prices that do not reflect their true construction or operating costs. This will reduce market revenues below the true costs of producing electric energy. Consequently, nonrenewable resources should be expected to make up lost revenue by raising their offers in the capacity market, but recouping costs in this way is only possible if the capacity market is allowed to set prices at the true marginal cost of providing adequate reliability. Allowing noncompetitive offers in the capacity market and compromising accurate price formation would significantly diminish interest from private investors and would hasten retirements of existing resources. That's why the current market rules limit resources with supply offers that are too low to be competitive – even if they are from a resource type that helps meet environmental goals.

As long as price formation is protected, the capacity market will continue to sustain and attract the private investment needed to meet reliability standards; will fulfill the original goal of markets of ensuring competitive technology renewal while shielding consumers from unwise investments; and will thereby serve as an efficient mechanism for seamlessly transitioning the region away from carbon-heavy resources.

Planning for a Reliable Future

ISO New England is strengthening the grid across the entire region – and enabling access to greener power – through our work to guide the interconnection of new power resources and to select cost-effective transmission system solutions.



Transmission Projects Are Strengthening the Grid and Enabling Its Transformation

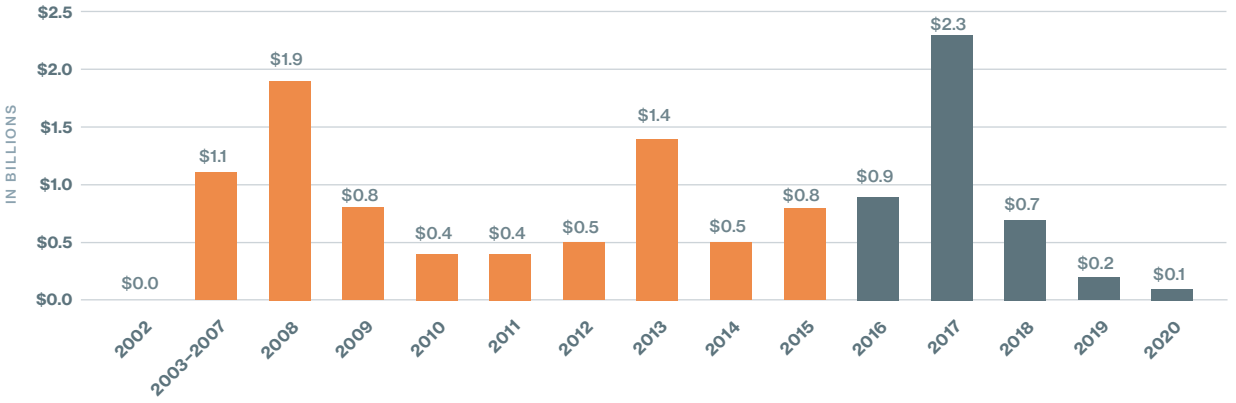
New England's transmission system includes about 8,600 miles of high-voltage power lines and related facilities spanning six states. Since 2002, transmission owners have placed close to 650 project components into service under the ISO's guidance to ensure that electricity continues to move reliably and efficiently across the region. Over 200 additional projects are anticipated over the next 10 years that will ensure the region continues to enjoy a highly reliable and economic power system, and system assessments continue across most of the region. Major reliability projects that have been completed since the beginning of 2015 or are under construction include the following:

- Maine Power Reliability Program
- Interstate Reliability Project
- Greater Hartford and Central Connecticut Projects
- Southwest Connecticut Projects
- Greater Boston Projects
- Pittsfield/Greenfield Reliability Project
- New Hampshire/Vermont 10-year Upgrades
- Short-term Southeastern Massachusetts/ Rhode Island upgrades associated with the retirement of Brayton Point Station in 2017

New transmission investment in New England to maintain reliability

The New England electric grid is a tightly interconnected system, so each state shares in the benefits – and costs – of reliability upgrades. The amount of electricity demand in an area determines its portion of costs for new or upgraded transmission facilities.

Estimated future investment includes projects under construction, planned, and proposed.



Source: *ISO New England Regional System Plan Transmission Project Listing*, October 2015

For full transmission project descriptions, read the *2015 Regional System Plan* (RSP), ISO New England's 10-year planning report.

www.iso-ne.com/rsp

Even More Transmission Upgrades Are Needed to Unlock Wind and Hydro Potential

Most of the region's wind resources are in northern New England – far from the greatest concentrations of electricity consumers. Many of the new wind power proposals are located where the transmission system is already constrained, particularly in Maine. Over 4,200 MW of new wind projects are proposed, but no margin remains on Maine's transmission system after accounting for existing generators plus New Brunswick imports.

To be able to deliver more power from existing wind resources and to develop new wind resources – as well as to access more Canadian hydropower – significant additional investment will be required in electric transmission infrastructure.

Interconnection standards and system impact analyses will also be required to ensure that new wind turbines – as well as grid-connected solar farms – provide adequate performance to ensure continued reliability. These resources typically use inverter-based generators, which are designed differently from conventional generators in the provision of voltage and frequency response – especially when interconnecting over long distances or in weak areas of the system.

A Strong Transmission System Benefits the Entire Region

- Electricity wherever and whenever it's needed
- Fewer system constraints, enabling the flow of the least-cost electricity
- The ability to integrate new, more efficient resources and to retire inefficient ones

The September 2015 *National Electric Transmission Congestion Study* from the US Department of Energy reported that generation and transmission additions in New England have contributed to low overall transmission congestion in the region.

Facilitating Wind Resource Integration

While the region will need additional transmission infrastructure to bring more large-scale wind to market, several ISO efforts are underway to help the region get the most out of its wind power.

GENERATOR INTERCONNECTION PROCESS

We're evaluating ways to speed up system impact studies for proposed inverter-based wind and solar generators, particularly those in weak areas, such as northern and western Maine. Some factors that cause study complications and longer timelines are beyond the ISO's control, though:

- The transmission system in Maine is already at its performance limit.
- The nature of wind generator technology requires more analysis than conventional generators.

MODELING

The ISO is incorporating proposed modeling and performance requirements being introduced by new NERC standards that should streamline the process and help reduce study times.

ECONOMIC STUDIES

The ISO is conducting three assessments to evaluate the potential economic effects on the regional power system resulting from different scenarios of wind integration and infrastructure improvements, following stakeholder requests in 2015. The studies cover areas in Maine, as well as offshore wind development near Rhode Island and Southeast Massachusetts.

ETU PROCESS

In February 2015, the ISO, after working with stakeholders, implemented improvements to the processes for evaluating the interconnection of Elective Transmission Upgrades (ETUs) and to incorporate ETUs into the Forward Capacity Market. ETUs are transmission lines funded by private parties – not through regional cost-sharing. While not necessary from a reliability standpoint, they can help enhance generator deliverability or facilitate the integration of renewable resources by enhancing portions of the grid. Eleven ETUs were in the queue as of January 2016.

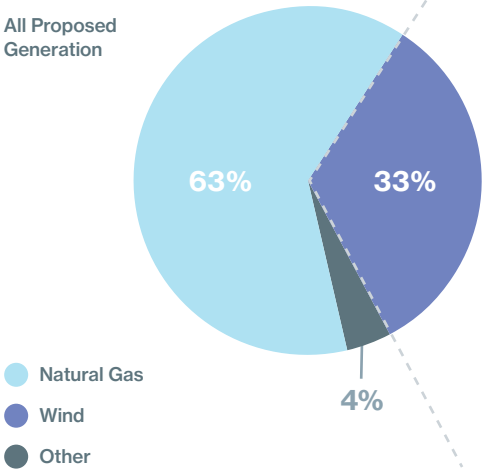
Supporting State Efforts to Integrate More Renewable Energy

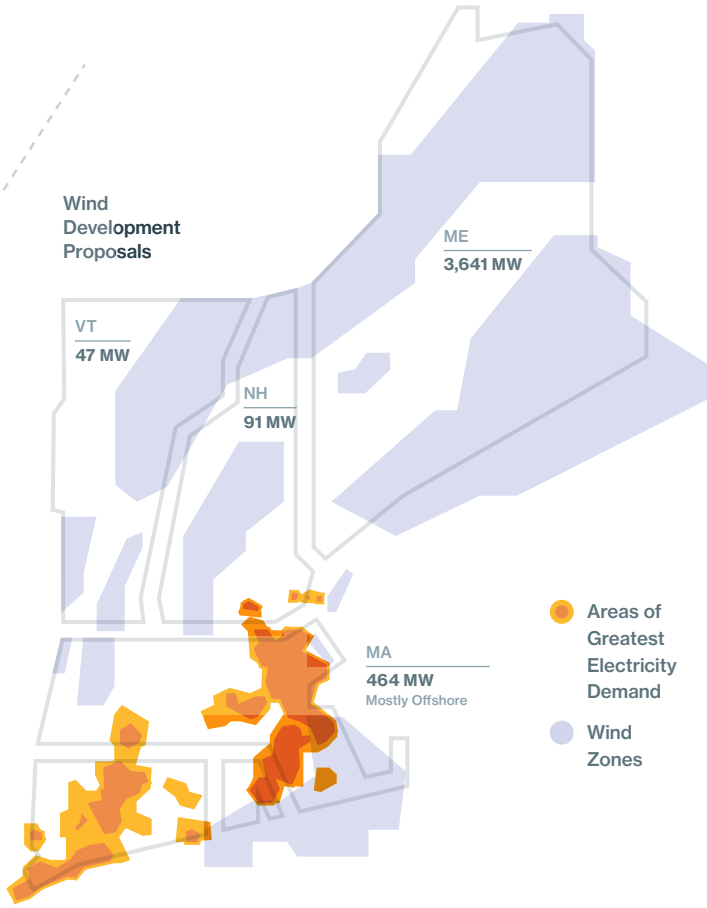
The New England states have taken the lead through a multistate request for proposals to potentially contract for additional transmission infrastructure to enable the connection of more renewable energy. The ISO's improved ETU process will help support this and similar efforts.

Delivering wind power to consumers remains a major challenge

New England holds significant onshore and offshore wind potential, and many projects are in the works to harness it. A third of the approximately 13,000 MW of proposed generation in the ISO Generation Interconnection Queue are wind resources. But delivering that wind power to far-away consumers is going to take major upgrades of the transmission system.

Source: ISO Generator Interconnection Queue (January 2016; FERC jurisdictional proposals only)





Planning on More Regional Solar Power

As many New England states' policies drive strong growth in solar photovoltaic (PV) resources, the ISO has been studying likely effects on the power system. A complicating factor is that most PV resources are invisible to the ISO: they are connected locally "behind the meter" (not to the regional grid), don't participate in the wholesale electricity marketplace, and aren't dispatchable by ISO system operators.

PIONEERING LONG-TERM FORECASTING

In 2013, we developed a long-term multistate PV forecast – the first in the nation – to project the anticipated growth and impact on New England's power system. Initially used in transmission planning studies, in 2015 the ISO began using the PV forecast in its annual 10-year system planning process. Developing the annual forecast involves close collaboration with state policymakers, distributed generation (DG) program administrators, and distribution companies to gather information on planned projects.

Counting Megawatts: Understanding Solar Resource Capacity

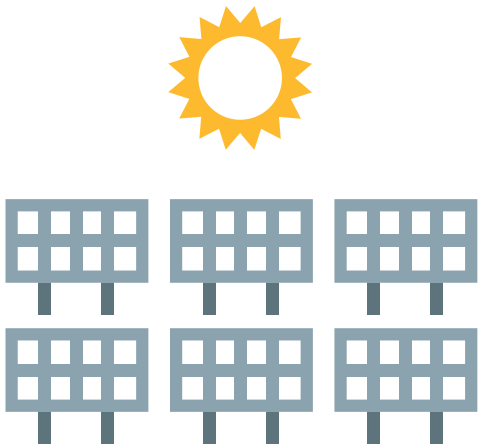
A generator's nameplate capacity – the megawatts it should produce under optimal conditions – and its measurable day-to-day performance can differ significantly. This is particularly true for solar power, due to PV's weather-dependent nature. That's why for planning purposes, the ISO counts about 40% of PV's nameplate capacity toward meeting the daily summer peak demand. (See the chart of projected PV capacity on page 10.) The ISO counts zero PV capacity toward daily winter peak demand because the demand for power in winter peaks in the evening after the sun – and PV's output – has set. (See the graph on page 18.) These values are based on an analysis of three years of estimated performance data for PV. The ISO will reexamine them as more actual operation data become available.

IMPROVING INTERCONNECTION STANDARDS

The ISO's forecasting efforts have revealed a potential problem: much of the region's PV isn't set up to "ride through" low-voltage conditions that can be caused when a transmission line or generator trips off line. Instead, they may automatically disconnect, exacerbating the problem. And if a large amount of PV were to shut down suddenly, demand on the regional grid would rise considerably, introducing instability. The ISO has been actively working with the New England states, distribution utilities, and standard-setting bodies to revise standards to enable future interconnections without posing risks to grid reliability.

COLLABORATION

The ISO is engaging with other ISOs/RTOs to share relevant methods and experience related to PV as it increases around the country.



Measuring the Region's Energy-Efficiency Measures

The New England states are national leaders in implementing energy-efficiency (EE) measures, such as the use of more efficient lighting, appliances, cooling, and building operation. To account for the long-term effects of EE on regional electricity demand, the ISO developed the nation's first multistate energy-efficiency forecast in 2012. We also use this forecast in our annual 10-year system planning process for meeting the region's needs.

Order No. 1000 Changes are Underway

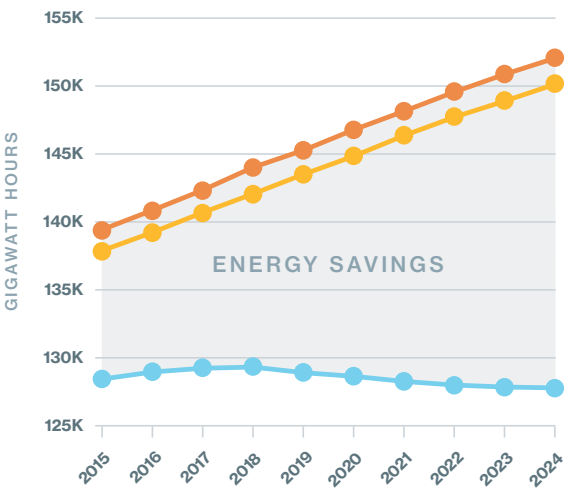
The ISO continues to implement FERC Order No. 1000, *Transmission Planning and Cost Allocation.* FERC's compliance order, effective May 18, 2015, requires changes to the regional and interregional transmission planning and cost-allocation processes that have been employed in New England since 2001. The ISO has already posted new process documents regarding how entities interested in providing transmission solutions in response to a competitive solicitation can apply to become Qualified Transmission Project Sponsors. The ISO is currently developing new processes for competitive solicitations for transmission projects to address reliability needs not expected to emerge within three years, as well as planning for transmission projects to meet public policy objectives, the latter of which the ISO expects to begin in January 2017.

Energy-efficiency measures are flattening growth and "shaving the peak"

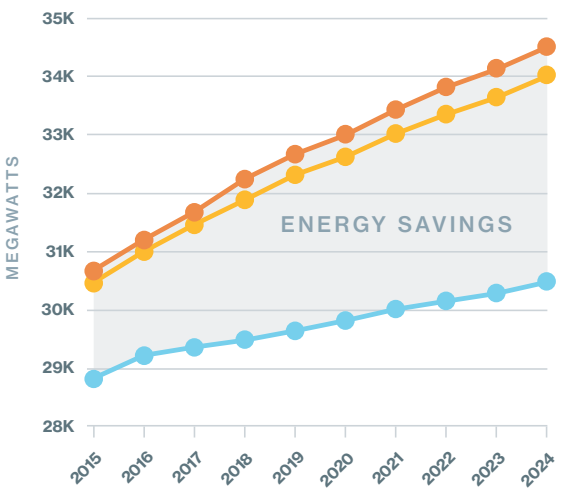
With approximately $1 billion being invested annually by the New England states, EE measures are helping to keep annual energy use effectively flat in the long-term. EE measures are also helping to slow the growth of peak demand (the periods of highest electricity usage).

Source: Data from *Final ISO New England Energy-Efficiency Forecast 2019–2024* and *Final 2015 Solar PV Forecast Details* (April 2015)

Annual Energy Use (GWh)
With and Without EE and PV Savings



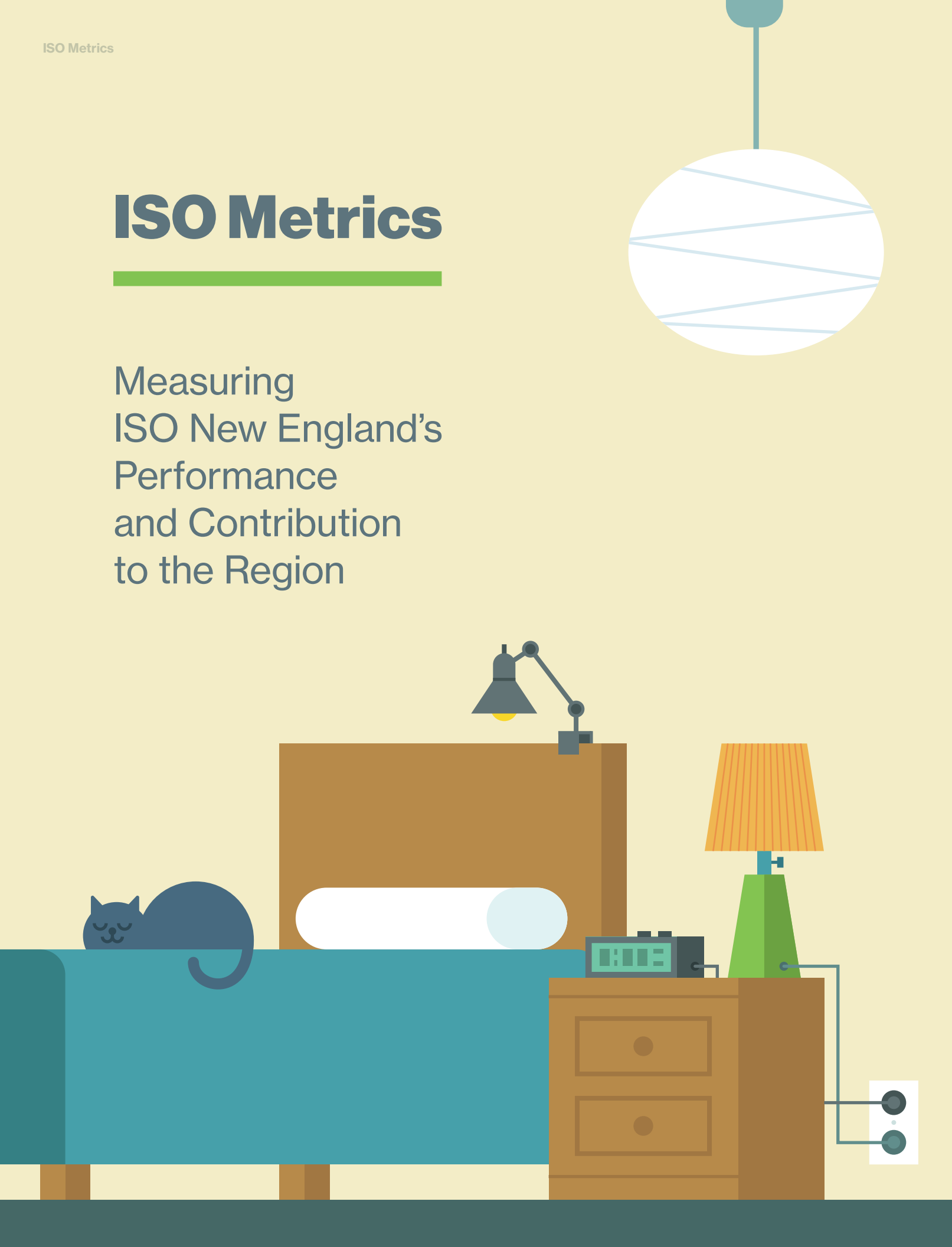
Summer Peak Demand (MW)
With and Without EE and PV Savings



- The gross load forecast (projected regional energy use)
- The gross load forecast minus forecasted solar PV resources
- The gross load forecast minus forecasted PV, minus EE resources in the Forward Capacity Market 2015–2018 and forecasted EE 2019–2024

ISO Metrics

Measuring ISO New England's Performance and Contribution to the Region



Accountability and Transparency

Open, fair, and independent actions are the defining characteristics of ISO New England's operation. To ensure the highest levels of transparency, industry stakeholders are an integral part of the ISO's budget processes, regional system planning, and market development. They also interact regularly with ISO staff and directors, take part in the nomination of the ISO Board, and participate in dozens of committees and working groups. For example, in 2015:

- The ISO held about 80 meetings of the Markets, Reliability, Transmission, and Participants Committees; 16 Planning Advisory Committee meetings, which stakeholder representatives from over 100 entities attended; and a public meeting in September to discuss planning issues facing the New England region.
- The Consumer Liaison Group met quarterly to share information about the economic impacts of New England's power system and wholesale electricity markets on consumers.
- ISO Customer Support handled almost 15,000 calls and helped customers resolve approximately 6,800 issues.
- About 1,150 stakeholders attended ISO classroom or web-conference trainings.
- About 50 e-learning modules and 150 presentations were maintained on the ISO website for stakeholder use.

A Robust Stakeholder Process Ensures Diverse Perspectives and Effective Solutions

By participating in one or more of the ISO's comprehensive advisory committees, interested parties can help inform solutions to regional challenges. The diversity of perspectives, expectations, interests, and ideas generated creates discussion and more effective outcomes for New England's consumers and market participants. The ISO's stakeholders are a wide-ranging group, including:

- The New England Power Pool (NEPOOL), the voluntary association of the participants in New England's wholesale electricity marketplace
- State regulators, including the New England Conference of Public Utilities Commissioners (NECPUC)
- State and federal legislators, attorneys general, and environmental regulators
- The six governors, primarily through the New England States Committee on Electricity (NESCOE)
- The Consumer Liaison Group, a forum of electricity consumers and state consumer advocates

Results on a Budget

We maintain a culture of cost accountability and transparency in our service to the region. The ISO is a not-for-profit entity without equity – as such, we rely on fees provided under the ISO Tariff to fund operational expenses. Our rigorous annual budgeting process includes meaningful stakeholder input, oversight from the ISO Board, and review by the Federal Energy Regulatory Commission (FERC).

The ISO's 2016 operating budget is $185.2 million – an increase of 3.8% over the 2015 budget – before incorporating the prior years' true-ups (actual expenses versus budgeted collections).

- More than half of the increase is for maintaining the ISO's current expertise and complex services to the region by funding competitive compensation for its highly skilled employees, software licenses and technology systems, and retirement and medical benefits.
- Most of the remaining increased costs are funding cybersecurity enhancements, including the establishment of a 24/7 cybersecurity operations center to allow around-the-clock monitoring and surveillance; enhanced market monitoring; and implementing FERC-approved changes to the Forward Capacity Market.

To help contain costs, the ISO has implemented a level pension-funding approach, used in-house staff to absorb more of the work previously performed by contractors and consultants, and reallocated existing resources to some new initiatives.

The services and benefits the ISO provides to keep the power flowing will cost the average New England residential electricity consumer $0.99/month in 2016, based on 750 kilowatt-hours per month usage.

Customer Satisfaction

ANNUAL CUSTOMER SURVEY

Stakeholder feedback is a helpful indicator of the quality of the products and services the ISO offers, as well as areas that need improvement. The latest survey of market participants (2015) revealed high overall satisfaction levels. Positive satisfaction among respondents with an opinion was 96%.

ISO RESPONSIVENESS TO MARKET PARTICIPANTS' ACCOUNTING NEEDS

Following requests from market participants, the ISO launched the Divisional Accounting Project to enable subaccount settlement reporting for each market participant, which helps them track and evaluate their ISO transactions by individual business unit, division, or generating facility. The complexity of this implementation across vast numbers of ISO systems required a multiphase project-release schedule between 2014 and 2016.

ENHANCEMENTS TO THE ISO WEBSITE AND ISO WEB APPLICATIONS

The ISO website and data portal, ISO Express, were redesigned in 2014 to improve the user experience. They received even more upgrades in 2015. Of note:

- *The enhanced real-time fuel mix chart* better reflects the percentage of each fuel that dual-fuel units are using.
- *A "one-stop shop" budget webpage* helps stakeholders quickly find the ISO's budget development materials.
- *The FCM Participation Guide* provides easy access to instructions for operating in the Forward Capacity Market.
- *The Energy-Efficiency Measure database* tracks the individual measures of EE programs participating in the FCM, helping the ISO in its qualification, auditing, and performance verification of resources. Market participants use the system for reporting and other needs.

Interregional Collaboration

In late 2015, the ISO updated systems and market rules to support **coordinated transaction scheduling.** The changes now allow ISO New England and the New York Independent System Operator (NYISO) to improve scheduling of wholesale electricity sales between the two neighboring regions. CTS increases the frequency of energy transactions, making more efficient use of the transmission lines connecting New England and New York; enables the two grid operators to coordinate the selection of the most economic transactions; and removes several fees that impeded efficient trade between regions. These sophisticated software improvements have the potential to reduce wholesale costs in each region many tens of millions of dollars annually by improving the ability of all market participants to access the lowest-cost source of power within the regions.

A Focus on Performance and Standards Compliance

The ISO is dedicated to the safe, reliable operation of the grid through extensive training for staff and continuous process improvement to ensure compliance with directives from FERC, the North American Electric Reliability Corporation (NERC), and the Northeast Power Coordinating Council (NPCC).

Last year, NPCC recognized the ISO for areas of excellence in its 2015 Operations and Planning Compliance Audit, which assessed ISO compliance with 38 standards and 124 requirements related to power system reliability. The NPCC Audit Team lauded the ISO's operating performance over the past three years – concluding that they had no improvement recommendations or areas of concern for the ISO.

Our work plan for 2016 and beyond includes efforts to address NERC Planning, Modeling, and Relay Protection and Critical Infrastructure Protection Standards. These involve:

- Studying long-term system needs using new contingencies and criteria
- Verifying that transmission owners identified facilities for physical protection in a manner consistent with their risk assessment study methodology

- Assessing new dynamic operating characteristic information provided by generation owners
- Studying the impact of geomagnetic disturbances
- Preparing to start comparing actual steady-state system performance and dynamic system events to simulations in 2017

Cybersecurity

The ISO has been working on several cybersecurity initiatives, as part of its commitment to protecting the grid:

- To be able to detect, withstand, and recover from any cyberattacks, the ISO has implemented an extensive system of process controls, advanced detection and response systems, and redundancy in systems and control centers.
- The ISO participated in NERC's GridEx III exercise on cybersecurity and physical security in November 2015.
- Building on existing tools, we launched the 24/7 Security Operations Center late 2015 to provide round-the-clock monitoring of the ISO network.
- An IT Asset Management System is being implemented to improve inventorying and monitoring of hardware and software assets.
- A transition is underway to NERC's revised critical infrastructure protection cybersecurity standards, effective April 1, 2016, which represent significant progress in mitigating cyber risks to the bulk power system.
- All ISO employees participate in annual cybersecurity training.

The ISO's financial statements and other metric reports are available online.

www.iso-ne.com/about

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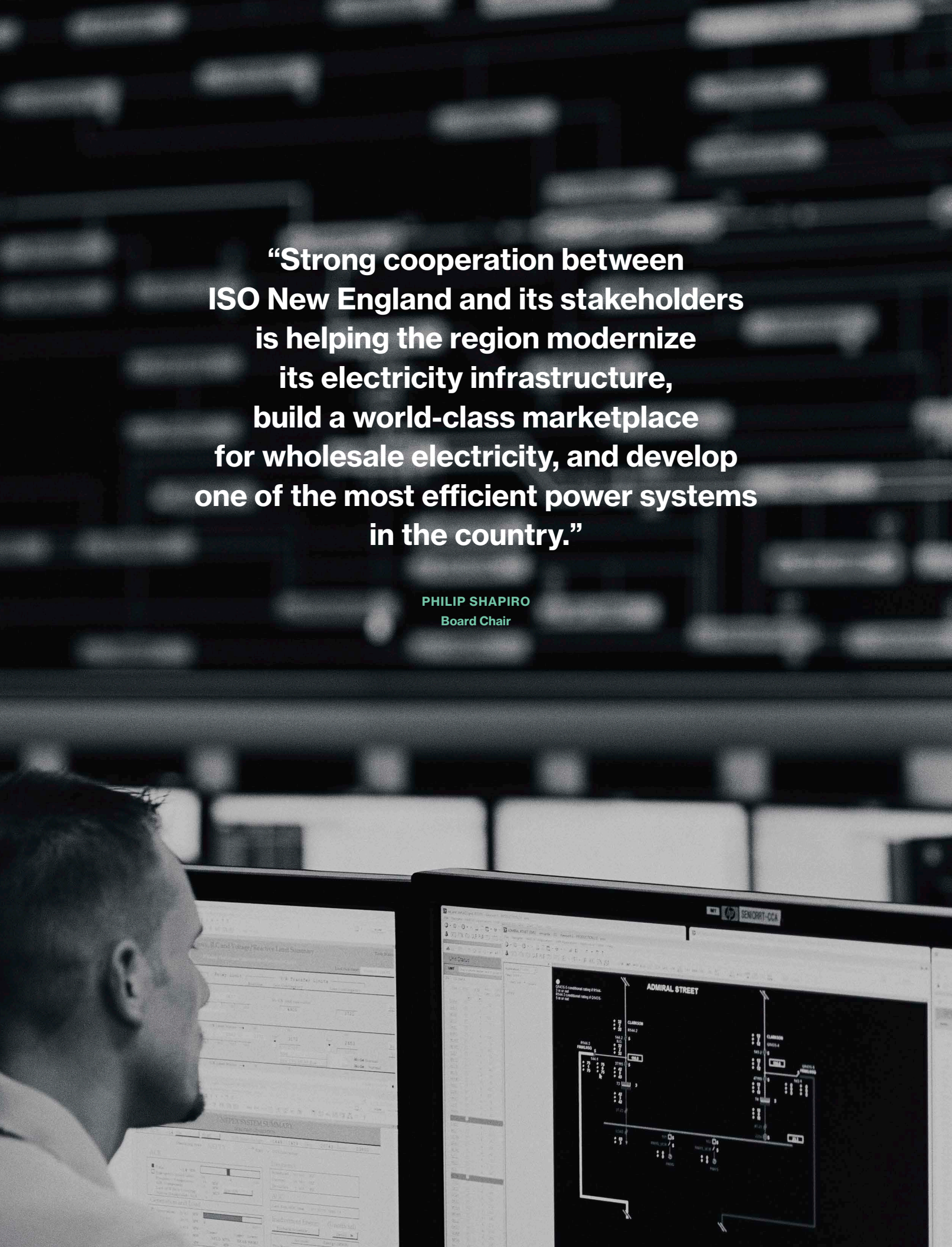

“Strong cooperation between ISO New England and its stakeholders is helping the region modernize its electricity infrastructure, build a world-class marketplace for wholesale electricity, and develop one of the most efficient power systems in the country.”

PHILIP SHAPIRO
Board Chair


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