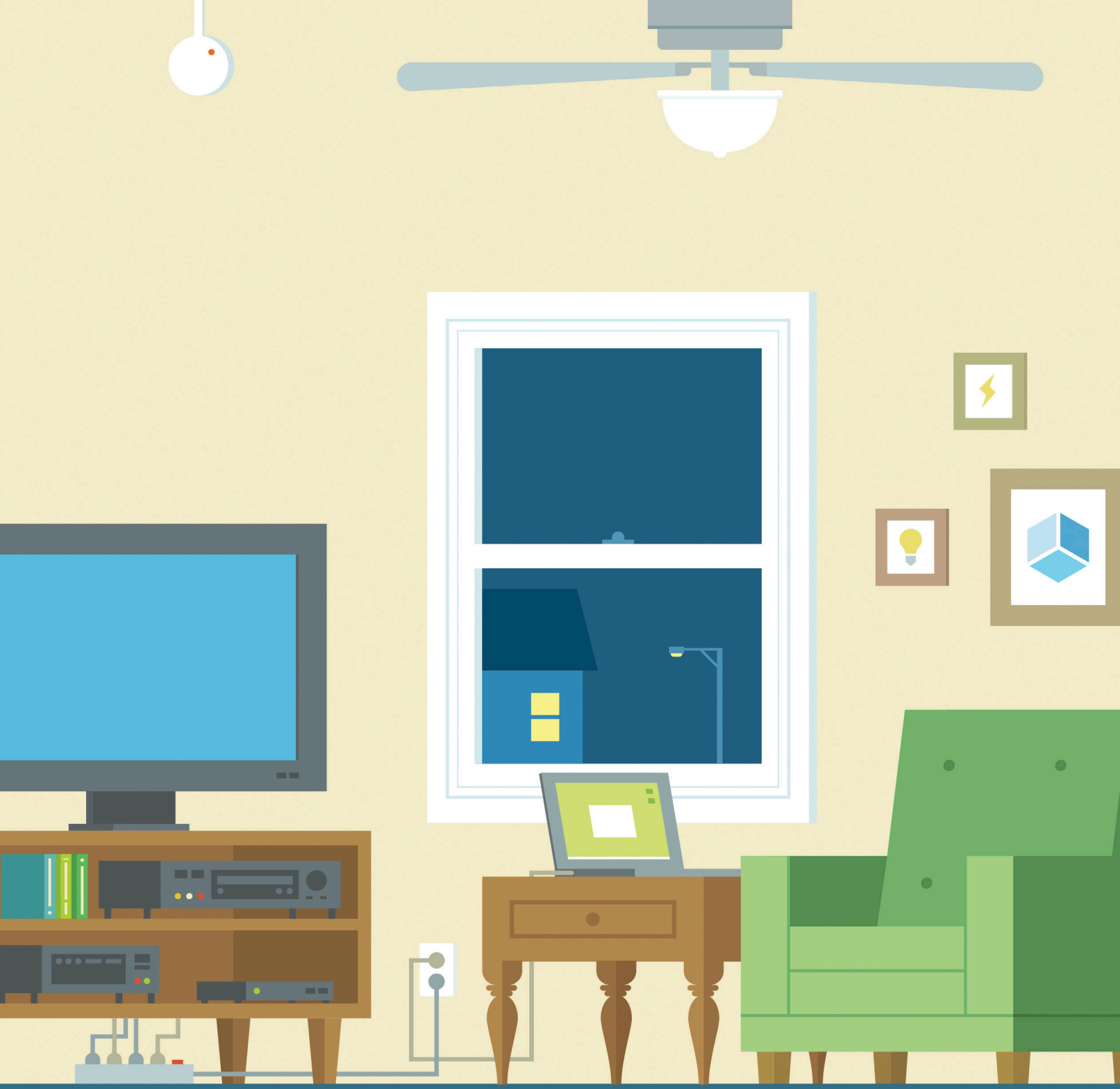
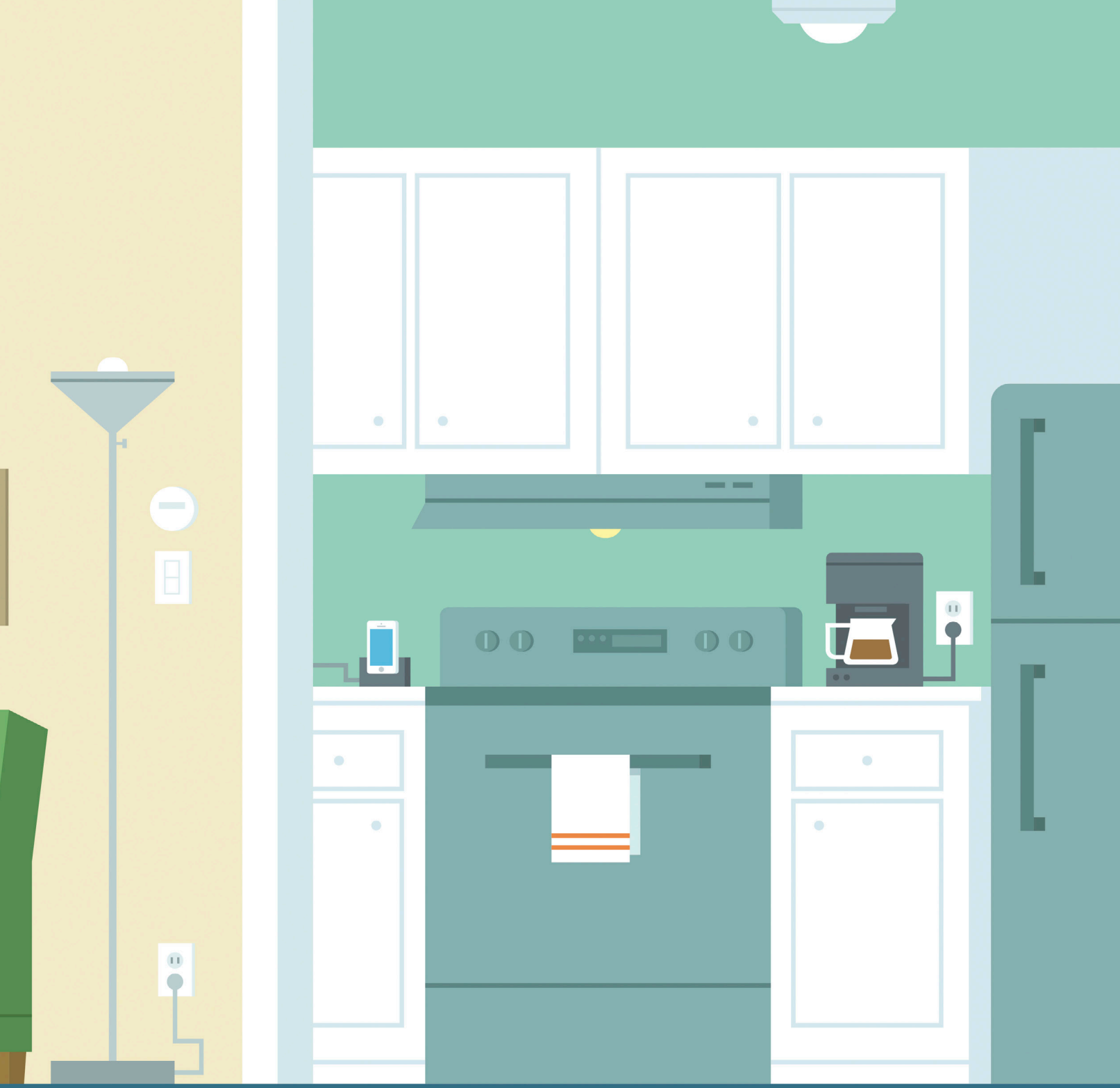
ISO new england

ISO New England

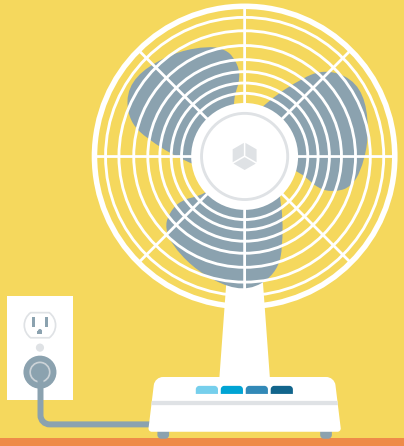
2015 Regional Electricity Outlook



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.



ABOUT THIS REPORT

The ISO'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. Together with the *Regional System Plan* and *Wholesale Markets Project Plan*, the *Regional Electricity Outlook* 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.

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Please note: The facts and figures in this report were current at publication in January 2015. However, the ISO is continually generating data and analyses. For the most current information, please visit 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.

Since ISO New England began serving the region in 1997, one of its central tenets has been that well-informed, engaged stakeholders are vital to the success of competitive wholesale electricity markets and regional system planning.

To this end, the ISO remains committed to striving for transparency in its market rules, operations, forecasting, analyses, and budgeting, and to the timely sharing of information.

The *Regional Electricity Outlook* (REO) is part of that effort — as are the *Regional System Plan* and the *Wholesale Markets Project Plan*. Through this trio of annual reports, the ISO provides a comprehensive overview of the evolving issues affecting the region's power system and actions underway to ensure continued reliability.

This year's REO focuses on the challenges related to New England's transition from a system dominated by grid-connected fossil-fired and nuclear generation to one that incorporates significantly more renewable generation and distributed resources – including distributed generation, demand resources, and microgrids. One of the most serious challenges is assuring fuel availability for the growing fleet of natural-gas resources that has replaced many of the region's coal and oil units, and which will be vital for balancing the variable output from wind and solar resources. This report also provides an update on market changes and other efforts to address our regional challenges, improve the day-to-day performance of New England's power plant fleet, strengthen the ISO's ability to reliably operate the grid, and further attract and retain the flexible resources that tomorrow's grid will rely on.

Key ISO efforts to innovate for the region and to engage stakeholders are described here, including the nearly 100 stakeholder committee meetings held in 2014 and the launch of a redesigned website that makes information easier and quicker to find. The ISO shares a multitude of data, market reports, training materials, and other informative documents via this online portal at www.iso-ne.com.

I consider chairing the ISO Board during this period of industry transformation a great privilege, and I thank you for your ongoing support and contributions as we work together to help shape the region's energy future.

Sincerely,

Philip Shapiro
Board Chair

From the CEO

New England is at the forefront of a rapid transformation underway in the country's electricity industry: environmental policies, low-cost shale gas, and technological advances are causing a turnover in the nation's power plant fleet.

Gordon van Welie is president and chief executive officer of ISO New England. Read his full bio at www.iso-ne.com.

Because New England has been experiencing the effects for some time now, its response is not only shaping the future of the grid, but serving as a model for the rest of the nation on how to adapt.

This isn't the first time New England's electricity industry has reinvented itself. The restructuring of the 1990s unleashed the power of market competition. Coupled with state energy policies and stakeholder collaboration, this dynamic force yielded substantial infrastructure investment and drove tremendous innovation and efficiencies in New England – and continues to do so.

Generating capacity – About 15,000 megawatts (MW) of high-tech, low-carbon-emitting generation and demand-side assets have been attracted to the region so far. Project proposals for 9,500 MW of new natural gas and wind-powered generation are competing to replace roughly 3,500 MW from resources retiring by 2018.

Transmission – To date, the region has invested approximately $7 billion in transmission expansion to move lower-cost electricity more efficiently across New England, with $4.5 billion more planned.

Consumer benefits – Regional advancements have bolstered power grid reliability, lowered electric energy costs by reducing congestion on the transmission system, and reduced air emissions well ahead of much of the rest of the country.

Transformation, however, can be difficult. Natural gas supplies in the region have become insufficient to serve power generation needs during cold winter days. Rapid retirements of non-gas power plants are straining the grid's ability to meet New England's peak electricity demand and, coupled with the development of renewable resources, will continue to increase dependence on natural gas to produce electricity. The region is now experiencing wholesale electricity price volatility because the markets are signaling that investment in energy infrastructure is needed for the power system to continue to provide a reliable supply of competitively priced electricity through this transition.

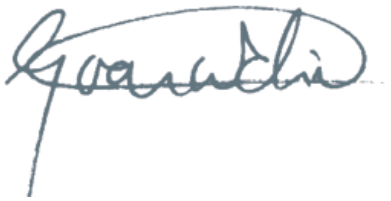
The ISO is addressing the challenges associated with fuel assurance for natural gas generators and retiring resources by fine-tuning the energy, reserves, and capacity markets to bolster infrastructure proposals in the right locations and better encourage generators to make investments to secure their fuel supply and perform as needed to ensure reliability. But many complicated, interconnected factors are at play that will affect how the region weathers this transition, including the way and speed at which the natural gas industry contracts for and builds pipeline, the pace at which the New England states seek to transition to renewable energy, and how quickly market

participants will retire old assets and invest in new ones. The ISO, state officials, and market participants will have to cooperatively tackle obstacles to the development of needed energy infrastructure, which may likely include a combination of new resources, natural gas pipeline, liquefied natural gas storage, dual-fuel capability for gas generators, and high-voltage transmission lines to enable greater delivery of renewable energy.

The evolving energy landscape has brought about a very active stakeholder process in recent years for exploring and negotiating solutions. There are many different views and ideas on how the region should manage this turbulent period when billions of dollars of future investments and energy revenues are at stake. Yet as a group, we have always been able to work toward the best possible outcomes for the region. Close collaboration will continue to hold the key to ensuring that today's grid in transition remains capable of meeting the electricity needs of New England's residents and businesses.

ISO New England remains committed to helping the region seek an efficient and sustainable response to regional challenges, as described at length in this report, while keeping our sights firmly fixed on the ISO's central mission: ensuring the reliability of New England's power grid. We will do this with the same high level of expertise, transparency, and judicious spending we have demonstrated in serving the region for the past 17 years. I look forward to working with our many colleagues in the industry and state agencies to craft solutions during these extraordinary times.

Sincerely,



Gordon van Welie
President and
Chief Executive Officer

"[Our] stakeholders **are vital** to the success of competitive wholesale electricity markets and regional system planning."

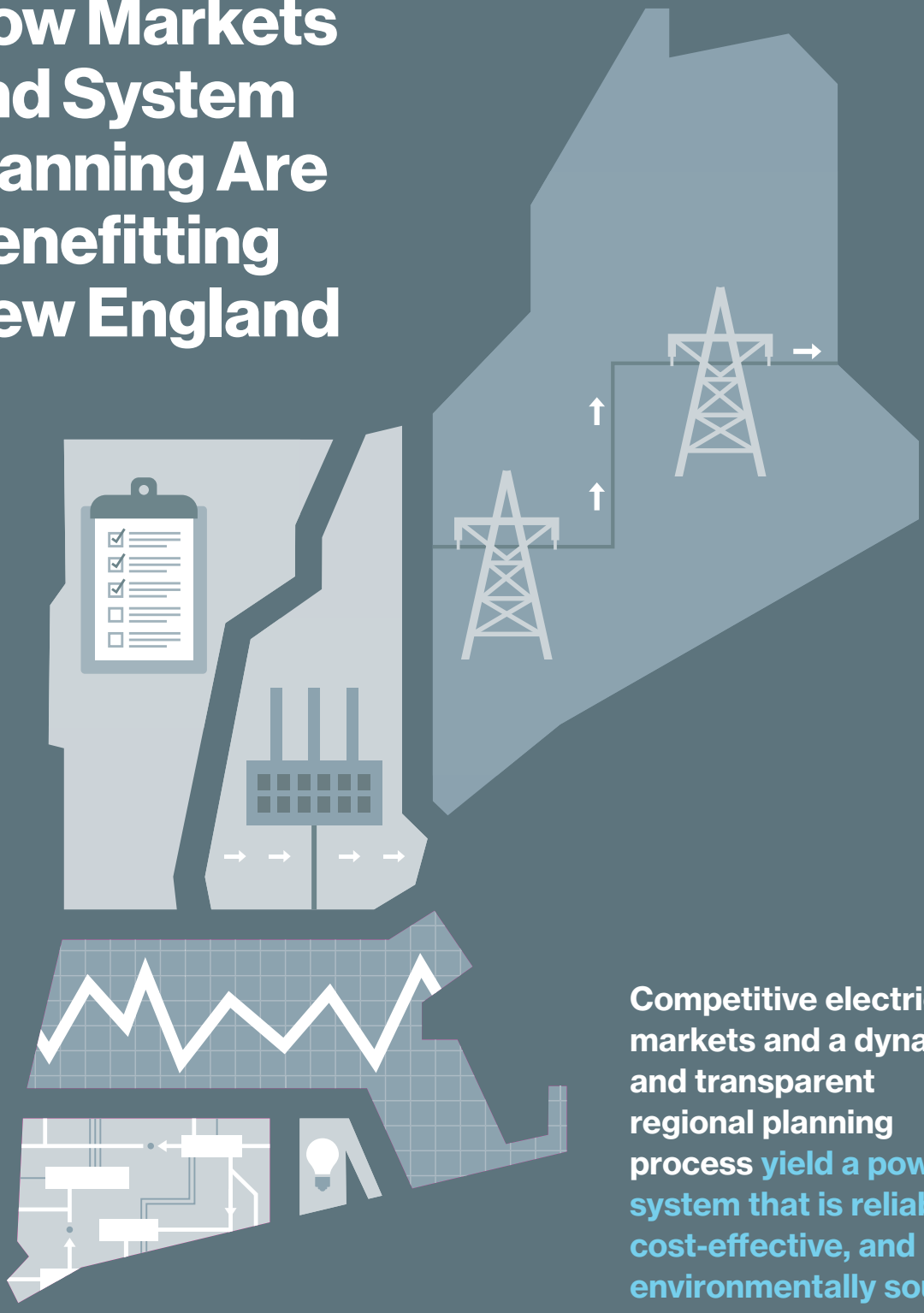
PHILIP SHAPIRO

"**The markets are signaling that investment in energy infrastructure is needed** for the power system to continue to provide a reliable supply of competitively priced electricity through this transition."

GORDON VAN WELIE

Getting Results

How Markets and System Planning Are Benefitting New England



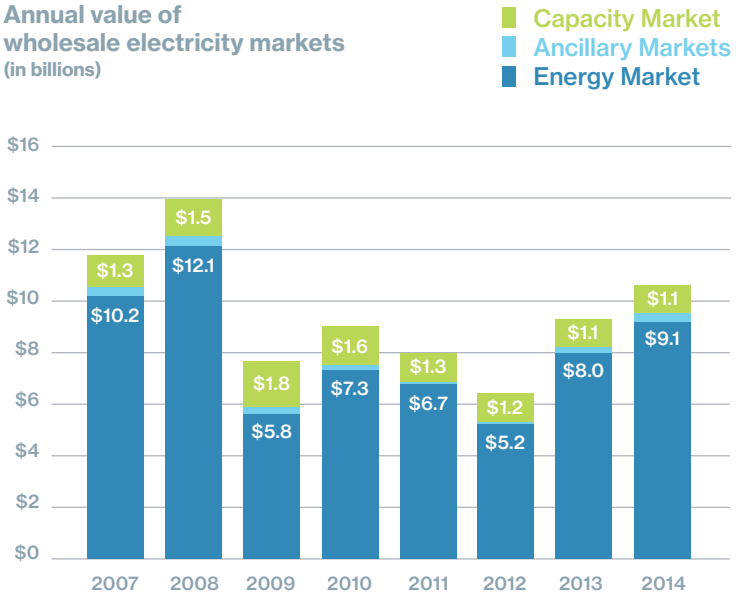
Competitive electricity markets and a dynamic and transparent regional planning process yield a power system that is reliable, cost-effective, and environmentally sound.

Wholesale Electricity Costs Reflect Wholesale Market Conditions

The restructuring of New England's electric power industry in the late 1990s created an open, competitive marketplace by ensuring a level playing field for a large and diverse mix of participants. New England's suite of world-class energy, capacity, and ancillary services markets facilitated the competition necessary to drive buyers and sellers to develop more cost-effective ways of producing and delivering electricity, to invest in new resources and technologies, and to manage electricity use – a strong process that continues today.

ENSURING COMPETITIVE PRICING

The wholesale electricity marketplace allows the ISO to secure sufficient electricity and related services for the region at the lowest prices. Those prices reflect suppliers' costs of delivering power to meet consumer demand, with fuel costs being the biggest component for most power resources. In 2014, the region's spending on wholesale electricity continued its upward trend, tracking natural gas prices and the loss of electricity supply in the region. The price of natural gas is a major determinant because of the large role gas-fired generators play in New England. (See page 14.) This trajectory in electricity prices is likely to continue over the next five years.



ATTRACTING POWER-RESOURCE INVESTMENT

Another important market function is to allow competitive market prices to signal when investment is needed and in which parts of the region. Higher prices typically reflect the need for new power resources, improved transmission, or both. (Today's higher prices also indicate the need for additional natural gas infrastructure or investment in alternative sources of energy to offset the demand for natural gas. See page 15.) Because private firms, not public utilities, pay for building new generation resources, consumers are shielded from the investment risks they had been exposed to before the introduction of competitive markets.

- The marketplace has attracted **more than 400 buyers and sellers** to the region, growing from just 200 in 2000. Greater numbers of market participants help ensure competitiveness.
- **Private investment in about 15,000 MW** of new, efficient, low-carbon-emitting generation has been brought in since 1997 when the ISO began operations.
- **About 9,500 MW of new generation projects** were being proposed as of January 2015, with over 25% situated close to load centers, which helps reduce the need for transmission system improvement.

PROMOTING EFFICIENCY GAINS

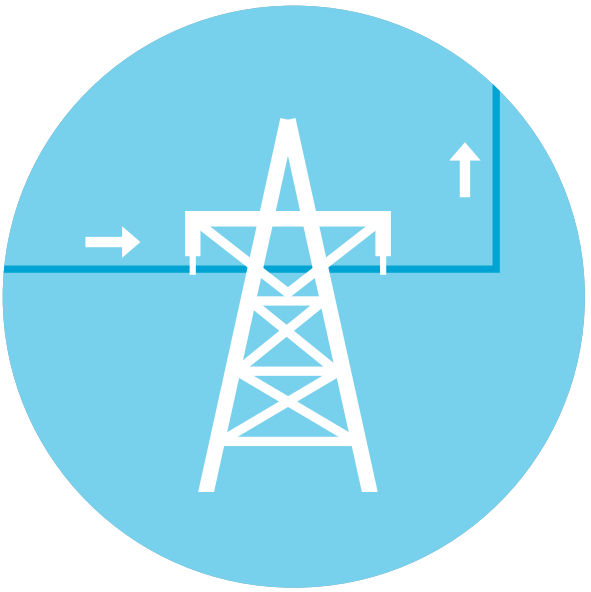
Open markets create incentives for power suppliers to improve their competitiveness. Some newer gas-fired resources, for example, are using technology improvements to more efficiently generate electricity – and therefore be more profitable – than older ones. Conversely, market forces can push out less competitive participants. More than 4,000 MW of primarily older, less efficient, and higher-emitting resources have already left the market, with another 3,500 MW exiting by 2018.

Demand resources compete in the markets by reducing the electricity consumers pull from the power grid. An added benefit is that they help minimize the need for new generation and transmission projects. Demand resources include load management, distributed generation, and energy-efficiency (EE) projects. New England now has about 1,200 MW of active demand response and about 1,500 MW of EE resources with capacity supply obligations in the Forward Capacity Market. State-sponsored EE programs are leading the way in this expansion, and the ISO's efforts to analyze the long-term impacts are ongoing. (See page 28.)

IMPROVING AIR QUALITY

Market forces and environmental policies have significantly driven down the use of oil- and coal-fired generation over the last two decades. As a result, the region leads much of the rest of the country in clean-technology investment. These factors have resulted in significant declines in regional air emissions over the long term. From 2001 to 2013, annual emissions for nitrogen oxides (NO_x), sulfur dioxide (SO_2), and carbon dioxide (CO_2) declined by 66%, 91%, and 23%, respectively. However, oil- and coal-fired electricity production has risen over recent winters, driving up emissions. (See pages 17 and 23.)

Transmission Upgrades Improve Reliability and Access to Cheaper, Greener Electricity

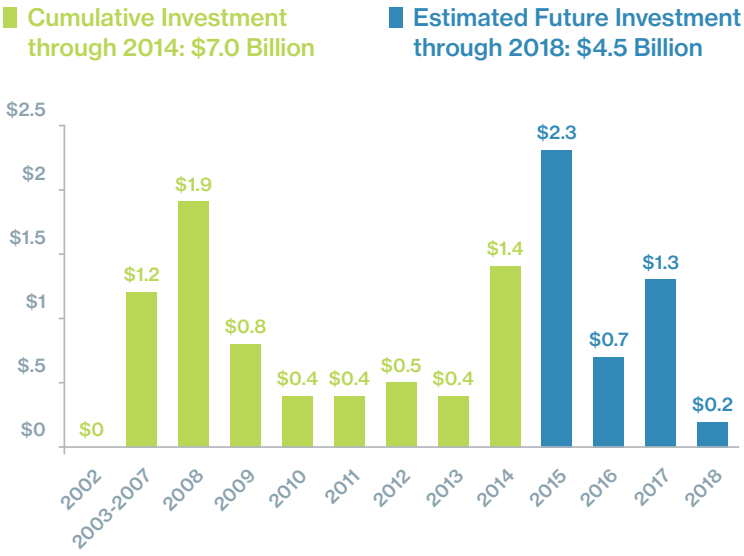


Each year, the ISO develops the *Regional System Plan* (RSP), a roadmap of system needs, in collaboration with stakeholders. The RSP looks out on a 10-year horizon, taking into account factors such as consumption patterns, power plant retirements, renewable resource development, and the impact of public policies on the regional power system. Based on the needs described in the RSP, the ISO works with New England's transmission owners to initiate projects to reinforce the reliable and efficient movement of electricity throughout the region. Since 2002, over 550 transmission upgrades totaling about $7 billion have been put in service across the states.

- Upgrades to date include **14 major 345 kV transmission projects** (11 completed) to reinforce load pockets, such as Southwest Connecticut and Boston, as well as less-densely populated areas, such as northwest Vermont.

- Improved transmission has virtually **eliminated congestion** on the system and decreased dependence on generating units located in load pockets.
- In the Greater Boston area, the Salem Harbor Station retirement in 2014 reduced generation resources in the area by over 20% (749 MW). To address immediate reliability concerns, **upgrades to five transmission lines** were identified and have been placed in service.
- **New interconnections** with neighboring power systems have been placed in service, which increases the ability of New England to import power from Canada.

New transmission investment in New England to maintain reliability (in billions)



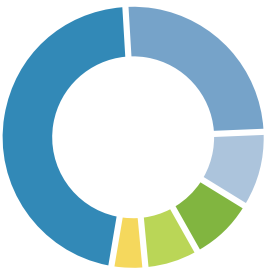
Estimated future investment includes projects under construction, planned, and proposed.

Source: *ISO New England RSP Transmission Project Listing*, October 2014

Approximately $4.5 billion more in transmission investment is projected through 2018 to meet reliability requirements, improve the economic performance of the system, and position the region to integrate renewable resources and alternative technologies. Furthermore, in its efforts to better align the transmission planning process and wholesale markets – and in response to stakeholder requests for more details about resources that could meet system needs – the ISO is now evaluating market resource alternatives (MRAs) to transmission upgrades. The ISO has begun analyzing MRAs in load pockets and will continue additional MRA analysis in 2015.

Shared benefits, shared costs

The costs of transmission projects required to satisfy a reliability need are shared by consumers across New England because all consumers benefit when the reliability of the region's highly interconnected network is improved. The costs are allocated to each state based on electricity use.



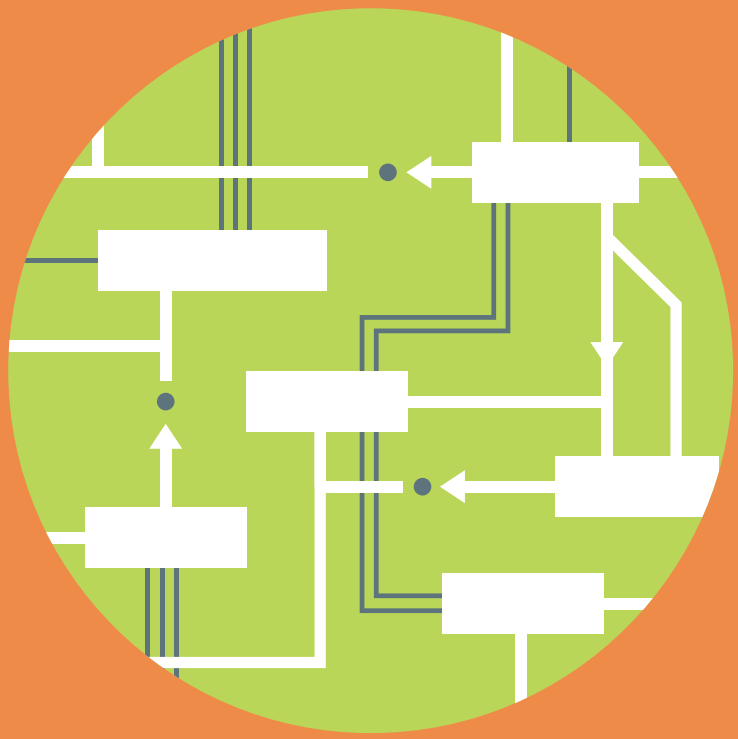
- Massachusetts: 46.6%
- Connecticut: 25.2%
- New Hampshire: 9.3%
- Maine: 8.2%
- Rhode Island: 6.7%
- Vermont: 4.0%

FOR MORE INFORMATION

To learn more about the region's markets, power system planning, and emissions, please see the *Wholesale Markets Project Plan*, *Regional System Plan*, and *Electric Generator Air Emissions Report* available at www.iso-ne.com.

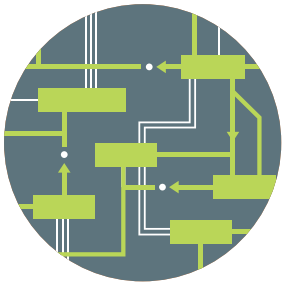
The Grid in Transition

Serious Challenges Loom as the Industry Evolves



The grid of the future is coming into sharper focus every day. It holds great potential benefits for the businesses pioneering tomorrow's technologies, for individual consumers, and for the region as a whole. But it comes with challenges that the ISO is helping address.

Ensuring Grid Reliability



Modern life and business are built around the dependable flow of electricity, which makes ensuring power system reliability the top priority for grid operators and planners such as ISO New England. Fulfilling that responsibility and meeting mandatory reliability standards require the ISO to keep the demand for and production of electricity in careful balance. To accomplish this, the ISO must be able to accurately predict patterns of electricity consumption and have a generating fleet it can count on to quickly follow dispatch instructions. Both forecasting and dispatch are getting much more complex.

Yesterday's Grid: Centralized, Diverse, More Predictable

As recently as 2000, several different fuels played a more prominent role in powering the region's fleet: coal, oil, nuclear, natural gas, and hydro. These types of fuels and their adequate supply helped give the region consistent electricity production, while on the demand side, daily patterns of peak electricity use were relatively predictable.

The Hybrid Grid: Moving toward a Greener, More Distributed, Less Predictable, More Vulnerable Power System

The majority of resources on the power system today are traditional, grid-connected generators fueled by imported fossil fuels. But public policy initiatives to curb emissions, advances and price drops in technology, and market forces (e.g., the availability and prices of power plant fuels) are driving an evolution in electricity production, delivery, and use in New England.

- Over the next several decades, the region's fleet will increasingly include wind and solar units whose output varies with the weather and time of day. Gas-fired generators, with their quick-start and ramp-up abilities, will prove vital in being able to pick up the slack when output drops from those units – or when demand unexpectedly increases.
- Coal and oil units will offer little – if any – generating capacity.
- Widespread residential solar-power systems, electric vehicles, smart meters, and smart appliances will change not only how much electricity people draw from the grid, but when they draw it. Daily demand peaks could begin shifting.
- And as the grid grows increasingly "smarter," it will require more investment in measures to defend against cyberattack.

Factors such as these are already having profound effects on the grid and how all its related systems must be planned, designed, and operated. As policymakers seek to reduce carbon emissions in other sectors, even greater demands will likely be placed on the regional electric grid – for example, as electric vehicles help decarbonize transportation.

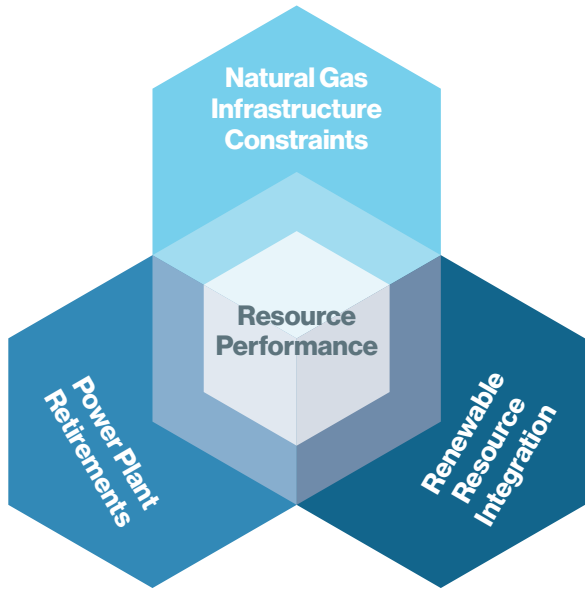
Challenges to Grid Reliability

Today, the region is traversing uncharted territory between the grid of the past and the grid of the future. For the past several years, the ISO has been concentrating on the factors that are most dramatically affecting the performance of power system resources and grid reliability during this transition:

- Natural gas infrastructure constraints
- Power plant retirements
- Renewable resource integration

Addressing these interrelated challenges is critical for ensuring that as the power system evolves, it continues to provide the same exceptional level of reliability for New England that it has to date. To keep pace with the changes, the ISO has been actively adjusting its operations, markets, and system planning processes.

These challenges are also driving an upward trend in wholesale electricity prices as the marketplace signals where investment is needed – a matter of particular importance to regional policymakers, businesses, and households.

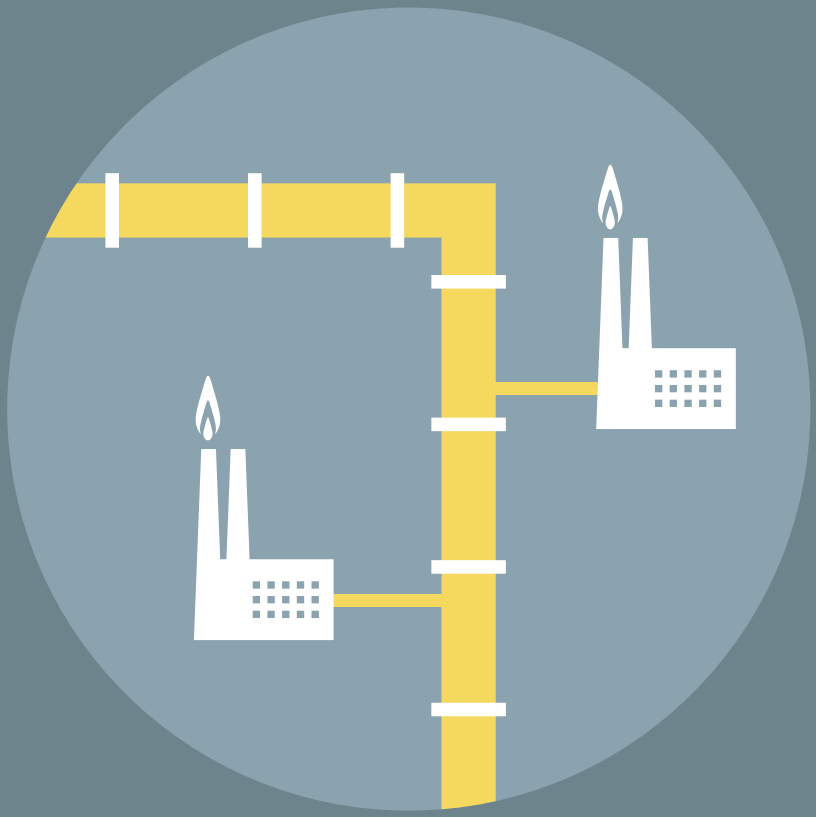


The Strategic Planning Initiative (SPI)

Major grid challenges were identified in 2010 through a collaborative, regional effort led by the ISO called the Strategic Planning Initiative (SPI).

Natural Gas Infrastructure Constraints

Inadequate Fuel Availability for Almost Half of Power Plant Fleet



The performance of the largest and most flexible portion of the region's generating fleet is being weakened by insufficient natural gas pipeline and LNG storage in the region.

The Rise of Natural Gas-Fired Generation

Natural gas has become the dominant fuel used to produce electricity in New England. Cleaner burning, highly efficient, relatively easy to site, and less expensive to build than other types of generators, natural gas combined-cycle units have made up the majority of the generating capacity developed by private investors since the late 1990s. With continuing technology improvements and inexpensive supply of fuel right at the region's doorstep in

the Pennsylvania and Ohio portions of the Marcellus Shale, natural gas remains the top fuel of choice for power plant construction, making up 57% of the new resources requesting interconnection to the grid. Natural gas generation's importance in the region is likely to grow as ISO system operators rely on these fast-responding units to balance increasing amounts of variable generation (i.e., wind and solar) on the system and as additional older, less flexible non-gas units retire.

The region's transition to low-carbon-emitting natural gas has helped the region meet environmental goals, and until recently, this fuel was helping to decrease the wholesale cost of electricity.

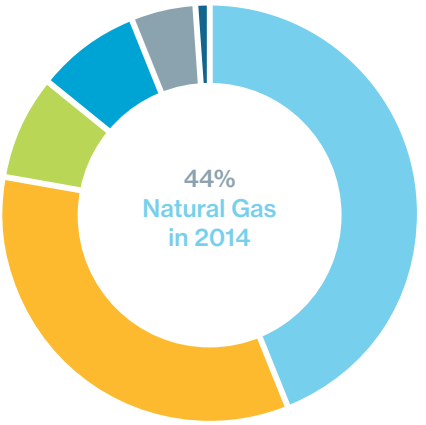
Increasing Fuel Availability Problems

During the last couple of years, a number of factors have been affecting the ability of natural gas plants to get the fuel they need to perform.

- **Inadequate infrastructure:** The existing pipeline system in New England is reaching maximum capacity more often, especially in winter. There is only so much space on a pipeline, and priority goes to customers who've signed long-term contracts. In New England, that's been the local gas distribution companies (LDCs) – the gas utilities that serve residential and commercial customers.

Dramatic changes in the energy mix

The fuels used to produce New England's electric energy have shifted as a result of economic, technological, and public-policy factors.

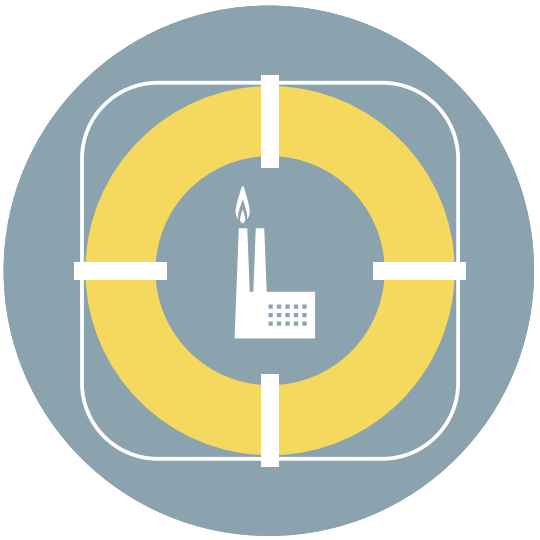


NET ENERGY

	2000	2014
Natural Gas	15%	44%
Nuclear	31%	34%
Renewables	8%	9%
Hydro	7%	8%
Coal	18%	5%
Oil	22%	1%

- **Interruptible fuel arrangements:** Most natural gas plants procure pipeline transportation on a day-to-day basis from LDCs. As more people and businesses in New England have converted to natural gas to take advantage of inexpensive shale gas, LDCs have had less pipeline capacity to release. There is also more competition among increasing numbers of gas-fired generators, which means generators risk not being able to obtain pipeline transportation for the gas needed to fuel their plants.
- **Expensive alternatives:** Fuel costs can be exacerbated by the price of liquefied natural gas (LNG) used to meet spikes in demand. Some generators can use LNG when the region's pipelines are fully congested. However, LNG tends to be four to five times more expensive than the typical price of gas from the Marcellus Shale because it is currently sourced and priced internationally.
- **Out-of-sync markets:** Natural gas and wholesale electricity markets in New England have different schedules, leaving generators short on time to arrange fuel for the operating day. This issue – as well as recent and proposed changes to address it – is described in more detail on page 36.
- **Limited fuel storage:** Unlike generators that use others types of fuel, many natural gas plants in the region have limited or no on-site storage, making them even more vulnerable to the pipeline supply

problems. Dual-fuel capability allows switching to oil when necessary, but only about 40% of the region's gas-fired units currently has this ability. The winter reliability program (see page 35) and Pay-for-Performance incentives in the Forward Capacity Market (see page 37) are helping to incentivize more investment in this technology, as well as some incremental investment in LNG storage.



Impact: Reliability Risks

Because natural gas plants make up such a large part of the generating fleet, the availability of this fuel has an immediate effect on power grid reliability. For example, the planned or unplanned outage of a major gas pipeline at any time of year would impact many thousands of megawatts of generation. Additionally, when gas-fired generators are unavailable to run or underperform, the ISO may need to commit significant amounts of additional generating resources – mostly oil and coal plants – to maintain system reliability. However, many of the oil and coal plants called on to run require a long time to start and ramp up, may have performance problems related to their age, and may not have enough fuel to run as long as needed. That can leave the ISO in a precarious operating position – unable to respond to an unexpected rise in power demand or a loss of facilities. In addition, many of these resources are retiring, limiting the number the ISO can call on during stressed system conditions. (See page 19.)

Impact: Price Spikes

HIGH FUEL COSTS IN HARSH WINTERS

Fuel costs are the biggest component of wholesale electricity costs. So the price of fuel for natural gas generators – the largest segment of power resources in the region – has a big effect on the region's electricity prices. And pipeline constraints can cause spikes in natural gas prices during very cold winters.

- From 2008 through 2012, the price of natural gas declined significantly in New England with increasing production from the Marcellus Shale and moderate winter weather that resulted in minimal pipeline constraints. Wholesale electricity prices declined concurrently.
- But in the winter of 2012/2013, this began to change. As pipelines into the region ran at full capacity to meet heating needs, New England experienced some of the highest natural gas prices in the country.

OUT-OF-MERIT DISPATCH

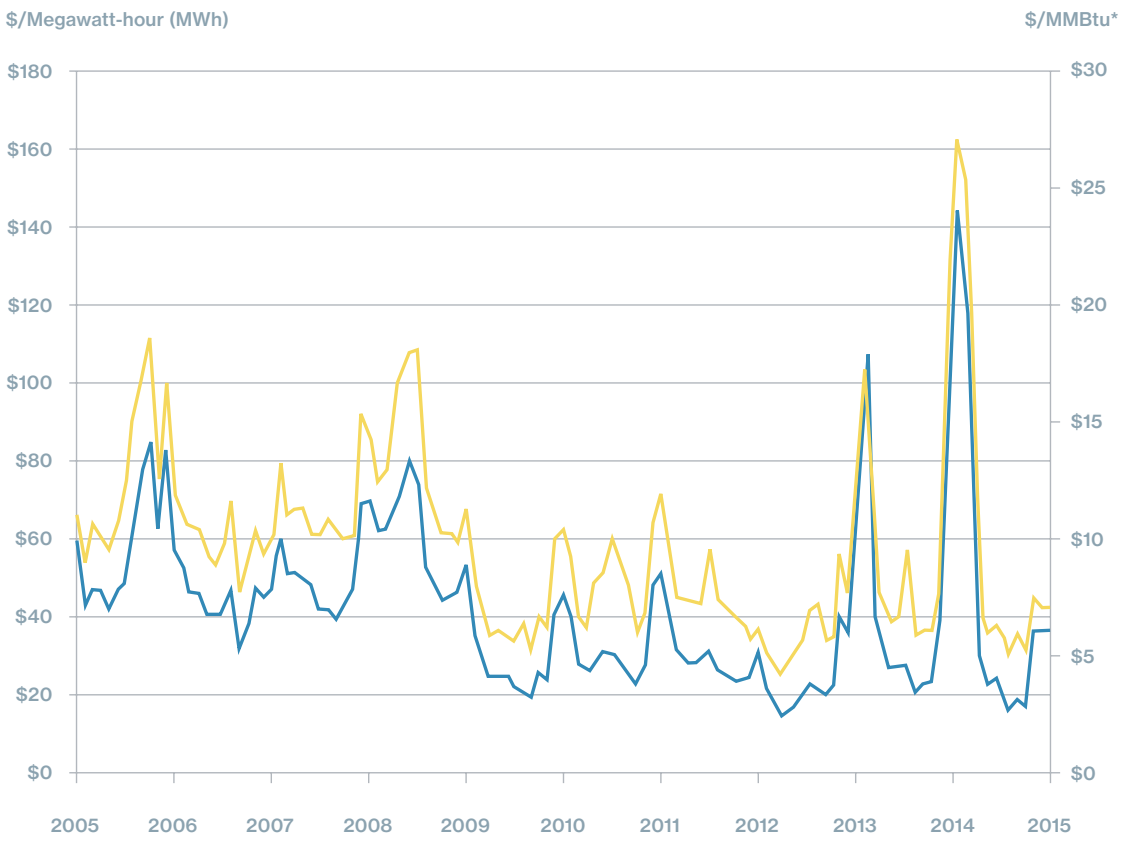
When the gas-fired fleet underperforms because of fuel transportation constraints, it adds to wholesale electricity costs. Net Commitment-Period Compensation (NCPC) payments (aka, "make-whole" payments) are made to resources dispatched out of economic-merit order for the sake of reliability. These payments have become concentrated in harsh winter months when fuel transportation for gas-fired generators is at greatest risk. For example, NCPC payments increased to over $20 million in January 2013 and over $70 million in January 2014. In comparison, NCPC payments for all of 2012 totaled $87 million. During the overall milder winter of 2014/2015, total NCPC payments fell.

RETAIL PRICE INCREASES

Consumers in the region who pay fixed prices for electricity may be shielded from the immediate effects of wholesale price increases. However, as contracts are renewed, the retail suppliers typically build them in.

Natural gas and wholesale electricity prices are linked

Because of New England's heavy reliance on this single fuel source, natural gas typically determines the price for wholesale electricity.



*MMBtu stands for millions of British thermal units.

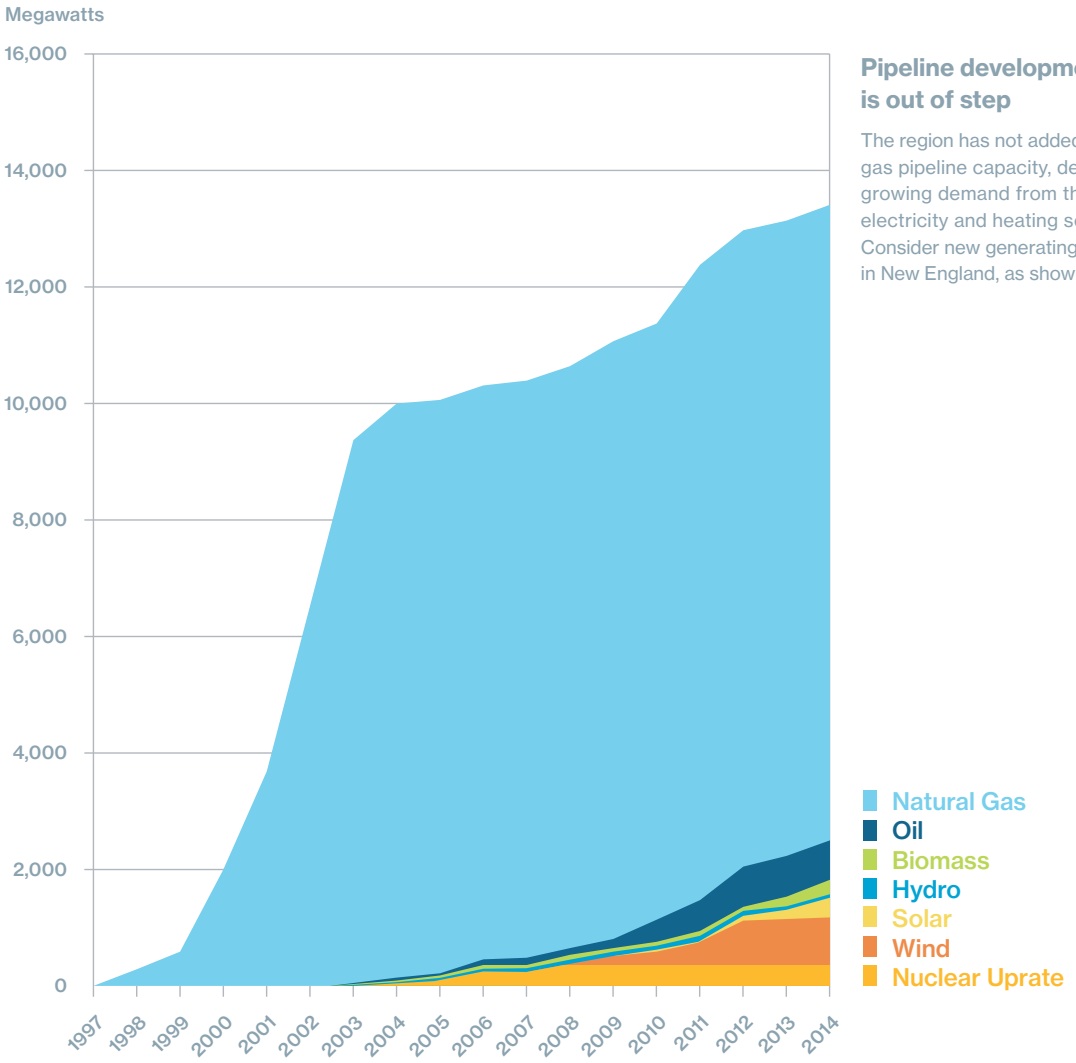
Impact: Increased Emissions

There's an environmental cost when the region can't use its gas-fired units to meet demand. Higher-emitting oil- and coal-fired plants run more often instead, leading to increases in regional air emissions.

The Performance and Infrastructure Investment Gap

Without significant expansion of natural gas pipeline and LNG storage serving New England, the impacts on reliability, price, and emissions are likely to continue. Recent changes in the capacity market create strong incentives for resource owners to ensure performance by investing in capital improvements and firmer fuel supplies, and give developers of new projects more financial certainty to help support those investments through a longer price lock-in. (See page 36 for details.) However, these changes alone are unlikely to spur development of additional natural gas pipeline.

Pipeline funding typically requires customers to commit to contracts of 15 years or more, which traditionally has been done by the gas utilities serving residential and commercial customers. These premium contracts for fixed gas transportation aren't as attractive to gas-fired generators, even though they'd help ensure fuel delivery. Because power resources maintain their competitiveness in the wholesale markets by keeping costs as low as possible, gas generators are likely to choose investment in lower-cost dual-fuel capability, instead, so they can switch to burning oil when the gas system is constrained.



Pipeline development is out of step

The region has not added natural gas pipeline capacity, despite growing demand from the electricity and heating sectors. Consider new generating capacity in New England, as shown here.

Power Plant Retirements

Traditional Resources Rapidly Diminishing

The closing of a substantial number of conventional plants increases reliance on natural gas and makes meeting peak demand more complex.

Age, Economics, and Environmental Policies are Pushing Out Oil and Coal Resources

Rising costs associated with oil and coal and the advanced age of many of the power plants that use these fuels make it difficult for these resources to compete against newer, more efficient generators – primarily natural gas units. For this reason, coal and oil units are now run mainly to meet peak demand, when natural gas plants are unavailable, or when natural gas price spikes surpass oil prices. The region's coal- and oil-fired generators represent about 28% of capacity in the region, but only produced about 6% of its electricity in 2014 – and very few coal units are left.

What's powering New England through the summer peak?

Look at fuel usage during high electricity demand on the peak of a summer day in 2013 – the hottest day in recent years. While coal and oil together produced 20% of peak electricity that day, these resources produced only about 7% of electricity over that entire year.

Natural Gas: 47%
Nuclear: 18%
Oil: 11%
Coal: 9%
Hydro: 10%
Other: 5%

The performance of oil- and coal-fired resources can be uncertain when called on, due to age and infrequent operation, posing risks to reliability. For example:

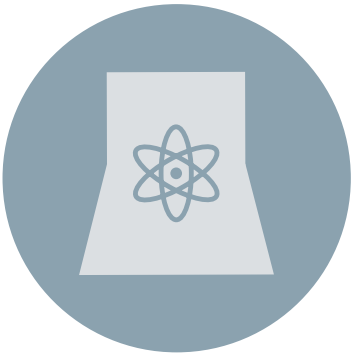
- **Equipment issues** can affect their performance when dispatched. **Unexpected outages** of older or poorly maintained units tend to increase during extreme cold conditions.
- They have **long start-up times.** Up to 24 hours are needed to reach full output, which makes it difficult for ISO operators to rely on these resources.
- Oil units typically keep **limited fuel supplies** on site to avoid the expense of purchasing oil that they may not use. So when called to run, they may not be able to run for very long. However, the winter reliability program (see page 35) has successfully created incentives for these resources to improve on-site oil supplies.

By operating infrequently, these resources can't recover the cost of capital investments to maintain their plants and ensure performance – nor can they afford new control technologies to meet stringent state, regional, and federal environmental requirements. For many, the only option is to retire.

The natural gas price spikes in recent winters have led to oil- and coal-fired units being more economical and thus selected in the energy market to run more frequently in winter. (See page 29.) This revenue stream could delay retirements for some resources; however, it's unclear how long the trend will continue or whether it will be enough to counter other economic and regulatory pressures. For example, once oil resources run more than 9% of the time, expensive capital investments may be required in order to meet air quality regulations. In some cases, state regulations restrict the number of hours that dual-fuel units can burn oil. And over time, the Regional Greenhouse Gas Initiative's cap and trade program for carbon dioxide emissions could make oil and coal less economic fuels.

Nuclear Power Is Waning

New England has long relied on its nuclear plants to help supply baseload power (the region's minimum electricity needs). But the 2014 closing of the Vermont Yankee Nuclear Power Station is another example of how interrelated market and policy forces are shaping the region's generating fleet. Energy prices in the wholesale electricity markets may be too competitive for some nuclear resources because of the shale gas boom – particularly those facing rising operating and capital costs related to age and Nuclear Regulatory Commission requirements. And the building of new nuclear resources in the region is unlikely.



Hydro Power Ebbs and Flows

Hydro power, too, has played a significant role in New England for many years. Many hydro units have been well-suited to providing system regulation and reserves due to their flexible operational nature. But they could lose some of this flexibility as part of state and federal environmental considerations during relicensing; licenses for almost 2,000 MW of mostly pumped storage capacity will expire between 2014 and 2022.

Questions Surround Regional Demand Resources

Demand resources (DR) in New England also currently face an uncertain fate. Ongoing legal challenges to FERC Order 745 (see page 45) could potentially remove some types of DR from the region's wholesale markets. If that happens, the region will need to find a way to support demand response at the retail level.

Retirements Affect Reliability and Prices

Over 3,500 MW of mostly coal- and oil-fired generation is retiring by 2018. And the ISO estimates that several thousand megawatts more is at risk for retirement by 2020. It's an expected market outcome for aging, uneconomic plants to retire at some point. However, the potential magnitude of retirements poses serious challenges to the region with far-reaching effects:

- Given current trends, the majority of the **replacement resources will be natural-gas-fired generation** – further straining regional fuel supplies and potentially driving up energy market prices. (See page 15.)
- Resource retirements, especially when coupled with transmission needs near load centers, can lead to **precarious operating conditions.**
- The ISO is forced to employ **costly, inefficient short-term strategies** to counter reliability risks, such as dispatching resources out of merit, implementing stop-gap energy procurement measures (see page 35), and potentially paying resources to delay retirement.
- Retirements can **drive up prices in the capacity market,** too. The region's Forward Capacity Market (FCM) allows the ISO to purchase commitments from resources three years in advance to provide power when needed. Before the eighth FCM auction was conducted early 2014, more than 3,000 MW of resources announced plans to retire. This resulted in a small deficit in resources needed for 2017/2018, as well as in an insufficient level of participating resources, which triggered administrative pricing rules designed to prevent market manipulation. The result was higher prices, with the 2017/2018 market value estimated at $3.05 billion. The region could see high prices in future auctions because of additional resource retirements, particularly if new generators or transmission projects face siting and permitting challenges that cause significant delays.

Retirements Can Undercut Infrastructure Improvements

Projects to improve natural gas infrastructure can improve fuel supplies for a major sector of the region's generating fleet. (See page 15.) But small gains can be quickly eaten up by retiring units. For example, Spectra Energy's Algonquin Incremental Market (AIM) pipeline expansion project is anticipated to relieve some pressure by winter 2016/2017. Yet, this will be more than offset by the exit of the coal- and oil-fired Brayton Point Station in 2017 – a net loss of capacity in the short term, and a long-term loss of a non-gas resource, as a new project to fill the gap will likely be gas-fired, based on current trends.

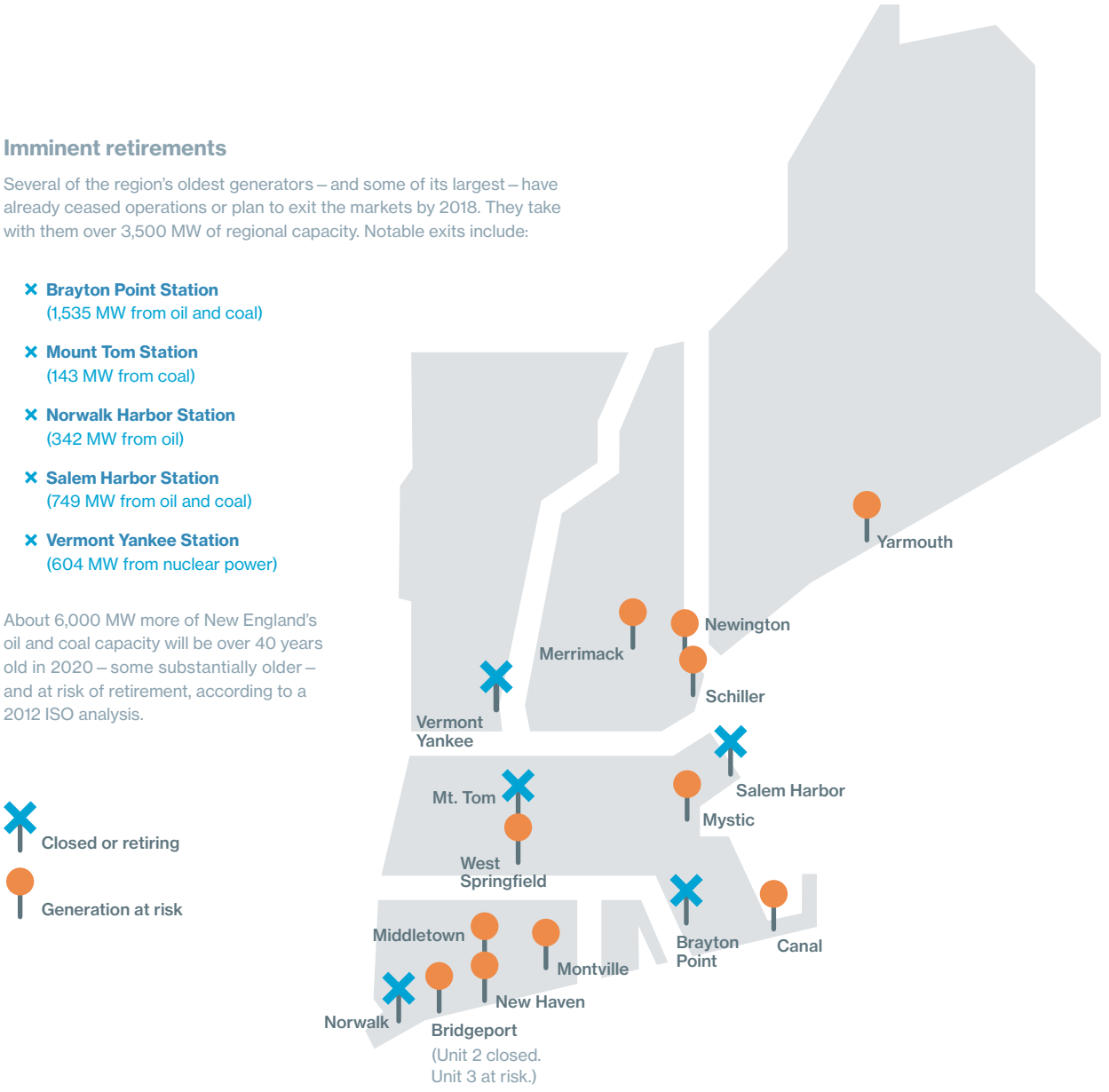
A study commissioned by the ISO highlights the predicament; ICF International's 2014 report projects regional shortfalls of natural gas supply during winter periods through 2020, even with the addition of 450 million cubic feet per day of new pipeline capacity. Recent studies by the Maine Public Utilities Commission and Massachusetts Department of Energy Resources have also noted shortfalls.

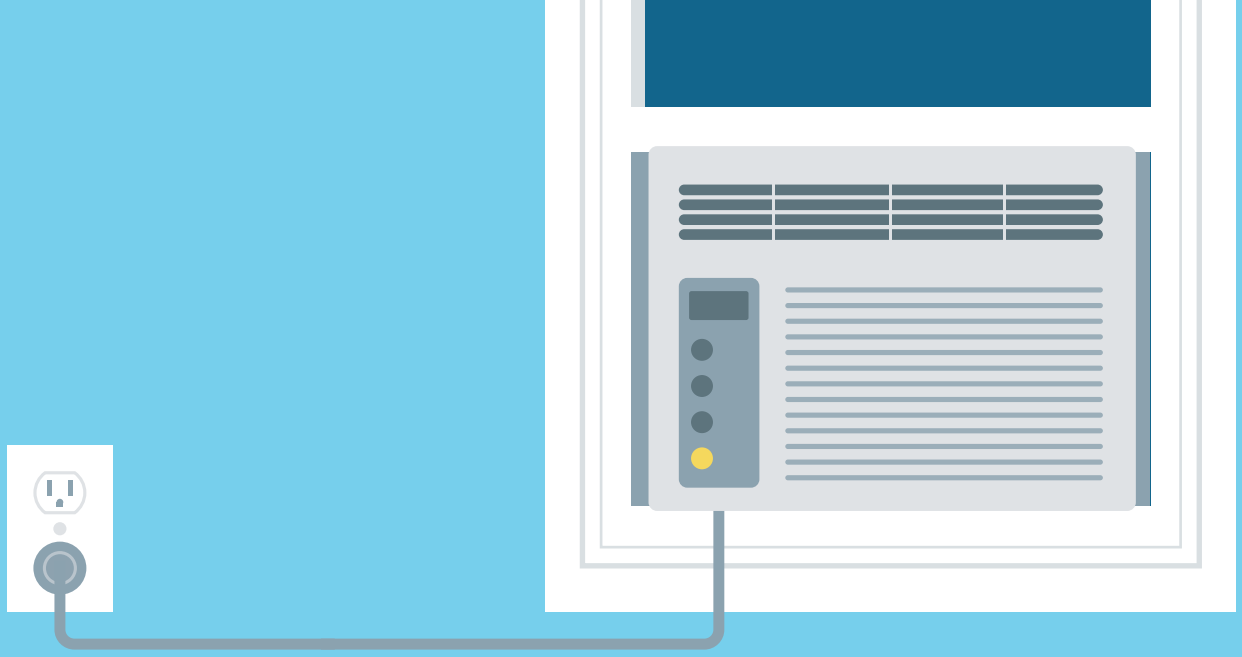
Imminent retirements

Several of the region's oldest generators – and some of its largest – have already ceased operations or plan to exit the markets by 2018. They take with them over 3,500 MW of regional capacity. Notable exits include:

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

About 6,000 MW more of New England's oil and coal capacity will be over 40 years old in 2020 – some substantially older – and at risk of retirement, according to a 2012 ISO analysis.



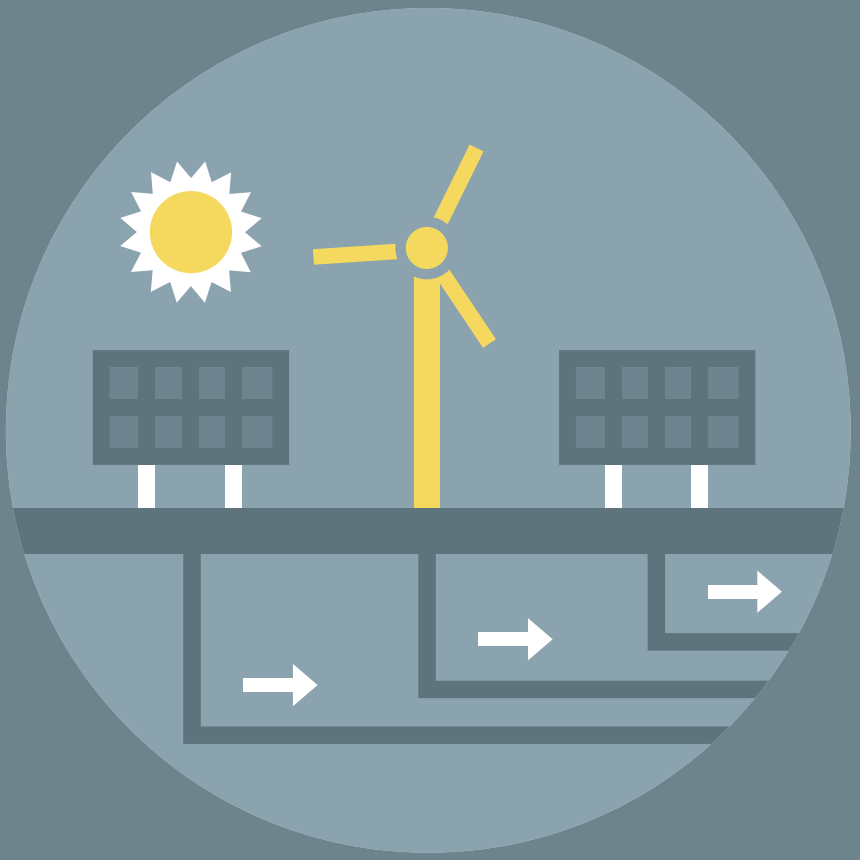


Understanding Peak Demand

If power systems were planned to simply meet average electricity use, there wouldn't be enough electricity at times of very high demand. That is why the power system is designed with enough capacity to meet *peak* demand (the points of highest use) even though it's just a couple of hours each day and for longer periods a few days in winter and summer. Like much of the country, New England's peak demand is growing faster than average demand because of things like greater household air conditioning use. As a consequence of greater peak demand:

- More regional capacity sits idle during non-peak hours. This is one reason a capacity market is so important; it values the region's need to keep capacity available for those peak hours and provides stable revenue to keep resources viable and able to run when called on – even if that's not very often. (See page 36.)
- Air emissions may rise. The units called on to meet peak demand tend to include higher-emitting oil- and coal-fired resources, as well as "peaking units" that are able to respond quickly. Quick-response units are often jet (aero-derivative) or combustion turbines with higher emission rates.

Integrating Renewables



Influx of Complex Resources

Interconnecting more "green energy" will help meet the New England states' environmental goals – but will increase reliance on natural gas and adds to operational complexity.

The Evolution of a Greener Grid

The New England states have set significant goals for increasing the amount of power supplied by renewable energy sources. Wind and solar energy have been expanding dramatically, spurred by state-sponsored programs, federal subsidies, and tax credits. Falling technology costs are also helping to make development of these resources more competitive with traditional power plants, thus enabling their entrance into the marketplace. While wind, solar, hydro, and all other renewable sources of generation taken together (except pumped storage) currently make up only 9% of the region's capacity, over 800 MW of wind projects have already been interconnected to the grid, and 42% of the proposed projects for development in the region are wind-powered.

"Fuels" with Complex Characteristics

Wind and solar resources will eventually help achieve federal and state environmental goals. Paradoxically, the operating characteristics of these renewable resources – which are different than traditional power plants – will increase reliance on fossil-fuel-fired natural gas generators. For example:

- Wind and solar resources can have **rapid and sizeable swings in electricity output** due to wind speed, time of day, cloud cover, haze, and temperature changes (which is why they are called variable or intermittent resources).
- These resources have a **limited ability to serve peak load.** Wind speeds can be at their lowest levels in the summer, while extreme cold and ice can also hinder output. Widespread use of solar power, meanwhile, will likely shift peak net load to later in the afternoon, just as output diminishes with the setting sun.
- **At times, the system can't bear full output** from wind resources. Rules for interconnecting wind resources to the grid are not the same as for traditional power plants. In addition, wind farms are often built in remote areas where the transmission system isn't designed to carry large amounts of power. To avoid overloading the transmission system, the ISO sometimes has to call on wind resources to reduce their electricity output.

What will tomorrow's energy mix look like?

Examining new generator proposals submitted to the ISO as of January 2015, it's easy to see how public policy and economics are driving the industry's choices for tomorrow's fuel sources.

To balance the variable output from wind and solar resources, the power system must hold more fast-start capacity in reserve. The types of units that can come on line quickly are typically natural gas generators and large-scale pumped storage. Large-scale pumped storage represents about 5% of capacity in the region, so it can offer only limited help; new projects are unlikely because of environmental concerns and high development costs. Other types of storage technologies, however, may one day be able to hold enough energy to carry New England through a cold snap or heat wave, making them a cost-effective balancing and peaking alternative to natural gas-fired generation.

The Growth of Distributed Generation and "Behind-the-Meter" Challenges

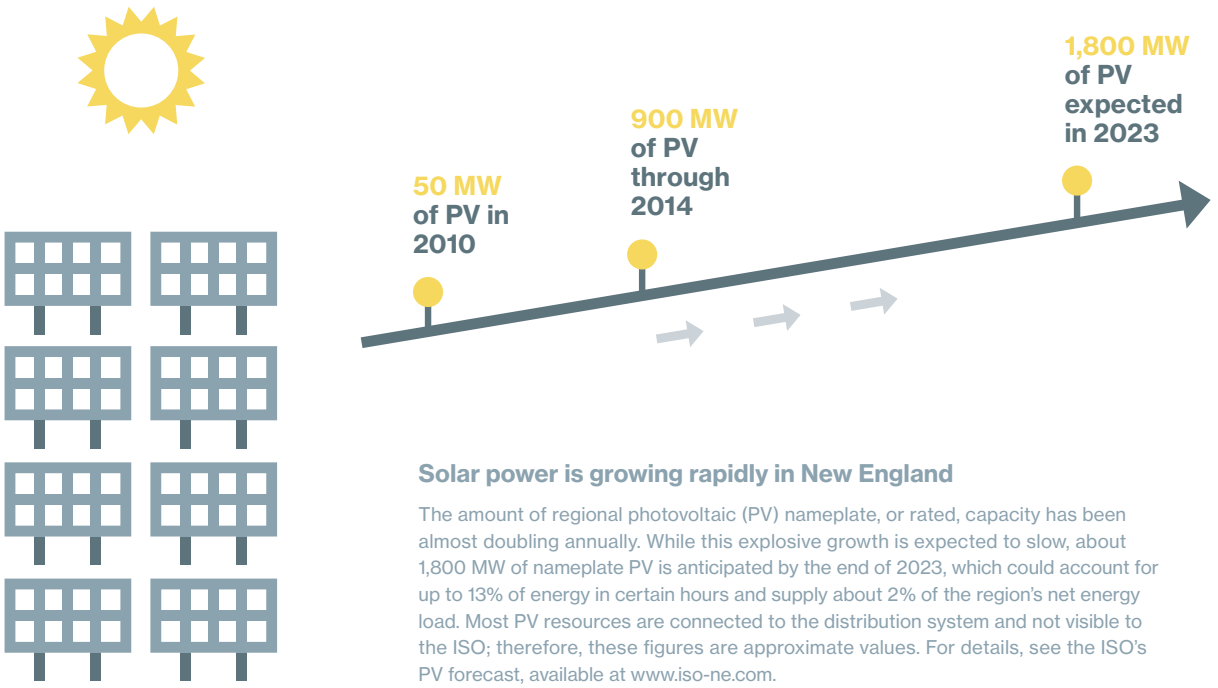
Distributed generation (DG) resources are relatively small, on-site systems (typically 5 MW or less in nameplate capacity) connected behind the meter directly to retail customers or to local utilities – and not to the regional power system. Solar photovoltaic resources (PV) are the largest component of DG by far. The ISO faces reliability issues related to increasing numbers of PV connected to the distribution system:

- **Data gaps** – Output isn't visible to or dispatchable by ISO system operators, making it difficult to account for and forecast in system planning and operations.
- **Inconsistent interconnection requirements** – State regulations typically don't require the ability to withstand system disturbances (such as the loss of a transmission line). If many PV resources tripped off line at once, there could be a sudden, unmanageable surge of demand.

Preparing the System for More Renewables

Integrating a significant percentage of variable resources requires wide-ranging changes across the transmission system, grid operations, markets, and system planning.

- The ISO is working to develop more **sophisticated forecasting and dispatch tools** to help system operators manage resources with swings in output. The ISO is already publishing daily, week-long wind power forecasts that provide greater situational awareness and allow for more efficient use of wind resources.
- The second phase of the ISO's **Wind Integration project** is scheduled to be completed by the end of 2015, adding functionality to incorporate wind and hydro resources into real-time dispatch and wind-power forecasts into the reserves scheduling and procurement processes.
- **Market enhancements** have been made – such as increasing the operational reserve requirements and enhancing performance incentives – to better attract and retain a flexible fleet that can balance renewable resources, and to incentivize fleet performance to ensure responsiveness to rapid changes in system conditions. (See page 32.)
- To quantify and better understand the impact of increased amounts of DG on both grid operations and future grid planning, in 2014, the ISO published its first annual **10-year forecast of regional PV growth and capacity**, available at www.iso-ne.com.
- Billions of dollars in **transmission expansion and upgrades** are needed to connect large amounts of remote wind energy to demand centers or to expand access to Canadian hydro resources. To facilitate this, the ISO is conducting transmission system reliability assessments and working with stakeholders on ways of improving the Elective Transmission Upgrade process.



Solar power is growing rapidly in New England

The amount of regional photovoltaic (PV) nameplate, or rated, capacity has been almost doubling annually. While this explosive growth is expected to slow, about 1,800 MW of nameplate PV is anticipated by the end of 2023, which could account for up to 13% of energy in certain hours and supply about 2% of the region's net energy load. Most PV resources are connected to the distribution system and not visible to the ISO; therefore, these figures are approximate values. For details, see the ISO's PV forecast, available at www.iso-ne.com.

Note: These proposed projects are NOT reliability projects, but are considered "elective" transmission projects.

Transmission is needed to bring renewables to market

Realizing the states' environmental goals will mean improving the power system's ability to bring the energy from remote wind units and Canadian hydro resources to regional demand centers. Many on- and off-shore transmission proposals are vying to move renewable energy to New England load centers. Representative projects and concept proposals include:

- **A.** Northern Pass – Hydro Québec/Northeast Utilities
- **B.** Northeast Energy Link – Emera Maine/National Grid
- **C.** Green Line – New England ITC
- **D.** Bay State Offshore Wind Transmission System – Anabaric Transmission
- **E.** Northeast Energy Corridor – Maine/New Brunswick/Irving
- **F.** Muskrat Falls/Lower Churchill – Nalcor Energy
- **G.** Maine Yankee – Greater Boston
- **H.** Maine – Greater Boston
- **I.** Northern Maine – New England
- **J.** Plattsburgh, NY – New Haven, VT
- **K.** New England Clean Power Link – TDI New England

Green Energy's Effect on Prices

Significant additions of wind and solar resources in New England could have complex effects on prices. With no fuel costs and falling project-development costs, these weather-dependent resources tend to drive down wholesale energy market prices – and by implication, the revenues available for resources that can provide the "missing energy" when the weather is uncooperative. This will likely cause the capacity market to become a more important revenue stream for conventional resources and future storage resources. Ensuring appropriate long-term price formation in the capacity market will be vital as the region gradually adds more renewable energy to the mix.

Shared regional costs are also likely to rise in the short term as the region invests in transmission upgrades to expand access to more wind and hydro power.

Grid Modernization Supporting Greener Energy

State efforts to modernize the grid open up new approaches to demand resources (including energy efficiency, demand response, and distributed generation) and for coordinating planning, operations, and pricing between the wholesale and retail sectors. Such efforts and their benefits include:

- **Improving distribution system reliability** by helping electric utilities immediately pinpoint problems requiring service and by enabling "self-healing" (automatic re-routing of service around system faults)
- **Promoting state-funded microgrid pilot programs** to help communities maintain critical services during major storms. Microgrids are mini power systems that can disconnect from the regional grid to run on their own, if necessary.
- **Integrating behind-the-meter resources** to allow more efficient use of control systems (for heating, cooling, lighting, and ventilation), of energy from distributed generation (such as on-site wind and solar resources), and of energy storage (including electric vehicles)
- **Reducing customer energy costs and stress on the grid** with service rates that vary by time of day like wholesale electricity prices do. The initiative adopted in Massachusetts in late 2014 is one example. These dynamic retail pricing efforts incentivize consumers to switch to a less expensive source of energy or to conserve energy when power system prices are higher.

The ISO serves as a resource to the states to help them understand potential effects on competitive markets and grid reliability. As customer power consumption becomes more price-responsive and as more customers produce their own power, demand becomes less predictable, supply less controllable, and operations more complex. Read more about the ISO's work on smart grid and other technologies on page 46.

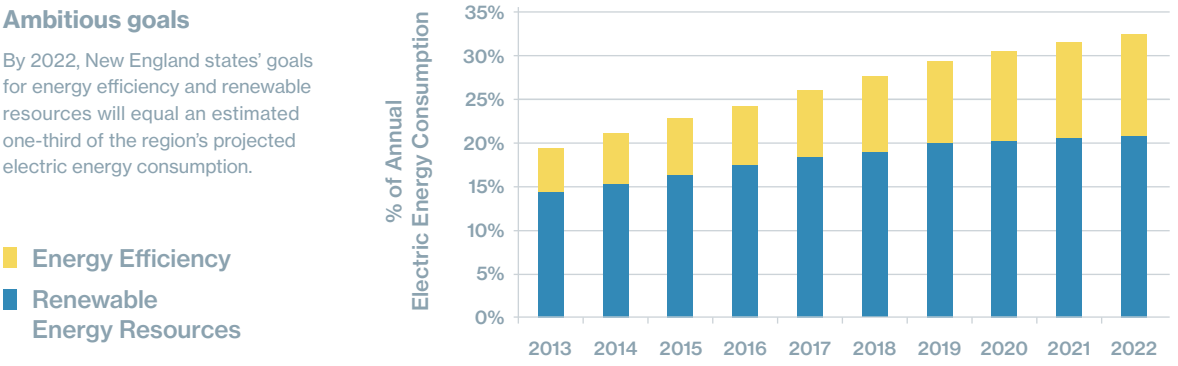
Leading the Nation in Energy Efficiency (EE)

New England is a national leader in EE policies, programs, and forecasting:

- All six states are ranked among the top 25 by the American Council for an Energy-Efficient Economy – with four of the six states in the top 10.
- The six states are expected to invest over $6 billion in EE between 2017 and 2023.
- ISO New England was the first in the nation to develop a multistate long-term EE forecast to plan for the effects of this growing resource.
- From 2018 to 2023, state-sponsored EE programs are forecast to save New England 1,518 gigawatt-hours (GWh) per year, keeping regional load growth essentially flat.

Ambitious goals

By 2022, New England states' goals for energy efficiency and renewable resources will equal an estimated one-third of the region's projected electric energy consumption.



Case in Point

Learning from Precarious Winter Operations

The last two winters clearly illustrated how the region's interrelated challenges create difficult operating conditions and price volatility.

Tight Operating Margins

Cold weather correlates to higher demand on the power grid, as well as less available fuel transportation for the natural gas-fired units making up almost half of the region's capacity. This has the ISO increasingly concerned about its ability to maintain power grid reliability during the coldest days of winter. Using tools at its disposal, the ISO has successfully kept power flowing and maintained adequate reserves required for reliability. But the close calls – times when operating reserve margins are running thin – are increasing. When unexpected resource outages occur, ISO system operators can find it difficult to get the additional resources needed to meet demand plus operating reserves, leaving the power grid extremely vulnerable. The loss of other resources or transmission facilities at these times would require the ISO to activate emergency procedures. In a worst-case scenario, controlled power outages could be needed to protect the integrity of the grid – something New England has never had to implement systemwide in its 40-plus-year history of coordinated grid operations.

Lessons Learned

Experiences over recent winters have shown that:

1. **Gas pipelines are now constrained even when demand from natural-gas-fired generators is relatively low.** For example, interstate pipelines that deliver fuel to the region from the west and south were constrained even during the comparatively mild winter of 2012/2013, as well as during the winter of 2013/2014 when natural gas generation drastically fell due to price spikes and outages.

2. **Adequate oil inventory has become vital to winter reliability.** The region is increasingly reliant on its oil units when natural gas units are unavailable or gas prices spike. Over winter 2013/2014, for example, gas prices exceeded oil prices on many of the coldest days and on 57% of all days (compared to 18% the previous season). But the oil-supply chain is fragile. Weather and other factors can limit truck or barge transportation, and cold weather increases competition for oil from the heating sector.

3. **Resource retirements exacerbate winter operating conditions.** The units most at risk of retiring in the region are non-gas units. Without them, ISO system operators lose critical alternatives that can pick up the slack when gas-fired generators are unavailable or uneconomic. For example, between winter 2013/2014 and 2014/2015, the region lost over 1,000 MW of non-gas capacity from Salem Harbor Station, Mount Tom Station, and Vermont Yankee Nuclear Power Station.

To complicate matters, siting and permitting new dual-fuel facilities (gas generators that can switch to oil) appears to be becoming more difficult regionally, while transmission projects that could help connect remote renewable resources to population centers have yet to gain momentum. And the integration of more renewables may not help winter operations sufficiently. Solar resources produce the least amount of power during the short days of winter. And while the region's windy winter conditions could mean increased output from wind turbines, their blades and other components can be hampered by extreme cold and ice. Transmission constraints may also limit their output. (See page 25.)

ISO Actions

Based on those lessons, the ISO has undertaken extensive efforts to shore up operations. These include:

- Implementing out-of-market **winter reliability programs** (see page 35) to incentivize oil-fired and dual-fuel generators, generators that can access LNG, and demand resources to secure fuel inventory, fuel-switching capability, and demand reductions when needed

- Refining market rules to improve **performance incentives**, such as the Energy Market Offer Flexibility Project, changing the timing of the Day Ahead Energy Market to better align with natural gas trading deadlines, improving price formation in the energy and reserve markets, and strengthening incentives in the Forward Capacity Market (Pay-for-Performance)

- The development of **tools that help operations personnel** more accurately predict the availability of natural gas supply for generators, improving unit commitment decisions

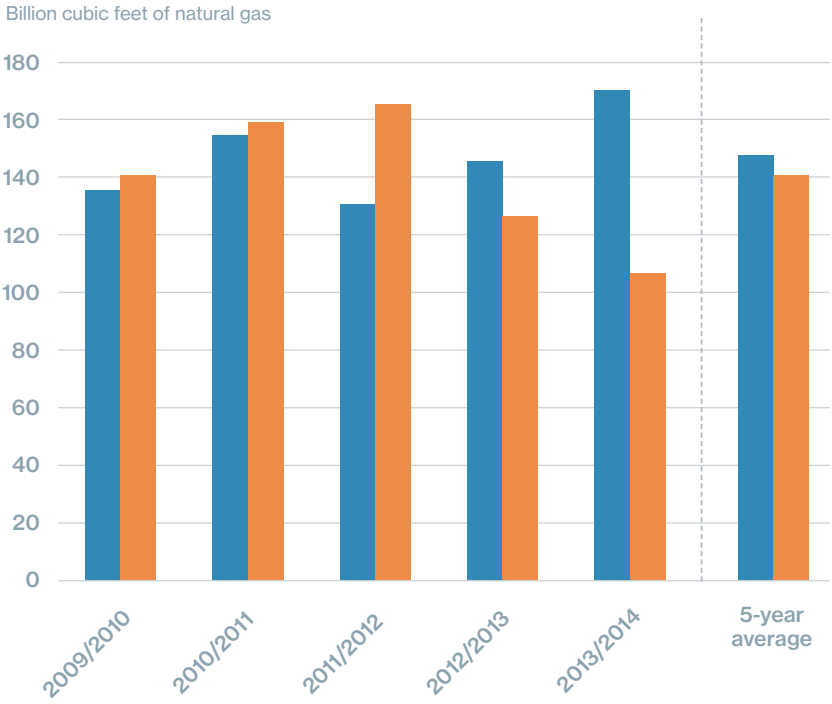
- **Increased communications with gas pipeline operators** (assisted by FERC Order 787) to verify whether natural gas generators scheduled to run will be able to obtain fuel

Heating trumps electricity generation in winter

Natural gas pipeline capacity in New England is increasingly being maxed out to serve heating customers in winter, leaving little to no extra space in the pipes to supply gas-fired generators. This graph shows competing demand from November through March.

Residential
Electric Generation

Source: US Energy Information Administration, *Natural Gas Monthly*



Oil units are playing a bigger role in winter

Take a look at generation by fuel type during the peak hours of a cold period in January 2014. Compare this to the annual energy mix on page 15.

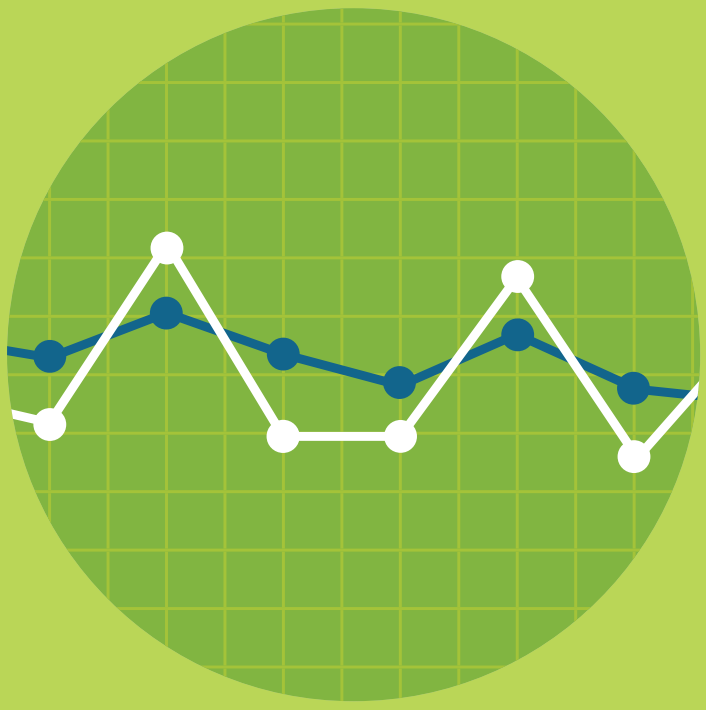
Nuclear: 26%
Oil: 25%
Natural Gas: 24%
Hydro: 10%
Coal: 8%
Renewables: 6%
Other: 1%

LNG: Global Factors, Local Effects

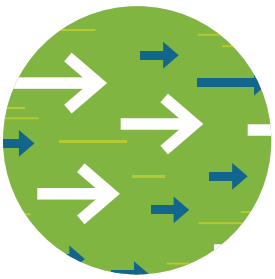
Increased use of liquefied natural gas (LNG) in the region is one possible way of alleviating the symptoms of regional pipeline constraints. However, shipments can be limited when international markets offer higher prices. As an added complication, transporting LNG in winter, when the region needs it most, is subject to weather delays. These factors make LNG prices volatile in New England, exceeding global prices on days when LNG facilities cannot keep up with regional demand. In the future, LNG could be produced from Marcellus Shale gas and stored locally in New England, potentially reducing its pricing and volatility.

Market-Based Solutions

Incentivizing Infrastructure Investment and Resource Performance



The ISO must continually evolve market rules to accommodate the wide-ranging effects of changes in the industry.



ISO New England does not own power plants or transmission lines, and cannot directly require power resources to make infrastructure investments or take action to improve their performance. Neither does the ISO have authority to require changes in the separate natural gas industry, despite its current sizable impact on the region's gas-fired generators and grid reliability.

Instead, it is the ISO's responsibility to ensure reliable wholesale electricity through competitive markets. To accomplish this, the ISO must continuously enhance the marketplace so that it sets the correct incentives to ensure that enough resources are developed, are available, and run when needed. To this end, the ISO has been actively collaborating with stakeholders on comprehensive, near- and long-term rule changes across the region's suite of energy, reserve, and capacity markets to address the major challenges facing the power system.

Descriptions of a few of the most significant projects follow. **The full range of market projects and their statuses can be found in the *2015 Wholesale Markets Project Plan* at www.iso-ne.com.** Market rules, information on regional power system planning, and much more can also be found on the ISO website.

Energy and Reserve Markets

The electricity the ISO manages minute-to-minute to meet instantaneous demand is bought and sold through the Real-Time Energy Market. Generating resources can also lock in prices and production schedules one day in advance by participating in the Day-Ahead Energy Market. Reserve markets support the energy markets by ensuring the grid has enough resources ready to come on line quickly in the event of an unexpected generator or transmission outage.

Because industry challenges have increased the need for flexible operations and reliable reserves, major rule changes have been recently made to these markets to bolster the ISO's ability to dispatch resources effectively; improve how resources perform and respond to these dispatch instructions and schedules; and help contribute to the reliable operation of the grid.

FOCUS ON PRICE FORMATION

Many of the ISO's recent and upcoming market-rule changes are designed to improve "price formation" – the ability of the wholesale electricity markets to set prices that more accurately reflect a power resource's operating costs under a variety of system conditions. 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.

Energy Market Offer Flexibility (EMOF)

Implemented in December 2014, this major revision to the ISO's systems allows generators to reflect fuel costs in their wholesale energy market offers as those costs change throughout the day. This improvement to real-time price formation assures that resources will receive appropriate compensation for the costs they incur to operate, providing them the incentive to perform. Resource owners are able to:

- **Submit power supply offers that vary by hour** in the Day-Ahead Energy Market, in contrast with previous rules requiring the same offer for the entire operating day
- **Change supply offers** in the Real-Time Energy Market (until 30 minutes before the hour in which the offer applies) versus previous rules restricting changes to a brief "reoffer period" the previous day
- **Submit negative offers** as low as –$150 per megawatt-hour (MWh)

In addition, this project expanded the dispatchable range of many resources, enabling energy prices to be set more competitively. This change is particularly helpful during low-demand conditions.

What's in a Rule Change?

Market design is an ongoing, iterative process, often based on the changing needs of the power system. Revising market rules is intensive and can take many months. First, ISO experts study the situation and possible solutions, and then bring proposed changes through a stakeholder process. Changes are then submitted for Federal Energy Regulatory Commission review and approval. A lengthy implementation phase may follow, which often requires software development, testing, and training – all of which can require several more months, or years, of ISO work. The ISO must be meticulous when making any market rule and technology changes, as errors could lead to market disruptions.

The Benefits of Negative Energy Offers

There are times – usually early in the morning – when consumer electricity use is very low, potentially resulting in more power generated than needed. To avert this imbalance, the amount of generation must be reduced. Previously, the ISO would set prices to $0 per megawatt-hour (MWh) to provide an incentive for generators to reduce output, but that wasn't always enough – some had to be ordered off line. As part of the Energy Market Offer Flexibility project, the lowest allowable offer a generator can now make has dropped to -$150/MWh. In other words, power resources can now *pay* to produce electricity, signaling how much they want to continue operating during times of low demand.

- The ISO dispatches the lowest-cost resources first to meet demand. Thus, by making such low offers in the market, generators can ensure that they are most likely to be selected to run. "Paying to produce" may be more economical for some resources than incurring the cost of shutting down and starting up again, for example. Other resources, such as wind plants that need to operate when the wind blows, have low or no fuel costs, and may have other sources of revenue tied to producing electricity, such as tax credits, which may allow them to operate economically even at negative energy prices.
- Market prices that dip below zero provide a clear incentive to other resources on the grid to very quickly stop production – without ISO administrative action – thus avoiding situations where there's too much generation on the system and ensuring power system reliability.
- Overall, negative pricing strengthens price formation and market competitiveness, ensuring the lowest-priced power supplies are used at all times to meet the region's electricity demand.

A primary project on the ISO's 2014 work plan, the EMOF changes required a significant effort to modify business processes and tools across many ISO departments, including system operations; market administration, settlements, and monitoring; and IT infrastructure and software.

Do Not Exceed Real-Time Dispatch

This project aims to help minimize manual generator curtailments (see sidebar), while also improving the ISO's ability to manage the system during rapidly shifting weather conditions. Changes being considered would set a maximum amount of economic wind generation that the system could handle per resource without risking reliability. The resource would be able to operate freely between 0 MW and that limit. This new dispatch functionality will improve price formation by enabling these resources to set the price at their locations on the basis of their economic offers and by allowing the Real-Time Energy Market to properly price congestion at their locations. The ISO is evaluating developing similar price-setting functionality for other traditionally nondispatchable supply resources, such as hydroelectric generation.

Fast-Start Pricing Improvements

The ISO is assessing ways to improve the Real-Time Energy Market's pricing logic when fast-start resources are deployed to supply energy. Presently, many fast-start units must be paid Net Commitment-Period Compensation (NCPC) payments (aka, "make-whole" payments) whenever they operate. Changes would enable these resources to set the energy

price more frequently, which could also help improve the performance incentives for all resources during system conditions when reliability is at heightened risk.

Multihour System Ramp Pricing

A potential new market product is also being evaluated to convey, through transparent prices, the costs incurred when the system must be redispatched in advance of a sustained, substantial load ramp (up or down). Currently, much of these costs are paid, not in the energy price, but through NCPC payments to generators dispatched "out of merit" to ensure the system is adequately prepared. This product addition should also improve the markets' longer-term price signals for new investment in resources that can respond flexibly and for a sustained period to significant changes in the system's net load.

Subhourly Real-Time Energy and Reserve Market Settlement

The real-time markets (energy, reserve, and regulation) are settled hourly, even though the ISO calculates real-time locational marginal prices (LMPs) every five minutes. Existing settlement rules tend to undercompensate certain resources, particularly more flexible generation and storage assets that respond quickly when system events result in tight operating conditions and there are significant midhour price changes. The ISO is discussing with stakeholders the move to subhourly settlements in both the Real-Time Energy Market and reserve markets. Compensating resources at the more granular, five-minute price helps improve price formation by ensuring that the price suppliers are paid for real-time performance is a more accurate market signal of the power system's current operating conditions. In the future, this change may also provide an additional revenue source for wholesale electricity storage resources.

LMP Calculator Replacement

The ISO is also proposing revisions to the LMP calculator algorithm used to determine real-time energy and reserve prices. In limited circumstances, the current algorithm may produce LMPs that do not correctly reflect the costs of real-time reserve constraints, requiring price reviews or corrections after the preliminary prices are published and before market settlement. The new algorithm will help improve price formation by producing prices that more closely reflect the locational dispatch rates in the ISO's security-constrained economic dispatch system.

2014/2015 Winter Reliability Program

For a second year, the ISO implemented a special program outside of its markets to mitigate winter reliability risks associated with the retirements of key non-gas generators, gas pipeline constraints, and generators' difficulties in replenishing oil supplies. As part of the 2014/2015 program, oil-fired and dual-fuel generators, LNG, and demand resources selected to participate were paid to secure fuel inventory and fuel-switching capability; were compensated for any unused fuel inventory; and were subject to nonperformance charges.

The 2014/2015 program includes two permanent improvements, as well. To help dual-fuel resources more effectively manage fuel supply on days when the price of oil and natural gas approach convergence, the requirement to prove that the higher-priced fuel was burned was eliminated. The ISO also gained the continued ability to test resources' fuel-switching ability and to compensate them for running the test.

Looking ahead, the ISO has initiated a stakeholder process to explore a proposal to address reliability concerns for winter 2015/2016 and at least until 2018 when capacity market refinements to incentivize performance begin to take effect.

TMOR RCPF and Replacement Reserve

In late 2013, the ISO increased its 30-minute operating reserves (TMOR) requirement and employed a new reserve-constraint penalty factor (RCPF) for replacement reserves. (RCPFs are caps on the price that the ISO may pay to procure reserves. They are triggered when the region is short of operating reserves – in other words, when resources are scarce.) The changes help ensure that adequate reserves are available to operate the system reliably. Beginning December 2014, RCPFs were further augmented to provide stronger signals for resources to boost supply and for customers to reduce demand during stressed system operating conditions. The RCPF changes are complementary to upcoming capacity market changes to help incentivize resource performance.

Day-Ahead Market Enhancements

The ISO is weighing possible design changes to procure and price operating reserves in co-optimized Day-Ahead Energy Market and reserves markets. Allowing suppliers to submit financially binding offers for reserves on a day-ahead basis would enable market prices to transparently signal the costs suppliers must incur to provide reliable operating reserves. For example, many gas-fired generators must make costly day-ahead fuel arrangements to provide reliable operating reserves the next operating day – fuel that may or may not be used, depending on whether a unit's reserves are deployed. This design enhancement may also decrease total NCPC payments.

Improving Gas-Electric Coordination

In 2013, changes accelerating the Day-Ahead Energy Market and Reserve Adequacy Analysis timelines went into effect to better align the timing of the wholesale electricity and natural gas markets, with the goal of improving reliability. The ISO found that one year later, the modifications had already incrementally improved gas-electric coordination, including positive impacts on system operations, with fewer committed units day-ahead that were unavailable in real-time due to gas procurement issues.

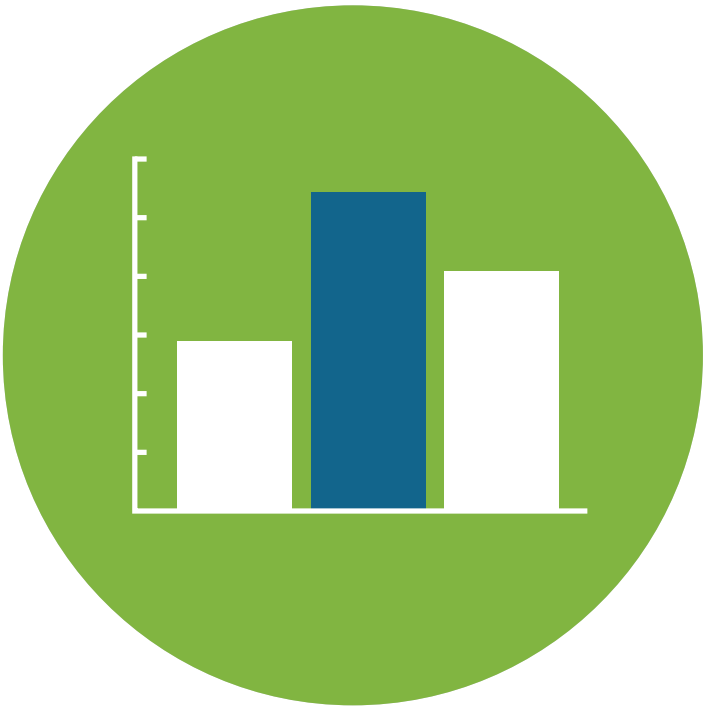
Despite improvements, electric suppliers have to manage two sets of gas prices, and the late start of the gas day means that generators can't know if they have adequate gas for the balance of the day before the close of gas trading. FERC is proposing revisions to the natural gas operating day and interstate pipeline scheduling practices, as well as further improvements to coordination and scheduling of natural gas pipeline capacity with electric markets. The ISO is participating fully in these proceedings.

Forward Capacity Market

Complementing the daily energy and reserve markets is the region's Forward Capacity Market (FCM). Long-term capacity markets such as the FCM provide economic incentives to attract investment in new and existing resources to achieve power system reliability requirements. In the FCM, the ISO holds an annual auction in which suppliers compete for the opportunity to meet the region's projected electricity demand three years out. Suppliers with the lowest-priced offers clear the auction and receive capacity payments – these payments are in addition to what resources receive in the energy and reserve markets. Because prices in the energy and reserve markets are more volatile and change as grid conditions change (for example, fuel prices, the fuel mix, and technology changes, and new infrastructure is built that may alter prices in some locations), resources rely on the FCM for a stable revenue stream to maintain their viability. In exchange for capacity payments, the resources have an obligation to be ready to run when called on. After several years of experience with the FCM, the ISO introduced recent modifications to serve as a catalyst for the long-term changes New England needs to produce a sufficient, more reliable, and more flexible fleet of power supply resources.

IMPROVING THE PERFORMANCE OF POWER SYSTEM RESOURCES

Pay-for-Performance (PFP), the principal change made to the FCM, was prompted by the ISO's determination that the market wasn't providing sufficient incentives for resource performance. This resulted in resources that sometimes failed to produce energy when needed most – despite receiving capacity payments – posing a serious threat to power system reliability. PFP goes into effect with the ninth Forward Capacity Auction (FCA #9) held in February 2015 for the June 2018 to May 2019 capacity commitment period. It applies a two-settlement capacity market design:



- First, resources that clear the auction will receive base capacity payments, as they did previously.
- Then, a second settlement happens during the delivery year. When scarcity conditions exist in a capacity zone, resources in the zone that perform well will receive a payment, while those that don't will receive a charge.

Pay-for-Performance will create stronger financial incentives for capacity suppliers to:

- ***Perform when called on during periods of system stress:*** With PFP, a resource that underperforms will effectively forfeit some or all capacity payments. Resources that perform in its place will get the payment instead. This means that the financial risk of nonperformance is placed on resource owners who have accepted capacity obligations; the capacity market price is not affected during times of system stress, thus protecting consumers.
- ***Make investments to ensure performance:*** The specific investment isn't prescribed. Examples of the many available options include ensuring robust maintenance practices and adequate staffing; upgrading to dual-fuel capability; entering in noninterruptible gas supply agreements; and investing in new fast-responding assets. Dual-fuel capability adoption could face opposition from stakeholders, however, because of oil's higher emissions and fuel costs.

By creating incentives for generators to firm up their fuel supply, Pay-for-Performance may indirectly incentivize the development of oil or LNG fuel storage or gas pipeline infrastructure. However, PFP will not take effect until 2018, and will not reach full effectiveness until the seven-year phase-in of the new performance payment rate is complete. Until that time, the region may be challenged to meet power demand any time pipeline capacity is constrained. PFP may also hasten the retirement of inefficient resources with poor historical performance, and the entrance of new, efficient, better-performing resources. Ultimately, Pay-for-Performance is an efficient and effective way to promote investments necessary to improve performance, to provide high-performing resources a stable revenue stream to maintain their viability, and to ensure continued predictable capacity prices and long-term reliability for consumers.

IMPROVING PRICE FORMATION TO BOLSTER INFRASTRUCTURE DEVELOPMENT

Other rule changes starting with FCA #9 relate to the ISO's goal of improved price signals to help reduce revenue volatility for suppliers and to ensure that new resources are built in the most valuable locations as many of New England's aging power plants retire.

Refining Capacity Zones – The region is now following a two-step process for creating, modifying, or collapsing capacity zones for each FCA. This helps ensure that the zonal structure is flexible enough to accommodate changes over time in the transmission system's capabilities and locations of highest need. Using this process, a new zone for the Southeast Massachusetts/Rhode Island (SEMA/RI) area has been designated for FCA #9. The development of resources near areas of highest need helps mitigate reliability risks associated with resource retirements and resource performance issues, and improves both system performance and the use of existing transmission infrastructure.

Using a Variable Capacity Requirement – A new systemwide downward-sloping demand curve is expected to yield smaller swings in capacity prices when the market moves from conditions of excess supply to periods when new capacity resources are needed. Previously, FCAs procured a fixed amount of capacity, regardless of the auction clearing price. The ISO will be working with stakeholders to develop the necessary rules to implement sloped demand curves at the zonal level by FCA #10.

Extending the New Resource Commitment Timeframe – The number of years new generation resources can choose to lock-in their capacity price has been extended from five to seven. This extension is intended to provide market certainty to attract new investment. A provision now allows a resource to apply for a one-year delay in its capacity commitment if the resource is needed for reliability, the delay was caused by reasons beyond its control, and the deferral is needed for the resource to become commercial.

New Mitigation Rules – Following a FERC directive, rule changes are being introduced systemwide to provide for the review and mitigation of importers' capacity offers into FCAs. A limited exemption from the buyer-side mitigation rules will also be allowed for renewable technology resources that are built specifically to advance state policy objectives. On deck for 2015 will be an exploration of how to amend market rules further to prevent the potential exercise of market power within constrained zones once zonal demand curves are introduced.

FCM Shortage-Event Triggers – A related notable development in late 2013 was the modification of FCM Shortage-Event Triggers. The definition of a shortage event – a period in which the total amount of available generation falls short of levels required for reliable operations – was revised to trigger shortage events under a broader and more accurate range of "at-risk" periods. As a result, resources have a greater incentive to perform during times of power system stress and to minimize the chance of outages.

A Balancing Act

Supportive Public Policies Also Critical for Solving Grid Challenges

A collaborative approach is needed to adequately address grid challenges.

Market Forces and Public Policy Help Define the Fuel Mix

The wholesale electricity markets do not favor any technology or fuel type over another – the primary objective is maintaining reliability at the lowest production cost, based on market participant offers into the energy, reserves, and capacity markets. Natural gas' dominance in generation shows that the competitive markets have been doing their job identifying the cheapest provider of the electricity and reliability services needed by the region. This open, fair, competitive marketplace enables new technologies to enter and compete regardless of fuel used, and displaces inefficient resources.

But while market forces shape the region's fuel mix, energy policies can influence market outcomes. State and federal policies such as those that support renewable energy development or access, that restrict high-emitting resources, or that require investment to comply with environmental regulations can determine the market competitiveness of different types of resources.

Policies are Needed to Support Infrastructure Investment, Grid Reliability

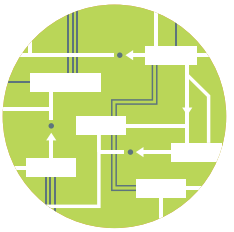
Energy market changes should produce positive effects on generator performance and price formation soon, and refinements to the capacity market are part of a longer-term solution to ensuring adequate infrastructure investment and resource performance. But when it comes to today's grid challenges, responses from the marketplace – the resource owners – are only one part of the solution.

The Quadrennial Energy Review (QER)

The US Department of Energy (DOE) examined New England's energy infrastructure challenges as part of its QER. The ISO worked extensively with the DOE throughout 2014 to articulate New England's challenges and highlight the region's increasing reliance on natural gas-fired resources and the need for additional energy infrastructure.

Market changes alone won't necessarily result in added natural gas pipeline or LNG storage, as individual generators aren't likely to enter into the contracts needed to fund additional gas infrastructure. However, the lower-cost alternative that gas-fired generators are more likely to pursue – investing in dual-fuel capability – is only a viable option if the states are willing to approve permits to burn oil. The ISO has observed that permitting has become increasingly difficult and likely will become more so as the region's policymakers seek to further lower emissions. While the region's efforts to expand energy efficiency and renewable resources are helping, they aren't enough to mitigate the region's immediate challenges related to natural gas dependency and fuel assurance.

The New England states are aware of these risks and have been considering various mechanisms to facilitate investment in additional gas pipeline, LNG storage, and renewable energy in the region. The ISO serves as a resource in the governors' efforts and to all other regional policymakers, providing data and analyses to facilitate informed decision making.



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 and business planning 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 2014:

- The ISO held over 70 meetings of the Markets, Reliability, Transmission, and Participants Committees; 14 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 16,000 inquiries, resolving approximately 6,500 customer issues.
- About 1,250 stakeholders attended ISO classroom or web-conference trainings.
- About 50 e-learning modules and 125 presentations were maintained on the ISO website for stakeholder use.

This type of collaboration and teamwork has been the critical factor driving the region's success in developing power system infrastructure and a competitive suite of wholesale electricity markets.

Results on a Budget

The ISO is a nonprofit entity without equity; as such, it relies on collections under its tariff to fund its operational expenses and is committed to cost accountability and transparency. Each year, ISO management and the ISO Board develop the company's business plan and budget through an open stakeholder process so that the ISO can accurately align its work plan with regional priorities, and so that all industry stakeholders have a clear understanding of the company's goals and objectives. The ISO meets with stakeholders multiple times to review the budget and get feedback. The proposed budget is then formalized with input from NECPUC and other state agencies, such as the states' consumer advocates. NEPOOL also reviews the budget and holds an advisory vote. After the ISO Board votes on the final proposed budget, it's filed for approval with the Federal Energy Regulatory Commission.

The company's operating budget for 2015 is $178.3 million – a 5.3% increase over 2014. However, after including the "true-up" for actual versus budgeted collections in 2013, the ISO's 2015 revenue requirement falls to $168.5 million – 1.6% lower than 2014's. The ISO also offset $4.3 million in increased costs for 2015 with savings, automation, and efficiencies. The increased costs are necessary to:

- Fund established regional initiatives, such as implementation of Coordinated Transaction Scheduling (page 43), Energy Market Offer Flexibility (page 33), and efforts to prudently address heightened cybersecurity risks (page 47)
- Cover rising costs related to the same high level of services already being provided to the region, such as increases in software relicensing fees, medical insurance, and fees for the Northeast Power Coordinating Council (NPCC) and North American Electric Reliability Corporation (NERC)

The Stakeholder Process: Ensuring Diverse Perspectives and Effective Solutions

The ISO fosters a robust stakeholder process. By participating in one or more of the ISO's comprehensive advisory committees, interested parties can help inform solutions for 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 those who form 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

The ISO's financial statements and other metric reports are available online at www.iso-ne.com.

$0.90 a month

The services and benefits the ISO provides to keep the lights on will cost the average New England electricity consumer just $0.90 per month in 2015, compared with $0.92 per month in 2014, based on 750 kWh/month. (In previous years, 700 kWh/month was used for this calculation.)

Increasing Competition for Electric Industry Professionals

Running the power grid requires highly skilled professionals – as do the ISO's other responsibilities for market operations and system planning. Approximately 25% of the ISO workforce will be eligible for retirement in 2016, but the US is currently not producing enough power system engineers to meet demand. The ISO must compete against grid operators across the US – and the world – to attract and retain an expert, innovative workforce that can handle New England's ever-evolving and increasingly complex power system. As the US economy has improved and the region has become more involved in emerging technologies, competition has become even fiercer.

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. Each year, the ISO asks market participants to rate their overall satisfaction. The latest survey (2014) revealed high overall satisfaction levels. Positive satisfaction among respondents with an opinion was 93%.

ISO RESPONSIVENESS TO MARKET PARTICIPANTS' ACCOUNTING NEEDS

Following requests from market participants, the ISO embarked on the Divisional Accounting project. This upgrade allows participants to have separate settlement accounts so they can easily evaluate their positions by individual business unit, division, or generating facility. Previously, ISO systems produced reports and invoices as net charges and credits across all aspects of a customer's business. The complexity of the implementation and the vast number of systems affected across the ISO required five phased releases over 2014 and 2015.

Inter-Regional Collaboration

The ISO expects to wrap up a major initiative to update systems to support the Coordinated Transaction Scheduling (CTS) project by about late 2015. The project's market rule changes, approved by FERC in 2012, will allow ISO New England and the New York Independent System Operator to improve scheduling of wholesale electricity sales between the neighboring regions. CTS will increase the frequency of scheduling energy transactions, making more efficient use of the transmission lines connecting New England and New York; enable the two grid operators to coordinate selection of the most economic transactions and reduce price disparity; and remove several fees that may impede efficient trade between regions. This has the potential to save millions of dollars annually on the wholesale level and will improve the ability of market participants to access the lowest-cost source of power within the regions.

Monitoring the Markets

The entire region benefits when New England's wholesale electricity marketplace is efficient and competitive – both in the market design and in participant behavior. The ISO helps ensure this through market monitoring and mitigation, as authorized by FERC. The ISO's Internal Market Monitor (IMM) – a team of economists, engineers, statisticians, and analysts – evaluates market transactions daily. The IMM then takes action if inefficient market rules or anti-competitive behavior are discovered. By reporting directly to the ISO Board of Directors' Markets Committee, the IMM can function independently of ISO management to help ensure fair, unbiased monitoring and mitigation. Any systematic attempt to manipulate market outcomes are referred to FERC for possible investigation. See the IMM's latest reports on the markets at www.iso-ne.com.

Achieving Compliance

STANDARDS

ISO New England takes pride in fulfilling its responsibilities to the highest standards. The ISO's teams dedicate themselves to the safe, reliable operation of the grid through extensive training and continuous process improvement to ensure the ISO achieves compliance with FERC, North American Electric Reliability Corporation (NERC), and Northeast Power Coordinating Council (NPCC) directives. They are not only mandatory, they also carry civil penalties for failure to perform. During the ISO's last NPCC compliance audit in March 2012, the ISO was found to have complied with all applicable standards and identified zero violations or areas of concern.

ORDERS

Major efforts continue at the ISO to comply with these FERC orders:

- **Order 1000, *Transmission Planning and Cost Allocation*,** requires fundamental changes to the transmission planning process as it has been conducted in New England since 2001. These changes have an impact on the transmission owners' right to build and the process for developing transmission projects. The order also requires planning to meet public policy objectives. While still awaiting action from FERC, the ISO has worked with stakeholders to establish a means of complying with Order 1000, which includes changing the interregional planning process and interregional cost allocation. ISO New England, NYISO, and PJM already develop coordinated system plans and work on other collaborative initiatives, such as efforts to address key interregional issues. These include the potential effects of environmental regulations on the power system, the integration of renewable resources, and the results of coordinated studies of the natural gas system. Additionally, the ISOs/RTOs have coordinated databases and models of their systems and have conducted production cost analyses and transmission analyses of planned system improvements and interconnections.

- **Order 755, *Frequency Regulation Compensation in Organized Wholesale Power Markets*,** required several changes to the design of the ISO's Regulation Market, including the creation of a new type of resource (i.e., regulation-only assets), the introduction of a new auction design, and extensive, sophisticated software modifications. The new Regulation Market goes into effect late March 2015.

  Regulation refers to the continuous process of minor corrections to system supply or output every four to five seconds to balance small demand and supply variations on the power system and ensure that the system frequency is maintained within specified limits.

- **Order 745, *Demand-Response Compensation in Organized Wholesale Energy Markets*,** set into motion a major business and information-technology project to develop and implement the market rules needed to enable the full integration of demand response into the energy markets and to allow for the extensive software changes required to both the market and system operations infrastructure. The full integration of demand response was planned for the capacity commitment period that begins June 1, 2017. However, because of ongoing court proceedings, it is now unclear whether Order 745 will remain effective; the ruling is being appealed to the US Supreme Court. The ISO developed and filed at FERC market rules to allow demand response resources to participate in the reserve market. The ISO is awaiting action on this proposal and will need to evaluate whether to begin expending the additional resources necessary to modify its software and system infrastructure to implement the changes. While action on Order 745 is pending, the ISO and stakeholders will begin discussions in 2015 to explore other options for demand response resources.

  Demand-side resources reduce their own electricity use and contribute to the diversity and flexibility of resources on the grid. They can help defer the need to build expensive power system infrastructure to support infrequent system peaks, decrease reliance on expensive fuels, and balance variable resources.

BACKUP CONTROL CENTER

In early 2014, the ISO's new Backup Control Center (BCC) became operational. The new BCC's size and closer location to ISO headquarters allows for full activation and staffing by critical ISO staff very quickly following a required evacuation of the Master Control Center. This ensures continuous reliable operation of all critical functions for the region, including operations, markets, and settlements. The facility is comparable to the BCCs of other ISOs and RTOs, and satisfies NERC and FERC requirements that specify a BCC should resume operations within two hours and be capable of prolonged operation in compliance with all reliability standards. The ISO has maximized the facility's usefulness by making it suitable for conducting training sessions for system operators and stakeholders, and large enough to help alleviate any potential staff overcrowding at the ISO's headquarters.

The Backup Control Center was awarded LEED® Gold certification by the US Green Building Council (USGBC). The LEED rating system was used as a guiding principle in the BCC's design due to the return on investment through long-term energy savings and staff health promotion. As part of efforts to achieve LEED-required low energy consumption, the BCC includes an 84-kilowatt rooftop solar photovoltaic system, which will annually generate an estimated 115,553 kilowatt-hours – roughly equivalent to 6.52% of the BCC's estimated electricity usage and $16,755 of electricity costs per year.

Technology and Innovation

Investing in a highly-skilled staff allows ISO New England to actively pursue innovations on behalf of the region to help create a more efficient, responsive, reliable power system that can handle expanded renewable generation and smart grid technology. Some examples of the ISO's involvement follow.

INTEGRATION OF RENEWABLES AND DEMAND RESPONSE

- The ISO is participating on the technical review committee for the **Eastern Renewable Generation Integration Study (ERGIS)**. This study by the National Renewable Energy Laboratory (NREL) aims to determine the operational impact of significant wind and solar penetration on the Eastern Interconnection and to evaluate options for managing its variable effects on the power system.
- ERGIS wind data is already being used in the ISO's **Qualified Capacity Estimator** – a new tool for the review and determination of wind and solar project capacity qualifying for Forward Capacity Market Auctions. The tool has generated cost savings for sponsors of those projects and both cost and time savings for the ISO, which can now perform its analysis in weeks versus months.
- **Watt-Sun**, an ongoing project sponsored by the Department of Energy in partnership with the IBM Thomas J. Watson Research Center, will include contributions from ISO staff. The results of this project to apply state-of-the-art machine learning technologies to improve solar forecasting will help support the reliable and efficient integration of increasing amounts of PV in the region.

Smart Grid Technology Can Benefit the Region

Grid modernization will help:

- Provide the information, price structures, technologies, incentives, and tools that can empower consumers to use electricity more efficiently and reduce their individual energy costs
- Improve the operational efficiency of the grid, particularly during peak times when the grid is most stressed and electricity is most expensive
- Reduce transmission and distribution system operation, maintenance, and construction costs by reducing electricity demands at times of system peaks
- Reduce regional wholesale and retail electricity costs by reducing electricity demand at times of system peaks

- In partnership with other ISOs/RTOs, ISO New England is providing technical and other support for the development of **demand-response-related standards** by the National Institute of Standards and Technology (NIST) and the North American Energy Standards Board (NAESB).

SMART GRID DEVELOPMENT

- Through its membership in the Smart Grid Interoperability Panel (SGIP), the ISO continues to participate in the development of **national smart grid standards** led by NIST.
- ISO staff are active in the **Institute of Electrical and Electronics Engineers (IEEE)**, a professional society that, among its many activities, is helping to develop standards for the interconnection and operation of smart grid technologies.
- A multi-year effort to bring **data from phasor measurement units** (PMUs or synchrophasors) into operations will be completed in 2015. The installation of 40 PMUs and associated computer systems for collecting and analyzing data was completed in 2013. The PMUs sample power conditions about 30 times per second. This project has already yielded benefits for New England by enabling

new monitoring of system dynamics, as well as fast and accurate post-event analysis, and validation of improved power system models. Upcoming uses that will further improve system reliability include enhancing visibility into neighboring networks, and enhancing islanding, disturbance, and oscillation detection and alarms.

- The region is a leader in the smart grid application of **high-voltage direct-current (HVDC) facilities** and **flexible alternating-current transmission systems (FACTS)**, which improve the use of system infrastructure.

OPERATIONAL EFFICIENCIES AND REGIONAL CHALLENGES

- To satisfy an increasing number of required transmission plan studies, ISO staff are exploring an innovative use of **cloud computing** to enhance the ISO's ability to use more detailed and sophisticated system models and scenarios, and to do so faster and at a cost savings. The initiative – the first of its kind for large-scale power system simulation studies in the industry – is already yielding successful early results.
- Various projects to create **new systems and tools** for greater operational and planning efficiencies and performance are also underway. These include projects related to voltage stability, control room visualization, and power system modeling.

Protecting the Grid from Cyberattack

The cyber and physical defenses of New England's electric grid remain a top priority for the region – the electric industry is the only industry subject to mandatory and enforceable digital security standards. Evolving and dynamic threats require close coordination and vigilance. The ISO is committed to digital security issues and is engaged at the regional and national levels to design and implement meaningful standards for the protection of critical assets. Cybersecurity training is an annual requirement for all ISO staff. The ISO is also pursuing a three-year cybersecurity initiative to improve corporate cybersecurity tools, procedures, and processes. And in the past two years, the ISO:

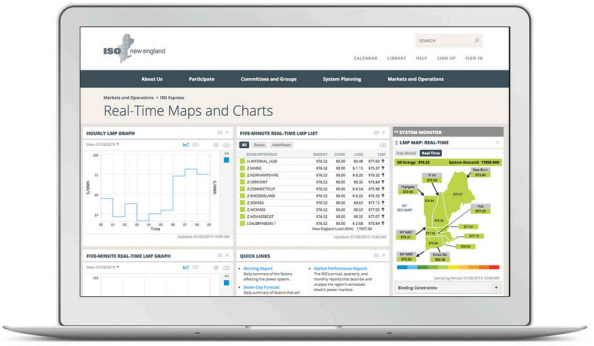
- Took part in the year-long process of standards creation for NIST's voluntary cybersecurity standards released in February 2014, the *Framework for Improving Critical Infrastructure Cybersecurity*
- Helped create a physical security standard, currently the subject of a Notice of Proposed Rulemaking by FERC
- Participated in the GridEx II cybersecurity exercise spearheaded by the US Department of Homeland Security

Keeping Stakeholders Informed 24/7

The ISO is continually looking for new and better ways to share information with stakeholders.

ISO EXPRESS

ISO Express, the ISO's data portal, provides stakeholders with convenient, customizable access to grid conditions and wholesale electricity market information, including real-time data, detailed historical report generation, and web-based notifications of changing system conditions.



ISO Express

ISO TO GO

The ISO offers a free mobile application for smartphones. The app helps educate New England's electricity users about the power grid and wholesale electricity markets and provides stakeholders with up-to-date system conditions and real-time information on the region's wholesale electricity prices.

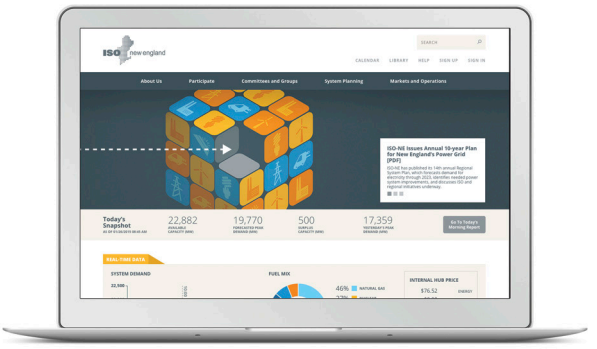
ISO NEWSWIRE AND ISO TWEETS

Through a regularly updated news blog (www.isonewswire.com) and Twitter account, the ISO helps stakeholders stay on top of developments at the ISO and in the wholesale electricity industry.

ISO Newswire

Improving Our Customers' Experience: A New Website

In August 2014, the ISO launched a redesigned website and data portal. With a reorganized site structure, more efficient navigation, and a new content management system, the website helps stakeholders more easily and quickly access the wide variety of data, information, and other tools the ISO makes available to market participants and other stakeholders.



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Key Facts

6.5 million households and businesses; population 14 million

350 generators

31,000 MW of generating capacity

All-time peak demand of 28,130 MW set on August 2, 2006

3,500 MW of generation capacity retiring over the next five years

9,500 MW of proposed generation capacity

1,200 MW active demand resources and 1,500 MW of energy efficiency with capacity supply obligations

8,500 miles of high-voltage transmission lines

13 interconnections to power systems in New York and Eastern Canada

Approximately $7 billion in transmission investment since 2002; $4.5 billion planned through 2018

$10.4 billion traded in wholesale electricity markets in 2014 ($9.1 billion in energy markets; $1.3 billion in capacity and ancillary services markets)

Over 400 buyers and sellers in the markets

ISO Board of Directors

(As of January 2015)

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(As of January 2015)

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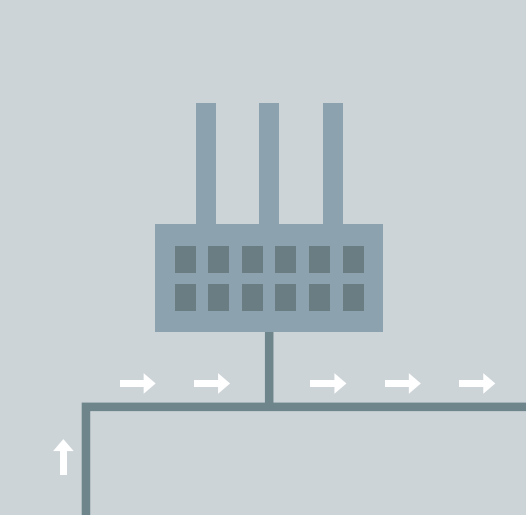
Vice President, System Planning

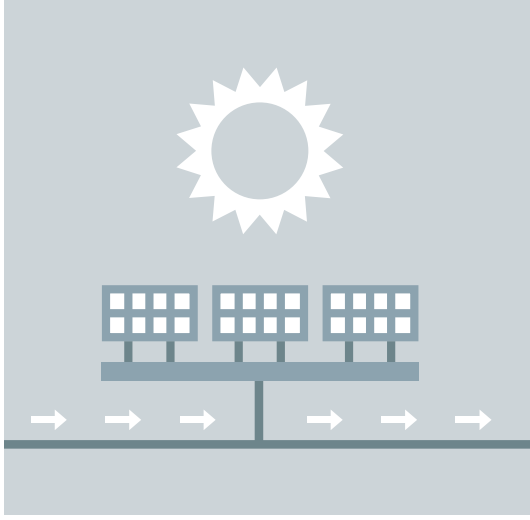
Reliability is the core of ISO New England's mission, fulfilled by three interconnected and interdependent responsibilities:

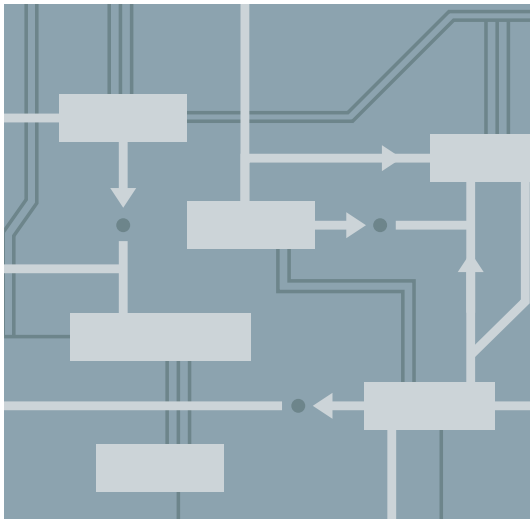
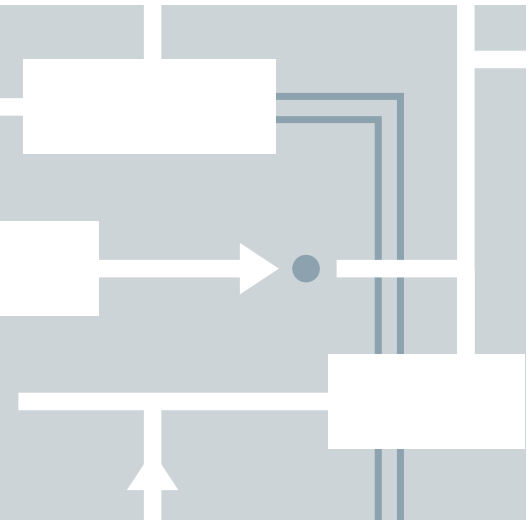
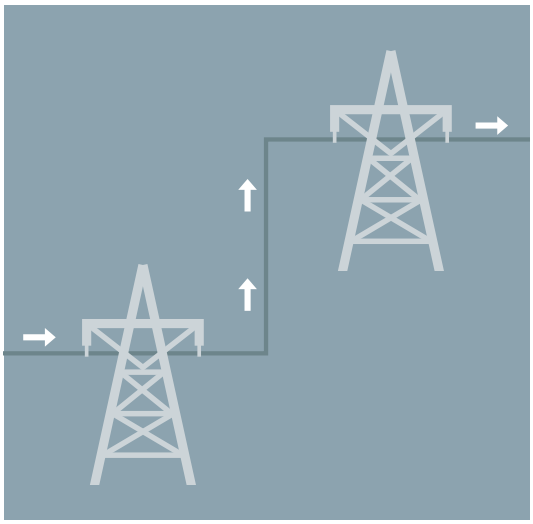
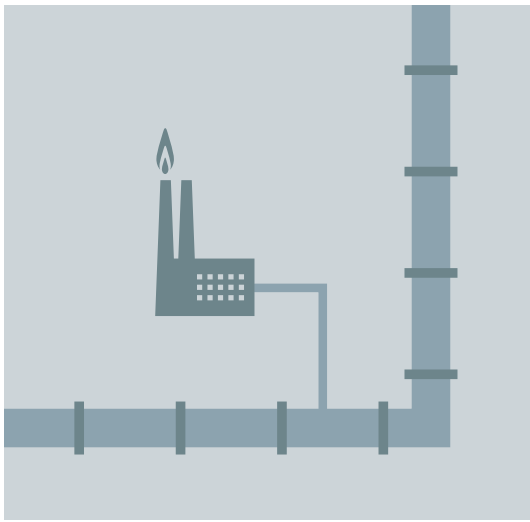
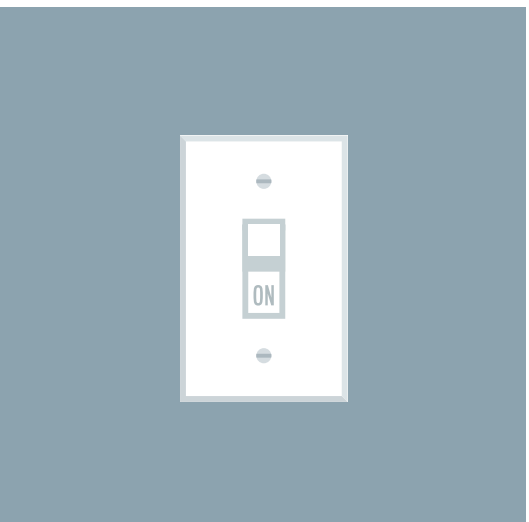
Overseeing the day-to-day operation of New England's electric power generation and transmission system

Managing comprehensive regional power system planning

Developing and administering the region's competitive wholesale electricity markets



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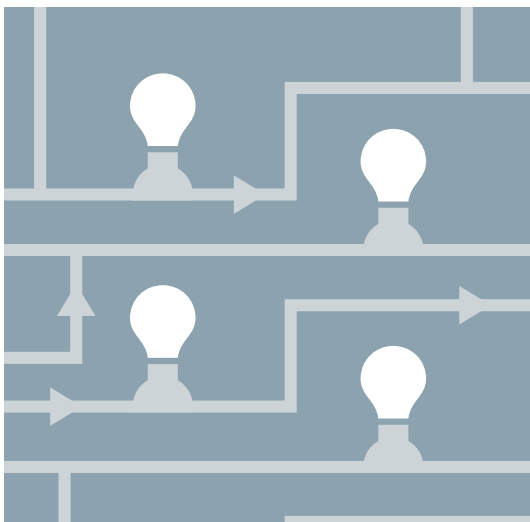

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