2018 Regional Electricity Outlook

ISO new england

About Us

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

Our Mission

ISO New England's mission includes three interconnected responsibilities:

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

About This Report

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

Please note: The facts and figures in this report were current at publication in January 2018. However, the ISO continually generates data and analyses.

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

From the Board Chair and CEO

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

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

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

For more than 20 years, ISO New England has worked to ensure a reliable supply of electricity for New England's consumers. We are proud of our accomplishments but also recognize that without our engaged stakeholders, the region's electricity industry wouldn't be as ready for the future as we are today. By embracing a competitive marketplace and upgrading its transmission system, New England has laid most of the foundation for the next phase of the evolution of the regional power system.

Restructuring in this region has progressed in stages over the past two decades. In the 1990s, ISO New England was created and worked with the New England Power Pool and the New England states to open the region's transmission lines to wholesale transactions and launch the marketplace for the purchase and sale of wholesale electricity.

Shortly thereafter, a robust stakeholder process led to transmission-cost allocation that fostered the development of transmission infrastructure needed for reliability. By relieving severe transmission constraints, the region eliminated hundreds of millions of dollars of annual congestion costs and out-of-market reliability contracts for generators in transmission-constrained areas. At virtually the same time, a large amount of new, mainly cleaner-burning natural gas generation was built through private investment, displacing older resources. These power plants helped New England meet record-breaking consumer

demand through the mid-2000s, lowered carbon dioxide emissions, and drove wholesale prices to the lowest levels the region has ever seen. Last year, natural gas plants provided nearly half of regional electricity production.

Competitive forces have unleashed new approaches for producing electricity in a cleaner way and integrating technology that enables different types of resources to participate in the wholesale markets. Beginning in June, demand resources will be included in the energy and reserve markets, setting prices, and taking on the same obligations as generators—a first for any ISO or RTO. This December, new fast-responding energy-storage resources also will be able to participate as dispatchable resources in the energy and reserve markets, in yet another step the ISO has taken to prepare for and manage the growth in clean-energy technologies.

The amount of wind and solar power continues to grow and is making a difference in how the ISO operates the power system and designs the wholesale markets. Simultaneously, significant investments in solar resources and energy-efficiency measures have been tempering electricity demand. However, the demand for electricity produced at the wholesale level may increase in the long term if the New England states push the transportation and heating sectors toward electric options as they strive to decarbonize the economy.

Responding to changes in the industry and public policy, the ISO periodically revises the rules that govern the energy, capacity, and ancillary markets, including most recently a proposal to change the Forward Capacity Market (FCM). The ISO and its stakeholders recognize that an increase in renewable resources procured by the New England states through above-market, long-term contracts could jeopardize competitive pricing in the capacity market. If accepted by the Federal Energy Regulatory Commission (FERC), the ISO proposal called CASPR, or Competitive Auctions with Sponsored Policy Resources, is intended to accommodate policy-sponsored, clean-energy resources while maintaining competitive pricing outcomes for new and existing power plants in the FCM that do not receive long-term contracts and that depend on wholesale market revenues.

Although the region has benefited greatly from industry restructuring, the road has never been an easy one, and the path forward will likely be equally, if not more, difficult. Currently, the biggest challenge to the reliability of the grid is the lack of fuel infrastructure to supply the fleet of natural-gas-fired generators, further emission restrictions on oil-fired generation, and the reality that older oil and nuclear generators are becoming less economically competitive and may retire before the region has added sufficient new energy sources to replace them.

During the recent cold stretch that gripped New England from December 26, 2017, to January 7, 2018, our system operators worked around the clock to keep the power flowing and the grid stable. Constrained pipeline capacity resulted in substantially higher natural gas and wholesale electricity prices, leading to less expensive oil and coal power plants operating instead of the usually competitive natural-gas-fired generation. With oil-fired generation running hard, oil supplies at plants around the region began to rapidly deplete over the two-week period, making system operations extremely challenging and significantly increasing the reliability risk to the system. In the coming years as more oil, coal, and nuclear leave the system, keeping the lights on in New England will become an even more tenuous proposition.

The ISO developed its *Operational Fuel-Security Analysis* report, which was issued in January, for this very reason. The basis of this report is two-fold. First, we wanted to better understand what levels of risk to reliability we would encounter as the grid operator under a wide range of possible combinations of

generating resources and fuel mixes. Second, in quantifying these scenarios, we wanted to provide regional policymakers and other stakeholders the information they need to help the ISO determine what level of risk the region will tolerate and what steps the region should pursue to mitigate the risk. The analysis demonstrates that if overall fuel security is not addressed, the region will face a setback to both future power system reliability and state efforts to transition to clean energy economy-wide, as well as increased energy costs.

The ISO is mandated to use wholesale electricity markets to ensure New England has sufficient power resources to maintain reliability. To help mitigate the fuel-security risks, we have the ability to seek authority from the FERC to further improve the market's pricing of fuel constraints, strengthen the financial incentives for power plants to secure more reliable wintertime fuel arrangements, and, if necessary, retain resources essential to ensure grid reliability.

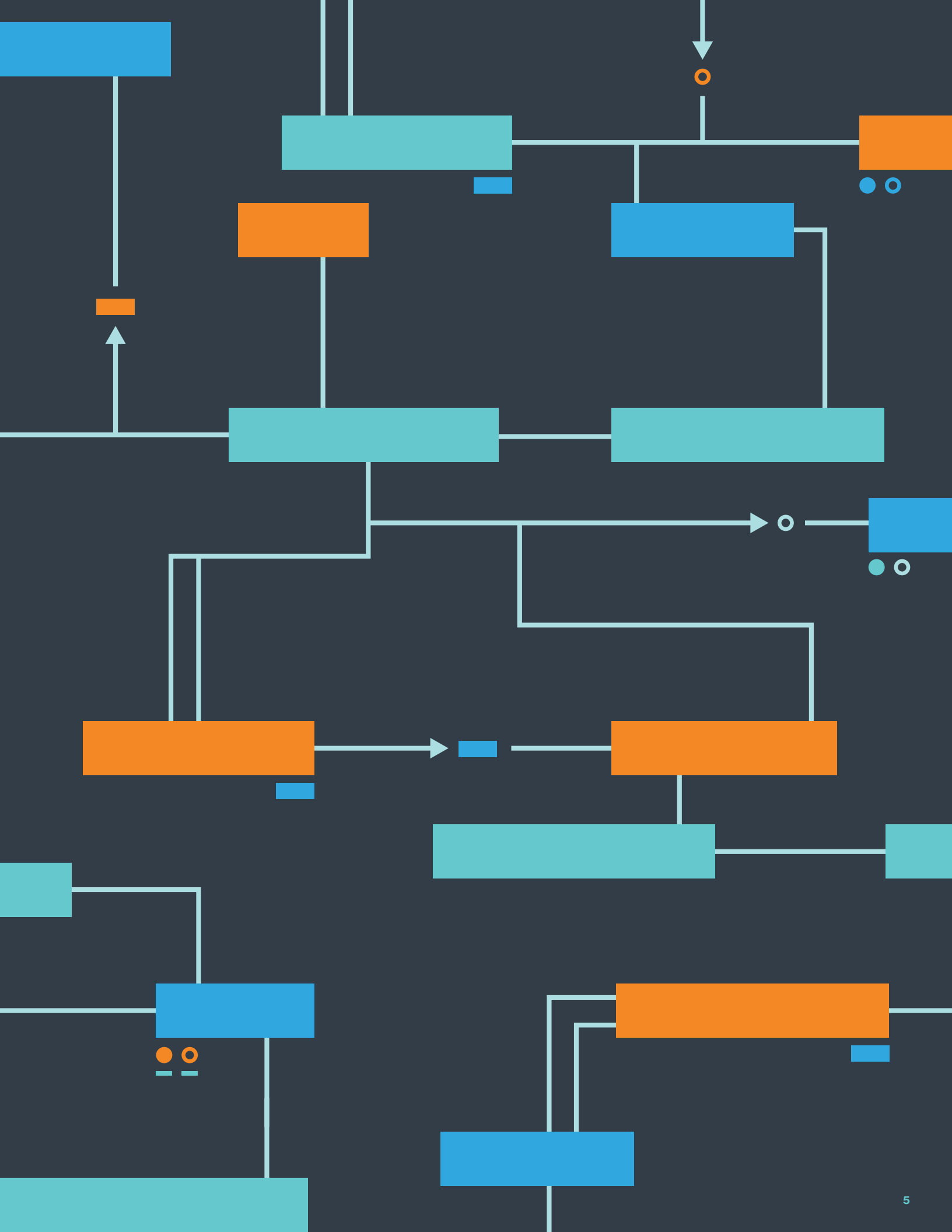
While these actions will improve market incentives and appropriately raise prices under scarcity conditions, they are only the stimulus to resolve the fundamental causes of the fuel-delivery constraints; it will be up to market participants and state officials to take actions to secure forward fuel arrangements or bolster supply- or demand-side infrastructure. Appropriate investments could include enhancements to natural gas infrastructure or the supply chains for liquefied natural gas and oil; relaxation of rules to allow easier permitting and operation of dual-fuel resources; investments in even more renewable energy and any transmission needed to deliver it; or further measures to significantly reduce demand on the power system or the gas system. Most likely, the solution for New England will be some combination of these.

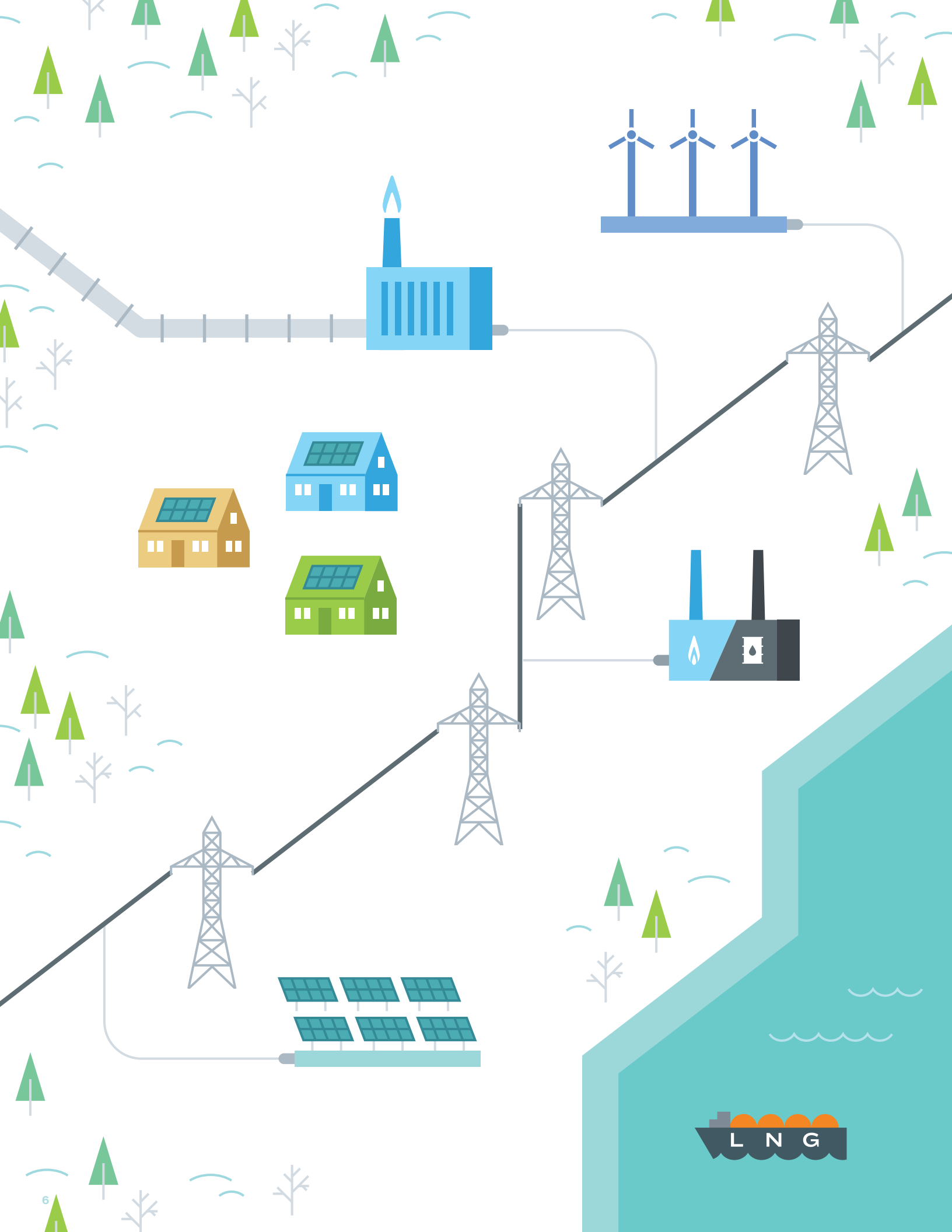
The ISO understands that policymakers must meet a broad range of economic and environmental goals for the region's homes and businesses beyond reliability goals. Consequently, it is important to highlight the reliability, economic, and environmental consequences of our situation: that regional action to resolve fuel-security risks will involve costly infrastructure investments and perhaps the retention of certain critical energy resources, but inaction will also come with a bill for high energy prices when energy supply is constrained—as well as the potential for greater risks to power system reliability and higher emissions.

New England faces tough choices. Industry representatives, state officials, and policymakers will have a vital role to play as we determine the course of action the region will take to keep our power system reliable; ensure competitive wholesale electricity prices; and transition to a cleaner, greener grid. Fuel security will not be an easy problem to solve. As a result, in 2018, we expect stakeholder discussions to intensify as we dig into this challenge and identify possible solutions.

In closing, after 20 years, making whole on the promise of industry restructuring is still something ISO New England takes seriously. As we begin a new decade of operation as an ISO, we stand ready to work with our stakeholders in evaluating various market design options and to support regional policymakers as they consider the difficult investment decisions or regulatory changes needed to ensure our region's energy future.

Sincerely,




L N G

Electricity Supply and Demand on the Evolving Power Grid

New England's competitive wholesale electricity markets and the New England states' clean-energy initiatives are facilitating a dramatic shift to cleaner power sources. Simultaneously, state investments in and consumer adoption of energy-efficiency measures are driving down electricity use, and distributed generation is reducing demand from the grid. ISO New England's innovative efforts are keeping the regional power system a step ahead of this transformation.

Demand Is Trending Downward over the Next Decade, but May Trend Upward in the Long Term

- 14.8 million people in 7.2 million households and businesses rely on New England's power system.
- Electricity consumers used over 121,000 gigawatt-hours (GWh) of electricity from the grid in 2017, down from a record high of 136,355 GWh in 2005.
- Weather drives consumer demand. During 2017's cooler summer, peak demand (the highest amount of electricity used in a single hour) hit only 23,968 megawatts (MW), in contrast to the all-time peak demand of 28,130 MW in 2006.
- Over 130,000 solar power installations span the six New England states, totaling about 2,400 MW (nameplate). Almost all are connected to local distribution utilities or "behind the meter" (BTM) directly at retail customer sites. The ISO doesn't direct the amount of electricity these resources produce; we see their impact as a reduction in demand on the grid.
- About 2,700 MW of active demand response and energy efficiency (EE) also reduce demand.
- In the long term, grid demand could increase if the transportation and heating sectors are electrified as part of the New England states' decarbonization efforts.

Supply Is Trending Cleaner

- New England has about 350 dispatchable generators, able to supply roughly 29,000 MW of electric power for summer 2018 and 31,000 MW for winter 2018/2019 (seasonal claimed capability).
- About 1,500 MW in summer and 1,000 MW in winter of imported electricity are also obligated to be available for New England's power needs—mostly from Canadian hydropower.
- Most of the region's generation is fueled by natural gas. Natural-gas-fired power plants represent about 45% of regional summer capacity, with an additional 11% listing natural gas as a secondary fuel.
- Oil, coal, and some nuclear power plants are retiring. Over 4,600 MW—an amount equal to about 16% of the region's current generating capacity—will have retired from 2013 to 2021. More than 5,000 MW of additional coal- and oil-fired generation could be retiring in coming years because of age and infrequent operation.
- Between 2001 and 2016, generator air emissions in New England have decreased significantly. The shift away from oil and coal and toward lower-emitting natural gas has helped drive down nitrogen oxides (NO_x) by 73%, sulfur dioxide (SO_2) by 98%, and carbon dioxide (CO_2) by 29%.

Energy Efficiency and Solar Power Are Driving Down New England's Annual Energy Use over the Next Decade

State-sponsored energy efficiency (EE) and behind-the-meter solar photovoltaic (PV) programs are reversing the growth in overall electricity demand and slowing growth in peak demand. The states are projected to spend $7.2 billion on EE between 2021 and 2026.

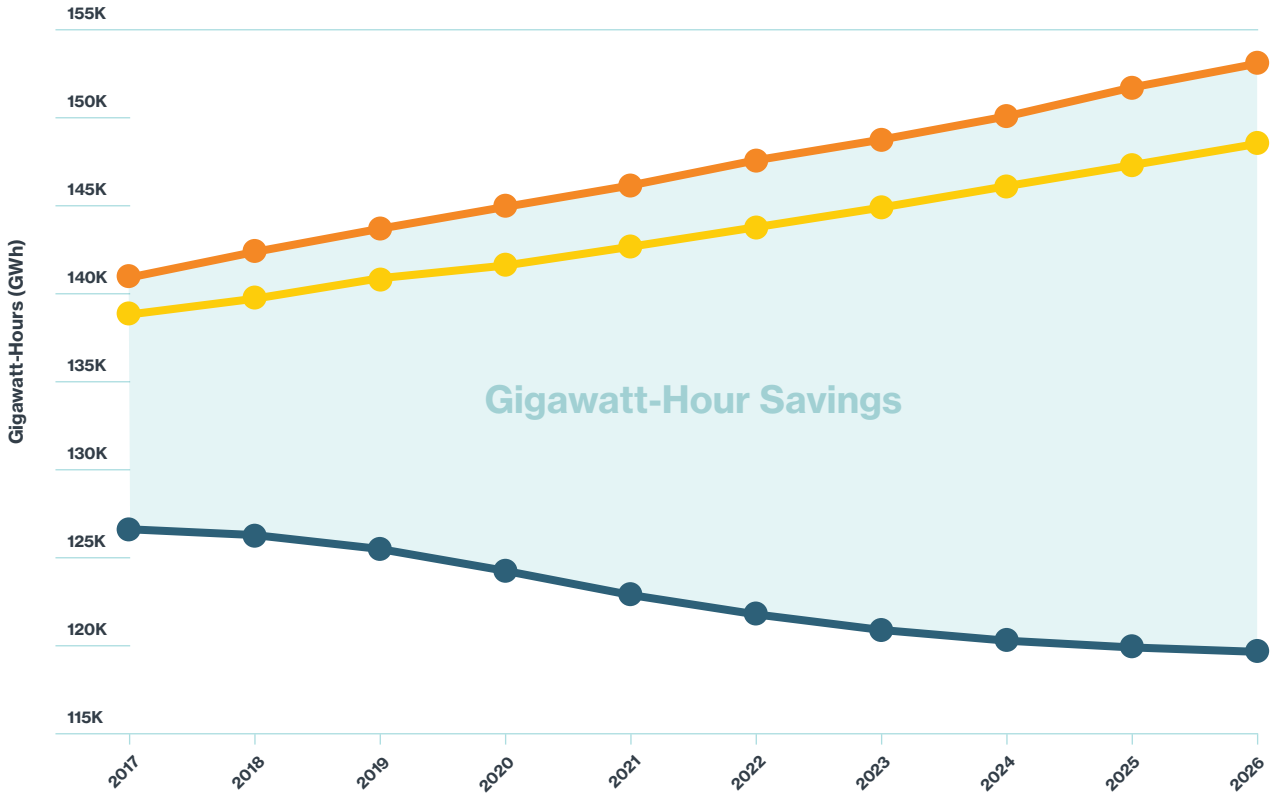
Gross Load
The gross load forecast (projected regional energy use)

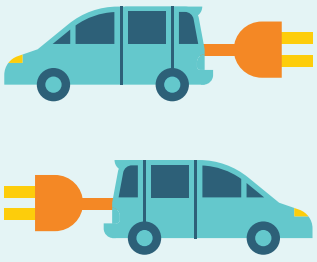
Minus PV
The gross load forecast minus forecasted BTM PV

Minus PV, EE
The gross load forecast minus forecasted BTM PV, minus EE resources in the FCM 2017–2020 and forecasted EE 2021–2026

Source: ISO New England, *Final Energy-Efficiency Forecast for 2021–2026* and *Final 2017 PV Forecast* (May 2017)

Projected Annual Energy Use with and without EE and PV Savings



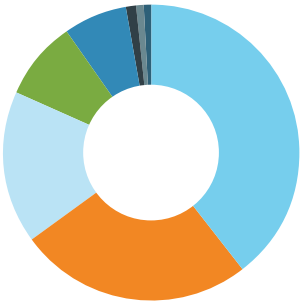


Decarbonization of Transportation and Heating Could Impact the Grid

A possible future trend that the ISO is watching out for is the increased adoption of electric vehicles (EVs) across the region and the greater use of electric heating. Both could increase in the future as part of the New England states' efforts to achieve their decarbonization goals. Vehicle manufacturers are also moving aggressively to include EVs in their product portfolios by the early 2020s. If rapid EV or electric heating adoption emerges, the impacts may need to be considered in the ISO's outlook for the region's demand and energy. The ISO plans to start working with regional stakeholders to quantify the impact of the states' decarbonization policies on long-term demand so that we can understand their potential effects on the power system and reflect these in future Regional System Plans.

Annual Net Energy for Load

2000		2017*
13%	Natural Gas	41%
27%	Nuclear	26%
14%	Net Imports	17%
7%	Renewables	9%
6%	Hydro	7%
16%	Coal	1%
19%	Oil	1%
N/A	Other**	<1%



Lower-Emitting Sources Fuel Most of the Region's Generation

In 2017, natural-gas-fired generation, nuclear, other low- or no-emission sources, and imported electricity (mostly hydropower) provided roughly 99% of the region's electricity.

* Data are subject to adjustments. Totals may not equal 100% due to rounding.

** "Other" represents resources using a fuel type that does not fall into any of the existing categories and may include new technologies or fuel types without sufficient quantity to have their own category.

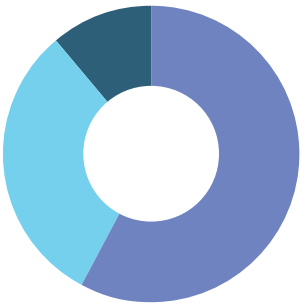
Source: ISO New England, *Net Energy and Peak Load by Source Report*

Significant Wind Power Is on the Horizon

In 2017, the amount of new wind power seeking interconnection in New England surpassed proposed new natural-gas-fired generation for the first time. About 4,000 MW of that wind power would be offshore of Massachusetts, with most of the remaining 4,500 MW located in Maine. Because of the large distances from some of the proposed onshore wind power projects to the existing grid, major transmission system upgrades will be needed to deliver more of this power from this weaker part of the system to far-away consumers. Proposed offshore wind projects closer to New England load centers may require fewer upgrades to the existing grid, but building wind turbines offshore is typically more costly than placing them on land.

New Energy-Project Proposals in New England

All Proposed Generation: ≈14,800 MW

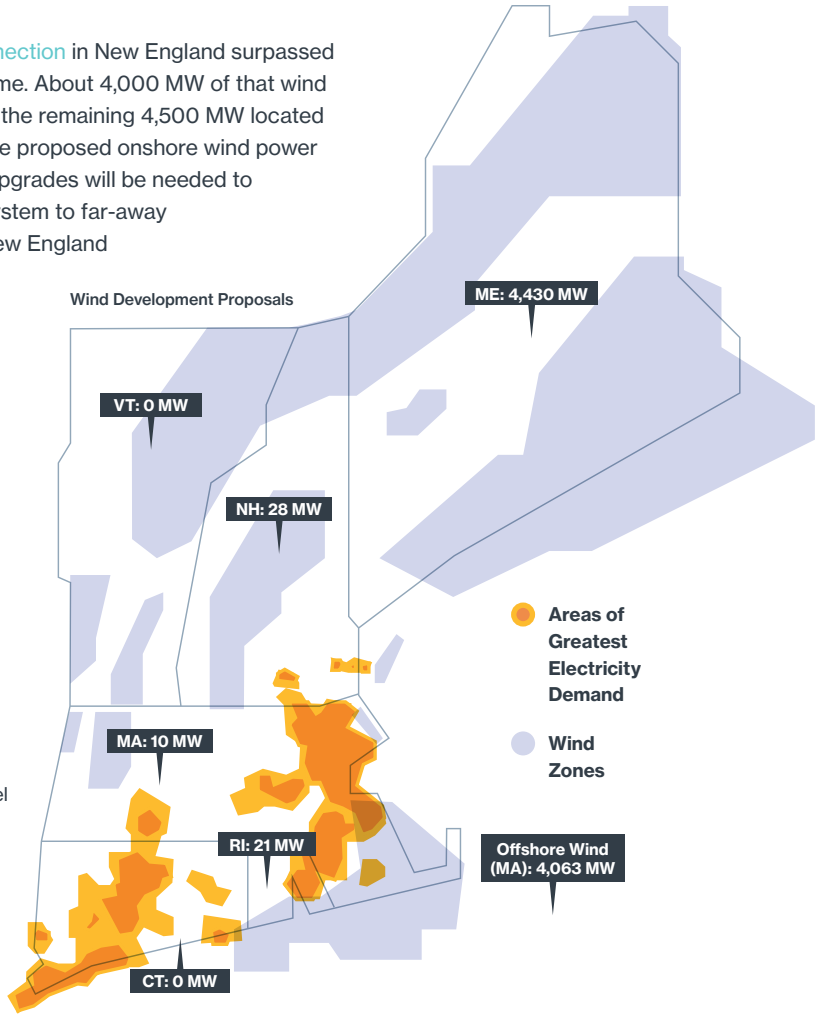


Wind*	58%
Natural Gas**	31%
Other	11%

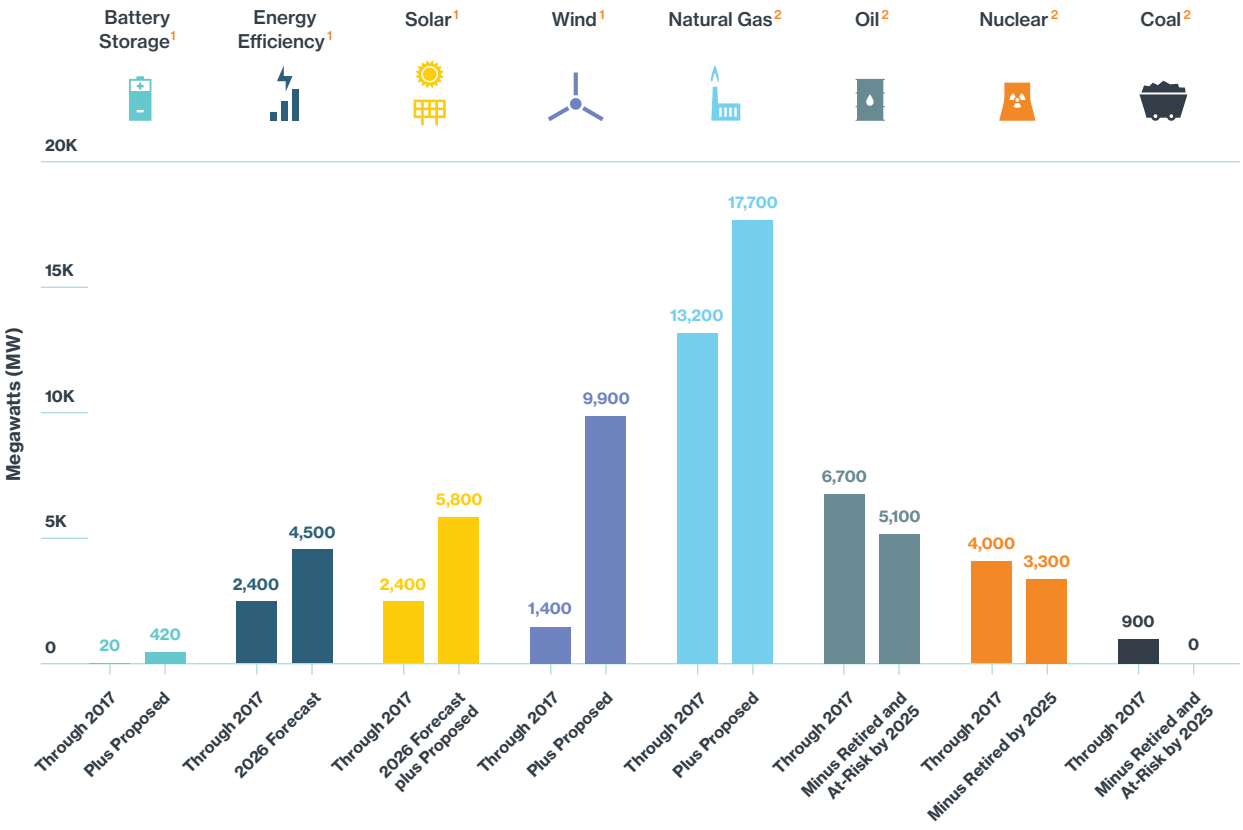
* Some wind projects include battery storage.

** Some natural gas projects include dual-fuel units (typically oil).

Source: ISO New England, *ISO Generator Interconnection Queue* (January 29, 2018)



Projected Changes in Key New England Power Resources and Energy Efficiency



Tomorrow's Power Fleet Will Be Even Cleaner, but Fewer Oil, Nuclear, and Coal Plants May Pose Reliability Challenges in the Future

Renewables, energy storage, and EE are on the rise in New England, as federal and state efforts, as well as technological advances and falling costs, catalyze their expansion. However, the region is still years away from getting most of its electricity from these sources, particularly at certain times of year; solar power doesn't help meet the winter peak, which happens after sunset, for example, and cannot produce power during cloudy conditions and during or soon after snowfall. New natural-gas-fired plants also continue to be proposed. In contrast, coal-fired, oil-fired, and nuclear power plants are closing largely because of economic forces and environmental-regulation costs. Coal- and oil-fired plants mainly operate on hot, humid summer days when demand soars. They're also critical on cold winter days when the natural gas pipelines serving New England are constrained and fuel for natural-gas-fired generators becomes expensive or unavailable. Fuel constraints and the continued loss of major non-gas-fired generation may pose a threat to keeping the lights on during future cold snaps. See page 24 for more on New England's fuel-security challenges.

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

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

2 **Nameplate capacity for proposed projects;** summer seasonal claimed capability for existing units based on primary fuel type. Some oil units can also burn natural gas and vice versa. **The 2025 values for oil and coal are hypothetical,** reflecting major planned retirements, plus the possible loss of over 5,000 MW of generation at risk due to plant age and infrequent operation.

Source: ISO New England, *ISO-NE Generator Interconnection Queue* (January 29, 2018), *CELT Report* (2010, 2016, 2017), *Final 2017 ISO-NE Solar PV Forecast, Final Energy-Efficiency Forecast Report for 2021 to 2026, Seasonal Claimed Capability Monthly Report* (January 2018), *Status of Non-Price Retirement Requests and Retirement Delist Bids* (August 2017), and *2016 Economic Studies Phase I Assumptions* (2016)

New England Will Be Ready for a Greener, Smarter Grid

The ISO is developing state-of-the-art processes and systems to apply new technologies and to integrate renewable and emerging resources onto the grid. In 2018, our efforts continue:

- Our pioneering **Oscillation Source Location Tool** will identify when a generator or substation is causing high-magnitude sustained oscillations so the ISO or plant operators can take corrective action to help avoid damaging mechanical vibrations or cascading power outages.
- **A new "clustering" methodology** enables interconnection requests from multiple generators and elective transmission upgrades to be studied together. This will help move forward the requests in northern and western Maine where thousands of megawatts of proposed new resources, mostly wind, are seeking to interconnect to the regional grid. It may also help generators save on interconnection costs.
- **Behind-the-meter (BTM) solar power will be integrated into operational load forecasts** to help the ISO predict levels of solar power output regionally with the higher degree of accuracy needed to operate the grid reliably and efficiently. We're also incorporating improved modeling of BTM solar power in the calculations that help determine the amount of capacity to procure through the Forward Capacity Market.
- Different approaches will be assessed for **pricing real-time generator flexibility** and **co-optimization of day-ahead energy and reserve offers**. The goal is to appropriately compensate power plants that efficiently help balance changes in power supply and demand. Pricing real-time flexibility may become more important with growing solar and wind resource development.
- We continue to pursue enhanced monitoring and dispatch software in preparation for an increasing amount of **grid-scale energy-storage devices**.

Transmission Investments Improve Pricing, Pollution, and Positioning

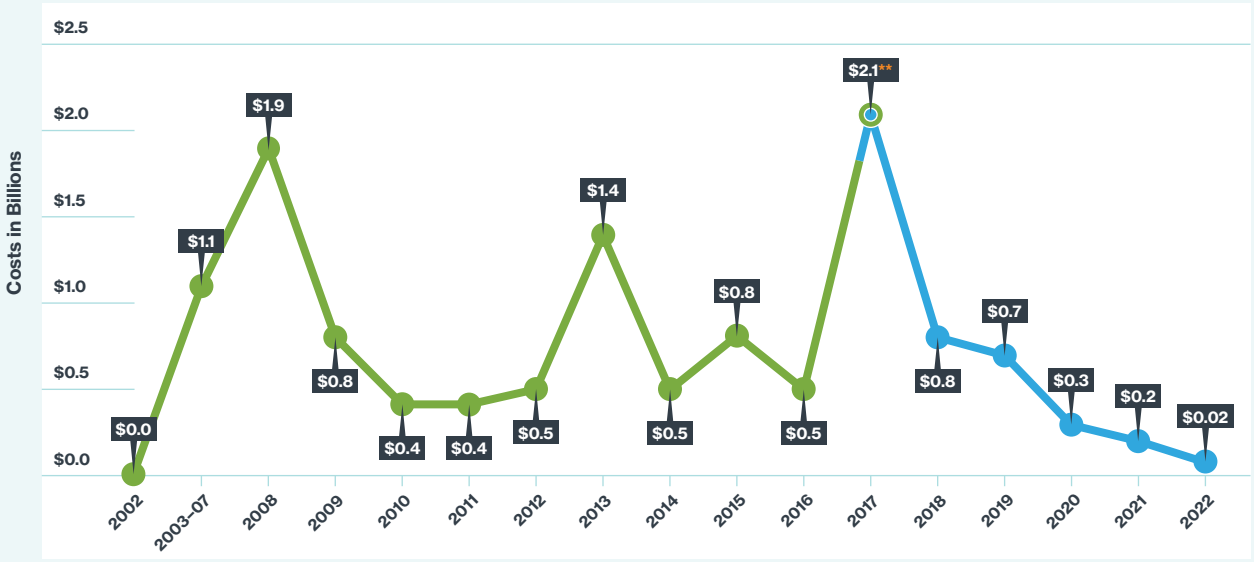
The regional transmission system includes about 9,000 miles of high-voltage transmission lines and 13 interconnections to electricity systems in New York and Canada. The ISO's continuous analysis has guided regional investment to fix weaknesses and bottlenecks, which, in addition to ensuring reliability of the transmission system, has enabled the interconnection of power plants with lower emissions, as well as the more efficient flow of low-cost power across the region. Today, New England's electricity consumers, who ultimately pay the transmission project costs, benefit from less risk of blackouts, lower wholesale energy costs, and less air pollution, all while the grid is being positioned to become greener and more flexible.

Because of this investment, fewer projects for reliability purposes are expected going forward; however, additional transmission projects could be driven by new reliability standards or to support efficiency of wholesale electricity markets or public policy goals. Private developers are also competing in state procurements to build transmission projects that will enable the delivery of clean energy from northern Maine, New York, or Canada. As of January 2018, over 20 elective transmission upgrades were proposed.

Guiding Strong Investment

As of October 2017, about 750 transmission projects had been placed in service since 2002, and 120 more were anticipated.

Transmission Investment in New England to Maintain Reliability



* Estimated future investment includes projects under construction, planned, and proposed. Totals may not equal 100% due to rounding.

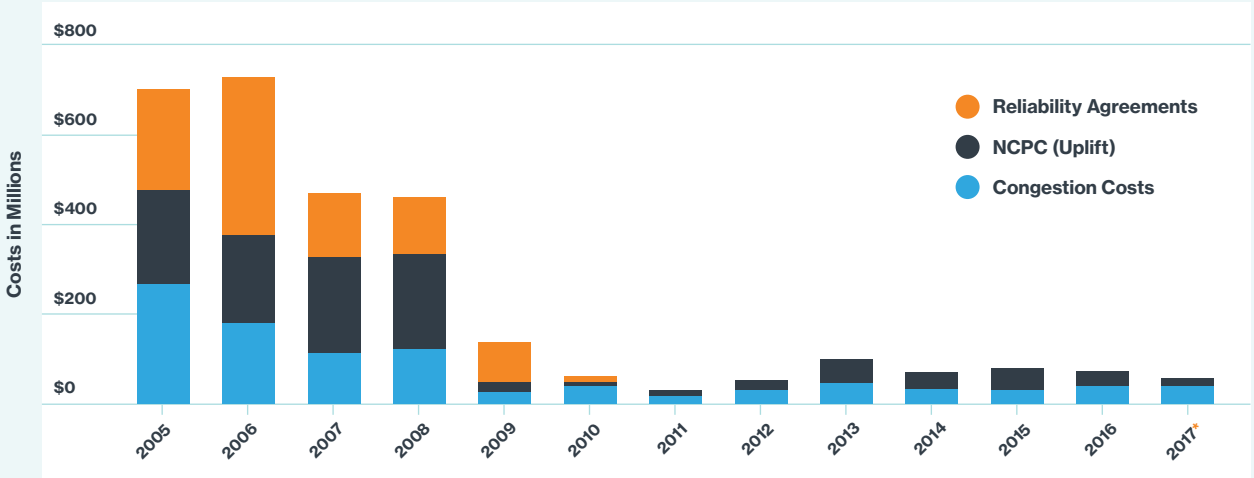
** $1.7 billion was in service through October 2017, with $0.4 billion estimated for November and December.

Source: *RSP Transmission Project List* (October 2017)

Helping Lower Energy Costs

New England's revitalized transmission system has contributed to striking decreases in congestion costs in the energy market and has, with the aid of low natural gas prices and other factors, helped drive down and mitigate uplift costs, as well (payments to make sure a resource following ISO dispatch instructions is no worse off financially than in the best alternative generation schedule). Additionally, the ISO has not had to use special reliability contracts since 2010. (These costs are included in the market values shown on page 17: congestion costs in the energy market, uplift costs in the ancillary market, and former reliability agreement costs in the capacity market.)

Costs for Congestion, Uplift, and Reliability Agreements



Note: Reliability agreements have not been used in the region since 2010. NCPC is Net Commitment-Period Compensation.

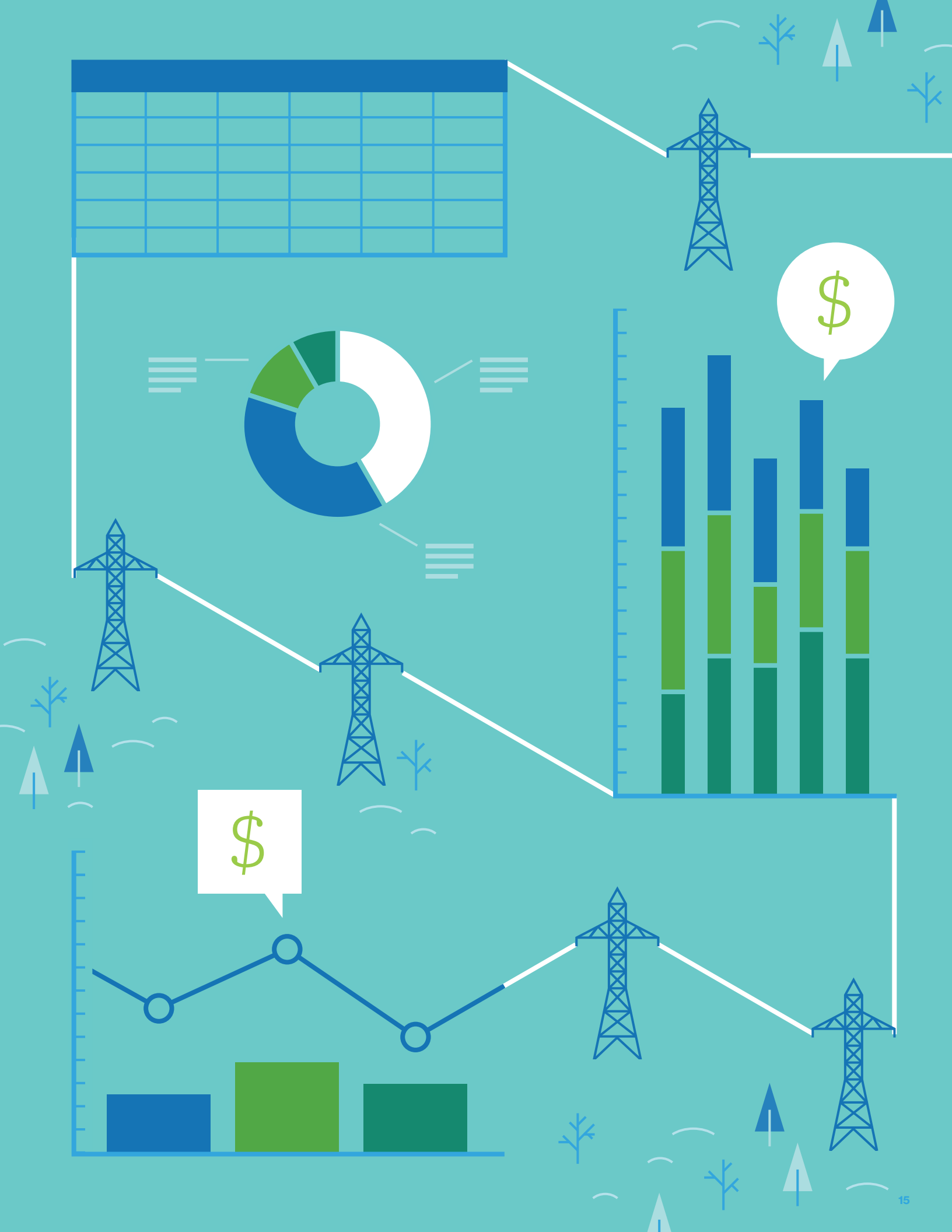
* Data are subject to adjustments.

Source: *Regional System Plans, Annual Markets Reports*

Competitive Markets

Are a Powerful Tool

The open, competitive, and transparent suite of wholesale electricity markets designed and run by the ISO has returned clear results and is the key for maintaining a reliable supply of power at competitive prices into the future.



Strong Competition Yields Investment

The region's energy, capacity, and ancillary (regulation and reserves) markets have attracted almost 500 companies that compete to sell, buy, and transport wholesale electricity and other grid-related services. Market participants have invested billions into new, efficient, relatively low-emitting natural-gas-fired generation over the past two decades. They are also making additional investments—aided by federal and state incentives and public policies—in renewable generating resources.

Cheap Fuel Translates into Lower Energy Prices

The high efficiency of natural-gas-fired generators and the generally low cost of nearby shale gas (which emerged as a resource in 2008) are largely responsible for a 35% decrease in the average price of New England's wholesale electricity between 2004 and 2017. (2004 was the first full year of the redesigned energy market.) These lower wholesale prices translate into lower power-supply charges for consumers. In contrast, high annual averages in 2013 and 2014 were largely due to spikes in natural gas prices during wintertime pipeline constraints. Similar spikes were experienced during winter 2017/2018.

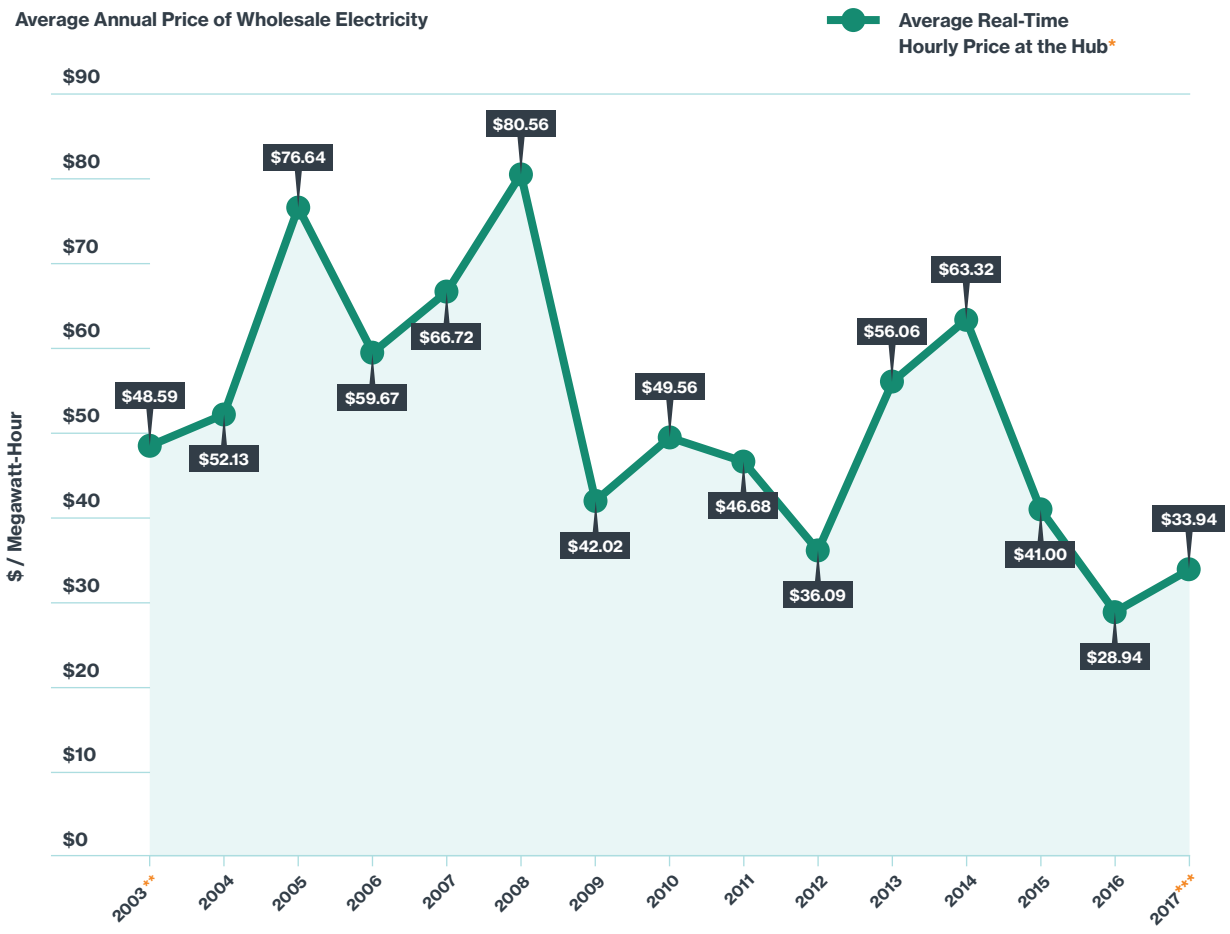
* The Hub is a collection of 32 locations in New England used to represent an uncongested price for electric energy. Starting with the March 2017 switch from hourly to five-minute market settlement, this is an average of the hourly average of five-minute locational marginal prices.

** Data start March 1, 2003, with launch of redesigned wholesale electricity markets.

*** Data are subject to adjustments.

Source: *SMD Hourly Data Reports*

Average Annual Price of Wholesale Electricity

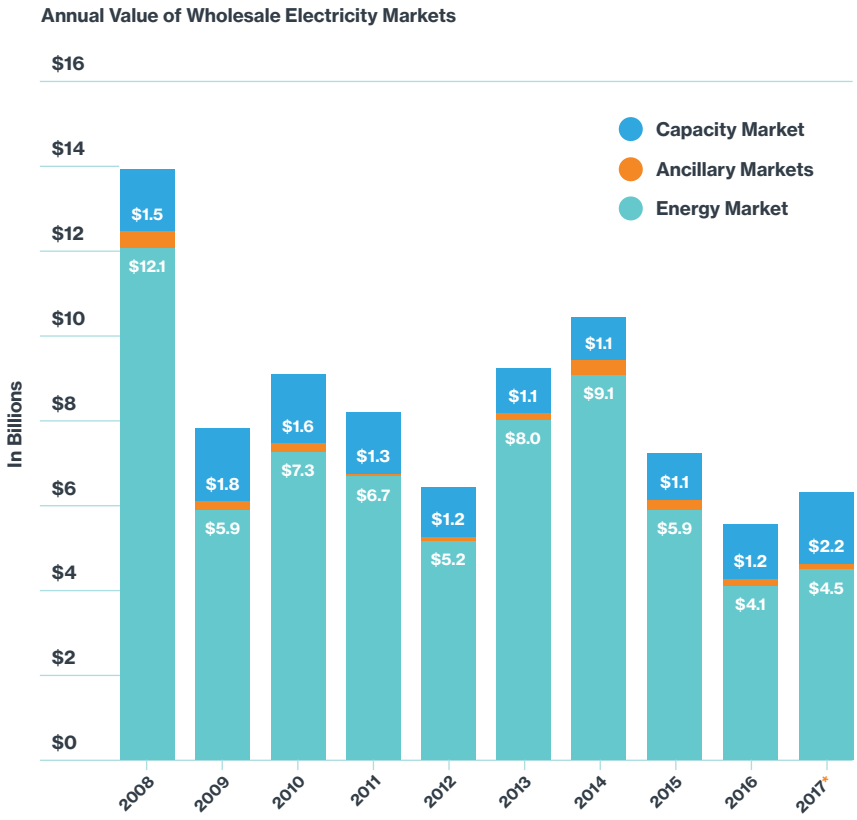


Market Values Reflect Prices and Demand

A frigid late December 2017 led to spikes in energy prices and higher consumer demand. Even so, the region's energy market remained at its second-lowest annual value ever last year because of lower prices and demand for most of the year. This helped keep the total combined value of New England's markets at one of its lowest levels, as well, despite the increase in capacity prices precipitated by the need to replace retiring generators.

* Data are subject to adjustments.

Source: ISO New England data



Three Keys to New England's Marketplace Success

1. **Competition** drives private investment in energy technologies that provide efficiencies and savings today, as well as in emerging technologies that may revolutionize energy production tomorrow.

2. **The ISO's selection of the lowest-priced offers** incentivizes power plant owners to price energy and other services as low as possible, closely reflecting their fuel and operating costs.

3. **Competitively determined prices,** which respond to real-world inputs, sustain the efficient power resources that meet consumers' energy needs. They also point to any constraints on the power system or power plants' fuel supplies, signal where and when private investment in resources is needed, and indicate where and when uneconomic power plants should retire. See page 26 for more on pricing the true costs of providing a reliable supply of electricity.

The Capacity Market Responds to Changing Times

Through the Forward Capacity Market (FCM), new, cleaner power resources are filling the gaps left by the retirements of older and typically less-efficient and higher-emitting power plants. In total, the last five auctions have attracted more than 3,600 MW in new generation. About 2,000 MW in new demand resources (including EE) have also participated.

The FCM compensates resources for taking on an obligation to meet the region's electricity needs in three-years' time. The region should expect to see capacity prices increase over time as renewable resources reduce energy prices, making developers of new resources and owners of existing resources more reliant on capacity market revenues. Diminished energy prices will affect traditional merchant resources first, but in time even renewable resources will be affected.

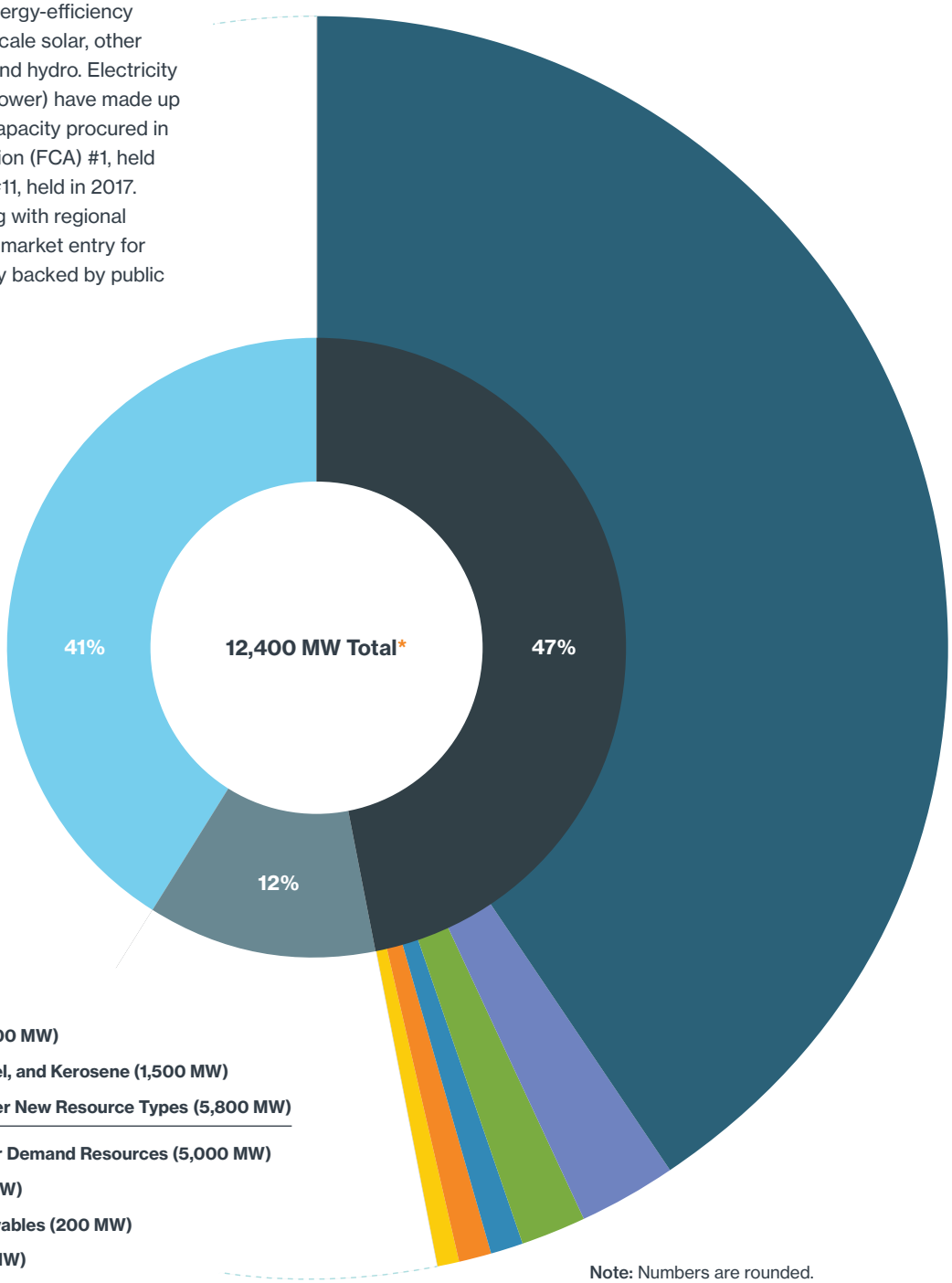
New England Markets Are in the Vanguard

Wholesale markets facilitate changes in the resource mix, encourage advancements in technology, and accommodate new and long-standing public policy goals. We continually update our market rules, procedures, and software to make sure they remain effective given these changes, as well as to enhance efficiency and transparency. Revising markets is an intensive process of collaboration with market participants, state utility regulators, and other stakeholders.

- **FCM "pay-for-performance" (PFP) incentives go into effect**—Beginning June 1, 2018, capacity payments will reward power resources that make investments to successfully boost performance during periods of system stress. Resources that don't perform will forfeit a portion of capacity payments.
- **A "substitution auction" is proposed**—The qualification process begins this year for the 2019 FCM auction (FCA #13), where, if approved by FERC, a second auction phase will be introduced to coordinate the entry of clean-energy resources sponsored by public entities and the exit of existing capacity resources. (More on page 27.)
- **New price-responsive demand (PRD) framework launches**—Coming June 2018, the ISO expects to become the first US grid operator to incorporate demand resources into the energy dispatch and reserve-designation process in a manner comparable to that of generating resources, adding to demand resources' long-standing ability to participate in the capacity market.
- **Energy-storage options expand**—Since the 1970s, New England has benefited from pumped-storage hydropower. The ISO marketplace offers a flexible framework to accommodate the unique attributes of these and other energy-storage assets, which can participate as generators, load, or both. Later this year, emerging energy-storage technologies will be able to begin participating as dispatchable resources in the energy market while continuing to participate in the regulation market.

Supporting the Entry of New Clean-Energy Resources

Of the new capacity coming from resources within New England, almost half has come from a combination of demand resources (including energy-efficiency measures), wind, grid-scale solar, other renewable resources, and hydro. Electricity imports (mostly hydropower) have made up about 5% of the total capacity procured in Forward Capacity Auction (FCA) #1, held in 2008, through FCA #11, held in 2017. The ISO is collaborating with regional stakeholders to enable market entry for even more clean energy backed by public policies. (See page 27.)



New Regional Power Resources Procured in FCAs #1–11*

- **New Natural Gas (5,100 MW)**
- **New Oil, Coal, Jet Fuel, and Kerosene (1,500 MW)**
- **Renewables and Other New Resource Types (5,800 MW)**
  - **New EE and Other Demand Resources (5,000 MW)**
  - **New Wind (300 MW)**
  - **Other New Renewables (200 MW)**
  - **New Hydro (100 MW)**
  - **New Nuclear (80 MW)**
  - **New Solar (70 MW)**

Note: Numbers are rounded.

* Not included as new capacity here are imports (because most existing imports must requalify as new for each FCA) and the demand-resource type once known as real-time emergency generation.


Yarmouth
Merrimack
Newington
Vermont Yankee
Schiller
Salem Harbor
Footprint
Mt. Tom
Mystic
West Springfield
Medway
Canal
Pilgrim
Clear River Energy Center
Wallingford
Middletown
Brayton Point
Canal
Montville
Towantic
Bridgeport
New Haven
Bridgeport (Units 2 & 3)
Norwalk
Natural Gas
Major New Generation Projects Clearing in FCM
Coal
Generation at Risk
Nuclear
Closed or Retiring
Oil

The FCM Is Attracting Efficient, Lower-Emitting, and Fast-Starting Resources Amid Retirements

Most of the major new resources attracted by the FCM are natural-gas-fired generators with the ability to start up quickly. Several also plan to have dual-fuel capability so they can switch to an alternate fuel (typically oil) to maintain reliability if gas is unavailable or at a premium, such as during wintertime pipeline constraints. They are also proposed to be built near the areas with greatest electricity demand in the region. These types of flexible resources will be necessary in the coming years, not only to meet demand, but to help balance intermittent output from wind and solar resources, as well as to provide the grid-stability services that renewables generally do not. The major power plants with planned shutdowns or that are more likely to close (i.e., are "at risk") are many of the region's coal, oil, and nuclear units. Closures of regional nuclear facilities will remove major sources of zero-emission energy for New England.

Recent Large Proposed Projects	FCM-Cleared MW	Type	Planned Dual Fuel	Operational Target*
Towantic	750	Combined Cycle	✓	2018
Footprint	674	Combined Cycle		2018
Clear River Energy Center (Unit 1)	485	Combined Cycle	✓	2020
Bridgeport	484	Combined Cycle	✓	2019
Canal	333	Combustion Turbine	✓	2019
Medway	195	Combustion Turbine	✓	2018
Wallingford	90	Combustion Turbine		2018

Source: Project webpages and Forward Capacity Auction Results Reports

* Subject to delays


L N G

Keeping New England a Step Ahead

Throughout 2018 and beyond, ISO New England will be targeting several major issues that stem from ongoing changes in technology, the power generation fleet, and the regulatory environment.

Fuel Security for Regional Generators

The dependable performance of New England's fleet of generators is the cornerstone of a reliable supply of electricity, but this performance hinges on their access to fuel, especially during the winter. Fuel-security challenges have been a growing concern during winter, particularly for generators that run on natural gas, but also for others, such as those that run on oil as a primary or back-up fuel. These challenges are exacerbated by recent and anticipated retirements of much of the region's existing nongas generation. The ISO has already taken several steps to boost performance incentives for power plants and to improve gas-electric coordination and situational awareness. However, additional measures may be needed—including some that fall beyond the ISO's jurisdiction.

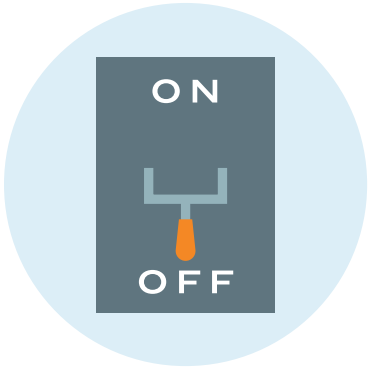
In January 2018, the ISO published an ***Operational Fuel-Security Analysis*** report that examines how a wide range of possible combinations of generating resources and fuel mixes could impact the reliable operation of the regional bulk power system during a future winter period. The study illustrates the number and duration of energy shortfalls that could occur that would require the implementation of emergency procedures to maintain reliability. Quantifying the level of risk provides information the region will use to discuss approaches to ensuring power system reliability. The analysis is available at www.iso-ne.com/fuel-security.

The Study in Brief

- The ISO studied 23 possible future resource and fuel scenarios during the entire winter of 2024/2025 to assess whether enough fuel would be available to meet demand under a wide range of possible conditions.
- The analysis found that inadequate fuel supply would lead to energy shortfalls in almost every scenario, requiring the frequent use of emergency actions to fully meet demand or protect the grid.
- Emergency actions that the public might notice range from requests to conserve energy to, as a last resort, load shedding (rolling blackouts affecting blocks of customers).
- While actual conditions could change earlier or later, winter 2024/2025 was chosen because the outlook for power system reliability by then is uncertain, largely due to the expected retirements of non-gas-fired power plants. The intervening years give the region time to act.

Five Variables Hold the Key

The study focused on five variables likely to be key factors in future power system reliability. Increased natural gas availability was not included because it was assumed that no significant natural gas pipeline capacity to serve generators would be added by winter 2024/2025. Notable findings regarding each variable:

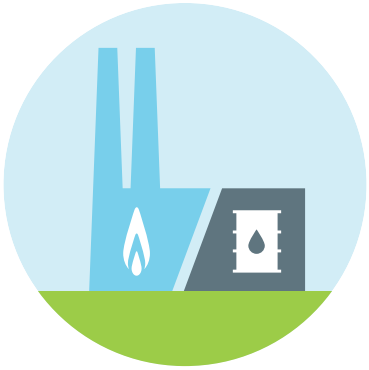


Resource Retirements

The retirements of coal-fired, oil-fired, and nuclear generators – resources with fuel stored on site – will have a significant impact on reliability and magnify the importance of other variables, particularly liquefied natural gas (LNG) supplies.

LNG Availability

Improving the volume and timeliness of winter deliveries of LNG could help reduce generators' fuel-security risk, while reduced volumes of this global commodity would raise risk.

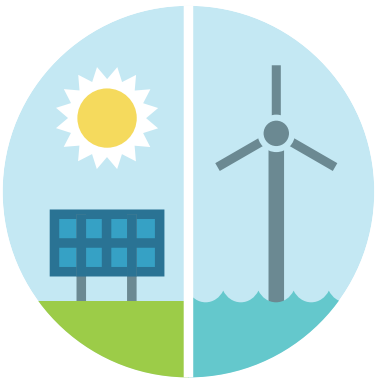


Oil Tank Inventories

The availability of oil stored in tanks on site is a key reliability factor and depends on the extent to which natural-gas-fired generators are able to add dual-fuel capability to burn oil, how often they can run on oil, and timely oil deliveries.

Imported Electricity

Expanding access to electricity from neighboring power systems would help mitigate fuel-security risk, but would require investment in transmission infrastructure.



Renewable Resources

Accelerating the growth of renewable resources would also enhance fuel security but would not eliminate reliance on LNG. It also would likely lead to more non-gas-fired resource retirements and may require transmission investment.

Six Major Findings for the Region to Consider

1. **Outages:** The region is vulnerable to the season-long outage of any of several major energy facilities, such as a large pipeline compressor station, a nuclear power plant, or an LNG facility.

2. **Stored fuels:** Future power system reliability will be heavily dependent on the region importing and storing enough LNG. More dual-fuel capability is also a key reliability factor, but permitting for construction and emissions is difficult.

3. **Logistics:** The timely availability of fuels of all types will be critical, highlighting the importance of fuel-delivery logistics.

4. **Risk trends:** All but four of the 23 scenarios result in fuel shortages requiring load shedding, indicating the trends affecting New England's power system may intensify the region's fuel-security risk. These trends include increasing resource retirements; the growth in natural-gas-fired power generation; growing demand from local gas utilities serving the heating sector; and an increase in renewable resources with variable output.

5. **Renewables:** More renewable resources can help lessen the region's fuel-security risk but are likely to drive coal- and oil-fired generator retirements. More LNG will be needed to counteract the loss of stored fuels.

6. **Positive outcomes:** More LNG, electricity imports, and renewables can help minimize system stress and maintain reliability but may necessitate transmission expansion and dependable delivery agreements for LNG and imports.

Ensuring Market Prices Reflect the True Costs of Reliability

Through competitive pricing, the region's wholesale electricity markets incentivize power plants to take action and make investments that help alleviate constraints threatening power system reliability. For this to happen, the costs of these constraints must be adequately reflected in market prices. It's expected that the new pay-for-performance (PFP) incentives will help motivate some power plants to secure more reliable wintertime fuel arrangements. However, the PFP rate was developed in 2013, and much has changed since then. The markets may need to present stronger rewards or forfeiture risks to drive change, particularly as the fuel constraints continue to worsen. This will mean higher prices in the energy and capacity markets, as the marketplace adjusts to reflect power resources' added costs and the price for keeping the lights on. But even with greater incentives, the wholesale markets are unlikely to drive market participants to make a collective investment in shared infrastructure, particularly if it's open-access fuel infrastructure available to all market participants, such as natural gas pipeline.

Does PFP need adjustment, or should steps be taken by the region to address constraints? These are some of the questions the ISO will focus on with the states and stakeholders in 2018 as part of the *Operational Fuel-Security Analysis* discussions. Answering them will require the region to first determine how much fuel-security risk it's willing to accept.

If solutions don't arrive soon enough, reliability interventions may be needed that could include the ISO taking steps to prevent resources with on-site fuel from retiring, not dispatching certain resources during adverse weather conditions to ensure fuel availability, and calling on resources outside of economic dispatch – all steps that increase wholesale electricity prices.

Accommodating the States' Clean-Energy Efforts While Maintaining Competitive Markets

The ISO is proposing changes to the Forward Capacity Market called Competitive Auctions with Sponsored Policy Resources (CASPR), which will help accommodate the entry into the FCM of renewable, clean, or alternative resources that receive revenue from state or municipal governments outside of the markets. At the same time, CASPR will protect the competitive pricing mechanisms that enable the FCM to both attract new and sustain existing power resources still needed to satisfy New England's electricity needs, balance intermittent renewable generation, and provide grid-stability services.

CASPR does this by introducing a second auction phase called a substitution auction. In this auction, new clean-energy resources with long-term government contracts or similar public financing can compete to buy the capacity supply obligations held by older, higher-emitting generators. In this way, CASPR will support the New England states' investments in clean energy, while also coordinating the exit of existing resources. And, importantly, it will ensure a level playing field for power resources that don't have state backing.

This last point is critical because to invest in the region, private developers need confidence that a new power project has a fair chance to achieve a return on investment. However, new power resources with public financial backing can sell their services at artificially low prices, undercutting the marketplace. At the same time, existing power resources are increasingly reliant on capacity revenues because current low energy market prices are providing fewer opportunities for resources to recover their fixed costs. As more renewables with no fuel costs and public financial support come on line, energy prices can be expected to continue to decline.

CASPR was designed around four principal objectives that will help ensure that the capacity market can continue to meet New England's reliability needs, while facilitating a competitive transition to a cleaner grid:

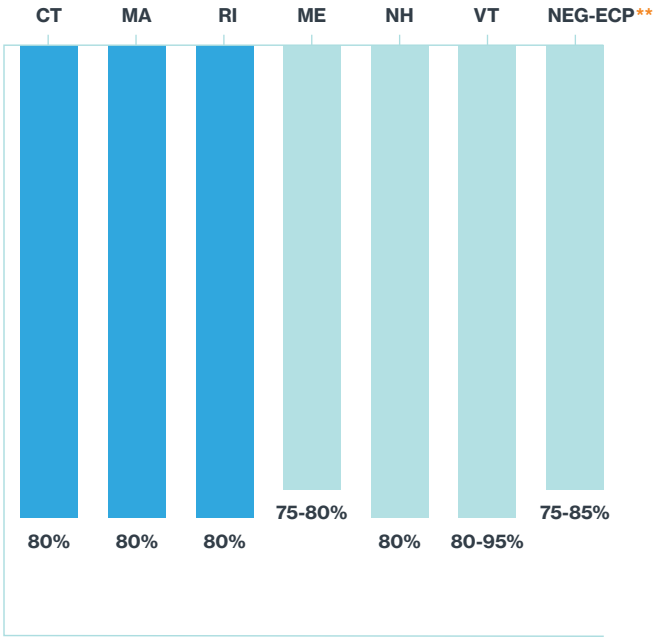
1. **Maintain competitive capacity pricing**—Minimize the price-suppressive effect of out-of-market subsidies on competitive (i.e., unsubsidized) resources.

2. **Accommodate subsidized new resources**—Help minimize the potential for New England to develop far more resources on the power system than the ISO requires to reliably operate it.

3. **Avoid cost shifts**—Minimize the potential for one state's consumers to bear the costs of other states' subsidies.

4. **Use a transparent, market-based approach**—Seek a practical solution that extends, rather than upends, the region's existing capacity market framework.

Reductions in Economy-Wide Greenhouse Gas Emissions below 1990 Levels by 2050*



Reducing CO_2

The electricity industry has been a logical starting point for the New England states' efforts to reach decarbonization goals. These include mandating air emission reductions for fossil-fuel-fired generators; offering tax incentives for renewable resources; and, more recently, establishing public policies that direct state agencies or electric power companies to enter into long-term contracts for clean energy.

Legislative Mandate

Aspirational Goal

* Some states have different baseline and target years

** New England Governors and Eastern Canadian Premiers (NEG-ECP)

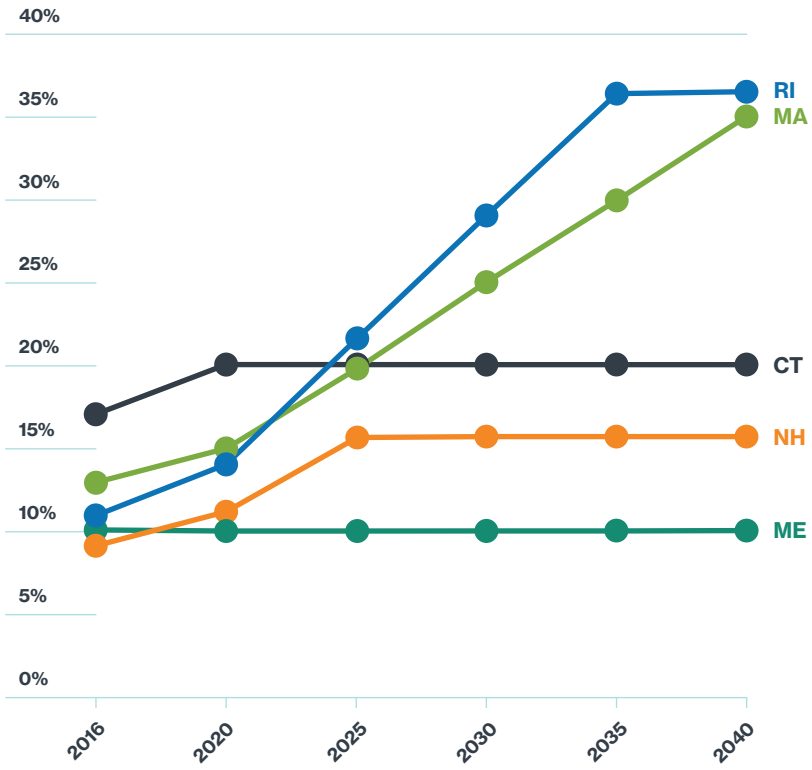
Increasing Clean Energy

All six states also have some form of renewable energy standards that require electricity suppliers to provide customers with increasing percentages of renewable energy.

Note: Vermont's standard recognizes new and existing renewable energy and is unique in classifying large-scale hydropower as renewable; it plateaus at 75% in 2032. Maine's requirement plateaued at 10% in 2017 and expires in 2022 but is held constant here for illustrative purposes.

Class I or New Renewable Energy (%)

VT: **55%** in 2018 **59%** in 2020 **63%** in 2025 **71%** in 2030 **75%** in 2035 **75%** in 2040



Possible New Grid-Resiliency Requirements

In January 2018, the Federal Energy Regulatory Commission ordered an examination of bulk power system resilience to evaluate whether additional actions to improve grid resilience would be appropriate. ISO New England will be providing FERC with requested information and will comply with any ordered changes.

Cybersecurity to Protect the Grid and Marketplace

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

- Our 24/7 Security Operations Center provides round-the-clock monitoring of the ISO technology network, and a 2017 project further tightened access to networked services and systems.
- We've heightened security controls for cyberassets and visitors to ISO facilities, in compliance with North American Electric Reliability Corporation (NERC) revised critical infrastructure protection (CIP) cybersecurity standards.
- In 2018, we'll be further strengthening security controls for hardware, software, and services associated with system operations, in response to NERC standards for supply-chain risk management.
- A new CIP and Systems Compliance Operations Group has been formed to, among other things, provide day-to-day support of infrastructure and cybersecurity compliance functions required by NERC CIP Version 5.
- We also participate in NERC GridEx exercises on cybersecurity and physical security, and conduct annual training for all ISO employees. In 2017, more than 70 employees participated in GridEx IV.

ISO Metrics

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

$1.03 per Month

The services and benefits the ISO provides to keep competitively priced power flowing will cost the average New England residential electricity consumer $1.03 per month in 2018, based on 750 kilowatt-hours per month usage. The ISO's 2018 operating budget of $195.5 million is the result of a lengthy stakeholder discussion to set priorities and is FERC-approved. Full financial statements are available at www.iso-ne.com/about.

96% Satisfaction

The latest survey of market participants (2017) revealed high overall satisfaction levels with the information and services the ISO provides. Positive satisfaction among respondents with an opinion was 96%. Responses help the ISO identify and prioritize improvements in system operations, market administration, the website, and other information products.

7,700 Questions Resolved

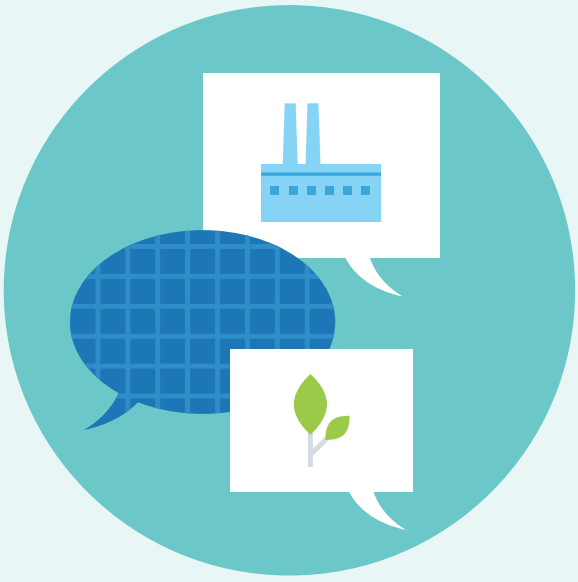
The ISO has a strong culture of responsiveness and outreach to keep market participants and other stakeholders well-informed. In 2017:

- ISO Customer Support handled over 12,000 calls, helping customers resolve 7,700 issues.
- We held classroom or web-conference trainings for over 1,000 stakeholders and made over 50 e-learning modules and 170 presentations available on the ISO website for stakeholders.
- Our extensive website was accessed over one million times by almost 250,000 unique visitors.
- ISO senior management, subject matter experts, and other staff met over 300 requests from stakeholders and the media for presentations, panel discussions, technical answers, and interviews.

In 2018, we'll be upgrading Ask ISO, our customer-issue management platform, to allow for even better service and performance.

60+ Stakeholder Meetings

The ISO's stakeholders are a wide-ranging group, from **market participants** to **regulators** to **policymakers** to **environmental advocates** and **retail consumers**. Their diverse perspectives help inform discussion and generate solutions to regional challenges. Stakeholders are an integral part of the ISO's budget processes, regional system planning, market development, and ISO Board nominations. They also interact regularly with ISO staff and participate in committees and working groups. In 2017, the ISO coordinated or participated in over 60 meetings of the Markets, Reliability, Transmission, and Participants Committees, and Planning Advisory Committee (PAC). The Consumer Liaison Group (CLG) also met quarterly to share information about the power system and wholesale electricity markets' impacts on consumers. The PAC and CLG are open to the public, while the rules governing the New England Power Pool, the association of regional market participants, determines attendance for the other committees.



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

Board of Directors

(As of January 2018)

Philip Shapiro
Board Chair

Gordon van Welie
President and Chief Executive Officer

Kathleen Abernathy

Roberta S. Brown

Brook Colangelo

Roberto R. Denis

Raymond Hill

Barney Rush

Vickie VanZandt

Christopher Wilson

Senior Management

(As of January 2018)

Gordon van Welie
President and Chief Executive Officer

Vamsi Chadalavada
Executive Vice President and Chief Operating Officer

Jamshid A. Afnan
Vice President, Information and Cyber Security Services

Peter T. Brandien
Vice President, System Operations

Janice S. Dickstein
Vice President, Human Resources

Robert Ethier
Vice President, Market Operations

Anne C. George
Vice President, External Affairs
and Corporate Communications

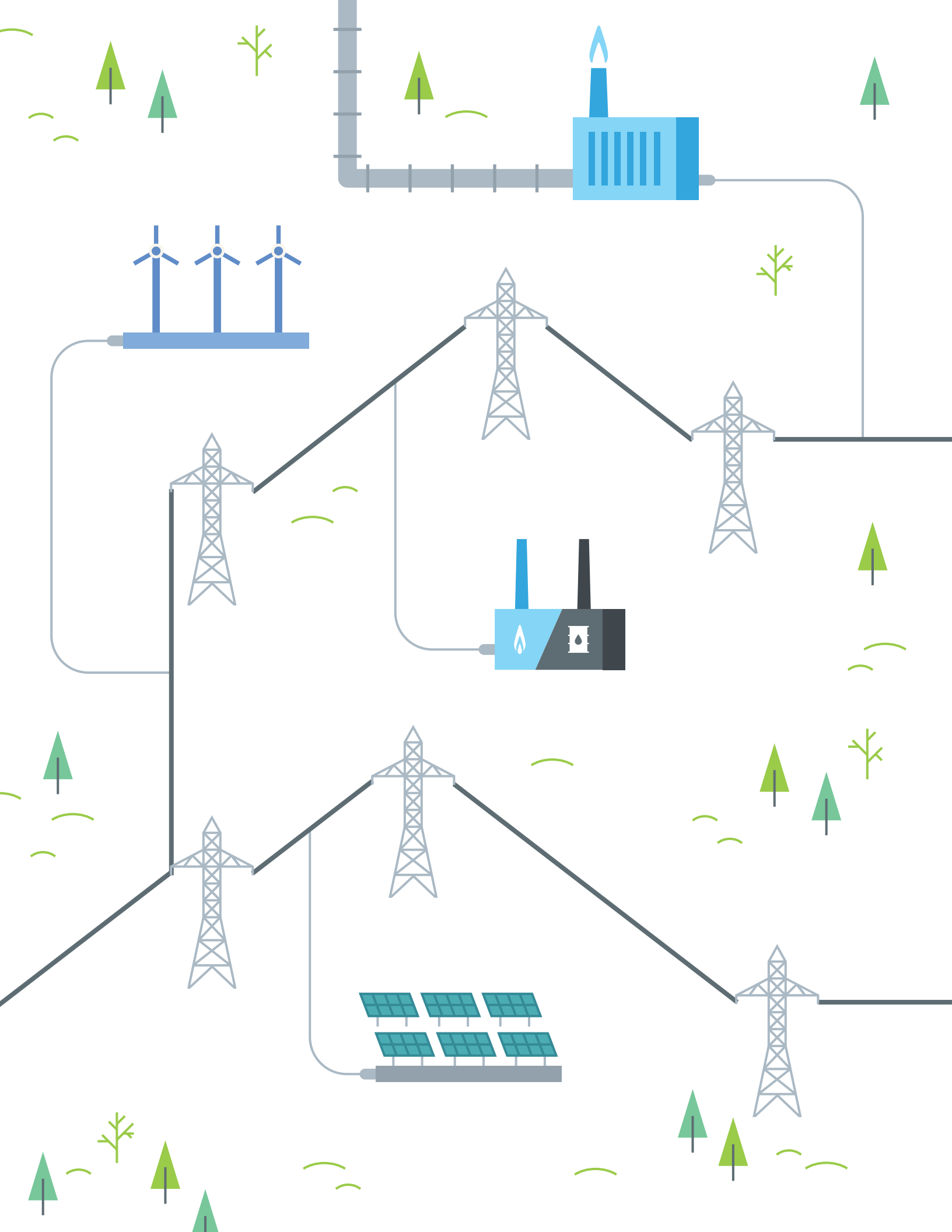
Raymond W. Hepper
Vice President, General Counsel,
and Corporate Secretary

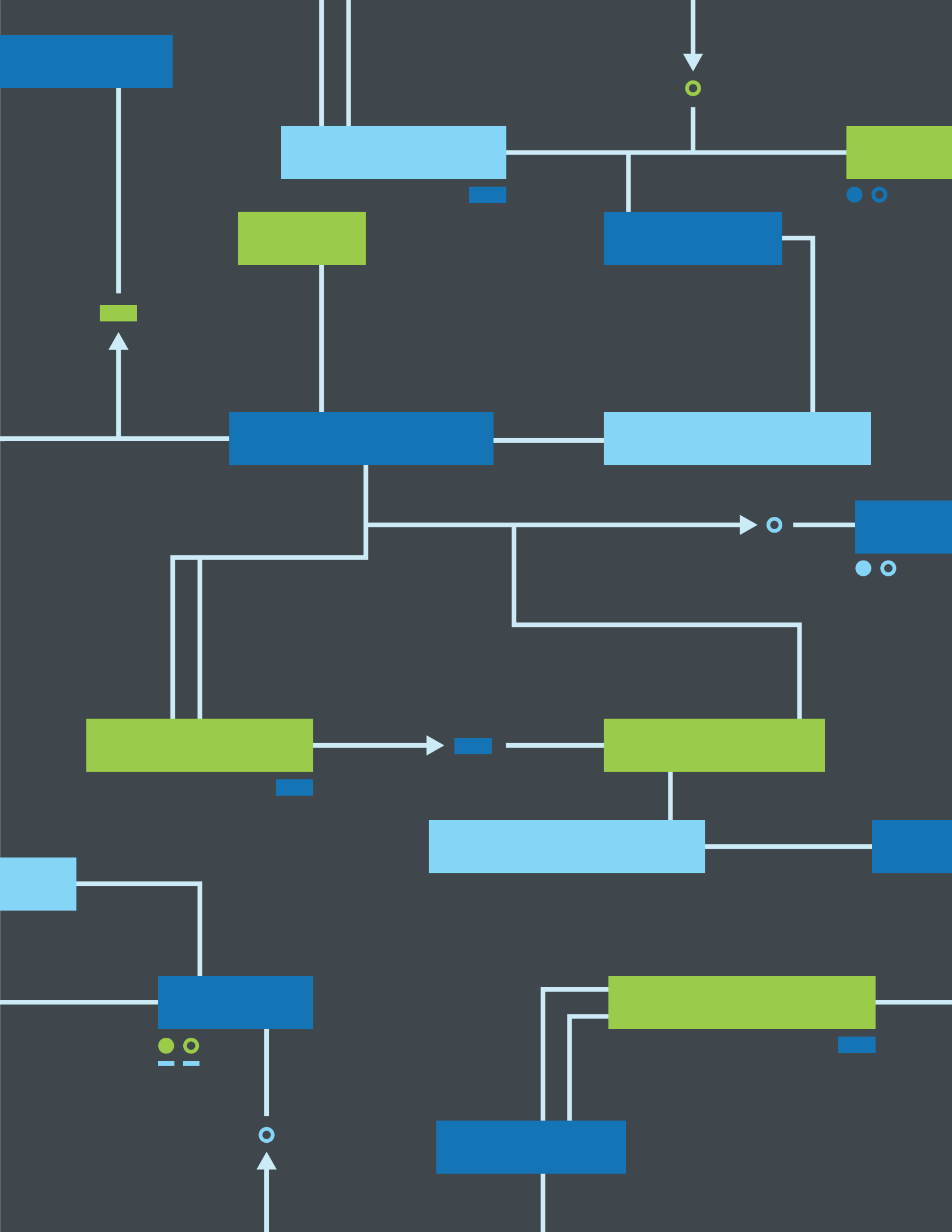
Mark Karl
Vice President, Market Development

Robert C. Ludlow
Vice President and Chief Financial
and Compliance Officer

Jeffrey McDonald
Vice President, Market Monitoring

Stephen J. Rourke
Vice President, System Planning





iso-ne.com

isoexpress.iso-ne.com

iso-ne.com/isotogo

isonewswire.com

@isonewengland

ISO new england

One Sullivan Road
Holyoke, MA 01040