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New England's Changing Resource Mix and the ISO's Analysis of Fuel-Security Risks

New Hampshire Residential Ratepayer Advisory Board

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ISO New England (ISO) Has Two Decades of Experience Overseeing the Region's Restructured Electric Power System

- **Regulated** by the Federal Energy Regulatory Commission
- **Reliability Coordinator** for New England under the North American Electric Reliability Corporation
- **Independent** of companies in the marketplace and **neutral** on technology

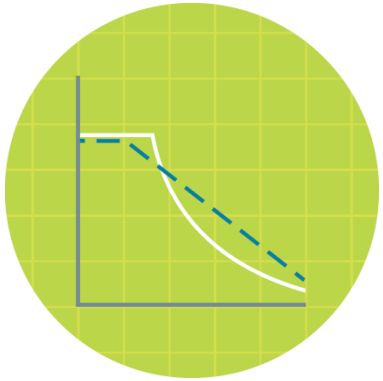
ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

Grid Operation

Coordinate and direct the flow of electricity over the region's high-voltage transmission system

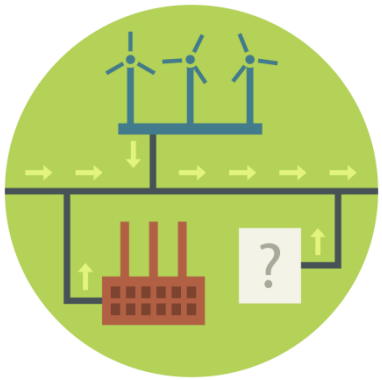
Market Administration

Design, run, and oversee the markets where wholesale electricity is bought and sold



Power System Planning

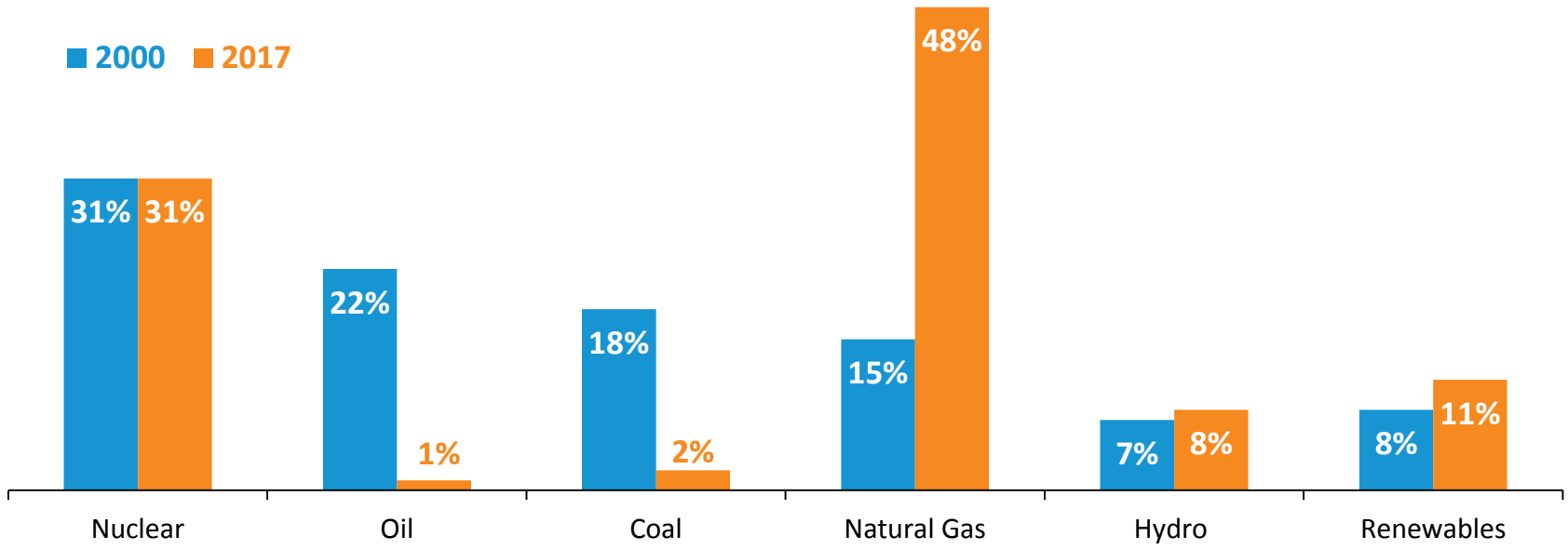
Study, analyze, and plan to make sure New England's electricity needs will be met over the next 10 years



Dramatic Changes in the Energy Mix

The fuels used to produce the region's electric energy have shifted as a result of economic and environmental factors

Percent of Total **Electric Energy** Production by Fuel Type
(2000 vs. 2017)



Source: ISO New England Net Energy and Peak Load by Source
Renewables include landfill gas, biomass, other biomass gas, wind, solar, municipal solid waste, and miscellaneous fuels

Power Plant Emissions Have Declined with Changes in the Fuel Mix

Reduction in Aggregate Emissions (ktons/yr)

Year	NO_x	SO_2	CO_2
2001	59.73	200.01	52,991
2016	16.27	4.47	37,467
% Reduction, 2001–2016	**⬇ 73%**	**⬇ 98%**	**⬇ 29%**

Reduction in Average Emission Rates (lb/MWh)

Year	NO_x	SO_2	CO_2
1999	1.36	4.52	1,009
2016	0.31	0.08	710
% Reduction, 1999–2016	**⬇77%**	**⬇ 98%**	**⬇ 30%**

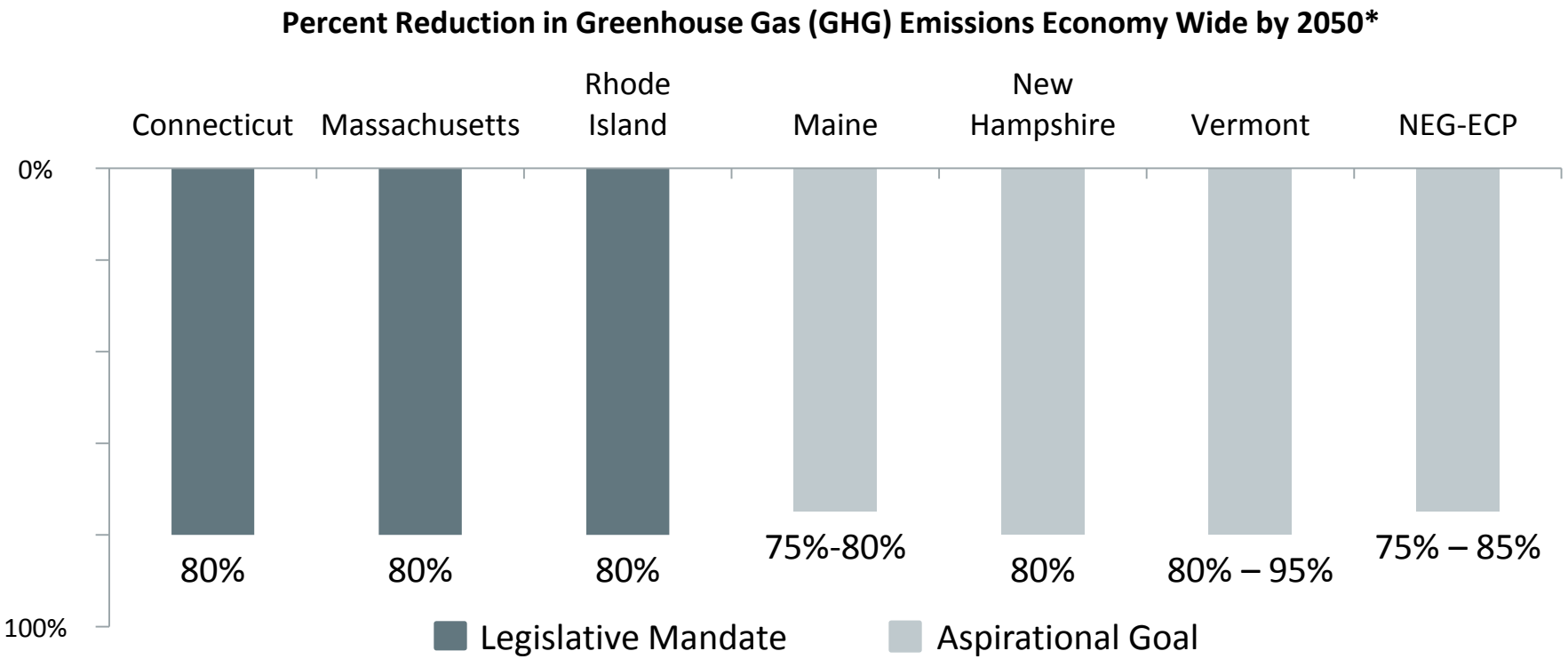
Source: 2016 ISO New England Electric Generator Air Emissions Report, December 2017 (draft)

The Region Has Lost—*and Is at Risk of Losing*—Substantial Non-Gas Resources

Major Generator Retirements:

- **Salem Harbor Station (749 MW)**
  - 4 units (coal & oil)
- **Norwalk Harbor Station (342 MW)**
  - 3 units (oil)
- **Mount Tom Station (143 MW)**
  - 1 unit (coal)
- **Vermont Yankee Station (604 MW)**
  - 1 unit (nuclear)
- **Brayton Point Station (1,535 MW)**
  - 4 units (coal & oil)
- **Pilgrim Nuclear Power Station (677 MW)**
  - 1 unit (nuclear)
- **Bridgeport Harbor Station (564 MW)**
  - 2 units (coal & oil)
- *Additional retirements are looming*

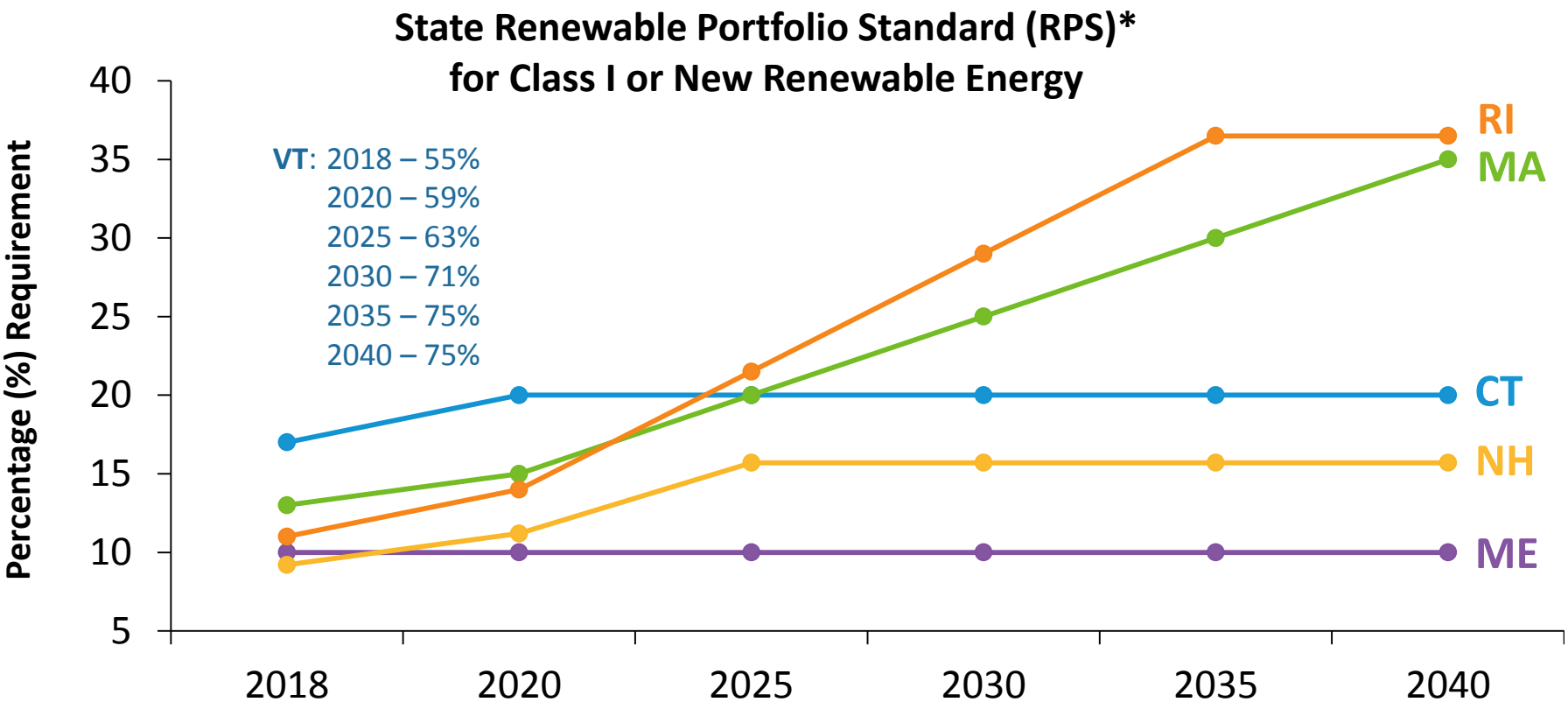
States Have Set Goals for Reductions in Greenhouse Gas Emissions: *Some Mandated, Some Aspirational*



The New England states are promoting GHG reductions on a state-by-state basis, and at the regional level, through a combination of legislative mandates (e.g., CT, MA, RI) and aspirational, non-binding goals (e.g., ME, NH, VT and the New England Governors and Eastern Canadian Premiers).

* MA, RI, NH, and VT use a 1990 baseline year for emissions reductions. CT and the NEG-ECP use a 2001 baseline. ME specifies reductions below 2003 levels that *may* be required "in the long term." For more information, see the following ISO Newswire article: http://isonewswire.com/updates/2017/3/1/the-new-england-states-have-an-ongoing-framework-for-reducin.html.

State Policy Requirements Drive Proposals for Renewable Energy

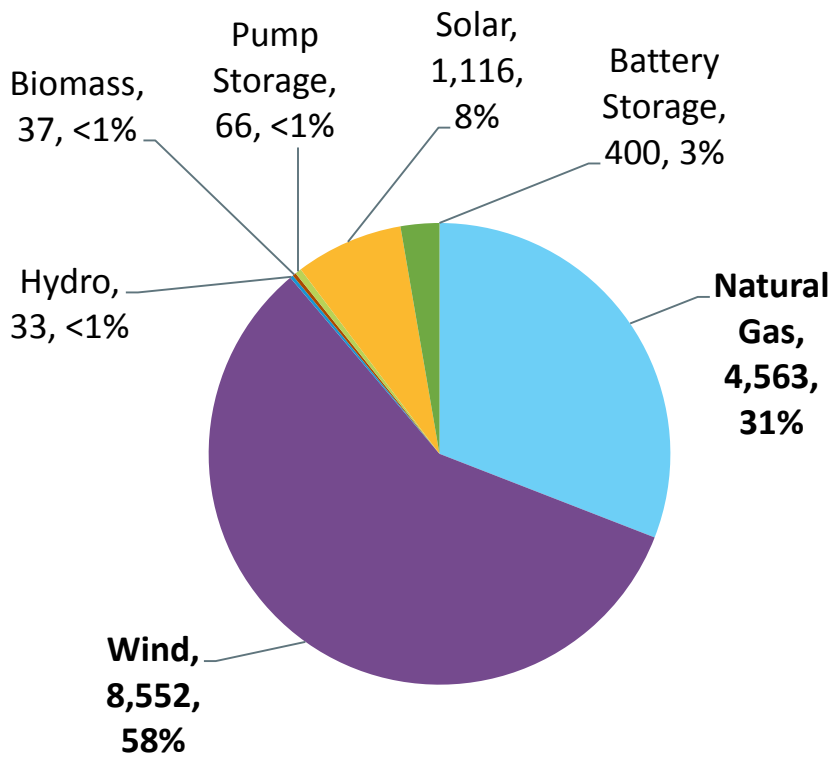


Notes: Connecticut's Class I RPS requirement plateaus at 20% in 2020. Maine's Class I RPS requirement plateaus at 10% in 2017 and expires in 2022 (but has been held constant in this chart for illustrative purposes). Massachusetts' Class I RPS requirement increases by 1% each year after 2020 with no stated expiration date. New Hampshire's percentages include the requirements for both Class I and Class II resources (Class II resources are new solar technologies beginning operation after January 1, 2006). New Hampshire's Class I and Class II RPS requirements plateau at 15.7% in 2025. Rhode Island's requirement for 'new' renewable energy plateaus at 36.5% in 2035. Vermont's 'total renewable energy' requirement plateaus at 75% in 2032; it recognizes all forms of new and existing renewable energy and is unique in classifying large-scale hydropower as renewable.

Wind Power and Natural Gas Dominate New Resource Proposals in the ISO Interconnection Queue

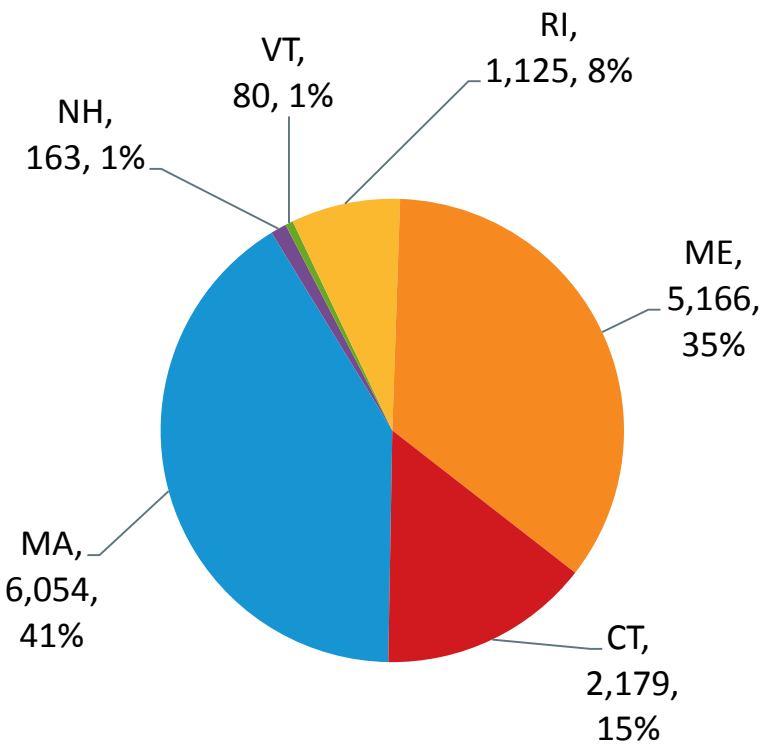
Approximately 14,800 MW

By Type



Note: Some natural gas proposals include dual-fuel units (oil); some wind and solar proposals include battery storage; megawatts represent nameplate capacity ratings; megawatts have been rounded for each proposal.

By State



Source: ISO Generator Interconnection Queue (January 2018) FERC and Non-FERC Jurisdictional Proposals

Developers Are Proposing Large-Scale Transmission Projects to Help Deliver Clean Energy to Load Centers

Map is representative of the types of projects announced for the region in recent years

- Developers are proposing **20+** elective transmission upgrades (ETUs) to help deliver **16,500+ MW** of clean energy
  - Mostly Canadian hydro and onshore wind from northern New England
- Wind projects make up **58%** of proposed new power resources, but most are remote
- Massachusetts has plans to contract for **1,600 MW** of offshore wind

Source: ISO Interconnection Queue (January 2018)

Key Grid Challenge: Fuel Security

Ensuring the region's generators have adequate fuel to produce electricity, particularly in the winter

- ISO finalized and released its *Operational Fuel-Security Analysis* upon resolution of the U.S. Department of Energy (DOE) Notice of Proposed Rulemaking (NOPR) on Grid Resiliency Pricing

ISO New England Publishes *Operational Fuel-Security Analysis*

- The goal of the study is to understand future effects of trends **already affecting** power system operations
- The analysis examines more than 20 cases of generating resource and fuel-mix combinations during the 2024-2025 winter, and quantifies each case's **fuel security risk**
  - *i.e.,* the number and duration of energy shortfalls that could occur and that would require implementation of emergency procedures to maintain reliability
- The study assumed **no additional natural gas pipeline capacity** would be added to serve generators during the timeframe of the study

Operational Fuel-Security Analysis Differs from Previous Studies

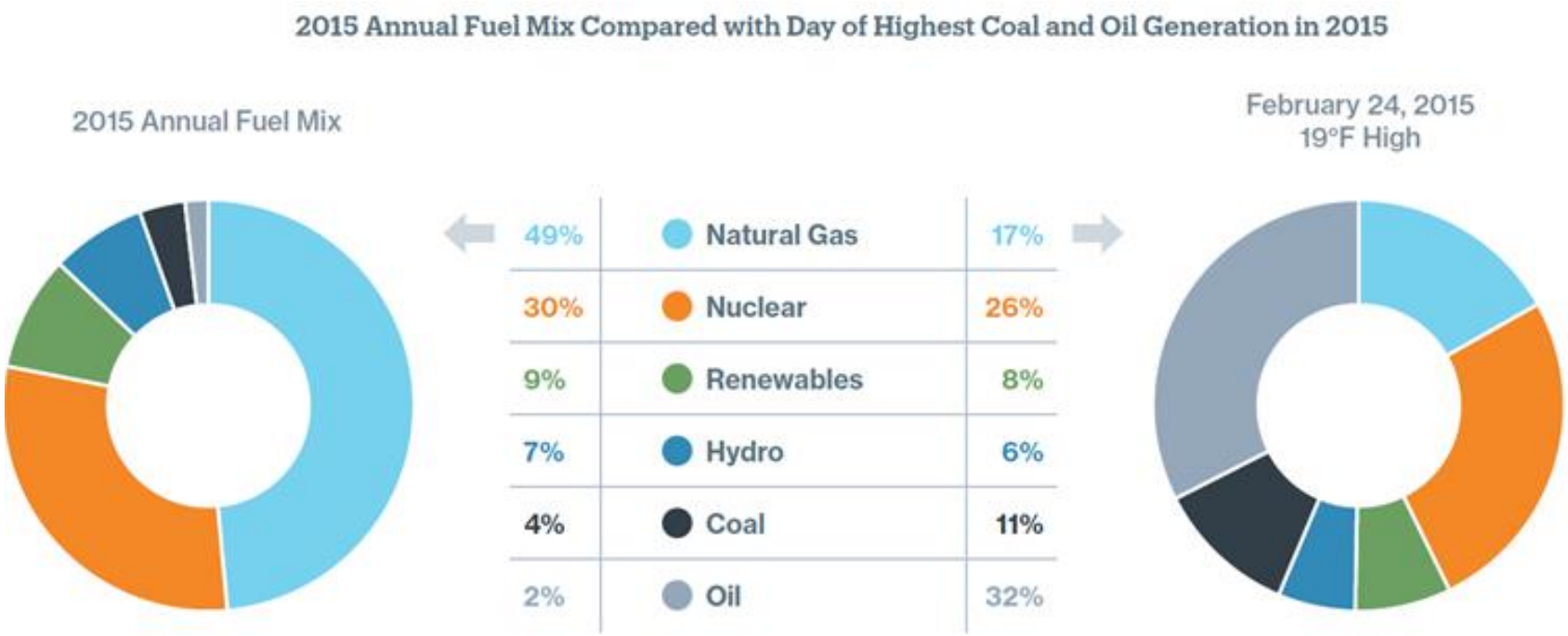
- Unlike the ISO's previous studies on fuel challenges, this study:
  - Quantifies *operational* risk by measuring energy shortfalls and system stress
  - Focuses on the availability of energy over an **entire winter** period rather than capacity availability on just peak days
  - Does not directly consider fuel costs or prices
  - Does not examine impacts of expanded natural gas pipeline capacity on a winter peak day
- As with all projections, the hypothetical resource combinations described may never materialize
  - Further, power systems conditions vary on a daily and hourly basis and may not behave exactly as predicted in study models

Six Major Conclusions

The study results suggest the following major conclusions:

1. **Outages**: The region is vulnerable to the season-long outage of any of several major energy facilities
2. **Key dependencies**: Reliability is heavily dependent on LNG and electricity imports; more dual-fuel capability is also a key reliability factor
3. **Logistics**: Timely availability of fuel is critical, highlighting the importance of fuel-delivery logistics
4. **Risk**: All but four of 23 scenarios result in load shedding, indicating a trend towards increased fuel-security risk
5. **Renewables**: More renewables can help lessen fuel-security risk, but are likely to drive oil-and coal-fired generator retirements which, in turn, require more LNG
6. **Positive Outcomes**: Higher levels of LNG, imports, and renewables can minimize system stress and maintain reliability; delivery assurances and transmission expansion would be needed

Generation Mix Changes on Cold Days



Source: ISO New England, 2000-2015 Net Energy and Peak Load by Source and Daily Generation by Fuel Type 2015

Key Fuel Variables

The study modeled a wide range of resource combinations that might be possible by winter 2024/2025 considering five key fuel variables:

1.

Retirements of coal- and oil-fired generators
   - The study assumes that New England will have no coal-fired plants in winter 2024/2025

2.
Imports of electricity over transmission lines from New York and Canada

3.
Oil tank inventories (i.e., how often on-site oil tanks at dual-fuel power plants are filled throughout the winter)

4.

Level of liquefied natural gas (LNG) injections into the region's natural gas delivery and storage infrastructure

5.
Level of renewable resources on the system

Key Fuel Security Assumptions – Renewables

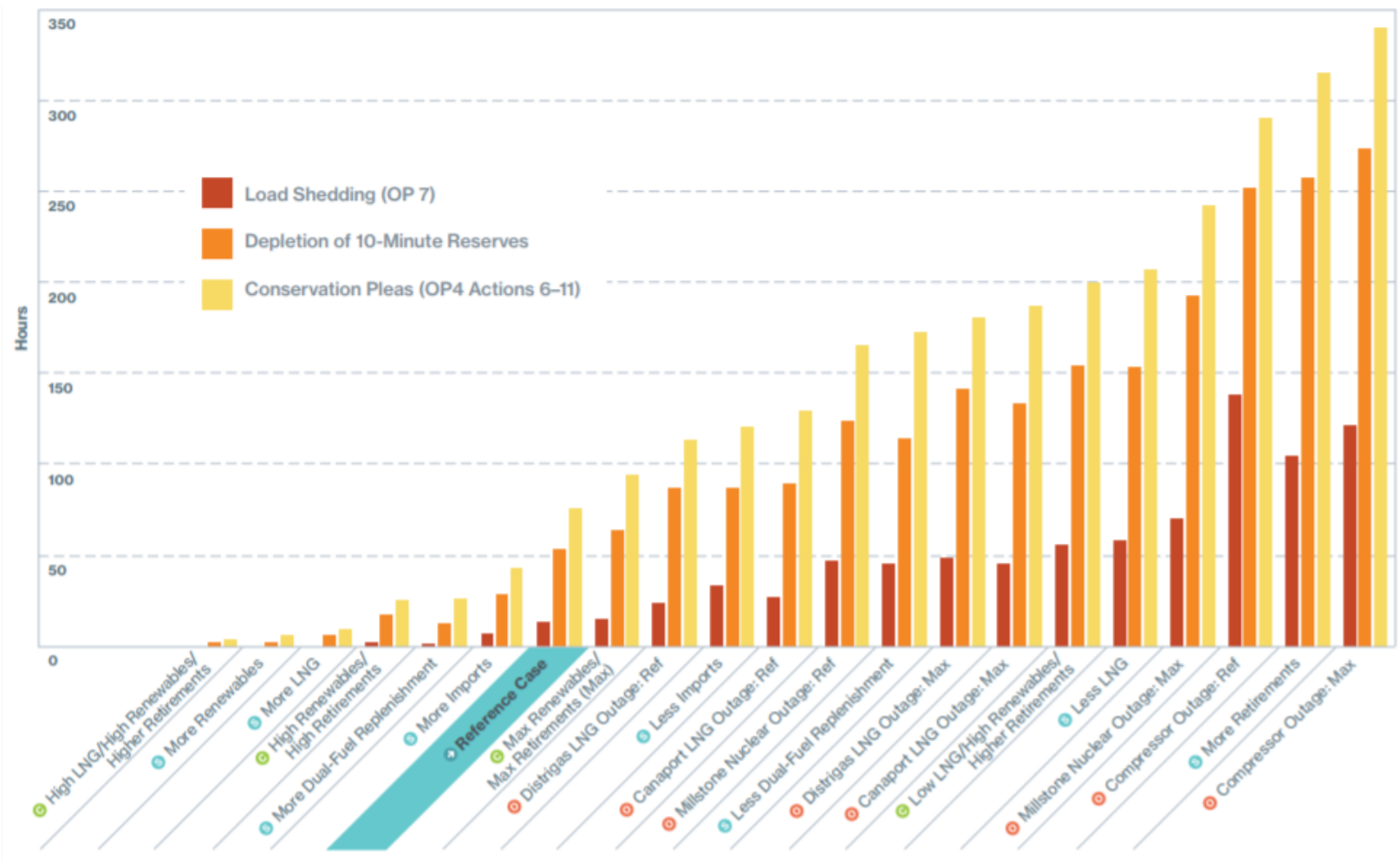
Case Scenario	Renewables Total MW (rounded)	Breakdown MW			
		Onshore Wind	Offshore Wind	PV	Other Renewables
2017	4,600	1,200	30	2,400	960
Reference Case	6,600	1,200	30	4,430	960
More Renewables	8,000	1,200	1,400	4,430	960
Max Renewables	9,500	1,200	2,000	5,330	960

Demand and System Stress Measurements

- System stress was measured by several operational metrics including:
  - Actions during a capacity deficiency (OP-4)
  - Depletion of ten-minute reserves
  - Load shedding

TOTAL WINTER IMPACT				
All OP 4 Hours	OP 4 Actions 6-11	Hrs. of 10-Min. Reserve Depletion	Hrs. of Load Shedding (OP 7)	Days with Load Shedding (OP 7)

Hours of Emergency Actions under Modeled Scenarios, Ordered Least to Most



Appendix A - Detailed Results

		INPUTS					TOTAL WINTER IMPACT									
							OP 4 Actions			Depletion of 10-Minute Reserves[1]			OP 7 Action: Load Shedding			
							All OP 4 Actions	Actions 6-11								
ROW		Retirements (MW)	LNG Cap (Bcf/Day)	Dual-Fuel (Oil Tank Fills)[2]	Imports (MW)	Renewables (MW)[3]	Hours	Hours	Avg. Hourly Power Deficit (MW)[4]	Hours	Avg. Hourly Power Deficit (MW)[4]	Load at Risk (MWh)[5]	Hours	Avg. Hourly Power Deficit (MW)[4]	Unserved Load (MWh)[5]	Days with Load Shedding
	Reference Case (i.e., Current Trends) **and Single-Variable Cases**															
1	High Boundary	-1,500	1.25	3	3,500	8,000	0	0	0	0	0	0	0	0	0	0
2	More Renewables	-1,500	1.00	2	3,500	8,000	24	6	408	2	765	1,530	0	0	0	0
3	More LNG	-1,500	1.25	2	2,500	6,600	40	9	440	6	545	3,272	0	0	0	0
4	More Dual-Fuel Replenishment	-1,500	1.00	3	2,500	6,600	69	26	319	13	609	7,913	1	696	696	1
5	More Imports	-1,500	1.00	2	3,000	6,600	103	43	404	28	816	22,859	7	290	2,031	4
6	Reference Case (Ref)	-1,500	1.00	2	2,500	6,600	165	76	419	53	980	51,963	14	743	10,397	6
7	Less Imports	-1,500	1.00	2	2,000	6,600	239	120	427	87	1,039	90,395	33	867	28,608	7
8	Less Dual-Fuel Replenishment	-1,500	1.00	1	2,500	6,600	317	173	410	115	1,079	124,045	46	1,005	46,232	10
9	Less LNG	-1,500	0.75	2	2,500	6,600	355	208	430	153	1,072	164,065	58	1,193	69,179	10
10	More Retirements	-4,500	1.00	2	2,500	6,600	455	316	454	258	1,078	278,135	105	1,431	150,297	16
11	Low Boundary	-4,500	0.75	1	2,000	6,600	811	692	480	642	1,394	895,145	475	2,080	987,872	31
	Combination Cases															
12	High Renewables/High Retirements	-3,000	1.00	2	3,500	8,000	84	25	373	17	760	12,918	2	535	1,070	1
13	High LNG/High Renewables/Higher Retirements	-4,000	1.25	2	3,500	8,000	18	4	405	2	500	1,000	0	0	0	0
14	Low LNG/High Renewables/Higher Retirements	-4,000	0.75	2	3,500	8,000	358	200	435	154	1,030	158,552	56	1,009	56,518	12
15	Max Renewables/Max Retirements (Max)	-5,400	1.00	2	3,500	9,500	206	94	408	64	934	59,790	15	907	13,609	6
	Outage Cases (Modeled on Ref and Max Cases; Assumed More Dual-Fuel Tank Fills)															
16	Distrigas LNG Outage: Ref[6]	-1,500	1.00	3	2,500	6,600	276	114	440	87	961	83,628	24	854	20,496	7
17	Distrigas LNG Outage: Max[6]	-5,400	1.00	3	3,500	9,500	346	181	442	142	971	137,814	49	1,016	49,805	11
18	Canaport LNG Outage: Ref[7]	-1,500	0.85	3	2,500	6,600	270	129	421	90	944	84,973	27	816	22,036	9
19	Canaport LNG Outage: Max[7]	-5,400	0.85	3	3,500	9,500	354	187	424	134	998	133,779	46	844	38,819	11
20	Millstone Nuclear Outage: Ref[8]	-1,500	1.00	3	2,500	6,600	349	168	433	124	1,015	125,852	47	874	41,080	10
21	Millstone Nuclear Outage: Max[8]	-5,400	1.00	3	3,500	9,500	389	243	450	193	1,012	195,358	70	1,147	80,312	12
22	Compressor Outage: Ref[9]	-1,500	1.50	3	2,500	6,600	458	290	468	252	1,231	310,183	138	1,411	194,705	17
23	Compressor Outage: Max[9]	-5,400	1.50	3	3,500	9,500	510	340	448	273	1,107	302,258	121	1,236	149,574	19

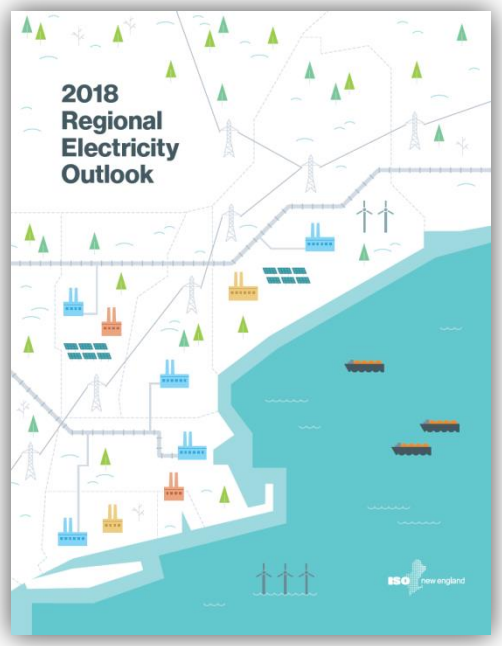
Reference Case

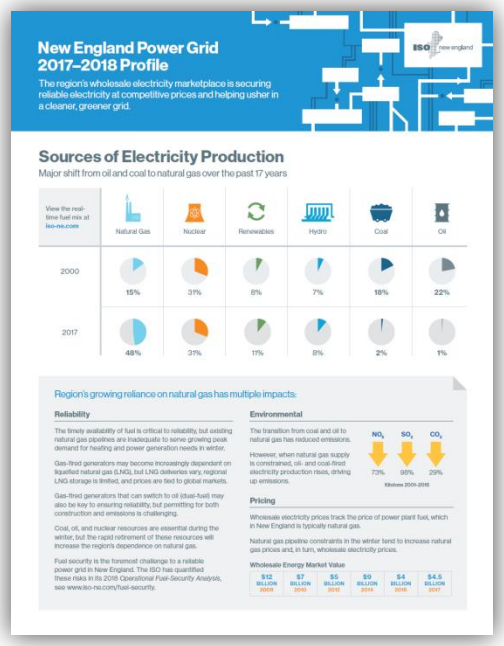
1. Once reserves are depleted, any resource loss or transmission line trip that cuts imports would trigger load shedding.
2. Count assumed tanks were filled before winter, plus refilled during winter. For example, "2x" counted the initial full tank, plus one refill.
3. Cases with increased renewables also included increased imports to reflect expected additions of clean energy imports from Canada or New York.
4. On average, one megawatt (MW) of electricity can serve about 660 homes in New England, which has about 7.1 million retail customers, encompassing not just residential customers but also commercial and industrial.
5. A megawatt-hour (MWh) of electricity can serve about 660 homes for one hour in New England, on average.
6. Case assumed a disruption to the Distrigas LNG import facility in Massachusetts, eliminating all the natural gas that can fuel the nearby, 1,700 MW Mystic 8 and 9 gas-fired generators, as well as 0.435 Bcf/d the LNG facility can inject into the Algonquin and Tennessee interstate gas pipeline systems (0.3 Bcf/d) and the local gas utility's distribution system (0.135 Bcf/d).
7. Case assumes the loss of Canaport, the major LNG import facility in New Brunswick, Canada, eliminating as much as 1.2 Bcf/d that could be injected into the New England and Maritimes pipeline systems.
8. Case assumes the loss of Millstone, one of the region's remaining two nuclear power plants, eliminating 2,100 MW of baseload power.
9. Case assumes the loss of a compressor station on a major natural gas pipeline, eliminating 1.2 Bcf/d and cutting off fuel for the entire winter to generators with a combined capacity of about 7,000 MW.

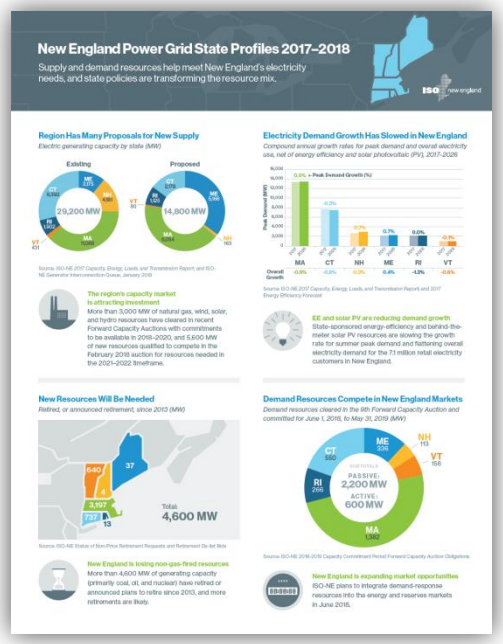
Next Steps

- The ISO released this fuel-security report January 17, 2018 and will continue to discuss its results with stakeholders
- A key question to be addressed will be the level of fuel-security risk that the ISO, the region, and its policymakers and regulators are willing to tolerate
- As the system operator responsible for system reliability, the ISO must independently assess the level of risk to reliable operation
- Discussions with stakeholders on potential solutions to address fuel-security risks are targeted to begin later in 2018

ISO New England Releases Several New Publications







2018 Regional Electricity Outlook

Provides an in-depth look at New England's biggest challenges to power system reliability, the solutions the region is pursuing, and other ISO New England efforts to improve services and performance

New England Power Grid Profile

Provides key grid and market stats on how New England's wholesale electricity markets are securing reliable electricity at competitive prices and helping usher in a cleaner, greener grid

New England State Profiles

Provides state-specific facts and figures relating to supply and demand resources tied into the New England electric grid and state policies transforming the resource mix in the region

Questions