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Operational Fuel-Security Analysis

State Implementation Plan Revision Advisory Committee (SIPRAC)

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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

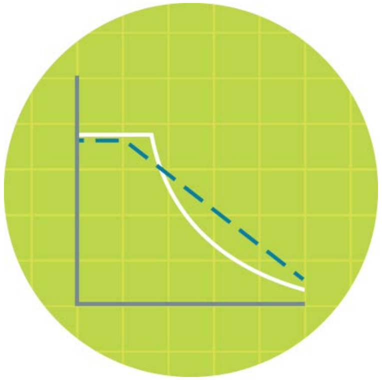
ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

Grid Operation

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

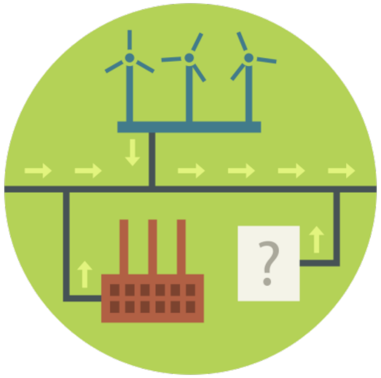
Market Administration

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



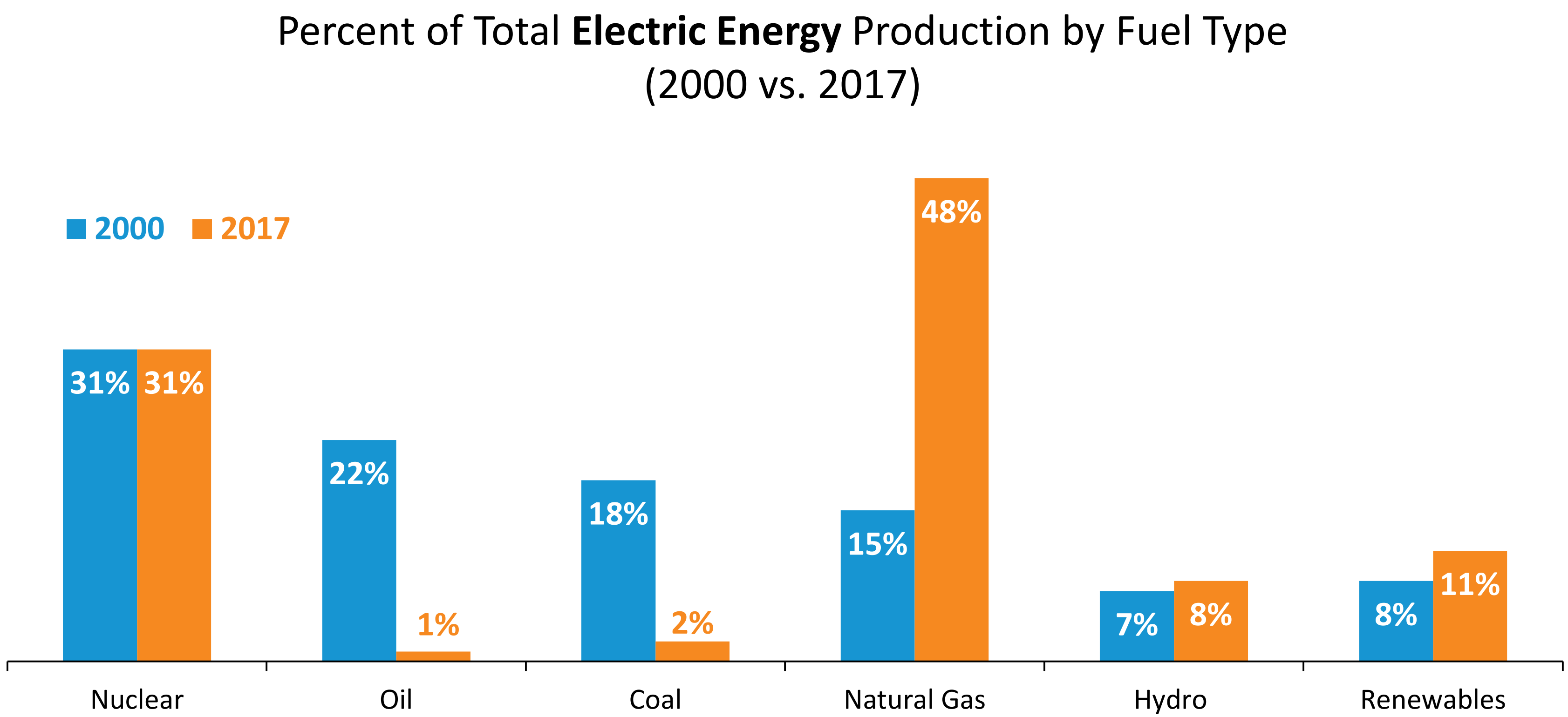
Power System Planning

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



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)

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

OPERATIONAL FUEL-SECURITY ANALYSIS:

Identification of fuel-security risks of multiple scenarios

- Study conducted to improve the ISO's and the region's understanding of operational risks and inform subsequent discussions with stakeholders
- The Operational Fuel-Security Analysis studied 23 possible resource combinations and outage scenarios during the 2024/2025 winter to illustrate a wide range of possible future power system conditions
  - Scenarios and results are not precise predictions of the future system or outcomes
  - Illustrates a range of potential operational risks that could confront a power system with fuel and energy constraints during an entire winter

Generation Mix Changes on Cold Days

2015 Annual Fuel Mix Compared with Day of Highest Coal and Oil Generation in 2015

2015 Annual Fuel Mix

2015 Annual Fuel Mix	Fuel	February 24, 2015 19°F High
49%	Natural Gas	17%
30%	Nuclear	26%
9%	Renewables	8%
7%	Hydro	6%
4%	Coal	11%
2%	Oil	32%

February 24, 2015
19°F High

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

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

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:

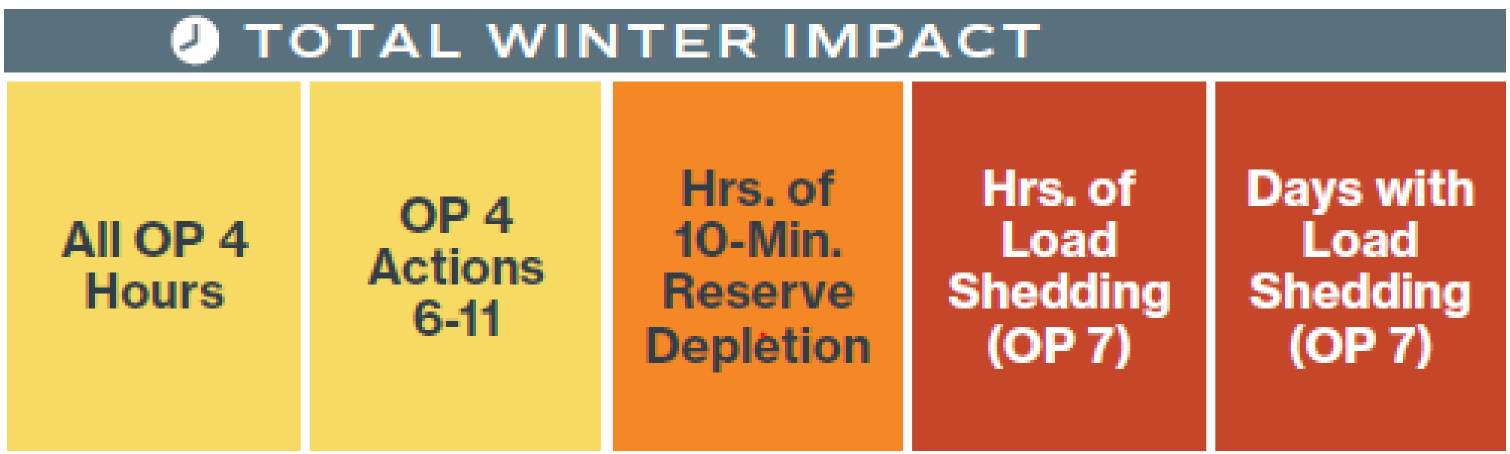
1. 

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

Demand and System Stress Measurements

- System stress was measured by several operational metrics including:
  - OP-4 actions
  - Depletion of ten-minute reserves
  - Load shedding



Key Fuel Security Assumptions

This section will summarize the assumptions used in the report for Winter 2024/2025:

- Fuel-security risk modeling
- Electricity demand
- Natural gas supply
- Natural gas demand
- No coal-fired generation
- Renewables
- Imports

Key Fuel Security Assumptions – Risk Modeling

Each scenario's future fuel-security risk is modeled by:

- Calculating the amount of electricity required to meet demand each hour of a 90-day winter (12/1/2024 through 2/28/2025)
- Calculating how much electric energy could be generated by each fuel type
- Calculating how much natural gas would be available, after all heating demand is met, as well as the levels of oil stored on site at oil-fired and dual-fuel power plants
- Comparing the amount of fuel required with the level of fuel the region's fuel-delivery system could supply in each scenario
- Assessing the magnitude and duration of emergency actions required if the fuels available were not sufficient to meet demand

Key Fuel Security Assumptions - Electricity Demand (Winters 2014/2015 and 2024/2025)

- Consumer demand in Winter 2014/2015 serves as a baseline because:
  - Winter 2014/2015 did not have the coldest days recorded in the last 10 years but had sustained cold, as measured by heating-degree days (four winters in the past 38 years were colder)
  - This level of sustained cold has a probability of occurring about once every eight years
  - It provides a wider perspective on cumulative use and replenishment of oil and LNG inventories over an entire winter

- While actual power grid conditions could change earlier or later, the study used Winter 2024/2025 for several reasons:
  - By winter 2024-2025, the outlook for power system reliability is uncertain
  - More retirements of the remaining oil, coal, and nuclear power plants are expected
  - Gives the region time to identify and address challenges by 2024, but no buffer to defer decisions about the region's fuel-security risks

Key Fuel Security Assumptions – Natural Gas Supplies: Pipeline

- The incremental pipeline expansions are expected to be used by natural gas utilities to serve their growing base of heating customers
- This study assumes that the **external** pipeline infrastructure capable of delivering natural gas into New England and the Maritimes in 2024/2025 would total **3.86** Bcf/d over four pipelines:
  - 1.91 Bcf/d from the west through Algonquin
  - 1.39 Bcf/d from the west through Tennessee
  - 0.26 Bcf/d from the west through Iroquois
  - 0.30 Bcf/d from Quebec through Portland Natural Gas Transmission

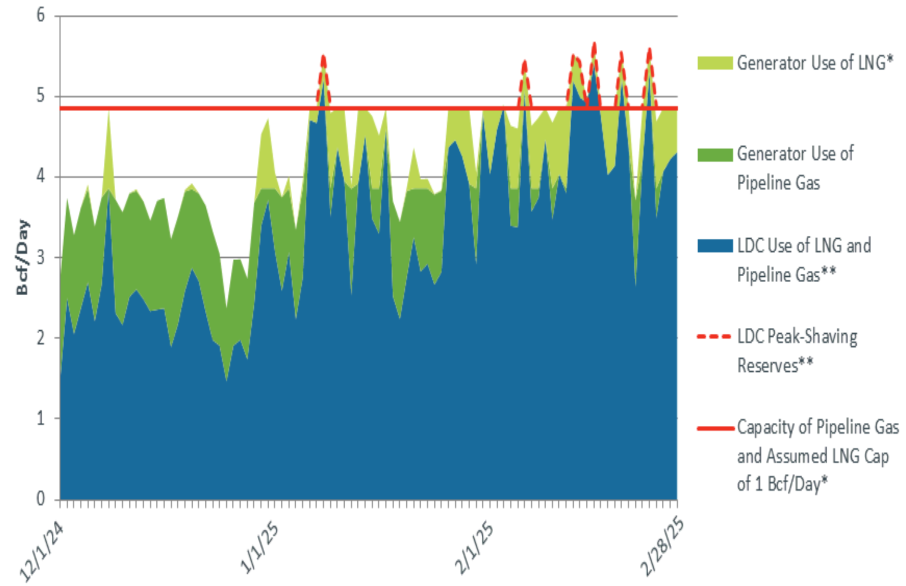
Key Fuel Security Assumptions – Natural Gas Supplies: LNG

- Gas from LNG was modeled from three sources: Canaport, Distrigas, and the Northeast Gateway Deepwater offshore buoy
- Maximum LNG delivery (i.e., injection) to New England and the Maritimes was modeled at 2.04 Bcf/d:
  - 1.2 Bcf/d from the Canaport facility (limited by current levels of Canadian demand on the Maritimes and Northeast Pipeline)
  - 0.43 Bcf/d from Distrigas
  - 0.40 Bcf/d from the off-shore buoy
- However, the maximum observed coincident delivery of LNG was 1.25 Bcf/d on one day in December 2016
- Therefore, scenarios in this study used daily LNG injection caps ranging from 0.65 Bcf/d to 1.5 Bcf/d for winter 2024/2025 deliveries

Key Fuel Security Assumptions – Natural Gas Demand

- Key issue: How much natural gas will be left for power generators after LDCs serve their customers?
- 2025 LDC gas demand based on an ICF analysis (*New England LDC Gas Demand Forecast Through 2030)*
  - ICF study found winter natural gas demand for heating:
    - Totaled 4.4 Bcf/d on the winter peak day (calendar year 2014)
    - Forecasted peak demand from LDCs alone could reach 5.45 Bcf/d by 2025, leaving little if any gas for electric generators during near peak gas demand days.

- **Winter 2024/2025 Supply of Pipeline Gas and LNG Compared to Use (Reference Case)**



Note: LDC use includes the Maritimes' gas utility demand.
*Graph does not include the Mystic 8 and 9 gas-fired generators' fuel use or supply from the LNG facility.
**Per data from ICF International, *New England LDC Gas Demand Forecast Through 2030* (December 14, 2016, presentation to Planning Advisory Committee) and *The Future of Natural Gas Supply for Nova Scotia* (March 28, 2013, for Nova Scotia Department of Energy).

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

Key Fuel Security Assumptions – Imports

- New England imports power over 13 high-voltage lines connected to New York, Quebec, and New Brunswick
  - 2,500 MW of imports in the Reference Case
  - 2,000 MW of imports in scenarios where imports are reduced
  - 3,000 MW and 3,500 MW of imports were assumed in scenarios incorporating the New England states' goals for more clean energy
    - Increases are assumed to be clean energy delivered over a hypothetical new transmission line from New York or Canada
- 500 MW of emergency imports when OP-4 actions are implemented were assumed in all scenarios
- New England and its neighbors experience winter weather at the same time and demand in Quebec and New Brunswick peaks in winter, possibly limiting exports to New England below the level of imports assumed in some of the scenarios studied

STUDY RESULTS

Reference Case (i.e., Current Trends) and Single-Variable Scenarios

– ↑ Reference Case +

		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								
		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
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 Scenarios

		INPUTS					TOTAL WINTER IMPACT									
							OP 4 Actions: All OP 4 Actions	OP 4 Actions: Actions 6-11		Depletion of 10-Minute Reserves[1]			OP 7 Action: Load Shedding			
#	Scenario	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
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
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

– 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 860 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 860 homes for one hour in New England, on average.

Outage Scenarios
(Modeled on Ref and Max Cases; Assumed More Dual-Fuel Tank Fills)

− Reference Case +

#	Scenario	INPUTS: Retirements (MW)	INPUTS: LNG Cap (Bcf/Day)	INPUTS: Dual-Fuel (Oil Tank Fills)[2]	INPUTS: Imports (MW)	INPUTS: Renewables (MW)[3]	TOTAL WINTER IMPACT — OP 4 Actions, All OP 4 Actions: Hours	OP 4 Actions, Actions 6-11: Hours	OP 4 Actions, Actions 6-11: Avg. Hourly Power Deficit (MW)[4]	Depletion of 10-Minute Reserves[1]: Hours	Depletion of 10-Minute Reserves[1]: Avg. Hourly Power Deficit (MW)[4]	Depletion of 10-Minute Reserves[1]: Load at Risk (MWh)[5]	OP 7 Action: Load Shedding: Hours	OP 7 Action: Load Shedding: Avg. Hourly Power Deficit (MW)[4]	OP 7 Action: Load Shedding: Unserved Load (MWh)[5]	OP 7 Action: Load Shedding: Days with Load Shedding
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	0.65	3	2,500	6,600	270	129	421	90	944	84,973	27	816	22,026	9
19	Canaport LNG Outage: Max[7]	-5,400	0.65	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	166	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	310,163	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
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

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

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

Questions

Acronyms Used in this Presentation

- Bcf = billion cubic feet
- Bcf/d = billion cubic feet per day
- EE = Energy Efficiency (passive demand response)
- ICF = ICF International, Inc.
- ISO = ISO New England Inc.
- LDC = Local Distribution Company
- LNG = liquefied natural gas
- MW = megawatt or megawatts
- MWh = megawatt-hours
- PV = photovoltaics
- RC = NEPOOL Reliability Committee