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Probabilistic Energy Adequacy Assessments of Extreme Weather Risk

Energy Systems Integration Group – 2024 Spring Technical Workshop

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Generation and Demand Resources Are Used to Meet New England's Energy Needs

- **350** dispatchable generators in the region
- **31,500 MW** of generating capacity
- Nearly **40,000 MW** of proposed generation in the ISO Queue
  - Mostly wind, storage, and solar proposals
- Roughly **5,000 MW** of generation have retired or will retire in the next few years
- Nearly **3,000 MW** of demand resources with obligations in the Forward Capacity Market*, including energy efficiency, load management, and distributed generation resources
  - Demand resources have had further opportunities in the wholesale markets since 2018

* In the Forward Capacity Market, demand-reduction resources are treated as capacity resources.

ISO-NE Is a Summer-Peaking System

New England shifted from a winter-peaking system to a **summer-peaking** system in the early 1990s, largely because of the growth of air conditioning and a decline in electric heating

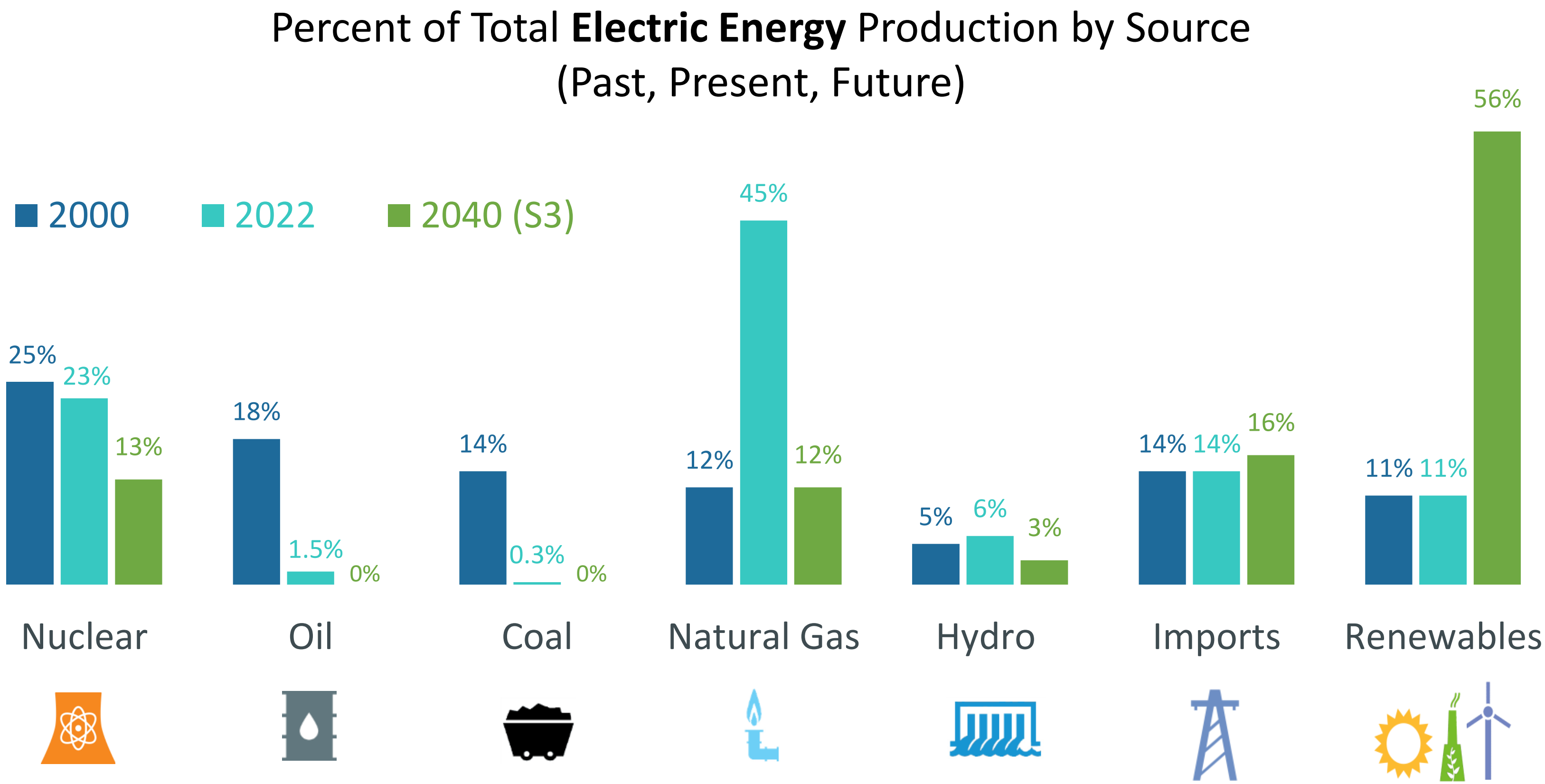
- Peak demand on a normal summer day has typically ranged from 17,500 MW to 22,000 MW
- Summer demand usually peaks on the hottest and **most humid** days and averaged roughly 25,600 MW since 2000
- Region’s all-time summer peak demand was **28,130 MW** on **August 2, 2006**

The region is expected to shift back to a **winter-peaking system** with the electrification of heating demand

- Region’s all-time **winter** peak demand was **22,818 MW** on **January 15, 2004**

Dramatic Changes in the Energy Mix

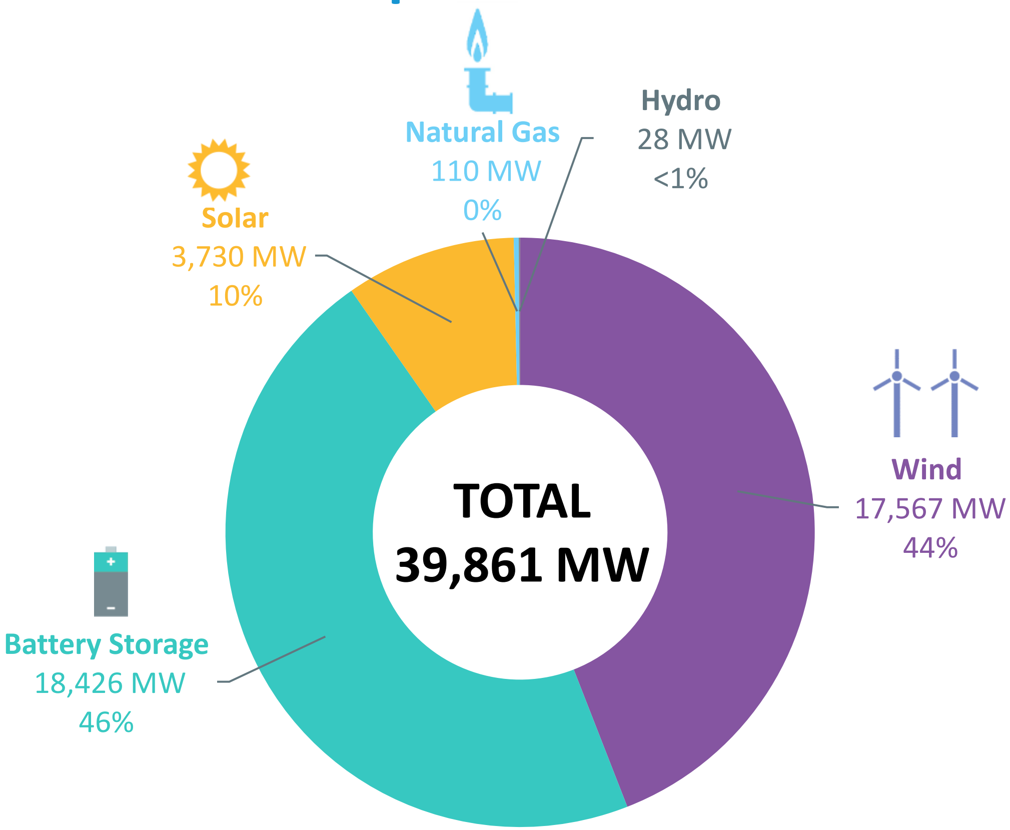
New England made a major shift from coal and oil to natural gas over the past two decades, and is shifting to renewable energy in the coming decades



Source: ISO New England Net Energy and Peak Load by Source; data for 2022 is preliminary and subject to resettlement; data for 2040 is based on Scenario 3 of the ISO New England 2021 Economic Study: Future Grid Reliability Study Phase 1.
Renewables include landfill gas, biomass, other biomass gas, wind, grid-scale solar, behind-the-meter solar, municipal solid waste, and miscellaneous fuels.

Wind Power & Battery Storage Comprise Most of the New Resource Proposals in the ISO Interconnection Queue

All Proposed Resources



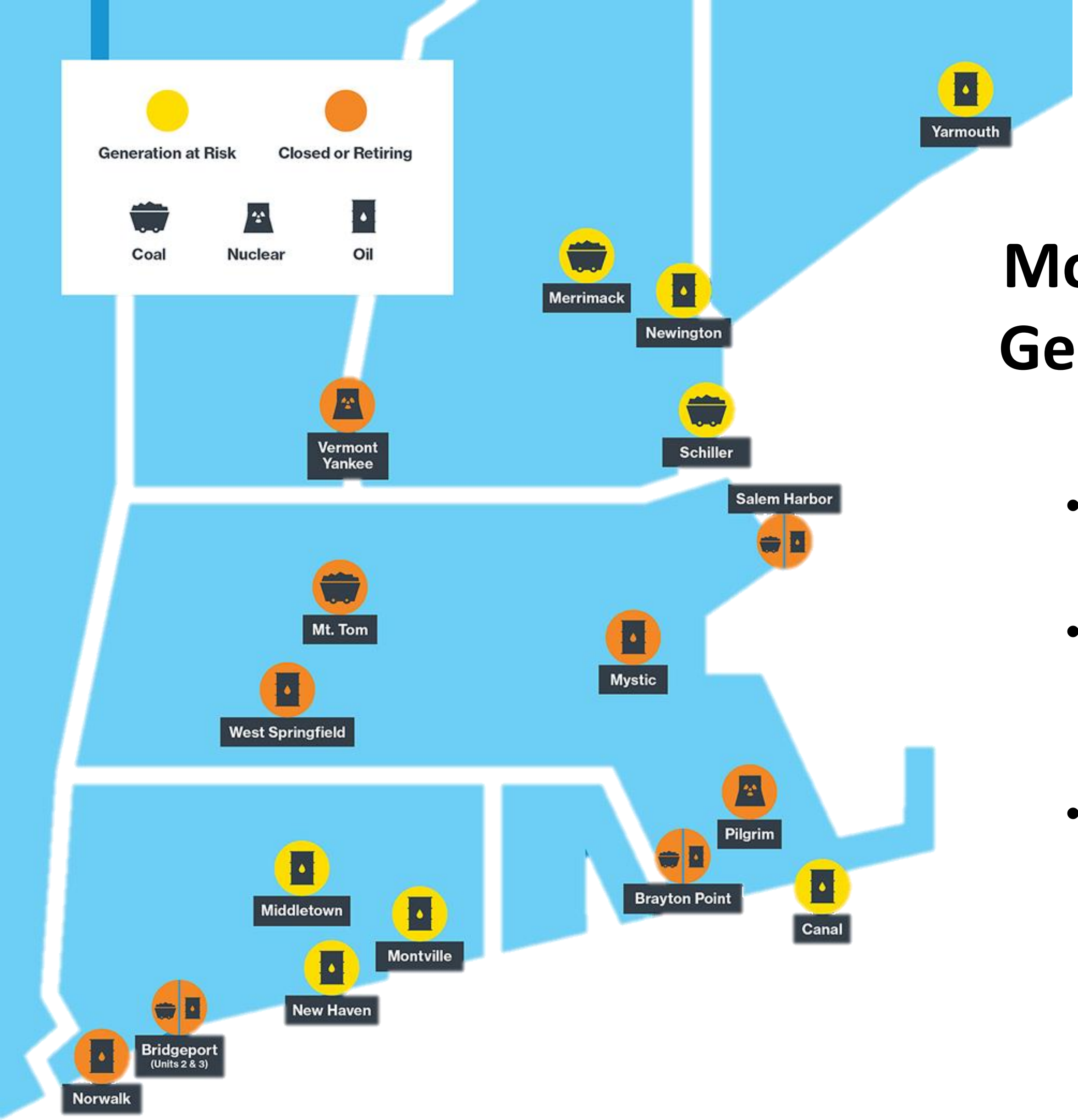
Source: ISO Generator Interconnection Queue (January 2024)
FERC Jurisdictional Proposals; Nameplate Capacity Ratings
Note: Some natural gas proposals include dual-fuel units (with oil backup).
Some natural gas, wind, and solar proposals include battery storage. Other includes hydro, biomass, fuel cells and nuclear uprate.

Proposals by State

(all proposed resources)

State	Megawatts (MW)
Massachusetts	22,958
Connecticut	8,653
Maine	5,437
Rhode Island	1,642
New Hampshire	1,082
Vermont	90
Total	**39,863**

Source: ISO Generator Interconnection Queue (January 2024)
FERC Jurisdictional Proposals



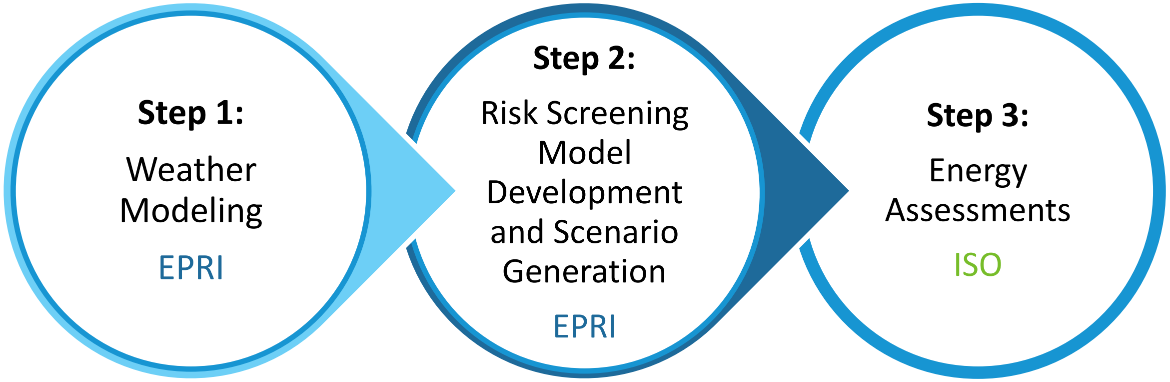
Source: ISO New England Status of Non-Price Retirement Requests and Retirement De-list Bids (April 2023)

From 2013 to 2022, More Than 5,200 MW of Generation Have Retired

- Include predominantly coal, oil, and nuclear resources
- Another **5,000 MW** of remaining coal and oil are at risk of retirement
- These resources have played an **important** role in recent winters when natural gas supplies are constrained in New England

Operational Impact of Extreme Weather Events – Energy Adequacy Study

- ISO collaborated with EPRI to conduct a probabilistic energy adequacy study for New England under extreme weather events; initial studies focused on 2027 and 2032
- Study established the Probabilistic Energy Adequacy Tool (PEAT) framework for risk analysis; it is expected that this framework will be essential as climate projections are refined and the resource mix evolves
- Study results have informed the region on energy shortfall risks over the next decade; results are expected to inform the development of a regional energy shortfall threshold (REST) in 2024
- This presentation briefly reviews the study framework and results of energy assessments completed for the 2027 and 2032 events



In Step 1, Historical Weather Trends and Climate Projections Were Reviewed

- This step included a review of New England's historical weather (1950 to 2021), analysis of global climate model projections, and development of hourly weather variable and resource profiles
- EPRI used five global climate models spanning a range of climate sensitivities and two emissions pathways to project changes to weather variables for use in subsequent steps in the study
- Future weather realizations were developed for the 2027 and 2032 study years; realizations consisted of hourly synchronous profiles for temperature, wind, and solar reflecting climate model projections
- Hourly profiles of weather variables were used to develop hourly demand forecasts and energy output profiles for wind and solar resources

In Step 2, a Risk Screening Model Was Developed to Facilitate Extreme Event Selection

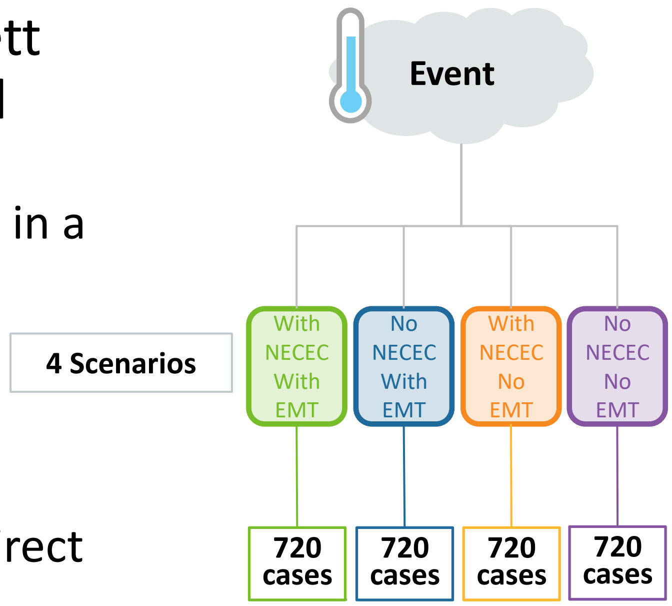
- The objective of the Risk Screening Model is to search the weather data and select a set of 21-day events that appear most stressful (extreme) to the future New England power system in terms of energy availability
- For each study year, the input to the risk screening model is 37,440 21-day events based on 72 years (1950 – 2021) of climate-adjusted weather
  - Output of risk screening model is 1,470 high risk events (top ~4%)
- A clustering algorithm was used to group the 1,470 events into clusters consisting of similar types of events

Events Selected by the Risk Screening Model for Study Years 2027 and 2032

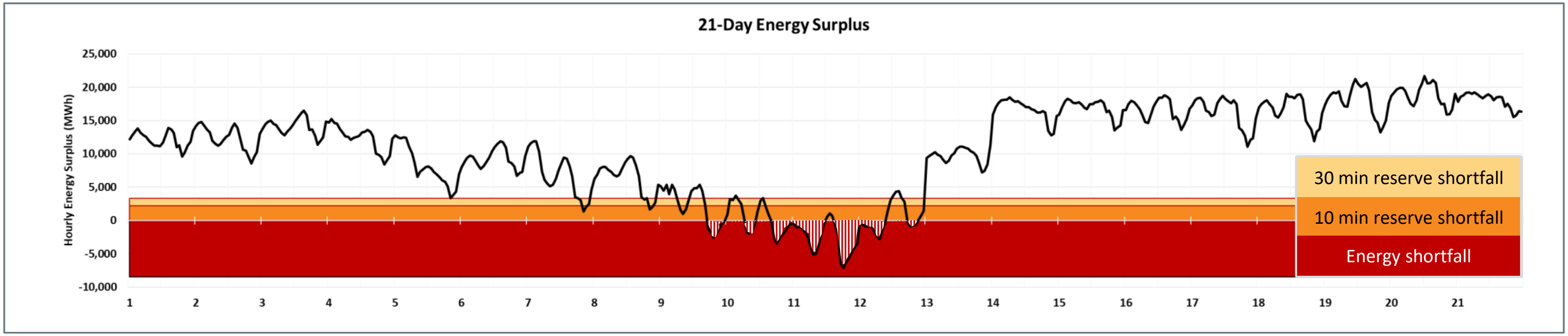
- For 2027 and 2032, two winter clusters were identified
  - Winter Cluster 1: consists of longer-duration events with low winds and low solar irradiance
  - Winter Cluster 2: consists of shorter-duration events with low winds and low solar irradiance
- Three distinct summer clusters were identified for each year of study, but results showed no energy shortfall
- A single winter event, the 21-day period beginning on Jan 22, 1961, was identified as having the highest potential for energy shortfall and was a focal point of ISO's winter energy assessments

Following Extreme Event Selection, Scenarios Were Developed for Use in Step 3

- Each selected event was studied with a combination of two key variables – the Everett Marine Terminal (EMT) and the New England Clean Energy Connect (NECEC) facility
  - Each combination of these two variables results in a "scenario", each of which was not assigned a probability of occurrence
- Each of the four scenarios is modeled using 720 "cases"
  - Each case reflects different combinations of indirect weather-related uncertainties (LNG and fuel-oil inventories, imports, forced outages, etc.), each having an assigned probability of occurrence
  - Uncertainty assumptions vary based on the unique characteristics of each 21-day event (e.g. event start date, temperatures, etc.)



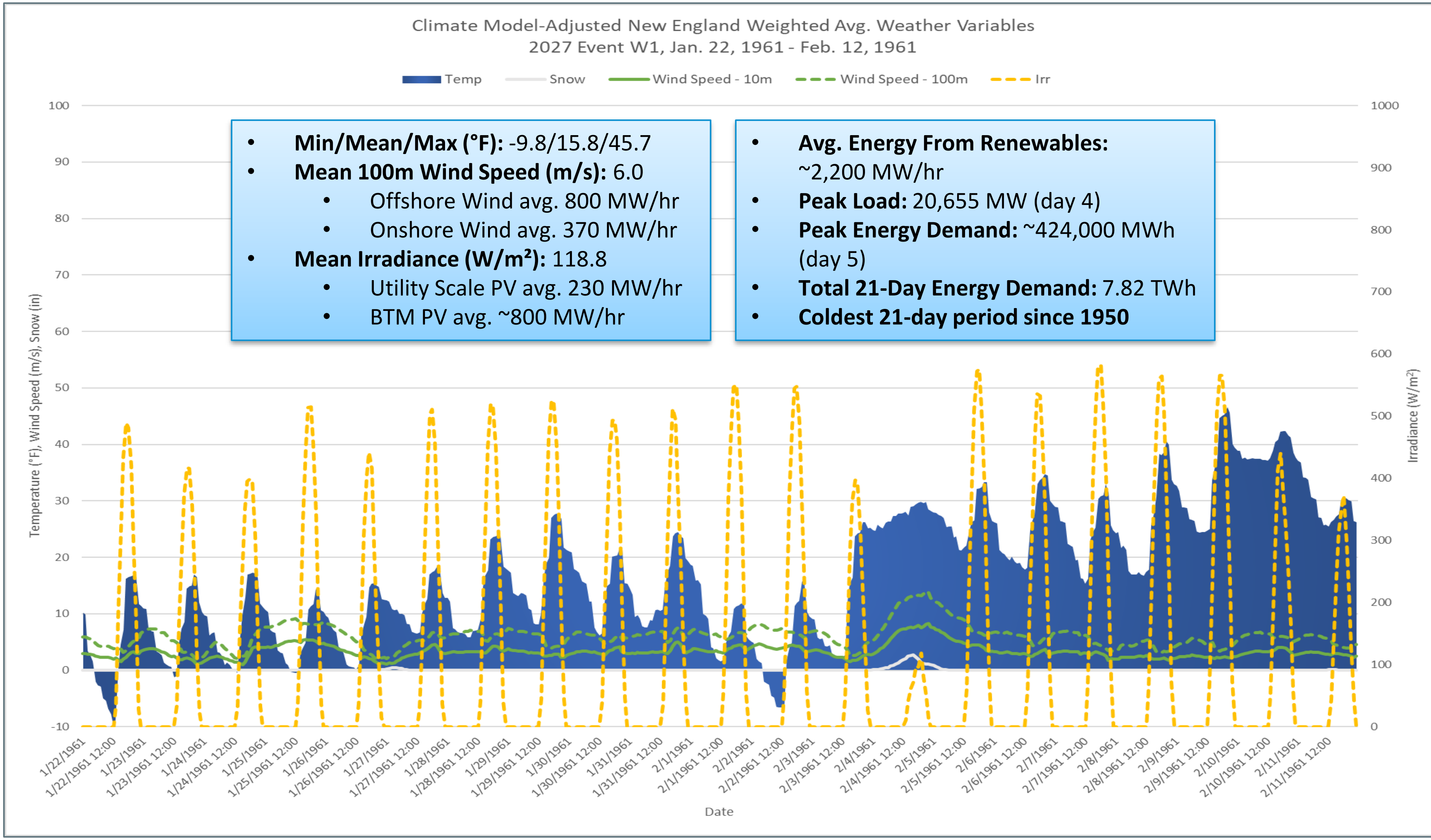
In Step 3, ISO’s 21-Day Energy Assessment Forecasts Hourly Energy Surplus for Each Case



*The figure above is an example illustration of a 21-day energy assessment forecast

- For each case, energy assessment results include:
  - Energy surplus (black curve)
  - Energy shortfall (red/white striped area): quantity in MWh and duration
  - Reserve shortfalls (black curve in yellow/orange): quantity in MWh and duration
- For each scenario, energy assessment results are a statistical summary across all 720 cases within scenario:
  - “Expected” energy shortfall = probability-weighted average across all cases
  - “Worst-case” energy shortfall = case with highest energy shortfall quantity

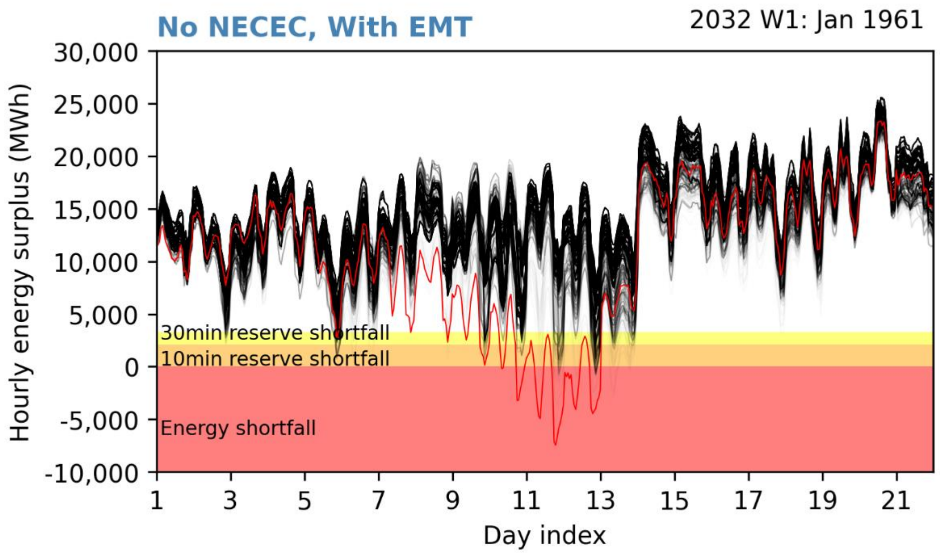
Jan 22, 1961 Event Consisted of a 12-Day Cold Wave Coincident with Low Wind and Very Low Solar

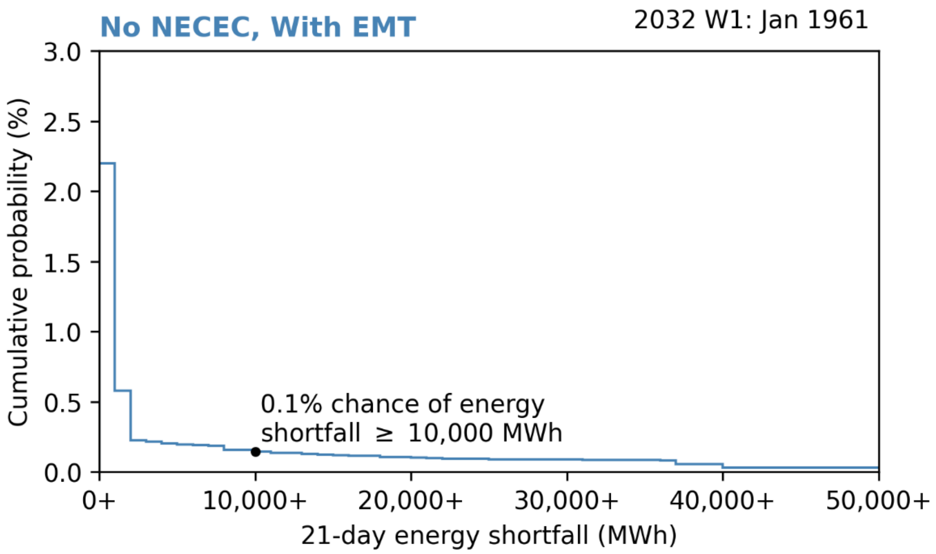


*temperatures, wind speeds, and irradiance are based on a New England ten-city weighted average

Summary of 21-Day Energy Analysis Results

Jan 22, 1961 Event; Scenario: no NECEC, with EMT

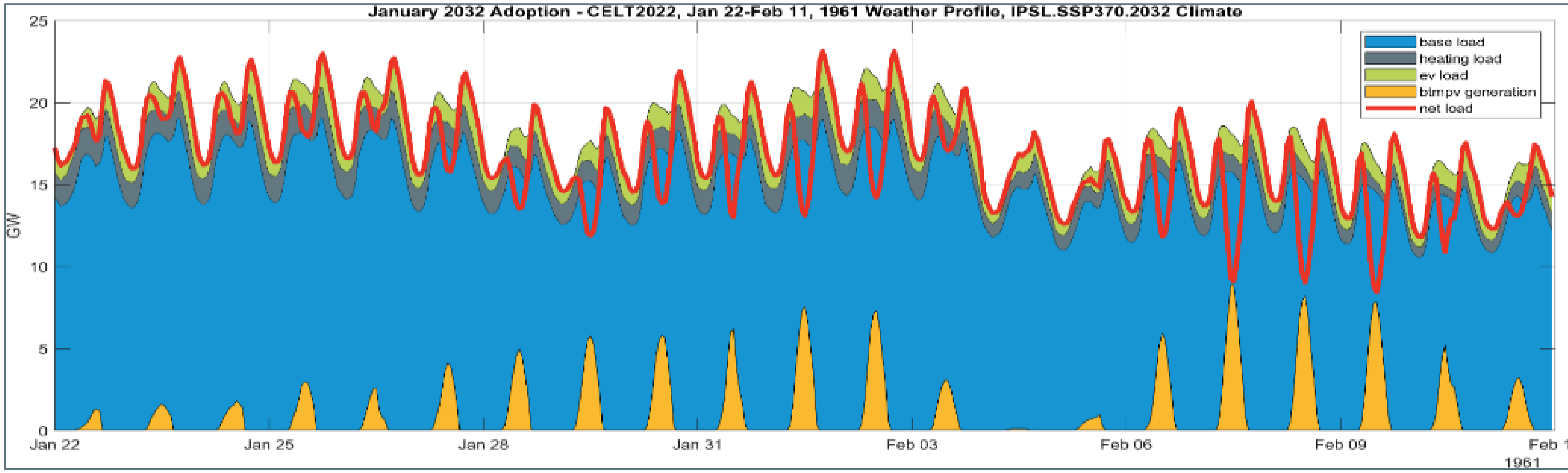




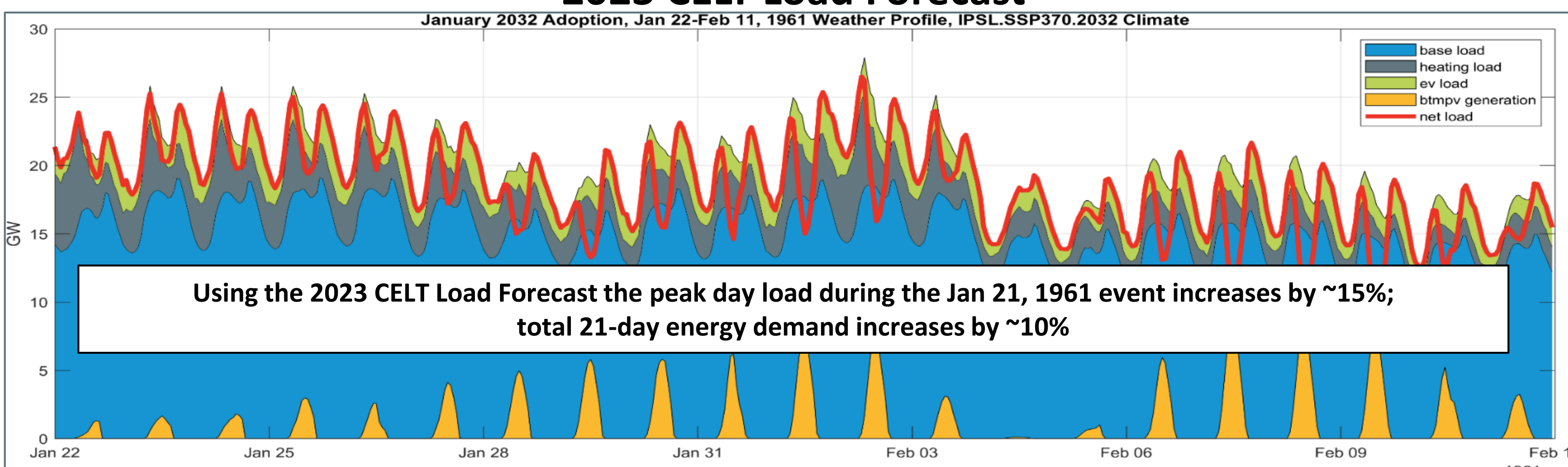
Study Year	# of cases having energy shortfall (of 720)	Max 21-day total energy shortfall in a case (MWh)	Min 21-day total energy shortfall in a case (MWh)	Expected avg. 21-day total energy shortfall per case with energy shortfall (MWh)	Probability of energy shortfall occurring	Probability of the case with max 21-day total energy shortfall
2027	233	**111,353**	36	421	7.6%	0.00055%
2032	232	**115,642**	21	69	2.2%	0.00055%

Load Increases Significantly When 2023 CELT Electrification Load Forecast is Used

2022 CELT Load Forecast

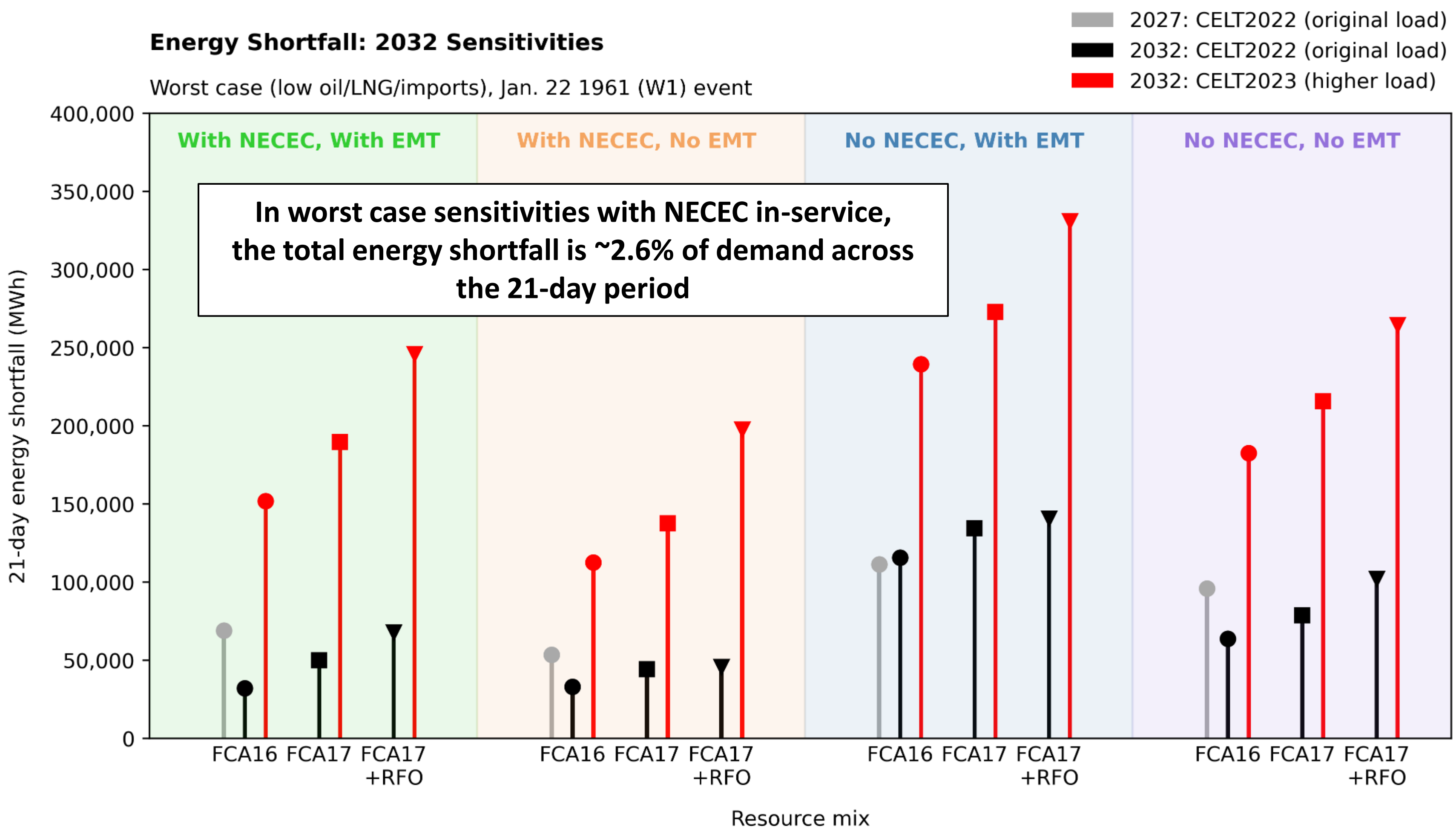


2023 CELT Load Forecast



Using the 2023 CELT Load Forecast the peak day load during the Jan 21, 1961 event increases by ~15%; total 21-day energy demand increases by ~10%

Sensitivities Highlight the Impact of Retirements and Electrification on Energy Shortfall Amounts



Key Takeaways of 2027 and 2032 Studies

- The region's energy shortfall risk is dynamic and will be a function of the evolution of the supply and demand profiles
  - Various assumptions inform the analysis and significant deviation from any of these assumptions may result in an increasingly risky profile
  - The studies anticipate a reliable gas system, a responsive oil supply chain, and no significant disruptions in energy production due to emissions limitations
- Results of the energy adequacy studies reveal a range of energy shortfall risk and associated probabilities
  - In the near-term, the winter energy shortfall risk appears manageable over a 21-day period; results are consistent with expectations for load growth and significant quantities of solar, offshore wind, battery storage resources, and additional imports

Key Takeaways of 2027 and 2032 Studies, cont.

- Sensitivity analysis of 2032 worst-case scenarios indicates an increasing energy shortfall risk profile between 2027 and 2032
  - Timely additions of BTM and utility-scale solar, offshore wind, and incremental imports from NECEC are critical to mitigate energy shortfall risks that result from significant winter load growth and retirements
- The PEAT framework provides a much needed foundation to study energy shortfall risk as the system evolves
- Study results are expected to help inform the development of a Regional Energy Shortfall Threshold (REST)
  - ISO expects that the REST will be a reliability-based threshold that reflects the region's level of risk tolerance with respect to energy shortfalls during extreme weather

Questions