MARCH 19, 2025 | PAC WEBEX

2024 Economic Study

Policy Scenario Sensitivities & Follow-Up to Stakeholder-Requested Scenario

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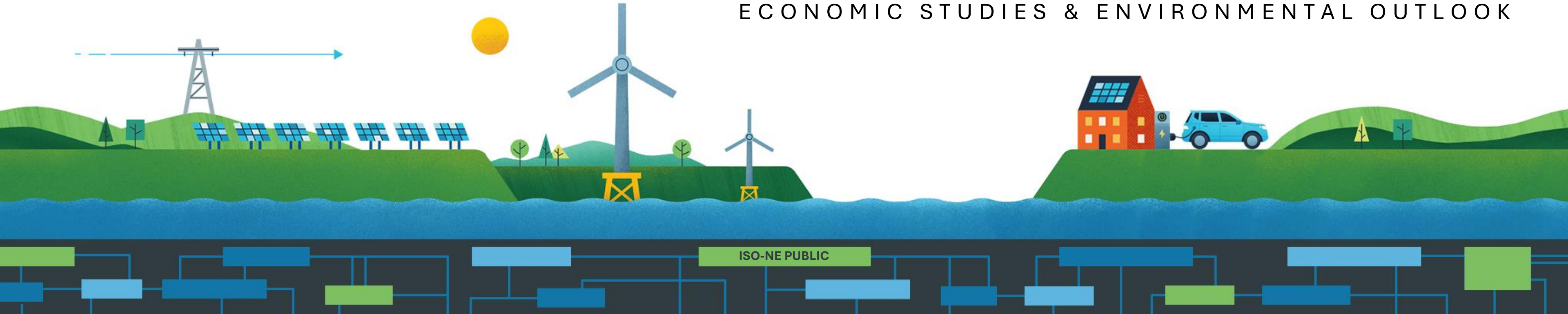
ECONOMIC STUDIES & ENVIRONMENTAL OUTLOOK



Overview of Presentation

- Overview of the 2024 Economic Study
- Policy Scenario Sensitivity: PLEXOS Resource Adequacy Analysis for Retirements
- Policy Scenario Sensitivities: Offshore Wind (OSW) Restrictions
  - No New OSW
  - Increased OSW Capital Cost Estimate
- Follow-up to questions asked from last PAC regarding the Stakeholder-Requested Scenario
- Timeline and Next Steps

Previous Presentations

Date	Presentation (with Link)
Jan 18, 2024	Initiation of the 2024 Economic Study
Mar 20, 2024	Stakeholder-Requested Scenario Timeline & Benchmark Scenario Assumptions
Jun 20, 2024	Preliminary Benchmark Scenario Results & Review of Stakeholder Requested Scenario Proposals
Aug 21, 2024	Final Benchmark Scenario Results, Publishing of the Public Benchmark Scenario, & Policy Scenario Assumptions
Oct 23, 2024	Interregional Model Assumptions / High Level Results
Nov 20, 2024	Preliminary Policy Scenario Results & Stakeholder-Requested Scenario Assumptions
Jan 23, 2025	Final Policy Scenario Results
Feb 26, 2025	Preliminary Stakeholder-Requested Scenario Results

OVERVIEW OF THE 2024 ECONOMIC STUDY

Objective of the Economic Study Process

- Provide information to stakeholders to facilitate the evaluation of economic and environmental impacts of New England regional policies, federal policies, and various resource technologies on satisfying future resource needs in the region
  - Identify system efficiency issues on the PTF portion of the New England Transmission System and, as applicable, evaluate competitive solutions to alleviate identified system efficiency needs
- The 2024 Economic Study is anticipated to conclude by December 2025, but timeline may vary depending on outcomes of the System Efficiency Needs Scenario

Economic Study Reference Scenarios

Benchmark Scenario – Model the previous calendar year and compare it to historical system performance. This scenario's purpose is to test the fidelity of models against historical performance and improve the models for future scenarios

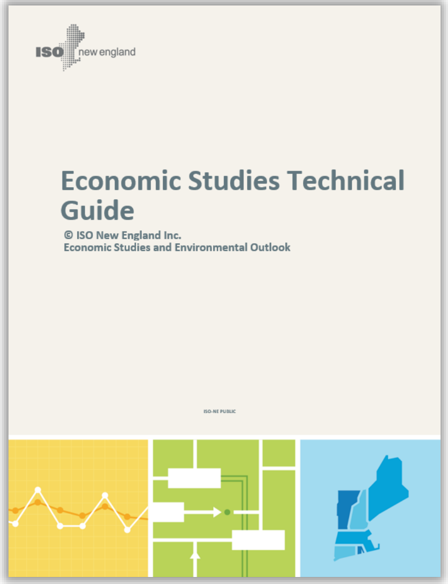
Policy Scenario – Model future years (>10-year planning horizon) based on satisfying New England region and other energy policies and goals

System Efficiency Needs Scenario (SENS) – Model a future year (10-year planning horizon) based on the ISO's existing planning criteria to identify system efficiency issues that could meet the threshold of a system efficiency Needs Assessment and move on to the competitive solution process for System Efficiency Transmission Upgrades needs

Stakeholder-Requested Scenario – Scenario with a region-wide scope that is requested by stakeholders and not covered by the other 3 scenarios or potential sensitivities on these 3 scenarios

Economic Studies Technical Guide

- The ISO published the first version of the Economic Studies Technical Guide (ESTG) on March 25, 2024
- This Technical Guide seeks to provide stakeholders, policy makers, and the public with a comprehensive document that describes the Economic Study process
  - Please refer to this document for detailed questions about assumptions and study procedures



Recap of Previous Policy Scenario Results

- The Policy Scenario uses a capacity expansion model followed by a production cost model. The objective of the scenario is to build a system that meets state emission reduction goals with lowest net present value (NPV)
  – From 2033-2040, the capacity expansion model builds PV, wind, and short-duration batteries. Small modular reactors (SMRs) and long duration energy storage (LDES) are most effective for emission reductions from 2045-2050
  – The cost of reducing carbon emissions increases exponentially as the system is decarbonized and more expensive resources are needed to serve load while meeting the carbon constraint

POLICY SCENARIO SENSITIVITY

Resource Adequacy Analysis for Retirements

PLEXOS Resource Adequacy Analysis Overview

- In the Policy Scenario, this analysis aims to determine the amount of fossil fuel resources that may still be needed from a resource adequacy perspective in the system built by the capacity expansion model
  - The base resource mix includes all existing generators that do not have announced retirements
  - The goal of the analysis is not to determine the exact capacity of resources required to meet the resource adequacy target (ICR), but to serve as a feasibility test of the resulting resource mix in meeting resource adequacy need for the studied year

Disclaimer on RA Analysis in PLEXOS

The results of this analysis are for **information only** and **should not be taken out of the context of the Policy Scenario**. The retirements presented in these results are entirely dependent on the resources built by the capacity expansion model and **are not indicative of the ability to retire any of these resources in the existing ISO-NE system**

Resource Adequacy Analysis in PLEXOS

- Economic dispatch parameters are not considered in traditional resource adequacy (RA) modeling. In PLEXOS, cost inputs can be manipulated to force the model to behave as an RA model would
  - Fuel, emission, and start costs are removed from the model. Dispatch order is set using VO&M costs. Using the standard objective to minimize production cost, lowest cost resources will be dispatched first
    - Storage resources have the highest VO&M costs to ensure their generation capacity is retained. Storage should only be dispatched if an unserved energy (USE) event is going to occur
  - The internal cost of USE is increased to $1 billion/MWh. Since PLEXOS is trying to minimize production cost, this very high value ensures the model will dispatch all available resources before allowing USE, which mimics the dispatch logic of RA assessments to minimize load shedding
  - Fuel constraints for 2050 are not considered in this analysis. Results could vary if constraints continue to exist

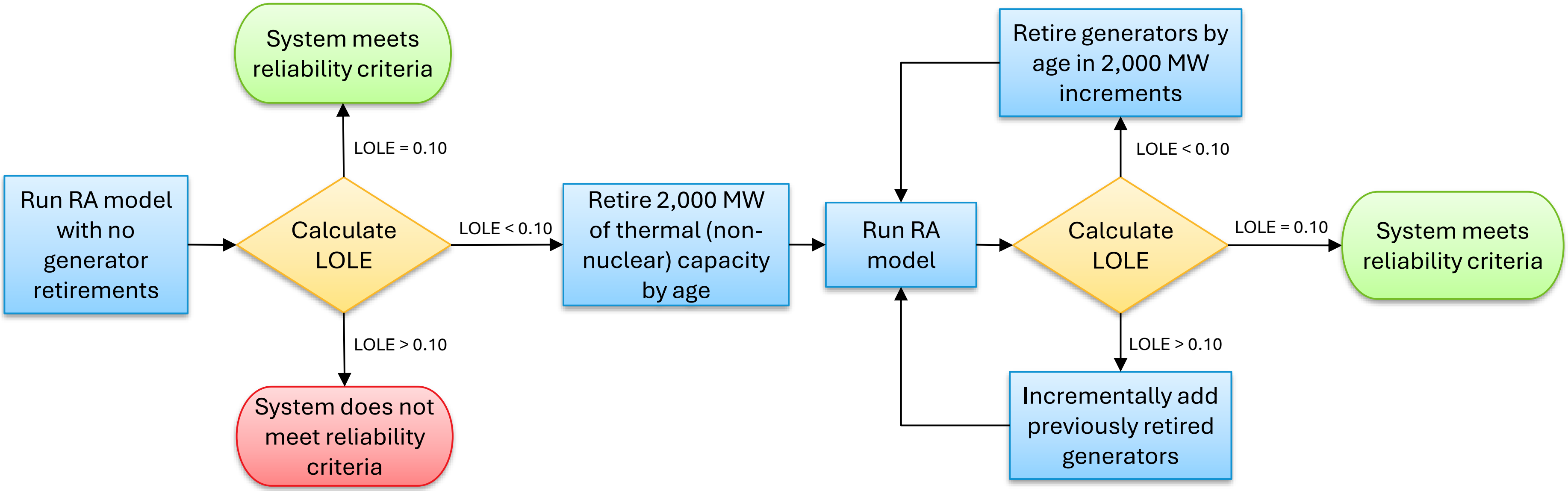
- PLEXOS is not a true RA modeling tool. The ISO's RAA team uses GE MARS for their analysis, but we are using PLEXOS's probabilistic outage modeling as an alternative for this analysis. It provides some insight into RA results without the time and resource commitment of converting the model to MARS

Resource Adequacy Metrics in PLEXOS

- Results of RA models in PLEXOS will be reported with the following commonly used metrics
  - Loss of Load Expectation (LOLE) [days/year]: Expected number of days during year where a loss of load event (unserved energy) occurs in the system
    - The LOLE RA planning criterion for ISO-NE is 0.1 days/year
  - Expected Unserved Energy (EUE) [MWh/year]: total estimated size of all the loss of load events in a year

- The capacity expansion model builds new resources to meet the emission constraint at lowest cost. The buildout does not consider RA criteria beyond the cost optimization that includes the assumed cost of USE

Resource Adequacy Analysis in PLEXOS, cont.



- Rather than using load forecast uncertainty multipliers to account for variation in future load shapes, simulations are run with 20 weather years of correlated wind, PV, and load profiles
- For each of the 20 weather years, 100 samples of outage draws are run using probabilistic modeling in PLEXOS

2050 PLEXOS RA Results

	Base	2,000 MW Retired	4,000 MW Retired	5,550 MW Retired	6,000 MW Retired
Total Capacity Remaining (MW)	126,257	124,257	122,257	120,707	120,257
LOLE [days/year]	**0**	**0**	**0.02**	**0.10**	**0.1545**
EUE [MWh/year]	**0**	**0**	**52**	**1,508**	**3,182**

- Up to 5,550 MW of legacy thermal (non-nuclear) generation can be retired by age in 2050 before the system exceeds 0.1 LOLE
- The capacity expansion model buildout surpassed reliability standards because it optimizes production cost by allowing storage to price arbitrage. The RA model incentivizes storage to retain energy

2050 Modeled Capacity

Modeled Capacity in 2050 (MW)

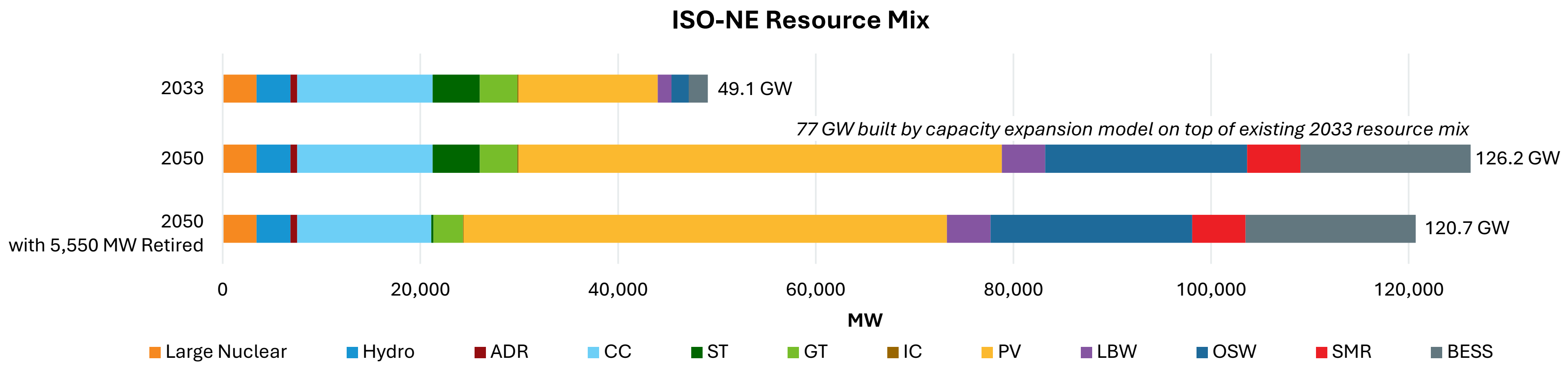
Resource Type	Base	2,000 MW Retired	4,000 MW Retired	5,550 MW Retired	6,000 MW Retired
Gas	15,343	15,315	15,209	15,209	14,807
Oil	6,164	4,241	2,347	1,298	1,298
LFG/MSW/WDS	876	827	827	326	278
Nuclear	8,814	8,814	8,814	8,814	8,814
Hydro	3,449	3,449	3,449	3,449	3,449
PV	48,911	48,911	48,911	48,911	48,911
LBW	4,399	4,399	4,399	4,399	4,399
OSW	20,413	20,413	20,413	20,413	20,413
BESS	17,210	17,210	17,210	17,210	17,210
ADR	669	669	669	669	669
Total	**126,248**	**124,248**	**122,248**	**120,698**	**120,248**

Impact of Retirements on Production Cost Model

- The retirement of 5,550 MW of legacy thermal generation has minimal impact on system operations in the 2050 production cost model
  - In the reference model with no retirements, the generators that will be retired only generate for 482 GWh in 2050, which is 0.22% of the total annual generation. In the model with retirements, this generation is easily replaced by remaining NG generators
  - Production cost does not change after the generators have been retired
  - Emissions from gas and oil increase because there is less generation from LFG/MSW/WDS

	Reference	With Retirements	Delta
Production Cost ($M)	1,306	1,306	0
Emissions (tons)	2,542,856	2,756,051	+213,195

RA for Retirements: Takeaways



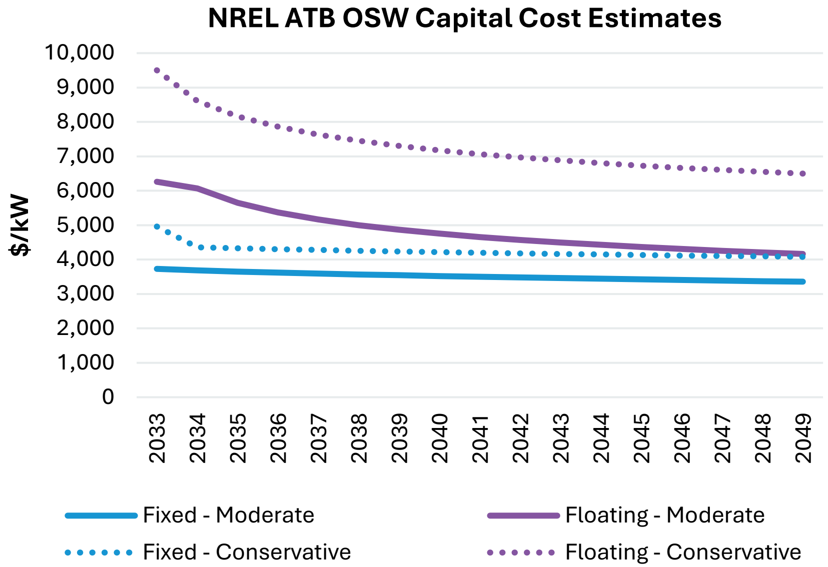
- Even with a buildout of 77 GW in the capacity expansion model, the system still needs 44 GW of capacity from the existing 2033 resource mix in order to meet reliability criteria
  - It is unlikely that all of these legacy resources will still be operational in 2050. This would necessitate an even larger capacity buildout
- Retirements do not have a significant impact on system operations during a moderate weather year

POLICY SCENARIO SENSITIVITIES

No New Offshore Wind, Increased OSW Capital Cost Estimate

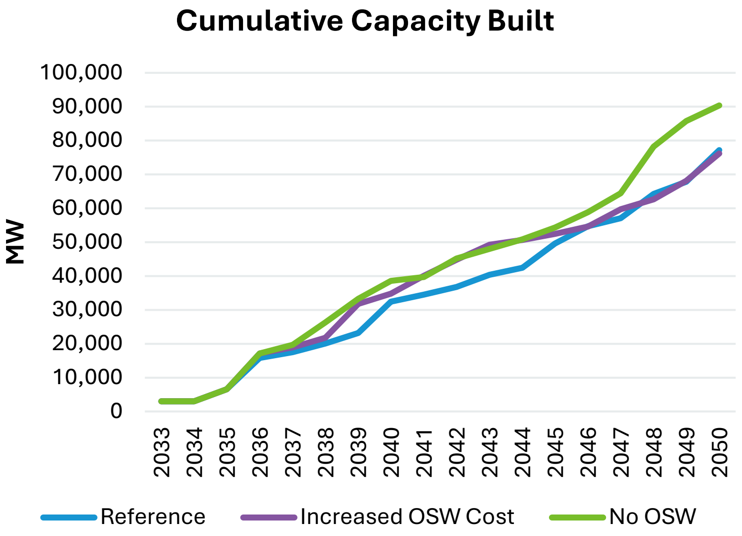
Sensitivity Overview – OSW Assumptions

- The Policy Scenario reference case assumes the inclusion of fixed and floating offshore wind as candidate resources
- Recent market trends have shown varying levels of investment across different renewable generation technologies. Participation in OSW has been lower than initially expected. These sensitivities examine the effects of adjusting OSW capital costs and availability in the model
    1. Increased OSW Cost: capital costs for OSW are increased to the NREL Annual Technology Baseline 'conservative' estimate (see graph)
    2. No OSW: OSW is not included as a candidate resource and can't be built by the capacity expansion model



OSW Sensitivity Results: Capacity Expansion

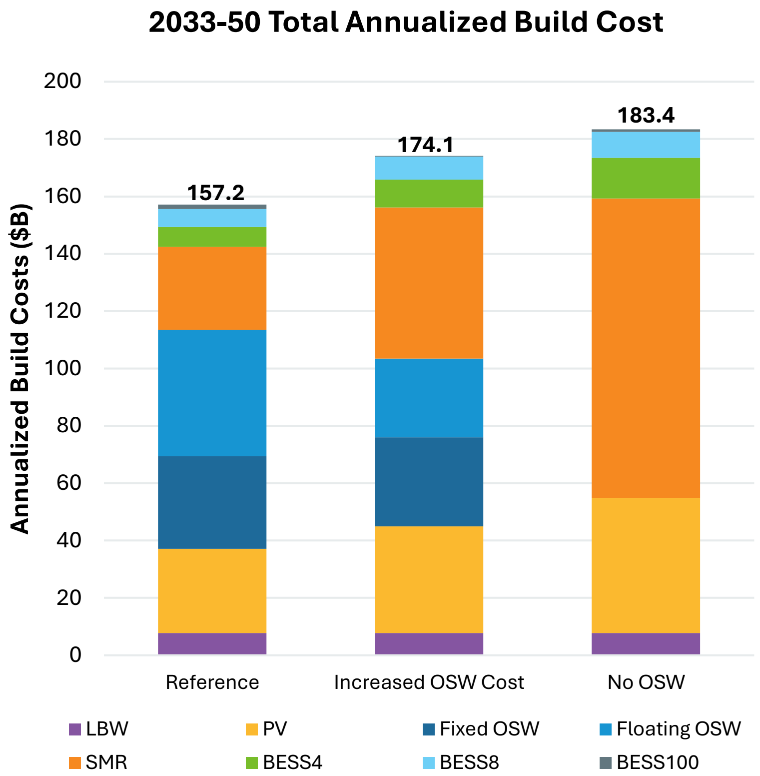
Type	Reference	Increased OSW Cost	Delta (Increased OSW Cost - Reference)	No OSW	Delta (No OSW - Reference)
PV	34,822	37,000	+2,178	51,676	+16,854
LBW	3,000	3,000	0	3,000	0
Fixed OSW	6,476	5,249	-1,227	0	-6,476
Floating OSW	12,193	7,461	-4,732	0	-12,193
SMR	5,400	7,325	+1,925	11,862	+6,462
Li-ion BESS	13,415	15,186	+1,772	21,234	+7,819
Iron-air BESS	1,870	957	-913	2,600	+730
Total (MW)	**77,177**	**76,179**	**-998**	**90,372**	**+13,195**



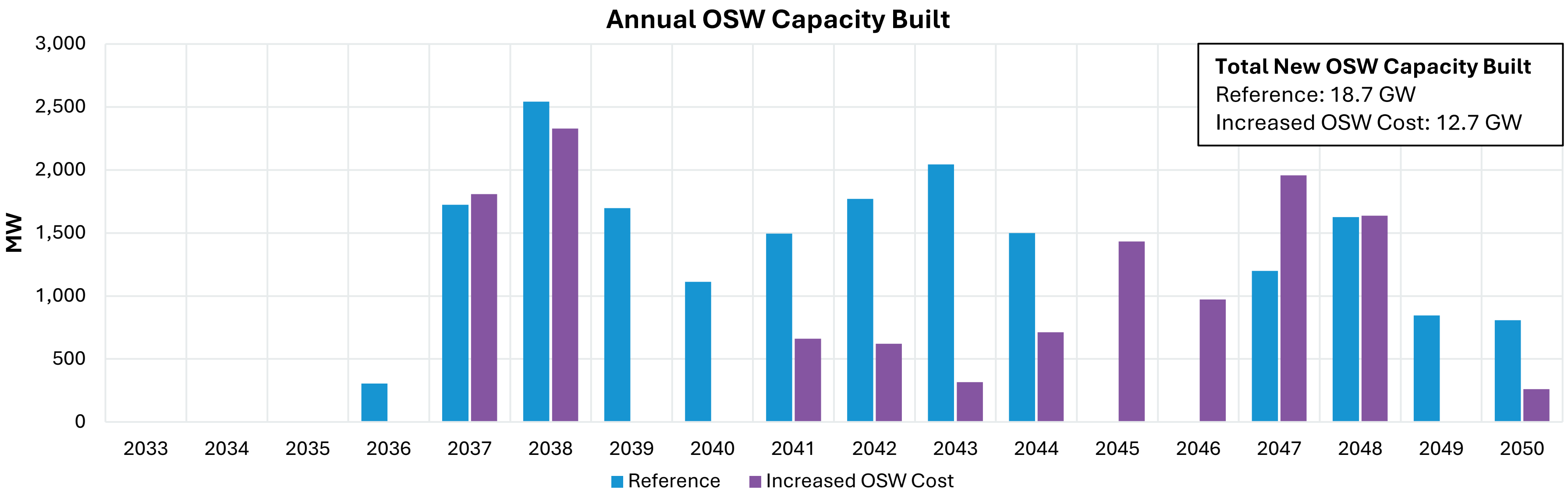
- When the model is not allowed to build OSW, there is a significant increase in the capacity buildout of other resource types, especially PV
  - 11.8 GW of SMRs is equivalent to about 40 units at 300 MW each
- Although the total capacity built in the Increased OSW Cost sensitivity is less than the capacity built in the reference case, the model is forced to build more SMRs, which are the most expensive resource

OSW Sensitivity Results: Capital Costs

- To meet the policy-based emission constraint without OSW, the total annualized build costs **increase by $26 billion**, or 16.6%
- Even when OSW is assumed to be more expensive than current estimates, it is still a cheaper option than the extensive PV, SMR, and BESS buildout that is modeled in the No OSW sensitivity



OSW Sensitivity Results: OSW Buildout Timeline



- Under the Increased OSW Cost sensitivity, the majority of the OSW buildout occurs in the 2040s, but there is still a 4.1 GW build early in the horizon
  - Capital cost estimates decrease over time to account for the development of new technology and supply chains

OSW Sensitivity Results: 2050 Operational Metrics

	Reference	Increased OSW Cost	No OSW
Production Cost ($M)	1,306	1,501	2,086
Annualized Build Cost ($M)	21,250	24,100	27,488
Fixed O&M Costs ($M)	4,109	4,071	4,267
Total 2050 Costs ($M)	26,665	29,672	33,841
Avg LMP ($/MWh)	24.73	28.81	38.70
LSEEE ($M)	6,935	7,942	10,269
Curtailment (GWh)	28,291	17,536	8,134
Emissions (tons)	2,542,856	2,806,843	3,624,260

- In 2050 alone, the net present value (production cost + capital costs) of the buildout with no OSW is $7.2 billion higher than the reference case NPV
- Without OSW, the cost of energy to customers increases by about 50% in 2050. Even when OSW capital cost estimates are increased, LSEEE and average LMPs are lower than the no OSW case
- Carbon emissions are 1.1 million tons higher in the case with no OSW

OSW Sensitivity: 2050 Generation by Fuel Type (GWh)

Type	Reference	Increased OSW Cost	No OSW
ADR	40	48	64
Oil	18	10	22
NG	5,512	6,157	7,973
LFG/MSW/WDS	537	625	812
Existing Nuclear + SMR	39,336	48,986	75,404
Hydro	6,996	7,385	7,654
Wind	93,741	73,577	21,578
PV	54,321	59,403	80,364
Imports	14,601	17,588	21,027

- The buildouts with less or no OSW must rely more on emitting generation, SMRs, and new PV resources. There is less curtailment of renewables and imports

OSW Sensitivity Takeaways

- New England needs new OSW resources to meet state emission goals at the lowest cost
  - In 2050, energy market costs could be up to 50% higher without OSW
- Even if OSW capital costs are higher than current estimates, the system will economically benefit from new OSW resources, although the ideal timeframe for building OSW shifts to after 2040
  - Note that results are dependent on cost assumptions for other resource types. Only OSW costs were varied in this analysis

STAKEHOLDER-REQUESTED SCENARIO

Follow-Up to Questions Asked

Questions Asked During the February PAC

- Stakeholders raised several questions regarding preliminary results of the Stakeholder-Requested Scenario during and shortly after the February PAC
- This section addresses those questions

Capacity Expansion Sampling Chronology

Q: Is unnecessary variability introduced to capacity expansion by allowing the model to sample different days between scenarios?

A:

- The sampling algorithm is designed to represent a wide range of operating conditions for profiled resources and loads
- Locking in specific days could bias the results by artificially undervaluing certain profiled resources
  - Ex. A day experiencing a significant ramp under a high EV electrification scenario might not be as notable under a scenario with lower EV adoption, making it less relevant for the model to sample
- The ISO is continuing to evaluate the correct sampling methodology to use for capacity expansion

Transmission Congestion Effects

Q: Is it possible to include transmission constraints in the Stakeholder-Requested Scenario to reflect congestion impacts?

A:

- Transmission constraints can be modeled but introduce significant complexity
- Capturing these constraints involves challenges with resource siting and coordination between capacity expansion and production-cost modeling
- Currently, the ISO does not have the bandwidth to perform this analysis

Load Electrification

Q: What percentage of the total load has been electrified?

A:

2040 Values	75% Electrification	90% Electrification	Base	110% Electrification	125% Electrification
Total System Load (TWh)	159.4	165.7	169.9	174.1	180.4
Electrification Load (TWh)	31.5	37.8	42.0	46.2	52.5
Electrified Load Percentage	20%	23%	25%	27%	29%

Electric Vehicle Loads

Q: Which EV loads were used and was there any load management for the EV load?

A:

- The same profiles are used that were developed for the EPCET Study
- No load management was assumed for EV load

NEXT STEPS

Next Steps

- Please send any feedback and to PACMatters@iso-ne.com
- Final Stakeholder-Requested Scenario Results will be presented at the May PAC
- Additional sensitivity results for the Policy Scenario will be presented at the May PAC
  1. Modeling of all candidate PV resources as bifacial single-axis tracking
  2. Accelerating emission constraint to meet full electric sector decarbonization goals by 2040

Questions

Acronyms

ADR	Active Demand Resource
BESS	Battery Energy Storage System
CC	Capital Cost
ESTG	Economic Studies Technical Guide
EUE	Expected Unserved Energy
FO&M Cost	Fixed Operation and Maintenance Cost
ICR	Installed Capacity Requirement
LBW	Land-Based Wind
LDES	Long Duration Energy Storage
LFG	Landfill Gas
LMP	Locational Marginal Price
LOLE	Loss of Load Expectation
LSEEE	Load-Servicing Entity Energy Expense

MSW	Municipal Solid Waste
NG	Natural Gas
NPV	Net Present Value
NREL ATB	National Renewable Energy Laboratory Annual Technology Baseline
OSW	Offshore Wind
PS	Pumped Storage
PTF	Pool Transmission Facility
PV	Photovoltaic
RA	Resource Adequacy
SMR	Small Modular Reactor
USE	Unserved Energy
VO&M Cost	Variable Operation and Maintenance Cost
WDS	Wood/Wood Waste Solids