Economic Planning for the Clean Energy Transition (EPCET) Pilot Study

Updated Interface Model Results and Capacity Expansion Primer

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Overview

- EPCET Pilot Study Overview & Status
- Market Efficiency Needs Scenario results
- Market Efficiency Needs Scenario detailed N-1 results
- Overview of Capacity Expansion

EPCET Pilot Study Overview

- As part of the 2021 Economic Study (Future Grid Reliability Study – Phase I), the ISO identified areas for improvement in our current Economic Study framework and software tools to perform the analyses
- The ISO filed Tariff revisions for Phase 1 of the Economic Studies process improvements with the Federal Energy Regulatory Commission on January 27, 2023
- The overall goal of the EPCET study is to prepare our models, tools, and processes such that informative and actionable results can be more readily produced in future Economic Study cycles
- The EPCET is a pilot study and not an Economic Study under the Tariff. The EPCET is an research and development effort that will help inform future study work and the next steps of the Economic Study Process Improvements. As such, the ISO will not pursuing a market efficiency Needs Assessment under the Tariff based on EPCET results.
- The EPCET study has three main objectives:
  - Take a deep dive into all input assumptions in economic planning analyses, propose updates to any assumptions based on our current experience, and test the effect of those modeling changes
  - Gain experience in the features and capabilities of our new economic planning software
  - Perform a trial run of the Economic Study process improvements

EPCET Pilot Study Scenarios

- The EPCET pilot study will perform trial runs of the three main scenarios proposed in the Tariff revisions being discussed with stakeholders to improve the Economic Study process:
  - **Benchmark scenario** – Model previous calendar year and compare it to historical system performance. This scenario's purpose is to test fidelity of models against historical performance and improve the models for future scenarios
  - **Market Efficiency Needs scenario (MENS)** – Model future year (10-year planning horizon) based on the ISO's existing planning criteria to identify market efficiency issues that could meet the threshold of a market efficiency need and move on to the competitive solution process for market efficiency needs
  - **Policy scenario** – Model future years (>10-year planning horizon) based on satisfying New England region and other energy and climate policies

Overall Status of the EPCET Study

- The ISO has presented results on the Benchmark and Market Efficiency Needs Scenario previously
- The last PAC presentation in December covered preliminary Market Efficiency Needs Scenario results
  - Most of the congestion was seen along historically binding interfaces
  - No sensitivity requests were received before the comment due date
- The ISO will begin work on policy scenario assumption development
- Today we are providing an educational overview of the capacity expansion modeling that will be part of the policy scenario

MARKET EFFICIENCY NEEDS SCENARIO (MENS) RESULTS

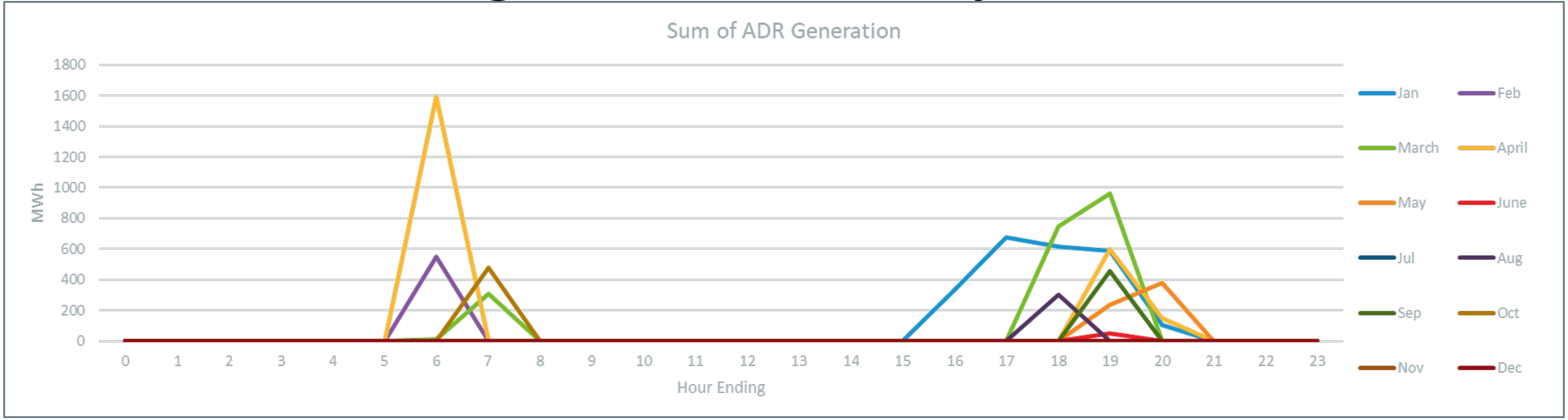
Modeling Changes Since December PAC

- The ISO has reflected interface voltage/stability limits in the MENS case
  - The interface voltage/stability limits will give a more accurate representation of the future grid
    - PLEXOS does not perform a voltage or stability simulation, so interface limits give a representation of voltage and stability limits

Result Overview

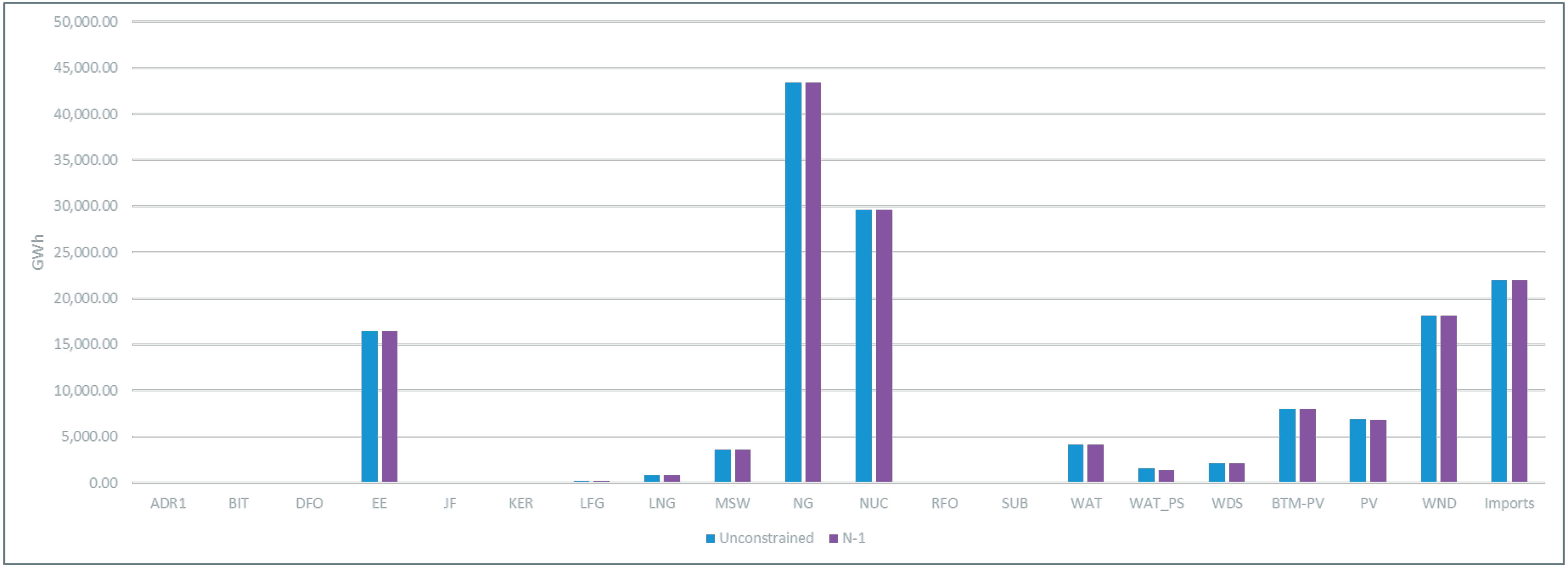
- Two models have been run:
  - An unconstrained model
  - An N-1 security constrained dispatch model with interface limits
- As in prior studies, the ISO will show a comparison of the two scenarios to examine the impact of constraints and congestion on LMPs, production cost, emissions, and dispatch by fuel type
- Examination of these statistics will give an idea of the economic and environmental impacts of congestion on a 10-year planning horizon system

Note on Peaking Unit & ADR Dispatch



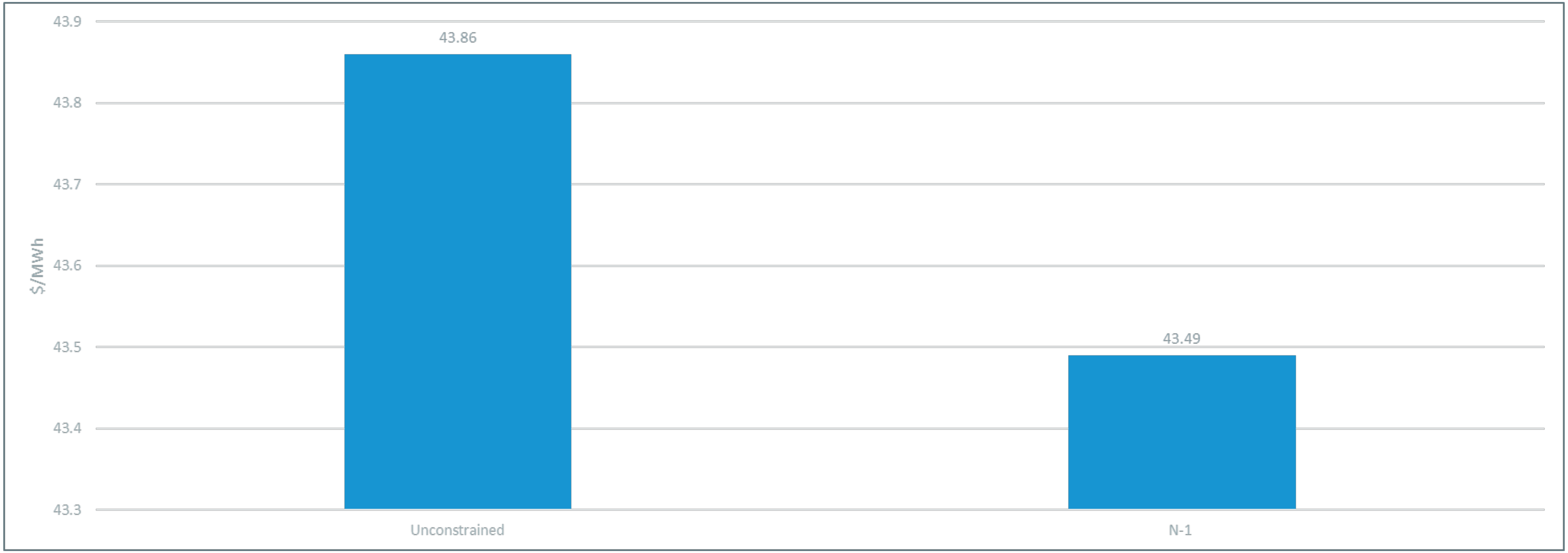
- In both models, there were a handful of hours where peaking units and ADR were dispatched between 6-7 AM and 6-8 PM, usually during shoulder months on low load, high PV days
  - These units run less during summer and winter months when loads are higher
- These dispatches are *not* the result of an exhaustion of natural gas resources or gas constraints. Rather, it is more economic to dispatch these resources for 1-2 hours at a time for morning and evening ramps than a cheaper combined cycle for a longer period
- These hours have high LMPs ($200-500/MWh)

Generation by Fuel Type in Unconstrained vs N-1 Cases



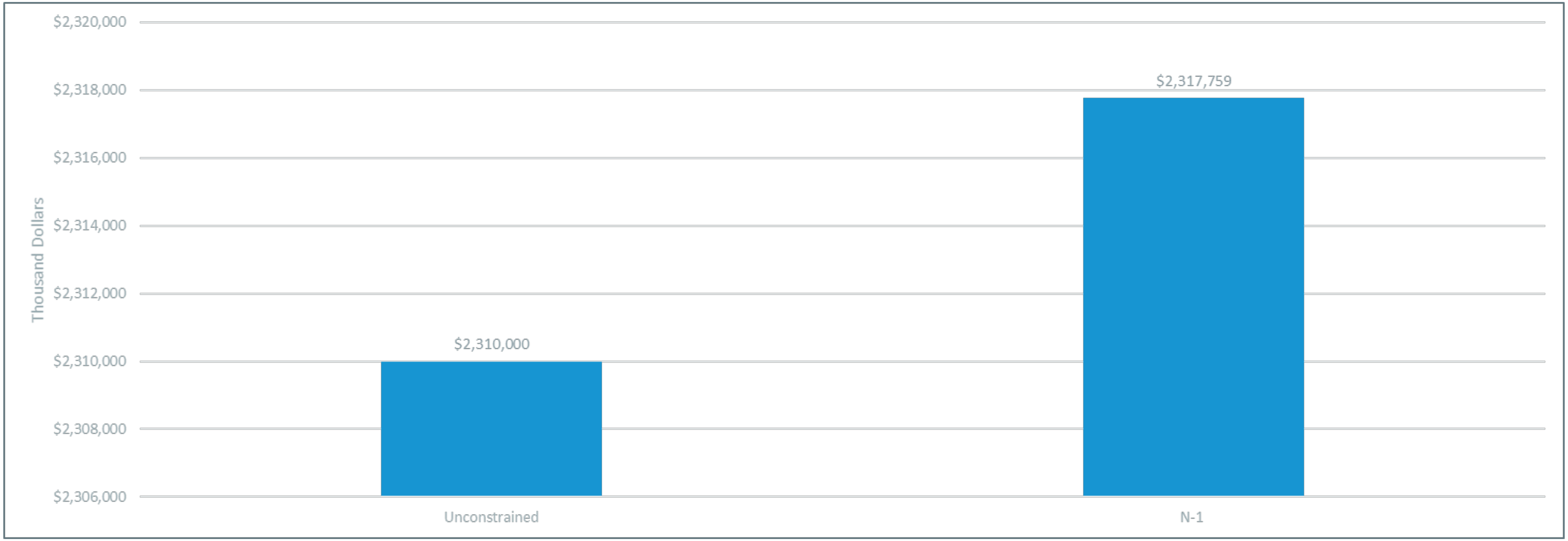
- The constraints in the N-1 constrained model slightly reduced generation from hydro, wind, and solar which resulted in slightly more gas, oil, and coal generation
  - 80 GWh of curtailed wind, solar, and run of river hydro were replaced primarily with gas generation, but also 11 GWh of oil generation and 7 GWh of coal generation

Annual Average LMPs in Unconstrained vs. N-1 Cases



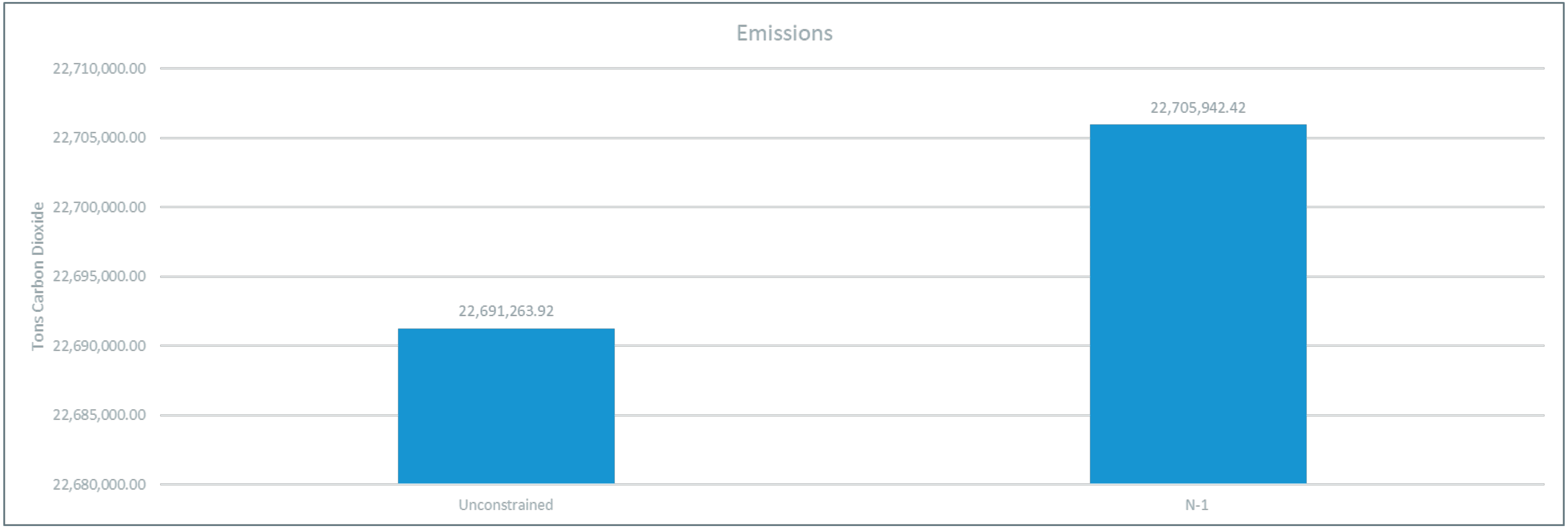
- N-1 constrained scenario decreased LMPs (-0.8%) due to additional curtailments lowering LMPs
- Additionally, average LMPs are reduced by $2.40/MWh in 2032 compared to historical 2021 LMPs

Production Cost in Unconstrained vs. N-1 Cases



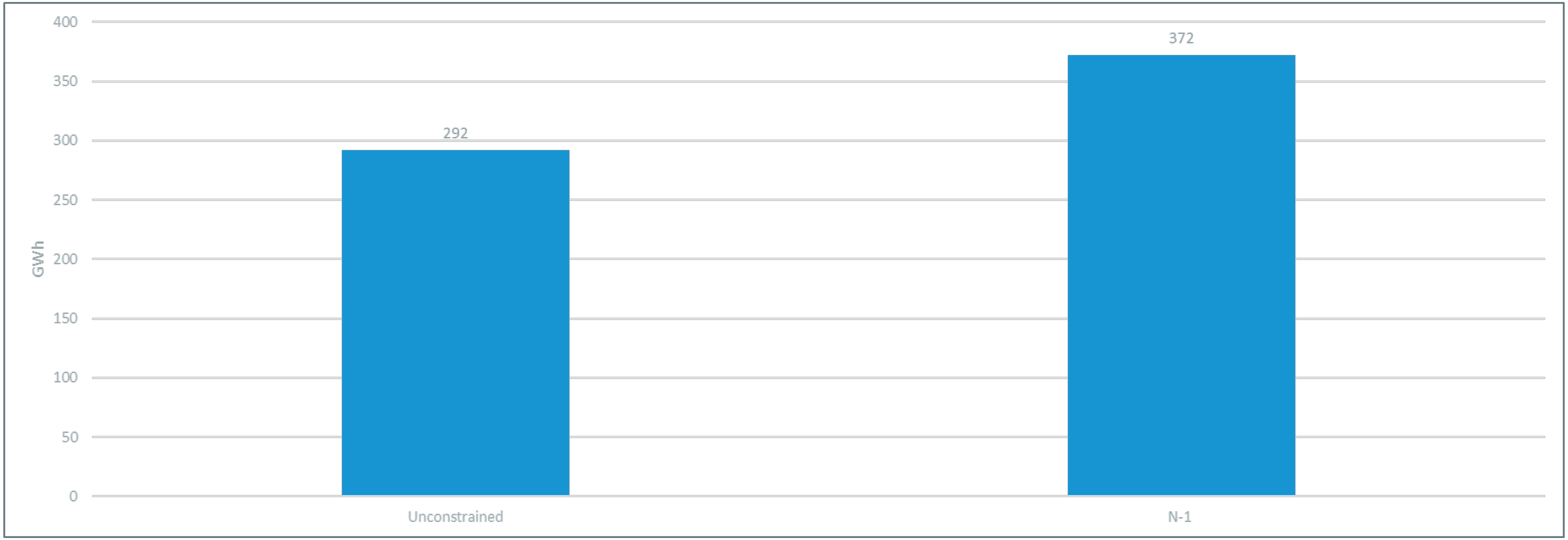
- Congestion on the N-1 case increased production costs by $7.7 million (+0.3%) due to more expensive dispatchable generation replacing zero cost resources

Multiple Case Results: CO_2 Emissions



- N-1 congestion increased CO_2 emissions by 15 thousand tons (+0.07%) due to additional gas, oil, and coal generation
- Emissions are reduced by 10.7 million tons in 2032 compared to the historical 2021 system (33.4 million tons)

Multiple Case Results: Curtailment



- 292 GWh of curtailment in the unconstrained case due to oversupply conditions
- Additional 80 GWh (+27%) of curtailment in the N-1 constrained case due to transmission congestion

MARKET EFFICIENCY NEEDS SCENARIO N-1 RESULTS

N-1 Detailed Results Overview

- More detailed results of the N-1 case will examine where congestion is happening and what the economic impact of this congestion is

- The ISO will examine:
  - Binding interfaces
  - Congested individual elements
  - Comparison to historical congestion & curtailment

N-1 Results: Interface Congestion

Interface	Hours Congested	Interface	Hours Congested
Boston Import	0	Northwest Vermont Import	**46**
Connecticut Export	0	Orrington South (FERC 715)	0
Connecticut Import	0	Sheffield-Highgate Export Interface	0
Keene Road Export Interface	0	Southeast Massachusetts / Rhode Island Export	0
Maine - New Hampshire	**295**	Southeast Massachusetts / Rhode Island Import	0
New England East-West	0	Southwest Connecticut Import	0
New England North-South	**32**	Surowiec South (FERC 715)	0
New England West-East	0	Western Connecticut Import	0
New Hampshire - Maine Interface	0	Whitefield-South + GRPW Interface	0
NNE - Scobie + 394	0	-	-

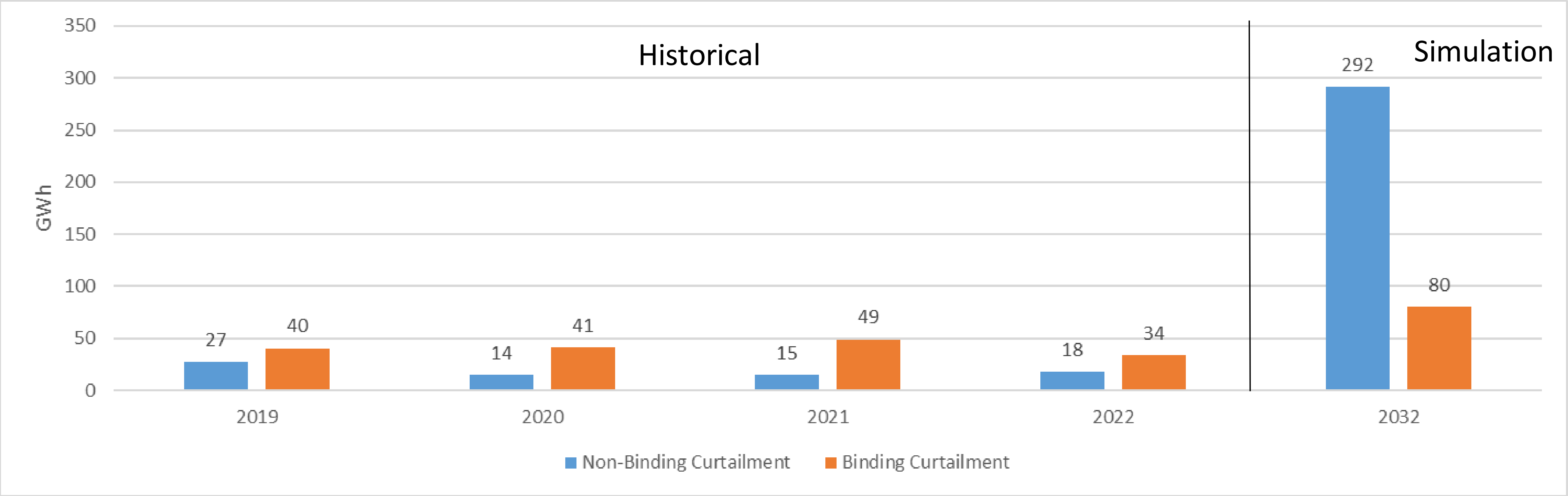
- Most interfaces are uncongested
- ME-NH and North-South are congested for some hours due to NECEC and wind/solar generation in Maine
- Northwest Vermont Import is congested during peak hours in the summer

N-1 Results: Most Congested Elements

Line	Substations	Average Shadow Price ($/MWh)	Hours Congested
O154	Paris to Lost Nation	39.56	1,425
Q195-1	Whitefield to Q195 Tap	51.08	923
K41	Highgate to Jay VT	42.92	3,722
E131-3	Bearswamp to Bearswamp Tap	39.66	1,947
S171	Johnston to Rise 171 Tap	19.03	5,444

- Most significant congestion happened along interfaces which are already binding in today's system (Whitefield South, Sheffield Highgate)
- There is some novel congestion in RI on S171

N-1 Results: Comparison to Historical Curtailment



- Historical curtailment is sorted into non-binding curtailment (not sensitive to a transmission constraint) and binding curtailment (sensitive to a transmission constraint)
- The above graph assumes model unconstrained curtailment = non-binding, additional N-1 constrained curtailment = binding
- There is an increase in curtailment due to transmission constraints, but significantly more curtailment occurs from non-binding conditions

Conclusions

- Most significant congestion happened along interfaces which are already binding in today's system (Whitefield South, Sheffield Highgate)
- Overall cost of congestion is relatively low ($7.7 million from all system congestion)
- Increase in curtailments from historical values are mostly due to oversupply conditions. There isn't significant additional curtailment due to transmission constraints
- The ISO will now shift its EPCET focus to the policy case, but may provide additional updates on the Benchmark or MENS case at a later date

CAPACITY EXPANSION PRIMER

EPCET Policy Scenario

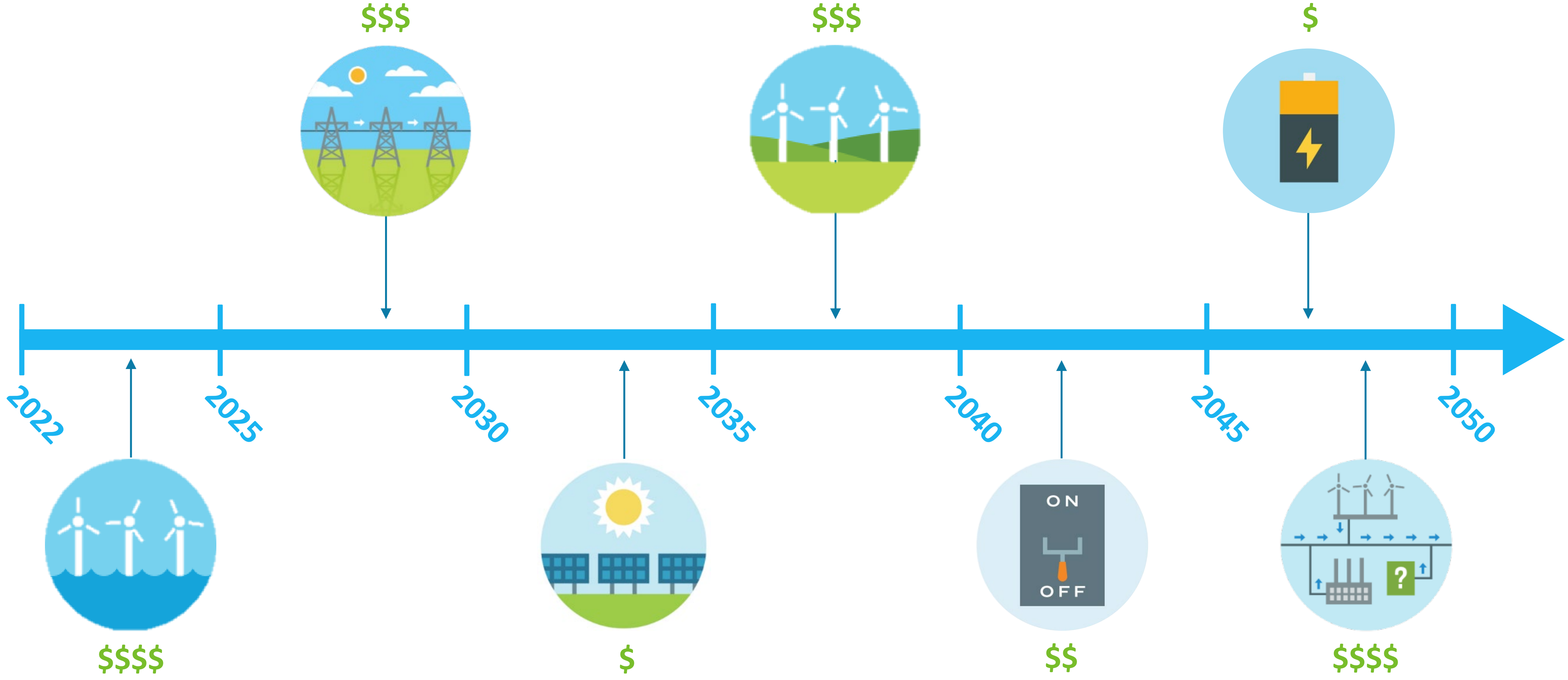
Policy Scenario

- This scenario seeks to show stakeholders and policy makers what a system could look like when all carbon reduction policies are met
- A capacity expansion tool (Energy Exemplar's PLEXOS) will inform which units could be built or retired

Similar Studies are Underway at other ISOs/RTOs

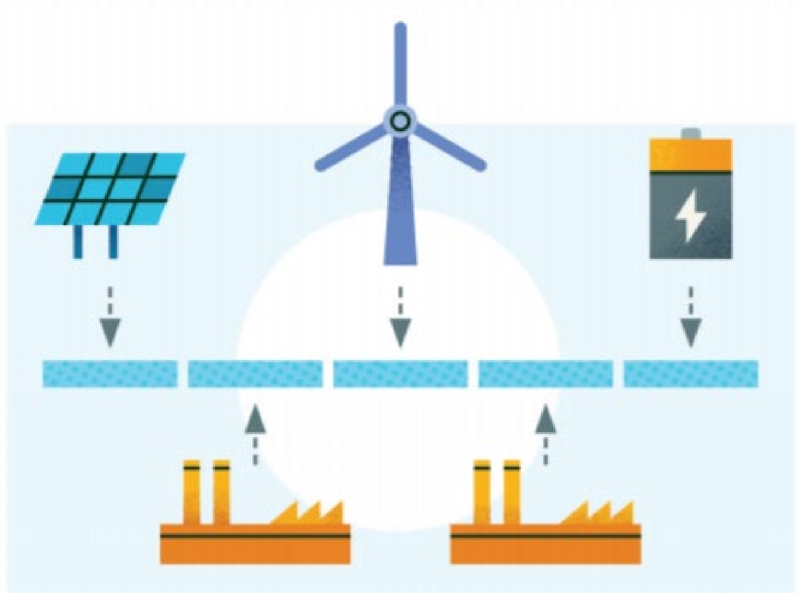
- Economic planning studies now have timelines reaching beyond the typical 10-year horizon, most relying on CapEx models:
  - ISO New England Pathways Study
  - NYISO 2021-2040 Outlook Report
  - IESO Pathways to Decarbonize Study
- This is not a problem ISO New England can solve in isolation; changes in our neighbors' systems must be considered

What is Capacity Expansion?



Overview of Capacity Expansion

- Units can be added and/or retired based on operating (production) and capital costs
- Inputs into model include:
  - Build cost
  - Cost to retire
  - Load forecast and electrification
  - Production Cost Inputs
    - Fuel Cost
    - Variable O&M
    - Generator characteristics
    - Load profiles
    - Generator Profiles



Objective Function of Capacity Expansion

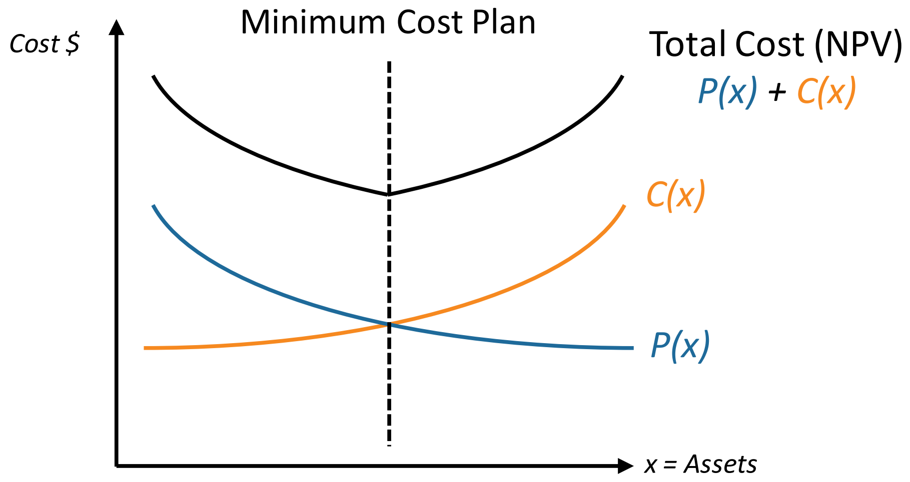
Goal is to minimize Net Present Value (NPV) of:

Production Cost – *P(x)*

- Cost of operating the system with any given set of existing and new builds and transmission network

Capital Cost – *C(x)*

- Cost of new generator builds
- Cost of transmission expansion
- Cost of generator retirements



$$Minimize\ [NPV(P(x), C(x))]$$

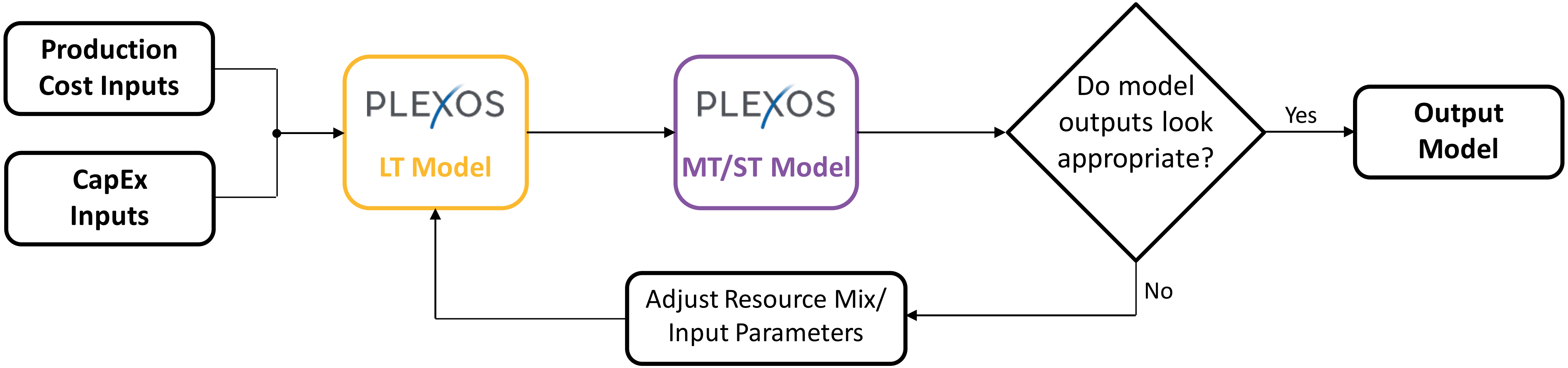
Capacity Expansion in Plexos

LT Model is capacity expansion model

- Runs a simplified production cost run while building units
- Builds new units/transmission or retires units in incremental steps

MT/ST Model is the 8760 production cost run

- Oversimplification of how units perform is revealed in this step
- This informs changes to input parameters for the next LT run



Challenges with Capacity Expansion

- Capacity expansion results will be constrained by two input parameters:
  - State CO_2 emission targets (drives expansion)
  - Economics (influences type and sequence of addition)
- How these two constraints are implemented will have a drastic effect on how units are built
  - It is likely that there will be a wide array of CapEx buildouts for the Policy Scenario
- The FGRS Phase I showed that dispatchablity is necessary in a future system
  - Candidate generators that fill this requirement are currently being explored by the ISO
- This is a new type of modeling to the ISO, there will be many iterations and false starts due to the R&D nature of this study

NEXT STEPS

Timeline

- Preliminary assumptions for Policy Scenario capacity expansion will be presented at the April PAC
- Preliminary results for Policy Scenario will be presented in Q3 2023

Questions

Acronyms

ACDR	Active Demand Capacity Resource	EE	Energy Efficiency
ACP	Alternative Compliance Payments	EFORd	Equivalent Forced Outage Rate demand
AGC	Automatic Generator Control	EIA	U.S. Energy Information Administration
BESS	Battery Energy Storage Systems	EPECS	Electric Power Enterprise Control System
BTM PV	Behind the Meter Photovoltaic	EV	Electric Vehicle
BOEM	Bureau of Ocean Energy Management	FCA	Forward Capacity Auction
CCP	Capacity Commitment Period	FCM	Forward Capacity Market
CELT	Capacity, Energy, Load, and Transmission Report	FGRS	Future Grid Reliability Study
CSO	Capacity Supply Obligation	FOM	Fixed Operation and Maintenance Costs
Cstr.	Constrained	HDR	Hydro Daily, Run of River
DER	Distributed Energy Resource	HDP	Hydro Daily, Pondage
DR	Demand-Response	HQ	Hydro-Québec

Acronyms, cont.

HY	Hydro Weekly Cycle
LBW	Land Based Wind
LFG	Landfill Gas
LFR	Load Following Reserve
LMP	Locational Marginal Price
LSEEE	Load-Serving Entity Energy Expenses
MSW	Municipal Solid Waste
NECEC	New England Clean Energy Connect
NESCOE	New England States Committee on Electricity
NG	Natural Gas
NICR	Net Installed Capacity Requirement
NREL	National Renewable Energy Laboratory

OSW	Offshore Wind
O&M	Operation and Maintenance
PHII	Phase II line between Radisson and Sandy Pond
PV	Photovoltaic
RECs	Renewable Energy Credits
RFP	Request for Proposals
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewables Portfolio Standards
SCC	Seasonal Claimed Capability
Uncstr.	Unconstrained
VER	Variable Energy Resource