AGENDA
JOINT MEETING
NEPOOL MARKETS & RELIABILITY COMMITTEES
Thursday, December 17, 2020

Location: Teleconference
Call-in Number: 1-866-711-7475 / Access Code: 8562734
WebEx: WebEx Link
WebEx Password: nepool

Item	Description	Time Allotted
1*	CHAIRS' OPENING REMARKS ***(A) Approval of Minutes [66.67% MC vote] [66.67% RC vote]*** • Joint MC/RC Meeting Date: November 12, 2020	9:30 - 9:45
2*	FUTURE GRID RELIABILITY STUDY (Project Administrator: Peter Flynn) (8th Joint MC/RC Mtg) Review roadmap of the meeting; begin discussion and review of the input assumptions portion of the framework document, with the goal of achieving consensus where possible.	9:45 - 12:00
	LUNCH	12:00- 12:45
2*	FUTURE GRID RELIABILITY STUDY (Project Administrator: Peter Flynn) (8th Joint MC/RC Mtg) Review how achieved consensus from November 12th meeting has been incorporated into the proposed study framework document, discuss outstanding areas, and discuss next steps.	12:45 – 3:30
3	OTHER BUSINESS	3:30 - 3:35

* Material distributed for this agenda item
AGENDA ITEMS with BOLD & ITALICIZED FONT: MC ACTION and RC ACTION Requested
WMPP: Wholesale Markets Project Plan

Future Grid Reliability Study

Framework Document Discussion
At Joint Markets and Reliability Committee Meeting
December 17, 2020

Peter Flynn, December 17, 2020

Overview

- Agenda for today:
  - Review framework document for substantive input
  - The document reflects consensus from last meeting on: areas of analysis, phased approach, matrix approach and matrix scenarios- provides additional detail
  - Some scenario assumptions have been put in- we'll consider assumptions piece first
  - Then review areas of consensus from last meeting and additional detail
  - After discussing document, consider whether we can make a request to ISO, recognizing some additional work on assumptions needs to be done
  - Discuss next steps

Next Steps

To incorporate your thoughts, additional data, and feedback, into the materials for the January 19th RC/MC discussion, please provide:

- your feedback on materials discussed today and
- assumptions on alternative scenarios

by December 31st to Erin Wasik-Guteirrez (ewasik-gutierrez@iso-ne.com)

NEPOOL Future Grid Study
Draft Proposed Study Framework

December 10, 2020

The New England states have enacted energy and environmental laws that call for a significant reduction in greenhouse gas emissions. Compliance with these laws is expected to result in changes in the generation and use of electricity. Generators that do not emit carbon will likely produce a much greater percentage of the region's power supply. In addition, electricity will likely become more prevalent in heating buildings and powering vehicles, significantly changing load amounts, peaks and profiles.

The New England Power Pool (NEPOOL) is embarking on this Future Grid Study (Study) to understand better the implications of this substantially changed future grid. Specifically, the Study will examine whether revenues from the existing markets will likely be sufficient to attract and retain the new and existing resources that will be needed to continue to operate the system reliably. It will also identify what operational and reliability challenges will need to be addressed in the future grid and identify possible ways to meet those needs.

This document presents the Study framework developed through the stakeholder process at joint meetings[1] of the NEPOOL Markets and Reliability Committees (MC/RC) with support from the New England States Committee on Electricity (NESCOE) and Independent System Operator - New England, Inc. (ISO-NE). Although referred to as a Study, the body of work will actually consist of several analyses using different computer models. No single model can address the range of issues that NEPOOL stakeholders desire to assess. The analyses will be conducted in a staggered iterative approach with the results from one analysis informing decisions about what to model or remodel in other analyses. Close collaboration will be required between ISO-NE and any consultants retained by NEPOOL.

I. Study Objective / Scope

NEPOOL approved the Study objective and scope in a document commonly referred to as the "bubble chart."2 The objective is to assess and discuss the future state of the regional power system in light of current state energy and environmental laws. The scope is to define and assess the future state of the regional power system identifying: 1) a resource mix or mixes for future years; and 2) resource and operational/reliability needs. The assumptions and future scenarios are being developed within a stakeholder process at joint meetings of the MC/RC. A gap analysis will determine whether, in the future state envisioned, the existing markets will likely provide sufficient market revenues to attract and retain the new and existing resources that will be needed to continue to operate the system reliably. The gap analysis will also identify any market deficits that may need to be addressed to assure operability and reliability in accordance with the

[1] Joint meetings of NEPOOL's MC and RC were held beginning April 2020. Six past/ongoing studies were identified for examination: (1) 2016 NEPOOL Economic Study; (2) 2019 NESCOE Economic Study; (3) Massachusetts 2050 Roadmap Effort; (4) Eversource "Grid of the Future" Study; (5) E3/EFI "Electric Reliability under Deep Decarbonization" Study; and (6) 2019 Brattle Group "Achieving 80% GHG Reduction in New England by 2050" Study. For more information, see: http://nepool.com/Future_Grid.php.

[2] See November 12, 2020 meeting materials, https://www.iso-ne.com/static-assets/documents/2020/11/a2_presentation_future_grid_reliability_study.pdf (slide 4)

standards of the North American Electric Reliability Corporation, Northeast Power Coordinating Council, Inc. and ISO-NE.

The Study will therefore encompass both economic and engineering analyses. The economic analyses (production cost and ancillary services simulations, and the revenue sufficiency analysis) will seek to answer questions such as what are the forecasted market revenues, and will they likely be sufficient to attract and retain the different types of resources that will be needed to reliably operate the system in that future. The engineering analyses (ancillary services simulation, resource adequacy screen, and the probabilistic availability and system security analyses) will seek to answer questions about what conditions will likely present operational or reliability issues, the nature of those issues, and whether the system will be able to operate reliably when, for example, variable energy resources (VERs) are the predominant generation resources, when production from VERs exceeds load, and when there may be a sustained reduction in VER production. The studies will be performed in two phases, with immediate efforts focused on phase 1 analyses as described below.

II. Areas of Analysis

A. Production Cost Simulation: ABB GridView (ISO-NE capable) or similar software (Consultant) – Phase 1

Objectives: Show economic dispatches and energy market revenues for different scenarios. Provide useful information related to the operational/reliability analyses, and identify conditions upon which further operational/reliability analyses may focus.

Scope: New England only; external interfaces are assumed profiles. Assume unconstrained internal transmission but interfaces at the Regional System Plan zonal level (RSP bubbles) will be monitored[A1] Some sensitivities that recognize constraints may be run. For the study year identified in each scenario

Methods: Customary approach to economic studies – scenario analyses - with some flexibility to: (i) reflect the variable operation and maintenance costs of resources, including electric storage cycling, in the simulated dispatch; and (ii) iterate model simulations with updated values informed by the results of other areas of analysis

Metrics: Using scenario analysis, perform energy market simulation studies that provide information on system performance, including production costs by resource type and fuel type, location marginal prices, load-serving entity energy expenses, uplift and environmental emission levels (CO_2, NO_X and SO_X) for all matrix and alternative scenarios

Learning points: High-level observations about conditions that may stress the grid and the timing of when those conditions might occur; observations about whether the results suggest scenarios for further study; the results will feed into the probabilistic resource availability analysis.

B. Ancillary Services Simulation: EPECS (‘ISO-NE and Consultant’ capable) or similar software (Consultant) – Phase 1

Objectives: Show if resources will provide the necessary amounts of ramping, load following, regulation, and reserves. Provide insight to expected revenues from the existing ancillary services markets under the scenarios studied.

Scope: New England only; assume unconstrained internal transmission but interfaces at the RSP bubbles will be monitored. Some sensitivities that recognize constraints may be run. For the: (i) study year; and (ii) selected time periods within the study year identified in each scenario

Methods: Using the same or complementary assumptions as the energy market simulations described above, use a methodology similar to what is used for those studies. Examine relationships between system imbalance estimates and: a) reserve products, and b) other ancillary services market products. Estimate quantities of ancillary services requirement gaps” indicated in the scenario analysis. There will be some flexibility to iterate model simulations with updated values informed by the results of other areas of analysis.

Metrics: For all matrix and alternative scenarios, analyze the load following, regulation, ramping, and reserves capability needed to maintain the supply/demand balance of the New England bulk electric power system with a significant VER penetration. (The EPECS model provides an integrated platform for assessing simulated operating reserves, interface flows, tie-line performance, and regulation performance. The one-minute time increment used in the EPECS model augments the GridView model, which uses one-hour time-step increments to analyze: day-ahead resource scheduling as a security-constrained unit commitment; real-time resource scheduling as a real-time unit commitment; real-time balancing as a security-constrained economic dispatch; and real-time physical power flow with integrated regulation service.) Environmental emission rates (CO_2, NO_X and SO_X) will be provided for resources providing ancillary services.

Learning points: High-level observations about conditions that may stress the grid, the timing of when those conditions might occur and any ancillary service gaps; observations about whether the results suggest scenarios for further study; the results will feed into the probabilistic resource availability analysis.

C. Resource Adequacy Screen and Probabilistic Availability Analysis: GE MARS (ISO-NE capable or Consultant) or similar software (Consultant) – Phase 1

The same modeling tool will be used to perform two different types of analyses as described below. There are some common elements:

Scope: New England only; assume unconstrained internal transmission but interfaces at the RSP bubbles will be monitored. Some sensitivities that recognize constraints may be run. For the study year identified in each scenario

Methods: Use a probabilistic approach (Monte Carlo simulations) that examines all 8760 hours of the study year.

Metrics: Loss of load expectation (LOLE) of one day in ten years

The objectives and methods of the two analyses differ in the following respects.

1. Resource Adequacy Screen

Objectives: Determine Installed Capacity Requirement (ICR) for each future scenario in preparation for the energy market simulation to ensure that LOLE is met for expected system peaks. Include the creation of marginal reliability index demand curves.

Methods: Customary approach to ICR performed at a high-level to screen for resource adequacy in preparation for energy market simulations; scenarios found to be resource inadequate will be identified and will add sufficient proxy resources3 for the case to solve. Some sensitivities could be performed for different proxy resources.

Metrics: Evaluate all matrix and alternative scenarios to determine system reliability during the peak hours of the study year. Produce marginal reliability curves for select scenarios chosen by the MC/RC.

Placeholder: Some issues that require further thought are: i) what should be the proxy resource(s) types and should they differ among the scenarios; and ii) what level of availability should be assumed for VERs.

2. Probabilistic Resource Availability Analysis

Objective: Analyze the periods of time and system conditions outside of system peaks that may not meet LOLE due to factors such as insufficient capacity, flexible demand, weather risk, etc.

Methods: For select matrix and alternative scenarios chosen by the MC/RC, examine correlation of loss of load risk and multi-day VER estimates. Examine the frequency with which elevated risk events are projected to occur over time (e.g., number of times and for how long). Examine the occurrence of loss-of-load probability and identify risk trends (e.g., daily or seasonal instances of increased resource availability risk). Revise scenario assumptions to model other elevated risk events as chosen by the MC/RC. Include flexibility to iterate with updated values informed by the results of other areas of analysis.

Learning points: Observations about conditions in which there may not be sufficient resources to meet the LOLE criterion, the timing of when those conditions might occur, and whether there may be a need for certain categories of resources in some amounts in order to meet that criterion; observations about whether the results suggest scenarios for further study or some iterations with the energy and ancillary services analyses; the results will inform the system security analysis.

[3] Proxy resources may be a single resource type or composed of various resource types. If various resource types are chosen, then priority order must be assigned to be added to the system first to meet LOLE.

D. Revenue Sufficiency Analysis: Consultant-based software tool (Consultant)–Phase 2

Objective(s): Compare revenues from the existing markets to resource costs by technology type.

Scope: Resources located in New England only; assume an unconstrained internal transmission system but interfaces at the RSP bubbles will be monitored. Some sensitivities that recognize constraints may be run. For the study year identified in each scenario

Methods: For some matrix and alternative scenarios selected by the MC/RC, conduct a Forward Capacity Market simulation for a few bookend" prices. Add the resultant revenues to the revenues from the energy and ancillary services market analyses results. Compare the revenues from these existing markets to resource going forward cost estimates. Present results in appropriate metrics for a technology type (e.g., $/kilowatt-month, $/year)

Learning points: High-level observations of whether revenues will be sufficient to attract and retain different types of resources.

Placeholder: Further thought is required on how to develop resource going forward cost estimates.

E. System Security – Phase 2

1. Transmission Thermal and Voltage Analysis: PSS/E or similar software (Consultant)

Objectives: Screen the transmission system for thermal overloads and voltage limits to identify key areas that may need transmission reinforcement. Unlock constraints so as to have secure cases on which to conduct the stability analysis.

Scope: High level review identifying the need for additional transmission and possibly other devices to develop secure cases for stability analysis

Methods: The MC/RC selects a few representative scenarios to do a high-level screen for the purpose of identifying and then relieving transmission constraints before performing the stability analysis. The level of detail is less than what is typically modeled in a transmission planning study. Assumptions will be made by the consultant to relieve constraints without optimizing potential solutions.

Metrics: Identification of significant thermal overloads or voltage constraints for which relief should be assumed before conducting a stability analysis for the selected scenarios.

2. Stability Analysis: PSS/E or similar software (Consultant)

Objectives: Do a high-level screen to show whether the decline in rotating machines combined with the growth of inverter-based resources will result in stability issues (The reduction in spinning inertia and generation with governors will reduce the system's ability to respond to large losses of generation and slow frequency decline before system governors can respond to replace the lost generation and restore frequency to normal levels). [A2]

Scope: New England only; an unconstrained transmission system based on the results of the thermal and voltage analysis.

Methods: Use the few representative scenarios that have undergone the transmission thermal and voltage screen. Test what frequency response would look like with no changes to current practices. Limit inertial pick up from outside New England. Start with light load conditions and consider also testing at peak loads.

Metrics: Determine if there is a gap that needs to be addressed by different operational or planning procedures or possible new market mechanisms to procure the required frequency response.

Learning points: The gap analysis will inform the separate discussion that will be held about potential market approaches to solutions such as resource retention, fast-frequency responsive load, primary frequency response from inverter-based resources, minimum inertial generation dispatch requirements (including operation as synchronous condensers), using ultra quick start inverter-based batteries to provide an increase in MW during a frequency decline, etc.

III. Scenarios

Use a matrix approach with alternatives to represent a range of possible futures based on Study proposals that stakeholders submitted to the MC/RC. [4]

Matrix of Scenarios for Energy and Ancillary Services Market Simulations

	OSW 8,000 MW DER 18,000 MW	**OSW 8,000 MW DER 25,000 MW**	**OSW 16,000 MW DER 30,000 MW**
Buildings 9,500 GWh Transport 7,000 GWh	Nat Grid 2035 + Alternatives	1 Case	Is this case realistic? Should it be omitted?
Buildings 6,500 GWh Transport 18,500 GWh	1 Case	Eversource 2040 + Alternatives	1 Case
Buildings 40,000 GWh Transport 37,500 GWh	Is this case realistic? Should it be omitted?	1 Case	NESCOE 2040 + Alternatives

OSW = Offshore wind
DER = Distributed energy resources (photovoltaics (PV) and electric storage)

The diagonal scenarios will be run first and, based on the results, an assessment will be made by the party doing the modeling (ISO-NE or consultant) whether any of the other matrix scenarios appear to be unrealistic, infeasible or not likely to tell something new. Based on that assessment, the MC/RC could decide to drop certain scenarios.

Stakeholders proposed some alternative scenarios. An assessment will be made by the MC/RC after the matrix scenarios as to whether to run each of the alternative scenarios based on factors such as whether an alternative scenario: 1) is likely to answer questions not already answered by the matrix scenarios or another study; 2) is feasible (meaning that the data/assumptions are available); and 3) can be completed in reasonable time.

<u>Alternative Scenarios</u>

1. Storage – Increase Storage (see Multi-Sector A)
2. Bi-Directional Transmission (see Nat Grid 2035)
3. Flexible Load / Vehicle to Grid (see Multi-Sector A)
4. Nuclear Retirement (see NextEra/Dominion)
5. On-shore and off-shore grids (see Anbaric)
6. 100% decarbonization (see Anbaric)

[4] Assumptions will vary between scenarios as described in section IV of this document. Additional sensitivities may also be performed varying the base assumptions provided by National Grid, Eversource and NESCOE.

Energy and Ancillary Service Market Simulations:
9 Matrix Scenarios + 18 Alternative Scenarios = 27 Potential Scenarios

A. Near Future Scenario (National Grid 2035)

This scenario assumes compliance with state requirements for 2035. The resource mix is comprised of approximately equal amounts (8000 megawatts (MW) each) of offshore wind, utility-scale PV, and behind-the-meter (BTM) PV, and 2000 MW of electric storage. It assumes approximately 16,000 gigawatt-hours (GWh) of building and transportation load weighted towards buildings.

B. Distributed Pathway Scenario (Eversource 2040)

This scenario assumes a pathway towards reducing emissions from the electric sector consistent with an 80% economy-wide emission reduction by 2050. The resource mix consists of approximately 12,000 MW of BTM PV, 9000 MW of utility-scale PV, 8000 MW of offshore wind and 4000 MW of electric storage. It assumes approximately 25,000 GWh of building and transportation load weighted towards transportation.

C. Offshore Pathway Scenario (NESCOE 2040)

This scenario assumes an economy-wide carbon reduction that would put New England on a pathway to compliance with state law requirements by 2050. The resource mix consists of approximately 16,500 MW of offshore wind, 15,000 MW of utility-scale PV, 12,500 MW of rooftop PV and [pending] of electric storage and [pending] energy efficiency. It assumes approximately 76,000 GWh of building and transportation load, weighted about equally, and load shapes consistent with such a high level of electrification.

D. Alternative Scenario #1:

The objective is to analyze the impact of higher levels of battery storage. It assumes 10,000 MW and 30 GWh of battery storage.

E. Alternative Case #2:

The objective is to analyze the impact of bi-directional controllable transmission to Quebec. It assumes the addition of a 1,200 MW bi-directionally capable controllable direct current line.

F. Alternative Case #3:

The objective is to analyze the impact of flexible load. It assumes 20% of demand is flexible to absorb surplus power or reduce demand.

G. Alternative Case #4:

The objective is to analyze the impact of the loss of the Seabrook and Millstone nuclear power plants. It assumes the retirement of both plants.

H. Alternative Case #5:

The objective is to analyze the impact of a power system that is carbon free in 2035 in line with the Biden July 2020 energy plan. It assumes the retirement of the current fossil fuel generation fleet.

I. Alternative Case #6

The objective is to analyze the different impacts of an on-shore and off-shore grid. It is a variant of Alternative Case #5 where higher proportions of off-shore wind are interconnected closer to load as suggested in the 2020 Brattle/GE/CHA study (e.g. more even split of OSW between SEMA, Boston and CT).

IV. Scenario Assumptions

	Nat Grid 2035	Eversource 2040	NESCOE 2040
Model	ABB GridView		
Cases / Scenarios / Sensitivities	27 Scenarios – See Matrix and Descriptions Above		
Resolution	Pipe-and-Bubble – RSP Zones of New England		
Year(s)	2035	2040	2040
Assumptions			

NEPOOL Future Grid Study
Draft Proposed Study Framework

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		Nat Grid 2035	Eversource 2040	NESCOE 2040
Load	Gross Load	Peak Load: 33,112 MW Gross Load 177.8 TWh Net Load (Gross – EE – BTM + transport + heat): 150 TWh Load from 2020 CELT extended to 2035; Gross and net load subject to change according to profile used which is scaled using peak load value 2020 CELT extended to 2035 May 20, 2020 PAC, slide 13 June 17, 2020 PAC, slides 19 & 20	Gross Summer Peak Load: 33,582 MW Net Summer Peak Load: 27,993 MW Net Winter Peak Load: 26,427 MW Gross Demand: 178.2 TWh Net Demand: 139.1 TWh All values driven by 80% economy wide C02 reduction by 2050. 2040 target determined by either specific state interim targets or linear reduction from 2020 to 2050 Gross values based on extended CELT forecast. Net values adjusted for EE, BTM resources, heating, and transportation load necessary to meet decarbonization target	Net Summer Peak Load: 39,985 MW *(July at 6pm)* Net Winter Peak Load: 42,525 MW *(January at 6pm)* Annual Net Load: 169.8 TWh *(including Energy Efficiency, **Rooftop Solar PV****, and new Heating and Transportation loads)* Hourly, zonal load forecast for 2040 from EnergyPATHWAYS model output from MA EEA 80x50 – adjusted to move rooftop solar PV to load side. EnergyPATHWAYS is a scenario analysis tool that is used to develop economy-wide energy demand scenarios. It is used to determine the demand for fuels (electricity, pipeline gas, diesel, etc.) over time, subject to economy-wide emissions constraints. also produces an hourly (8760) electricity load shape for each of the six New England states.

		Nat Grid 2035	Eversource 2040	NESCOE 2040
	Energy Efficiency	Peak Reduction: 6,777 MW Annual Energy Reduction: 36,030 GWh 2020 CELT extended to 2035: The same amounts of Energy Efficiency added in 2029 (174 MW of peak load reduction and 791 GWh of energy reduction) are assumed to be added annually through 2035. May 20, 2020 PAC, slide 13 June 17, 2020 PAC, slides 19 & 21	Summer Peak Reduction: 7,366 MW Winter Peak Reduction: 6,886 MW Annual Energy Reduction: 47.1 TWh EE growth based on 2028-2029 growth rate in 2020 CELT forecast EE profile based on ISO-NE's on-peak and off-peak hours, adjusted to smooth transition from on-peak to off-peak	n/a Energy Efficiency is already reflected in the net load forecast discussed above (estimated amounts are unavailable)
	Behind-the-Meter Distributed Energy Resources	Nameplate 7,681 MW Peak Load Reduction: 1,774 MW (23.1%) Energy Production: 8,579GWh 2020 CELT extended to 2035, includes PV <5MW May 20, 2020 PAC, slide 13 June 17, 2020 PAC, slide 19 July 22, 2020 PAC, slide 22	Distributed Solar PV: 11,899 MW Nameplate 17.3 TWh Annual Generation Both Distributed PV and Utility PV modeled as supply in capacity expansion model. However, Distributed PV is included in Net Demand calculation. Distributed PV growth rate based on extrapolating 2020 CELT forecast	Rooftop Solar PV: 12,671 MW Nameplate *Total* (~16.1 TWh Annual Gen) (8,870 MW Nameplate *Incremental Rooftop Solar PV*) Both Rooftop PV and Ground Mounted PV modeled as supply in capacity expansion model. However, Rooftop PV is included in Net Demand calculation.

		Nat Grid 2035	**Eversource 2040**	**NESCOE 2040**
	Storage (Profile shape and target MW)	Incremental Storage: 2000 MW • Aggregated by RSP Zone based on grid-scale storage in the ISO-NE queue • 4-hour duration • 86% efficiency for battery storage • Responds to LMP • Provides System Capacity • Provides regulation and reserves June 17, 2020 PAC, Slide 24 July 22, 2020 PAC Slides 32-37	New Storage Capacity: 3,940 MW Range of 1-hr to 8-hr discharge capability at 90% efficiency No distinction between BTM and utility-scale, aggregated by zone	n/a (on the load side) *Batteries (600MW) & Flexible Load (Pending) on the supply-side* *(Preference for Pumped and Battery Storage to be dispatched economically on the supply side)* *(Open to adopting same dispatch parameters and participation modes for battery storage)*

		Nat Grid 2035	**Eversource 2040**	**NESCOE 2040**
	Heating (Profile shape and target MW)	Peak: 5,214 MW Demand: 9.6 TWh Projections by load zone Profile based on 2015 weather year but can be adjusted *2035 building heat electrification assumptions represent a top-down projection of primarily air-source heat pump (ASHP) adoption resulting in electrification of ~18% of non-electric building heat (compared to <1% today) and including a 14% decline in building heat demand due to efficiency gains.* May 20, 2020 PAC, slide 13 July 22, 2020 PAC, slides 29-31	Heating Peak MW 2,991 MW Heating Demand: 6.6 TWh Heat pump forecasts based on heating sector emission targets combined with census population data kW peak and annual kWh per heat pump based on ISO “Final Draft 2020 Heating Electrification Forecast”	38.9 TWh (embedded in load forecast from EnergyPATHWAYS) (Primary fuel type emissions reduced by approximately two-thirds relative to 2020)

		Nat Grid 2035	Eversource 2040	NESCOE 2040
	Transportation (Profile shape and target MW)	Peak: 1,817MW Demand: 7.3TWh Hourly shapes, broken down by subarea proportional to population; Generally charging is lowest in the morning and peaks at hour ending 18:00 *2035 EV assumptions represent a top-down projection of electric vehicle adoption. It focuses on light-duty vehicles and is absent of significant incremental policy support, including policies designed to impact EV charge timing. The EV load represents 2.2 million light-duty vehicles electrified by 2035 in ISONE (~19% of vehicle stock, 50% of new sales).* May 20, 2020 PAC, slide 13 June 17, 2020 PAC, slides 22-23	EV contribution to winter 8PM peak: 3,578 MW EV Demand: 18.5 TWh EV stock based on forecast total vehicle miles and transportation sector emission targets EV demand profiles based on ISO-NE "Final Draft 2020 Transportation Electrification Forecast", adjusted to account for more coordinated charging	Transportation 37.5 TWh (embedded in load forecast from EnergyPATHWAYS) (Primary fuel type emissions reduced by approximately two-thirds relative to 2020)

		Nat Grid 2035	Eversource 2040	NESCOE 2040
Infrastructure	Transmission Topology / Interface Transfer Limits	Assume unconstrained internal transmission but interfaces at the Regional System Plan zonal level will be monitored atfor 2029 limits June 17, 2020 PAC, slides 5-6	Internal New England interface limits were relaxed to allow for relatively unconstrained flows. Interface increases and new storage additions both used for balancing inter-zonal supply and demand	Zonal transfer limits from RIO[5] model results were mapped to the system topology used in this study: • RIO had six New England state zones, plus New York, Hydro Quebec, and New Brunswick • RIO included economic transmission expansion from 2020-2050 based on $/MW-mile cost assumptions drawn from ReEDS[6] documentation
Resource Portfolio	Existing resources	*Open to adopting consistent approach* FCA 14 resources with a CSO, Modeled at their SCC value (or CSO if no SCC) June 17, 2020 PAC, slides 10 July 22, 2020 PAC, slides 18-19	2020 CELT generator list *Open to adopting consistent approach*	Same as Others Resource Mix from RIO[7] model output from MA EEA 80x50

5 RIO is a capacity expansion model that uses hourly reserve margin constraints by zone and optimizes the portfolio for operations and investment decisions, subject to Renewable Portfolio Standard and power sector carbon emissions constraints, among others.

6 The Regional Energy Deployment System (ReEDS) is a National Renewable Energy Laboratory's capacity planning model for the power sector. For more information, see https://www.nrel.gov/analysis/reeds/.

7 The RIO resource mix results from the MA EEA 80x50 study were optimized every five years from 2020-2050, with the 2040 resource mix represented here.

		Nat Grid 2035	**Eversource 2040**	**NESCOE 2040**
	Existing external ties *Import* Limits	Historical flows on external ties with existing limits monitored; Interested in exploring adjusting exchange with NY to reflect a future where NY is decarbonized as well *(National Grid has a forecasted flow with this in mind that could be used)* June 17, 2020 PAC, slides 7-8 for Import Limits	Historical flows on external ties with existing limits monitored	Historical flows on external ties with existing limits monitored
	Existing external ties *Export* Limits	Historical flows on external ties with existing limits monitored; Interested in exploring adjusting exchange with NY to reflect a future where NY is decarbonized as well *(National Grid has a forecasted flow with this in mind that could be used)* July 22, 2020 PAC, slides 7	Historical flows on external ties with existing limits monitored	Historical flows on external ties with existing limits monitored

		Nat Grid 2035	Eversource 2040	NESCOE 2040
	New Ties	NECEC (1,200 MW nameplate) May 20, 2020 PAC, slide 14	NECEC (1,200 MW nameplate) and one additional 1,000 MW tie injecting into Northern New England	NECEC (1,200 MW nameplate) and one additional 1,000 MW tie injecting into Northern New England 450 MW increase in transfer limit between NY and ISO-NE (subject to continued review of zonal transfer limits from RIO model results)
	Retirements	FCA 14 cleared retirements plus, all New England coal units, and 75% of the conventional New England oil, including dual-fuel units, based on age June 17, 2020 PAC, slides 11	Retirements: Millstone 2 (870 MW) 8,400 MW fossil fuel units (including all remaining coal & oil) Millstone retirement based on NRC license expiration in 2035 Fossil fuel unit retirements based on age, heat rate, market revenues, and emissions targets.	FCA 14 cleared retirements plus, all remaining Coal, Oil and Refuse (subject to continued review of resource mix from RIO model results)

		Nat Grid 2035	**Eversource 2040**	**NESCOE 2040**
	Additions	Incremental Additions: 1,330 MW Land-Based Wind 8,009 MW Offshore Wind (assumes existing 29MW for Block Island) 7,122 MW Solar PV, >5MW (assumes existing 1666MW) Renewable additions include announced additions, as well as generic additions to bridge the gap between what is announced and what may be required to meet announced policy needs (i.e. RPS/CES requirements). Generic utility-scale PV, onshore wind, and offshore wind installed quantities/locations selected based on implied needs in policies goals to achieve a balanced portfolio across renewables types and zones that could plausibly be constructed. Offshore Wind interconnected proportional to ISO-NE's queue at NESCOE 2019 Economic Study locations June 17, 2020 PAC, slides 18 July 22, 2020 PAC, slides 20, 21 & 23 for details of wind & solar estimates	Incremental Additions: 7,290 MW Utility Scale PV 9,469 MW Distributed PV 1,500 MW Onshore Wind 7,904 MW Offshore Wind Total Capacity: 8,820 MW Utility Scale PV 11,899 MW Distributed PV 2,803 MW Onshore Wind 7,934 MW Offshore Wind	Total Capacity: 15,467 MW GroundMount PV 8,032 MW Offshore (Fixed) 8,601 MW Offshore (Floating) 600 MW Battery Storage (subject to continued review of resource mix from RIO model results)

		Nat Grid 2035	Eversource 2040	NESCOE 2040
	Storage Approach	July 22, 2020 PAC, slides 33-37 for details of battery storage estimates; except that variable O&M costs will be reflected in dispatch of electric storage *(Slide 35 in the cited presentation assumes them to be zero.); See also Storage under Load above*	Storage capacity added as needed as a balancing resource Storage operation is not on a fixed schedule, charge/discharge is an output of hourly model driven by wholesale energy prices.	Batteries (600MW) & Flexible Load (Pending) *Similar to other scenarios, preference for Pumped Storage and Batteries to be economically dispatched, not profiled* *Flexible Load: Supply side resource that shifts vehicle charging demands by 8 hours*
	Resource Availability	Same as used in FCA 14 Need for MARS runs only (EFORd and Maintenance Hours)	Based on historical availability	Same as Others
	Profiled Resource Production	*Open to adopting consistent approach* DNV-GL weather profiles for onshore wind, offshore wind, and PV June 17, 2020 PAC	Solar PV and Onshore wind based on historical ISO-NE production since 2012 Offshore Wind based on NREL SAM model *Open to adopting consistent approach*	Same as Others – (Presumably most resent DNV GL profiles)

		Nat Grid 2035	Eversource 2040	NESCOE 2040
	Weather Year	*Open to adopting consistent approach* 2015	*Open to adopting consistent approach*	RIO - 2012 Weather Year (open to comparability) *(Preference for latest available resource production)*
	Active Demand Response	Same as used in FCA 14, 592MW Modeled as dispatchable in GridView: • First 100 MW dispatched at $50/MWh • Remainder at $500/MWh June 17, 2020 PAC, slides 15	Extrapolated from 2020 CELT	Same as Others *(See also Flexible Load under Storage)*
	Curtailment Prices / Threshold Prices	*Open to adopting consistent approach*	*Open to adopting consistent approach*	*Open to adopting consistent approach*
	Reserve Margin / Capacity Assessment	*Open to adopting consistent approach* 120% of the first contingency in ten minutes split between Ten-Minute Spinning Reserve (TMSR) = 50% Ten-Minute Non-Spinning Reserve (TMNSR) = 50% June 17, 2020 PAC, slides 14	[Pending]	RIO results based on hourly zonal reserve margin constraints Open to adopting consistent approach, including reserve requirement assumptions

		Nat Grid 2035	Eversource 2040	NESCOE 2040
	Effective Load Carrying Capability	*Open to adopting consistent approach* FCA 14 QC or SCC values for renewables	FCA 14 QC used for wind and solar. Open to testing impact of ELCC methodologies	Same as Others
Marginal Cost Inputs	Fuel Price Forecasts	*Open to adopting consistent approach cognizant of different study year* EIA's 2020 AEO Base Forecast	EIA's 2020 AEO Base Forecast	Same as Others
	Seasonal Volatility Adjustments	*Open to adopting consistent approach*	Same as Others	
	Emission Allowance Price Forecasts	*Open to adopting consistent approach cognizant of different study year* NO_X = $ 4.00 /ton SO_X = $ 2.00 /ton CO_2 = $33.52 /ton June 17, 2020 PAC, slides 13	Same as Others	

Issue for further consideration: what to assume for load growth on traditional loads and how to model that growth in the different scenarios?
Note: Anbaric proposes adding to the table each sponsor's assumption as to grid decarbonization and economy-wide decarbonization for the study year.

V. Deliverables and Output Results

A. Resource Needs: For the resource mix proposed in each scenario studied, provide information related to resource viability in the current New England markets.

B. System Operational and Reliability Needs: For select scenarios, determine if the resource mix proposed: a) meets the reliability criterion, and b) creates system security concerns at a high level.

C. Carbon Emissions: Provide information on whether each scenario meets New England state law requirements and the resulting degree of grid decarbonization.

VI. Timing - Preliminary Schedule

– Phase 1

Study assumptions are finalized by March 1, 2021

Preliminary production cost simulation: March 2021 – September 2021

Final production cost simulation: September 2021 – March 2022

Ancillary services simulation: September 2021 – January 2022

MARS analyses: October 2021 – January 2022

Report writing: February 2022 – May 2022

– Phase 2

Revenue Sufficiency Analysis: TBD but will not start before September 2021

System Security analyses: TBD but will not start before September 2021

VII. Deliverables

The deliverables will include: 1) periodic status updates to and consultations with the MC/RC; 2) an interim PowerPoint presentation on the preliminary production cost simulation results; and 3) a final PowerPoint presentation and written report on the Study results and key findings and observations.