2016 Economic Studies Phase I Scope of Work Assumptions

Planning Advisory Committee Meeting

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BACKGROUND

NEPOOL 2016 Economic Study Request

- Discussions concerning the 2016 NEPOOL Economic Study request have been ongoing
  - PAC presentation was held on April 20
  - The ISO has met with representatives of NEPOOL
- The proposal assumes base assumptions with variations for scenarios
  - The generation fleet, including some retirement cases
  - Several load, energy efficiency (EE) and PV projections
  - Fuel and emission allowance prices
  - Modeling of only 2025 and 2030
  - A base transmission topology with evaluation of additional transmission needs
  - Net Installed Capacity Requirement (NICR) projections
  - Location of new generation
- Today the ISO is seeking PAC input on the scope of work and assumptions of tasks scheduled for completion in 2016

Scope Summary

- The 2016 Economic Study request will be addressed in two phases
  - Stakeholder input will be sought throughout the study process
- Phase I will consist of traditional economic study analyses
  - Production cost analyses and related metrics will be summarized
- Phase II will supplement the Phase I analysis by discussing several market and operational issues
  - Examine representative Forward Capacity Auction (FCA) clearing prices for several scenarios
  - Analyze intra-hour ramping, regulation, and reserve requirements
  - Assess natural gas system deliverability issues
  - Can be achieved only with the help of consultants

Schedule of Deliverables

- Phase I is scheduled for completion during 2016
  - Scope of work and high level assumptions – focus of today's discussion
  - Assuming scope of work and assumptions can be finalized very soon, complete initial results – 3rd Quarter
  - Conduct additional sensitivity analyses and issue report – 4th Quarter
- Phase II is scheduled for completion during 2017
  - Scope will be determined later this year once Phase I results are better understood
  - Stakeholder discussions are anticipated later this year

Stakeholder Process for Conducting 2016 Economic Study

- The ISO will seek input from the PAC
  - High-level scope of work
  - General study assumptions
  - Overall study results and conclusions
  - Review of draft report
  - Status reports and updates to be provided at every PAC meeting
- Special economic study working group can be formed to provide the ISO input on very detailed technical modeling and simulation methods not of interest to the more general PAC audience
  - This has been done to support past economic studies
  - Past study groups required a very limited number of conference calls
- Alternatively or in addition to the economic study working group
  - PAC presentations will be structured to discuss the general PAC economic study issues upfront
  - More technical discussions with PAC members as a last meeting agenda item

THE SCENARIOS

Five Scenarios

See the NEPOOL memo and the discussion of assumptions in this presentation

1. Generation fleet meeting existing Renewable Portfolio Standards (RPS) and retired units replaced with natural gas combined cycle (NGCC) units
   - Use the base assumptions, including the retirement assumption
   - Assume that targeted energy requirement for the New England states' RPS goals as of April 1, 2016 will be met by physical renewable/clean energy resources
     - Guidance on the RPS will be posted on the ISO website that provides a method of prioritizing resource types and locations
   - Replace all retired units with NGCC
   - Meet any net ICR shortfalls with additional NGCC units
2. Generation fleet meeting existing RPS and all future needs, including retirements, met with new renewable/clean energy resources
   - Same as Scenario 1, except assume all needed capacity will be met by renewable/clean energy resources
   - Assume the mix of renewable/clean energy resources provided by the RPS guidance posted on the ISO's website

Five Scenarios, cont.

See the NEPOOL memo and the discussion of assumptions in this presentation

3. The “RPS-plus scenario” - Generation fleet meeting existing RPS plus additional renewable/clean energy resources and some modified base assumptions that are the same as Scenario 2 except include additional MW by 2025 and 2030 of new renewable/clean energy resources above the existing RPS requirements
   - The mix of resources and demand are very different than the historical experience
   - Specifics of Scenario 3 are discussed later in the assumptions section and will be further developed through additional discussion with the PAC

Five Scenarios, cont.

See the NEPOOL memo and the discussion of assumptions in this presentation

4. Generation fleet meeting existing RPS in part through Alternative Compliance Payments with NGCC additions, and with no retirements (the "no retirement scenario")
   - Use Scenario 1, except assume: (a) RPS requirements are met first physically with renewable/clean energy resources that are interconnected to the system, under construction or have an approved I.3.9 as of April 1, 2016, and then through alternative compliance payments for any RPS requirements not physically met; (b) any new generation resources added to meet NICR will be NGCC units; and (c) no retirements
5. Existing fleet meeting existing RPS in part through Alternative Compliance Payments and retirement replacement with NGCC additions
   - Same as Scenario 4, except use retirement assumption and replace retired units as needed to meet NICR with NGCC generation

Scenario Summary

Scenario	Retire Oldest Oil/Coal	Gross Load	PV	EE	Wind	New NG Units	HQ and NB External Ties
1	½ in 2025 ½ in 2030	Based on 2016 Forecast	Based on 2016 Forecast	Based on 2016 Forecast	As needed to meet RPS	Add NGCC	Based on Historical Profiles
2	½ in 2025 ½ in 2030	Based on 2016 Forecast	Based on 2016 Forecast	Based on 2016 Forecast	Used to satisfy Net ICR	None	Based on Historical Profiles
3	½ in 2025 ½ in 2030	TBD	8000 (2025) 12000 (2030)	TBD	5250 (2025) 6800 (2030)	None	Based on Historical Profiles plus Additional Imports
4	None	Based on 2016 Forecast	Based on 2016 Forecast	Based on 2016 Forecast	Existing plus I.3.9	NGCC	Based on Historical Profiles
5	½ in 2025 ½ in 2030	Based on 2016 Forecast	Based on 2016 Forecast	Based on 2016 Forecast	Existing plus I.3.9	NGCC	Based on Historical Profiles

Retire oldest oil and coal units in 2025 and remaining units in 2030
NGCC – Natural Gas Combined Cycle
RPS – Renewable Portfolio Standard

METRICS TO BE PROVIDED

Resource Metrics – Economic
GridView Results

- Systemwide production costs
  - Includes energy production plus unit commitment costs ($)
- Average Locational Marginal Prices by RSP bubble ($/MWh)
- Load-Serving Entity Energy Expenses (LSEEE) ($)
  - The total electric energy revenues that resources and imports from neighboring systems would receive for supplying electric energy to the wholesale market plus the cost of congestion
- Congestion ($)
  - Difference in LSEEE results from constrained and unconstrained cases
  - Interface flows of major interfaces
    - Annual duration curves
    - Chronological curves
    - Percent of time above 90% of limit

Resource Metrics – Fuels
GridView Results

- Annual generation energy production by resource type
  - The fuel that sets the marginal clearing price summarized annually
  - Total production in GWH and percent
    - The ISO will provide generation by resource type
    - PV, EE, and Active Demand Resources are inputs, but can be summarized
    - Imports
    - Storage (consumption and provision of energy)

Resource Metrics – Contributions to Fixed Costs
GridView Results

- Wholesale energy market revenues by resource type
  - Contribution to the fixed costs of generic new generation
    - The ISO can provide generic capital costs of new generating facilities (similar to RSP15)
    - An assumption of 14% to 16% annual carrying charges can be assumed for new generating units and be presented by the ISO
    - Results will be presented so that users can make their own assumptions on annual carrying charges

Transmission Metrics – Costs

- Transmission improvements known as of the March 2016 RSP Project List will be reflected as interface limits
- The ISO will identify transmission infrastructure that can be added to interconnect requested generation in Maine as part of the 2016 Maine Resource Interconnection Study – Scheduled for 4th Quarter
  - MW quantity of generation that could interconnect
  - Order of magnitude cost of the transmission infrastructure
  - Expected time to construct
  - Does not include behind-the-meter (BTM) wind plant collection system
  - See: http://www.iso-ne.com/static-assets/documents/2016/03/a2_maine_resource_integration_study_scope_of_work.pdf

Transmission Metrics – Costs, cont.

- Any additional conceptual transmission expansion costs can be estimated
  - Measure distance to Millbury (as a proxy for the hub) and add 10% for routing
  - Use judgement to identify needed transmission capacity without conducting detailed technical analyses
  - Estimate cost of needed transmission expansion based on generic costs
  - Stakeholders can provide a range of annual carrying charges
  - Can be added to generation cost metrics to obtain total investment costs

Environmental Metrics

- Total air emissions (from GridView Program)
  - CO2 (Compare with RGGI regional goal)
  - NOx
  - SO2
  - Hg (not expected to be material)

Operability: Reserves, Ramping, and Regulation

- 2016 Economic Study results will show systemwide:
  - Ramp rates over hourly periods
  - Hourly operating reserve requirements
  - Hours where the spinning reserve requirements are not met
- The ISO will monitor generator unit performance and note results that appear inconsistent with expected operating characteristics
  - Example: New NGCC units with a capacity factor under 30% may suggest the need for a sensitivity case where they are replaced with GTs
  - Example: Nuclear units with frequent ramps may suggest the need for more storage on the system

ASSUMPTIONS

Background: Key Simulation Inputs and Assumptions

- Simulations require detailed information that answers
  - What?
  - Where?
  - When?
  - How?
- The ISO will use a pipe and bubble representation for the production cost simulations
- The following base assumptions can be applied to all cases unless otherwise noted
  - PAC input is sought today

Common Simulation Tools and Assumptions Miscellaneous

- ABB GridView Production Simulation Model
  - Generation production simulation using pipe and bubble format
- GE MARS Loss-of-Load Expectation (LOLE) model
  - Reliability simulation model to calculate ICR for a specific scenario when deemed necessary
- Simulation Years – 2025 and 2030
- State Renewable Portfolio Standards
  - Based on states' RPS goals as of April 1, 2016
  - Uses an EXCEL spreadsheet that develops states' RPS assumptions similar to the ISO's previously posted spreadsheets
    - See the RPS spreadsheet and data posted on ISO website

Common Simulation Tools and Assumptions
Fuel Prices

- Based on 2016 EIA Annual Energy Outlook fuel price forecast for New England
  - Similar to the 2015 Economic Study model
    - Natural gas prices are increased 10% over the nominal price in the winter and reduced 10% of the nominal price in the summer
    - Reflect the EIA Appendix prices for New England coal, oil, and natural gas
  - The impact of alternative fuel prices can be determined exogenously unless they affect the dispatch order of resources
  - Use high and low fuel price sensitivities to determine effect on dispatch order
  - After initial runs are done, determine whether any fine tuning of the EIA prices should be done to recognize seasonal price or basis differentials

2025 and 2030 Gross Load, EE, and BTM PV Forecasts

Scenarios 1, 2, 4, and 5

- Similar to all economic studies, all cases will use a 2006 load shape to achieve time synchronized models for gross load, EE, and PV (and wind generation)
  - The ISO has standard models that have been vetted before stakeholders and are readily available
  - The model will reflect separate MW values for gross peak load, EE, and PV with locations that are consistent with the 2016 CELT
- Simulations for the year 2025 will reflect the gross peak load, EE, and PV quantities summarized in the 2016 CELT
- Quantities for 2030 can be determined using previous methodologies and 2016 CELT quantities
  - 2030 values (peak, EE, and PV) can be calculated using the 2016 CELT values for 2025 and growing them to the year 2030 using data from 2024 and 2025
    - Example: For 2030 Peak Load: the 50-50 gross peak of 2025 x [(50-50 gross peak of 2025/50-50 gross peak of 2024) *5]
    - Example: For 2030 EE and PV: total value for the year 2025 + [incremental growth for the year 2025 * 5]

2025 and 2030 Gross Load, EE, and BTM PV Forecasts – Scenario 3

- Use standard ISO models for the duration curves and locations of gross load, EE, and PV consistent with Scenarios 1, 2, 4, and 5
- Synapse to provide the following values

Year	Gross Load	EE	PV	Utility PV
2025	X	R	4,000	4,000
2030	Y	S	6,000	6,000

Active Demand Resources and Storage

Scenarios 1, 2, 4, and 5

- Real-time Emergency Generation (RTEG) will not be simulated
- Simulate FCA10 Active DR
  - Dispatch to peak shave
- Storage will be dispatched to equalize the daily high and low loads
  - Pumped storage will be assumed to have approximately 78% efficiency

Active Demand Resources

Scenario 3

- RTEGs will not be simulated
- Simulate FCA10 Active DR
  - Dispatch to peak shave
- Add a total of 500 MW of Active Demand Resources to the FCA10 resources by 2025
  - Dispatch first 100 MW as 12,000 heat rate NGCTs with 0 emissions
  - Dispatch the remaining amount at $500/MWHr
- Add an additional 500 MW of demand resources by 2030
  - Dispatch 100 MW of new DR as 12,000 heat rate NGCTs with 0 emissions
  - Dispatch the remaining amount at $500/MWHr

Storage and Plug-in Electric Vehicles

Scenario 3

- Storage will be modeled similar to how it was treated in the 2009 Governors' study
  - Dispatched to equalize the daily high and low loads
  - Pumped storage will be assumed to have approximately 78% efficiency
  - Battery storage will be assumed to have approximately 90% efficiency
- Add battery storage totaling 1,200 MW in 2025 and 2,500 MW in 2030
  - The ISO will simulate cases with and without battery storage
- Add a total of 2.5 million PEVs in 2025 and a total of 4.2 million in 2030
  - Locations will be distributed by state in accordance with the request and further distributed by RSP bubble in proportion to load (1% reduced from MA to eliminate rounding issue)
    - 43% in MA
    - 23% in CT
    - 12% in ME
    - 11% in NH
    - 6% in RI
    - 5% in VT
  - The 2009 Governors' Study model will be used to simulate charging of the PEVs
  - No discharge will be assumed

Interchange with Neighboring Systems

Scenarios 1, 2, 4, and 5

- Use energy profiles for Quebec and the Maritimes with a methodology similar to the 2015 Economic Studies
  - Simulate imports as price takers that never set the clearing price
  - Assume import threshold prices for curtailments
    - $10 from New Brunswick
    - $5 from Quebec
- Assume no interchange with New York

Interchange with Neighboring Systems, cont.

Scenario 3

- Model existing ties similar to Scenarios 1, 2, 4, and 5
- Add one new tie to WEMA and one new tie to NEMA with equal capability and energy
  - New interconnections totaling 1,500 MW in 2025 (750 MW in each location)
  - New interconnections totaling 2,000 MW in 2030 (1,000 MW in each location)
  - Use energy distribution similar to the existing ties or monthly distribution provided by stakeholders

Resource Retirements – All Scenarios

- Existing resource retirement in accordance with FCA10 results
- In addition to FCA10 resource retirements:
  - Retire oldest half MW of the conventional oil- and coal-fired steam units by 2025 (including dual fuel units)
  - Retire next oldest half MW of the conventional oil- and coal-fired steam units by 2030 (including dual fuel units)

Renewable Portfolio Standards and Wind Generation

- RPS goals for each state
  - Load energy has been discounted to reflect EE, BTM PV, and Municipal loads not subject to RPS
  - Add renewable projects until RPS is met as follows:
    - Use PV that is not BTM
    - Sequentially add 75% of the interconnection request capability in the active queue, which shows amounts and locations
    - Add additional renewable generation, if needed, proportionally based on current locations of generation in the queue
- The ISO will provide a resource dispatch that estimates energy production for different types of resources
- Wind resource modeling
  - Use NREL profiles and calculate capacity values

Wind Generation Scenario 3

- Add onshore wind totaling 4,250 MW by 2025 and 4,800 MW by 2030
  - Scale up resources simulated in other scenarios
- Add offshore wind totaling to 1,000 MW by 2025 and 2,000 MW by 2030
  - Same as the 2015 Economic Study Evaluation of Offshore Wind Deployment wind addition assumptions
  - Interconnect mainly in SEMA/RI
- Wind resource modeling
  - Use NREL profiles to model energy production
  - Capacity value based on a percent (TBD) of nameplate assumption

Capacity

The ISO will not conduct detailed FCA deliverability tests

- Cases will assume sufficient resources to meet a reserve margin 14% above the gross 50/50 peak load net of BTM PV
  - This is a reasonable base scenario assumption based on NICR summarized in recent RSPs
  - EE is considered a resource
  - Capacity values for wind units will be assumed
  - The ISO may conduct LOLE analysis to confirm the validity of using the 14% base assumption for all scenarios
- Deliverability may be assumed because:
  - Resource expansion will be assumed at resource retirement sites and at the hub
  - GridView results will show the potential need for transmission expansion across major interfaces

Nonrenewable Resource Additions

- Generation that is operating or under construction but has not cleared in an FCA as of April 1, 2016
- Generation with an approved I.3.9 and that is still in the interconnection queue as of April 1, 2016
- Generation Operating Characteristics
  - Known operating characteristics (heat rate, ramp rate, minimum down time, minimum up time, etc.) will be used
  - If operating characteristics are unknown, ISO will use generic (details to be provided later)
- Additions of NGCC not in the interconnection queue will be first added at retirement sites and later added to the hub

NEXT STEPS

Schedule

- June 10 PAC Meeting
  - Discussion of detailed assumptions
- July 13 PAC Meeting
  - Finalize all detailed assumptions
  - Discussion of sensitivity cases
- 3rd Quarter
  - Draft results for stakeholder discussion
- 4th Quarter
  - Final results (based on limited number of additional sensitivity cases)
  - Draft report for stakeholder discussion
  - Final report (target)
  - Discussion of Phase II Scope of Work

Questions