AGENDA
JOINT MEETING
NEPOOL MARKETS & RELIABILITY COMMITTEES
TUESDAY, APRIL 7, 2020

LOCATION: Teleconference
Call-in Number: 1-866-803-2146 / Access Code: 7169224
WebEx: WebEx Link
WebEx Password: nepool

Item	Description	Time Allotted
TUESDAY, APRIL 7		
1*	CHAIRS' OPENING REMARKS	12:30 – 12:35
2*	TRANSITION TO THE FUTURE GRID STUDY (NESCOE: Heather Hunt & Ben D'Antonio) (1st MC/RC Mtg) Presentation of NESCOE's preliminary suggestions to kick off discussion on process-oriented ideas associated with the upcoming "Transition to the Future Grid" study (assess future state of the regional power system in light of the requirements of state energy and environmental laws) and preliminary thoughts on related analysis tasks. In addition, discuss an overview of recent carbon-related studies.	12:35 – 3:00
3	OTHER BUSINESS	3:00 – 3:05

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

NESCOE
New England States Committee on Electricity

Transition to the Future Grid:
Preliminary Discussion of Study-related Process

On March 5, 2020, the NEPOOL Participants Committee expressed strong and uniform interest in advancing in the nearest term discussion about analysis of the future state of the regional power system in light of current New England state energy and environmental laws, referred to as *Transition to the Future Grid*.[1]

NESCOE appreciates NEPOOL's broad expressions of support for New England to move forward to analyze our power system and market structures in contemplation of the foreseeable and binding requirements of law and to do so on a firm calendar that is established in-region.

Since the March 5th meeting, world health challenges have arrived in force in New England. Health and human safety take priority.

ISO-NE is rightly focused on maintaining our power grid and being vigilant in protecting its employees who are indispensable to that end.

Similarly, various personnel of market participants that together keep the lights on in New England are also focused on maintaining essential services and doing so in a way that puts employees' health first.

State governments and officials are likewise focused on supporting core public services, including the reliability of the electric power system and consumer protections.

With gratitude for this priority focus, and in furtherance of NEPOOL members' expression of interest in beginning the *Transition to the Future Grid* discussion in technical committees, NESCOE has prepared some material to enable a continuation of our regional conversation in April. Further, in recognition of ISO-NE's and various market participants' attention on current

[1] Last summer, NESCOE and, separately, various market participants requested that ISO-NE plan to allocate market development and planning resources in 2020 to support states and stakeholders in analyzing and discussing potential future market frameworks that contemplate and are compatible with the implementation of state energy and environmental laws. See http://nescoe.com/wp-content/uploads/2019/07/WorkPlan2020Request_16July2019.pdf.

operational matters, NESCOE offers to present preliminary material to facilitate others' reaction and discussion at subsequent meetings.

NESCOE provides the following materials and offers to present them to the NEPOOL Joint Markets and Reliability Committees in April:

1. Some preliminary process-oriented ideas about the *Future Grid Study* in response to NEPOOL members' broad expressions of interest in an inclusive and transparent study process.
2. A draft conceptual study schedule that highlights steps and milestones.
3. A very high-level summary of carbon reduction-related studies conducted in 2018-2019 by diverse interests.

In addition to giving a high-level overview of recent relevant studies and outputs as they relate to the Future Grid Study (item no. 3, above), NESCOE offers to give a staff sense of ISO-NE study tools and outputs as they relate to the Future Grid Study and would welcome hearing market participants' views of the same in April and at subsequent committee meetings.

To be clear, all the materials are preliminary and offered for the purpose of facilitating reactions, questions and discussion at subsequent meetings. We hope this is helpful in bringing forward constructive feedback that will help move the process ahead. Please note that none of the materials reflect the views of NESCOE or any NESCOE Manager. Indeed, NEPOOL's feedback may help inform those views.

Finally, nothing in this material is intended to imply a view about NEPOOL processes and none should be inferred.

SOME IDEAS TO FACILITATE AN INCLUSIVE AND TRANSPARENT FUTURE GRID STUDY

Preliminary and for discussion only
Does not represent the views of ISO-NE, NEPOOL, NESCOE or any NESCOE Manager

A. Contract Management and Transparency

- Consultant will be retained by ISO-NE to conduct analysis for ISO-NE, States and NEPOOL Participants (together, "New England Study Group")
    - Consultant will sign a non-disclosure agreement (NDA) with ISO-NE in connection with confidential information, data, etc.
    - Throughout the study and modeling process, Consultant will bring input/modeling options directly to the New England Study Group, which will jointly determine direction according to the provisions below.
    - States, ISO-NE, and NEPOOL Participants will not have input opportunities to the consultant outside of the process described below to allow for contract management, cost containment and transparency.

B. Process for Consultant Direction

- The process for New England Study Group to provide direction to the consultant is as follows:
    - New England Study Group will discuss the study and its elements at joint NEPOOL Markets and Reliability Committee meetings ("MC/RC meetings"). New England Study Group will not have input opportunities to the study outside of the MC/RC meetings to allow for contract management, cost containment and transparency (without limiting consultant's practical need to obtain information or data).
    - The consultant will present modeling options with pros and cons and information about implications of such options, along with the consultant's independent recommendation and the basis for it, at MC/RC meetings for New England stakeholder discussion.
    - New England Study Group may suggest alternatives to the consultant's recommendation at MC/RC meetings. Consultant will retain authority to decline to adopt alternatives if such alternative is impossible or in the consultant's independent professional judgment would materially and adversely affect the study objectives. If the Consultant declines to adopt alternatives, consultant will provide an explanation in writing and discuss with the RC/MC upon request.

C. Voting Structure

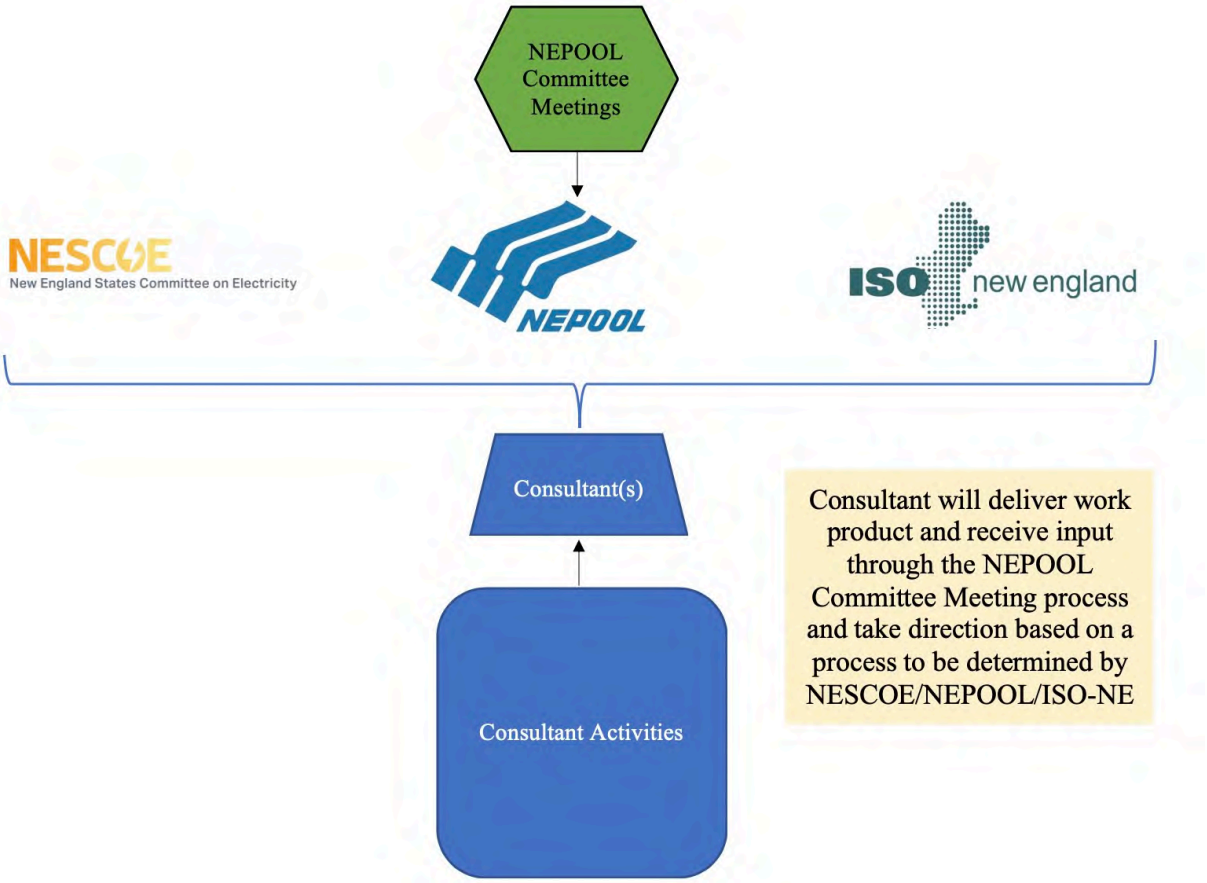
- As in all matters, ISO-NE, NEPOOL and NESCOE will try to reach agreement in the first instance.
- NEPOOL will have one vote on the consultant's recommendation and any alternatives to it, which vote will be pursuant to its governance arrangements.
- NESCOE will have one vote on the consultant's recommendation and any alternatives to it.
- ISO-NE will have one vote on the consultant's recommendation and any alternative to it.
- A majority vote of the NEPOOL/ISO-NE/NESCOE votes will constitute direction to the consultant.
- In light of the study's purpose to examine a future system operating in the context of the requirement of state laws, NEPOOL and NESCOE will each have unilateral authority (i.e., not subject to a New England Study Group vote) to identify one future scenario. This does not preclude a range of futures as defined by New England Study Group.

Voting Structure Example:

- *Example 1*: NEPOOL votes 80% (illustrative) to support the consultant recommendation, NESCOE votes to support the consultant recommendation, and ISO opposes the consultant recommendation. Consultant proceeds according to the 2/3 support.
- *Example 2*: If none support the consultant's recommendation, the consultant proposes an alternative. This may be an alternative offered in New England Stakeholders' MC/RC meetings or consultant's substitute recommendation.

In addition to discussing the issues above, New England Study Group need to discuss other issues before commencing a study, such as, for example, if there are any additional conditions around Consultant's ability to exercise professional judgment around alternatives the Consultant deems problematic (i.e., to retain the benefits of the Consultant's expertise), and other issues that arise in initial conversations.

EXHIBIT A


NEPOOL Committee Meetings
NESCOE
New England States Committee on Electricity
NEPOOL
ISO new england
Consultant(s)
Consultant will deliver work product and receive input through the NEPOOL Committee Meeting process and take direction based on a process to be determined by NESCOE/NEPOOL/ISO-NE
Consultant Activities

(NEPOOL meeting and voting schedule for items that require a vote need to overlayed; this is not intended to offer a view on NEPOOL's business processes and none should be inferred)	**Number of Days per Task**	**Number of Days from the Start**	
Task	**Days**	**Begin**	**End**
Continuing State Consideration of Mechanisms and Options • States consider alternative mechanisms to achieve the requirements of state laws		Ongoing	
Identify Analysis Objectives • Establish a statement of purpose for the study and identify questions the study is intended to inform • Determine relevant metrics and related deliverables	17	1	18
Develop Study Scope and Methods • An approach for conducting the study with enough detail to determine feasibility, milestones, and processes • Describe the analytical tools and / or methods of analysis that will provide useful information related to the study's objective or statement of purpose • A hypothetical schedule and coordination framework • Expectations around inputs, outputs, and process	14	19	33
Establish Analytical Team and Delegate Deliverables • Group of advisors that will provide suggestions, comments, and recommendations around study issues, input assumptions • Group of technical experts and/or consultants with the expertise, capabilities, and availability to perform analyses described in scope • Assign responsibility / delegate analytical tasks with milestones and dates	30	34	64
Assumption and Scenario Development • Development comprehensive sets of assumptions related to future electric sector scenarios (e.g., loads, resource mixes, fuel and allowance prices, etc.). • Design a range of scenarios that provide a distribution of outcomes that provide useful information related to the study objective or statement of purpose	25	65	90
Issue Milestone Report 1: Objective, Scope, Methods, Assumptions • Initial report describing the effort, the plan for analyzing the issue(s), and the agreed up on set of assumptions that will go into the rest of the assumptions	15	91	106

(NEPOOL meeting and voting schedule for items that require a vote need to overlayed; this is not intended to offer a view on NEPOOL's business processes and none should be inferred)	**Number of Days per Task**	**Number of Days from the Start**	
Task	**Days**	**Begin**	**End**
Modeling Scenarios of the Future System • An initial four-month modeling exercise to conduct several simulations of the future power sector (and other sectors of the economy?) • The type of modeling is TBD – but could be production cost and/or capacity expansion. Time frame enables many detailed simulations.	120	107	227
Issue Milestone Report 2: NEPOOL Summer Mtg, Studies Update, Analysis Gaps, Legal Issues • A second report providing an update on regional coordination efforts, an update on the modeling, a description of the gaps (or shortcomings) in the proposed plan for conducting the modeling (or identification of complementary analysis), and an overview of legal issues related to markets and policies.	15	200	215
Issue Preliminary Modeling Results • The modeling results from the initial simulations are provided to stakeholders. • The Analytical Team and/or Consultant interprets the results for stakeholders and answers questions about the initial results. • The Analytical Team and/or Consultant suggests / recommends additional simulations to perform based on the initial results (i.e., sensitivity analysis, exploration of result "surprises") and/or additional analyses to answer stakeholder questions in response to preliminary results.	15	228	243

(NEPOOL meeting and voting schedule for items that require a vote need to overlayed; this is not intended to offer a view on NEPOOL's business processes and none should be inferred)	**Number of Days per Task**	**Number of Days from the Start**	
Task	**Days**	**Begin**	**End**
Model Sensitivity Cases • Another two months to conduct additional simulations.	60	244	304
Perform Related Economic Analysis • Examine impacts on other electricity and/or related markets • Further examine the bases for input assumptions / analyze reasonableness of certain modeling outcomes and results • Examine impacts on environment and / or economy • Analyze resource-level economics implied by certain modeling outcomes • Consider alternative assumptions, analyses, and approaches • Consider cost-effectiveness of various modeling and analytical results	90	244	334
Perform Related Engineering Analysis • Transmission Feasibility and/or System Impacts of New Interconnections • Thermal, Voltage, and Stability of Future System Resource Mixes and Topologies • Probabilistic Resource Adequacy • Examine system information and other operational requirements	90	244	334
Issue Final Modeling Results • The modeling results from the secondary simulations are provided to stakeholders. • The Analytical Team and/or Consultant interprets the results for stakeholders and answers questions about the secondary results.	15	305	320
Issue Milestone Report 3: Preliminary Study Results • A third report providing an overview of the modeling results, a high-level interpretation of the modeling results, discussion of any issues uncovered during the modeling, and description of how the pending related economic and engineering analyses will supplement the modeling results.	15	321	336

Concurrent Efforts

(NEPOOL meeting and voting schedule for items that require a vote need to overlayed; this is not intended to offer a view on NEPOOL's business processes and none should be inferred)	**Number of Days per Task**	**Number of Days from the Start**	
Task	**Days**	**Begin**	**End**
Integrate Modeling, Economic, and Engineering Analyses • The Analytical Team and/or Consultant interprets and synthesizes the results of the modeling, economic, and engineering analyses • The study results are organized and integrated into a cohesive whole • The Analytical Team and/or Consultant develops a list of observations	90	335	425
Issue Milestone Report 4: Final Study Results • A fourth and final report recapping all the work performed and directly addressing the study objective and statement of purpose • A list of conclusions from the study • Detailed results for the entire study	15	426	441
NEPOOL, NESCOE, ISO-NE Determine Next Steps	15	442	457

Clean Energy Accelerator by Brattle

Weiss, J.; Hagerty, J.; Achieving 80% GHG Reduction in New England by 2050: Why the region needs to keep its foot on the clean energy accelerator (September 2019)
Funder: Coalition for Community Solar Access

Purpose: Estimate whether and how much clean energy resource additions in New England need to achieve the 2050 decarbonization goals.

> **Limitation:** Resource cost estimates were used in selecting resource mixes, otherwise the study provides no economic results – just clean capacity MW/year estimates.

Premise: To achieve the 2050 goals, New England must electrify the largest remaining sources of GHG emissions – transportation, residential heating, and commercial heating – and so a sustained focus on adding clean energy resources and decarbonizing the electric sector is essential to meeting these goals.

Scenarios: Efficiency Focused, Electrification Focused, and Electrification and Renewable Fuels with various combinations of clean energy portfolios: Large-Scale Resources, Balanced Portfolio, and Local Solar and Storage.

Notable Observations:
- Offshore wind and solar provide the vast majority of potential clean energy resources and the total technical potential for clean energy resources is 10x higher than projected 2050 demand in a decarbonized economy.
- Existing imported hydroelectric power with new transmission is projected to be the least cost clean energy resource until 2030, when offshore wind and solar become least cost on a levelized $/MWh basis.

Findings: **Annual clean energy resource additions need to increase by a factor of four to eight times the current level (4x to 8x) to achieve 2050 carbon emissions reduction goals**, requiring approximately 5,100 MW of new clean capacity per year. Each clean energy resource faces additional constraints that may limit its role.

Deep Decarbonization with HQ

Williams, J.H., et al.; Deep Decarbonization in the Northeastern United States and Expanded Coordination with Hydro-Québec (April 2018)
Funders: Sustainable Development Solutions Network and Hydro-Quebec

Purpose: Economic scenario analysis of the Northeast (New York and New England) and Hydro Quebec energy supply mix in 2050.

> **Limitation:** The results are sensitive to dated cost assumptions that are rapidly changing. The analysis relies on three-year-old cost estimates for offshore wind, which have decreased approximately by half.

Premise: Economy-wide 80% reduction in GHG emissions by 2050 implies there must be a major increase of electric load, roughly doubling today's load by mid-century, accompanied by a must be a vast increase in low carbon generation.

Scenarios: Low Decarbonization and Deep Decarbonization with various combinations of Wind, Hydro, and Transmission expansion.

Notable Observations:
- In 2050, two-thirds of all generation comes from solar PV and wind power.
- Systems with high penetrations of wind and solar have greater ramping and load-following requirements than those with a more balanced portfolio – such requirements may exceed natural gas carbon constraints.
- HQ reservoir capacity can provide balancing on a seasonal scale. More interconnections would enable south-north flows of excess solar generation. Storing excess solar generation in the HQ reservoir may reduce renewable curtailments and emissions associated with balancing the ISO-NE system.

Findings: **More interconnections between the Northeast and HQ may be a less expensive approach to decarbonization than an alternative with an even greater reliance on offshore wind and solar.** Imported Canadian onshore wind firmed with hydro may be less expensive than some offshore wind resources.

Deep Decarbonization in California by E3

Ming, Z., et al.; Long-Run Resource Adequacy under Deep Decarbonization Pathways for California (June 2019)
Funder: Calpine Corporation

Purpose: Examine resource adequacy under future scenarios in which California's economy is deeply decarbonized and heavily dependent on renewable energy. Builds on several prior studies examining decarbonization pathways.

> **Limitations:** Other low-carbon alternatives to natural gas generation, including nuclear and renewables with ultra-long duration energy storage, were not considered in the study. The resource adequacy model did not include any transmission limitations.

Premise: Some form of firm generation capacity is needed to ensure reliable electric service. Natural gas capacity is likely to play a role in balancing renewable generation and maintaining resource adequacy.

Scenarios: High Biogas (for space heating and industrial processes) and High Electrification with various combinations of renewable resources and storage.

Notable Observations:

- Total installed capacity on the system more than doubles from 2020 to 2050
- It would be extremely costly and impractical to replace all natural gas generation capacity with solar, wind and storage, due to the large quantities of these resources that would be required
- The biggest driver of reliability challenges in a system where most generation is intermittent is the potential for multi-day periods of low renewable production

Finding: **The least-coast electricity portfolio to meet the 2050 economy-wide greenhouse gas goals for California includes 17-35 GW of natural gas generation capacity for reliability (compared to the California's current natural gas fleet totaling approximately 29 GW).**

FCEM Detailed Design by Brattle

Spees, K., et al.; How States, Cities, and Customers Can Harness Competitive Markets to Meet Ambitious Carbon Goals: Through a Forward Market for Clean Energy Attributes (September 2019)
Funder: nrg

Purpose: Propose a detailed market design for a competitive, regional forward clean energy market (FCEM) for clean energy attributes.

> **Limitation:** Third-party administrator of such a market, such as a state agency, a multi-state organization, or even an independent system operator, may require enabling legislation and/or regulatory approval of implementing tariff changes.

Premise: Achieving ambitious renewable and clean energy goals is unlikely to be achieved cost-effectively using traditional policy instruments.

Scenarios: A variety of different resources and technologies procured to achieve clean energy goals under (i) technology-specific subsidies and bundled contract procurements and (ii) a competitive FCEM.

Notable Observations:

- It is possible to establish technology-specific "carve outs" to ensure a minimum share of the procurements could include nascent technologies that may be higher cost.
- A multi-year forward procurement with moderate commitment and forward periods short enough to respond to changes in market conditions leaves the burden of technology and market fundamental risks with developers and investors who are best equipped to assess and mitigate risks and invest accordingly.
- A single state or group of states could collaborate to develop and implement the clean energy market through an appropriate agency, possibly with a governance model similar to that used in the Regional Greenhouse Gas Initiative (RGGI).

Finding: **Broad competition will minimize the costs of achieving carbon goals.**

NESCAUM White Paper

In September 2018, the Northeast States for Coordinated Air Use Management (NESCAUM) issued a white paper: **Greenhouse Gas Mitigation Analysis for New England**. The white paper is designed to provide high-level insights about the magnitude of actions needed to achieve New England's ambitious climate goals. There are several key lessons that can be drawn from excerpts of this analysis:

- ***Immediate action is required***. The scale of change that needs to occur is massive. Given the long time-horizon for stock-turnover, New England policy-makers need to start implementing policies now to **avoid costly early retirements of fossil fuel technologies**. This is particularly pertinent to the electric grid, which operates on a decadal time-scale and is critical to decarbonize early to provide a low-carbon source of energy for the electric technologies needed to reduce carbon emissions in the other major sectors.
- ***Electrify end-use energy consumption***. To reduce GHG emissions, end-use energy consumption should be shifted to electric technologies, such as electric vehicles in transportation and air source heat pumps for residential and commercial buildings, which emit no direct emissions. These electric technologies are also typically more energy efficient than fossil fuel technologies, which reduces overall energy demand in the economy.
- ***Decarbonize the electric grid***. The increase in electrification will shift emissions from the end-use sources to the power plants that produce electricity. **New England will need to deeply decarbonize the electric grid in order to ensure that GHG emissions significantly decline from the electric generation sector as the grid experiences a significant increase in load.** A continuing shift to natural gas, even though less carbon-intensive than coal and oil, is not capable of meeting the region's 2030 and 2050 goals, and diverts investments from longer-term zero-carbon technologies.
- ***Focus on building thermal.*** The New England region is unique in the amount of energy needed to heat homes and businesses and the amount of heating oil consumed to do so.
- *Energy efficiency is effective at reducing GHGs in the short-term, but is not, in and of itself, a long-term solution to deep decarbonization.* Energy efficiency is a cost-effective method for reducing emissions and flattening load growth under current conditions. However, **if future GHG reduction targets are to be met through electrification of other end-use sectors, like transportation and buildings, electric demand will increase significantly, potentially 2 to 3 times above current generation by 2050**. To meet this growth, new zero-carbon generation will need to be added to the grid, while continuing to displace all forms of current fossil generation. As the grid decarbonizes, energy efficiency as a GHG reduction strategy will have diminishing impacts. Other benefits, however, will continue to exist, such as reducing the extent of needed electric capacity additions. Therefore, it should be recognized that at some future point decreasing demand from a low-carbon electricity grid will not be a significant GHG reduction strategy. Instead, it will be driven by other goals, such as cost reductions.
- ***A price on carbon could simplify carbon reductions.*** In addition to implementing individual discrete policies to push multiple markets toward low-carbon technologies in each sector, an **economy-wide price on carbon** could provide a relatively simple and effective method to achieve the required GHG reductions.

Recent ISO-NE Economic Studies Relevant to Future New England Grid

Markets Committee/Reliability Committee
April 7, 2020

DAY PITNEY LLP

Overview

- Several recent ISO-NE Economic Studies provide insight relevant to New England's future grid. The analysis, data and results from these studies could help inform the Transition to Future Grid study.

- Note: while these ISO-NE studies are relevant, the future grid study is not intended to be an Economic Study under the Tariff.

- The most relevant studies are the 2016, 2017, and 2019 Economic Studies done by ISO-NE, pursuant to Attachment K of its Tariff, for NEPOOL, CLF, NESCOE, Anbaric and RENEW. High level summaries of these studies have been provided below. ISO-NE's Economic Studies page, with postings of reports/findings from past studies can be accessed here:

  https://www.iso-ne.com/committees/planning/planning-advisory/?document-type=Economic Studies

NEPOOL 2016 Economic Study

- Requested by NEPOOL in April 2016; completed by ISO-NE in late 2017. The study produced extensive data and findings related to the potential effect of public policies on markets, transmission, emissions and system operations.

- The requested scenarios considered several public policies assumed to be in effect in the six New England states in the two study years of 2025 and 2030, including Renewable Portfolio Standards; energy-efficiency, solar, and net-metering programs; and the Regional Greenhouse Gas Initiative allowance pricing

NEPOOL 2016 Economic Study

- The Phase 1 final report, published November 17, 2017, is available here:

  https://www.iso-ne.com/static-assets/documents/2017/11/final_2016_phase1_nepool_scenario_analysis_economic_study.docx

- The Phase 2 final presentation, dated December 20, 2017, is available here:

  https://www.iso-ne.com/static-assets/documents/2017/12/a2_2016_economic_study_phase_2_ramping_regulation_reservers_scenario_results.pdf

NEPOOL 2016 Economic Study

- NEPOOL requested study of the potential effects of public policies on markets, system reliability and operability, resource costs and revenues, and emissions. Six scenarios were studied, including:

  - **Scenario 1—"RPSs + Gas",** where the generation fleet meets existing Renewable Portfolio Standards (RPSs), and natural gas combined-cycle (NGCC) units replace retired units.

  - **Scenario 2—"ISO Queue",** where the generation fleet meets existing RPSs, and new renewable/clean energy resources meet all future needs, including retirements, with the wind resources located mostly in Maine in the same locations indicated in the ISO's Interconnection Queue.

  - **Scenario 3—"Renewables Plus",** where the generation fleet meets existing RPSs, and the system has additional renewable/clean energy resources.

NEPOOL 2016 Economic Study

- **Scenario 4**—"**No Retirements beyond FCA #10**", where the generation fleet has natural gas combined cycle (NGCC) plant additions and no retirements after the tenth Forward Capacity Auction (FCA #10) and where local load-serving entities meet existing RPSs, in part through alternative compliance payments (ACPs).

- **Scenario 5—"ACPs + Gas",** where the existing fleet meets existing RPSs in part through ACPs, and NGCC additions replace retired units.

- **Scenario 6—"RPSs + Geodiverse Renewables",** which is similar to Scenario 2 with the generation fleet meeting existing RPSs and new renewable/clean energy resources meeting all future needs, including retirements, but with more geographically balanced onshore wind, offshore wind, and solar photovoltaic (PV) resources.

- The scenarios examined data sets for two years, 2025 and 2030, with the transmission system constrained and unconstrained and with all resource mixes meeting the net Installed Capacity Requirement.

CLF 2017 Economic Study

- In 2017 Conservation Law Foundation requested study of several low-carbon-emitting resource-expansion scenarios and potential effects on resource adequacy, operating and capital costs, and options for meeting environmental policy goals ("Least cost emissions-compliant scenarios"). The final report on the study is available here:

  https://www.iso-ne.com/static-assets/documents/2018/10/2017_economic_study_final.docx

- The study used the following metrics: energy production by resource type; system-wide production costs; average locational marginal prices; average load-serving entity energy expenses and congestion; generic capital costs and annual carrying charges for each resource type; transmission-expansion costs; generation by fuel type and the amount of "spilled" renewable resources; system-wide carbon dioxide emissions; effects of transmission-interface constraints that may bind economic power flows

CLF 2017 Economic Study

- The CLF 2017 study used the following scenarios:

- **2016 NEPOOL Scenario Analysis Scenario 3—"Renewables Plus",** where the generation fleet meets existing Renewable Portfolio Standards (RPSs), and the system has additional renewable/clean energy resources
- **2017 Economic Study Scenario A—"EE + Offshore"** reflects a change from the Renewables Plus scenario by modifying the resource mix of new renewable/clean energy resources, with emphasis on energy efficiency (EE) and offshore wind in southern New England
- **2017 Economic Study Scenario B—"Onshore Less EE/PV"** simulates a change in the mix of Renewables Plus resources with new renewable/clean energy resources, with emphasis on onshore wind in northern New England (and less on EE and solar photovoltaics [PV])
- **2017 Economic Study Scenario C—"Wind Less Nuclear"** considers the replacement of some of the baseload nuclear generation in the Renewables Plus scenario with renewable/clean energy resources, especially onshore wind in northern New England

NESCOE 2019 Economic Study

- NESCOE requested study of the effects of increasing amounts of offshore wind in New England on transmission and wholesale markets.
- The study looks at up to 8,000 MW of offshore wind interconnecting at various points on the ISO-NE system in the time period up to 2030.
- ISO-NE has not finalized the study yet but provided results most recently in a February 20, 2020 presentation, which can be accessed here:

  https://www.iso-ne.com/static-assets/documents/2020/02/a6_nescoe_2019_Econ_8000.pdf

- ISO-NE expects to publish a final report by June 1.

Anbaric 2019 Economic Study Request

- Anbaric also requested study of impacts of increasing amount of offshore wind on energy market prices, air emissions and regional fuel security.

- The study looks at additions of up to 8,000 - 12,000 MW of offshore wind interconnecting in southern New England by 2030.

- ISO-NE has not finalized the study yet but provided results most recently in a February 20, 2020 presentation, which can be accessed here:

  https://www.iso-ne.com/static-assets/documents/2020/03/a8_anbaric_2019_economic_study_prelim_results_marpac.pdf

- ISO-NE expects to publish a final report in June/July.

RENEW 2019 Economic Study

- RENEW requested study of the economic impact of conceptual increases in hourly operating limits on the Orrington-South interface from conceptual transmission upgrades to allow bottled-in wind generation in Maine access to the rest of New England. While this study does not expressly look at public policies, it does look at getting wind energy out of Maine, and the market effects of large additions of wind energy on the New England grid.

- The study will model the transmission system using 2025 internal interface transfer capabilities, with the exception of the Orrington-South interface.

- As with the NESCOE and Anbaric studies, the RENEW study will include production cost simulations.

- ISO-NE has not finalized the study yet but expects to provide some results in April.

Conclusion

- Several recent ISO-NE Economic Studies exist or are in the process of being completed that could provide relevant analysis and data for the Transition to Future Grid study process.

- The Economic Studies done since 2016 through the present for NEPOOL, CLF, NESCOE, Anbaric and RENEW provide analysis and data, covering the time periods out to 2025, 2030 and/or 2035.

- Stakeholders may want to consider if analysis and data from these past studies could help support the Transition to Future Grid effort.

WORKING LIST OF REPORTS/STUDIES/PRESENTATIONS

"TRANSITION TO THE FUTURE GRID" SUBJECT

We have been asked to begin assembling a digital library of documents that may be relevant to New England's "Transition to the Future Grid" effort. In this first pass, we decided to cast a wide net to identify potentially relevant studies, reports, papers, and presentations. ***Please note, the summaries included below were mostly cut and pasted from the studies' executive summaries, abstracts, or the like.*** As indicated in the Table of Contents, the studies are organized into four high-level categories.

As we more fully digest the various studies and reports referenced below and receive input from stakeholders, we will supplement the list and/or remove those documents that are not relevant to the "Transition to the Future Grid" subject. Further, while we attempted to locate relevant materials from various sources, we most assuredly missed some studies, reports and presentations that folks think are relevant to the effort underway. Because our research remains on-going, please let us know of any such studies or reports not listed in the attached document. The goal is to upload an appropriate list of materials (with hyperlinks to the documents) within a "reference library" on the NEPOOL website and to augment that list and digital library as additional relevant studies, reports, and presentations are identified.

We would appreciate your input on the attached work-in-progress. Any input can be sent directly to NEPOOL Counsel (Sebastian Lombardi (slombardi@daypitney.com) or Rosendo Garza, Jr. (rgarza@daypitney.com)).

Table of Contents

I. Future Grid/Decarbonization Studies

Brattle Group - Achieving 80% GHG Reduction in New England by 2050 (2019)
Brattle Group - Achieving 80% GHG Reduction in New England by 2050 (Tech App'x)
"Study Purpose: Estimate whether and how much clean energy resource additions in New England need to accelerate to achieve the 2050 decarbonization goals."

"To achieve the 2050 goals, New England must *electrify* the largest remaining sources of GHG emissions–transportation, residential heating, and commercial heating–and so a sustained focus on adding clean energy resources and decarbonizing the electric sector is essential to meeting these goals."

"Electricity demand will likely double by 2050 across plausible scenarios. . . . Supplying the increasing demand will require a massive buildout of clean energy resources."

Brattle Group - NYISO Grid in Transition Study (2020)
"NYISO has retained Brattle to develop simulations of NYISO markets through 2040 to inform the Grid in Transition effort.

- New York has established aggressive clean energy and decarbonization mandates, codified in the Climate Leadership and Community Protection Act (CLCPA).
- NYISO's Grid in Transition effort seeks to understand the reliability and market implications of the State's plans to transition to clean energy sources.
- NYISO has retained Brattle to simulate NYISO market operations and investment through 2040to inform NYISO staff and stakeholders on market evolution."

"Study design makes several simplifying assumptions, such as:

- Zonal, 'pipe and bubble' transmission topology
- Stylized representation of generators
    - Aggregated generators by zones and types
    - Economic additions and retirements in continuous increments, not 'lumpy'
- Implementing current market rules and policies."

Deep Decarbonization Pathways Project - Deep Decarbonization in the Northeastern United States and Expanded Coordination with Hydro-Québec (2018)
"This study analyzes what achieving an 80 x 50 goal [80% below 1990 levels by the year 2050] throughout the region implies for the way that energy is supplied and used . . . . The research was sponsored by the Sustainable Development Solutions Network (SDSN) in collaboration with Hydro-Québec (HQ), and conducted by Evolved Energy Research (Evolved) using the EnergyPATHWAYS energy system model, with contributions from SDSN and HQ's research institute, IREQ.
The analysis has three main objectives:
1. To understand what changes in energy system infrastructure and technology are required to achieve the 80 x 50 goal in the Northeast
2. To understand the potential effect of expanded Northeast-HQ coordination on the cost of achieving the 80 x 50 goal in the Northeast

3. To determine if potential benefits warrant examination in greater depth, and if so what are the right questions, tools, and stakeholders for a Phase 2 study[.]"

Energy and Environmental Economics (E3) - Long-Run Resource Adequacy Under Deep Decarbonization in CA (2019)

"This study examines electricity system resource adequacy under future scenarios in which California's economy is deeply decarbonized and heavily dependent on renewable energy. Resource adequacy standards ensure that sufficient resources are available to meet electric load under the broadest possible range of weather and resource outage conditions, subject to a standard for acceptable reliability. The study builds on prior work that E3 completed for the California Energy Commission which evaluated alternative pathways for California to achieve 80% reductions in greenhouse gas emissions from electricity, buildings, transportation, and industry by 2050. The previous work identified measures California could take to achieve greenhouse gas reductions and renewable energy targets within the electricity sector. The current study takes an in-depth look at electricity system resource adequacy requirements and which resources are needed to maintain acceptable long-run resource adequacy in a cost-effective manner under a range of plausible assumptions. This study was funded by the Calpine Corporation."

Energy Futures Initiative (EFI) (Ernie Moniz group) - Pathways for Deep Decarbonization in CA (2019)

- "Meeting California's carbon reduction goals by 2030 will require a range of clean energy pathways across all economic sectors—Electricity, Transportation, Industry, Buildings, and Agriculture . . . . . This is due to the uncertainty of each pathway and the fact that there are no 'silver bullet' solutions."
- "California's ambitious policy to double economywide energy efficiency is an important step for meeting 2030 decarbonization targets."
- "Transportation is the single largest emitting sector in California and requires transformational change to achieve aggressive decarbonization by 2030. Existing policies will have a major impact on the sector's emissions reduction by 2030."
- "Clean fuels (e.g., renewable natural gas [RNG], hydrogen, biofuels) are critical clean energy pathways due to the enormous value of fuels in providing flexibility and reliability for energy systems."
- "California can meet its 60 percent RPS target by 2030 with continued expansion of wind (both onshore and offshore) and solar resources; some geothermal and increased imports of clean electricity will play a role as well."
- "Natural gas generation will continue to play a key role in providing California's electric grid with operational flexibility and system reliability, while enabling the growth and integration of intermittent renewables."
- "Policies that affect natural gas in some sectors (e.g., building electrification) may have unintended impacts on other sectors that consume and rely on natural gas."
- "Meeting California's deep decarbonization goals by midcentury will be extremely difficult (if not impossible) without energy innovation."
- "There are several cross-cutting technologies or classes of technologies that can help meet the large-scale decarbonization needs for several economic sectors. These include

technologies for large-scale carbon management (LSCM), hydrogen applications, leveraging carbon infrastructure and expertise, and smart systems and platforms."

NYISO - Reliability & Market Consideration for a Grid in Transition (2019)
NYISO - Reliability & Market Consideration for a Grid in Transition (PPT)
"This white paper is intended to facilitate a thorough review of a recommended set of market enhancements to ensure that the market signals provided through the energy, ancillary services and capacity markets are aligned with system reliability needs in order to attract investment and retain competitive suppliers through the transition to 70% renewable energy by 2030. We need to take the necessary steps to prepare and further shape the competitive markets, and identify strategic transmission investment opportunities for the change that is underway and then continue to evolve our markets as a better understanding of the long term challenges is developed."

"In order to further that objective this whitepaper: 1) describes the emerging reliability and economic challenges; 2) presents our initial identification of gaps to address; and 3) proposes next steps. We focus on market design improvements, but also identify the required operations and planning studies that will inform the trajectory of how to meet reliability as we transition to a carbon free future."

II. Recent New England Reports/Papers/Presentations

ISO-NE - The Clean Energy Transition and Future Pathways (2020)
"This presentation examines how ISO New England is currently enabling the Clean Energy Transition through a competitive market for power system reliability services and considers the implications of future evolutionary pathways for the region's wholesale electricity markets."

ISO-NE - Transmission System Needs for a Decarbonized Electric System (2020)
PPT exploring regional transmission investment, the integration of renewables and storage, and the need to change planning assumption in the transmission system.

ITC Mass Renewable Investigation (Invest. No. 332-574) (2020)
"Following receipt on January 23, 2020, of a request from the Committee on Ways and Means (Committee) of the U.S. House of Representatives, under section 332(g) of the Tariff Act of 1930, the U.S. International Trade Commission (Commission) instituted Investigation No. 332-574, Renewable Electricity: Potential Economic Effects of Increased Commitments in Massachusetts, for the purpose of providing a report regarding the potential economic effects of increased renewable energy commitments in Massachusetts, and the role of renewable electricity imports in meeting these commitments."

Massachusetts Attorney General's Office - Wholesale Electric Market Design for a Low-No-Carbon Future (2020)
"[O]n October 24, 2019, the Massachusetts Attorney General's Office . . . convened a small group of energy market design experts, thought leaders, and stakeholders to participate in a day-long, professionally facilitated symposium to discuss long-term wholesale power market design options that will best support New England's clean energy transition, regional climate goals, and

emissions reduction mandates while maintaining reliability and reasonable costs (the 'Symposium'). The purpose of the Symposium was to inform and advance a regional, solutions-based discussion about the future of New England's competitive electricity markets."

"The Symposium examined two guiding questions ('Guiding Questions'):
1. What market design construct(s) for New England will most effectively support an electricity system comprised exclusively of renewables and other zero/very low carbon resources (many/most of which have variable output, and near zero marginal cost to operate) (the 'decarbonized end-state')?
2. How do we effectively transition the wholesale electric markets (during which gas will likely still be needed for reliability purposes, at least) to ensure that we achieve this long-term vision (what needs to happen and when)?"

"This paper captures the thinking and visions that emerged during the discussions at the Symposium, which included surprising areas of consensus—the need for meaningful carbon pricing and more effective scarcity pricing—and raised many questions, including, importantly, the role of the New England states in shaping resource considerations in the wholesale power market."

Northeast Region Emissions Reduction Summit - Accelerating to 80 (Driving the Northeast's Deep Decarbonization Targets)
"In order to brainstorm ideas for what would be an unprecedented undertaking and to set the stage for regional coordination efforts throughout the Northeast, Mintz, the Northeast Clean Energy Council (NECEC), and The Brattle Group convened an invitation-only summit of senior-level clean economy leaders from the public, private, and nonprofit sectors. The event brought together over 30 thought leaders and stakeholders from a broad range of invested constituents: local and state governments, utility companies, industry associations and trade groups, advocacy groups focused on the environment and transportation, and venture capital and project finance funds that invest in sustainable businesses, and private companies ranging from green energy start-ups to Fortune 500 companies."

III. Miscellaneous

Davis Noll and Unel - Markets, Externalities, and the Federal Power Act: The Federal Energy Regulatory Commission's Authority to Price Carbon Dioxide Emissions (2019)
"This Article examines how FERC has embraced market efficiency as the key tool for ensuring just and reasonable rates and has addressed all of the standard market failures that would otherwise distort the efficiency of prices: market power, asymmetric information, public goods, and externalities. The Article then shows that any economically rational effort to achieve an efficient market must attempt to address the external cost of CO2 emissions as well. This Article argues that, from an economic perspective, FERC's authority to pursue market efficiency should extend to either approving utility plans to internalize those external costs or to set a carbon price, just as it extends to other market failures."

Glick and Christiansen - *FERC and Climate Change*
"This article discusses one of those federal agencies—the Federal Energy Regulatory Commission (FERC or the Commission)—and how its actions can have substantial consequences for climate change. . . . This article examines several areas of the Commission's jurisdiction that have particularly important consequences for GHG emissions."

MITEI - "The Future of" Studies
A "[c]omprehensive multidisciplinary MIT analyses that shape and influence policy, technology development, and future research."

PJM Study - Response to PA PUC OH Consumers' Counsel Requests to Analyze Certain Impacts of Nuclear Power Plant Retirements (2019)
"In response to separate requests from the Pennsylvania Public Utility Commission (PA PUC) and the Ohio Consumers' Counsel (OCC), PJM Interconnection studied cost and emission impacts of potential nuclear power plant retirements in Pennsylvania and Ohio.

- To evaluate these impacts, PJM simulated market results for the year 2023 under various resource mixes, including what exists today, projected conditions for the future and several combinations of potential nuclear unit retirements.
- The PJM base case includes the announced retirements of nuclear units in Pennsylvania and Ohio: Three Mile Island (TMI), Beaver Valley 1 & 2, Davis-Besse and Perry, and also includes new generation with a planned in-service date of 2023 and an executed Interconnection Service Agreement.
- Modeling the base case, considering retirements and new entry, shows that wholesale energy market net-load payments would decrease by $1.6 billion across the PJM region compared to today's system due to the significant entry of new, efficient resources.
- PJM executed three simulations of the requested nuclear unit retirement scenarios. These scenarios assume the requested combinations of nuclear unit retirements occur and also assume that those generators in the queue that have executed an Interconnection Service Agreement and are planned to come online between 2020 and 2023 would enter the market as scheduled."

Power Systems Engineering Research Center - Public Report on the Future Grid
"Funded by the U.S. Department of Energy (DOE) 'The Future Grid to Enable Sustainable Energy Systems' project focuses on how to integrate higher penetrations of renewable generation and other future technologies into the grid while enhancing grid stability, reliability, and efficiency. It also aims to stimulate discussion among the academic, industry, and government communities on what it will take to shape the future grid for the mid-twenty-first century."

IV. Potential Future Market Frameworks/Options

A. Carbon Pricing

i. NYISO's Carbon Pricing Efforts

- Analysis Group - NYISO Carbon Pricing Report (2019)
- Analysis Group - NYISO Carbon Pricing Report (PPT) (2019)

- Analysis Group - NYISO Carbon Pricing Report (Technical App'x) (2019)
  "New York has a home-grown tool—a proposed carbon pricing mechanism in the state's wholesale market administered by NYISO—that can provide a number of benefits, including support for New York policy makers' goals to reduce carbon emissions as quickly and as economically as possible. Introducing a carbon price in the state's wholesale electric market administered by NYISO can lead to a number important outcomes . . . . Without the carbon price, New York policy makers may be inadvertently tying one hand behind the market's back, at a time when New York's aspirations for a clean energy economy call for all hands to be clapping together in unison."

- Brattle Group - Analysis of a New York Carbon Charge (PPT) (2018)
  - "Internalizing a carbon charge would invite a broad range of solutions to compete to meet decarbonization goals cost-effectively, which should improve economic efficiency over existing policies alone"
  - "The proposed design helps prevent distortions at NYISO's seams that could reduce economic efficiency gains"
  - "We estimate economic savings of $7m/yr in 2022, rising to $50m/yr by 2030"
  - "A separate question is how much of the economic gains are enjoyed by consumers vs. producers, and if higher energy prices transfer wealth from consumers to producers"
  - "We estimate a carbon charge could reduce emissions of CO_2 and NO_x"
  - "Benefits could increase with more innovative emissions reductions the market might produce in response to prices (but not captured in the analysis) . . . ."
  - "Benefits could be much greater if carbon charges prevent conflicts between state programs and wholesale electricity markets"

- Brattle Group - Pricing Carbon into NYISO's Wholesale Energy Market (2017)
  "At the request of its stakeholders, the New York Independent System Operator (NYISO) commissioned The Brattle Group in August 2016 to explore whether and how New York State environmental policies may be pursued within the existing wholesale market structure. In developing its analysis, Brattle received valuable input from the NYISO, the New York Department of Public Service (DPS), and stakeholders. The resulting report, presented here, considers that input but solely reflects the opinions of its authors. This report is intended to provide a first step in a discussion on how to harmonize state policy and wholesale markets in New York."

- NYISO - Carbon Pricing in NY (2019)
  "Overview on carbon pricing in NYISO; discusses Climate Leadership and Community Protection Act and integrating markets and public policy through carbon pricing."

- NYISO - IPPTF Carbon Pricing Proposal (2018)
  "The Integrating Public Policy Task Force (IPPTF) was created as a forum for the NYISO, New York State Department of Public Service, New York State Research and Development Authority, electricity market participants, members of the public, and interested stakeholders to explore concepts and proposals for incorporating the social cost of carbon emissions in wholesale energy markets to better harmonize the state's energy

policies and the operation of those wholesale markets. On April 30, 2018, a straw proposal was released outlining a potential design to incorporate the social cost of carbon dioxide emissions in the wholesale electricity markets (Carbon Pricing Straw Proposal)."

ii. PJM's Carbon Pricing Senior Task Force

Last year, a Carbon Pricing Senior Task Force (CPSTF) was established in PJM to "engage in education and then investigate any process and rule changes necessary to integrate regional or sub-regional carbon pricing mechanisms." To access PJM's dedicated CPSTF website, please click here. What follows are some of the presentations/reports provided at CPSTF meetings to date.

- Institute for Policy Integrity - Carbon Pricing in RTO Markets Jurisdictional Considerations (2019)
  A PPT reviewing jurisdictional consideration in carbon pricing.

- Monitoring Analytics - Carbon Pricing Education (2019)

- PJM - Advancing Zero Emission Objectives Through PJM's Energy Markets (2017)
  "PJM Interconnection believes market design can advance state policy initiatives and adapt to changing conditions to ensure the PJM region continues to reap the benefits of competitive markets. To address the desire of some states to subsidize supply resources to meet carbon-reduction initiatives, this paper explores how all or a subregion of PJM could affix a price on carbon that could be reflected in wholesale energy market prices. Specifically, we examine how regional and subregional carbon pricing could be implemented in the region PJM serves."

- PJM - Carbon Pricing Impacts on LMP (2019)
  Review of the potential impacts of carbon pricing on LMPs.

- PJM - Carbon Study Objective & Assumptions (2019)
  Discussing PJM's carbon study objective and methodology.

- PJM - Study of Carbon Pricing & Leakage Mitigation Mechanisms (2020)
- PJM - Expanded Results of Study of Carbon Pricing & Potential Leakage Mitigation Mechanisms (2020)
- PJM - Study of Carbon Pricing & Potential Leakage Mitigation Mechanisms Example Problem Formulations (2020)
  A review of a production-cost model and modeling of carbon prices from RGGI.

- Resources for the Future - Concepts for Carbon Pricing (PJM) (2019)

- Solar Wind Energy Assoc. & Solar Energy Industries Assoc. - Jurisdictional Considerations Related to Carbon Pricing in PJM

B. Forward Clean Energy Market

Brattle Group - How States, Cities, & Customers Can Harness Competitive Markets (2019)
"In this whitepaper, we propose a new forward clean energy market (FCEM) in order to harness technology-neutral, broad-source competition and innovation. The FCEM would provide a competitive, regional market for clean electricity attributes. It would enable states, cities, and customers to achieve their ambitious carbon targets at lower costs. Furthermore, it would complement existing competitive wholesale electricity markets."

C. Other Proposed Alternative Approaches/Ideas

Grid Strategies - The Need for Capacity Market Replacement or Reform (2019)
"This paper summarizes capacity market performance, outlines key design flaws that regulators have approved, and provides some ideas for future directions that state and federal policy makers could take to improve the reliability and efficiency of markets for customers."

Grid Strategies & Regulatory Assistance Project - Wholesale Electricity Market Design for Rapid Decarbonization a Decentralized Markets Approach (2019)
"Paper argues that a market structure with a central spot market and active de-centralized forward procurement between wholesale buyers and sellers (including exchange-based trading) will lead to sufficient investment to achieve resource adequacy, will facilitate a sufficiently rapid decarbonization, and will do so at the lowest reasonable cost to consumers."

Wilkinson Baker Knauer (prepared for American Public Power Association) - Mandatory Capacity Markets & the Need for Reform (2020)
"The reforms proposed in this paper recognize that state and utility resource planning for electricity supply should be fully accommodated within a workable paradigm for the RTOs/ISOs. Comprehensive resource planning benefits customers, as does the ability to access a voluntary market to sell or procure marginal supply, and to achieve the efficiencies of the centralized dispatch of resources through the current RTO/ISO energy markets. As discussed further in this white paper, this reform proposal rests on two pillars: (1) the transition of mandatory capacity constructs to voluntary residual markets to supplement primary methods of procuring capacity (bilateral contracting or self-builds); and (2) a framework for a greater role in resource planning and procurement for the LSEs and the states to enhance the first pillar."

Grid Strategies - Retail Electric Market Structure Reforms (2020)
"The study identifies two key flaws in retail market structures that hinder resource procurement: rules around default service provision that undermine retail suppliers' incentive to sign long-term contracts, and insufficient creditworthiness of retail suppliers. States can improve retail structures by: 1. Leveling the playing field between default and competitive services; 2. Ensuring retail suppliers are sufficiently creditworthy to execute long-term contracts. Together these recommendations to improve retail structures both improve their performance and enable beneficial wholesale market reforms."