WHOLESALE ELECTRIC MARKET DESIGN *for a* LOW/NO-CARBON FUTURE

REPORT ON THE OCTOBER 2019 SYMPOSIUM & PROPOSED NEXT STEPS

Massachusetts Attorney General's Office
Regulatory Assistance Project
March 2020

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ACKNOWLEDGEMENTS

This white paper summarizes the key insights gained over the course of a symposium on the future of wholesale electricity markets in New England ("Symposium"), convened by the Massachusetts Attorney General's Office ("AGO"), with funding from the Barr Foundation, and support from Michael Hogan of the Regulatory Assistance Project ("RAP").

In planning for and convening the Symposium, the AGO received extensive input from a wide spectrum of the region's electric industry stakeholders and academics, and Dr. Jonathan Raab of Raab Associates, who helped design and facilitated the Symposium.

The Symposium participants represented a wide range of points of view, experience, and expertise. The findings summarized here are a synthesis of the collective discussion; nothing presented here should be taken to reflect the views of any single participant, including the AGO, unless otherwise stated.

SYMPOSIUM ATTENDEES

Hosts
AG Maura Healey, AGO
Melissa Hoffer, AGO
Rebecca Tepper, AGO

Moderator
Jonathan Raab, Raab Associates

Panelists
Steve Corneli, Strategies for Clean Energy Innovation
Peter Fuller, Autumn Lane Energy Consulting
Robert Gramlich, Grid Strategies, LLC
William Hogan, Harvard Kennedy School
Paul Joskow, Massachusetts Institute of Technology
Abigail Krich, Boreas Renewables
Karen Palmer, Resources for the Future
Robert Stoddard, Charles River Associates
Susan Tierney, Analysis Group

AGO Attendees
Christina Belew
Marlon Dos Santos
Fiona Dwyer-McNulty
Michael Firestone
Benjamin Griffiths
Megan Herzog
Liam Paskvan
Timothy Reppucci

Observers
Shanna Cleveland, Barr Foundation
Mariella Puerto, Barr Foundation

Students
Hannah Perls, Harvard Law School

Participants
Jessica Bell, New York University
Janet Besser, Smart Electric Power Alliance
Tanya Bodell, Energyzt
David Cavanaugh, Energy New England
Judy Chang, The Brattle Group
Elizabeth Delaney
Thorn Dickinson, Avangrid
Daniel Dolan, New England Power Generators Association
Deborah Donovan, Acadia Center
Benjamin Downing, Nexamp
David Errichetti, Eversource Energy
Michelle Gardner, NextEra
Paul Hibbard, Analysis Group
Michael Hogan, Regulatory Assistance Project
Heather Hunt, New England States Committee on Electricity (NESCOE)
Douglas Hurley, Synapse Energy Economics
Thomas Kaslow, FirstLight Power
Brett Kruse, Calpine Corporation
Tim Martin, National Grid
Aleksandar Mitreski, Brookfield Renewable Partners
Samuel Newell, The Brattle Group
Ari Peskoe, Harvard Law School
Mary Smith, Harvard University
Phelps Turner, Conservation Law Foundation
Dennis Villenueva, Partners HealthCare
Andrew Weinstein, Vistra Energy Group

INTRODUCTION

Over the past year, in the United States and around the world, a sea change has begun to occur. It is characterized by both growing alarm regarding the peril we face from the many threats of climate change—environmental, economic, and social—and awareness of the many ways in which virtually every aspect of our lives will be touched and changed in the transition now underway.

As global markets realize the systemic financial risks associated with climate change, demand for clean energy is accelerating. Leading consultants are warning of the high social and economic costs of the physical impacts of climate change, like droughts and sea level rise, and the world's central banks have sounded the alarm that climate change could trigger the next global systemic financial crisis. In light of these developments, in January 2020, the world's largest asset manager announced initiatives to prioritize sustainability, including exiting high-risk investments like carbon intensive energy and expanding investment in renewable energy.

There is no question that we must rapidly transition to clean energy to supply our electricity needs across all sectors—and that we must electrify our transportation and building sectors so that they may be powered with clean energy and reduce carbon emissions more cost effectively than under alternative approaches. At the same time, we must ensure that our power system remains reliable and resilient in a climate disrupted world. We should be considering now how market design could be affected by new physical risks (e.g., storm, flood, and heat impacts on energy infrastructure) and new transition risks (such as the potential for rapid asset reallocation and repricing). Our wholesale electricity markets are not adapting at the necessary pace or scale.

The New England states have long made power sector emissions reductions a priority with nation-leading programs, such as the Regional Greenhouse Gas Initiative ("RGGI"), which became effective in 2009. Yet, wholesale market innovations in New England have remained reactive, despite profound changes to state mandates and clean energy goals. The patchwork capacity market changes embedded in ISO-New England's ("ISO-NE's") Competitive Auctions with Sponsored Policy Resources ("CASPR") program to integrate state-sanctioned renewables do not adequately recognize the large amount of renewable generation that will need to enter the market to meet the states' requirements. Similarly, when it began to address the Federal Energy Regulatory Commission's ("FERC's") perceived "fuel security" problem through the Energy Security Initiative ("ESI"), ISO-NE proposed a complex new energy market auction mechanism to ensure, essentially, the availability of more liquified natural gas and fuel oil—rather than exploring non-fossil fuel alternatives.

Deliberations regarding the ESI process rekindled interest in re-examining New England's capacity market construct. Why was it not creating incentives for the development of adequate clean energy resources? If there really was an energy security problem, why wasn't the capacity market, coupled with other existing market mechanisms, solving it? What value is ISO-NE's capacity market continuing to provide as it insulates high-carbon incumbent generators from market forces that might otherwise render them uneconomic? These questions, in turn, have sparked broader discussion about what we need to do today—thinking big and outside the box—to ensure that by 2050, and the years leading up to it, the region's wholesale market design delivers a low/no-carbon electricity system while ensuring reliability and reasonable electricity costs for customers.

With those questions in mind, on October 24, 2019, the Massachusetts Attorney General's Office ("AGO") 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)?

Symposium participants considered these questions in the contexts of wholesale electric markets in New England and other considerations: (i) the energy market; (ii) the ancillary services markets; (iii) resource adequacy; and (iv) actions outside of the wholesale markets, including retail pricing and state clean energy policies.

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.

Building on the work of the Symposium, the AGO concludes this paper with recommendations on concrete actions the region can take in the short-term to define a working market design proposal and build support for it among stakeholders.

Regional stakeholders have an opportunity—and an obligation—to put in place now the regional power markets that will deliver the clean energy that New England states want to see developed to help ensure a livable future, and together, we can achieve that goal.

SYMPOSIUM OUTCOMES

AREAS OF BROAD AGREEMENT

Symposium participants reached broad agreement—approaching consensus—regarding the following:

1. Given the structure of wholesale power markets in New England, more effective **scarcity pricing** in the energy market will provide more robust price signals reflecting the value of scarce resources, flexibility, and reliability needs. Improved price formation will facilitate more meaningful participation by dispatchable generation, intermittent generation, energy storage, and flexible demand.

2. As the region's reliance on intermittent generation increases, **demand flexibility** will take on increased importance. Demand must be able to observe and adaptively respond to price signals and variability of the supply and demand balance.

3. **Ancillary services** will grow more important as the share of intermittent generation increases and creates new (but surmountable) challenges for system security and stability. Many of the challenges of a low/no-carbon grid dominated by intermittent resources will result in flexibility services requirements, rather than traditional capacity needs. This will result in demand for new, specialized services that value flexibility.

4. **Meaningful regional carbon pricing** will be necessary, but not sufficient, for decarbonization of the regional power system or economy. Carbon pricing (in one form or another) will more fairly compensate low-carbon resources during the transition and will prevent backsliding towards fossil fuels in the decarbonized end-state. To avoid leakage and free-rider effects, carbon pricing mechanisms should be regional and economy-wide.

5. The concept of, and standards for, **resource adequacy** will need to transition from ensuring adequate supply to meeting the electrical requirements of a system's peak hour, to ensuring that there are adequate resources (both in capacity availability and in terms of flexible supply) to meet customers' requirements throughout the year.

6. Additionally, **new techniques, tools, and markets** will be required to ensure resource adequacy as well as a low-carbon electricity supply in the decarbonized end state. Improved energy and ancillary service markets may be insufficient to ensure that the market reflects the value of access to enough of the right kind of resources. ISO-NE's Forward Capacity Market ("FCM"), in its current or similar form, is not suited to doing so in the decarbonized end-state.[1]

7. The adoption of **time-varying retail tariffs and enabling technologies**, paired with scarcity pricing in the wholesale markets, may improve real-time coordination between intermittent supply and flexible demand and enable more efficient use of the energy supply. Improvements to retail tariffs should be paired with accelerated deployment of enabling technologies such as advanced metering functionality, grid modernization, and smart electric vehicle ("EV") charging.

1 There was less agreement as to the FCM's role during the transition.

8. The support of the **New England states, traditional stakeholder groups**, and the **broader public** is crucial to the success of any regional market design construct. Cooperation and coordination between and among the states on market design will lead to significantly better outcomes for everyone. Involving stakeholders and the broader public early and often also will be necessary and important.

AREAS OF MORE DIVERSE PERSPECTIVE

1. Despite the broad agreement among Symposium participants on numerous aspects of the design of wholesale electric energy markets and ancillary services, as well as and the benefits of carbon pricing, there was less agreement among participants regarding resource adequacy.
2. Specifically, participants differed over whether an ISO-NE centralized market to assure resource adequacy in a decarbonized end state was necessary (in addition to an electric energy market that reflects scarcity pricing and ancillary services reform), and if so, how it should be designed.

In addition, Symposium participants raised **numerous questions** that require further discussion:

a. What tools are best suited to deliver timely and efficient replacement of fossil generation (e.g., energy scarcity pricing, long-term power purchase agreements, capacity markets, some hybrid, or some other new tool)? What tools are best suited for the decarbonized end-state?

b. Who should define, assure, and deliver resource adequacy: ISO NE? States? Market participants? Some hybrid or other entity?

c. What role should the states play in determining the resource mix on which those states' power supply will rely?

d. What are the resilience challenges in the transition and in the decarbonized end-state, and how can the states, ISO-NE, and stakeholders address them in the envisioned market context?

e. What is the appropriate timetable for the transition to a market design aligned with a decarbonized power system?

STRUCTURE OF THE SYMPOSIUM

The day-long event consisted of two half-day sessions, the first addressing market design for a decarbonized end state, and the second focusing on transition strategies, as set forth in the Guiding Questions.[2]

Both sessions began with a panel of five experts who each provided summary remarks, followed by a moderated panel discussion.[3] These panels were followed by break-out sessions in which Symposium participants were divided into three pre-assigned groups, each with an assigned

2 See Appendix 1 for the Symposium agenda.

3 Most of the expert panelists provided papers in advance that were meant to develop more fully their viewpoints. The papers and presentations may be accessed here: https://www.mass.gov/lists/energy-market-symposium-2019-wholesale-market-design-in-a-lowno-carbon-electricity-system

facilitator, to lead a discussion about the respective Guiding Question and the panelists' viewpoints and included polling of participants.[4] Each of the break-out sessions concluded with a report from the facilitators of the respective sessions to all Symposium participants. The day concluded with a plenary session in which participants had an opportunity to reflect on the day's conversations, make additional observations, and raise unresolved questions and concerns.

Jonathan Raab of Raab Associates assisted the AGO in the design of the Symposium and facilitated the plenary sessions. Susan Tierney, Tanya Bodell, and Jonathan Raab facilitated the break-out groups. Michael Hogan of the Regulatory Assistance Project assisted in the gathering and reporting of the outcomes of the proceedings, as well as the preparation of this white paper.

ATTORNEY GENERAL HEALEY'S OPENING REMARKS

Attorney General Maura Healey opened the Symposium by citing the urgent need to address the climate crisis and calling on the gathered thought leaders to conceive of a future where the wholesale markets support a low/no-carbon generation fleet. She encouraged attendees to identify a path toward this future grid that is clean, equitable, low-cost, and reliable. Noting her statutory obligation as the Massachusetts ratepayer advocate to represent electric and gas customers in matters before state and federal energy regulatory bodies and her Office's leadership in advancing Massachusetts customers' interests at ISO-NE and FERC, AG Healey emphasized that decisions by ISO-NE and FERC directly affect over half of the total amount New England customers pay each month on their retail electricity bills. She also observed that ISO-NE and FERC decisions greatly impact the region's clean energy future, as evidenced by the fact that, while state laws mandate a low/no-carbon future, the New England wholesale markets are not adequately facilitating the achievement of these long-term energy and climate goals. AG Healey expressed her support for competitive markets as the best way to achieve reliability at least cost but also noted that recent incremental market changes are costing customers money and are not advancing the states' clean energy priorities. She challenged the group to chart a better course.

MORNING SESSION: MARKET DESIGN FOR A DECARBONIZED SYSTEM

SPEAKERS

The morning session's expert panel addressed visions for decarbonized end-state market designs that would support most effectively an electric system comprised almost exclusively of renewable resources and other zero/very-low carbon resources. The panel included five of the leading experts on wholesale power market design in a low/no-carbon power system.

While there was broad agreement on the challenges that lie ahead, the panelists presented a range of prescriptions for a decarbonized end-state market that could continue to attract needed investment in flexible and no-carbon resources, while delivering on the objectives of reliability and affordability.[5]

4 See Appendix 2 for an overview of the break-out group discussion format.

5 Expanded summaries of the speakers' presentations are provided in Appendix 3, and their slides can be found at https://www.mass.gov/lists/energy-market-symposium-2019-wholesale-market-design-in-a-lowno-carbon-electricity-system

- **Dr. William Hogan** (Raymond Plank Research Professor of Global Energy Policy, Harvard Kennedy School of Government) argued that a comprehensive rethinking of the market design is not required, although operators in different ISOs must integrate best practices and focus on improving and extending existing market design. He spoke forcefully in favor of scarcity pricing as a necessary tool to drive efficient market activity.

- **Dr. Paul Joskow** (Professor of Economics, Emeritus, MIT) shared Dr. Hogan's basic market design philosophy for efficient dispatch of generation, storage, and demand-response but was skeptical that these markets alone could provide sufficient revenue to drive adequate investment in low/no-carbon generation to meet the region's aggressive carbon reduction goals for the electric power sector. He doubted that the current markets could support the optimal resource mix of intermittent and dispatchable generation, as well as storage, consistent with close to complete decarbonization, and suggested that other tools will be required to procure and maintain low/no-carbon infrastructure to meet these decarbonization goals.

- **Rob Gramlich** (Grid Strategies LLC and former FERC staff member) agreed with Drs. Hogan and Joskow on energy market operation. He suggested that resource adequacy could be best satisfied by abandoning capacity markets and instead relying on decentralized forward procurements. These forward procurements would have loads self-supply their own resource adequacy by signing contracts with suppliers. Policy direction would be important for setting retail purchase obligations and policing market power.

- **Steven Corneli** (Strategies for Clean Energy Innovation) acknowledged the essential role of well-formed energy and ancillary service markets. But to ensure resource adequacy and operational reliability, Mr. Corneli advocated in favor of a centralized mechanism that combines integrated energy planning—using new power system modeling tools—with competitive procurement. Under this framework, a periodic competitive procurement would solicit bids to develop or maintain a variety of clean energy resources (e.g., variable renewables, nuclear, storage, and transmission upgrades). These bids would then be used as inputs into the optimization models used in the planning process. The modeling and planning process would identify the set of projects and resources that are sufficient to ensure reliability in the most cost-effective manner. Long-term, cost-based contracts with strong performance standards would then be awarded to these projects and existing resources.

- **Dr. Susan Tierney** (Analysis Group and former federal and Massachusetts state energy and environmental policy official) was skeptical that the energy markets envisioned by Dr. Hogan would be politically feasible in New England and, separately, expressed concerns that location-specific market power could arise—and would need new forms of mitigation—in a highly decentralized energy market. Dr. Tierney proposed segmenting responsibility for resource adequacy: centralizing support for local resource adequacy needs under the ISO-NE and decentralizing the provision of system-wide resource adequacy to the states.

BREAK-OUT SESSIONS

After the expert panel, participants engaged in break-out sessions. The topic for discussion was the same one addressed by the morning panelists. Specifically, what is the wholesale market construct that will most effectively support an electric system comprised almost exclusively of renewables and

other zero/very-low carbon resources. The discussion below provides the AGO's summary of the key concepts from the three different morning break-out sessions.

The Energy Market in the Decarbonized End-State: Still Needed but with Better Price Signals

Symposium participants almost universally agreed that a real-time energy market, providing price signals identifying the instantaneous value of energy, should be a cornerstone of any decarbonized end state wholesale market design. Participants also agreed that the security-constrained economic-dispatch paradigm employed by ISO-NE and in other power markets across the United States is fundamentally sound.

There was broad support for more transparent scarcity pricing as a necessary (though not necessarily sufficient) component of an end-state energy market, especially given the connection between scarcity pricing and the role of active demand. However, there also was recognition of the history of the energy market in New England and the practicalities of finding a solution that is both effective and acceptable in the New England context.

MARKET POWER IN ENERGY MARKETS

Market power means that a buyer or seller can affect the price of a commodity through intentional market behavior. In wholesale electricity markets, sellers generally exercise market power by either removing capacity from the market (physical withholding) to increase prices on reduced output, or, if a seller has a monopoly over a product due to market share or location, by submitting inflated supply offers. Buyers can exercise market power by withholding a portion of their expected demand from the market – suppressing energy prices. In both instances, careful market designs and FERC rules help to prevent the exercise of market power and its detrimental effects on consumers or producers.

At the same time, Symposium participants generally agreed that the decarbonized end-state will require enhanced price formation and robust demand-side participation. Robust demand-side participation will allow for better price formation and a reduction in the importance of administrative resource adequacy constructs (which exist, in part, because of limited demand-side participation).[6]

Participants also commented on the need for the energy market to become very granular to account for network topology changes spurred by the rise of location-dependent behind-the-meter resources. It was noted that in the decarbonized end-state, it will be challenging for the market to capture localized pricing.

Finally, participants noted that in a highly distributed future, market power could become common at many price nodes and innovative techniques may be needed to ensure that market prices are both transparent, and just and reasonable (and reflect market-power mitigation where needed).

Ancillary Services Markets: Transformed and Expanded; Continuing Role for ISO-NE

Symposium participants generally agreed that (1) the nature of ancillary services will be considerably transformed in the decarbonized end-state; (2) the suite of required services likely will be expanded; and (3) some services that will be the most important for maintaining reliable operations are either non-existent or unimportant today.

6 Without meaningful demand-side participation, the energy market can only be balanced by changing supply. In today's market, the demand curve is effectively vertical. This means that during periods of tight supply and high prices, demand will shift to lower priced hours to restore the system's balance—because the cost of electricity is higher than its value to price-responsive demand. Thus, active demand participation allows the market to respond to system tightness naturally, rather than relying on high-cost emergency or out-of-market actions by system operators.

A distinction may emerge between traditional "ancillary services"—services maintained by the system operator to address short-term threats to system stability—and the services that will become necessary to address longer-cycle challenges, especially the challenges of multi-day or seasonal stress induced by low output from intermittent resources. As with the existing suite of ancillary services, it will be important to ensure that demand for these new services is reflected in real-time energy prices, regardless of how they are procured and compensated. Participants also noted that the need for, and cost of, the future suite of services could be mitigated by the development of better modeling and forecasting practices and by co-optimizing procurement of these services with the demand for energy in the energy market.

Given the technical aspects of designing and deploying ancillary services, there was general agreement that in the decarbonized end-state ISO-NE should continue to administer ancillary service markets. ISO-NE would continue to identify hour-to-hour operational challenges to reliability and be held to account to operate the market in a way that brings forward the lowest cost solutions to those challenges.

Near Unanimous Agreement that Meaningful Regional Carbon Pricing is Necessary

There was nearly unanimous support for some form of regional carbon pricing that is priced to help create incentives for compliance with the region's clean energy goals. Symposium participants offered differing opinions on its required magnitude and importance and on the impact of carbon pricing in the electricity market if economy-wide (or multi-sector) carbon pricing is not in place.

Two key themes emerged. First, there seemed to be general agreement that, even in the decarbonized end-state where there are little to no fossil resources directly affected by a carbon-pricing mechanism, maintaining some form of carbon pricing will be required to counter the incentive to backslide to using fossil fuels for electricity generation. There also was broad agreement that the same or comparable mechanisms will be needed to extend carbon emission disincentives across other sectors of the economy to ensure a level playing field for carbon-free resources.

In the nearer term, carbon pricing also may improve the economics of low-carbon resources. Carbon prices will tend to increase energy prices and offer increased revenues to inframarginal, low-carbon resources. As these low-carbon resources come to dominate the supply mix and as energy prices fall towards zero in many hours, however, the value of these inframarginal low-carbon energy rents will fall. Thus, carbon pricing may drive needed technology innovation in the short-run but is unlikely to provide these benefits in the decarbonized end-state.

There was much support for the idea that states should retain control of implementation of their own clean energy policies. Symposium participants contemplated the political feasibility of a regional, economy-wide carbon pricing policy. There also was recognition that a comprehensive regime will be important in mitigating carbon leakage between states, between regions, and between the United States and Canada. Some expressed the need for consistency or coordination across the region with respect to carbon pricing. Like scarcity pricing, many Symposium participants viewed carbon pricing as necessary, but not sufficient on its own, to drive the transition to decarbonization.

Resource Adequacy in the Decarbonized End-State: What, Who, How, When?

Resource adequacy was the issue that generated the most vigorous debate, while achieving the least consensus among Symposium participants. This topic was more complicated and nuanced than

discussions of the energy or ancillary service markets, because it touched on both techno-economic considerations, subjective policy preferences, and views about the political feasibility of different market designs.

Traditionally, the concept of resource adequacy focuses on ensuring that there are enough resources available to a system operator to meet an electric system's coincident peak demand and reserve requirements. Implicitly, the core discussions at the Symposium reflected this view of what "resource adequacy" means, even though some commenters suggested that the resource adequacy concept will need to transition from ensuring that particular outcome to ensuring that there are adequate resources (both in terms of capacity availability, flexible supply, and responsive demand) to meet customers' requirements at all times and all places.

Also, the discussion focused less on whether the system needs to have adequate resources to meet consumers' electricity demand, but rather more on how such resource adequacy can be accomplished as part of the structure of the industry and of wholesale markets in New England.

High reliance on intermittent generation will pose new challenges to meeting the goal of ensuring resource adequacy.[7] Intermittent resources may not be available to generate electricity, with their availability affected by patterns in the energy sources themselves (i.e., it is not sunny at night; wind varies over time and space). And statistically, these resources may tend to be unavailable during periods of peak demand on the system. As a result, resource adequacy constructs and mechanisms will need to be retooled; new techniques, mechanisms, or markets will be required to ensure resource adequacy in the decarbonized end-state.

Moreover, despite general agreement that improved energy and ancillary service markets (combined with flexible demand) are essential planks in the market design and together would lessen the problems posed by intermittency, most Symposium participants still believed that "something else" is needed to ensure that the market provides fair compensation to resources for their contributions to system reliability, even when they are not actually producing electricity.

There was broad consensus among Symposium participants that the ISO-NE Forward Capacity Market in its current or similar form is unsuited to the needs of ensuring resource adequacy in the decarbonized end state. Participants generally agreed that the FCM's method of ensuring resource adequacy by assessing megawatts of firm generation capacity available during the system's peak hour will not be an accurate measure of resource adequacy going forward. Given a low/no-carbon end state generation fleet and price-sensitive demand, new resource adequacy constructs must include consideration of locational and temporal variability of resources on a more granular basis.

Several advantages of scarcity pricing as compared to other resource adequacy mechanisms, were identified, including that it (1) maintains the primacy of the energy market; (2) compensates resources based on their actual performance during periods of system stress, rather than on prospective engineering studies assessing how they might perform; and (3) reflects the value of reliability in real-time. Scarcity pricing, using a method such as the Operating Reserve Demand Curves employed by Electric Reliability Council of Texas ("ERCOT") to ensure that the price of energy properly reflects the demand for reserves and security of supply, may create incentives for market participants to invest

7 Some participants, echoing the sentiments of Dr. Karen Palmer, wondered whether it was worth reconsidering our underlying reliability standards (e.g., "1-in-10").

in zero-marginal cost resources and energy storage. Contracting for these new resources provides a hedge against volatility in low carbon markets, where prices oscillate between zero-price periods and price spikes during scarcity periods.

While this approach recognizes the need for contracting and hedging opportunities to mitigate investor risk efficiently, many expressed concerns that the market-based contracting on which it relies would be insufficient to deliver the desired level of reliability and to meet New England's climate objectives. "Something else" may be needed to ensure enough of the right kind of "iron-in-the-ground," but there was no agreement on what this other mechanism should be and under what authority it should be administered.

The question of who should carry the responsibility to "own" (or assure) resource adequacy was equally fraught. While some thought it should remain with ISO-NE, others thought responsibility should lie with the states and/or individual market participants.[8] Most Symposium participants concluded that it would be problematic, or at least present challenges, in New England if the six states did not share a common approach to resource adequacy. Many of the Symposium participants also expressed a desire for states to play a more active role in determining resource adequacy than they do today. Some suggested that the states should replace ISO-NE's resource adequacy role. There was little support for the idea that ISO-NE would become the "central planner," and there were only a few Symposium participants who advocated for eliminating ISO-NE's role in resource adequacy entirely. Potential resource adequacy mechanisms might include:

- Centralized planning/procurement at a state or regional level (see comments of Paul Joskow and Steve Corneli)
- Decentralized self-supply of resource adequacy (see comments of Bill Hogan and Rob Gramlich)
- Hybrid approaches (see comments of Sue Tierney)

Symposium participants agreed that resolving the resource adequacy question will be essential for long-term market success. The uncertainty about preferred courses of action suggest that this topic will require careful examination as part of any wholesale market redesign.

ERCOT, PPAS, AND DECENTRALIZED RA

ERCOT's unique "energy-only" market foregoes a formal capacity market, and relies on energy price signals alone for both hourly operation and long-term investment. ERCOT's implementation of Scarcity Pricing means that while energy prices are generally low (approximately $35/MWh), during periods of system tightness they can rise all the way to $9,000/MWh. These price spikes are essential to a well-functioning energy-only market, because they signal scarcity and provide revenues that can attract new investments, but they also cause volatility that most customers want to avoid.

To reduce their exposure to this price risk, Retail Electric Providers ("REPs") hedge by procuring power through PPAs on behalf of their retail customers. The PPA locks in prices for consumers (increasing predictability) and helps finance new generation (by providing guaranteed revenue to developers).

These PPAs are the principal mechanism to ensure resource adequacy in ERCOT.

8 Note that in the legal and public policy literature the question of who "owns" resource adequacy often relates to the question of federal/state jurisdiction. Symposium participants focused less on these jurisdictional divides and more on what mechanisms are used to induce resources to be available to the system when it needs electricity supply to satisfy demand at any point in time.

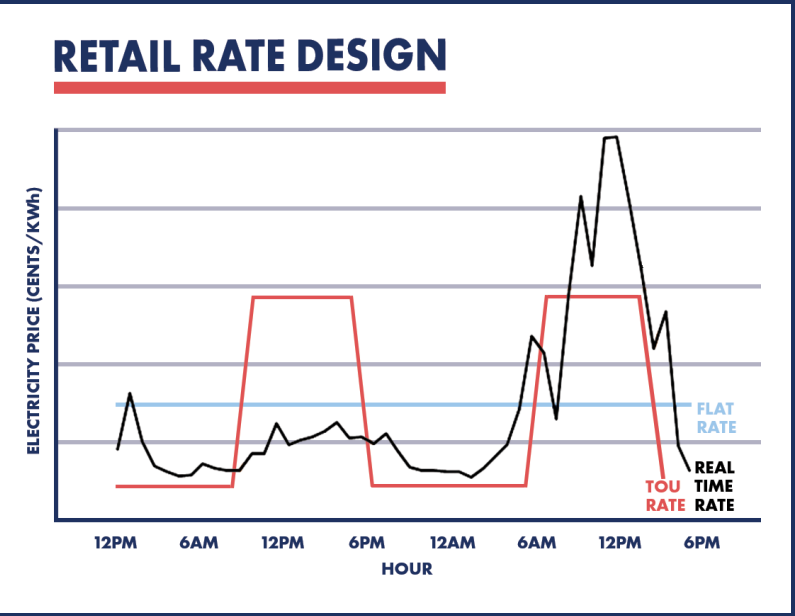
Actions Outside the Wholesale Market

Symposium participants held different views about how states should exercise their policy preferences on matters that affect the performance of wholesale markets. Although it was broadly acknowledged that individual states will continue to implement their own energy and environmental policies (e.g., renewable portfolio standards, clean energy standards, technology-specific contracts), some Symposium participants argued that those state policies must be designed so as to harmonize with efficient wholesale market designs while other participants observed that wholesale markets need to be structured so that they can account for variation in state programs.

Separately, Symposium participants agreed that the states must significantly increase the integration of wholesale and retail markets and suggested that dynamic retail tariffs should and will play a key role in accomplishing that. Real-time (i.e., dynamic) retail tariffs can mobilize flexible demand. There was broad consensus that these tariffs, in some form, will need to become more prevalent in New England in the decarbonized end-state, with some support for the idea that real-time tariffs should become mandatory for at least certain customers and loads.

Even though energy prices in wholesale electricity markets change every five minutes, most residential retail customers pay a constant, flat rate (blue line). Flat rates limit customer confusion, but obscure hour-to-hour volatility and blunt the economic incentive to shift usage to lower cost periods.

Other retail rate structures better reflect wholesale energy costs. For example, time-of-use rates (orange line) charge customers based on when use occurs during predefined peak and off-peak periods that reflect average energy costs during periods of higher and lower system use. Real-time rates (black line) vary with the real-time price of electricity in the wholesale electricity market, and provide customers with accurate price signals (but also expose them to increased price volatility).



There was general support for the idea that both time- and locational-based retail pricing will be necessary, to whatever level of geographical granularity is technically feasible and consistent with principles of fairness. There was also recognition of the threat of a fragmented set of incompatible state retail tariff regimes. States can be expected to take different approaches to issues such as protecting vulnerable consumers and regulating retailers' risk management practices and financial health. There was acknowledgement of the importance of coordination among the states on this issue given that retail tariff design is and will remain exclusively the purview of the states.

AFTERNOON SESSION: TRANSITIONING TO A LOW/NO-CARBON FUTURE

SPEAKERS

The afternoon session addressed the challenge of facilitating the transition to a low/no-carbon energy system. The panel included four leading experts on the integration of increasing amounts of zero-carbon resources into legacy power systems.[9]

- **Dr. Robert Stoddard** (Charles River Associates and Power Market Economics, LLC) offered tepid support for today's FCM and spoke favorably of the forward clean energy market concept ("FCEM"), where a FCEM would procure megawatt-hours of clean energy on a forward basis, or a combined market which simultaneously procures megawatts of capacity and megawatt-hours of clean energy. He focused on the urgency of effective regional coordination and voiced concern that if a market solution is not found, states would return to the sorts of central resource planning and state-backed investment favored before the electric industry was restructured in New England.

- **Dr. Karen Palmer** (Resources for the Future) argued that carbon pricing is a critical decarbonization tool, but likely insufficient to facilitate state goals by itself. Separately, she suggested that resource flexibility, including a more price-responsive demand curve, will become more important than the traditional concept of resource adequacy.

- **Abigail Krich** (Boreas Renewables, LLC) emphasized the need to remove barriers in the existing ISO-NE market design to accelerate the transition to a decarbonized New England energy system. She focused on shortcomings of the FCM and argued that the capacity market is the biggest impediment to a rapid transition. Her recommendation was to dramatically redesign the centralized (ISO-controlled) investment market model and, in the meantime or in the absence of that redesign, to continue with state-administered programs of long-term power purchase agreements for resources needed to achieve an optimized (clean) regional resource mix.

- **Peter Fuller** (Autumn Lane Energy Consulting, LLC) broadly supported the existing market paradigm, but thought it should be enhanced to ensure participation by renewable energy, storage, demand flexibility, and flexible dispatchable (thermal) generation. Mr. Fuller's recommended policy initiatives included (1) economy-wide greenhouse gas emissions pricing; (2) a FCEM-style market; and (3) the development and deployment of real-time retail rate designs to realize the potential of flexible demand.

BREAK-OUT SESSIONS

The afternoon break-out sessions focused on methods for achieving aspects of the decarbonized end-state market that had garnered broad support in the morning break-out session. To guide the discussion, each group was asked to comment on: (1) the most important transitional steps; (2) who should do what, when; and (3) priorities.

9 Summaries of the speakers' presentations are provided in Appendix 4.

The AGO's summary of these discussions follows below, and observes that, like the morning session, most Symposium participants agreed on issues related to the energy market, ancillary services, and carbon pricing, with little consensus on issues relating to resource adequacy.

The Region Should Implement More Effective Scarcity Pricing

Symposium participants widely supported the view that ISO-NE should raise its energy market price caps and adopt more effective New England-tailored administrative scarcity pricing, soon. Many participants observed that this was a necessary measure regardless of whether the decarbonized end state relied on a decentralized or centralized procurement model. Some participants argued that scarcity pricing could be implemented with more ease than revisions to the FCM.

One early step to modify today's market design to ensure a low/no-carbon market by 2050 would be to reform or replace ISO-NE's existing scarcity pricing mechanism (the Reserve Constraint Pricing Factor or "RCPF") to bring it more into line with the shape and magnitude of the reserve shortage pricing mechanisms currently in operation in ERCOT and recently proposed in PJM.

The Region Should Quickly Implement Meaningful Regional Carbon Pricing

There was strong support among Symposium participants for moving quickly to implement some form of regional carbon pricing that has materially higher prices so that it is in line with the region's clean energy goals. Current carbon pricing schemes in the region, such as the RGGI, are a good start, but have prices which are too low to meaningfully change the resource mix. Where RGGI prices are generally below $10/ton, participants discussed near-term carbon pricing at $50/ton or higher. Some Symposium participants suggested that NYISO's proposed carbon pricing scheme could provide a template for ISO-NE's markets.

There was almost equally strong support for extending coordinated or harmonized carbon pricing mechanisms beyond the power sector and into other sectors of the region's economy as quickly as possible, in part to remove barriers to beneficial electrification in those sectors. However, many participants expressed the view that carbon pricing alone will not be enough in the transition to achieve the outcomes anticipated for a low/no-carbon economy or power system.

Resource Adequacy Is the Most Difficult Issue to Tackle

Some participants proposed that the states should undertake a study to envision what the end state energy system might look like in New England. There was also some support for a state-led fresh look to determine the appropriate resource adequacy mechanism for the region, especially in light of the urgency regarding retirement and replacement of legacy fossil and nuclear generation. Participants also noted, however, that ISO-NE's expertise and the cross-region perspective would be needed to implement any new or modified mechanism.

While most argued that the FCM should be phased out in the long-run, opinion was varied as to whether it made sense to maintain, reform, or replace the FCM in the short-run. There was strong support for the view that on-going disputes over ISO-NE's Minimum Offer Price Rule, demand participation, and efficiency demonstrate that the FCM will continue to hinder retirement of surplus or poorly adapted thermal generation and unreasonably advantage central-station supply-side solutions over other, other solutions which may be cleaner, more flexible, and lower cost. Others argued that the FCM could be phased out and resource adequacy could be ensured using a backstop solution (such as Reliability Must Run agreements). A Forward Clean Energy Market that

would be co-optimized with a forward market for capacity was also mentioned in the discussions as a possible transitional market measure. This combined market would simultaneously procure megawatts of capacity and megawatt-hours of clean energy.

There was wide, if not universal, agreement among Symposium participants that state clean energy procurement policies will continue to be an important part of the regional picture during the transition. Many felt that better coordination of those policies among the states will be important regardless of the resource adequacy pathway pursued. There was considerable discussion about the state policy measures that will be needed to drive replacement of legacy high-carbon resources at the pace needed for the transition, beyond what a sufficiently reformed market would achieve. Some participants expressed skepticism about the likelihood of coordinated policies among the New England states. Some expressed the view that, absent some amount of central planning and procurement, no amount of energy market reform or carbon pricing will be sufficient to bring the technologies needed in the transition and the end-state market forward in a timely manner.

Retail Pricing Must Become More Dynamic

Many Symposium participants voiced strong support for accelerating the deployment of technologies to realize the potential of flexible demand (e.g., through interval metering, grid modernization, smart EV charging, expanded broadband service). Many participants observed that time-of-use or real-time tariffs are important for sending the right price signals to help unleash flexible demand. Participants proposed focusing in the near term on particular customer segments, including EV customers, where efficacy and capacity will be highest, as a way of proving the concept before expanding its reach.

AGO'S CONCLUSIONS AND PROPOSED NEXT STEPS[10]

New England's competitive wholesale electricity markets were designed for and implemented in an electric grid dominated by large coal, nuclear, and natural gas power plants. Today, that regional electricity mix is evolving rapidly. New resources that emit no carbon and with different operating characteristics than those legacy thermal facilities are playing an ever increasing role in supplying electricity to the region. There is no doubt that this trend will continue at an accelerated pace. Our wholesale electricity markets must be ready to support this wide scale deployment of low/no-carbon resources as well as the decarbonization of the heating and transportation sectors.

The AGO agrees with Symposium participants that the wholesale markets as they are structured today will not support our future needs. Market modernization is needed now to bring wholesale market design into alignment with the reality of the region's evolving electric generation mix and state laws requiring carbon reduction from the electricity sector. The ancillary services and energy markets must continue to evolve to reflect the increase in intermittent generation and the need for flexibility services. Addressing carbon pricing and resource adequacy requires further regional discussion and decision-making. Below are some potential next steps the AGO has identified to help advance this effort.

10 The conclusions and next step recommendations in this section were developed by the AGO based on the Symposium—but were not developed at the Symposium or vetted by the Symposium participants. The AGO recognizes that these recommended actions are among many ideas for advancing the regional discussion and looks forward to participating in any discussion/forum designed to determine and implement the best path forward.

WHOLESALE & RETAIL MARKETS COORDINATION

The AGO agrees with Symposium participants that the retail and wholesale markets should work together to advance real-time coordination between variable supply and flexible demand. Proposed next steps in furtherance of these goals include:

- ISO-NE and NEPOOL should study options for improved scarcity pricing in the energy market to provide more robust price signals and facilitate demand participation.

- State public utility commissions should adopt policies that allow for time of use rates or other dynamic retail tariff options and advance enabling technologies such as advanced metering functionality, grid modernization, and smart EV charging.

RESOURCE ADEQUACY

The AGO agrees with Symposium participants that the FCM as designed today is not compatible with the region's future electric-system needs. Given the Symposium discussions that revealed varying views regarding the best techniques, tools, or markets to ensure resource adequacy going forward, considerably more work on this topic is warranted. Many Symposium participants emphasized the need to move forward with a resource adequacy discussion as soon as possible. Many commented that a productive regional discussion requires the New England states to provide guidance on the threshold question of who should define and deliver resource adequacy (ISO-NE, states, market participants, other entity, or some hybrid). Some participants noted that the states need not wait for any in-depth study on how a wholesale market solution might be designed or implemented to answer this threshold question.

Against this backdrop, potential next steps include:

- In 2020, the states should work collaboratively to address and attempt to answer the threshold question of who, going forward, should define and deliver resource adequacy that aligns with state clean energy policies and goals. This process could take varying forms. For instance, the states could convene a small advisory task force of state representatives and representative stakeholders to inform and assist in resolving this question. The states could commission a study outlining different approaches to resource adequacy, including approaches that have been applied in different parts of the country (ERCOT, MISO, NYISO, CAISO), and the relative risks and costs for market participants.

- Because time is of the essence, while the states consider the threshold question, NEPOOL/ ISO-NE should commence the process to consider possible wholesale market frameworks that are compatible with the implementation of state energy and environmental laws, as outlined in NESCOE's July 16, 2019 letter to ISO-NE.[11] This process could be assisted by an independent facilitator dedicated to ensuring an efficient and productive process.

11 New England States Committee on Electricity, "Memo to ISO-NE Requesting Resources and Analysis in 2020 Work Plan", July 2019. http://nescoe.com/resource-center/2020-workplan-jul2019/.

CARBON PRICING

Symposium participants broadly supported meaningful regional carbon pricing, but had differing opinions on the appropriate scope, required price, and implementation. Next steps to advance this effort include:

- Building on the region's success with RGGI and its current work on the Transportation and Climate Initiative, the New England states should convene a regional task force to consider tools for achieving the states' emissions reductions mandates, including the expanded use of carbon pricing.

- To ensure that the burden of carbon-pricing policies is shared equitably across all communities, the AGO will review existing studies and, if warranted, form a task force to consider the relative socio-economic and geographic impact of expanding the use of carbon pricing/budget in New England.

EDUCATION AND PUBLIC PARTICIPATION

Finally, the AGO emphasizes that resolving these issues will require the input and support of both traditional stakeholders and the broader public, including grass root advocates, academics, elected officials, and the upcoming generation of young people who are passionate about addressing climate change. As the Massachusetts ratepayer advocate charged with representing Massachusetts customers on these matters, it is particularly important to AG Healey that the public have opportunities to express their views on these matters. In furtherance of these priorities, the AGO will:

- Host a "teach-in" that will provide opportunities for the public to learn about these important issues and to express their views.

- Meet with elected officials to discuss the benefits of addressing these issues expeditiously, relative to inaction.

- Provide educational opportunities to enhance the knowledge of young people and other concerned citizens about New England electrical grid and its relationship to the states' climate policies.

- Continue to work with the region's other consumer advocates and attorneys general to ensure that consumer voices throughout the region are heard.

APPENDIX 1: SYMPOSIUM AGENDA

Massachusetts Office of the Attorney General Symposium: Wholesale Market Design in a Low/No-Carbon Electricity System: Visions for the Future and How to Get There

Federal Reserve Bank
600 Atlantic Ave, 3rd floor Boston, MA
October 24, 2019, 8:45 a.m. – 6:00 p.m.

Objective: Learn about and discuss the best long-term wholesale electricity market design options to support New England's sustainable clean energy and climate goals and requirements, while ensuring reliability and reasonable electricity costs for customers.

AGENDA

8:45–9:15 **Check-in, coffee & continental breakfast**

9:15–9:30 **Welcome**
Introductory Remarks: Attorney General Maura Healey
Strategy for Day: Facilitator: Dr. Jonathan Raab, Raab Associates

9:30–11:00 **Panel One: Long-Term Wholesale Market Design Vision**

Dr. Paul Joskow, Massachusetts Institute of Technology
Dr. William Hogan, Harvard Kennedy School
Dr. Susan Tierney, Analysis Group
Rob Gramlich, Grid Strategies, LLC
Steven Corneli, Strategies for Clean Energy Innovation

What wholesale market design construct(s) in 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)?

- Will capacity markets (or another resource adequacy mechanism) still be needed in the long-term?
- Will there be a need to price carbon once we are in an electricity system comprised exclusively of renewables and other zero/very low carbon resources (or only during the transition to that end state)?
- How does your proposal respond to system changes such as: a) a significant increase in electricity demand due to electrification of buildings and transportation; and b) the rise of distributed energy resources?

11:00–12:15	**Facilitated working groups** (3 groups of 10-12 people)
12:15–12:45	**Report out/Full-group discussion**
12:45–1:15	**Lunch**
1:15–2:45	**Panel Two: Achieving the Vision; An Effective Transition—What Needs to Happen When** Dr. Robert Stoddard, Charles River Associates Dr. Karen Palmer, Resources for the Future Abigail Krich, Boreas Renewables, LLC Peter Fuller, Autumn Lane Energy Consulting, LLC How do we effectively transition the wholesale markets (during which gas will likely still be needed) to ensure that we achieve the long-term vision(s) discussed in the morning? • What are the most significant things that need to happen to effectively transition our wholesale markets and when and by whom should they be done? • Will capacity markets (or another resource adequacy mechanism) still be needed during the transition? • Do we need to price carbon in the wholesale markets during this transition, and if so how?
2:45–4:00	**Facilitated working groups** (3 groups of 10-12 people)
4:00–4:30	**Report out/Full-group discussion**
4:30–4:45	**Closing remarks (AGO)**
5:00–6:00	**Post-symposium reception**

APPENDIX 2: BREAK-OUT GROUP DISCUSSION FORMAT

After both panel sessions, symposium participants were split into three pre-assigned, facilitated groups. Participants in each group met for 75 minutes to discuss their own perspectives on the future of wholesale markets. A note-taker recorded anonymous participant observations.

The mechanics of the break-out sessions called for each group to address four discussion categories that might affect their views about the design of a low-carbon wholesale market in New England:

1. Energy Markets;
2. Ancillary Services Markets;
3. Resource Adequacy; and
4. Actions outside of the wholesale markets (such as retail tariffs and state clean energy policies).

To facilitate the discussion, each group was provided with a matrix and discussion guide for each of these categories. For each category, the matrix provided a discussion guide:

1. discuss the end-state market visions presented by the panelists;
2. propose any substantially different visions;
3. compare the visions based on relative benefits/costs and feasibility/ease of implementation; and
4. determine areas of general consensus.

APPENDIX 3: PERSPECTIVES OF THE PANELISTS IN THE MORNING SESSION

DR. HOGAN: PRICE SIGNALS EMBEDDED IN WHOLESALE MARKETS WITH SCARCITY PRICING ARE FUNDAMENTALLY CORRECT

Dr. Hogan argued that a comprehensive rethinking of the market design is not required, but that operators in different ISOs must integrate best practices and focus on improving and extending existing market design. An affordable and reliable power system in the decarbonized end-state will require well-designed pricing mechanisms for energy and reserves, including a comprehensive scarcity pricing mechanism which reflects the value of reliability when reserves are low, along with an appropriate level of carbon pricing.

If we "get the prices right," then we can better elicit and reward demand participation and distributed energy resources. Given current uncertainty regarding the design of an actual decarbonized end state market, Dr. Hogan emphasized the importance of adaptability in the market design, and the efficacy of good energy and reserves market pricing in enhancing adaptability.

Dr. Hogan noted the shortcomings in historical price formation in most markets (including ISO-NE), due to inadequate price signals that, in turn, fail to drive efficient demand-side response to real-time market conditions. A primary failure in price formation is the failure to adequately account for the value of reserves during periods of system stress, and the failure to fully link the value of reserves to the value of energy. Dr. Hogan mentioned the efforts of market operators like the Electric Reliability

Council of Texas ("ERCOT") and, more recently, the PJM Interconnection ("PJM") to introduce administrative mechanisms designed to reflect marginal opportunity costs in energy prices in periods with shortages, as offering a path forward.

DR. JOSKOW: THE DECARBONIZED END-STATE MAY REQUIRE SIGNIFICANT OUT-OF-MARKET INVESTMENTS

Dr. Joskow suggested that zero-marginal cost resources will push our current markets to the brink, and doubted whether the "standard" RTO/ISO market design could support a long-run equilibrium with the required quantities of intermittent and dispatchable generation, as well as storage, consistent with close to one-hundred percent decarbonization of the electricity sector.

Dr. Joskow shared Dr. Hogan's basic market design philosophy for energy spot markets but was skeptical that these markets could provide sufficient revenue to drive investment in low/no-carbon generation and storage to meet the most aggressive decarbonization goals. He doubted whether capacity markets, predicated on assumptions of resource substitutability, dispatchability, and reasonably predictable demand patterns, could survive in a decarbonized end state with very high penetrations of grid-based wind and solar, as well as small scale distributed solar. The challenge is to deal effectively and efficiently with intermittency. Energy markets with scarcity pricing would be, in Dr. Joskow's view, more effective in supporting efficient investment in generation and storage and demand-side response than are current capacity market designs. He noted, however, that even the best-designed market would most likely not deliver the decarbonized end-state on its own. He expressed concern that the policy interventions that will be deployed to hasten the transition towards zero-carbon will lead to generation becoming heavily—and irreversibly—reliant on revenues from out-of-market contracts. He suggested that the end result may combine a command-and-control (rather than market-driven) investment framework with market-based generator dispatch.

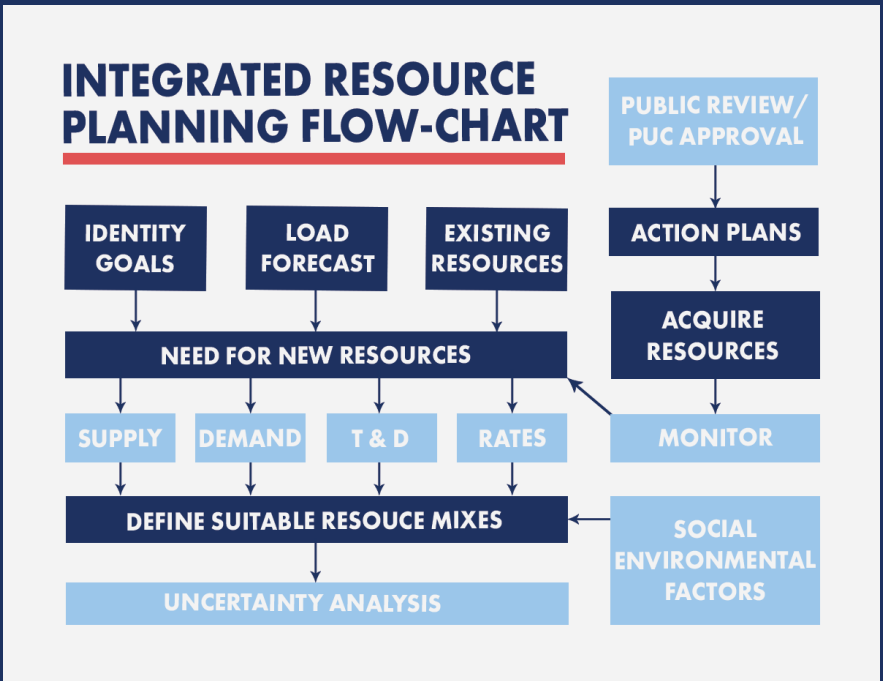
MR. GRAMLICH: RESOURCE ADEQUACY SHOULD BE ACHIEVED THROUGH DECENTRALIZED PROCUREMENTS

Mr. Gramlich largely agreed with Drs. Hogan and Joskow that a centralized spot market for energy and reserves will continue to provide for the efficient use of the system on an hour-to-hour basis, but thought that another tool will be necessary to ensure resource adequacy. He outlined four basic models for creating the necessary commitments, including (1) an ERCOT-like market with scarcity pricing and decentralized bilateral contracting (as described by Dr. Hogan); (2) a more centrally administered, Integrated Resource Plan-based investment market with little or no retail competition; (3) a market built around vertically-integrated utilities with the wholesale market serving largely to organize short-term resource deployment (e.g., MISO and Southwest Power Pool); and (4) the FCM model exemplified by markets like ISO-NE and PJM.

Of these options, Mr. Gramlich thought that resource adequacy could be best satisfied using decentralized forward procurements (i.e., bilaterals between market participants). In this approach, EDCs, competitive suppliers, large customers, and other parties would sign contracts with suppliers to hedge their market price risk. Unlike today's centralized market, however, each customer would enter into its own contracts based on their expected needs and risk tolerances.

While expressing his preference for shifting resource adequacy planning and procurement to market participants, Mr. Gramlich also proposed that, in such a scenario, state regulators would assume a greater role in setting and ensuring compliance with market objectives and participation requirements, including enforcement of minimum licensing standards for any entity seeking to serve retail customers, based on its financial capacity to manage the associated forward risks. Regulators also would need to continuously monitor and enforce supply- and buyer-side market power mitigation. He noted that all the options available for the end-state market rely on investors having access to contracts or comparable arrangements, coupled with the need to prevent free-riding by wholesale buyers.

Separately, Mr. Gramlich identified multiple shortcomings of the current FCM model, including the: (1) challenges it presents to the viability of many zero-carbon resources and flexible demand; and (2) way in which it inappropriately involves regional transmission operators and the FERC in the environmental policy business.



Integrated Resource Planning is conducted by a central authority (e.g. a state public utility commission) or a public utility to forecast annual peak and energy demand, then define suitable resource mixes or supply-side and demand-side resources to meet those needs.

Once resource needs have been established, those resources may be developed through a centralized auction, bilateral power-purchase agreements, or another procurement mechanism.

Adapted from Figure 1 in "Best Practices in Electric Utility Integrated Resource Planning," Regulatory Assistance Project, June 2013.

MR. CORNELI: RESOURCE ADEQUACY SHOULD BE ACHIEVED THROUGH CENTRALIZED PROCUREMENTS

Mr. Corneli shared Dr. Joskow's view that spot markets for energy alone, even the kind envisioned by Dr. Hogan, were unlikely to drive efficient levels of investment in low/no-carbon generation. To overcome this hurdle, Mr. Corneli envisioned a centralized planning/procurement process, combining integrated resource planning—enhanced to identify an efficient mix of variable renewable and other clean energy resources—with centralized procurement of the specific projects included in that efficient resource mix.

Under this framework, optimization models would be used by a central entity to identify least-cost clean energy resource mixes needed to balance regional reliability and affordability. Cost and performance data for the modeling and planning exercise would be based on bids submitted by resource owners and developers in a competitive procurement process. Long-term contracts would then be offered to those projects and resources identified as efficient through the planning process.

The planning and procurement process could be sponsored either by a single central buyer such as an ISO, or in a more decentralized manner by the various states in the region. Efficient state level planning and procurement, however, would require each state's energy plans and procurement goals to be informed by a collaborative approach to regional integrated energy modeling and planning. Multi-state coordination on high-level policy targets, operational analysis and procurement will be critical to minimize costly wasted investment, incompatible resource choices, and over-procurement.

DR. TIERNEY: THE UNIQUE CASE OF THE NEW ENGLAND END-STATE

Dr. Tierney shared Mr. Corneli's view that the current market paradigm could not be made to work under the conditions of the decarbonized end-state electric system, but her views differed from his and the other panelists in important ways. Dr. Tierney observed that New England is not Texas, noting that the differences between the two regions include a fundamentally different set of values regarding price volatility, security of supply, and the threat of market power abuse. Moreover, these value sets could differ even among the six New England states. This led Dr. Tierney to conclude not only that New England cannot rely on the existing paradigm to function well in the decarbonized end-state, but that some of the essential features of the proposed end-state alluded to by the other panelists—for example, robust scarcity pricing and widespread deployment of real-time retail tariffs—would not be politically feasible on a sustainable basis in the New England context.

Dr. Tierney sketched out a hybrid approach to resource adequacy, where states or suppliers might be responsible for provisioning most aspects of resource adequacy, but a central buyer would procure products or needs which are non-rationable or non-uniform. Dr. Tierney proposed segmenting responsibility for resource adequacy to reflect a more fragmented end state system, centralizing support for certain resources (presumably including demand-side investment and other distributed energy resources) which are needed for local reliability purposes under ISO-NE, and decentralizing the provision of system-wide resource adequacy through state-defined obligations placed on retail providers, all governed by state-based policy objectives.

She described one investment market option as being a centrally allocated system of contracts for-differences, combined with a short-term bid-based energy market. However, she suggested that the imperatives of market power mitigation in countless particular locations where certain resources do not operate frequently but are needed for reliability might drive a return to production-cost-based dispatch rather than offer-based dispatch.

APPENDIX 4: PERSPECTIVES OF THE PANELISTS IN THE AFTERNOON SESSION

DR. STODDARD: REGIONAL COORDINATION IS KEY

Dr. Stoddard's recommendations focused on the urgency of effective coordination across the region to drive the needed investment in zero-carbon resources. He noted that the region's comparatively small footprint and limited access to geographic and resource diversification placed a high premium on regional coordination and transmission planning. He extended this theme to the question of carbon pricing and how various resources will be treated in the region's clean energy targets. He suggested that a regional market designed to facilitate the transition would struggle to perform in the face of inconsistent definitions of "clean." He suggested that the only practical alternative to a coordinated regional market approach was a system of state-administered long-term contracts: in effect a return to pre-restructuring, which he felt would be a considerably more costly approach. He also focused on the need for wider deployment of enabling technologies and real-time retail tariffs to mobilize flexible demand and identified wider access to broadband service in the region as a key enabling technology. He offered tepid support for the FCM, noting that its shortcomings reflect the underlying problems in the markets for energy and ancillary services. While he felt it still served a purpose in the near term, he agreed that improving the energy and ancillary services market to address the growing importance of ensuring adequate supplies of energy in each hour of the year should be the focus, rather than ensuring adequate capacity only during the hours of peak demand. He described a FCEM, which would procure both megawatts of capacity and megawatt hours of clean energy, as a possible successor to the FCM.

DR. PALMER: CARBON PRICING IS IMPORTANT, BUT NOT THE ONLY COMPONENT OF THE DECARBONIZED END-STATE

Dr. Palmer's recommendations focused on various aspects of carbon pricing policy and the meaning of resource adequacy in a transition where demand flexibility will be crucial. She pointed to the emerging New York strategy on carbon as a possible model, noting the relatively strong price signal (projected at $63 per ton (nominal) in 2025) combined with a focus on equitable distribution of costs and benefits among all ratepayers and communities. However, she emphasized that, even at this level, a carbon price alone is unlikely to be sufficient to drive the transition at the rate needed to achieve state and regional climate objectives. To the extent the carbon pricing regime falls short of what is needed to meet state goals, strengthened renewable portfolio standards, clean energy standards, or long-term PPAs will be required as companion policies.

Dr. Palmer emphasized the importance of enabling technologies in expanding the role of temporal and locational differences in the cost of electricity. Like Dr. Stoddard, Dr. Palmer also emphasized the need for expanded broadband internet access (to communicate with meters) along with more aggressive deployment of interval metering technology and real-time retail tariffs. She noted that, in the transition, resource flexibility, including a more price-responsive demand curve, will become more important than the traditional concept of resource adequacy. Given the intermittent nature of many low-carbon resources, having demand that could ramp up or ramp down based on available supply as signaled by time varying market prices would make it easier to keep supply and demand in constant balance. New sources of electricity load, such as electric vehicle charging and electric

space and water heating could be particularly amenable to time shifting given their inherent energy storage capabilities. Dr. Palmer's recommendations focused on various aspects of carbon pricing policy and the meaning of resource adequacy in a transition where demand flexibility will be crucial.

MS. KRICH: THE FCM'S SHORTCOMINGS AND THE NEED FOR AN ACCELERATED TRANSITION SUPPORTED BY STATE PROCUREMENTS

Ms. Krich emphasized the need to remove barriers in the existing ISO-NE market design to accelerate the transition to a decarbonized New England energy system. She focused on shortcomings of the FCM and argued that the capacity market is the biggest impediment to a rapid transition. She described how the FCM can provide sufficient revenue confidence for the financing of low capital cost gas-fired generation but not for high capital cost clean energy resources. States facing a market that externalizes or understates the cost of carbon-emitting resources are forced to rectify this through state policy-driven incentives for forward contracting. In response, ISO-NE seeks to nullify these state measures through its Minimum Offer Pricing Rule ("MOPR"). This dynamic artificially entrenches the position of both existing and new gas-fired generation in the market, whether or not they are needed for reliability or represent the least-cost option. In addition to the MOPR she listed several other structural inequities in the way the capacity market treats intermittent renewables relative to thermal generation, but concluded that no amount of incremental changes to fix these issues could be expected to fix the problem of the ISO-NE's markets failing to provide a financeable revenue stream to clean energy resources. She stated that an improved energy and reserves market and carbon pricing will be insufficient to provide clean resources with a level of revenue confidence comparable to that of thermal generators. Her recommendation was to replace the FCM with a market design that can make least-cost clean energy resources financeable while ensuring a sufficient probability of meeting demand in all hours of the year. Absent such a market redesign, or in the meantime, state-administered programs of long-term power purchase agreements are the best way to ensure the addition of resources needed to achieve an low-carbon and economically efficient regional resource mix.

MR. FULLER: CHANGING THE EXISTING MARKET TO ENSURE A SUCCESSFUL TRANSITION

Mr. Fuller supported the existing market paradigm, with incremental design improvements, the addition of an explicit clean energy requirement in the wholesale market plus other policy and market design improvements. Mr. Fuller described the four products necessary for successfully serving demand in the future: renewable energy as the primary source of electric energy, storage, demand flexibility to time-shift and balance supply and demand, and flexible dispatchable (thermal) generation to fill in remaining gaps. Mr. Fuller's recommended policy initiatives included economy-wide greenhouse gas emissions pricing and aggressive electrification of transport and heat, the latter representing an opportunity both to drive new clean investment through demand growth and to add large flexible end-uses to the demand portfolio. He noted that the New York proposal to apply carbon prices only to the price of electricity may create a barrier to electrification. On market design, he emphasized improved energy and reserves market price formation, including enhanced scarcity pricing, to reveal the value of needed existing and new flexibility services. He also recommended deployment of real-time retail rate designs, where appropriate, to realize the potential of flexible

demand. Finally, he proposed to retain the FCM as a vehicle for ensuring a given level of resource adequacy, but to modify it by adding a co-optimized FCEM. The goal would be to introduce into the wholesale markets the specific objectives of state energy policies (decarbonized electric energy supply) and achieve an efficient balance between the two objectives of clean energy investment and resource adequacy.

GLOSSARY

Ancillary Services. Services provided to the Bulk Power System to maintain reliability and power quality, including load regulation, spinning reserves, non-spinning reserves, replacement reserves, and voltage support.

Bulk Power System. The interconnected electrical system responsible for producing and transmitting electrical energy within a region, generally operated at 69 kV or higher, including generation resources, transmission facilities, tie lines with neighboring systems, and other associated equipment used to produce electric energy.

Capacity. The maximum output an electricity generator can physically produce without exceeding manufacturer design limits, measured in megawatts (MW). Resource capacity may be derated in Capacity Markets (cf. FCM) to reflect expected output during peak periods or adjusted to reflect lower potential output due to ambient weather conditions.

Carbon Pricing. Pricing regime that sets a price on carbon pollution (or the carbon content of fossil fuels) and incorporates that amount into the cost of goods sold. In power markets, carbon pricing may be implemented using a cap-and-trade system such as RGGI, or carbon tax.

Clean Energy Standard ("CES"). Policies and or legislative mandates requiring public utilities or retail electricity suppliers to procure a fixed or increasing amount of electricity used to serve retail load from non-carbon emitting resources, similar to an RPS. Unlike an RPS, however, a CES would allow a public utility or retail supplier of electricity to meet its CES requirements by procurement of zero-carbon resources that may not satisfy RPS renewable requirements, such as nuclear or large-scale hydropower.

Dispatchable Generation. A generation resource (e.g., nuclear, natural gas, large-scale hydropower, energy storage) that is available to serve customer load, on-demand and at the request of an ISO/RTO. Demand response can be a dispatchable resource comparable to generation.

Distributed Energy Resources. Resources located at places connected to the distribution system that can provide energy supply, storage energy for later use, or avoid energy demand. Non-exhaustive list of examples include: rooftop PV system; utility-scale solar facilities; electric batteries; small-scale wind; dispatchable or flexible electric loads in buildings; small-scale cogeneration systems; energy efficiency measures; electric vehicle charging stations.

Electric Reliability Council of Texas ("ERCOT"). The RTO for most of Texas.

Energy. The actual amount of electricity that a generation resource produces over a specific period of time.

Federal Energy Regulatory Commission ("FERC"). Federal regulatory agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, oil pipeline rates, and gas pipeline certification.

Flexible Demand. A demand resource with the ability to reduce or increase load in response to a request by an ISO/RTO, a demand aggregator, or a price signal.

Flexibility Services. Products such as ultra-fast response and ramping services, used to maintain operational reliability and grid stability of a renewables-heavy bulk power system. Flexibility resources may include rapid responding generation, flexible demand, and energy storage.

Forward Capacity Market ("FCM"). A forward, auction-based market that allows an ISO to secure future commitments from generation resources to supply energy to the Bulk Power System, to better ensure resources to meet future demand for electricity. In New England, the ISO administers an annual FCM auction, in which generation resources bid to obtain a commitment to supply energy during a future, three-year capacity period, in exchange for a market-based payment. During the relevant capacity period, each generator holding a capacity supply obligation must be available to provide energy to meet system demand as necessary, when called upon by ISO-NE.

Forward Clean Energy Market ("FCEM"). Forward market for clean or renewable energy that would procure megawatt-hours of clean energy through a centralized procurement.

Grid Modernization. Regulatory and legislative actions to achieve a more resilient, responsive, and interactive electric distribution system.

Independent System Operator ("ISO")/Regional Transmission Operator ("RTO"). Independent, regional entities regulated by FERC to oversee the non-discriminatory coordination of electricity on the Bulk Power Systems to maintain system safety and reliability, administer the wholesale electricity market in a given region of the U.S., ensure open access to transmission lines.

Inframarginal Resource. A resource dispatched for energy, but which is not setting the market price. Inframarginal resources generally have low marginal costs and can recover a portion of their fixed costs through inframarginal rent (the difference between the market's price and the resource's marginal cost of generation).

Integrated Resource Plan ("IRP"). A plan by a state or public utility to ensure that it has sufficient resources to meet its forecasted annual peak and energy demands, over a specified timeframe. An IRP may serve as a tool to ensure resource adequacy.

Interval Metering Technology. Metering equipment technology capable of measuring customer electricity usage at regular and more frequent intervals (e.g., 15, 30, or 60 minutes) than traditional customer meters, which typically measure customer usage only on a monthly basis.

ISO New England ("ISO-NE"). The RTO for the six New England states.

Midcontinent Independent System Operator ("MISO"). The RTO for all or part of fifteen States in the midwestern United States, and the Canadian Province of Manitoba.

PJM Interconnection. The RTO for all or part of 13 Mid-Atlantic and Midwestern states, and the District of Columbia.

Power Purchase Agreement ("PPA"). Contract, under which a generation resource agrees to provide power to the buyer for a set term at a set price.

Real-time Retail Rate. Retail customer rate that varies to reflect real-time pricing in the wholesale electricity market.

Regional Greenhouse Gas Initiative ("RGGI"). Regional cap-and-trade program intended to reduce carbon emissions, in which participating states in the northeastern U.S., including all of New England, establish a regional cap on carbon emissions, and prohibit facility-specific carbon-emissions in excess of each facility's amount of tradable emissions allowances, obtained through competitive auction. Proceeds from emissions allowance auctions allow for investment in related areas including energy efficiency, customer bill assistance, and clean energy resources.

Renewable Portfolio Standards ("RPS"). Policies and/or legislative mandates requiring electric public utilities and retail suppliers, as applicable, to procure a certain percentage of retail electricity sales from renewable resources, such as wind and solar. RPS may be subject to incremental increases over time and may include carve-outs for particular renewable energy technologies.

Reserve Constraint Penalty Factor ("RCPF"). The maximum price ISO-NE will charge for operating reserves. When the system is deficient on reserves, reserve prices hit their RCPF. The purpose of the RCPF is to provide a price signal to the marketplace that resources are scarce, such that generation resources increase supply and that price-responsive customers reduce demand.

Resource Adequacy. Measures to ensure the bulk power system's ability to meet aggregate load requirements including demand, losses on the system, and reserve margins.

Restructuring. Regulatory and legal process intended to increase competition in the wholesale and retail electricity markets, by which a vertically-integrated utility divests itself of some or all generation resources, typically pursuant to legislative act. Subsequent to restructuring, the public utility owns and operates the transmission and distribution system used to serve customer need within a service territory, and purchases necessary electricity from the wholesale electricity market or through contracts with suppliers or owners of generation resources. Retail customers may also contract for supply of electricity through third-party suppliers. In the 1990s, each of the New England states implemented some form of electric industry restructuring, except for Vermont.

Scarcity Pricing. In the wholesale electricity market context, scarcity pricing generally refers to pricing schemes which increase the price of power as reserves are diminished and the system becomes "tight," as a method to more accurately reflect the increased value of electricity during such periods. In some wholesale electricity markets, scarcity pricing is implemented in the form of specific price adders that are assessed when the system reaches predefined levels of tightness. In others, scarcity pricing is developed using a continuous curve with prices ranging from zero to the "value of lost load" (i.e., the value of avoiding curtailments of firm load).

Southwest Power Pool ("SPP"). The RTO for all or part of fourteen states in the central United States.

Time-Of-Use Rates ("TOU" Rates). A retail rate that may vary to reflect the time of day, season, and/or day type (weekday or weekend). TOU Rates are set in advance by the responsible regulatory authority, and unlike pricing under a real-time retail rate, do not vary to reflect real-time pricing.

Intermittent Generation. Generation resource (e.g., solar, wind, run-of-river hydro) that may not be dispatchable on-demand and at the request of an ISO/RTO to meet customer load, due to intermittency (e.g., lack of wind or sunlight).

Vertically-Integrated Utility. A public utility that owns and controls all generation, transmission, and distribution system components used to serve customers within a service territory.

Wholesale Electricity Market. Centralized, ISO-run market for the purchase and sale of electricity from electric-generating resources to public utilities and retail suppliers.