EJM

White Paper

Electricity Market Design for a Low-Carbon Future

Wholesale Market Design Solutions for PJM and Other Markets

September 2021

Exelon Corporation asked EJM Associates to lead a dialogue to identify solutions, hear from a broad suite of stakeholders, and—if possible—approach consensus for wholesale electricity market reforms needed to accommodate a transition to a clean, low- to no-carbon future. This white paper reflects, in part, discussions from two stakeholder workshops conducted under the Chatham House Rule. While the authors have attempted to accurately capture areas of significant agreement among participants, these observations are not meant to reflect complete consensus. Participation in the workshop does not imply that the host, organizer, or individual participants endorse any of the event's conclusions and outcomes.

ABOUT EJM ASSOCIATES

EJM Associates is a strategic consulting firm based in Washington, D.C. founded by former Secretary of Energy Ernest J. Moniz. It offers real-world solutions on energy policy, geopolitical risk assessment and systems innovation. EJM's leaders are respected across the political divide for developing government policies in partnership with industry and academia to propel innovation and attract transformative energy investment.

ABOUT EXELON CORPORATION

Exelon Corporation is a Fortune 100 energy company with the largest number of electricity and natural gas customers in the U.S. Exelon does business in 48 states, the District of Columbia and Canada and had 2020 revenue of $33 billion. Exelon serves approximately 10 million customers in Delaware, the District of Columbia, Illinois, Maryland, New Jersey and Pennsylvania through its Atlantic City Electric, BGE, ComEd, Delmarva Power, PECO and Pepco subsidiaries. Exelon is one of the largest competitive U.S. power generators, with more than 31,000 megawatts of nuclear, gas, wind, solar and hydroelectric generating capacity comprising one of the nation's cleanest and lowest-cost power generation fleets. The company's Constellation business unit provides energy products and services to approximately 2 million residential, public sector and business customers, including three-fourths of the Fortune 100.

Table of Contents

Summary

Across much of the United States, buyers and sellers of electricity conduct their transactions in wholesale electricity markets based on rules established by the market administrators: Regional Transmission Organizations (RTOs) or Independent System Operators (ISOs). These markets are critical for facilitating the entry, retention, and exit of resources to assure that a cost-effective, reliable transmission system operates in a technology-neutral manner.

Current electricity market designs have been relatively well-suited to the technical characteristics of generation technologies and the policy requirements of the past. In the two decades since their inception, though, wholesale electricity markets have not sufficiently evolved to assure continued achievement of their original mission in the context of new technologies and policy priorities.

Looking forward, several factors are upending historic assumptions underpinning today's market designs. They include the pace and scale of needed future emissions reductions, the proliferation of intermittent generation with zero marginal cost, the growing role of the grid as sectors of the economy increasingly use and rely on electricity, and concerns about cybersecurity and climate resilience. These new circumstances warrant a new look at electricity market design.

The need to take a fresh look at market design is not lost on the sector's regulators, policymakers, market participants, and advocates. Stakeholders across the country—especially in the New York, Mid-Atlantic, and New England regions—are exploring options to improve the design and function of their markets. Several exciting ideas have already emerged. Additional discussion is urgently needed to create the consensus required to translate viable ideas into practice.

To advance this dialogue, the Exelon Corporation asked EJM Associates to convene two workshops that would engage a broad range of stakeholders. The purposes of the workshops were to collaboratively develop a set of fundamental principles that wholesale power markets should be designed to achieve (see "Workshop 1" section below); to establish guideposts for evaluating market reform proposals (see "Workshop 2" section below); and to evaluate current and proposed market designs against these principles and identify market designs most compatible with present and future circumstances for the region encompassing the PJM Interconnection (see "Workshop 2" section below).

The workshops were held in December 2019 and April 2021. Participants brought a broad range of expertise and perspectives on organized wholesale markets across the United States, with professional backgrounds that included: supply-side market participants (i.e.,

electricity generators); consumer advocates; ISO/RTO operators; trade associations; public power entities; the Federal Energy Regulatory Commission (FERC); state public utility commissions; and environmental non-governmental organizations.

The path ahead for wholesale electricity markets must be defined rapidly, decisively, and collaboratively. While no specific reform proposals emerged during the workshops as a clear consensus choice for the PJM Interconnection region, several market design elements discussed in this report achieved broad support from workshop participants. It will be crucially important to consider these design elements in future market reform conversations within PJM, at the FERC, and elsewhere. Continued dialogue informed by the insights in this report will be instrumental to preparing the PJM market for the decades ahead.

Workshop 1

MARKET DESIGN PRINCIPLES

Workshop participants collaboratively developed several principles that wholesale power markets should be designed to achieve:

1. Accommodate public policy objectives—especially the ambitious pace and scale of carbon reduction targets—or facilitate achieving public policy objectives at the request of and in coordination with subnational governments (e.g., establishment of a CO_2 price by NYISO).
2. Achieve market objectives in an environment with high proportions of zero-fuel cost resources.
3. Maintain affordability.
4. Promote competition and its cost-reducing benefits, which include mitigating market power.
5. Efficiently allocate risk among market participants.
6. Enable demand-side flexibility and encourage demand-side participation.
7. Allow supply and demand-side resource procurement based on attributes sought by specific customer segments (e.g., corporate procurement, green tariffs).
8. Ensure technology-neutral product definitions and market rules to the extent possible.
9. Coordinate effectively with retail markets.
10. Coordinate efficiently with neighboring regions.
11. Enable electricity consumers to make individualized tradeoffs between cost and reliability.
12. Incorporate externalities into market outcomes through market-efficient means (e.g., carbon pricing).

Workshop 2

CRITICAL QUESTIONS FOR EVALUATING MARKET REFORM PROPOSALS

Workshop participants identified guideposts for developing market reforms that would be timely, enduring, and compatible with long-term changes in the power sector. These guideposts can be framed as a set of key questions for examining market reform proposals and assessing their compatibility with the above-mentioned Market Design Principles for wholesale power markets.

1. How does the proposal accommodate the diversity of state clean energy policies?
2. How does the proposal improve on today's resource adequacy approach as technology, costs, and risks evolve?
3. How does the proposal support innovation and reduce barriers to the adoption of innovative technologies?
4. How does the proposal enable transparent, voluntary, and bilateral markets among many buyers and sellers?
5. How could the simplicity and transparency of the proposal garner stakeholder confidence in market outcomes?
6. How could the proposal be implemented quickly given the rapid pace of emissions reductions being set as targets by policymakers?

PROMISING MARKET REFORMS FOR PJM

Several market reform proposals evaluated by workshop participants emerged as promising options for PJM. They were judged to be realistic to implement in the near-term and to align with the core Market Design Principles:

- CO_2 Price or Clean Energy Standard
- Capacity as a Commodity
- Forward Clean Energy Market
- Integrated Clean Capacity Market

Evolving Characteristics of the Power Sector

The technologies, policies, and economic realities facing organized wholesale electricity markets have evolved greatly over the past two decades, warranting a fresh look at market design.

Twentieth-century assumptions that shaped power market design are becoming less valid by the day. Large, centralized, and mostly fossil-fuel and nuclear generation resources that were favored by economies of scale in the past are giving way to smaller-scale and distributed renewable energy resources and battery electric storage. Inflexible and slow-growing loads of the past are being joined by fast-growing and dynamic sources of demand from transportation, industry, and other sectors. Customer and policymaker focus on electricity cost and reliability is also broadening to encompass more environmental and societal concerns, climate change being chief among them. The changes now afoot in the electricity markets are likely to accelerate in response to climate policy.

Ultimately, the pace and scale of the emissions reduction challenge paired with the evolving characteristics of the power sector are spurring discussion among stakeholders and policymakers about the fundamental shortcomings of current market designs.

Today's markets—designed around locational marginal pricing (LMP) with complementary elements including ancillary services or capacity markets in some Regional Transmission Organizations (RTOs)—have been relatively well-suited to the technical characteristics of generation technologies and policy requirements of the past. These market designs vary between regions and are regularly updated through stakeholder governance processes.

In these markets, very large, mostly fossil-fired power plants have provided stable electricity supply for years, but increasing shares of intermittent renewable energy resources are rapidly changing grid operations. As recently as 2005, more than 70 percent of total electricity generation came from fossil fuels. Nuclear power contributed 19 percent, hydropower 7 percent, and various renewables another 2 percent.[1] Today, renewable generation contributes 20 percent of the total U.S. generation and the interconnection queues are loaded with solar, wind, and battery electric storage projects.[2,3] As of March 2021, these projects make up 94 percent of PJM's 57 gigawatt interconnection queue.[4] These new technologies have low or zero marginal costs, are weather-dependent and have limited energy output, and have a higher capital intensity than technologies they are displacing.

These characteristics are changing the fundamentals of market operations around the United States. They are raising questions about the ability of today's capacity markets to guarantee

long-term reliability and resource adequacy. Prevailing short-term energy prices are becoming lower and more variable, a trend anticipated to continue. The fundamental reliability challenge of maintaining adequate generating capacity to meet net load is shifting from being solely focused on a singular peak reserve margin to a 24x7 challenge requiring an ideal bundle of technologies with distinct, yet complementary, attributes to meet demand *in every sequential hour*.

Electricity consumption and peak demand across most regions fell or have remained flat over the last two decades, despite a growing population and economy. Now, though, proliferation of short-duration storage devices, smart appliances, and other sources of demand response are making electricity demand more dynamic—increasing the variability of daily, hourly, and sub-hourly net demand. Yet, these innovations are also providing the foundation for electricity demand to be more responsive to real-time market signals.

Electrification of buildings, transportation, and industrial end uses are anticipated to set electricity demand on an upward trajectory in the future. This new wave of electrification will likely require more investment in transmission and distribution infrastructure to (1) provide fair market access to supply and demand-side resources, (2) promote economic efficiency, and (3) improve reliability. However, it remains challenging to site, permit, and build new infrastructure.

Policymakers and customers are increasingly seeking to influence market outcomes through their policies and purchases, expressing preferences for electricity resources that are cleaner and more environmentally just. Several states are pursuing policies aimed at preserving and incentivizing clean electricity production, creating and retaining jobs and tax revenues, and promoting social equity, outcomes not addressable through competitive electricity markets that are designed only to assure resource adequacy.

For example, in announcing New Jersey's expanded procurement of offshore wind in 2019, Governor Murphy referred to the expansion of clean energy, resilience, jobs, and economic development as motivations for a policy aimed at supporting offshore wind resources outside the traditional market.[5] Similarly, Virginia's Governor Northam noted that benefits of 2020 legislation adopting 100 percent clean energy requirements included advancing environmental justice, creating clean energy jobs, and supporting communities transitioning from fossil fuels.[6] Currently, 17 states, the District of Columbia, and Puerto Rico have goals for 100 percent clean electricity, and 11 states and the District of Columbia have goals for net-zero emissions economywide in the midcentury timeframe.[7,8]

Growing Tensions between State Policy Ambitions and Market Outcomes

The intensity of debates over the adequacy of existing wholesale power market designs has increased in recent years, as have the political and economic consequences of inaction. Solutions are urgently needed to create market outcomes that will be seen as fair, efficient, and adequate.

These concerns are particularly apparent in the Northeastern power markets of the PJM Interconnection, ISO-New England (ISO-NE), and the New York Independent System Operator (NYISO). In these power markets, regional system operators use mandatory capacity markets to ensure system resource adequacy. Policymakers from states across the Eastern RTOs have been outspoken in highlighting the tension between federal, state, and local interests in advancing climate policy and the outcomes resulting from the organized capacity markets.

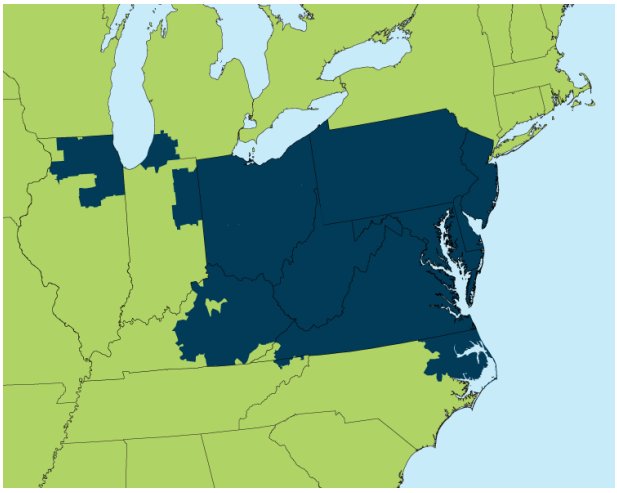
State policymakers, in particular, have voiced concern about the disconnect between wholesale market design and state policy objectives. An October 2020 energy system transformation vision statement released by the New England states claimed that ISO-NE's markets are not aligned with a rapidly transitioning resource mix and consumer investments in clean energy and decarbonization.[9] Similarly, in response to policy discussions regarding how state-supported resources should be allowed to participate in the capacity market, in January of 2021 the Organization of PJM States identified principles that should govern work in PJM to improve wholesale market design to better align with state policies and retain robust competition.[10]

FERC has recently hosted several technical conferences to identify solutions to challenges facing wholesale power markets. A FERC technical conference in May 2017 discussed ideas for improving the interaction of wholesale power markets in the eastern United States with state resource support policies.[11] More recently, FERC hosted a technical conference on March 23, 2021, on resource adequacy in the evolving electricity sector.[12] In June 2021, FERC hosted another technical conference to discuss the reliability implications of climate change and extreme weather events and to identify means of improving resilience—a topic likely to grow in importance for power market design.[13]

THE PJM CONTEXT

Though the PJM market has admirably served the region in which it operates (Figure 1) since PJM's inception, the time is ripe for reform. The diversity of member state perspectives, long-standing challenges facing the capacity market, and controversial directives from the FERC have brought market design issues to a head. PJM and FERC both are now proactively identifying market reform options to overcome existing challenges and prepare the region for the changing sector dynamics to come.

Figure 1. Territory Served by PJM[14]



Source: PJM

Many aspects of PJM's market design have operated well. Importantly, the region served by PJM has accommodated a large shift in resource mix. The share of natural gas-based electricity generation has increased from 6 to 40 percent over the last 15 years in response to fuel cost declines, largely displacing coal-based electricity generation (which has fallen from 57 to 19 percent).[15] The operational performance of the system has generally improved through innovations in technology and market product definitions. Demand-side resources have made headway in the market, albeit primarily as capacity resources. Aspects of the capacity market, such as its three-year time horizon, provide some of the revenue certainty needed by supply resources. Short-term energy and ancillary services markets are being reformed to produce market prices that are more consistent with the economics and operational performance of generators under normal operating conditions.

There is widespread consensus, however, that the PJM capacity market is not operating well. Its customers are now paying for large amounts of generator overcapacity (i.e., generation not needed to meet grid reliability and resiliency needs). This overcapacity is driven by two factors: demand forecasts that are consistently higher than the actual demand realized, resulting in marginal fossil resources being sustained, and state-driven resource development that falls outside of PJM's capacity market design.

Capacity market rules and design in PJM also favor lower-capital-cost resources, such as natural gas combined cycle plants, at the expense of higher-capital-cost resources such as wind and solar power. Resource participation rules and market design impede market participation by non-standard supply, storage, and demand resources. In sum, the capacity market design forces all customers to pay for a mandated reliability level that does not reflect changing end-use technologies and that does not enable customers to make risk- and cost-informed choices to acquire their desired level of reliability.

A December 2019 order from FERC extending the Minimum Offer Price Rule (MOPR) to nearly all state-supported capacity resources in PJM further increased stakeholder concern. This version of the MOPR creates a PJM-determined price floor that has to be met or exceeded by resources seeking participation in the capacity market auction process. State-supported resources must ignore their actual costs when submitting capacity supply offers, lowering the likelihood their supply will be used to meet market demand. The MOPR increases capacity market clearing prices—despite the fact that the region already far exceeds its target reserve margin—and increases costs to states for achieving their program goals, because state-supported resources require additional revenues to make up for lost revenues from the capacity market. States have expressed concern that the MOPR could force some generators out of the capacity market, even though they contribute to resource adequacy (e.g., existing nuclear and new renewables). Excluding the contribution of these generators to regional reserves forces consumers to pay twice: first for the generation needed to meet the resource adequacy requirements established by the eligibility criteria for the capacity market auction, and second for the policy-preferred resources that were forced out of the capacity market.

States in PJM generally have an unfavorable view of the expanded MOPR. In August 2019, U.S. Senators from five of the 13 PJM states (representing the vast majority of the load served by PJM) wrote FERC to raise concerns that the MOPR would increase prices, threaten jobs, and stymie their clean energy policies.[16] Maryland and Illinois were considering legislation that would provide state regulators the option to opt out of PJM through a fixed resource requirement (FRR).[17] New Jersey also considered the FRR, but, due to fears of increased impacts on ratepayers, it is also investigating a regulatory exit option through alternative resource adequacy mechanisms.[18] FERC has opened the door to legal challenges. After FERC decided in April 2020 to deny a rehearing on its MOPR rules, Illinois, New Jersey, and Maryland—all states with offshore wind targets or clean energy goals—filed lawsuits challenging FERC's authority to implement MOPR expansion.[19]

In response to these growing technical and political challenges, FERC and PJM each initiated stakeholder dialogues to identify market reforms that better accommodate state clean energy goals and the changing realities of the power sector. As previously mentioned, FERC held a technical conference on capacity market reforms in the Eastern RTOs in March 2021.[20] In early 2021, PJM hosted a series of stakeholder workshops to discuss and explore enhancements to the PJM capacity market, from which PJM has set forth a multi-year plan to address many facets of capacity market design and inputs.[21] The first step in this plan is to scale back the MOPR: as of July 2021, the PJM Board approved PJM's planned approach—a proposal vetted through their stakeholder workshops—and sent it to FERC for review.[22] In later steps, PJM will engage stakeholders in a broader reform effort to examine the structure of the current capacity market, improve inputs to the PJM capacity procurement model, and evaluate additional policy and reliability procurement processes.[23] PJM plans to work with stakeholders in the late summer of 2021 to develop a timeline and prioritization for the wide range of matters under review. Stakeholder deliberations are expected to extend into 2022.

Guideposts for Market Reform

In the context of collaborative and solutions-oriented dialogues at FERC and PJM, EJM Associates convened stakeholders to discuss market reform principles and options for PJM.

These conversations identified guideposts for developing market reforms that are timely, enduring, and compatible with long-term changes in the power sector. They did not, however, identify the myriad complementary changes to regulations, institutions, standards, and other non-market tools necessary to implement alongside—and in some cases in lieu of—the markets themselves. More progress is needed on these fronts.[a] The following guideposts emerged from foundational design principles identified by workshop participants and by examining the strengths of several existing market design proposals.

ACCOMMODATE STATE POLICY

Wholesale electricity market reforms should aim to *accommodate* state clean energy and related policies, rather than become the primary instruments by which those policies are achieved. Several market reform proposals envisage incorporating clean energy and other policy objectives directly into the market objective functions that determine clearing prices. However, states—especially those in the PJM market—prefer not to relegate the mechanics of achieving diverse state clean energy policies to regional RTOs. Instead, participants emphasized that market design should allow states to pursue clean energy goals on their own terms, with strong regional coordination to support reliability and cost effectiveness.

To date, a broad range of PJM stakeholders have endorsed wholesale market reform proposals that would give states, in the absence of overriding national policy, control of their own clean energy policy and outcomes, to the extent that those policies do not overtly conflict with FERC wholesale ratemaking. Even in the context of a federal clean electricity policy, it would still be likely that states would want some say over the type, quantity, and location of preferred resources; ideal market designs would be suited to this hybrid federal-state clean energy policy approach. Assuring state primacy in valuing clean energy attributes is also useful when convincing states and those states' constituents to ultimately agree to a particular reform.

a In addition to design principles, workshop participants identified a number of preconditions for achieving ideal wholesale market outcomes:

1. Effective governance (e.g., market stakeholder process, operators).
2. Coordination and cooperation among and between states within and across regional markets and between federal and state entities.
3. Large regional footprints for operations and market efficiency (though political and institutional realities may warrant limiting geographic extents).
4. Market transparency for participants and non-participants.

Empowering state clean energy leadership will at times require navigating difficult tradeoffs among differing goals. The markets and the institutions that govern them should be equipped to address anticipated and unforeseen tradeoffs as they arise—for example, balancing costs against reliability and emissions criteria, or the cross-border impacts of policies in neighboring states.

IMPROVE ON TODAY'S RESOURCE ADEQUACY APPROACH

The need to maintain reliability as energy technology, costs, and risks evolve is a compelling motivation for electricity market reform in of itself. Movement toward a lower-emitting system while serving an economy with even greater reliance on electricity—all in the face of more frequent and damaging climate-driven weather events—amplifies reliability challenges. The traditional reliability approach of ensuring a total installed capacity equal to forecasted peak demand plus a reserve margin is incompatible with and inappropriate for a system dominated by (1) energy-limited and weather-dependent supply resources and (2) much more dynamic demand-side resources. The February 2021 cold weather event in Texas provides an example: while there was adequate *capacity*, systemic, operational, and widespread failures of natural gas power plants contributed to blackouts for a third of the ERCOT interconnection. Workshop participants supported reforms that would include new approaches to ensuring resource adequacy.

Unlike today's resource adequacy approach in PJM and elsewhere, locational marginal pricing (LMP) received widespread support by workshop participants for its role in supporting reliable operations and cost-effective dispatch. Participants strongly supported reforms that maintained a central role for LMP.

SUPPORT INNOVATIVE TECHNOLOGIES

The necessity of innovation for achieving deep reductions in power sector and economywide emissions was discussed in both workshops. There are two primary ways markets can support innovation: making it easy to enter and exit the market, and providing targeted support for innovative resources. Reducing barriers to new, lower-cost technologies entering the market while simultaneously preventing the retention of outdated and costly technologies—considering their full environmental and reliability contributions—creates a dynamic market that supports innovative technologies and should be a primary focus of market reform proposals. Market carve-outs and targeted financial incentives (through payments outside the wholesale market structures) were discussed as two possible approaches to support the deployment of new technologies that may be temporarily more expensive than more mature technologies.

ENABLE TRANSPARENT, VOLUNTARY BILATERAL MARKETS AMONG MANY BUYERS AND SELLERS

The extent to which wholesale market reforms incorporate fundamental economic principles, wherein many buyers and sellers voluntarily transact on individualized terms, increases the likelihood they will be efficient, flexible, and enduring. Transparency and price discovery enabled by dynamic bilateral markets help all participants make better informed and lower

risk decisions. Having a multitude of market participants also reduces the ability of one or more participants to influence prices through exerting market power. Effective participation in markets by many participants will reduce political conflict and require less administrative oversight for market power mitigation.

Standardized product definitions facilitate larger and more liquid markets. For example, renewable energy credits allow cross-border trading of clean energy attributes among certain PJM states. While one might argue that standardized product definitions could restrict the range of customer choice, fewer, broader definitions could also expand market liquidity for product trading. What these product definitions cover and the manner in which they are implemented are key. Should all renewable resources be traded under a single market product, with other zero-emissions resources under a different product (e.g., nuclear)? Should distributed resources have a unique product? Should it matter whether a resource is in or out of state? These questions imply tradeoffs for which there are no easy answers yet are at the heart of many market reform proposals.

MINIMIZE COMPLEXITY AND SIMPLIFY IMPLEMENTATION

Market designs that are overly complex may not garner support from federal regulators, state policymakers, and the public they serve. Designs relying heavily on complex modeling could also lead to opaque market outcomes, thereby eroding confidence in those outcomes and making it difficult for resource developers to forecast future market conditions. These concerns were raised specifically in the context of reforms that included a single market clearing mechanism to satisfy multiple market objectives (e.g., reliability *and* clean energy attributes) given the complexity of market operations and diversity of clean energy preferences.

BE QUICKLY ACHIEVABLE

The fleet of generation resources must evolve quickly to achieve climate policy milestones at the state and federal levels. Supply-side resources take years to site, permit, and build—meaning that there is a tight timeframe for implementing market reforms to ostensibly guide such investments. Opportunities for quick wins—particularly clean energy policy external to the market and expansion of clean demand-side resources for load reduction and renewables integration—should be sought while deeper reforms are perfected for later implementation.

Promising Options for PJM Market Reform

Workshop participants evaluated several market reform proposals in the context of the identified principles as well as the challenges facing the PJM marketplace.

All proposals had strengths and weaknesses. Several emerged as promising options for PJM that were judged to be realistic to implement in the near term and that aligned with core Market Design Principles. Only the highest ranked proposals are included here along with a summary of participants' observations. The others were generally considered too nascent to assess fully or were not well suited to PJM. Of those, several were noted to be likely better suited to other regions.[b] The following options are not mutually exclusive; most proposals are partly or wholly complementary to other reforms and can be divided into constituent parts to be reassembled into distinct market designs. Summaries presented here are meant to accurately reflect key design elements of each proposal. Readers are urged to read the original proposals for completeness and accuracy, by following the links embedded in the text.

CO_2 PRICE OR CLEAN ENERGY STANDARD

A national CO_2 price (or a Clean Energy Standard effectively functioning as a CO_2 price for the power sector) could be a first-best solution to achieve climate targets. These options are not market reforms or market designs so much as policies that would guide markets by placing a price on emissions or prioritizing clean resources and kilowatt-hours traded within existing and future power markets. The CO_2 price could be a charge to generation (e.g., as in the Regional Greenhouse Gas Initiative, or RGGI) or a shadow price for dispatch (e.g., NYISO proposal), and would need to be compatible with leakage mitigation to protect the environmental benefits of these approaches.

There are several obstacles to implementing a carbon price high enough to elicit emissions reductions at the pace and scale commensurate with state and federal policy ambition, including the complexity of designing effective leakage mitigation measures and the potential financial burden to consumers. Nonetheless, establishing an *achievable* carbon price (i.e., low enough that cost and leakage concerns are not significant

b Market reform proposals discussed at the workshop but not included here for the sake of brevity are: the *Three-Part Market Design*, the *Standardized Fixed-Price Forward Contract (SFPFC)*, the *Precise Renewable Integrating System Expansion Models (PRISM)*, and the *Organized Long-Term Market (OLTM)*.

enough to necessitate leakage mitigation measures) would provide immediate clean energy dispatch and investment incentives compatible with a variety of other reforms.

Every region in the U.S. with a prevailing carbon price also has a Renewable Portfolio Standard, and those regions differ significantly in their market designs. A Clean Energy Standard could also be designed to functionally operate as a carbon price, achieving most of the efficiency and environmental benefits but through a potentially more politically attractive framework. This approach relies on awarding credits based on the extent to which a resource displaces carbon emissions.

CAPACITY AS A COMMODITY

Capacity as a Commodity (CAAC), proposed by Gabel Associates for American Clean Power, would establish a new bilateral trading platform for customers to directly procure their preferred type and quantity of capacity.[24] Eligible buyers—be they load serving entities or corporate end-users—would buy the type and quantity of clean capacity credits (denominated by 0.1 megawatt [MW] for a single future year) commensurate with their clean energy ambitions. Sellers could offer any unsold credits in a residual capacity market that, accounting for the unoffered quantity of bilaterally traded clean credits, would procure sufficient capacity to meet resource adequacy requirements. The residual capacity market would function very similarly to today's capacity market in PJM, where a central buyer allocates resource adequacy costs across all load-serving entities.

Among the primary advantages of the CAAC model discussed by workshop participants is that it would enable customer choice differentiation by providing direct access to various clean energy resources through bilateral trading and secondary markets for clean credits. Customer choice and the transparency of secondary markets would also provide price discovery, similar to commodity markets, and offer ample opportunity for hedging. It would also require relatively few changes to PJM's existing capacity market design and resource adequacy construct.

One challenge with this approach is an increased potential for market power: as capacity product definitions grow narrower to reflect more specific customer preferences, the supply of each product type could become so limited that any one seller could increase the clearing price. The potentially small quantity of capacity being sold into the residual market could create the same situation. These circumstances may require new market power rules to prevent such situations. This approach would likely require a complementary clean energy policy to achieve the pace and scale of emissions reductions sought by policymakers. The ability of demand-side resources like demand response, energy efficiency, and distributed energy resources to be included in the capacity crediting mechanism should be further evaluated.

FORWARD CLEAN ENERGY MARKET

The **Forward Clean Energy Market** (FCEM), designed by Brattle on behalf of NRG, offers an example of a regional, market-based, technology-neutral mechanism that could value carbon-reducing policy targets alongside power markets.[25] Built around three core ideas—competition, smart product design, and multi-year forward procurement—the FCEM would price the environmental attributes of power generation through competitive supply auctions held outside of the wholesale power markets, providing an extra-market revenue stream for low-carbon

power generation and opportunities for buyers to purchase customized clean energy portfolios. Credits for 1 megawatt-hour of clean energy attributes would be regularly auctioned three years forward. The delivery term would be one year for existing resources or seven years for new resources. The FCEM could be administered by states, a multi-state organization, or an ISO. Eligible credit buyers include states, cities, or corporate end-users.

The FCEM approach would rely on competitive supply auctions that permit potential buyers to express their desired purchase price and quantity for the fungible clean energy attribute. Implementing the FCEM could be relatively expeditious given its out-of-market design framework and similarities to existing renewable energy credits (RECs). Clean-energy-attribute markets would complement existing wholesale electricity markets. Participants also noted the potential cost-saving advantages of having broad technology and geographic eligibility criteria for clean energy resources.

One limitation of this approach is that it would merely formalize the potential for joint state carbon crediting—an opportunity that already exists, but that states have not undertaken. It would also not facilitate customized state preferences; clean-energy-attribute credits would not be differentiated based on attributes policymakers seem to prefer, including resource type or local environmental or economic benefits. Nor does the FCEM address evolving resource adequacy needs. Lastly, both the capacity market and the FCEM would cover resource costs net of energy, ancillary services, and other revenues; this design may make it difficult to develop bidding strategies for electricity suppliers intending to bid into both the FCEM and capacity market simultaneously.

INTEGRATED CLEAN CAPACITY MARKET

The **Integrated Clean Capacity Market**, developed by Brattle, envisions co-optimized procurement of capacity and clean energy attribute credits (CEAC).[26] It puts forth a three-year forward market for co-optimized procurement of capacity (in MW) and CEACs to achieve reliability and state policy goals—for example, the total percentage of load a state aims to procure from non-carbon-emitting resources—and defines new resource adequacy products for central procurement (i.e., seasonal, with flexibility attributes, etc.). Credits would be tradeable on a secondary market; ideally CEAC definitions would be uniform across states to provide the largest pool of potential buyers and sellers, but state and voluntary buyer preferences would be honored. Suppliers would submit revenue requirement offers, and CEAC and capacity would clear at separate prices. New resources would be awarded a term of seven to 12 years.

Workshop participants noted the potential economic benefit of simultaneously optimizing for reliability and policy criteria, and that contract durations were long enough to reduce investor risk. This design was also commended for its ability to more precisely account for state preferences than today's approach and many of the other proposals.

Participants expressed concerns that the multiplicity and complexity of modeling constraints under this approach would reduce market transparency and make anticipating future prices more difficult, thereby increasing investment risk. The fungibility of the tradeable credits requires broad agreement on their definition, a consensus that may be hard to come by. Several saw this proposal as a logical second step after adopting the FCEM.

Conclusion

Organized wholesale power markets are often forgotten, and for good reason: for more than two decades they have provided electricity to two-thirds of the U.S. population at reasonable costs with high levels of reliability. While the PJM market has not been without reform since its inception, the decades ahead demand increased attention. Rapid technology and policy change and the ongoing shift towards a more climate-friendly portfolio create new expectations for the role and outcome of wholesale power markets.

Changes to address these climate and technological developments are already underway in the PJM market, reflecting the concerns that its current design will not support the full scope changes needed for the clean energy transition to address the climate crisis. Increasing concerns regarding climate resilience and grid modernization further amplify the need for change. Current market design in PJM does not incorporate or facilitate the key attributes sought by states, customers, and federal policymakers, nor is it equipped to address the evolving reliability and operational challenges of an evolving resource mix. These shortcomings are leading to inefficient outcomes, higher costs to customers, and reliability challenges.

The path ahead for wholesale electricity markets must be identified rapidly, decisively, and collaboratively. This document has summarized the key findings from two workshops designed to elicit expert advice from a broad suite of stakeholders and to evaluate and approach consensus on potential wholesale electric power market reforms in the PJM region that would support a decarbonized electric grid. While no specific reform proposals emerged during the workshops as a clear consensus choice for the PJM Interconnection region, several market design elements discussed in this report shared broad support from workshop participants. It will be crucially important to consider these design elements in future market reform conversations occurring within PJM, at the FERC, and elsewhere. Continued dialogue informed by the insights in this report will be instrumental to preparing the PJM market for the decades ahead.

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