Workshop Summary

Market Design for the Clean Energy Transition: Advancing Long-Term Approaches

December 16-17, 2020 | Virtual

Contents

EXECUTIVE SUMMARY

Policymakers in the U.S. and many other countries are questioning whether current electricity market designs are well-suited to support the efficient and rapid decarbonization of the power sector. Most experts agree that current market designs function adequately at managing daily system operations and maintaining resource adequacy in a system that is still largely fossil-based. However, a growing body of research suggests that these designs face challenges in terms of rationalizing the mix of new technologies and supporting efficient investments within them, as public policies and consumer preferences drive deep emissions reductions in the power sector and as demand for electricity expands, powering the decarbonization of other sectors of the economy. Accordingly, this workshop was designed to explore new ideas for organized long-term markets, designed to operate in parallel to today's energy markets, and intended to identify and support the financing and development of efficient, reliable mixes of clean (i.e., zero- and very low-carbon) resources.

To date, market designs in RTO/ISOs in the U.S. can be grouped in three general categories:[1]

1. Energy-only (ERCOT)
2. Energy and capacity markets (PJM, NYISO, ISONE)
3. Energy market plus state-level planning reserve (resource adequacy) requirements for regulated utilities (MISO, CAISO)

A spirited debate has emerged regarding how well each of these three types of market designs can enable a least-cost, deeply decarbonized electric grid that relies heavily on generation resources with variable and intermittent output and very low operating costs. The workshop provided a forum for four experts to present conceptual designs that would involve a conventional energy-only market paired with an organized long-term market aimed at rationalizing and supporting investment in zero- and low-carbon resources, beyond the voluntary long-term bilateral hedging spurred by current market designs.

The workshop directly addressed the long-standing view that, in theory, an energy-only market paired with a policy that prices carbon at its social cost should represent a "first-best" approach to the pursuit of efficient prices and outputs in the electricity sector, and that any other market design would represent a "second-best" (i.e., less efficient) approach. However, workshop participants held a wide range of opinions on whether these customary precepts continue to be valid in theory (given the growing importance of non-firm clean energy technologies) or in practice (given the revealed preferences of market regulators).

Several plenary speakers set the stage for the workshop by making the case for exploring options for organized, long-term markets to augment or complement Security Constrained Economic Dispatch (SCED) markets. Professor Paul Joskow observed that such "hybrid markets" are not exercises in central planning, but instead embody two distinct phases of competition: competition **for** the market, resulting in long-term contracts that enable investment, and competition **in** the market, meaning the current day-ahead and real-time energy markets. He noted that a rudimentary form of a hybrid market can be seen in states' competitive procurements for wind and solar power aimed at meeting clean energy and greenhouse gas emissions reduction goals, with the resulting resources then dispatched and operated competitively in the SCED electricity markets. In addition, businesses and other large consumers are using long-term contracts to drive major investments in wind and solar power, motivated largely to meet voluntary targets for renewable purchasing and often without regard to system needs. Joskow argued that an effective, efficient hybrid market would replace today's somewhat ad hoc approach to the selection of clean energy resource types with some kind of rationally-derived indicative plan designed to work well in conjunction with short-term markets, which would then guide vigorous competition **for** the market.

Joskow addressed the "first-best" school of thought that holds that prices arising from energy-only markets can be sufficient to guide investment. This approach depends on the cyclical appearance of scarcity conditions (reserve shortages) to produce "scarcity prices" that are high and frequent enough to provide adequate returns on investment in existing and new plants over time. However, Joskow noted that with variable renewable energy (VRE) making up larger portions of the generation mix, and having near-zero marginal cost, growing uncertainty over the frequency, timing, and level of energy prices will create greater and increasingly hard-to-manage risks for investors. Hybrid markets could offer more stable revenues under long-term contracts and better support the volume and mix of clean energy investment required to meet aggressive decarbonization goals.

In his plenary remarks, Professor Richard Schmalensee made a similar point on volatility in future energy markets. He presented MIT modeling results for high VRE scenarios that forecast extraordinarily high energy prices (over $1000/MWh) in just a handful of hours, and very low (or zero) prices for the vast remaining percentage of total hours.

[1] In addition, all three designs include ancillary services markets in various forms.

He argued that, in practice, market regulators are unlikely to allow the extremely high scarcity that energy-only markets would require to guide investment and ration demand. In a world where the "first-best" is unattainable, Schmalensee pointed to the need for a less volatile and uncertain supplement to energy-only market revenues and noted that capacity market revenues for dispatchable resources available at times of peak demand would not guide the needed investment, given the low correlation of wind and solar availability with peak load and peak net load. He emphasized the need for a "second-best" market design to aim for both short-run and long-run efficiency, and for retail rates to vary with real-time wholesale energy prices in order to encourage electrification and thus decarbonization of other sectors.

Four authors presented conceptual designs for an organized long-term market aimed at guiding investment in zero- and low-carbon resources. Each would operate parallel to existing day-ahead and real-time markets. Below are capsule summaries of the four designs, each identified by author. The workshop webpage provides the four papers and a matrix that summarizes key features across the four market designs, along with plenary presentations and videos.

Steven Corneli: Every three years, precise renewable integrating system expansion models (PRISM) evaluate bids for new clean energy resources and select the set of resource types, locations, and quantities that meet the models' key constraints (constant system balancing, declining carbon budget, etc.) at least cost when added to the existing system. Selected projects receive long-term contractual revenue hedges based on their levelized cost of energy, less than their received energy and ancillary service market revenues.

Susan Tierney: The market design has three elements: (1) competitive, co-optimized wholesale energy and ancillary service markets to ensure efficient dispatch; (2) a resource adequacy (RA) approach for ensuring capacity of the right types in the right places; and (3) retail pricing to enable loads to see and decide whether to respond to dynamic prices and provide flexible resources. The RTO would determine various types of RA needs in future periods, and conduct annual long-term resource procurements to solicit proposals for RA based in part on input from states on necessary attributes of resources (e.g. zero-emitting) not otherwise recognized in the RTO's RA requirements. The latter include: local RA (to ensure adequate resources in zones with delivery constraints), flexible RA (to assure real time balancing services), and system RA (to otherwise meet peak load and reserves). Load Serving Entities (LSEs) can meet their RA obligation through RTO procurement, or ownership or bilateral contracts.

Eric Gimon: The Organized Long-Term Market (OLTM) calls for periodic, centrally-optimized selection of bids (by WIS:DOM-like system model) from resources to deliver hourly schedules of megawatt-hours over multi-year periods. Schedule specification may range from as-produced/take-or-pay to firm hourly shapes for physical or financial delivery to the Day-Ahead/Real-Time (DA/RT) market. The objective function for the optimizer is least-cost for the collective demand. Winning bids are eligible for swap contracts, based on the project's bid prices for scheduled energy delivery to the DA/RT market. Voluntary buyers then subscribe to shares of energy deliveries promised by winning bidders. Fully subscribed projects' contracts are finalized, and upon commercial operation, projects begin delivering energy to the DA/RT market, with buyers paying as-bid prices to projects outside of the DA/RT market and receiving a financial derivative (e.g., a swap) for the project's delivered or scheduled energy revenues at DA/RT prices. Contracts are envisioned to be highly tradable and to support liquid secondary financial and physical (e.g., providers of storage and flex load) markets to lay off or take on changing positions and to more efficiently match actual production and consumption to scheduled deliveries.

Brendan Pierpont: The market mechanism results in long-term contracts with a specified production profile. Winning resources are awarded financial, long-term contracts with the market or with individual LSEs on the basis of their as-bid cost of power per megawatt-hour, for a bidder-determined fixed hourly and seasonal profile of power production for the contract term. Under the contracts, the seller is paid its fixed as-bid price for all contracted forward energy production and the seller pays the buyer all real-time energy prices, as determined by the short-term SCED market, for all the contract's contracted production profile. In other words, the long-term contract is a financial contract for differences applied to a specific hourly and seasonal production profile. The seller is also paid the SCED market price for any excess energy delivered, above the scheduled amounts. The long-term market's two alternative clearing mechanisms are intended to select resources with the highest expected energy market revenues relative to project costs.

Six breakout group discussions followed the presentations by the four authors. Each group was assigned a set of cross-cutting topics:

- Product/Pricing/Payment: Product definition, pricing methods, payment methods, interaction with day-ahead/real-time markets, winner selection methods and key Variable Renewable Energy (VRE) risk implications.
- Long-term Market Sellers: Existing unit participation, encouraging retirements, self-supply, and promoting innovation.
- Resource Adequacy: How the market design ensures/contributes to resource adequacy, especially as approaches to resource adequacy evolve with increasing shares of variable, non-dispatchable resources.
- Climate: Meeting climate goals; interaction with state/federal climate, clean energy, and/or renewable energy policies.
- Transitions: Interaction with existing federal/state electricity laws and regulations; ways the transition to new design could occur.
- Modeling: Feasibility of model features and capabilities implied by these market designs.

Breakout discussions are summarized in Section 4 below.

In closing plenary remarks, former FERC Chair Jon Wellinghoff focused on the policy processes needed to help advance deep decarbonization of the electricity sector, particularly with respect to market reform and transmission expansion. He observed that while states have led the way in the path toward decarbonization, federal action is needed going forward and that effort should be in collaboration with the states. He noted that FERC is uniquely well-positioned within the federal system to effectuate and support such collaboration. Wellinghoff expressed hope that the collaboration between FERC and the states on new approaches to market design could benefit from some of the ideas presented during this workshop.

INTRODUCTION

This two-day virtual workshop (December 16-17, 2020) was co-hosted by Karl Hausker, Ph.D., Senior Fellow, Climate Program, World Resources Institute, and Karen Palmer, Ph.D., Senior Fellow and Director of the Future of Power Initiative, Resources for the Future. The workshop featured plenary speakers, presentations of four papers on organized long-term market designs, and a background paper on experience with clean energy resource procurement and planning. WRI and RFF also prepared a matrix document that provided a summary description of each market design and details on specific market design features in each proposal organized into six topics areas. These six topic areas formed the basis of the six breakout groups that met twice during the two-day workshop.

Modified Chatham House rules applied to this workshop. Speaker videos, presentations, and papers are public, but this workshop summary, which covers discussions in plenary and breakout sessions, does not attribute statements or positions to specific persons or organizations. Workshop participants included representatives from RTO/ISOs, utilities, IPPs, state and federal government, NGOs, academia, and consulting firms.

These proceedings are organized as follows:

- Day One presentations and discussion
- Day Two presentations and discussion

- Discussions in the six breakout groups

DAY ONE

Opening Remarks: Karl Hausker, World Resources Institute (WRI) and Karen Palmer, Resources for the Future (RFF)

Karl Hausker opened the first day of the workshop by explaining the motivation for the event and introducing Karen Palmer to explain the overall project leading up to the two-day workshop. Dr. Hausker pointed out that nearly all studies of pathways to limit warming to 1.5 to 2 degrees by mid-century point to a need for major expansion of zero- and low-carbon electricity generation, increased energy efficiency efforts, and expanded electricity use to electrify much of the transportation, buildings, and industrial sectors, all of which present challenges across the utility industry, both for traditional vertically-integrated utilities and for jurisdictions with restructured generation markets. In restructured areas, market design will need to promote or enable rapid build-out of wind, solar, storage, and demand-side resources, paired with continued operation of the existing nuclear fleet to achieve decarbonization goals. At the same time, market design should promote innovation and commercialization of additional clean (low- and zero-carbon) technologies and guide investment in the best combinations of all clean technologies, given the complementarity among these resources.

The transition to power grids with high penetration of variable renewable energy with very low to zero short-run marginal costs presents new challenges for market operations. Dr. Hausker asked if current market designs can meet these challenges, considering they were designed for power systems dominated by large thermal plants with a range of non-zero marginal costs and for resource adequacy metrics focused on peak load demands. The absence of a national price on carbon represents an additional obstacle to any market design's ability to facilitate the transition to clean generation sources.

Dr. Hausker noted that experts have presented concepts for organized long-term markets that would operate in parallel to the current day-ahead and real-time energy markets and are intended to address these challenges. To date, reactions to these concepts have been mixed, with some experts more receptive to long-term approaches while others remain more focused on incremental changes to current energy and capacity markets. While there are many improvements that can be made to day-ahead and real-time markets, he explained that this workshop would focus on long-term markets and on gathering participant insights on why or why not these proposals may work.

Dr. Palmer then explained that the convening would build off previous events co-hosted by WRI and RFF and a project by Energy Innovation, and present updated new papers outlining proposals for long-term markets. The purpose of the project is to disseminate these proposals to a group of stakeholders and experts, collect feedback, and identify next steps.

The project also generated a background paper on real-world experiences in competitive procurement for renewable energy and advances in long-term planning through Integrated Resource Planning (IRP) that may be relevant to concepts for long-term organized markets. From the competitive procurement examples, lessons included: how product definition and technology specification influence which party bears performance risk and resource diversity; why competitive procurements face tradeoffs between competition and contract fulfillment risk; and that contract provisions can reduce risks related to contract fulfillment and counterparty risk. Lessons from recent innovations in IRPs in California, Hawaii, and Colorado highlight the need for evolved planning to better capture future system needs, that balancing the contributions of future resources will require more sophisticated models to identify reliability needs, and that accurate and up-to-date inputs on resource costs and operating characteristics are needed. Linking resource planning activities to state goals, procurement, and other planning activities will become more important as the system becomes more complex.

Plenary Remarks: Paul Joskow, Massachusetts Institute of Technology (MIT)

Dr. Joskow began by observing that the goal of rapid, deep decarbonization increases interest in whether and how markets may be adapted to achieve decarbonization while maintaining reliability at the lowest cost in a system dominated by variable renewable energy, with efficient prices at wholesale and retail levels. He remarked that this reevaluation is not limited to the U.S., but is also occurring in the U.K. and the E.U. Many of the proposals involve integrating short-term energy and ancillary service markets that operate the system efficiently with long-term contract markets and supporting planning or related institutions to identify the investments needed for low-cost and reliable decarbonization. Such integrated energy and long-term markets, according to Dr. Joskow, are best termed “hybrid markets.”

The U.S. seems to be migrating to hybrid markets, though unguided, especially in the Northeast. Joskow noted that the papers to be presented at the workshop contain elements of hybrid markets, and further development of hybrid market design could bring order to what he sees as the current “wild west” approach in the U.S. Joskow noted that the E.U. is ahead of the U.S. in this regard, and the U.K. is already on its third iteration of its liberalized market design, which is a hybrid market. In many countries, the need for deep decarbonization is changing the context for market design, including how to maintain security of supply or reliability, get prices right, and engage consumers.

One of the objections to hybrid markets Joskow has heard is the belief that the adoption of them means abandoning competition. He reminded attendees that the visible hand still plays a large role in today’s utility industry through vertically-integrated utilities, administratively set resource adequacy obligations and demand curves in wholesale markets, regulated retail prices, out-of-market actions, new market designs, and the use of non-market mechanisms to meet climate goals.

Rather than abandoning competition, Joskow argued that hybrid markets instead create a separation between investment planning and day-to-day operations. He distinguished between competition ***for*** the market and competition ***in*** the market. In current U.S. market designs, competition in the market is presumed to be sufficient to induce efficient competition for entry into the market. But in hybrid markets, competition ***for*** the market is moved to a separate, long-term procurement market, which is designed to align with the resources needed for efficient, reliable decarbonization as identified through a planning-based process. Once the resources needed for reliable, low-cost decarbonization are identified and competitively procured, competition ***in*** the market continues to take place through the short-term energy and ancillary services market. Joskow noted that the ad hoc rudiments of this approach, though often without the requisite planning or integration, can be seen in many state competitive procurements for wind and solar under long-term contracts to meet state clean energy and GHG emissions reduction goals.

States are moving in this direction because, as designed, current wholesale markets cannot incentivize the investments necessary to meet clean energy goals, especially in the absence of comprehensive federal GHG emissions reduction policies. Under this ad hoc approach, however, concerns about resource adequacy, reliability, and costs are growing. In addition to these concerns, Joskow noted that due to the increased prevalence of intermittent resources with zero marginal costs, energy market price risk and volatility will also rise and will be harder to hedge over the long run. Specifically, there will be more hours with low to zero prices when intermittent resources are on the margin, with the result that clean energy resources will find they can only earn energy revenues in a much smaller number of hours when there is actual scarcity. The uncertainty of the frequency and level of such prices will, he noted, create significant and growing risk for clean energy investors. In his view, this risk underscores a major reason why hybrid markets offering more stable revenues under long-term contracts will likely be needed to support the volume of clean energy investment required to meet state and broader decarbonization goals. Numerous examples of such long-term contracts already exist; for example, in state-mandated procurement in restructured states, contracts related to renewable portfolio standards (RPS), PURPA, or related to IRPs in states that are not fully restructured. Voluntary contracts, in the form of power purchase agreements (PPAs), are also becoming more prevalent as ways for customers with clean energy and GHG emissions reduction goals to support clean energy development intended to meet those goals.

Joskow suggested that in any move to hybrid markets it is important to consider how they can work as efficiently and reliably as possible. In terms of competition ***for*** the market, there's a need for transparent, well-designed auctions, evaluation and qualification criteria, and contracts. Planning approaches will need to evolve to harmonize reliability criteria with decarbonization goals and to find the right balance among technology types. Allowing voluntary entry and bilateral contracting consistent with greenhouse gas emissions policies can support fairness and efficiency and counter any tendency for market designs to be influenced by rent-seeking rather than by competition for the most cost-efficient solution. A move toward hybrid markets, however, is not a panacea -- it won't address many existing challenges in terms of competition ***in*** the market. As such, continuing redesign of short-term energy and ancillary service markets will be needed to ensure efficient dispatch pricing and reliability.

As he concluded his remarks, Joskow pointed out that competition ***for*** the market was not a substitute for competition ***in*** the market and that the two were instead complementary. He stressed that understanding how they complement one another would be critical for getting this kind of model to work efficiently and effectively.

Author Presentation: "A PRISM-Based (Precise, Renewable-Integrating System Models) Configuration Market" -- Steve Corneli

Mr. Corneli began his talk by explaining the importance of advanced modeling with geographic detail across an entire electrical interconnection and with granular data on wind and solar availability across many hours and years for achieving a low-cost and reliable grid with high penetration of renewable energy. He highlighted that future market design will need such precise, renewable-integrating system models (PRISMs) to overcome challenges such as the high information costs system operators face in supporting system balance for renewables relative to fossil resources, the more complex coordination across projects and development companies that will be needed, and the high risks of failure related to cost and climate impacts. Corneli explained his market proposal is inspired by the use of *central managerial optimization* and *contracts* to achieve complementary combinations of inputs in other competitive industries.

He then provided an overview of how his proposed *configuration market* would look. The market could be hosted by a regional entity, including an RTO, and facilitate procurement rounds every three years based on sealed, all-in project cost bids and selected by a PRISM analysis tool that would identify a portfolio of resources to meet carbon and system-wide constraints at the lowest cost. Winners would be awarded financial swaps with load, the length of which will vary but could be 15-20 years. The goal would be to ensure that efficient mixes of clean energy resources are developed while avoiding the high information costs and expensive financing costs that are likely to result from reliance on Security Constrained Economic Dispatch (SCED) markets alone.

Corneli suggested the market optimize stepwise, every three years rather than planning out over long time frames. Its optimization would be based on bids from new clean energy resources and the use of publicly available data on existing resources, which would generally not bid into the configuration market. Corneli also described how the PRISM-based market would integrate carbon and balancing constraints, resource adequacy, and resource retirements and existing bids. He also noted specific scenario analysis outside of PRISM-based market process that would address "chicken and egg" resource issues like transmission-dependent new resources or the inclusion of distributed energy resources. Self-supply options would allow a Load Serving Entity (LSE) to either sell its alternative portfolio into the configuration market and thereby reduce their configuration market costs, or to opt out of the configuration market completely, provided its self-supply portfolio passes a PRISM screening to ensure the portfolio will not increase total system costs.

One participant questioned how the market would interact with state preferences for labor or siting, and Corneli replied that such preferences could flow into the contract evaluation. While his paper didn't address this specifically, he pointed out that Gimon's paper does suggest solving issues like these with side payments, shadow prices, or other adjustments if these preferences result in higher costs.

Another question asked for clarity on performance requirements. Corneli explained that in his model, payments to generators would be like tolling agreements in the sense that they can generate whenever fuel is available and would be guaranteed sufficient payments to continue operating. Moral hazard would be reduced by smart contracts based on verification of resource availability and installations at each site.

One question focused on the ability of the configuration market to avoid locking into any long-term purchases that subsequently become inefficient. Corneli pointed to the tradeoffs between retiring or updating plants that turn out to be less efficient in the future and the difficulties of trying to get the optimal mix of resources. Within the continuum of approaches, he suggested the contracts be long enough to enable low-cost financing but not so long that the developer faces no risk related to technology. Another participant asked if contract lengths could be part of bid options, which Corneli agreed could be variable but was not included in the paper.

In terms of the clearing mechanism, one participant asked what the optimization function was, considering some resources might choose to not participate in the market, resources might not clear the market, the lack of one clearing price, or other moving parts. The key optimization in this type of model is the balancing constraint so that resources must be there in each interval and jointly not exceed the GHG limit. The objective function is to minimize the costs of that. The model selects the group of resources that meets those constraints and offers it swaps -- monthly payments to meet revenue requirements in return for their energy and ancillary services revenues. Existing resources are included in the optimization and the model may flag those likely to retire if their prices or emissions are too high to earn revenues.

Author Presentation: "Let's Get Organized! Long-Term Market Design for a High Penetration Grid" -- Eric Gimon

Dr. Gimon opened his presentation by pointing out that his proposed model shared several common features with Corneli's configuration model but is a concept showcasing a wider set of options, with the configuration model just one among them. His idea for an Organized Long Term Market (OLTM) would connect long-term investment in clean energy with short-term marginal pricing, allow multiple sellers and buyers to contract for standardized long-term energy contracts, and help the bulk power system deliver resource adequacy 24/7, all year long. Gimon also framed his talk with a description of the Energy Markets Cascade concept, that long-term markets flow into year- or month-ahead commitments that flow into day- or hour-ahead commitments and finally reach real time markets. This cascade conceptualizes a continuum of markets flowing downward (rather than splitting into competition ***for*** or ***in*** the market) that all work together to provide risk management, align technology characteristics, and facilitate planning and commitment of resources.

Gimon focused on three principles for this cascade. First, all markets should be a derivative of the real time market, most of the markets are swaps, and the types of swaps in the Corneli paper are at the top of the cascade in long-term markets. An OLTM would assemble resources into portfolios optimized around buyer criteria (least-cost, production shape, emissions). The other principles were that participation in long-term markets should be voluntary and that markets along the cascade need to be non-discriminatory, transparent, and liquid.

In describing what proposed OLTMs would look like, Gimon explained that there are several versions ranging from simple to more complicated. Overall, resources would be assembled into portfolios to achieve diversity benefits and then several buyers could purchase contracts that are easily retraded and can be combined adaptively to meet needs. The market would require OLTM optimizers to compile portfolios and an exchange to manage obligations, types, and secondary sales. The OLTM differs from the configuration model by allowing several optimizers rather than one entity optimizing for the entire footprint.

In addition to clean resources, the portfolios would include facilitating resources like transmission, storage, dispatchable resources, flexible demand, and innovative contractual arrangements. Portions of the portfolios that are more variable could also be separated out and sold at a lower price. Gimon concluded by pointing out several existing challenges in markets that OLTM could solve, such as creating diverse portfolios that smaller customers or munis would struggle to do on their own or reducing market intervention on resource adequacy that creates tension between RTOs and their states.

One participant asked what would motivate buyers to "show up" for this market. Gimon noted that almost every buyer today has a long-term contract and these new portfolio products would be more liquid, lower-cost, and lower-risk. Another participant asked where state regulation would play a role as it is a voluntary market. Gimon pointed out that there are roles states can play that are aligned with the principles of the OLTM and address issues like market caps or valuing demand flexibility. The next questioner asked how smaller entities will be able to manage in this market considering Community Futures Trade Commission (CFTC) regulations. Gimon again pointed to a role for states to assist but explained much of the proposed market features are in line with practices already used today.

The next question came from a participant who was concerned that the OLTM would eliminate consideration of physical constraints and obligations from capacity markets. Gimon questioned if there would be another way to handle the residual unit commitment process and that a new approach would be needed. Capacity markets, for example, are in violation of the principles laid out earlier in the presentation. There can be other contractual mechanisms that could be put in place to assist without creating a product that is not a derivative of energy. Corneli also weighed in on the physical nature of the market and emphasized the need for physical constraints tied to contracts and not just financial signals.

The next questioner asked for clarity on how carbon constraints are introduced into the model. Gimon explained that constraints, whether a customer or state goal, would be external and pass the signal through demand for contracts that meet those goals. They could also buy products off the market and then pay extra for fully clean products or local products to meet their needs. These adjustments could help manage the tradeoffs between specificity and liquidity.

Another participant asked if there could be competition across different exchanges so that a state or customer could choose between products from the OLTM- or PRISM-based platforms. Gimon saw the possibility for diverse portfolio assembly but argued that there would be efficiency issues in having multiple exchanges. The final question was about competition between portfolio assemblers, noting that these types of portfolios already exist in Spanish markets. Gimon suggested an assembler of last resort may be needed and also highlighted that the Spanish market has provided evidence that long-term markets can reduce anti-competitive behavior. This is tied to the earlier question about the state role, as there could be a regulatory role to ensure there is competition between portfolios.

DAY TWO

Opening Remarks: Peter Fox-Penner, Boston University Questrom School of Business

Dr. Fox-Penner opened the second day of the workshop with some discussion on the future of electricity. He emphasized that in order to decarbonize the economy, we need to plan for two main changes: expanded demand for electricity and updating markets that were designed for a fossil-based system.

Plenary Remarks: Dick Schmalensee, MIT Sloan School of Management

Professor Schmalensee began his remarks by presenting three objectives for electricity markets:

- Achieving short-run production efficiency, given available assets;
- Achieving long-run production efficiency, producing asset fleets capable of reliable, low-cost production, taking into account all costs; and

- Inducing efficient consumption of electricity with variable retail rates that reflect short-run marginal cost (essential for economy-wide decarbonization).

Schmalensee then turned to an exploration of how an energy-only market design could, ***in theory***, achieve these objectives, drawing from modeling work underway as a part of the MIT Energy Initiative's Future of Storage Project. The project is modeling electricity systems with high penetration of variable renewables and storage, and with varying emissions constraints. Using an optimization model that assumes perfect information and foresight, and a $50,000 Value of Lost Load, the MIT analysis indicated that an energy-only market could achieve short-run and long-run efficiency under all emission constraints scenarios, assuming that very high scarcity prices are allowed to occur without regulators interfering or instituting price caps. In such scenarios, generation and storage resources would earn very large portions of their revenues during a small number of hours with very high scarcity prices, and would receive very low or zero prices during the remaining majority of the hours of the year. In general, wholesale prices would be much more variable than in current markets. These results also hold when demand response is included in the modeling.

Another important insight from the model results is that system operators would no longer focus on peak demand to maintain reliability. With high penetration of variable renewable generation, system stress and loss of load could occur well off-peak. Capacity mechanisms based on nameplate would make no sense.

Schmalensee then turned to whether an energy-only market could succeed ***in practice***. He noted that investors will be reluctant to make investments where profitability depends on very few hours of very high prices. This is a financing problem, but likely solvable with forms of long-term contracting.

Schmalensee argued that the key problem with an energy-only market design ***in practice*** is that, even today, most system operators find extreme price variability problematic and they intervene, directly or indirectly, to avoid high prices (as happens in ERCOT and other RTO/ISOs). He argued that historically regulators and other policymakers have regularly second-guessed markets, and that the increased price volatility of a high variable renewable generation mix will only strengthen that impulse.

Schmalensee then offered thoughts on the key elements of a good second-best market design -- subject to the constraint that regulators won't tolerate extremely high prices and rapid, unmanaged change in the character of the system. He argued for a supplement to the energy-only markets, but one that preserves the short-term efficiency benefits of those markets and ensures that the retail electricity prices consumers face are low during periods of abundant zero-carbon electricity. Such low prices, together with time-varying price patterns, will help promote electrification of transportation and other end-uses, along with efficient distributed storage.

For some key elements of such a system, Schmalensee pointed to the need for something resembling historical Integrated Resource Planning (IRP). He noted that evaluating asset portfolios with the new technologies is not as simple as, for example, forecasting how much capacity is needed for a target reserve margin. A least-cost system needs a suitable mix of solar, wind, storage, etc., along with transmission investments. Identifying and procuring such a mix is a complex process. He pointed to the important but challenging tasks of figuring out bidding rules, bidding frequency, counterparties, and so on. There has to be a strategic, careful process. Policymakers should not "shoot from the hip" as some are doing now.

Another key element is that long-term contracts should not distort operating incentives. He noted that Renewable Portfolio Standards yield positive cost per megawatt-hour prices for Renewable Energy Credits, giving wind and solar generators negative marginal cost and making it difficult to operate a system efficiently. Hawaii is moving toward a better kind of contract focused on megawatts, not megawatt-hours. This type of contract guarantees a certain level of revenue, with penalties for under-supply, but does not compensate on the margin for incremental generation.

Finally, returning to retail rates, Schmalensee recommended that fixed costs of capacity should be recovered through (equitable) fixed charges at retail, potentially similar to the monthly subscription charges widely associated with mobile telephones. If regulators load these costs on per-kilowatt-hour charges, the high marginal energy charges will impede the electrification needed to decarbonize other sectors.

Author Presentation: "Wholesale Power Market Design in a Future Low-Carbon Electric System" -- Dr. Susan Tierney

Dr. Tierney gave a presentation on her proposed market design that opened with some discussion on framing and assumptions underlying her paper. She described the "architecture" of the electric system as being composed of three layers: 1) physical infrastructure; 2) information, communication and controls; and 3) institutional and financial systems. She discussed how the paper would focus primarily on the third layer, while acknowledging the importance of the first two. She also explained some assumptions that affected her proposed market design, which included that society (both government and private sector) will continue to move toward zero-emissions in the power sector, that the electric sector will continue to grow, and that there is great uncertainty regarding what the power system will look like in the coming decades. She also emphasized that the definition of "resource adequacy" needs to change from "having enough resources to meet peak demand" to "having enough resources to meet demand around the clock." Lastly, she assumed that a price on carbon alone will not be sufficient to meet resource adequacy needs and an efficient resource mix, and that in the absence of a federal climate policy, effective market design at the RTO level is even more imperative.

Dr. Tierney's proposed market design relies on three building blocks: 1) wholesale energy and ancillary services markets, 2) a newly proposed resource adequacy approach that would be done in conjunction with state policy and would select for particular generator attributes, and 3) price-responsive demand.

Dr. Tierney went on to discuss a fourth building block that was not included in her paper but is equally important – transmission planning. She explained that expanded transmission capacity will be necessary for accommodating a high penetration of renewables in the future, but that there are many constraints with respect to transmission investment and siting. Some comments in the chat expressed that this was an important feature that was left out of the proposal.

With respect to the first building block, Tierney explained that her proposal is essentially the same as the short-term energy markets that operate today but with the assumption of carbon policy mechanisms that would impact dispatch and prices.

On resource adequacy, Tierney explained that her proposal would introduce several new resource adequacy products that would reflect preferred system attributes in order to meet both system needs and low-carbon requirements. Some of the proposed products include "System RA" which is similar to capacity requirements today, "Flexible RA" which would provide flexibility services such as ramping, and "Local RA" which would reflect the benefits of having certain resources in certain locations.

A participant asked if a flexibility resource adequacy product would limit real time price volatility and if it would limit the price signal. In her response, Tierney acknowledged that there was a tradeoff and that it would make the most sense to wait to procure the flexibility RA product after first seeing how the market responds.

As part of this new resource adequacy approach, Tierney explained that a FERC tariff would enable states to choose their own requirements for resource adequacy over the long term, which would include attributes such as zero-carbon resources or even specific technologies. Then, given these state requirements, the RTO would conduct an annual long-term (ten-year) procurement for resources that meet those requirements. The RTO would select resources based on best-fit criteria for the lowest cost, with winning bids entering into long-term contracts with LSEs with payments based on as-bid costs.

Tierney explained that her approach could address greenhouse gas emissions in two ways: first, by having any policy-directed carbon price incorporated into the RTO markets; or second, through a FERC tariff that would enable states to incorporate a carbon price into the energy market or create a new RA product with carbon constraints.

Dr. Tierney's presentation sparked a robust set of questions from participants. One participant asked why this proposal links emissions reductions to capacity rather than to energy given that, particularly in the 2030s and 2040s, a significant amount of fossil capacity may still be around but not used frequently to generate electricity. In response, Tierney offered that, without a meaningful price on carbon, the energy market alone will not be sufficient for driving investment in clean energy technologies that are needed to meet zero-carbon emissions goals and emphasized the need for long-term planning and contracting as a way to address this need.

Another workshop participant questioned the feasibility of defining a relevant set of resource adequacy products for existing markets given the inherent complexity (with multiple subproducts already being proposed). In response, Tierney explained that the resource adequacy products would be expected to evolve over time as the result of the stakeholder process.

One theme of the discussion among participants was the role of price volatility in energy markets to contribute to a missing money problem for new investment. Some argued that the absence of scarcity pricing is a major contributor to the missing money problem. In response, one participant argued against the idea of a missing money problem with respect to operational flexibility, noting how energy storage enables operational flexibility for renewables.

Other comments focused on transmission expansion planning. One comment suggested that the transmission planning part is "easy," while actual transmission expansion is much harder since there is no tariff language governing how states should select and pay for new transmission assets. Some noted that successful transmission expansion projects have taken place in ERCOT and CAISO, both of which are single-state RTOs. Tierney agreed that significant tariff changes would be necessary for her idea to work, one of which would be changes to transmission cost allocation.

Other comments emphasized the need for the transition to be both efficient and equitable, with stress on the equity portion that economists can overlook, which Tierney later emphasized again (once in her talk and later in response).

There was some skepticism in the comments about the benefits of breaking resource adequacy into four subtypes. Tierney clarified that while most of the RA products that she anticipates being developed would be focused on general system RA, the others are needed for ensuring that the right resources are optimally located, which cannot be captured in the system RA.

There was some skepticism expressed that any approach to encouraging decarbonization that did not involve a carbon price would be politically acceptable given the relatively higher cost of other approaches to decarbonization. As such, trying to achieve decarbonization in part through electricity market designs could be politically risky. In response, Tierney explained that FERC is likely unable to put forth a carbon price in the markets without a federal carbon policy, and thus relying on the "first best" solution alone is likely not practical.

The last comment was that the ERCOT model (which does not include a centralized long-term energy market but instead relies on shortage pricing in energy markets to help encourage investment) enables long-term bilateral contracting outside of the market, and even if states were responsible for resource adequacy, there is an argument that scarcity pricing would still have to play a vital role in the markets. In response, Tierney argued that the ERCOT model was not likely to spread to other markets and that regulators would likely not let prices rise uncapped, thus some supplement to scarcity pricing is needed.

Author Presentation: "Wholesale Power Market Design in a Future Low-Carbon Electric System" -- Brendan Pierpont

Mr. Pierpont opened his presentation with his views on the objectives that should guide long-term market design. These objectives include using simple and easy to understand designs, enabling efficient short-term markets, limiting opportunities for gaming, allocating risk appropriately among participants, accurately reflecting different resources' values, and being compatible with (likely state) policies.

Before diving into his proposed design, Pierpont highlighted the assumptions regarding short-term markets and clean energy policies that underlie his proposal. He argued that in order for his design to work, short-term markets must work efficiently including valuing scarcity, allowing the demand side to participate, and incentivizing resource adequacy. On the policy front, Pierpont argued that long-term markets must be able to work with a variety of different policy drivers, and that a carbon policy was necessary to transform the sector.

Pierpont then introduced his market design, which he described as essentially a contract for differences in which the seller earns a fixed price per megawatt-hour for a contracted load shape net of the real time price for the energy delivered, while the buyer bears the price risk for their contracted load shape. To clear the market, Pierpont suggests that winning bids are selected either based on highest net value evaluated using well-accepted future energy price projections and then are allocated among participating load serving entities on a pro-rata share, or based on an optimization of bids based on lowest bid price and the buyer's willingness to pay for load of a particular shape.

Pierpont explored some considerations for implementing his proposed design, including who would operate the market (a government agency, RTO, or third-party), the types of resources eligible to participate (could be tied to a specific policy or specific attribute, like carbon-free resources), and how the market would work alongside carbon policies.

One participant noted that suppliers face risk under this market design in the long-term market of missing production if delivered energy falls short of the contracted load shape, which could be costly for them. This participant noted that such risk should be addressed.

One question addressed how firming resources would participate in this market and how they would be co-optimized with the other bids, to which Pierpont responded that those resources would likely not participate in the long-term market and would instead rely exclusively on the short-term market for revenues. Alternatively, Pierpont suggested that portfolios of resources that include dispatchable resources in addition to others could submit bids as well.

Another question was whether Pierpont had considered incorporating a zero-carbon willingness to pay for buyers. Pierpont responded that while he had not considered it, incorporating a carbon constraint into the optimization model could be done fairly easily.

Plenary Remarks: Jon Wellinghoff, CEO of GridPolicy, Inc and Former FERC Chair

Former FERC Commissioner Jon Wellinghoff focused his high-level remarks on the policy processes for helping to advance deep decarbonization of the electricity sector, particularly with respect to market reform and transmission expansion rather than focusing on the details of market reform itself.

Wellinghoff explained that while states have led the way in the path for decarbonizing, federal action is needed going forward and that effort should be in collaboration with the states. Comments in the chat indicate that several participants shared the view that federal policy is necessary going forward. In particular, Wellinghoff advocated for a standard market design, potentially requiring the expansion of existing RTOs to encompass new regions. Wellinghoff emphasized that President Biden had indicated that national decarbonization policy is a priority and is aiming for a decarbonized grid by 2035. Federal policy, either through an executive order or through legislation, would enable FERC to begin considering market reform and transmission planning. Wellinghoff indicated that in the absence of a new federal policy on decarbonization and electricity markets, market reform could be done through the RTO stakeholder process, but that this approach is extremely time-consuming.

Wellinghoff expressed hope that a collaboration between FERC and the states on new approaches to market design could benefit from some of the ideas presented during this workshop and could evolve toward a “first-best” solution.

Summary of Breakout Groups

Group A was tasked with evaluating the proposals based on design features such as product definition, pricing and payment structure, interaction with existing markets, and risk allocation. The group’s discussion focused on comparing the “first-best” solution or an energy-only market design like ERCOT with the “second-best” hybrid markets reflected in Tierney and Corneli’s proposals. They concluded that we should be pushing for a first-best solution but recognized its limitations in replicating the design outside of ERCOT, and that, as a result, we are likely headed toward a hybrid market instead. They also discussed whether or not RTOs should take on a larger role as implied by both Tierney and Corneli’s proposals, and the group concluded that RTOs should remain in a more technical role in the implementation of market designs and take policy direction from the states.

Group B’s discussion focused primarily on risk allocation, incorporating carbon goals, and addressing resource adequacy. The group concluded that while companies with large portfolios would likely be able to hedge risks, more evaluation is needed to understand how these proposed designs would affect regulators’ attitudes toward customers taking on more resource adequacy risk. They also argued that more clarity was needed on how the proposals would satisfy resource adequacy requirements. In terms of meeting carbon goals, the group felt that a “first-best” approach might not be feasible, but that the mechanism used in these “second-best” markets should be as direct a carbon price signal as possible. Lastly, the group expressed concerns about these bifurcated markets being able to send market signals for entry and exit and stressed the need for all market participants to receive the same market signals.

Group C’s discussion focused primarily on resource adequacy. The group responded favorably to Tierney’s proposed resource adequacy products, arguing that resource adequacy needed to evolve beyond definitions based on peak demand. The group noted that while Tierney and Corneli’s proposals address resource adequacy, the Pierpont and Gimon proposals do not adequately address it. The group argued that addressing resource adequacy requires: 1) forecasting how much load is inflexible, 2) identifying the mix of resources and functions needed to meet that load, 3) enabling clear financing and compensation opportunities for the entities providing resource adequacy, and 4) creating more demand-side flexibility and resilience to counter the increasing probability of supply-side failures to meet load.

Group D focused on how the proposals addressed carbon emissions and how well they would work with state or federal policies. They noted that Tierney and Corneli’s proposals addressed ways to incorporate a diverse set of state policies into their proposed markets, while Pierpont and Gimon’s proposals did not and treated carbon policies as exogenous to their models. They noted that in all of the cases, the proposals still require a federal or state climate policy driver, and that FERC is not an environmental regulator and therefore must rely on states or the federal government to drive policy. Lastly, they argued that long-term contracts that focus on capacity would be difficult to reconcile with state policies that focus on energy and recommended additional analysis to understand this interaction.

Group E focused on the transition from current market design to the proposed market designs. They concluded that it was difficult to assess how such a transition would transpire because the proposals were vague and did not discuss relevant topics in depth. The group argued that while the Tierney and Corneli proposals were an evolution of the existing market structure, the Pierpont and Gimon proposals were really more of a “revolution” than an evolution. Given the time it takes to implement new market designs, the group agreed that the Tierney proposal was the most practical and most attractive for near-term implementation.

Group F focused on the accuracy and specificity of the proposed models. Regarding Tierney’s proposal, for example, they expressed concerns about the model’s ability to co-optimize all of the resource adequacy products, while they found that optimizing prices over the long-run in Pierpont’s model could also be very tricky. Moreover, the group found both models to be lacking in incorporating energy storage, co-optimizing with transmission, and including distributed resources. The group suggested having multiple rounds of balancing markets to help mitigate the inability to forecast future prices and quantities over the long-term.

BREAKOUT GROUPS

A. PRODUCT-PRICE-SELECTION-RISK

Day One Discussion

It was the intention of this group to focus on the following two aspects of the price-product selection aspect of these market designs: (1) the pros and cons of having products take the form of contracts for firm hourly energy schedules versus payments to resources selected from bidders using sophisticated system and weather modeling resources, and (2) the incentives for bidding actual costs and efficient performance after the fact under the different approaches to winner selection. For the proposals discussed on day one, approaches include Corneli's approach of using a sophisticated least-cost, best-fit approach covering the entire supply portfolio and respecting supply demand balance and carbon budget constraints to identify winning resources, and Gimon's mix of a least-cost, best fit analysis combined with a secondary matching of proposed supply schedules for portfolios of resources match with load preferences to find the best set of long-term contracts.

However, from the start, the conversation instead pivoted to the topic of contract structure with a focus on Gimon's proposal, highlighting features not covered in his presentation. Gimon proposed: (1) contracts for a specific production pattern ahead of time (e.g., for storage, this means specific charge/discharge patterns), and (2) trading the resulting production profiles (based on a single resource or portfolio of resources) on an exchange. The discussion then focused on the incentives that buyers have to contract for these production profiles ahead of time (e.g., multi-year, one year ahead), and how the exchange that Gimon proposes differs from current bilateral agreements that are available in the markets today.

The incentive for contracting for fixed schedules and portfolios of resource operation in advance is to bring more certainty to the market and limit sensitivity to short run pricing fluctuations closer to the time of consumption, moving through what Gimon calls the energy cascade from long-term markets to day-ahead to real time. The projected profile of supply is not meant to be accurate in terms of ultimately matching demand in real time, rather, the purpose is to balance across the different temporal markets (year ahead, closer in time, etc.). For example, a year-ahead profile may be a baseline-level shape of solar/wind, fulfilling 60% of anticipated hourly needs. Then as we approach the dispatch timeframe, balancing power purchased day-ahead or in real time can refine the overall profile of supply. The ability to trade standardized profiles can help project developers hedge some of the risks they face including both production risk and location risk (hub versus node).

This approach can help address issues of transparency and accessibility that exist with current bilateral contracting approaches that are used by developers to hedge risk. The centralized exchange approach faces its own risks relative to today's bilateral agreements, including the difficulty of trading very customized market shapes where markets might end up being very thin and market power could become an issue. The easiest shape to ensure a thicker market would be a fixed one -- however, corporate entities in search of green power may not like such an approach, as companies like Google are looking for shaped energy portfolios that meet their demand 24/7 (not just relying on non-time denominated Renewable Energy Credits to satisfy clean power pledges). The group discussed current hedging contracting formats, which include classic utility power purchase agreements (PPAs) which obligate the buyer to take power as generated at a fixed price, bank hedges that specify fixed volumes, for 12x24 hour blocks, and corporate PPAs which take a different form. Comparing these different approaches shows that there are tradeoffs between customizing the shapes versus the number of parties able to provide a particular desired shape, leading to potential market power concerns.

The group also discussed whether the market will be able to capture the fact that different consumers will value different production shapes differently and if the exchange will auction these portfolios to the buyer with the highest willingness to pay. There were also questions about the ways that the Gimon proposal would or could interact with regional transmission planning, as the location and extent of transmission investment could affect the deliverability of these power portfolios to customers and also the outcomes of the proposed long-term market.

The group also discussed the issue of more active demand-side participation in energy markets and the extent to which that might be a way to help enable a market-based and low-cost approach to resource adequacy in a renewables rich system.

Day Two Discussion

1. **Need for a "Visible" Hand in Long-Term Electric Power System Planning**

In his remarks, Joskow noted that even in the ERCOT market, there are many out-of-market mechanisms that undermine the invisible hand. So should we move toward a design with more out-of-market intervention? If so, what does the second-best approach look like?

Some participants gave lots of praise for the ERCOT model; others observed that the Texas model is not easily implemented elsewhere, across multiple states. The breakout group discussed three issues:

- **Competitive wholesale market**: Should carbon prices be included into dispatch bids? The mechanism for doing this has already been implemented (for example, RGGI price in the Northeast). However, policymakers haven't yet addressed how to deal with leakage issues (as electricity crosses state borders). Separately, current market clearing relies very much on forecast demand from RTOs/ISOs, and more active demand-side participation will be needed. This could be increasingly enabled by higher uptake of electric vehicles and smart appliances/meters. This type of flexible demand can help smooth out production shapes (as envisioned in some of the papers).
- **Interregional transmission planning**: Co-investment of generation and transportation is the key challenge here, particularly when transmission decisions typically span state borders. Given that merchant investments are unlikely given the uncertainty of investment signals, a visible hand is much needed (for example, CREZ lines in Texas are a success story). Another challenge is that current FERC rules are not fit for purpose. New thinking is required on interregional transmission planning.
- **Competitive retail market**: Consumers need to face more real-time pricing to enable price-responsive demand. This is essential to increasing active demand-side participation.

2. **Other Discussions**

- What is the role of RTOs? Is it to implement policies generated at the federal and state level (more of a technocratic role)? Or should it take on more of a policymaking role? Most participants opposed the latter role, given current RTO membership and governance.
- What lessons can we gain from international experiences? For example, Chile has centralized long-term planning. Many participants thought a careful review of international experience would be useful. Others questioned how applicable it could be in a country like the U.S., where states have vastly different priorities and interests.

B. LONG-TERM MARKET SELLERS

Day One Discussion

1. Market Ability to Enable Tech and Innovations for Climate Objectives

Even if the pollution damages are accounted for in the market, there still may be room for providing support for innovative technologies. This relates to the externalities that surround innovative technologies (e.g. knowledge spillover externalities, network externalities, etc.) and for firm clean resources, their potential for cutting the electricity sector's costs.

The optimal treatment of innovation in long-term markets may differ depending on how mature a technology is for the market. It does not seem plausible to include carve-outs for relatively new technologies which have not proven their functioning yet – signing contracts with such technologies 20 or even ten years in advance, without knowing whether they are actually reliable, would be very risky. For such technologies, out-of-market support (subsidies, preferential tax treatment, etc.) would be preferred. For more mature technologies, carve-outs are a more viable path, although the group was divided over their role. Some supported them, while others suggested that markets are best for trading and achieving efficiency gains and that government should set policies and provide subsidies outside of the market.

One difficulty with policies implemented within markets (such as carve-outs) occurs for multi-state trading areas, when states differ in the policies they pursue (for instance, in the set of emerging technologies they want to support).

There was also a suggestion for a separate, voluntary market where the contracts with innovative, more expensive technologies are sold to purchasers willing to support such technologies. In such a setting, individual customers and governments would be able to choose between incumbent resource types and new, low-carbon approaches. These new technologies might be available in short supply and at a premium at first, but they could attract enough activity to compete with incumbents, bolstered at first by policy and then eventually on their merits, which would eventually lead to their addition to the "main" market.

2. Retirements

The long-term constructs will lead to "correct" retirements if the constructs themselves are designed correctly and in a manner that is coherent with short-term markets. They need to value the same attributes as the short-term markets (e.g. absence of pollution, flexibility) and include all participants in a non-discriminatory manner. The latter implies that both new and existing units should be allowed to participate in the long-term constructs.

Day Two Discussion

1. Treatment of Existing Unit, Exit and Retirement Signals & Considerations of Entrants and Technologies

A big issue that arose was how risk would be distributed in a market design that requires foresight into deliverability in 20 years, with time granularity. The risk might be particularly high for prospective technologies (e.g., floating solar). In addition, the papers gloss over the issue of correlated risk and the risk of systemic grid failure.

Large companies with large portfolios are perhaps best positioned to deal with that risk, as they have the resources to create a portfolio that is diversely composed of some emerging tech while hedging with sure bets. This is similar to the financial hedging they are already doing, so in a sense, the designs resemble a financial intermediary. Regulators might not be willing to take the risk associated with the designs as they prioritize grid reliability rather than diversity or portfolio composition, and customers simply are not in the best position to absorb curtailment risk. So the largest market players are likely best positioned to trailblaze new technologies and shape long-term retirement signals.

To achieve the right entry/exit incentives for decarbonization, there needs to be a direct price signal. If there is no direct signal, the market design should get as close as possible, whether it is a constraint or some other form. In that sense, Corneli paper seems to perform much better.

Also, it is better to have a single market that can provide the same price signal instead of bifurcated markets for new/existing resources, different types of capacities, etc. The price signal would be stronger that way.

2. Takeaways

- More clarity should be added to the papers about who is determining resource adequacy, especially if the markets are simple bilateral voluntary markets. The papers should be evaluated from the perspective of an LSE that has resource adequacy obligations.
- To achieve carbon goals, a second-best approach is preferable if a carbon price is not possible.
- Bifurcated markets may create fuzzy exit signals because not every participant within them is receiving the same info.
- Companies with large portfolios should bear risk because they can hedge.
- The Corneli approach is preferred for decarbonization goals because of the market design's external carbon constraint.

3. Other Topics Discussed

- In contemplating ways to ensure resource adequacy in the long term, the papers propose additional complexity on the current system. Are there simpler, practical solutions in a second-best world that may not necessarily need to take a 20-year view?
- Corneli discussed the idea of optimizing resources coming on the grid and backing up as you go to help create long-term signals.
- Piecemeal state-by-state solutions are not ideal. Streamlined, simple solutions are best implemented on a larger scale.

C. RESOURCE ADEQUACY

<u>Days One and Two Combined Discussion</u>

With high levels of VREs, there will be fewer "firm" megawatts from generation resources, and resource adequacy will become a time- and location-specific challenge. Providing adequate resources will require building portfolios and combinations of generation, storage, and demand resources that work for different times, timespans, and locations. What provisions of these market models make it more or less likely that each can successful deliver resource adequacy under these more complex circumstances? How will these market models accommodate flexibility and uncertainty? How do these more versus less centralized approaches to resource adequacy compare in this regard?

1. Key Concepts in Resource Adequacy

In these papers, resource adequacy seems to mean having enough supply to cover demand. Looking ahead, demand will be complicated by combinations of electrification, automation and flexibility, energy efficiency, heat, storms, behind-the-meter generation, and storage; and supply will require storage as well as generation and inverter capabilities.

Relevant resource adequacy questions include:

- How much load needs to be served and with what level of reliability, what mix of resources, and what functions? Who or what is the entity or mechanism that knits them all together, and how does that get financed and compensated in ways that make sure that usable resources show up when needed? All of the load that doesn't have other options (DG, DR, storage, ability to give up some consumption, willingness to voluntarily turn off load as a civic contribution) is the minimum level of load that we want, with supply and storage resources ready and able to serve.
- How much supply do we need to procure in advance (buy forward) and how much can we trust to show up in real time? Most of these models explicitly assume that it is necessary to buy firm supply in advance to meet non-flexible load, and aim to buy forward enough that you don't have to shed load in real time.
- What is the level of reliability? With or without VRE (but possibly more now with high VRE penetrations), system security can go wrong in more ways at more peak and off-peak times. More VRE and supply variability means there is a risk of outages in hours beyond simply the gross system peak load hour, so RA is becoming more of an 8760-hour challenge than it has been historically.
- Traditional reliability metrics such as LOLP and planning reserve margin are convenient but require more context (or may not be appropriate at all) for a system with high VREs and growing demand-side flexibility. Depth of lost load, not just its frequency, is important. There is a big difference between putting 10,000 customers out for two hours and 100,000 customers out for two days.
- RA calculations (e.g., capacity credits, ELCC) should involve stochastic modeling around many alternative resource (supply, storage, demand) scenarios. These are complicated further by interactive effects between the different resources (wind, solar, weather, electrification, dumb pricing schemes) affecting types, quantities, timing, proximity, and variability associated with these combinations. Currently, RA (reliability) modeling is typically done before resource planning (economic) modeling to simplify the resource planning modeling, though some models are combining both elements.

2. How Market Models Might Handle Resource Adequacy and Reliability

- The Gimon and Pierpont models are not designed to explicitly address resource adequacy. However, they support the general idea that LMPs/scarcity pricing should be high enough to allow units to recover costs and to provide operational incentives for reliability.
- The Gimon model focuses on linking the long-term markets to the real time spot price, which represents real time electricity need. Commenters point to ERCOT, a Gimon-like market that handles resource adequacy through scarcity pricing rather than aiming to meet a target quantity of "effective" capacity. (To date, the ERCOT model has kept the lights on and has spurred large participation of active customer demand response.) While this has worked to date in ERCOT, driving resource adequacy based on scarcity pricing will not work as long as regulators: (a) artificially suppress or limit the height of scarcity prices to "protect consumers," and (b) give most customers flat retail rates rather than time-of-use rates. These practices prevent customers from seeing and reacting to prices that reflect stressed system conditions. It is also unclear whether capital recovery from scarcity pricing will be sufficient to compensate resource capital costs, as growing penetrations of VREs drive average LMPs lower and lower.
- The Corneli and Tierney models both attempt to solve the resource adequacy issue explicitly. However, all these models leave the hard work and RA math to the market operator to figure out what demand levels will be, what mix of resources (of all types) and services are needed to meet varying demand levels and operating circumstances, how and when to get those resources into the market, and what to do if and when those resources don't show up. This is even more challenging since all of the market models proposed make market participation voluntary for both supply

and demand parties, which means that some non-market party's poor analyses or decisions could impose bad reliability outcomes for many or all of the entities and customers actively participating in the markets.

- Tierney's paper breaks resource adequacy into granular products (time-dimensional, functional, locational, contextual such as flex RA, local RA, system RA, and other unnamed products). This is conceptually appropriate, although it's not clear whether on a practical basis the proliferation of products (as emerging in California) will be workable. The success of this approach will depend on the ability of market modelers and planning to accurately forecast system conditions, design policies/market products in response to these products, and effectively link and integrate or co-optimize those services from both supply and demand-side sources.
- One advantage of the Corneli PRISM model is that it can account for different RA characteristics of different systems. Corneli's proposal recognizes that the amount of one technology type (e.g., solar) can have a large impact on the reliability contribution of another technology type (e.g., storage). This means there is no need to create a standard RA product to compensate units (though this could be part of compensation). However, the levels of uncertainty and computational complexity are so huge that it could be difficult for the PRISM or RTO planning models to perform all of the stochastic analysis needed for actionable insights. There may be a need to separate out more detailed RA modeling from the resource selection modeling, which is consistent with current practice. A larger model that "does it all" would be ideal, but since modeled results depend as much on the quality of the inputs as on the quality of the models, we're not optimistic that determining useful resource goals and portfolios is a feasible task over the next 10+ years.
- Both the Tierney model and the Corneli model recognize and are intended to accommodate state/federal preferences for low-carbon resources. The Tierney model provides a path to resolve many of the jurisdictional issues facing Eastern capacity markets, essentially by deferring to states' RA preferences. Most state-expressed preferences do not address what types of resources should be used or offered into the market and don't set resource adequacy or reliability requirements.

3. Other Key Ideas

- Many of the services in the market models are ill-defined. In general, the less tethered services are to scarcity energy pricing (or the less that they have a clear definition, functional performance requirement, and path to compensation), the less confident we are that they'll show up. Higher levels of liquidity for energy and other services should improve operator and retail electric provider capability to deliver reliability.
- Higher levels of liquidity for energy and services improve operator and retail electric provider capability to deliver reliability.
- How do we determine the level of non-firm energy services needed (particularly for flexibility), and how do we procure the right levels and mix of these services? This matters for all hours, not just at times of peak or system stress. We can't just say it's a co-optimization challenge. The fact that hybrid and distributed resources and storage straddle supply and demand makes this more complicated.
- None of these models explicitly address the question of who is responsible for knitting all the reliability and resource adequacy pieces together and making sure that all of the functions and services are provided at sufficient levels when needed. Tierney tells LSEs to cover their load obligations: this is an old peak load concept that ignores operational and ancillary services requirements in an 8760 RA world. Corneli assumes that whoever is doing the planning should provide the resources, but doesn't clearly explain how to pay for all of the needed resources or what to do when forecasted needs are wrong. None explicitly address the idea of a "reliability provider of last resort" that identifies

and meets inelastic customer loads that no other providers or resources are showing up for, nor address how to pay for that.

- All these market designs say that central market participation is voluntary, and that retail electric providers (including utilities, CCAs, etc.) can self-provide or sign bilateral contracts. But no market designer talks much about what obligation to put on the retail providers (other than creditworthiness or buying enough supply to cover customers' demand) to assure reliability for its customers.
- As customers' demand elasticity grows and they get more accustomed to losing power for reasons other than lost supply (fires, storms, cyber attacks, etc.), their sense of value of lost load (VOLL) will change and be more context-specific (when do you lose power and for how long?) and may no longer be a good proxy for the value of resource adequacy.
- It is not clear that market designers and operators recognize or trust the existence and reaction of demand-side resources that are not bid into an energy or capacity market (non-aggregated, individual customer DG and storage, individual decisions about AC thermostat settings, etc.), although these can affect market outcomes as much as market-bid demand resources.
- Elastic demand and active demand side participation makes real time operational reliability easier to achieve and may lower overall costs. If we get more creative and aggressive about building DR, DG, storage, and energy efficiency capabilities, we will increase demand flexibility and reduce the consequences associated with failures on the supply and analytics side of grid and market operation. Much of that will need to be done outside the energy-plus market to overcome the many transactional and agency obstacles to increasing investments in DR, DG, storage, and energy efficiency. These measures need to be done quickly and at great scale (particularly energy efficiency) to reduce carbon emissions and take the pressure off supply side and market modification while everyone debates and drags through power market design and implementation.

D. CLIMATE

<u>Day One Discussion</u>

1. Voluntary Versus Mandatory Mechanisms

Strong feelings were expressed in favor of a voluntary mechanism. This was felt to be a practical requirement due to political realities, and was also preferred for its flexibility. If not binding, a proposal simply adds an option for transactions and greatly reduces downside risk that might come from a flawed design.

2. Exogenous Climate Policy

Climate policies have to be developed exogenously and not as a part of market design. The design can accommodate them. With that perspective, both proposals can accommodate these exogenous policies. There is a clear difference between Corneli's approach where the optimization function would consider policies directly (as part of the optimization), or Gimon's approach where exogenous policies show up in the market design as part of market prices (offer prices, etc.). There were different views as to which was preferred. This is a fundamental question and tied in directly to the day two discussion of first-best and second-best solutions. (There seemed to be some confusion over these terms. In economics, a first-best solution is one where price alone leads to the optimal solution. That is often the case, but not always. That isn't true, for example, if there is a desire to reduce carbon and one can't simply put a price on carbon emissions. Any option that tries to optimize by creating a non-price influence on the market will lead to a second-best solution. There are no third-best options, but some second-best solutions are better than others.)

3. Geography

The exogenously-driven policies are often adopted for a geographic footprint that does not match the market. This causes considerable problems in implementing changes to the market.

4. Price Volatility

There was discussion as to whether market prices, and price volatility in particular, provide appropriate incentives for needed supply, including such things as storage, pre-commercial product development, and possibly locational issues. There was a clear difference of opinion on this.

Day Two Discussion

1. Market Design and Climate Policy

It seems that Tierney went straight at this trying to find a long-term contract mechanism that reflected these elements. Pierpont's proposal is more exogenous. It's hard to see how those mechanisms support these policies. There is agreement with Tierney's assessment to accommodate the state policy implementation.

Pierpont agrees with Tierney's assessment. There is focus on product and mechanism design more than a whole system framework. Climate and clean energy policies enter exogenously (state programs incentivizing clean energy), which helps stabilize the revenue the projects are earning. It can function as an incremental tool to help with low-cost financing. It could be constrained or have participants bid a preference for carbon-free energy and use it for a procurement mechanism for voluntary carbon-free goals or a clean energy standard. A carbon price can be incorporated in the short-term market, which would be the basis of evaluation.

2. Utilities Obligated to Buy RECs & a Long-Term System Focused on the Wholesale -- An Accounting Challenge or a Real Challenge?

States have long-term plans to achieve decarbonization goals. They are setting out types of resources and have complementary mechanisms to procure them. Once that is done, contributions to resource adequacy needs to be accounted for. We are in the second-best world and properly accounted for, it works. It is okay to sell RECs across state lines. Tierney's approach takes these disparate state imperatives and flattens them, while establishing a long-term contract mechanism which acknowledges the reliability benefits. The resources need additional financing. They need to run through existing state policies and be fit into a framework. Tradeoffs are on balance because of long-term contracts.

Load-serving entities don't have long term visibility on load. There is a reasonable way to accommodate that but there is flattening happening. Each policy needs evaluation to check feasibility.

3. Exogenous Versus Endogenous

Either of the two can work. RPS and CES can work and it isn't the RTO's job to participate. Tierney's approach is an opt-in approach, which is critical. FERC doesn't have the authority to mandate RTOs to participate.

4. Free-Rider Issues with Opt-In Approach & Prices/Market Design for Deep Decarbonization

A voluntary market is a brilliant market because there is no limit to what you can do, and is important because you can't wait for federal legislation. Energy prices will be telling wind, solar, and storage what to build. These markets will saturate with 20% solar penetration due to very low prices, and that market price will tell solar to not build. Wind will have lower capacity value than solar. Over time, we'll be able to get to 30-40% penetration until it runs out of value, which will be reflected in energy prices. Similarly, there will be high prices for storage when the sun goes down, only until storage grows and the market saturates. In such cases, exogenous policies will help meet goals. Well-designed power markets are key – and RTOs can procure reliability services.

5. Market Drivers for Carbon-Free by 2030 or 2050

Market drivers to get to carbon-free are a carbon price or a clean energy standard. States can implement these as they see fit while Congress can when it gets the votes. However, there is no voluntary market mechanism to drive the decarbonization at the scale we need. It just doesn't happen with the policy driver. It is worth exploring market designs, when the policy stars align. The target and driver of clean energy procurement would be outside the market.

E. TRANSITIONS

Days One and Two Combined Discussion

1. **For the proposed market design that you find most compelling:**
   - **What are the biggest challenges in transitioning from current market designs to the one embodied in the proposal?**
   - **What new features or changes in the proposal would best help facilitate its successful deployment?**

For this discussion on transitions, our group focused on some of the issues with the proposed models that might create barriers to adoption.

The first issue raised was that Gimon proposed that the LT market be regulated by the CFTC. The group found this idea to be largely unworkable. They emphasized that handling resource adequacy or reliability is not in the CFTC's wheelhouse and also that the CFTC and FERC had encountered significant difficulty working together or dividing up responsibility in previous years. The group believed that FERC should be the primary regulator of that any market design and its operation.

The group raised concerns about both Corneli's and Gimon's proposals as being very difficult to get through the stakeholder process – in part because they seem to rely on economic and infrastructure decisions being made within a "black box" yet to be defined. Revisions to the stakeholder process might need to take place prior to a transition to these proposals being possible. In general, the group also found both proposals to be highly aspirational and not likely to be adopted in the near-term. They did find Corneli's proposal to be useful as guidance for a future to work toward but not as a near-term solution.

Overall, the group found that there was a disconnect between the goal of the workshop in working to promoting rapid decarbonization through market design and the probability of these proposals being adopted in reality. They believed the proposals might not make rapid enough progress toward addressing climate change, even if they were adopted.

2. **Outside of any of these proposals: Are there other policy or law changes at the federal level that you think are achievable and would substantially help wholesale markets support the deployment of the clean energy resources needed for rapid decarbonization?**

In this discussion, the group discussed various pathways for FERC to promote rapid decarbonization. Some in the group argued that that FERC needs a presidential administration directive to justify moving forward with significant market design reform, while others argued that FERC could do so without any White House or administration policy directives by reevaluating what constitutes "just and reasonable" and evaluating whether current rates and the treatment (or nontreatment) of carbon pricing is unjust and unreasonable. The group was similarly curious about how FERC would react to each of these proposals and which of them would be most viable.

While FERC would ideally rely on an administration or federal law directive to justify major market design changes, the group recognized the challenges with passing federal climate legislation. One group member suggested that one possibility could be for President Biden to issue an executive order to decarbonize the grid by 2035. FERC could then use this policy directive as a basis for beginning the market restructuring process.

3. **What next steps would you recommend to advance evolution in market design that will support rapid, least-cost decarbonization?**

The group agreed that immediate next steps would be to reform or reverse the MOPR in PJM's capacity market while at the same time ensuring continued operation of a competitive market. The group agreed that the existing MOPR conflicts with state renewable energy policy and increases consumer prices.

While the group agreed that both Gimon's and Corneli's proposals were unlikely to be implemented in the near future, some members suggested that the ideas could be useful in the near-term, particularly Corneli's proposed configuration model. One person suggested that the proposed models could be helpful in the near term for use in IRPs.

F. MODELING

Days One and Two Combined Discussion

1. **Accuracy, Specificity, and Model Enhancements**

The winner selection approach suggested by Corneli and Gimon would require relatively high levels of accuracy and specificity in its results. "Accuracy" means the resources it selects would need to perform in the real world, in terms of balancing, operating costs, and carbon emissions, very much like they do in the modeling environment. Inaccurate models could select inefficient resources instead of efficient ones. "Specificity" means the selected resources would have to outperform portfolios with other configurations. Otherwise, the results of the market would appear arbitrary and unfair. The model results could lack specificity even if they are accurate. For example, if there are many winning combinations that would perform the same, at the same costs, then there is no good reason from choosing one winning portfolio out of the many comparable alternatives.

- Consider how much accuracy is needed for the success of the Corneli/Gimon market designs. Given what you know about such models, are they capable today of producing such accuracy?
- Consider how much specificity is needed. Are models capable of providing such specific results today?
- If the answers to either questions above are "no," is there a clear line of sight, in terms of model enhancements, to achieve the amount of accuracy/specificity needed for them to be used to clear a market? Does that fact that LP/MIP models are used today in competitive IRP processes support or contradict your conclusions?

In the Day One discussion, the group vote suggested about a third of the participants thought existing models are sufficiently good to implement Corneli and Gimon's proposals in terms of accuracy and specificity, while about half of the participants thought the models could be further developed to serve the purpose.

A couple of themes came up during the discussion. For the accuracy aspect, data quality and the uncertainty of data is an important concern to achieve a high level of accuracy in modeling, especially in a world with high penetration of variable renewable resources. Metrics and methods to validate models and to evaluate whether models are accurate are also needed.

In terms of specificity, the pay-as-bid contract structure itself brings in some concerns in potential strategic behaviors. Some forms of uniform price structure may help mitigate this problem. Another specificity-related concern is the relationship between different generation resources and transmission resources in the competitive environment as substitutes. Developing more accurate modeling methods for all resources and their coordination can serve as a first step to ensure specificity in this regard. Accuracy is about both data and representation of relationships among resources (complements, substitutes).

Two other structural issues in market design are also important to achieve market goals. First, considering demand side participation in market design guidelines, as well as in the modeling process, can be critical for all long-term markets. Also, the capability of the market proposal to adapt to uncertainties that are not yet modelled would also impact the outcome of the market. For example, the frequency of auctions may help market participants to reconfigure their positions/commitments, and thus the flexibility and the adaptability of the market.

Concerns related to accuracy and specificity were also raised regarding Tierney and Pierpont's proposals during Day Two discussion. There are serious limitations of models to precisely forecast the types and quantities of products needed in the future (and their prices). In particular, it might be difficult for existing modeling frameworks to accurately determine the need for Tierney's resource adequacy products (such as flexible capacity) and to co-optimize among them, especially over ten years. So too might it be challenging to precisely forecast electricity prices that underpin Pierpont's market model.

Improved models and modeling frameworks could mitigate concerns of accuracy and specificity to some extent, but our group thought that a more fundamental issue was the centrality of modeling to the entire function and design of the market proposals. In other words, the problem lies in the market designs, not in the models. There is uncertainty to key modeling parameters—load, generation profiles, technology cost and performance, etc.—that cannot be avoided. Market design can be made robust to uncertainty by allowing for market participants to adjust their positions as new information becomes available, using shorter time horizons, or decentralizing decision-making, just to name a few. Our group thought that the proposals could all improve in this regard.

2. **How could modeling be improved to become better suited for the roles imagined in the market design proposals?**

- More and better data on resource behavior, including weather data.
- In particular, future weather condition simulations that reflect a changing climate would be helpful.
- Incorporating interactions between resource types. This will be increasingly difficult as the share of intermittent and energy-limited resources come to dominate the resource mix.
- Better incorporation of transmission planning co-optimization (either guiding anticipatory investment like the CREZ in Texas or co-optimized with supply and demand side resources like PRISM).
- Better incorporation of distributed resources.
- It is not clear how DER are incorporated into market proposals themselves or the modeling done on their behalf.
- Endogenizing dynamic load.
- Evaluating robustness and failure modes, for example, uncertainty around critical parameters like load growth, resource outages, climate anomalies, etc.