RFF REPORT

The Future of Power Markets in a Low Marginal Cost World

Workshop Summary

Amelia Keyes, Dallas Burtraw, and Karen Palmer

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RESOURCES FOR THE FUTURE

The Future of Power Markets in a Low Marginal Cost World: Workshop Summary

Amelia Keyes, Dallas Burtraw, and Karen Palmer *

Executive Summary

The National Renewable Energy Laboratory and Resources for the Future held a workshop governed by Chatham House rules to discuss the changes underway in the electric power sector and extract insights for future market design and policy. This report summarizes the insights from that workshop. The workshop agenda and participant list are included at the end of the report. Workshop participants discussed the economic, technological, and policy drivers of declining marginal costs of generation and expanding capacity of generation resources. Participants agreed that market and policy design should serve the central goal of improving economic efficiency, but debated how to properly value the various attributes of different generation resources while also creating incentives for efficient long-term investment and balancing the policy objectives of individual states. The workshop illuminated a set of important questions for future research:

1. What specific attributes of generation resources should be explicitly valued in wholesale markets and how should this valuation be done?
2. Can scarcity pricing, revealed through variability in short-term price signals for generation services, create adequate incentives for long-term investments?
3. In organized markets, are capacity markets necessary to create efficient investment incentives, or could an alternative market design create incentives for both efficient investment and dispatch?
4. How can demand-side services and demand responsiveness be brought into the market as resources, while balancing political considerations and consumers' aversion to risk in electricity pricing?

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1. Introduction and Workshop Summary

The power sector is experiencing a period of transformation. Technology, policy, and the economics of electricity supply are driving changes that are already altering the sector and promise to continue doing so. Coal and nuclear generation are being displaced by natural gas and renewable generation. In many regions of the country, natural gas and renewables currently have lower marginal costs compared to historical marginal costs, and their rapid entry has contributed to an ample supply of capacity across the nation. In addition, demand-side resources are playing an increasingly important role in the market and total electricity demand has flattened. The organization of markets is also changing as several regional wholesale markets expand their borders, a trend that has improved dispatch efficiency. Consequent to these changes, prices in wholesale energy and capacity markets are reaching historical lows. In the absence of explicit policy intervention to alter the direction of changes in the industry, the rapid sector-wide transformation is expected to continue and even accelerate.

The changing generation mix and declining marginal costs of energy pose challenges for both restructured and regulated electricity markets. The National Renewable Energy Laboratory and Resources for the Future invited 40 academics, regulators, and industry participants to discuss these challenges and the future of the power sector. The workshop began with an overview presentation on the current state and expected future of the electricity sector, followed by four panels focused on various approaches to the organization of electricity markets and the ability of each approach to address these changes. In conjunction with this workshop, NREL and RFF have also released a working paper on the topic.[1] An early draft of this working paper was circulated to all participants prior to the workshop and served as a touchpoint for much of the discussion.

The workshop addressed five main questions:

1. What are the contributing factors to recent changes in electricity markets, and what do those changes foreshadow for the future?
2. Are electricity markets working now, and will they continue to work in the future?
3. How many markets are we talking about? Are energy markets sufficient? Are capacity markets necessary?
4. What are the challenges in regulated markets resulting from the proliferation of low- and zero-cost resources? Is re-regulation of deregulated markets a potential pathway for addressing the challenges presented by the expansion of these resources? Are hybrid systems in regions that contain restructured markets and regulated IOUs desirable? How can we improve upon regulation?
5. What are the implications of technology and wholesale market changes for retail companies? What is the role for demand-side services in the future? Will the retail company assume a growing responsibility for reliability? Will energy services migrate to a platform structure?

The following sections highlight the major lessons that emerged from this workshop. Section 2 focuses on current and expected changes in the electricity sector. Section 3 focuses on lessons for market design. Section 4 focuses on lessons for policy.

[1] D. Bielen, D. Burtraw, K. Palmer, and D. Steinberg, 2017. "The Future of Power Markets in a Low Marginal Cost World," RFF Working Paper 17-26.

2. Electricity Sector Changes

A major point of emphasis among workshop participants was that electricity markets are currently in a state of transition as opposed to a state of equilibrium. Market disruption has been driven by dynamic market and policy forces. One major driver has been a shift in the relative costs of various generation resources. Since 2008, the price of natural gas has fallen precipitously and is reflected in lower costs of electricity generation. The capital costs of renewables—particularly wind and solar—have been on a steady decline since 2000 and have fallen dramatically in the last decade. The declining prices of these resources have corresponded with an overall shift in the power generation portfolio. Natural gas has become the overwhelmingly dominant new capacity source, with renewables beginning to enter the portfolio in an important way. It is also important that electricity demand growth has leveled off over the last decade even as substantial new investments in gas and renewables have come into the market.

Policy changes have also affected the status of the markets. State-level renewable portfolio standards (RPS) and the federal investment tax credits (ITC) and production tax credits (PTC) have helped to lower renewable electricity costs to developers and drive investment. In some cases, the rate of growth in RPS targets encourages capacity additions greater than necessary to accommodate the rate of growth in demand, contributing to excess capacity. Meanwhile, the costs of coal generation have been affected by environmental regulations that have contributed to the retirement of some older and less efficient coal plants, and required capital investments at other plants. On net, however, policy changes appear far less important that market forces in driving the electricity sector transformation.

Increased generation from lower-cost sources (natural gas, wind, and solar), along with higher total capacity and lower than expected demand growth, have all contributed to the phenomenon that was the primary focus of the workshop: marginal costs of electricity generation are decreasing, both in absolute terms and as a proportion of the total costs of generation. Lower marginal costs lead to rightward shifts in wholesale electricity supply curves and, in turn, lower wholesale prices; Figure 1 displays this dynamic in the PJM market.[2] Figure 2 draws upon an Analysis Group study to provide an illustrative example of the relative impacts of various causal factors on declining wholesale prices in PJM.[3] In this case, declining natural gas prices have by far the greatest impact on wholesale prices.

[2] "A Proposal for Enhancing Energy Price Formation," PJM, November 15, 2017.

[3] Hibbard, Tierney and Franklin, "Electricity Markets, Reliability and the Evolving U.S. Power System," June 2017.

FIGURE 1. AVERAGE PJM AGGREGATE REAL-TIME GENERATION SUPPLY CURVES

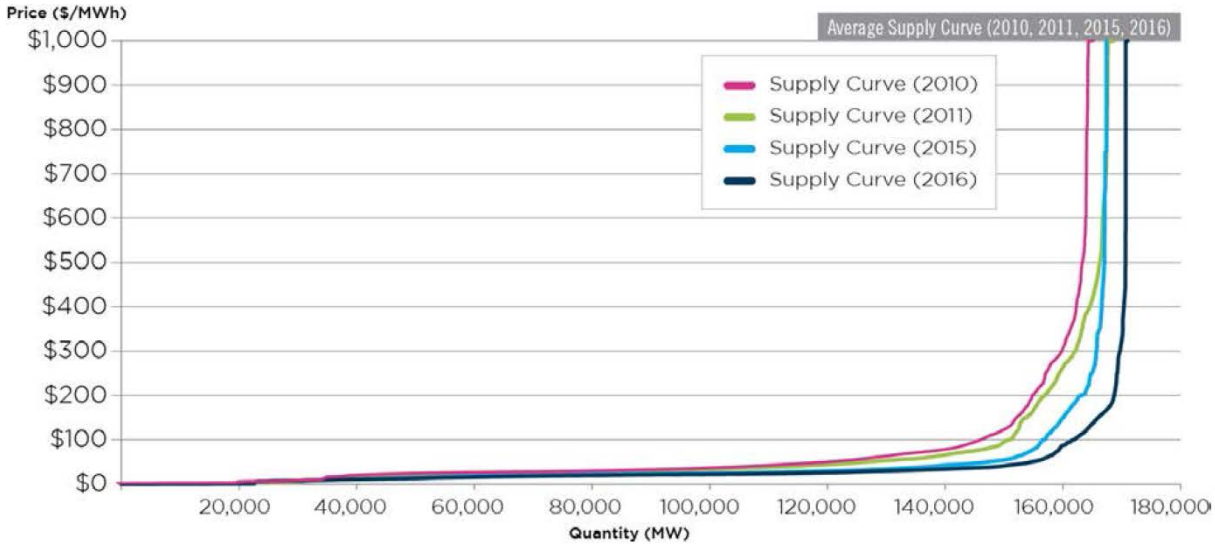
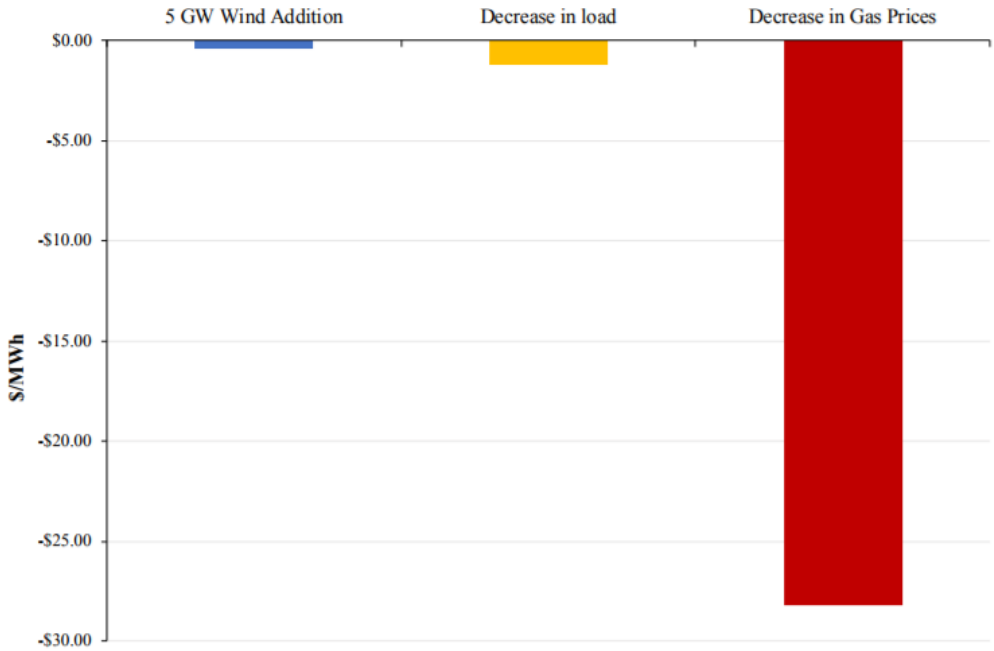


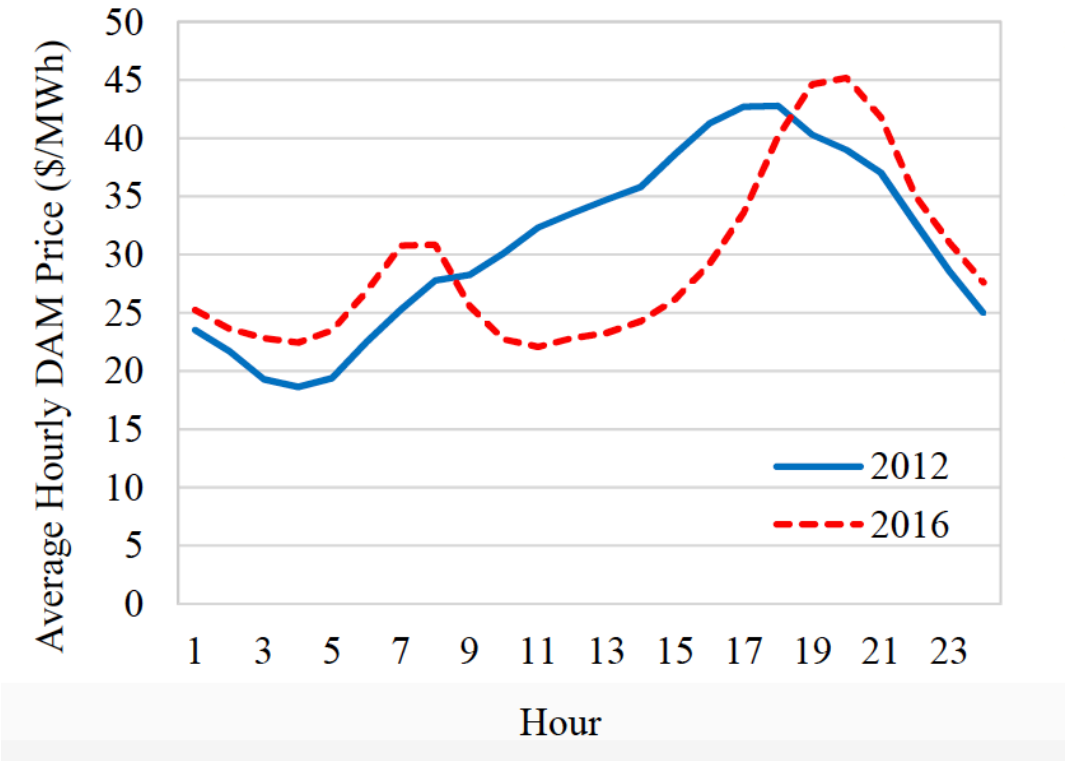
FIGURE 2. ILLUSTRATIVE IMPACT OF DIFFERENT FACTORS ON PRICES IN PJM



Note: Impact of wind addition demonstrates impact of adding 5 GW of wind to all of PJM on marginal electricity price for all of PJM. Decrease in gas price shown between 2005-2008 and 2009-2015 periods in PJM East.
Source: SNL Financial.

Workshop participants noted that wholesale prices are not lower across all hours compared to the past. For example, in regions where solar is an important source of generation, periods of low wholesale prices are accompanied by higher prices during hours when solar generation rapidly declines and load remains high (e.g., evening hours). This dynamic reflects the fact that even with abundant low and zero marginal cost generation sources different types of scarcity will continue to exist. California is a prime example of this phenomenon. Figure 3 shows that in the CAISO region, a so-called "duck curve" is emerging in hourly prices that aligns with the already widely discussed duck curve for net load.[4] While the average hourly price has declined substantially since 2012, the prices in 2016 are higher than those in 2012 before sunrise and after sunset.

FIGURE 3. CAISO AVERAGE HOURLY DAM PRICE



[4] J. Bushnell and K. Novan, "Pricing Impacts of Renewable Electricity", Working Paper, UC Davis.

The broad trends identified above, notably the entry of new generation resources, stabilization of demand, and the decline in wholesale energy prices, have coincided with a reduction in the marginal value of generation capacity and lower prices in capacity markets. Together, the decline in capacity price ($/MW) coupled with the decline in energy price ($/MWh) has led to a decline in total revenue that has sparked concern about the survival of incumbent resources in the long run. Nevertheless, substantial capacity remains today in every region of the country and there is over-attainment of resource adequacy goals, so the reliability of electricity supply is not an issue in the short run, a point made by several workshop participants. In fact, currently there is concern that consumers are paying too much for reliability and for the wrong kind of reliability. Very high levels of reliability provided by generation capacity have a higher cost than many market participants would want to pay if they could choose not to pay. Moreover, when electricity supply disruptions occur, they are most often associated with the distribution and transmission system rather than generation resources. While transmission and distribution reliability was not a focus of the workshop, workshop participants observed that, from a system perspective, market participants are required to procure too much generation reliability and not enough distribution and transmission reliability.

While supply reliability is not generally believed to be a central concern in the short run, the electricity sector does potentially face several economically significant challenges in this transition period. One issue, as noted above, is that decreased revenues for providing energy and capacity may lead existing high fixed cost base load units to exit the market, while the resources that survive may not be able to provide the same suite of grid services such as black start, frequency regulation, and ramping/load following at similar cost. However, some note that there are a variety of ways to provide the grid services necessary to maintain reliability even with the evolving capacity mix.[5] Further, gas-fired generation relies on a fuel that historically has had volatile prices and that is not practically storable on site, which could lead to volatility in energy prices. Renewables are variable resources and thus additional forms of generation may be required to provide energy during times of low wind and solar resource availability.

On the other hand, workshop participants noted it could be that the markets are not providing efficient signals for capacity to exit, which may pose a different type of challenge. An oversupply of existing capacity accompanied by new capacity additions (some of which is encouraged by technology policies), and the associated low wholesale energy prices, may blunt innovation. New sources of electricity services on the supply and demand side may not be adequately rewarded to justify new investments. Inefficient levels of innovation have long-run market impacts, including fewer improvements in renewable energy technology, advanced nuclear, storage, and demand-side technologies.

A changing resource generation mix, increasing capacity, flat demand, and declining wholesale prices are not the only features of the current and expected future electricity sector transition. Many power markets are also reorganizing and expanding. Power markets that encompass broader

[5] For example, see https://energy.gov/epsa/downloads/maintaining-reliability-modern-power-system.

geographic areas have lower variability in generation from variable resource renewables, are less likely to experience interruptions in fuel supply, and have greater opportunities for demand response. It may be that the expansion of power markets and the more efficient utilization of resources provide yet further pressure on the economic viability of existing resources that are facing declining revenues. Additionally, although flat electricity demand is a feature of today's electricity markets, electrification of the transportation sector and building and water heating could dramatically alter this trend in the future. Expanding power markets and the looming electrification of other sectors may mute the concerns precipitated by the trends currently observed in energy and capacity markets, but there is a great deal of uncertainty.

3. Lessons for Market Design

Discussion of the electric sector transformation led to a workshop dialogue on the lessons for electricity market design. These lessons are informed and given urgency by the sector transformation; however, they provide insights for efficient electricity market design regardless of the specific changes that are now occurring. The lessons described below apply to deregulated power markets. Unsurprisingly, the core concept embedded in these lessons is the efficiency of market operations.

Workshop participants provided important insights on electric grid reliability, a major concern of the Department of Energy. Many participants agreed that the "one day in 10-year outage" reliability standard is arbitrary and is not rooted in economics[6]. A better approach would allow consumers to express their willingness to pay for reliability in the market, taking advantage of technical capabilities of advanced meters. Participants discussed that efficiency is a greater concern than reliability, given the current situation of surplus capacity throughout the nation, and thus the focus should be on guarding against unnecessary costs, including those incurred by arbitrarily stringent reliability standards. It was noted that lower reliability standards and lower payments for capacity might exacerbate the incentive for some plants to shutter; however, reliability can be improved through improved identification and reward for the specific necessary services that various resources bring to the electricity system.

An important idea that was articulated is that for any other aspect of the electricity market to be efficient, the operation of existing facilities in the real-time wholesale market must be efficient. This standard is central to market design because if it is not satisfied, market participants will anticipate the flaws in the market and exploit them. Ensuring the efficiency of the real-time market is therefore the critical first step in market design.

Achieving this efficiency relies in large part on wholesale market rate design. Wholesale market prices do not currently reflect the range of values provided by various generator types, including location, flexibility, and carbon intensity. Market rate design should reward attributes that have always had value, but were perhaps taken for granted prior to current sector shifts. For example, fast ramping and the ability of a resource to reliably provide capacity when called upon are currently not properly rewarded, yet are essential to system reliability and therefore should be valued in the marginal price paid for various services. The difference in value

[6] http://www.nerc.com/gov/bot/Agenda%20Minutes%20and%20Highlights%20DL/2004/BOT_Complete_Agenda_Package_0604.pdf

between fossil fuels and renewables is not limited to their emissions intensities. In a market context, rewarding and penalizing all resources (emitting and non-emitting resources alike) for performance and reliability is one way to incent an efficient outcome. In a regulated system the same issues are of concern as well, and might be addressed through system planning. Many workshop participants emphasized that environmental performance also should be rewarded or penalized.

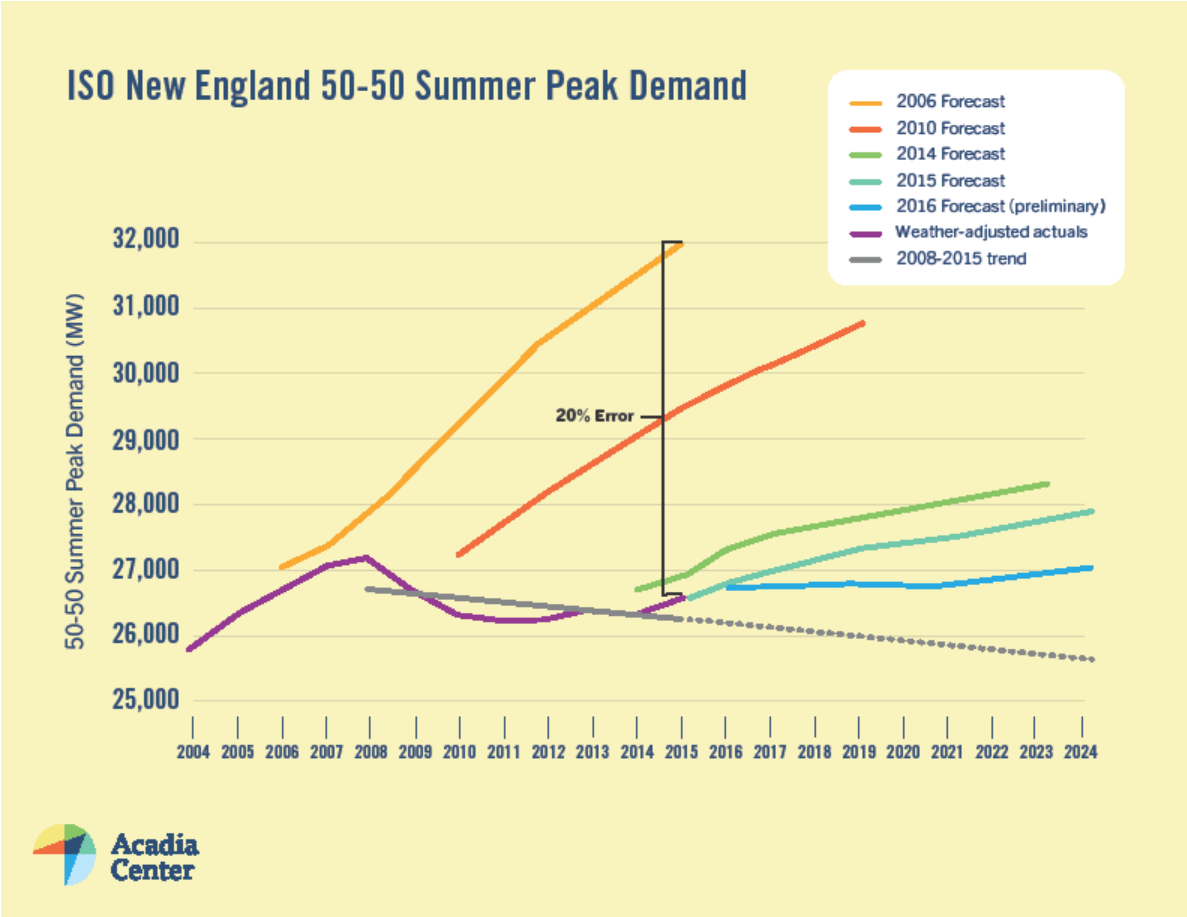
Participants also argued that equilibrium in the electricity market should relate prices to scarcity of supply, leading to depression of prices when supply gluts occur and heightened prices when supply is scarce. For example, markets should respond to the expanded availability of solar with decreasing mid-day prices and increasing prices in the shoulder to reflect relative scarcity. Energy markets in equilibrium should exhibit scarcity pricing, making short-run prices more relevant as a guide for investment. This dynamic is a necessary condition for least cost operation, by signaling the need for complementary resources such as battery storage and demand-side scheduling. However, the fact that with substantial renewable penetration a substantial portion of revenues are recouped in a relatively small number of hours when prices are very high has the drawback that it makes investment planning more difficult. Due to its implications for long-term investments, price volatility may need to be addressed through long-term contracts for suppliers. Another point of discussion—but perhaps not consensus—among participants was that regulators and elected leaders are reluctant to let scarcity pricing occur in energy markets or to expose customers to unfettered market prices.

Another point of dialogue in the workshop was the role of capacity markets in the electricity sector. While this debate is not new, the increasing relative importance of the fixed costs of generation over marginal cost makes it even more pertinent today. The core issue lies in incentivizing generation investment efficiently, and capacity markets have not proven to be an effective way to resolve it. Capacity markets had few defenders at the workshop, but there is an understanding that policymakers perceive risk from a market structure that does not directly price capacity. The overarching sentiment was that if capacity markets are politically necessary, they must be made more efficient—or in some views, less harmful. Again, one important feature for their effective operation is reward and punishment for performance when capacity is called upon to produce.

Using consumers as resources in the electricity system promotes efficient, least cost operation. Power markets should invoke better demand responsiveness to price through the provision of short-term price signaling. The introduction of demand price-responsiveness is critical to capturing the full value of scarcity pricing in the market and may also increase the political viability of scarcity pricing. Consumers who would like to hedge against the risks of price volatility could opt in to fixed price contracts at a premium, an approach that is already evident in power purchase agreements between project developers and large industrial and commercial consumers. However, while one view of the ideal structure for a market environment is dynamic retail pricing with long-run hedging contracts, this is just one of many ideas. Additionally, the way in which consumers engage the market is unresolved. Still, whether through individual consumption planning, which many participants doubted would be widespread, or through aggregators that bundle consumers with similar preferences, the building block for efficient markets is to have consumption patterns based on incentives created by the market.

One general takeaway of the various market design lessons discussed is that markets should be built based on design principles including economic principles. Market structures based on forecasts of market conditions can be problematic, as these forecasts are never fully accurate (see Figure 4).[7]

FIGURE 4. ISO NEW ENGLAND 50-50 SUMMER PEAK DEMAND



[7] Source: Acadia Center: The Hidden Costs of Energy: Overpaying for an Outdated System (2016).

4. Lessons for Policy

Electricity sector trends also provide insights for policy. Workshop participants questioned whether regulated or deregulated markets are better equipped to accommodate current and future trends. Participants suggested that a well-regulated market could attain better outcomes than a poorly designed deregulated market; however, a well-designed deregulated market would generally achieve the greatest efficiency.

Regulated markets tend to have an advantage in project planning and financing, and a bias in terms of reward, towards large central station power plants. Many observers felt that we are unlikely to see new large central station projects built in deregulated markets going forward. It is more likely in regulated regions due to a range of factors, including the fact that project risks are transferred to customers, the lower capital costs regulated firms face, the "Averch-Johnson effect" that biases firms in regulated regions towards capital investment, and the portfolio planning process.

Participants from regulated regions made the point that, despite the workshop's focus on marginal costs, a discussion of total costs is important as well. The average cost pricing scheme used in regulated regions depends on total costs rather than on marginal costs, and the sectoral trend towards lower marginal costs does not necessarily translate to lower total costs. Additionally, resources with low marginal cost may not be the resources with lowest total cost. Therefore, the incentives and the planning process evident in regulated markets may lead to different resource mix outcomes than those in deregulated markets.

State-level policy mandates in both regulated and deregulated regions may play several important roles in determining the efficiency of the electricity market. In evaluating state-level policies like RPS, participants asked: are these mandates rewarding (or disadvantaging) attributes that are not already recognized by the market, such as unpriced emissions or geographic locations of resources? If so, mandates can mitigate market inefficiencies. Additionally, mandates can provide insights for future market design by illuminating objectives that could be incorporated directly into markets. Participants also observed that the introduction of carbon pricing in some locations has given advocates of clean technology mandates like RPS more enthusiasm for expanding technology policies, not less, despite the widely-held belief of economists that direct pricing of attributes, such as emissions, is a more economically efficient policy intervention than mandating or subsidizing specific technologies. Participants discussed whether price-based or technology-based policies are preferable, acknowledging that in practice the two may serve different objectives and are not necessarily substitutes.

Participants also discussed the future of financial contracting for generation resources, although a clear path forward was not established. Contracts continue to expand, especially in organized markets, although a major distinction across regulated regions is the degree to which new capacity, particularly renewable capacity, is built by third-party developers under contracts versus built by utilities and included in the rate base. Procurement of contracts can be competitive but existing resources are often excluded from eligibility for contracts. This type of discrimination results in capacity additions and increases the potential of stranded costs as more and more capacity comes online. However, the option of including existing capacity in the contracting process would result in contracting for the entire system, a solution that would not be favored by many workshop participants.

Finally, workshop participants made the point that addressing market power will be particularly important in competitive power markets with low marginal costs accompanied by times of scarcity pricing. Market participants with a high level of market power will have incentives to extend the number of hours and the severity of scarcity pricing. This concern led to the imposition of price caps. Conversely, market power has been the justification for the minimum offer pricing rule in capacity markets. To some extent, rules to address potential market power can undermine capacity markets' ability to work well. Workshop participants noted that issues posed by market power could be addressed in part by including the demand side into the market.

5. Conclusion

From this workshop emerged a clearer view of the various drivers of the major changes that are currently occurring and are expected to continue occurring in the electricity sector. Participants linked these changes and their drivers to insights for both market design and policy. One of the major points emerging from the workshop was that focus should shift from reliability of generation to efficiency of generation, beginning with efficiency of the real-time market. Improving market efficiency requires properly valuing the different economic attributes of generation resources while balancing the various policy priorities of individual states, which often favor certain generation resources and create excess capacity. Additionally, lower and more variable wholesale prices reinforce the importance of creating efficient long-term investment incentives, through either more efficient capacity markets or alternatives.

The Future of Power Markets in a Low Marginal Cost World

September 14, 2017 | 8:30 A.M. – 4:30 P.M.
Resources for the Future, 1616 P Street NW, Washington, DC

8:30 a.m. - 9:00 a.m. Registration and Breakfast

9:00 a.m. – 9:15 a.m. Introduction and Opening Remarks

Richard Newell, RFF President

Robert Margolis, NREL

9:15 a.m. – 9:45 a.m. Electricity Sector Overview

Speaker: Sue Tierney, Analysis Group

9:45 a.m. – 11:00 a.m. Panel 1: Lessons from Electricity Markets of Today

Speaker: Jim Bushnell, University of California at Davis

Respondents: Hung-po Chao, PJM; Matt Barmack, Calpine

11:00 a.m. – 11:15 a.m. Coffee Break

11:15 a.m. – 12:30 p.m. Panel 2: The Design and Number of Optimal Electricity Markets

Speaker: William Hogan, Harvard University
Respondents: Carlos Batlle Lopez, MIT; Michael Hogan, Regulatory Assistance Project

12:30 p.m. – 1:30 p.m. Lunch

1:30 p.m. – 2:45 p.m. Panel 3: Electricity Market Regulation

Speaker: David Littell, Regulatory Assistance Project
Respondents: Ron Binz, Public Policy Consulting; Charles Rossman, Southern Company

2:45 p.m. – 3:00 p.m. Coffee Break

3:00 p.m. – 4:15 p.m. Panel 4: Wholesale Markets meet Retail Markets

Speaker: Sonia Aggarwal, Energy Innovation
Respondents: Hannah Polikov, Advanced Energy Economy; Jesse Jenkins, MIT

4:15 p.m. – 4:30 p.m. Closing Remarks

Speaker: Sue Tierney, Analysis Group

"The Future of Power Markets in a Low Marginal Cost World"

Workshop Participants

September 14, 2017 | 8:30 AM – 4:30 PM
Resources for the Future, 1616 P Street NW, Washington, DC, 20001

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Sonia Aggarwal
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Calpine

Carlos Batlle Lopez
MIT

Aaron Bergman
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