The Role of Forward Capacity Markets in Increasing Demand-Side and Other Low-Carbon Resources

Experience and Prospects

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Forward capacity markets create a revenue stream for resources that can commit to being available at times of system peak several years in the future — but this financial incentive is clearly not the only factor driving the mix of resources in the power sector, and their resulting carbon footprint.

The Role of Forward Capacity Markets in Increasing Demand-Side and Other Low-Carbon Resources

Experience and Prospects

by Meg Gottstein and Lisa Schwartz[1]

Auction-based capacity markets held several years ahead of need — called "forward" capacity markets — are a relatively new approach for addressing resource adequacy in the power sector. Early experience in the United States (US) suggests that these markets have the potential to play a supporting role in delivering capacity from low-carbon, demand-side resources, including energy efficiency. However, auction results to date also suggest that these markets encourage the construction or continued operation of high-emitting supply-side resources to meet reliability targets. Market design improvements and additional policies can serve to better align these capacity markets with carbon reduction goals.

[1] The authors gratefully acknowledge technical assistance from Paul Peterson and Doug Hurley, Synapse Energy Economics, Inc.

Introduction and Summary

For most of the US power sector's history, the quantity and mix of resources built to meet customer demand for electricity was determined or "planned" by utilities and regulators using a range of analytical tools and methods. The revolution in computing technologies during the 1970s and '80s made possible the development of sophisticated planning models that were used to identify the least-cost mix of resources to meet demand for electricity, given a specified level of reliability. In the mid-1990s – with the emergence of electric industry restructuring in some parts of the US – came the expectation that competitive markets would now determine both the optimal amount and the optimal mix of resources. The result was a move away from involvement of regulators in the planning and procurement of electricity, toward almost exclusive reliance upon markets for deciding how much and what kind of generating capacity would be available to meet customer demand.

Real world experience quickly demonstrated that early market designs were not going to deliver the amount of generating capacity required for reliability needs. Stated another way, these markets were not eliciting sufficient investment in plant capacity to meet resource adequacy requirements. The response in parts of the US was to introduce a regional planning and procurement process into organized power markets[2] to address this shortcoming. Regional system operators, using traditional planning studies, were now tasked with determining the level of capacity needed for resource adequacy several years into the future. They also became responsible for procuring the required amount of capacity by augmenting existing energy markets with a forward looking capacity auction.

More specifically, in these auctions the system operators solicit bids to meet the level of resource commitment they estimate will be needed to meet future peak demand on the system, and then provide market-based revenues to resources that can fulfill that commitment. The revenues take the form of a stream of capacity payments[3] — at a price determined through a regional competitive auction. Only those resources bidding at or under the market clearing price of the auction receive capacity commitments and payments for being available, and for measured and verified performance when called upon, during the expected system peak hours. This particular approach to planning and procurement in the power sector became generally referred to as a "forward capacity market."

Forward capacity markets are a development to watch because they combine traditional planning with organized markets into a unique formula that, based on experience to date in the US, appears to overcome the limitations of earlier energy-only or capacity market designs in meeting resource adequacy needs.[4] More important, they represent the first time that energy efficiency resources have been expressly designed into organized power markets and permitted to compete directly with supply-side power generators.

Demand-Side Resources

Demand-side resources (also referred to as demand resources) are customer-based resources that reduce energy needs at various times of the day and year — across some or many hours. They are generally defined as follows:

1) **Energy efficiency** — installing more efficient equipment or using more efficient processes/systems to achieve a continuous and permanent reduction in energy use without reducing the quality of service
2) **Demand response** — changing a customer's electricity demand in response to dispatch instructions or price signals
3) **Distributed generation** — generating electricity at the customer site, in some cases using the waste heat produced in the electric generation process to also deliver useful heat or steam (combined heat and power)

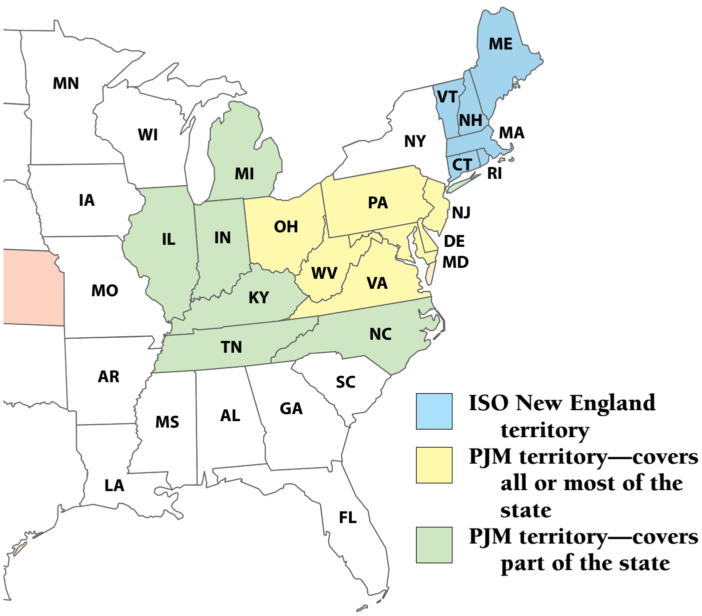
2 "Organized power markets" refers to power markets with an Independent System Operator (ISO) or Regional Transmission Organization (RTO) that operates a regional energy market, capacity market, or both. This paper does not distinguish between RTOs and ISOs — which provide equivalent reliability services — and we refer to these entities generically as regional "system operators" in the following sections.

3 Capacity payments are in US$/megawatt (MW)-day or US$/kilowatt (kW)-month. Conversion: $100/MW-day ≈ $3/kW-month.

4 An overview of that experience is presented above.

Figure 1

ISO New England and PJM Territories



Two organized markets in the US — PJM[5] and ISO New England (ISO-NE)[6] — now conduct forward capacity auctions that permit a wide range of demand-side resources to compete with supply-side resources in meeting the resource adequacy requirements of the region. (See Figure 1 below.) The response of demand-side resources in the PJM and ISO-NE auctions is impressive, and their participation is clearly demonstrating that reducing consumer demand for electricity is functionally equivalent to — and cheaper than — producing power from generating resources for keeping supply and demand in balance. One study suggests that participation of these resources in the first New England auction potentially saved customers as much as $280 million by lowering the price paid to all capacity resources in the market.[7] And in the most recent PJM auction, demand-side resources are credited with reducing the unit clearing price from $178.78 to $16.46 in unconstrained zones — a savings of $162.32/MW- day.[8] Detailed results for the PJM and ISO-NE forward capacity auctions are presented in Appendix 1.

There are two additional capacity markets in the US – one run by the New York ISO and the other (as of June 2009) by the Midwest ISO.[9] However, only PJM and ISO-NE run auctions several years in advance of need and permit energy efficiency along with other demand-side resources to compete with generation to meet future reliability requirements. They also offer the longest track record for forward capacity markets covering multiple states. Brazil is the only other country with a forward capacity market, but it does not permit demand-side resources of any kind to compete.[10] Therefore, our discussion focuses on the forward capacity markets run by PJM and ISO-NE.

This paper examines how auction-based forward capacity markets address resource adequacy, with particular focus on their potential to increase the availability of

[5] PJM Interconnection is an RTO that operates a competitive wholesale electricity market and manages the high-voltage electricity grid for all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and the District of Columbia.

[6] ISO-NE oversees New England's bulk electric power system, serving the states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.

[7] Cheryl Jenkins, Chris Neme, and Shawn Enterline, Vermont Energy Investment Corporation (VEIC), "Energy Efficiency as a Resource in the ISO New England Forward Capacity Market," ECEEE 2009 Summer Study Proceedings.

[8] Joseph Bowring, Monitoring Analytics, "Analysis of the 2012/2013 RPM Base Residual Auction," Sept. 10, 2009, Table 20. "Unconstrained" zones do not experience any distribution or transmission bottlenecks for the delivery of electricity to the end-user, whereas "constrained" zones experience such limitations and pay clearing prices that reflect those constraints to capacity available during peak hours in those zones. Accordingly, the reduction in prices due to demand resources for any individual constrained zone will be higher or lower than $162.32 per MW per day for this auction, depending in part on the quantity of demand-side resources located in that zone.

[9] For more information on these capacity markets, see Paul Peterson and Vladlena Sabodash, Synapse Energy Economics, Inc., "Energy Efficiency in Wholesale Markets: ISO-NE, PJM, MISO," ACEEE 5th National Conference — Energy Efficiency as a Resource, Sept. 29, 2009, and New York ISO, "Installed Capacity Manual 4," October 2009.

[10] Sam Newell, Kathleen Spees, and Attila Hajos, The Brattle Group, *Midwest ISO's Resource Adequacy Construct: An Evaluation of Market Design Elements*, prepared for the Midwest Independent System Operator, January 2009. http://www.brattle.com/_documents/uploadlibrary/upload832.pdf.

demand resources to meet future capacity requirements. However, experience to date also makes a strong case that more is needed in a carbon-constrained world, where the total mix of resources is as important as the total quantity, both in the short- and long-term. In particular, construction and continued operation of high carbon-emitting, supply-side resources dominate the mix of capacity clearing these auctions, and therefore these resources are receiving the bulk of market incentives (capacity payments). The results of recent studies — as well as market experience — also suggest that carbon pricing alone is unlikely to reduce this dominance in forward capacity markets (or in energy-only markets) at the pace or scale required to meet aggressive carbon reduction targets.

In light of these observations, we pose the following question to policymakers: How can the planning and procurement process through forward capacity markets be strengthened to work in concert with carbon reduction goals and policies, rather than at cross purposes? This paper suggests a menu of options that could reduce carbon emissions from the power system by:

- Providing premium capacity payments to low-carbon resources
- Selecting auction winners based on level of carbon emissions as well as bid price
- Making capacity payments only to those resources with low- or zero-carbon emissions
- Phasing out capacity payments to existing, high-emitting resources
- Allowing a longer price commitment or establishing fixed-capacity floor prices for low-carbon resources
- Properly considering energy efficiency in load forecasts that set auction capacity needs
- Refining existing market rules, as needed, to ensure that energy efficiency can fully compete on an equal basis with power generators, including distributed generation[11]

More generally, forward capacity markets create market incentives in the form of capacity payments for resources that can commit to being available at times of system peak, beginning several years into the future. But these capacity payments are clearly not the only factor driving the mix of resources to meet customers' current and future electricity needs. Existing market rules and procurement policies that affect the mix of resources meeting the system's energy requirements — as well as policies and regulations that affect access, location, and cost recovery for transmission and distribution facilities — have enormous impact on both the short- and long-term resource mix in the power sector.

It is beyond the scope of this paper to fully explore how market rules, regulations, and policies can be harmonized and strengthened to meet customers' energy needs reliably in a carbon-constrained world. Nonetheless, we observe that many states in the US, including those where forward capacity markets and carbon pricing currently exist, have made large and long lasting commitments to demand-side and renewable resource procurement through additional policies and regulations. These include:

- Strong energy efficiency codes and equipment standards
- Stable and sustained funding to provide audits, financial incentives, and financing for home and business efficiency improvements, including through carbon auction revenues
- Energy efficiency resource standards that require achievement of specified energy-saving targets
- Renewable energy standards that require meeting a percentage of energy consumption with renewable resources, along with long-term contracting requirements in some cases
- Decoupling of utility profits from revenues, financial incentives for shareholders, or both where the utility is the efficiency portfolio manager — or performance contracting with third-party administrators to deliver comprehensive, large-scale efficiency programs
- Complementary resource planning and procurement practices designed to increase the mix of demand-side and renewable resources that can meet resource adequacy requirements

Finally, we recognize that not all regions will create capacity markets for the purpose of addressing resource

[11] For example, energy efficiency resources that clear the PJM auction cannot receive capacity payments for more than four delivery years, whereas under the ISO-NE market rules these resources are eligible to receive payments over the full life of the installed measures. All other resources are eligible to participate in these capacity markets for as long as their ability to reduce demand or generate power continues.

adequacy needs, and we do not attempt to evaluate in this paper whether they should. The evolution of capacity markets in certain regions of the US has its own, and unique, history. (See text box.) Establishing forward capacity markets and their associated auctions involves complex market rules and a myriad of market design choices along the way, all with major implications for the relative costs and benefits to consumers and resource providers. Options for addressing resource adequacy needs that do not involve the development of a capacity market should also be explored by policymakers, particularly in the context of a carbon-constrained power sector. The starting point of this paper, however, is that such markets already exist (or are in the planning stages). It is within this context that we offer our observations and recommendations.

Resource Adequacy in the US

In the US, resource adequacy refers to the "ability of the electric system to supply the aggregate electrical demand and energy requirements of the end-use customers at all times" — in effect, to provide reliable supply 99.97 percent of the time.[12] This high standard of reliability reflects the unique "serve all, or serve none" nature of the electric system: If it falls short in meeting even one customer's power needs, all customers relying on that electric circuit are literally left "sitting in the dark." Contrast this with other goods and services sold to consumers — for example, milk sold at a grocery store. If there are only 15 cartons of milk on the shelf and 16 customers come in at the same time to purchase milk, only one customer walks away empty handed (and that person could at least find a substitute product at the store to quench his/her thirst). In contrast, if that product were kilowatt-hours, and peak demand (or peak load) exceeds the ability of the system to generate electricity at that time, then the store "shuts down" and all customers walk away empty-handed.

To ensure against such an outcome, utilities and other companies that sell electricity in the US and in many other power markets in the world are obligated to own or purchase enough capacity to reliably meet their customers' peak demands ("loads"). We call them "load-serving entities" or "LSEs," and unless otherwise noted, do not distinguish between regulated LSEs (e.g., distribution utilities) and non-regulated LSEs (retail electricity suppliers). In either case, the LSE's resource obligation in a forward capacity market is expressed in terms of its share of projected capacity needs for the region several years in the future.

An electric system must perform three functions well to ensure resource adequacy — that is, to ensure that there is sufficient capacity committed to meeting customers' peak loads at all times. These are:

1) Estimate when the peak loads are likely to occur and the level of capacity commitment needed to reliably meet them.[13]
2) Obligate LSEs to have sufficient capacity available to them during those projected periods of peak loads.
3) Put policies and rules in place to ensure that sufficient resources will commit capacity to operate (or to reduce loads) during these periods, both in the short- and long-run.

In other words, ensuring resource adequacy involves a planning process (what level of capacity commitment is needed and when?) and a procurement process (how to acquire it?) that focus on the quantity and timing of resources, but not the mix of resources required to meet system reliability. The attribute a resource is required to demonstrate for resource adequacy purposes is that its obligated capacity will be available when called upon, during the projected hours of peak system loads. Resource adequacy rules are indifferent to other attributes, including environmental attributes of resources.

12 North American Electric Reliability Corporation, Glossary of Terms Used in Reliability Standards, April 20, 2009, at http://www.nerc.com/docs/standards/rs/Glossary_2009April20.pdf. Put another way, resource adequacy means having sufficient electric supply resources in place to maintain the "one day in 10 years" standard of reliability (which translates to reliable supply 99.97 percent of the time). See also N. Jonathan Peress and Kenneth A. Colburn, "Connecting Market Design: From Carbon to Electric Capacity," October 2005, Vol. 3, No. 1, Energy Committee Newsletter, American Bar Association.

13 The level and timing of peak loads are estimated before the fact, and the projections are less reliable the farther out in time they are made.

How Forward Capacity Markets Evolved in the US[14]

Forward capacity markets in the US evolved as a way of ensuring resource adequacy at reasonable costs to electricity consumers through a combination of system planning and organized markets. Prior to the development of organized markets in parts of the US,[15] power "pools" established a reserve margin requirement and each participating LSE was responsible for acquiring installed capacity to meet its individual loads plus that margin, or face financial penalties. The setting of capacity requirements for the pool as a whole meant, however, that each LSE's reserve requirements were significantly lower than they would otherwise be if it were a stand-alone entity; that is, participants in the pool benefited from the greater diversity of loads and supply resources that characterized the combined system. The pools also facilitated the trading of capacity through bilateral agreements, which had particular value in those pools where individual system peaks were temporally differentiated (as in New England whose northern states peaked in the winter and southern states in the summer). After market restructuring, LSEs also could trade capacity in auctions run by the system operator responsible for the reliability of the region's electric grid. In those early days of competitive wholesale markets, auctions generally were held just a few days before the one-month delivery period.

These nascent capacity markets provided insufficient incentives for plants to be available when called on. The result was "bipolar pricing." If there was a supply surplus, capacity prices were effectively zero. If there was any shortfall, capacity prices rose to the price cap (if any). Moreover, short time horizons for the auctions limited offers for new capacity. In addition, market power[16] concerns surfaced after utilities sold their power plants under electric industry restructuring, particularly in areas with significant transmission constraints. The Federal Energy Regulatory Commission (FERC) responded with price caps for the energy market that, as a side effect, limited scarcity price signals. Thus, "energy-only" power markets — that is, markets that pay clearing prices for energy on a day-ahead or shorter basis — were not paying high enough prices for investors to build sufficient peaking resources to meet future reliability needs.

Meanwhile, merchant generators were buckling under high fuel prices for new natural gas-fired plants, and owners of older, less efficient plants filed requests for retirement. To maintain system reliability, federal regulators approved expensive "reliability must-run" contracts to keep needed plants going and then mandated the development of a more systematic approach for paying for capacity. The resulting process produced a mechanism to make capacity payments to all generators, not just those applying for retirement, and to develop more efficient capacity where it was most needed. But the high price tag of such contracts for the New England states led to legal action that ended with a novel settlement in 2006: a capacity market run by ISO-NE that allows energy efficiency and other demand-side resources to compete with generation to meet reliability requirements several years in advance of need. In 2007, much of the Mid-Atlantic and Midwest region adopted a similar capacity market run by PJM.

14 This description draws upon Robert Stoddard and Seabron Adamson, CRA International, "Comparing Capacity Market and Payment Designs for Ensuring Supply Adequacy," Proceedings of the 42nd Hawaii International Conference on System Sciences, 2009, and Sandra Levine, Doug Hurley, and Seth Kaplan, "Prime Time for Efficiency," *Public Utilities Fortnightly*, June 2008.

15 See footnote 2 for a definition of "organized markets." Southern and western states, except for California, have not developed organized power markets.

16 Such as withholding power to extract higher prices.

How Forward Capacity Markets Work

A forward capacity market is an administrative market run by a regional system operator who collects supply bids to meet planning targets for regional peak capacity needs, runs a competitive auction to establish capacity prices, and then procures capacity at the market clearing price to meet the resource adequacy requirements of the region. The regional system operator is the sole buyer in this market. LSEs are individually responsible for meeting their customers' peak loads, and are allocated a pro-rata share of the capacity costs incurred by the system operator to meet those loads.

In forward capacity markets, LSEs must demonstrate on a "forward" basis that they will have sufficient capacity to meet their own customers' peak loads (plus required reserves) several years into the future. As discussed further below, LSEs have the option to meet this requirement through bilateral contracting or LSE-owned generation, referred to as "self-supplied" or "self-scheduled" resources, depending on the market. However, the ISO-NE and PJM capacity markets are mandatory for LSEs in the sense that the system operator will procure any residual needed capacity[17] through the auction and assign cost responsibility to LSEs. In addition, all existing capacity must be offered into the auction along with new demand- or supply-side capacity offerings, with certain exceptions.

The forward auctions in both PJM and ISO-NE are held three years before the delivery year. And the LSEs' "forward" capacity obligations and amount of capacity put out to bid are established in advance of each auction. Three years was selected to roughly match the minimum lead time required for the construction or development of new capacity once demand- and supply-side resources receive a price commitment from the auction. In particular, it was chosen to reflect a reasonable construction period for new peaking (e.g., gas-fired) power plants, as well as a reasonable "ramp up" period for energy efficiency projects.[18]

For each auction, the system operator establishes the level of capacity needed for the delivery year by forecasting (with input from the LSEs and other stakeholders) regional resource adequacy requirements — peak loads, plus required reserves. PJM performs this planning function by developing a downward-sloping demand curve with built-in price elasticity for each auction, whereas ISO-NE establishes a single, price-inelastic quantity of demand that it auctions in successive rounds of bidding.

The capacity bid into the market (the "supply curve") is comprised of capacity commitments (MW) offered by existing and new resources. These markets and associated auction rules are designed to allow new resources, when needed, to set the clearing price. Existing resources are generally "price-takers" in the sense that they are unlikely to set price unless there is over-supply of existing capacity in the region.

The market clearing price becomes the uniform price for all capacity that clears the auction. That is, the market clearing price is paid to all capacity committed by existing resources and all new resources that have bid into the auction at or below that clearing price. There are separate auctions for constrained zones – locations

Sample Calculation of Revenue for a Successful Bidder[19]

Assume a service provider cleared 20 MW of demand-side resources in a capacity auction that had a clearing price of \$100/MW-day, and that the provider delivered the 20 MW as contracted during the year. The annual revenue stream for the year would be 20 MW * \$100/MW-day * 365 days = \$730,000.

17 The system operator determines the level of residual capacity that it needs to procure to ensure system reliability and purchases that quantity; it also must approve the LSE's showing of the level of capacity commitment it can meet through owned resources and bilateral contracts.

18 See Jenkins, et al., p. 178, and Johannes Pfeifenberger, Samuel Newell, Robert Earle, Attila Hajos, and Mariko Geronimo, The Brattle Group, *Review of PJM's Reliability Pricing Model*, June 30, 2008, at http://www.brattle.com/Experts/ExpertDetail.asp?ExpertID=67.

19 See PJM, *Reliability Pricing Model: Demand Response and Energy Efficiency,* at http://www.pjm.com/markets-and-operations/demand response/~/media/markets-ops/rpm/20090406-dr-ee-in-rpm-collateral.ashx.

that are experiencing distribution or transmission bottlenecks for the delivery of electricity to end-use customers. The clearing prices in these auctions reflect congestion costs and in effect pay a locational adder to capacity available during peak hours in those zones.

Only resources that clear the market receive capacity payments. However, in order to maintain reliability, under very limited circumstances out-of-market payments may be made to resources that do not clear. The system operator may determine that a resource critical to maintaining reliability for a given locational zone must continue to run even if its cost of operation is higher than the auction

Illustration of Forward Capacity Markets From the LSE's Perspective

Using simple assumptions, the general "workings" of a forward capacity market from the perspective of an individual LSE can be described as follows: The system operator forecasts the regional capacity requirements for the future delivery year (2012) and plans to hold the capacity auction for that delivery year three years in advance. Each LSE knows its forecasted capacity obligation for 2012 some months before the auction. Let's assume there are only two LSEs in the region, and they each account for 50 percent of the total regional capacity requirement of 10,000 MW projected for the delivery year.

At the time of the auction, the system operator approves LSE #1's showing that it has bilateral contracts in place to meet 3,500 MW of its capacity obligation for the delivery year. LSE #2, on the other hand, has no bilateral contracts (or generation that it owns) to meet any of its capacity obligation for 2012.

Here's how it works: LSE #1 will offer the 3,500 MW under its bilateral contracts as "self-supplied" or "self-scheduled" resources into the auction at a price of zero — and they will automatically clear the auction.[20] However, as described below, the auction clearing price will have no impact on what LSE #1 actually pays for this resource. It will only pay the capacity price negotiated under its bilateral contracts.

Now let's flash forward to 2012, and assume that the actual 2012 peak capacity needs of the customers served by LSE #1 and LSE #2 turn out exactly as the system operator forecasted for that year, [21] and that LSE #1's resources under bilateral contracts were available to meet peak capacity needs as expected. At the end of 2012, the system operator calculates what it spent to meet the region's peak capacity needs. LSE #2 will get a bill from the ISO for purchasing on its behalf 50 percent of the regional capacity needs (5,000 MW) at the auction price for the 2012 delivery year. LSE #1 will get a similar bill from the ISO — but with an offsetting credit for the 3,500 MW of capacity under its bilateral contracts. So, in effect, LSE #1 only pays the auction price for the "residual" capacity of 1,500 MW — the capacity that the system operator purchased to meet the remaining capacity obligation of LSE #1.

The scenario is similar if actual 2012 peak loads are greater than forecasted levels. LSE #2 will still pay the auction price for all of the capacity that was purchased on its behalf to meet its actual peak capacity needs, and LSE #1 will pay that auction price for the (now higher) residual amount, above its contracted capacity. In this way, LSEs can elect to use bilateral contracts to hedge against high capacity prices in the capacity auctions, just as they can hedge against high prices in energy markets.

Appendix 2 presents a series of slides illustrating this numerical example of how forward capacity markets work.

20 Unless the contracts are structured as a contract-for-differences (see discussion of that option further below). The net effect in either case is the same, in terms of the LSE only paying the contracted price for that capacity.

21 In actual practice, the percentage allocation of capacity costs to LSEs for the delivery year is based on the previous year's actual peak loads (plus reserves) of each LSE relative to the regional totals — but, as noted, this is a simplified example.

clearing price. Under these circumstances, the system operator can still require LSEs to pay for reliability must-run contracts at a cost determined outside the auction process. To date, the amount of MW under reliability must-run contracts in the PJM and ISO-NE regions is very small. In the first few auctions, almost all reliability must-run contracts were voided. Most of the resources previously under reliability must-run contracts, however, have been retained through the forward capacity auctions and receive the annual market clearing price.

Market Rules to Ensure Performance and Competition

To ensure that any successful bidder will have a very high likelihood of performance during the commitment period, resources cannot bid capacity into the market unless they are prequalified by the system operator. In particular, bidders must demonstrate that they can meet their commitment to provide capacity for the delivery year and their bids must satisfy market rules designed to mitigate market power.[22] They must pay a qualification deposit, must provide financial assurance to ensure commercial operation, and can be penalized for performance failures.

Further, to ensure against a condition in which capacity occupies a place in the power system, but is withheld from energy markets and drives up prices, all generation and demand-response resources committed in the capacity market must offer into the region's day-ahead *energy* market whenever available. To mitigate excessive profits to resources also receiving capacity payments from the forward capacity market, the system operator reduces these payments to reflect the impact of high energy market prices. The ISO-NE makes this reduction on an annual basis to reflect especially high energy prices in the preceding year.[23] In the case of PJM, this reduction is implemented through a built-in adjustment to the auction demand curve, described below.

The following section describes some of the unique features of the PJM and ISO-NE capacity markets, highlighting in particular their differences.

PJM's Capacity Market

PJM's current forward capacity market — called the "Reliability Pricing Model" — was implemented on June 1, 2007, replacing an earlier capacity market design in place since 1999. Eligible capacity resources include new and existing demand and supply-side resources (including generators outside the PJM footprint). PJM recently added energy efficiency as an eligible demand-side resource, joining demand response and distributed generation.

Each year, PJM holds a Base Residual Auction three years in advance of a future delivery year (that runs from June 1st to May 31st). PJM establishes the target capacity level, and the auction establishes the price and the actual amount of capacity procured. A mechanism called the "Variable Resource Requirement" administratively adds demand elasticity into the auction by imposing a downward-sloping demand curve that adjusts resource amounts procured based on auction prices. (See Figure 2.) If capacity prices are low, PJM intentionally purchases capacity in excess of its target, but the total payment by load is also lower. If capacity prices are high, PJM procures less than the target, leaving some capacity to be acquired (at potentially lower prices) in incremental auctions for the delivery year.[24]

In PJM, resources are eligible only for a one-year capacity

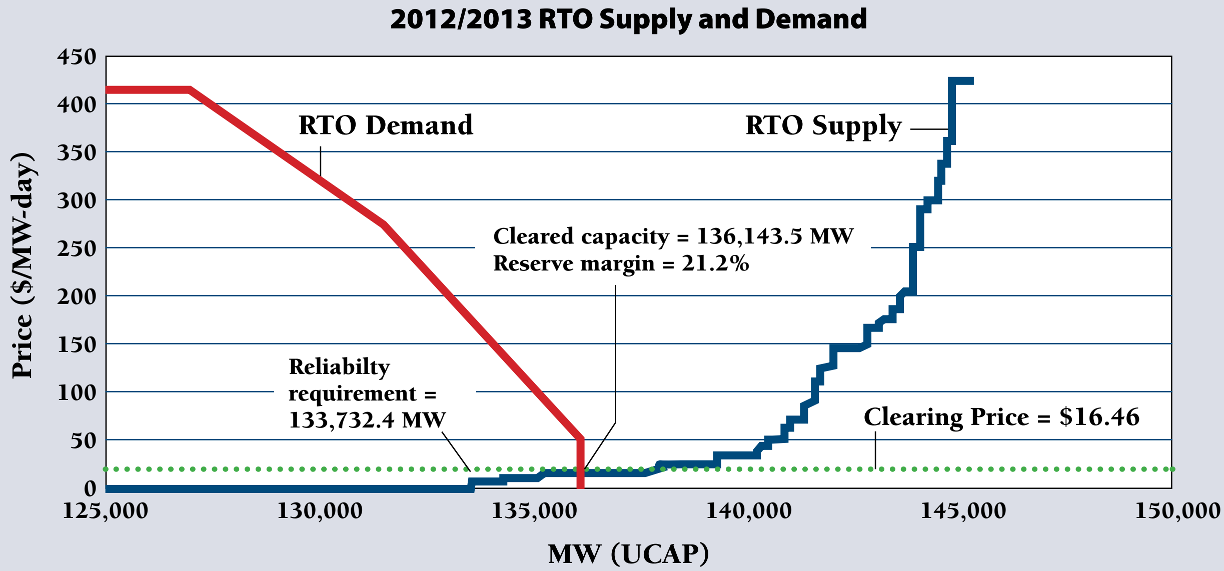
[22] For example, in the PJM auction, suppliers of existing resources are limited to bidding their demonstrated going-forward costs for nearly all capacity, and new resources offered below cost because of support from an LSE contract have a limited ability to set the clearing price.

[23] This adjustment is not currently applied to energy efficiency resources, because they are not eligible to participate in the wholesale energy markets.

[24] The purpose of administratively developing a downward-sloping demand curve, rather than relying on a descending clock auction (as described below for the New England auction), is to help stabilize prices over time when supply is price-inelastic. Figure 2 and further details on the mechanics of the Reliability Pricing Model are available from PJM's "Reliability Pricing Model Training," November 2009, at http://www.pjm.com/training/~/media/training/core-curriculum/ip-rpm/rpm-training-section-d-auctions.ashx.

Figure 2

Establishing the Market Clearing Price in PJM - 2012/2013 Base Residual Auction[25]



Note: *To establish the clearing price when the supply and demand curves do not intersect, PJM does one of the following, depending on the circumstance: 1) Short of supply - Extend the supply curve up vertically until it intersects the demand curve; 2) Short of demand - Extend the demand curve down vertically until it intersects the supply curve; or 3) Supply curve above demand curve - No capacity will be cleared.*

commitment resulting from each annual auction — that is, the resource is only guaranteed the auction clearing price for a one-year contract period.[26] However, as long as that resource remains listed in the market, it is eligible to receive the auction clearing price for each succeeding year.[27] Capacity that was offered but not cleared in the Base Residual Auction is eligible to bid into incremental auctions for the same delivery year.

In general, each LSE is obligated to pay its pro rata share of capacity costs acquired by the PJM system operator through a "locational reliability charge."[28] However, as described above, LSEs can enter into bilateral contracts (or own generation) to hedge these charges and submit the capacity into the auction as a "self-scheduled" resource at a price of zero.[29] When the monthly billing/settlement is completed, the locational reliability charge to the LSE will be offset (credited) for capacity delivered through self-scheduled resources. The net effect of these financial transactions within the market is that the LSE pays the contract price for self-scheduled contracts and does not get paid (or charged) for generation it owns and self-schedules into the auction. However, self-scheduled resources are counted by the system operator in establishing available capacity to meet regional peak demand (plus reserves), and

25 "UCAP" in this figure refers to "unforced capacity." Unforced capacity as defined for the PJM auction represents the MW level of a generating unit's capability after removing the effect of forced outage events. It excludes outage events outside of management control.

26 There is an exception for a new resource that relieves a congestion constraint. It can receive a fixed capacity price for more than one year, subject to a review of the congestion relief that it is providing.

27 As discussed below, energy efficiency is not eligible to remain listed in the PJM capacity market after four years.

28 This charge is based on the LSE's peak loads, adjusted for demand response resources, and the applicable zonal capacity price.

29 See *PJM Manual 18: PJM Capacity Market Revision 9*, March 1, 2010, pp. 4 and 38, at http://www.pjm.com/~/media/documents/manuals/m18.ashx.

are subject to applicable performance requirements.

In addition to self-scheduling by LSEs, PJM provides a complete "opt out" – the "Fixed Resource Requirement Alternative" – for LSEs that take full resource planning responsibility for all loads in their service area for a five-year period. The projected peak capacity needs for LSEs selecting this alternative are not included in the PJM planning process to establish the region's capacity needs for the auction, and the LSE's capacity resources (including capacity acquired through bilateral contracts) are not offered into the auction. Moreover, under this opt-out alternative, the LSE cannot bid any excess capacity into the auction or acquire any capacity through it.

Capacity suppliers can cover any auction commitment shortages through the bilateral market, facilitated by an electronic system at PJM. If capacity shortfalls reach triggering conditions, PJM can delay deactivation of a generating resource or hold a backstop reliability auction for capacity resources for a term of up to 15 years.[30]

To improve the availability of capacity resources when needed, the capacity product in the PJM market is defined to include forced outage rates based on historical performance, and penalties are imposed if the plant is not up and running during a shortage.

Contracts for Differences

Instead of a bilateral contract for physical delivery of capacity, an LSE and resource owner can sign a "contract-for-differences," which means that the level of payments (and who makes them) depends on the auction clearing price. For example, if the contract price is $50 per MW-day and the clearing price is $46 per MW-day, the LSE will pay the resource owner the difference of $4 per MW-day. But if the auction clearing price is higher than the contract price, the resource owner pays the difference (to the LSE). As in the case of self-scheduled bilateral contracts, the LSE will end up paying only the contract price for that capacity. However, in the case of contracts-for-differences, the resource underlying the contract will bid into the market and (if cleared) will receive the auction clearing price. And the LSE will be allocated the full locational reliability charge, receiving no credits for the contracted capacity. The reconciliation happens outside the auction between the LSE and resource owner, rather than as part of the monthly billing/settlement process.

ISO New England's Capacity Market

As in PJM, eligible capacity resources in New England include both new and existing demand-side and supply-side resources (including generators outside the ISO-NE footprint). From the start, ISO-NE's forward capacity market allowed energy efficiency, demand response, and distributed generation to compete with generation on an equivalent basis, which meant, among other things, that new demand resources could set the market clearing price.

Like PJM, each year ISO-NE holds a capacity auction three years in advance of the delivery period and sets the amount of capacity to be purchased in each auction. In addition to the annual forward capacity auction, ISO-NE holds voluntary monthly and annual reconfiguration auctions that allow deficient suppliers to procure replacement capacity. These auctions also provide the system operator the opportunity to buy additional capacity if the load forecast increases or to sell capacity if the forecast decreases.

However, ISO-NE does not establish a downward sloping demand curve (Variable Resource Requirement) for its auctions. Rather, ISO-NE puts out a single quantity of capacity for bid, referred to as the "Installed Capacity Requirement." Then, ISO-NE uses a descending-clock auction in which market prices are reduced until the quantity of available supply bids matches this capacity requirement. Bid quantities and prices decline through successive bidding rounds (with bidders withdrawing resources from the auction as prices decrease) as long as excess capacity is still offered or until the floor price is reached. To address start-up issues, ISO-NE established a temporary price cap (or "starting price" — see figure below)

[30] See PJM Open Access Transmission Tariff, Section 16, at http://www.pjm.com/~/media/documents/agreements/tariff.ashx.

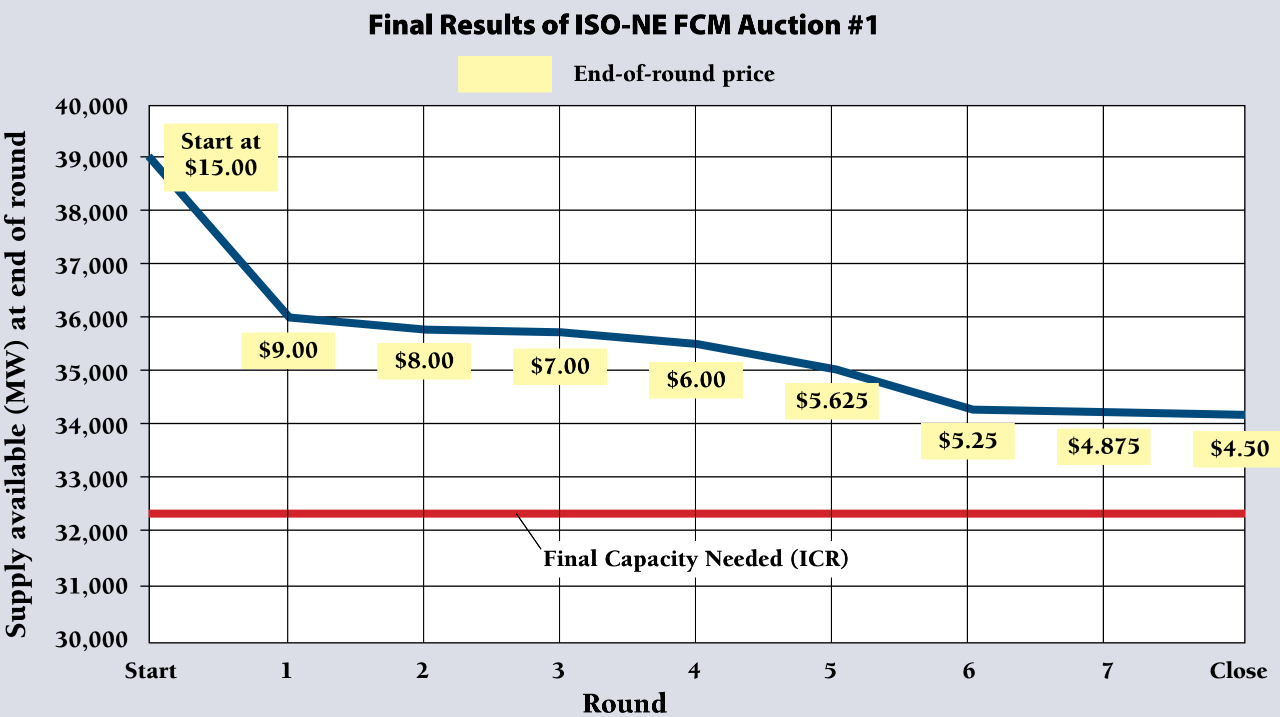
and price floor for the auction. The most recent auction for ISO-NE ran seven rounds over two days, concluding when the auction reached the floor price of $2.951/kW-month.[31] However, by rule the load only pays Installed Capacity Requirement times the clearing price, so the floor price is further reduced (pro rata) to achieve that effect.[32] Figure 3 below illustrates the descending clock auction process for ISO-NE's first forward capacity market auction.

There's another key difference: To encourage investment, ISO-NE allows new resources to lock in a capacity price for up to five years (with a one-year minimum term), regardless of clearing prices in subsequent auctions. The capacity price is indexed for inflation after the first year, and the bidder must select the proposed contract term in advance of the auction. Existing resources, including existing demand-side resources, are eligible only for a one-year price commitment — as is the case for PJM.

While ISO-NE also permits LSEs to meet their capacity requirements with self-supplied resources (owned resources and resources under bilateral contracts), ISO-NE does not provide an "opt out" alternative as described above for PJM. Similar to PJM's "self-scheduled" option, the

Figure 3

Example of Descending Clock Auction for ISO-NE's Forward Capacity Market[33]



Note: *Prices are in $US/kW-month. By rule the load only pays Installed Capacity Requirement times the clearing price, so the floor price is further reduced (pro rata) to achieve that effect.*

31 The caps and floors were originally scheduled to be eliminated following the third forward capacity auction. However, a recent filing by ISO-NE to implement the results of a stakeholder process proposes to continue these mechanisms for the next three auctions. For more information on how the descending clock auction functions and how these caps/floors are established, see ISO-NE Internal Market Monitoring Unit, *Review of the Forward Capacity Market Auction Results and Design Elements,* June 5, 2009, at http://www.iso-ne.com/committees/comm_wkgrps/othr/fcmwg/mtrls/2009/aug72009/6-05-09_market_monitor_report_for_fcm.pdf.

32 With some exceptions, resources have the option to pro-rate their cleared MW (rather than take a lower price).

33 Jenkins, *et al.*, p. 178.

LSE's full capacity obligation (including that portion met through self-supply) is included in the Installed Capacity Requirement put out to bid, and the self-supplied resources are also counted towards the resources available to meet that requirement (at a price of zero) in the auction process. The net effect for the LSE is also the same: The capacity committed as self-supply does not receive any capacity revenue, and the LSE's capacity obligations satisfied through self-supply are not subject to capacity charges. Further, the LSE's self-supplied resources are subject to applicable penalties, and the LSE is subject to capacity charges for any needed residual capacity that the ISO purchases through the auction on its behalf.

The penalty provisions in the two regions also differ: While both PJM and ISO-NE impose stiff penalty charges if a unit fails to perform when obligated to run, ISO-NE also reduces payments to units that are not producing energy at their full capacity level during shortage events — similar to the mechanism it uses to reduce capacity payments when prices in the energy market reach very high levels.

Role and Eligibility of Demand-Side Resources in FCMs

As discussed above, electric systems face a reliability challenge not faced by other commodity markets: Because customers are physically interconnected, because electricity cannot be meaningfully stored, and because electric service is central to economic and social well-being, the balance between demand and supply is critical at all times, and this balance must be assured over a sustained period of time. The FCM design described in this paper recognizes that actions taken on the demand side of the market can effectively moderate price spikes and enhance reliability in a comparable manner as capacity commitments from supply-side generation — through short-term customer demand responsiveness during system peak, or through permanent and continuous reductions in peak demand (energy efficiency). This market design recognizes that demand-side resources broadly defined to encompass demand response, energy efficiency, and distributed generation can meet system needs, lower costs, and add value to power markets in a variety of circumstances. The most important opportunities include:[34]

- Lowering the cost of power delivery, reducing congestion, and improving the reliability of the delivery system
- Enhancing regional power system reliability by using a broad range of demand-side resources to meet planning and operational reserves
- Economically balancing supply and demand in wholesale power markets through demand-side bidding and market transactions for energy supply released through demand reduction
- Cost-effectively reducing long-term demand and lowering throughput through energy efficiency resources, both on the power grid as a whole and within the resource portfolio of power suppliers

To capture these benefits, energy efficiency and demand response (including distributed generation) can now compete on a level playing field with generation in the ISO-NE and PJM forward capacity markets. Like generating resources, demand-side resources must meet market rules for eligibility and availability, including demonstrating they will be available at the start of the proposed delivery year. Each type of demand-side resource has a specific set of performance hours across which load reductions are required. To be eligible for the auction, service providers must demonstrate in advance their ability to perform during those hours. Like other resources, demand-side resources are subject to penalties if there is a mismatch between their capacity commitment and their performance.

Demand-side resources must meet comprehensive standards for measurement and verification (M&V). Failure to comply with M&V protocols makes the resource ineligible for the auction; failure to submit post-installation M&V reports results in a final capacity offering of zero for the delivery year, plus penalties. Generally, penalties cannot exceed the revenue that would have been collected if the resource performed as specified in the contract. Energy efficiency resources also are audited for compliance. Although the capacity obligations and associated penalties for non-performance among supply-side and demand-

[34] Richard Cowart, Regulatory Assistance Project, and Jonathan Raab, Raab Associates, Ltd., *Dimensions of Demand Response: Capturing Customer-Based Resources in New England's Power Systems and Markets: Report and Recommendations of the New England Demand Response Initiative*, July 23, 2003, at http://www.raponline.org/docs/RAP_Cowart_DemandResponseAndNEDRI_2003_07_23.pdf.

side resources are not identical in these capacity markets, they are designed and intended to provide comparable incentives to perform during specified hours.[35]

Currently, the key difference in eligibility requirements for demand-side resources in the ISO-NE and PJM capacity auctions is the circumstances under which energy efficiency resources may participate. Under PJM's rules, energy efficiency resources may participate in Base Residual Auctions only up to four years. This means that efficiency measures are limited to receiving compensation for their capacity contribution to four years of their measure life, rather than their full measure life. Demand response resources (including distributed generation) can participate in the PJM capacity market for as long as their ability to reduce demand continues. In contrast, all demand-side resources in ISO-NE are eligible to bid capacity for their full measure life, an approach that recognizes the full contribution of these resources to regional resource adequacy requirements and that encourages long-lived energy efficiency assets. Further description of eligible demand-side resources and performance requirements in these markets is presented in Appendix 3.

Forward Capacity Auction Results

In the following sections we summarize the overall level of capacity cleared from existing and new resources in the PJM and ISO-NE auctions, the level of incremental capacity successfully bidding into these markets, and how different types of resources have fared to date — with particular focus on demand resources. More detailed results for the PJM and ISO-NE forward capacity markets are provided in Appendix 1.

Performance Incentives: Demand- vs. Supply-Side Resources

Some stakeholders claim that demand resources are not as available as generation, yet they get paid the same price for capacity (implying that they should receive a lower price). A closer examination of the ISO-NE rules reveals several problems with this generalization. In particular, generation availability can actually vary quite widely because these resources are excused from performing if they are on scheduled maintenance (e.g., nuclear plants are paid their full monthly capacity payment even when they are shut down for weeks of re-fueling). And other generation resources are "allocated" a specific number of hours for annual maintenance and are paid as if they are providing capacity services when they are off-line. Demand resources have pre-established hours they must be available and are penalized for performance failures differently than traditional generation—some argue more severely. For example, a demand resource that fails to perform is assessed a penalty for that month and its capacity value is reduced going forward (for all future months). While it is possible to re-establish the capacity value through future performance (demand response) or with updated M&V (energy efficiency), the process is a slow one that can take many months or more. A generation unit that fails to perform is assessed a penalty for that month, but its capacity value is either unchanged or can be reestablished with a test run at anytime, and the monthly capacity payments continue with no reduction. Generation plants with long notice requirements (e.g., 24 to 48 hours' notice for coal-fired plants if the system operator wants them on-line and actually providing energy) are paid the same as a demand response resource that is required to be dispatchable by the system operator within 30 minutes throughout the year to address shortage events. (See Appendix 3.) Clearly, there are individual rules that stakeholders can argue work to the advantage of supply-side over demand-side resources and vice versa. Overall, the intent of such variations should be to make obligations, penalties, and payments for demand and supply resources roughly comparable, while recognizing the unique operational issues associated with all resources.

[35] Nonetheless, there continues to be debate among stakeholders over whether the appropriate balance has been reached. See text box.

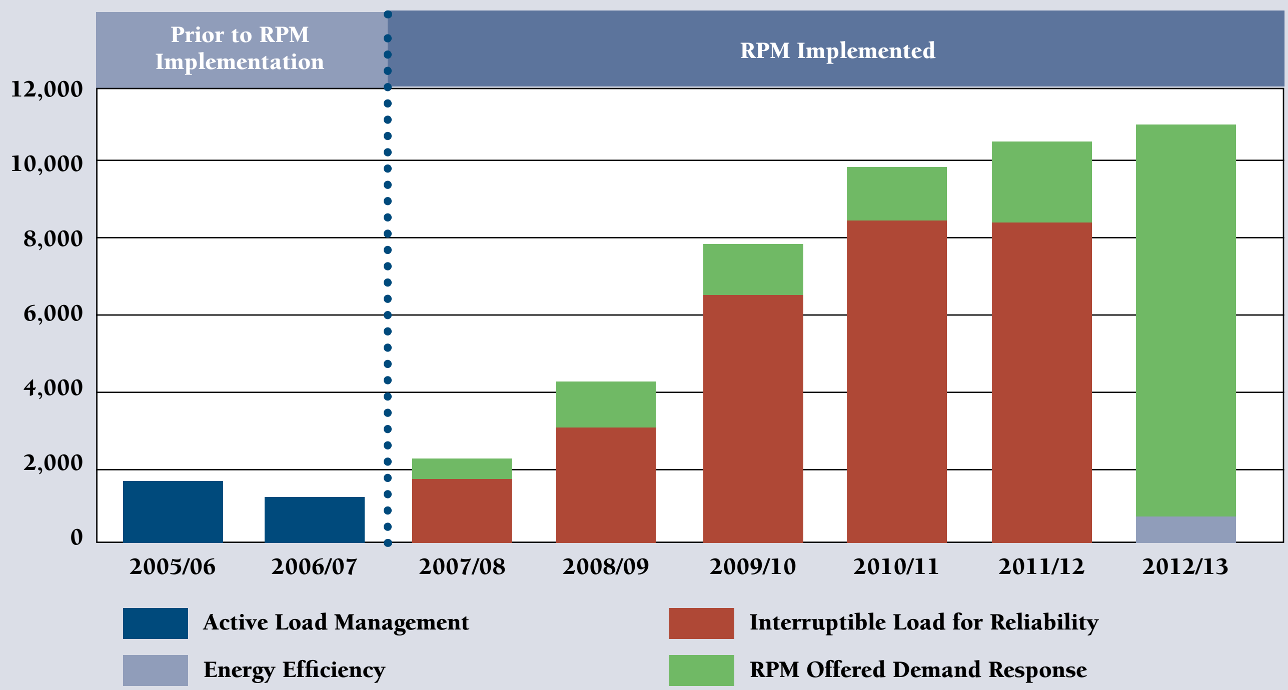
Auction Results for PJM[36]

PJM has held five Base Residual Auctions, including the most recent May 2009 auction for the 2012/2013 delivery year. PJM serves a large market: The 2012/2013 Base Residual Auction cleared a total of 136,143.6 MW of capacity. While generating resources account for nearly all of this committed capacity (128,527.4 MW), demand response resources (including distributed generation) represent 5 percent of the total (7,047.2 MW). New for the 2012/2013 delivery year, 568.9 MW of energy efficiency also cleared the market. Table 1 in Appendix 1 lists capacity resources offered and cleared to date. As indicated in that table, the vast majority of demand-side resources offered into the market cleared each PJM base residual auction. Figure 4 below illustrates the increasing role of demand-side resources in PJM.

Renewable generating resources also are gaining some traction in the capacity market, although not anywhere near the magnitude of demand-side resources, in terms of their overall contribution to resource adequacy requirements. This is due to the predominance of wind resources and their variable nature. PJM applies a 13 percent on-peak capacity factor to these resources — for every 100 MW of wind resources, only 13 MW are eligible to meet capacity requirements. Some 323.4 MW of wind capacity resources cleared in the most recent Base Residual Auction — 95 percent of the amount offered. While this capacity level is miniscule compared to the total capacity clearing the auction, it translates to a large nameplate rating — 2,488

Figure 4

Demand-side Participation in PJM's Reliability Pricing Model (RPM) Auctions



Note: *Demand-side resources included Active Load Management prior to the 2007/2008 delivery year. Interruptible Load for Reliability and Demand Response were first eligible for the 2007/2008 delivery year. Energy Efficiency resources were first eligible for the 2012/2013 delivery year (May 2009 auction). The large increase in demand response participation in the 2012/2013 delivery year is in large part due to the elimination of PJM's ILR program.*

[36] Except where noted, information and figures in this section, and referenced tables in Appendix 1, are from PJM, "2012/2013 RPM Base Residual Auction Results," at http://www.pjm.com/~/media/markets-ops/rpm/rpm-auction-info/2012-13-base-residual-auction-report-document-pdf.ashx.

MW of wind resources.

PJM reports that the Base Residual Auctions have attracted 15,029.4 MW of incremental capacity in the region to date. Incremental capacity refers to new generation resources, capacity upgrades to existing generation resources, new demand response resources, upgrades to existing demand response resources, and new energy efficiency resources.[37] Natural gas- and coal-fired plants account for most of the incremental capacity, with nuclear plants (from uprates) also making a sizable contribution. Tables 2 and 3 in Appendix 1 provide details on the incremental capacity procured. It is important to note that the figures in these tables represent resources new to the capacity market, including uprates — not all are newly built. However, they include a new merchant coal plant built for the PJM market.[38]

True to one of the original goals, the PJM capacity market also has been successful in retaining existing capacity from power plants that were originally under high-cost, reliability must-run agreements.[39] Since FERC approved the Reliability Pricing Model, existing capacity that would otherwise have been deactivated or retired has accounted for 3,276.8 MW of procured capacity. Table 4 in Appendix 1 shows these changes in resource deactivation and retirement.

Market clearing prices for resources in PJM's Base Residual Auctions to date have ranged from $16.46 to $174.29 per MW-day, not including any locational price adders for constrained areas. (See Table 5 in Appendix 1.) Importantly, the $16.46/MW-day clearing price for the 2012/2013 delivery year represents a decrease of $93.54/MW-day from the previous Base Residual Auction, due in part to significant increases in capacity from demand response and the introduction of energy efficiency resources into the bidding process. Moreover, the participation of demand-side resources is estimated to have reduced the market clearing price for the 2012/2013 delivery year by an astonishing $162.32/MW-day in unconstrained zones (i.e., from a clearing price of $178.78/MW-day without these resources in the bid stack to the actual clearing price of $16.46/MW-day). Table 6 in Appendix 1 shows the calculation by PJM's independent market monitor.

Auction Results for ISO-NE

ISO-NE's forward capacity market is about a quarter of the size of the PJM capacity market — the Installed Capacity Requirement set by ISO-NE for the 2012/2013 delivery year was 31,965 MW. ISO-NE has held three forward capacity auctions to date, and all of them cleared at the administratively set floor price ($4.50/kW-month, $3.60/kW-month, and $2.95/kW-month, respectively) with surplus capacity above the Installed Capacity Requirement set by ISO-NE to meet reliability needs. The first auction secured 1,772 MW above the requirement, the second auction cleared 4,755 MW of excess capacity, and the third auction cleared 4,649 MW of excess capacity. (See Table 7 in Appendix 1.)

Demand resources have consistently represented about 8 percent of the resources cleared in the three auctions (2,554 MW, 2,937 MW, and 2,898 MW, respectively), an amount that exceeded expectations. Energy efficiency accounted for about a quarter of the demand resources in the first auction and about a third in more recent auctions. Real-time demand response comprises the largest share of demand resources. Emergency generation (i.e., distributed generation whose state air quality permit limits operation to "emergency" conditions) also makes a sizeable contribution. Non-emergency distributed generation, however, comprises a negligible amount of the total. Table 8 in Appendix 1 shows detailed results for demand resources.

Figure 5 shows the growth in demand resources offered and cleared in the first two ISO-NE auctions, by type. There has been a steady growth in demand-side resources in New England since the first demand-response programs operated by ISO-NE. The forward capacity auctions have contributed to and solidified these gains.

Participation of demand-side resources in the ISO-NE forward capacity auction has been credited with making the clearing price lower than it would have been otherwise,

37 The increase is partially offset by capacity de-ratings to existing generation resources.

38 See Pfeifenberger, *et al.,* at 27.

39 As discussed above, these contracts have not been dispensed with altogether, however.

as it has in the PJM region. Analysis of the first auction bids, for example, suggests that the participation of these resources saved ratepayers as much as $280 million by lowering the price paid to all capacity resources in the market.[40]

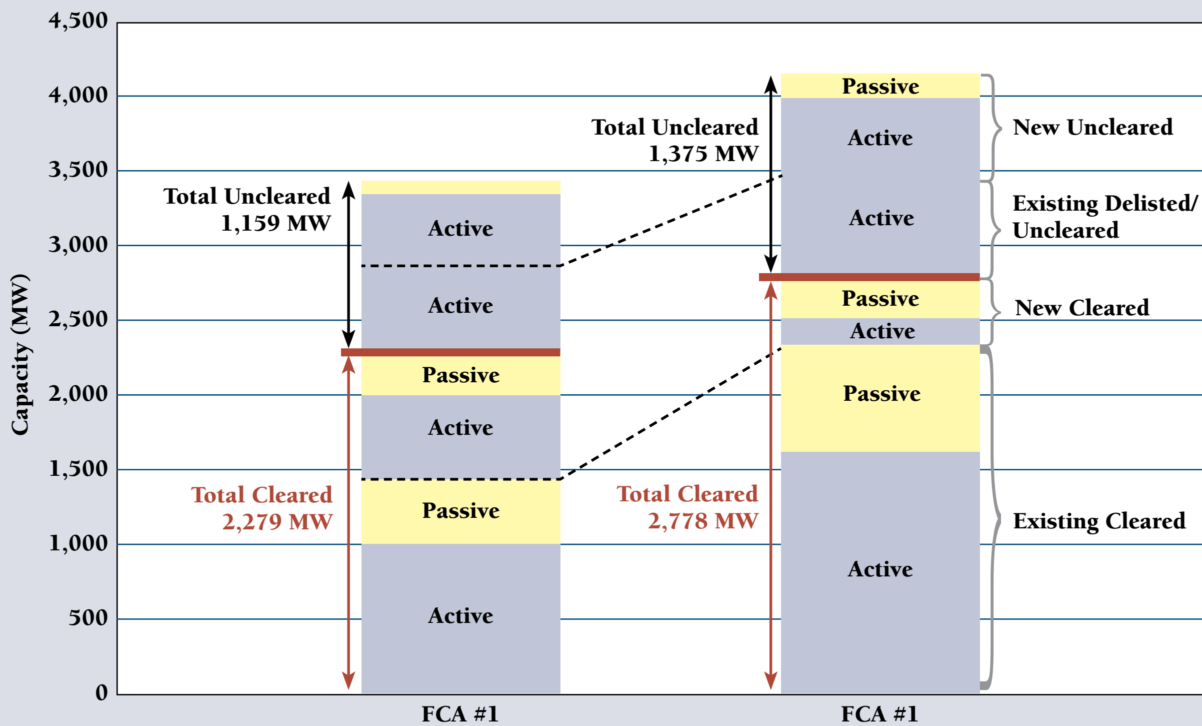
Moreover, by contributing to the excess capacity that kept capacity payments at relatively low floor prices in New England, the participation of demand-side resources has also contributed to lower overall market revenues, inducing some inefficient oil-fired generating units to shut down, at least temporarily. Nonetheless, existing and new fossil-fuel resources continue to dominate the capacity commitments in this region, as is the case for PJM.

Overall, renewable generating resources (primarily wind resources) are making some headway in the region's forward capacity market, but as in PJM, they are not

Figure 5

Demand-Side Participation in ISO-NE Capacity Auctions by Type[41]

© ISO New England Inc.



***Note:** Active" resources include demand response and emergency generation; energy efficiency is considered a "passive" resource. Clearing amounts reflect ISO-NE's maximum limit of 600 MW of Real-Time Emergency Generation. In contrast, Table 8 in Appendix 1 shows the actual amount of such resources that cleared the auction. Capacity payments to these resources are pro-rated if cleared levels exceed 600 MW.*

40 See Cheryl Jenkins, et al. This calculation reflects what the market clearing price would have been in the auction given the Installed Capacity Requirement put out to bid by the system operator, which assumes no impact of energy efficiency programs on loads (because energy efficiency is bidding). Therefore, the calculated reduction in clearing price represents a theoretical maximum — excluding demand resources from the market would likely have been at least partially offset by a lower amount of capacity put out to bid. As a result, the difference in the market clearing price (and savings to consumers) would likely have been smaller than the number calculated here, although it is difficult to say by how much. However, even if demand-side resources were not permitted to bid, they would contribute to lower prices for consumers by lowering the total quantity of capacity required.

41 Internal Market Monitoring Unit, ISO-NE, June 5, 2009.

a major contributor to the region's resource adequacy requirements at this time. In the most recent (third) auction, 166 MW of wind capacity cleared the auction — with a nameplate rating an order of magnitude larger.[42]

Unlike PJM, ISO-NE does not apply a deemed on-peak capacity factor to wind and other variable generation resources. Instead, all such resources must provide data that demonstrate the claimed summer and winter qualified capacity. The capacity factor is adjusted over time based on actual performance during specified hours.

Forward Capacity Markets in the Context of Carbon Constraints

Power market rules are not constructed in a vacuum; rather they are designed to address specific public policy goals. As described above, forward capacity markets in the US were developed to ensure resource adequacy in the power system at a reasonably competitive price. In the face of growing carbon constraints, however, power market rules need to be redesigned to work in concert with carbon reduction goals and policies, rather than at cross purposes. The challenge of substantially de-carbonizing the power sector in the coming years is too great to ignore this interaction. In particular, policymakers should carefully consider what elements of the current planning and procurement process to achieve resource adequacy contribute to the following effects – and then work to revise the market rules accordingly:

- Do the market rules encourage new investments in high-emitting resources (including repowering) at the expense of low-carbon alternatives?
- Do they encourage the continued (or increased) operation of existing, high-emitting power plants?
- Will they result in a build-out of capacity and cumulative emissions that conflict with the level of de-carbonization required in the power sector — or make attainment of that level more costly to the economy?

This paper is not intended to evaluate the PJM and ISO-NE capacity markets and auction rules in any depth with respect to these issues. However, we offer below general observations based on the auction design and results to date in these regions and other studies. Following that, we provide policy recommendations, related design options, and additional actions for consideration.

General Observations on Forward Capacity Markets and Results

Based on our review of FCM auctions to date and related studies, we offer the following observations:

- **The ISO-NE and PJM forward capacity markets are meeting their resource adequacy objectives.** Sufficient levels of capacity have cleared the market to meet each region's anticipated peak demand, and adequate resources are now committed on a forward basis to ensure reliable coverage in future years (up to the 2012/2013 delivery year). But in a carbon-constrained world, the mix of resources is as important as the quantity, in both the short-term and the long-term. Most resources that are available during peak demand hours also produce electricity or reduce consumption during many more (or all) hours of the year, and the carbon intensity of that mix of resources will drive the level of cumulative emissions in the power sector.[43] As discussed in this paper, capacity markets as currently designed provide compensation based on the level of available capacity, not the mix of resources providing that capacity. It is worth repeating here that the only (non-price) attribute a resource needs to demonstrate for resource adequacy purposes is that it will be available when called upon, during the projected hours of peak system loads. In a carbon-constrained world, policy makers should ask whether the planning and procurement process for acquiring a sufficient level of capacity at a reasonable price is also moving the resource mix in the right direction — towards zero or low carbon-emitting demand- and supply-side resources.

[42] Compiled from auction results at http://www.iso-ne.com/markets/othrmkts_data/fcm/cal_results/ccp13/fca13/index.html.

[43] With the exception of gas-fired peaking units or demand response resources that are dispatched to meet (or reduce) loads only during peak system hours.

- **Expressly designing demand-side resources into forward capacity markets appears key to achieving all three objectives – resource adequacy, low-carbon resource mix, and reasonable price.** Energy efficiency and demand response resources are faring well in auction-based capacity markets — and this is a positive outcome for several reasons. First, energy efficiency and other demand-side resources can substitute for existing and planned generation that have a higher carbon footprint, thereby reinforcing carbon reduction policies and targets for the region. Second, demand-side resources can dramatically reduce the costs of meeting the region's resource adequacy requirements — as evidenced by the results of the PJM and ISO-NE auctions. In addition, the increase in demand-side resources facilitated by capacity auctions can reduce market power, because more suppliers and more resources means individual generators have less ability to affect bid offers and clearing prices. And because demand-side resources lighten the load at the end of the supply/delivery chain, they enhance the reliability of each link in the chain, from fuel supply and generation to the local distribution network.

- **Differences in the impact of demand-side resources on carbon emissions should be recognized in capacity markets and associated auction rules.** Energy efficiency decreases carbon emissions because (by definition) it reduces energy use for an equivalent level of service and, at the margin, almost all power systems are running higher carbon resources. In contrast, the net impact of demand response on carbon emissions will depend upon specific circumstances, including the mix of plants serving loads at the margin. For example, when coal is primarily serving baseload and intermediate needs, emissions may increase when customers shift loads from on-peak (when natural gas is on the margin) to off-peak periods.[44] Elsewhere, however, demand response — including any conservation side-effect — may reduce emissions from less efficient peaking plants. In addition, demand response includes real-time emergency generation, which is often fossil-fuel powered (e.g., by diesel or natural gas). Any analysis of the costs and benefits of demand response resources in capacity markets should account for such effects. Policies and market rules for demand response should be aligned with its environmental costs and benefits.[45]

- **Renewable generating resources are beginning to make some headway in forward capacity markets — in particular wind resources.** This is in large part because the markets described here recognize some capacity value for variable renewable resources (wind, solar, and run-of-river hydro), either through a deemed on-peak capacity factor or a demonstration of claimed capacity for specified on-peak periods. Policymakers need to pay attention to how these values are established so they can be confident the committed capacity will be available when called on, while at the same time encouraging participation of all low-carbon resources in the market. More generally, as renewable resources become a more significant part of the resource mix, a forward capacity market creates the opportunity to recognize their aggregate capacity value to the system.[46]

[44] For example, PJM recently released figures on carbon emissions of generating units that operate on the margin during on-peak vs. off-peak hours. See http://www.pjm.com/~/media/about-pjm/newsroom/2010-releases/20100325-pjm-reports-new-carbon-dioxide-emissions-data.ashx and http://www.pjm.com/documents/~/media/documents/reports/co2-emissions-report.ashx.

[45] See section 3.16 and Mechanism E in Attachment 1 of Pacific Northwest National Laboratory, *The Smart Grid: An Estimate of the Energy and CO_2 Benefits,* January 2010 (PNNL 19112), at http://energyenvironment.pnl.gov/news/pdf/PNNL-19112_Revision_1_Final.pdf.

[46] Variable renewable resources will qualify for higher capacity value if they are bundled with other resources for reliability (e.g., demand response, hydroelectric dams, or energy storage). In addition, confidence in the capacity value of variable resources increases as their geographic diversity on the system increases. See, for example, the report on the Eastern Wind Integration and Transmission Study at http://www.nrel.gov/wind/systemsintegration/pdfs/2010/ewits_final_report.pdf.

- **Nonetheless, renewable resources are hard-pressed to successfully compete with the thousands of megawatts of existing and new fossil-fuel resources participating in these auctions that are able to bid below the true societal cost of their operations under current market rules.** In fact, capacity auctions as currently designed can breathe new economic life into high carbon-emitting plants that were previously planned for significantly reduced operations or retirement. Along with new capacity from fossil-fuel generation, allowing such a large amount of existing capacity from high carbon emitters to clear the auction is likely to crowd out renewable resources that are able to address resource adequacy requirements equally well. Such results may not represent an "efficient" (or desirable) outcome for a carbon-constrained power sector. This is especially true where the carbon costs of a fossil-fuel plant are not fully recognized in the energy market that plant also will be bidding into.

- **A market price for capacity or energy that favors the construction and operation of high carbon-emitting resources over clean resources will lead to increases — rather than reductions — in the cumulative level of carbon emissions in the power sector.** A carbon tax or carbon cap-and-trade regime internalizes some or all of the otherwise un-priced carbon costs of electricity production and would improve the relative economics of clean resources in both forward capacity and energy markets. However, carbon pricing alone may be insufficient to change the dispatch of existing, high-emitting power plants or their ability to clear these capacity markets (and be paid additional revenues as a result) in such overwhelming numbers.[47] In fact, the very modest impact of carbon pricing on the performance of fossil-fuel plants has been documented in several reports.[48] (See text box below.)

Carbon Pricing Alone Is Insufficient to De-carbonize the Generation Mix

The Electric Power Research Institute modeled the effect of various levels of carbon taxes or allowance prices in the upper Midwest (coal-dependent) and in Texas (heavily reliant on natural gas). The study found that close to a doubling of the wholesale prices of electricity in the Midwest region (through carbon-related charges) would produce only a 4 percent reduction in regional emissions given the current generation mix. Similar results were observed for Texas, where natural gas plants are on the margin.[49] And in the Northeastern US, due to initially low carbon prices and a host of factors that dampen the price signal, the Regional Greenhouse Gas Initiative (RGGI) has not yet resulted in generator operational changes.[50] One of those dampening factors is the single clearing price that is typically set through wholesale energy markets — which dilutes the market signal sent by a price on carbon emissions by allowing fossil-fueled plants to recover most or all of their allowance costs through higher clearing prices reflecting the cost of allowances.[51]

Studies also have shown that the price of carbon must rise (and be maintained) at very high levels to obtain sufficient market pull for the level of new investments in clean generation required. For example, a recent analysis in California concluded that it would take a carbon price of $100 per tonne[52] to make economic investments in renewable resources compared to fossil fuel-fired generation, in order to reach carbon reduction targets in the power sector beyond what current state requirements will achieve.[53] Further, price signals may be diluted if a portion of the carbon allowances are allocated in a manner that shields high-emitting power plants from carbon costs, or if high-emitters located outside the capped region can sell into the market on a long-term basis.

[47] With or without carbon prices, policymakers also might want to consider the implications of paying existing power plants the market clearing price for capacity — and the potential windfall profits for plant owners — for making no changes in plant operations. See, for example, Ezra Hausman, Paul Peterson, David White, and Bruce Biewald, Synapse Energy Economics, Inc., *RPM 2006: Windfall Profits for Existing Base Load Units in PJM: An Update of Two Case Studies,* Feb. 2, 2006, at www.synapse-energy.com.

- Carbon pricing alone will have limited impact on consumer decisions to invest in permanently reducing their peak demand by making cost-effective investments in energy efficiency. Well-designed time-varying pricing options can successfully shift demand from high-price hours to lower price hours.[54] Such shifting also reduces peak demand on transmission and distribution systems. Overall energy use will decline somewhat in response to price. But long-term reduction in energy use due to price increases is relatively small. The numerous market barriers to capturing the full cost-effective potential of energy efficiency – through improvements in building construction practices and industrial processes, retrofits of existing buildings, and installations of high-efficiency appliances and equipment in homes and businesses – are well-documented. They include lack of information, high first-costs, consumers' high discount rates, and the landlord-tenant split incentive problem, among others.[55] Recent empirical analysis of demand elasticities suggests that the long-term price elasticity of demand for electricity is even lower than earlier studies have indicated, for both liberalized and regulated markets. (See text box on page 21.)

In sum, while forward capacity markets are meeting their resource adequacy objectives and clearing an impressive amount of clean, low cost demand-side resources, on balance these markets (as currently designed) are not working sufficiently in concert with carbon reduction goals and policies in the face of growing carbon constraints. For the reasons discussed above, carbon pricing alone

Demand for Power Is Relatively Price-Insensitive — Even Over the Long Term

Modeling by the US Department of Energy suggests that a 10 percent increase in power prices will reduce demand for electricity by just 2.5 percent to 3 percent over 20 years, assuming that the price effects persist over that entire period.[56] This would only offset the normally expected US load growth in two out of those 20 years.[57]

More recently, a 2009 empirical analysis of the demand for electricity in the US concludes that price elasticity of residential demand has actually decreased since retail price deregulation was first introduced in the US. The results suggest that a 10 percent increase in power prices will reduce residential electricity demand more on the order of 1.2 percent to 1.7 percent, based on 2001-2008 data for both deregulated and regulated states.[58] Price responsiveness is further dampened by the income-elasticity of demand, which is positively correlated with consumption: As incomes increase, consumption of electricity goes up, and the conservation impact of any price increase is diminished.[59] The equivalent historical figure for a 10 percent increase in power prices in the UK residential sector is -2.3 percent, but the income-elasticity is such that a 10 percent increase in income results in an increase of demand of 3.4 percent – i.e., household income is just as important as energy price in determining energy demand.[60]

[48] See Testimony of Richard Cowart, Regulatory Assistance Project, Before the Committee on Energy and Commerce Subcommittee on Energy and Environment, U.S. House of Representatives, April 23, 2009, "The Consumer Allocation for Efficiency: How Allowance Allocations Can Protect Consumers, Mobilize Efficiency, and Contain the Costs of GHG Reduction," at http://energycommerce.house.gov/Press_111/20090423/testimony_cowart.pdf.

[49] See Victor Niemeyer, "The Change in Profit Climate: How Will Carbon-Emissions Policies Affect the Generation Fleet?" *Public Utilities Fortnightly,* May 2007, at 20, 24.

[50] See "RGGI marks its first year with success, and lesson on effect of market pressure," Electric Utility Week, Dec. 14, 2009. Ten Northeast and Mid-Atlantic states participate in RGGI, the first mandatory cap-and-trade program in the US: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. Nine of them participate in either the ISO-NE or PJM forward capacity markets described in this paper.

[51] PJM Interconnection, "Potential Effects of Proposed Climate Change Policies on PJM's Energy Market," Jan. 23, 2009, p. 5. See also "Because That's Where the Money Is: The FERC's Ability to Reduce the Cost of Slowing Global Warming," Samuel A. Wolfe, Chief Counsel, New Jersey Board of Public Utilities, December 2009, at http://www.naruc.org/publications/WOLFE-%20Panel%203.pdf.

is unlikely to shift the power sector resource mix at the pace or scale required to meet aggressive carbon reduction targets – or correspondingly, to substantially change the dominance of high-carbon resources clearing forward capacity auctions under current market rules. An increasing number of studies makes a compelling case that our economy and our society cannot afford this dominance to persist much longer, if we are to contain climate change to a livable level. In fact, close to full de-carbonization of the power sector is being discussed in international forums as the only way to meet essential carbon reduction targets by 2050.[61] While capacity markets alone are unlikely to support the full value of clean energy resources in a carbon-constrained power sector by themselves, with appropriate design elements they can serve to reinforce actions taken at federal, regional, and state levels that provide larger and longer lasting commitments to clean demand-side and renewable resources.[62]

52 A tonne, or metric ton, is a unit of mass equal to 1,000 kilograms (roughly 2,205 pounds) or approximately the mass of one cubic meter of water at four degrees Celsius. A tonne is not the same as either a "short" ton (2,000 pounds) or a "long" ton (2,240 pounds).

53 Energy and Environmental Economics, Inc., *Greenhouse Gas Modeling of California's Electricity Sector to 2020: Updated Results of the GHG Calculator Version 3*, prepared for the California Public Utilities Commission, October 2009, pp. 66-67, at http://www.ethree.com/documents/GHG_10.22.09/CPUC_GHG_Final_Report_28Oct09.pdf.

54 Ahmad Faruqui and Sanem Sergici, The Brattle Group, "Household Response to Dynamic Pricing of Electricity: A Survey of the Experimental Evidence," Jan. 10, 2009, at http://www.hks.harvard.edu/hepg/Papers/2009/The%20Power%20of%20Experimentation%20_01-11-09_.pdf.

55 See, for example, American Council for an Energy Efficient Economy, "Quantifying the Effects of Market Failures in the End-Use of Energy" pp. iii-vi, 2007, at http://old.aceee.org/energy/IEAmarketbarriers.pdf. This study details the various types of market barriers to end-use energy efficiency and reports that up to 50 percent of residential energy use in the US is affected by such barriers.

56 The US Department of Energy's National Energy Modeling System (NEMS) has price elasticity built into it. The long-run elasticity (assuming price effects remain for 20 years) are –0.31 for residential electric use and –0.25 for commercial electric use. See Steven H. Wade, "Price Responsiveness in the NEMS Buildings Sector Model," in Energy Information Administration's *Issues in Midterm Analysis and Forecasting 1999,* pp. 55, 58, table 1, at http://www.eia.doe.gov/oiaf/issues/pdf/060799.pdf.

57 This would require a much larger rate increase just to offset expected load growth over 20 years, let alone to reduce demand sufficiently to permit absolute reductions in emissions from the nation's huge generation fleet. See Testimony of Richard Cowart.

58 T. Nakajima and S. Hamori, "Change in Consumer Sensitivity to Electricity Prices in Response to Retail Deregulation: A Panel Empirical Analysis of the Residential Demand for Electricity in the United States," *Energy Policy* (2010), available at www.sciencedirect.com.

59 *Ibid.*

60 John Dimitropoulas, Lester C. Hunt, and Gary Judge, "Estimating Underlying Energy Demand Trends Using UK Annual Data," at http://userweb.port.ac.uk/~judgeg/AEL_04.pdf.

61 See, for example, *Meeting Carbon Budgets – The Need for a Step Change: Progress Report to Parliament Committee on Climate Change,* October 2009, at http://www.theccc.org.uk/reports/progressreports; Christopher Jones and Jean-Michel Glachant, *Why and How the European Union Can Get a (Near to) Carbon-Free Energy System in 2050,* MIT Center for Energy and Environmental Policy, March 2010, at http://downloads.theccc.org.uk/docs/21667%20CCC%20Executive%20Summary%20AW%20v4.pdf; *Roadmap 2050: A practical guide to a prosperous, low-carbon Europe,* The European Climate Foundation, April 2010, at www.roadmap2050.eu.

62 Without such policies, it is unlikely that even RGGI's modest carbon reduction goals will be achieved. See Paul Peterson, Doug Hurley, and David White, Synapse Energy Economics, Inc., *ISO New England Scenario Analysis Companion Report: Constructing a Future That Meets Regional Goals,* Aug. 8, 2007, at www.synapse-energy.com.

Policy Recommendations and Auction Design Options

We present below recommendations and a menu of auction design options for forward capacity markets that support and enhance carbon policies and carbon reduction targets.

- **Power market rules should be constructed to recognize and limit the adverse environmental consequences of power generation.** The power system and the environment are inextricably linked. Explicit consideration of environmental costs and benefits of various electricity resources is not only reasonable, but necessary to meet the enormous challenge of climate change.

- **Forward capacity markets should reinforce carbon reduction policies,** which could be accomplished by incorporating one or more of the following into the auction rules:

  Auction rules could apply an Emissions Performance Standard (EPS) to promote capacity commitments from low-carbon resources and discourage bids from high-emitting power plants. An EPS can be expressed as a maximum level of greenhouse gas emissions per unit of electrical output or as a percentage reduction in (annual) plant emissions. It can vary with fuel type and incorporate other design variations.[65] It may be appropriate to adopt an EPS — within the auction qualification rules or by regulation — particularly if current market signals are not sufficiently discouraging new construction or repowering of high-emitting generating resources with long lifetimes, while forward capacity markets are providing a new revenue stream to keep them running.

ISO-NE Rules for Emergency Generators Advance Environmental Goals

Emergency ("backup") generators typically are diesel-fired, and states in New England and elsewhere in the US have restricted the number of hours and days they may be operated through the state permitting process. At the time the first regional demand response tariffs were being designed in New England, a collaborative of energy regulators, environmental regulators, the ISO, utilities, and other stakeholders realized that active demand response programs could lead to substantial incentives for diesel-fired backup generators to operate more often, when air quality was at its worst. Regulators and the ISO proposed a rule limiting those generators to run for reliability purposes during system emergencies. This is a concrete example of reliability rules being written to advance environmental goals as well as power system needs.[63] In addition, a regional working group developed model emissions standards for small generators for states' consideration.[64]

To reinforce regional air quality policies and goals, ISO-NE limits the total amount of emergency generators in the regional capacity market to 600 MW. To the extent any excess amount clears the auction, capacity payments to these resources are pro-rated.

[63] See Cowart and Raab, p. 26.

[64] See *Model Regulations for the Output of Specified Air Emissions From Smaller Scale Electric Generation Resources,* Oct. 31, 2002, at http://www.raponline.org/showpdf.asp?PDF_URL=%22/docs/rap_issuesletter-outputbasedemissioninsert_2003_07.pdf%22.

[65] Edward S. Rubin, Carnegie Mellon University, "A Performance Standards Approach to Reducing CO2 Emissions for Electric Power Plants," June 2009, at http://www.pewclimate.org/publications/report/coal-initiative-series-performance-standards-approach-reducing-co2-emissions-ele. Also see Chris Simpson and Brenda Hausauer, "Emissions Performance Standards in Selected States," Regulatory Assistance Project Research Brief, November 2009, at http://www.raponline.org/docs/RAP_Simpson_EPSResearchBrief_2009_11_13.pdf.

Auction rules could disqualify inefficient generators from participating (and from receiving capacity revenue) or, more generally, require their retirement through financial incentives, regulations, or both.[66] Since 2007, China has been phasing out such plants and intends to retire approximately 50 gigawatts (GW) of small, inefficient coal-fired power plants nationwide and 7 GW to 10 GW of small natural gas-fired units, as well as halt construction of small, inefficient power plants. The policy is being put in place three ways: the direct rescission of operating permits, the transfer of generation rights, and price reductions.

Capacity payments could vary by the emissions rate of the resource. Instead of one price paid to all generation that clears the auction, adders could be applied to payments for low-emitting units, and deductions could be applied to high-emitting units.[67] For example, a sliding-scale percentage reduction to the per-unit ($/kW-month or $/MW-day) clearing price could be established based on the average, annualized carbon footprint of fossil-fuel resources, whereas a price adder above the clearing price could be established for zero-emitting resources.

Imputed "carbon adders" could help curtail high-emitting resources. Carbon adders are imputed costs that reflect at least a portion of the societal cost of emissions. They are generally used in the context of resource planning and acquisition by a regulated LSE — as a way of ensuring that high-carbon risks and low-carbon alternatives are properly valued in the resource selection process. But these imputed costs do not get passed on to ratepayers or consumers for every unit of power consumed, in contrast to carbon pricing.[68] Similarly, the rules in a forward capacity market could be modified so that carbon adders are applied in determining what resources clear the auction (and will receive the market clearing price for their capacity commitment).

A "zero-carbon resource portfolio standard" could establish auctions for separate tranches of resources by emissions level. For example, one tranche could include energy efficiency and renewable resources. The size of each tranche would be based on carbon reduction goals for the region. The higher the goals, the larger the tranche for energy efficiency and renewable resources. These resources decrease carbon emissions because at the margin most power systems are running higher carbon resources.

- **Policymakers should consider a longer price commitment in forward capacity markets — at least for low-carbon resources.** The contract period for new capacity in these markets is short (one year in PJM, up to five years in ISO-NE), in part so there is greater certainty over forecasts of resource needs for system reliability (to mitigate the risk of over-supply).

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66 Small and old coal plants are the most inefficient and polluting, both in terms of greenhouse gases and particulate matter. By some estimates 50 MW plants may use as much as 200 grams more per unit of electricity output than a plant larger than 300 MW. See Frederick Weston, Rebecca A. Schultz, David Moskovitz, and Max Dupuy, Regulatory Assistance Project, "China's Climate Change Initiatives: Do new policies adopted in China offer any guidance for the transformation of the US power sector in a carbon-constrained world?" November 2009, at http://www.raponline.org/docs/RAP_China%20Climate%20Initiatives_NARUC_2009_11_01.docx.

67 See N. Jonathan Peress and Kenneth A. Colburn, "Electrical Connections: Aligning Capacity Market Changes With RGGI in the Northeast," Discussion Draft, March 2005, at http://www.puc.nh.gov/EPAB/Symbiotic%202005-03-18%20Peress-Colburn%20Letter%20to%20FERC-Wood.pdf.

68 Both high carbon resources and low carbon resources clearing in power markets (characterized by single-price auctions) are paid the same price. So whenever fossil resources are on the margin (most of the time in most places), consumers are seeing the same price for both fossil and clean resources, and the cost of carbon allowances (or carbon taxes) for that marginal resource is reflected in the clearing price for all power bought in the market. Carbon adders, on the other hand, are not actually paid to any resource or reflected in prices for all units sold in the market.

Auction winners can generally participate in future auctions and receive the market clearing price, but have no assurance of future prices. Moreover, under current rules in PJM, energy efficiency resources cannot receive capacity payments over the full life of the measures — only for four consecutive delivery years. This constraint puts energy efficiency on a different footing than other demand resources — as well as all supply-side resources — which are paid for their capacity as long as they provide the benefit.

The short commitment period and lack of price certainty may not provide market signals that are strong and consistent enough to ensure sufficient new generation, or encourage plant operators and investors to make efficient choices for the long-term — even where carbon prices are expected to increase substantially in the future due to a dramatically declining carbon cap or a high carbon tax. Allowing clean resources to opt for a longer period of time over which the price is known would in particular facilitate renewable resources, whose typically high upfront capital costs and low operating costs — compared to natural gas-fired plants in particular — may require such a long-term commitment to procure financing.[69] Another option might be to establish fixed floor prices for clean energy resources for a long-term period to provide assurance of a minimum revenue stream.

- **Regional load forecasting should be reviewed for treatment of demand-side resources acquired outside the capacity market.** In particular, the system operator determines the capacity that will be auctioned for each delivery year (three years hence) based on a 10-year load forecast, which is updated on an annual basis. Under the current planning process in forward capacity markets, this forecast only reflects the demand-side resources that have cleared in prior auctions. The system operator's load projections do not take into consideration any load reductions from demand-side resources procured outside of the auction, such as energy efficiency programs, that LSEs have committed (or are obligated) to fund and implement in the coming one to three years or beyond.[70] If the magnitude of these load reductions is substantial, the ISO may be systematically overstating the level of capacity put out to bid for each delivery year. Depending upon the existing mix of resources and market conditions in the region, this overstatement may have a sizeable impact not only on the level of cleared capacity and the market price, but on the resulting resource mix and level of carbon emissions as well.

Additional Actions

Careful design of the planning process and auctions undertaken through forward capacity markets can help to ensure that they reinforce and do not work at cross purposes with climate reduction goals and targets. However, forward capacity market signals (capacity prices) are only one component of a market and regulatory landscape that affects investment and operating decisions in the power sector. Market rules and procurement policies that affect system energy requirements – as well as policies and regulations that affect access, location, and cost recovery for transmission and distribution facilities – have an enormous impact on both the short- and long-term resource mix.

It is beyond the scope of this paper to fully explore how

[69] LSEs in PJM and ISO-NE can contract for generating resources through the bilateral market to hedge energy and capacity costs and to meet renewable energy standards. Renewable resource projects that successfully negotiate such contracts, if they are long term, may not need a long-term commitment in the forward capacity market. Still, a short-term capacity payment stream, with uncertain prices thereafter, weakens the ability of renewable resources to secure long-term financing.

[70] Some of the econometric models that the system operators use for their load forecasts may capture the impacts of federal appliance standards and building codes. However, to our knowledge there has been no explicit accounting to date for the impacts of state and utility energy efficiency programs where the capacity is not bid into the auctions.

market rules and other policies and regulations can be harmonized and strengthened to meet customers' energy needs reliably in a carbon-constrained world. Larger and longer lasting commitments to demand-side and renewable resources are certainly needed to ensure a mix of resources that will significantly reduce greenhouse gas emissions in the power sector. This has been the conclusion of US policymakers who have put in place additional policies to facilitate long-term acquisition of low-carbon resources in regions that operate both forward capacity markets and a cap-and-trade program (under RGGI):[71]

- States have adopted a variety of mechanisms for sustained and aggressive energy efficiency programs:
  - Strong building codes and equipment standards
  - Stable funding through a system benefit charge
  - Third-party administration of programs or, where the utility is the efficiency portfolio manager, decoupling of utility profits from revenues, financial incentives for shareholders, or both
  - Recycling of carbon auction proceeds into energy efficiency investments
- Some states require long-term resource plans or resource procurement plans that must include energy efficiency. There's renewed interest in long-term planning and procurement, particularly for demand-side and renewable resources, following a period where these efforts were largely abandoned with electric industry restructuring and development of organized markets.[72]
- Several states have adopted energy efficiency resource standards that require achievement of specified energy-saving targets.[73]
- Most of the states have renewable energy standards,[74] and several states require long-term contracting of renewable resources to meet the standards.[75]
  - Connecticut, Maryland, Pennsylvania, and Rhode Island require contract terms of 10 years or longer.
  - New York requires central procurement of renewable energy credits by a state agency under long-term contract; Illinois is likely to acquire long-term contracts for renewable resources under its central procurement mandate.
  - Massachusetts' Green Power Partnership purchases renewable energy credits for up to 10 years, using its renewable energy fund.

These are just examples, and certainly not an exhaustive list, of the ways in which careful design of forward capacity markets coupled with additional policies at the federal, regional, and state level can serve to reinforce both resource adequacy requirements and carbon reduction goals.

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71 Regulatory Assistance Project policy grids summarize state-by-state requirements for resource planning and energy efficiency, at http://www.raponline.org/Feature.asp?select=116. For a summary of renewable energy standards in the US, see Ryan Wiser and Galen Barbose, Lawrence Berkeley National Laboratory, "State of the States: Update on RPS Policies and Progress," State-Federal RPS Collaborative, Nov. 18, 2009, at http://www.cleanenergystates.org/Meetings/RPS_Summit_09/WISER_RPS_Summit2009.pdf.

72 More broadly, 30 states nationwide require integrated resource plans or resource procurement plans that include energy efficiency.

73 Includes states with strict energy efficiency standards, states with Commission-ordered efficiency targets, states that allow efficiency to count toward renewable energy standards, and states with a rate cap that triggers a relaxation of requirements. See Laura A. Furrey, Steven Nadel, and John A. "Skip" Laitner, ACEEE, *Laying the Foundation for Implementing a Federal Energy Efficiency Resource Standard,* March 2009, at http://aceee.org/pubs/e091.htm.

74 Some 29 US states and the District of Columbia have renewable energy standards; five other states have non-binding goals. See Wiser and Barbose.

75 For a US database of state incentives for renewable energy and energy efficiency, see http://www.dsireusa.org/.

Connecticut's Marriage of Resource Planning and Markets

An example of an approach that attempts to "marry" integrated, least-cost resource planning with forward capacity markets is the resource planning and procurement process recently established by the Connecticut Legislature.[76] The law requires the utilities, Energy Advisory Board, and Department of Public Utility Control to plan for current and future energy and capacity needs and provide a mechanism for procuring resources that meet specified economic, reliability, and environmental objectives[77] to satisfy the identified need. Further, the law requires that resource needs first be met through energy efficiency and demand reduction resources that are cost effective, reliable, and feasible. Based on the resulting resource plans, LSEs enter into contracts to acquire the required capacity (level and mix) through a competitive bidding process. The law also requires that any resources winning contracts for capacity agree to let the LSE bid that capacity into the forward capacity auction as a "self-supplied" resource. This approach permits LSEs to determine both the quantity and mix of resources through integrated resource planning that will meet their resource adequacy requirements and state policy goals (e.g., carbon reduction). The LSE pays the contracted capacity price (under its bilateral contracts), instead of paying the auction clearing price to everyone that offers capacity into the forward capacity market (e.g., existing fossil fuel or nuclear plants).[78]

76 Conn. Gen. Stat. §§ 16a-3a, 16a-3b and 16a-3c.

77 Costs and benefits; cost-effectiveness; cost impacts on customers; the extent to which load growth can be eliminated and peak demand reduced; reliability including energy security and economic risks; impacts on meeting state environmental standards including emissions goals; optimization of existing generation and generation sites; the extent to which renewable resources can be used to meet needs; and fuel types, diversity, and supply. See Department of Public Utility Control, Final Order in Docket No. 08-07-01, Feb. 18, 2009.

78 This approach is not without some controversy. A contracted new resource in Connecticut has the potential to displace an alternative "competitive" new resource in the region that would have bid at a higher price — had Connecticut not been allowed to designate the contract as self-supply. ISO-NE's Internal Market Monitoring Unit has commented on this issue in a report to FERC. See Internal Market Monitoring Unit, ISO-NE, June 5, 2009.

Conclusions and Recommendations

Auction-based capacity markets in the US have been successful to date in attracting the capacity needed to maintain system reliability in an economically efficient manner. In particular, these markets have been successful in facilitating new demand-side resources, with ratepayers and society reaping the economic and environmental benefits. However, policymakers also should consider capacity markets in the context of carbon reduction policies and targets for the power sector. Even markets that successfully integrate demand-side and renewable resources into the auction process are still encouraging the construction or continued operation of high-emitting, supply-side resources to meet reliability targets.

Existing capacity markets should be evaluated to assess whether the market is responding in this way. And if it is, policymakers need to critically assess whether a continuation of that market response over the coming years will make it possible to achieve the cumulative level of carbon reductions required from the power sector to avoid the worst effects of climate change. Depending on the results of this inquiry, policymakers may need to refine the auction rules and adopt additional policies for the power sector — such as those described in this paper — to ensure the alignment of capacity markets with both short- and long-term carbon reduction goals.

More generally, forward capacity markets create a revenue stream for resources that can commit to being available at times of system peak several years in the future — but this financial incentive is clearly not the only factor driving the mix of resources in the power sector, and their resulting carbon footprint. Market rules, policies, and regulations that affect investment and operating decisions for meeting the system's energy requirements — as well as those that affect access, location, and cost recovery for transmission and distribution facilities — have an enormous impact on both the short- and long-term resource mix in the electric system. Policymakers will need to consider how this entire market and regulatory landscape — including forward capacity markets — can be strengthened and harmonized to reliably meet customer demand for electricity in a carbon-constrained world.

Appendix 1

Detailed Results for PJM and ISO-NE Capacity Markets

Cleared capacity values in the following tables represent all capacity committed by existing resources remaining in the market and all new resources that bid into the auction at or below the market clearing price. Cleared capacity includes "self-supplied" or "self-scheduled" resources entered into the auction by LSEs. However, as described in this paper, when the monthly billing/settlement process is completed, the capacity charges allocated to the LSE will be offset (credited) for the cleared capacity delivered by these resources.

Incremental capacity in the tables below reflects: 1) new generation resources, 2) capacity upgrades to existing generation resources, 3) partial offsets to incremental generation capacity due to capacity de-ratings to existing generation resources, 4) new demand response resources, 5) upgrades to existing demand response resources, and 6) new energy efficiency resources.

PJM Results[79]

PJM has conducted five Base Residual Auctions since its inception in 2007 for delivery years beginning in 2008/2009 (that each run from June 1 to May 31). Capacity cleared in the PJM auction is defined in terms of "unforced" capacity, that is the capacity of a resource adjusted for availability and deliverability based on historical performance (e.g., forced outages).

Table 1

Generation, Demand Resources, and Energy Efficiency Resources Offered and Cleared in PJM Base Residual Auctions (Unforced Capacity in MW)

Delivery Year	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013
Generation Offered	131,164.8	132,614.2	132,124.8	136,067.9	134,873.0
DR Offered	715.8	936.8	967.9	1,652.4	9,847.6
EE Offered*	-	-	-	-	652.7
Total Offered	**131,880.6**	**133,551.0**	**133,092.7**	**137,720.3**	**145,373.3**
Generation Cleared	129,061.4	131,338.9	131,251.5	130,856.6	128,527.4
DR Cleared	536.2	892.9	939.0	1,364.9	7,047.3
EE Cleared	0.0	0.0	0.0	0.0	568.9
Total Cleared	**129,597.6**	**132,231.8**	**132,190.5**	**132,221.5**	**136,143.6**

** Energy efficiency resources were first eligible in the 2012/2013 auction.*

79 All information for PJM compiled from "2012/2013 RPM Base Residual Auction Results," at http://www.pjm.com/~/media/markets-ops/rpm/rpm-auction-info/2012-13-base-residual-auction-report-document-pdf.ashx.

Table 2 **Incremental Capacity Additions and Reductions in PJM Base Residual Auctions (Installed Capacity in MW)**

Delivery Year	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	Total
Increase in Generation Capacity	602.0	724.2	1,272.3	1,776.2	3,576.3	1,893.5	9,844.5
Decrease in Generation Capacity	-674.6	-375.4	-550.2	-301.8	-264.7	-3,253.9	-5,420.6
Net Increase in Demand Resource Capacity	555.0	574.7	215.0	28.7	661.7	7,938.1	9,973.2
Net Increase in Energy Efficiency Capacity	0	0	0	0	0	632.3	632.3
Net Increase in Installed Capacity	482.4	923.5	937.1	1,503.1	3,973.3	7,210.0	15,029.4

Note: *Change in generation capacity is cumulative; net increase in demand-side resources is relative to previous year's Base Residual Auction.*

Table 3 **Breakdown of Incremental Capacity Resource Additions in PJM Base Residual Auctions (Installed Capacity in MW)**

	Delivery Year	CT/GT	Combined Cycle	Diesel	Hydro (Coal)	Steam	Nuclear	Solar	Wind	Total
New Capacity Units	2007/2008			18.7	0.3					19.0
	2008/2009			27.0					66.1	93.1
	2009/2010	399.5		23.8		53.0				476.3
	2010/2011	283.3	580.0	23.0					141.4	1027.7
	2011/2012	416.4	1135.0			704.8		1.1	75.2	2332.5
	2012/2013	403.8	585.0	7.8		36.3			75.1	1108.0
Capacity From Reactivated Units	2007/2008					47.0				47.0
	2008/2009					131.0				131.0
	2009/2010									0
	2010/2011	160.0		10.7						170.7
	2011/2012	80.0				101.0				181.0
	2012/2013									0
Uprates to Existing Capacity Resources	2007/2008	114.5		13.9	80.0	235.6	92.0			536.0
	2008/2009	108.2	34.0	18.0	105.5	196.0	38.4			500.1
	2009/2010	152.2	206.0		162.5	61.4	197.4		16.5	796.0
	2010/2011	117.3	163.0		48.0	89.2	160.3			577.8
	2011/2012	369.2	148.6	57.4		186.8	292.1		8.7	1062.8
	2012/2013	231.2	164.3	14.2		193.0	126.0		56.8	785.5
Total		**2835.6**	**3015.9**	**214.5**	**396.3**	**2035.1**	**906.2**	**1.1**	**439.8**	**9844.5**

Note: *Values represent capacity commitments. Nameplate ratings of variable resources (solar and wind) are far larger than shown here.*

Table 4

Changes to Generation Retirement Decisions
Since Reliability Pricing Model Approval (Unforced Capacity in MW)

Generation Resource Decision	Changes Capacity Cleared
Withdrawn Deactivation Requests	1798.7
Postponed or Cancelled Retirement	1302.9
Reactivation	175.2
Total	**3276.8**

Note: *Unforced capacity cleared in Base Residual Auctions from resources that withdrew their request to deactivate, postponed retirement, or were reactivated (i.e., came out of retirement or mothball state).*

Table 5

PJM Base Residual Auction Clearing Price

Delivery Year	Clearing Prices ($/MW-day)
2007/2008	$40.80
2008/2009	$111.92
2009/2010	$102.04
2010/2011	$174.29
2011/2012	$110.00
2012/2013	$16.46

Note: *Values do not include any locational price adders. Simple conversion of $/MW-day to $/kW-month: multiply by 3 and divide by 100.*

Table 6

Effect of Demand-Side Resources on PJM Market Clearing Price
2012/2013 Base Residual Auction[80]

Actual Auction Results		Calculated Results Without Demand-Side Resources		
Clearing Prices ($/MW-day)	**Cleared Unforced** Capacity (MW)	**Clearing Prices** ($/MW-day)	**Cleared Unforced** Capacity (MW)	**Savings** ($/MW-day)
$16.46	136,143.5	$178.78	133,568.2	$162.32

[80] Bowring, Monitoring Analytics, Table 20.

ISO-NE Results

ISO-NE has held three forward capacity auctions to date. The first auction (FCA #1), in February 2008, was for capacity delivery beginning in June 2010 (2010/2011 delivery year). The second auction (FCA #2) was held in December 2008 for delivery in 2011/2012, and the third auction (FCA #3) was held in October 2009 for delivery in 2012/2013. "Cleared" amounts in these tables include resources from earlier auctions that remain listed, as well as new resources, less resources that drop out.

Table 7

Summary Results for ISO-NE Capacity Auctions[81]

	Net Installed Capacity Requirement	Total Resources Cleared (MW)	Excess Capacity (MW)	Clearing Price ($/kW-month)	Net Price ($/kW-month)[82]
FCA #1	32,305	34,077	1,772	$4.50	$4.25
FCA #2	32,528	37,283	4,755	$3.60	$3.12
FCA #3	31,965	36,996	4,649	$2.95	$2.54

Note: *Net Installed Capacity Requirement values exclude the interconnection benefits associated with the Hydro-Québec Phase I/II interface. Excess capacity is not adjusted for Real-Time Emergency Generation in excess of the 600 MW limit. Net prices reflect prorating of clearing prices due to excess capacity clearing the auction. Simple conversion of $/kW-month to $/MW-day: divide by 3 and multiply by 100.*

Table 8

Demand-Side Resources Cleared in ISO-NE Capacity Auctions (MW)[81]

	Distributed Generation-Fossil Fuels	Distributed Generation-Renewable Resources	Energy Efficiency	Real-Time Demand Response/Load Management	Real-Time Emergency Generation	Total Demand-Side Resources
FCA #1	46	<0.2	655	978	875	2,554
FCA #2	93	<0.2	890	1,195	759	2,937
FCA #3	86	0.7	975	1,206	630	2,898

Note: *Demand-side values are grossed-up for avoided transmission and distribution losses and reserve margin (no reserve margin for FCA #3). Total resources cleared include excess capacity above the Net Installed Capacity Requirement. Real-time emergency generation refers to distributed generation whose state air quality permit limits operation to "emergency" conditions. See Appendix 3.*

81 ISO-NE Forward Capacity Market Results at http://www.iso-ne.com/markets/othrmkts_data/fcm/cal_results/index.html.

82 Communication with Henry Yoshimura, director, Demand Resource Strategy, ISO-NE, March 2009.

83 Eric Winkler, ISO-New England, "Third Regional Energy Efficiency Initiative Meeting," July 7, 2009, and "FCA Update," Demand Response Working Group Meeting, Dec. 2, 2009. Total resources cleared (Capacity Supply Obligation) from Forward Capacity Market Auction Results for the 2010/2011, 2011/2012, and 2012/2013 auctions at http://www.iso-ne.com/markets/othrmkts_data/fcm/cal_results/index.html.

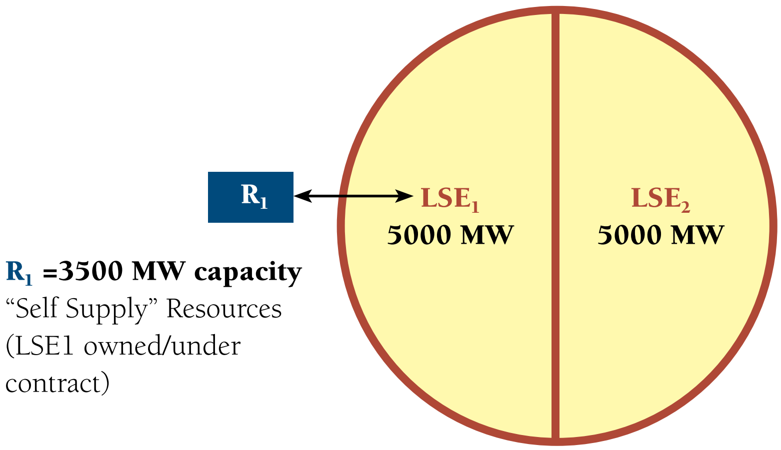
Appendix 2

Illustration of "How Forward Capacity Markets Work"

Step #1

System Operator (SO) Plans "Forward" for the Region

2012 Projection of Peak Demand = 10,000 MW (incl. reserves)
Each "Load Serving Entity" (LSE)* is obligated for its 50% share

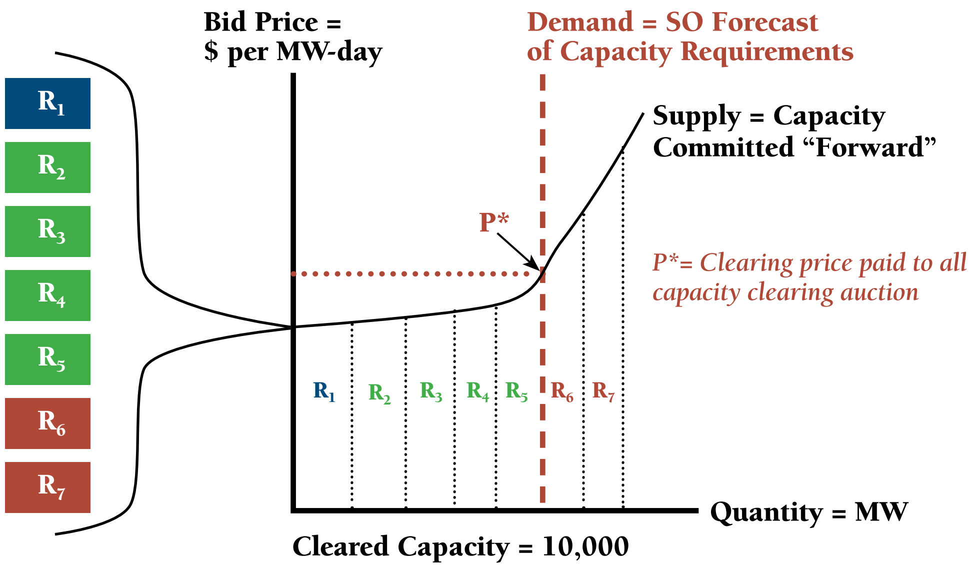


SO purchases capacity in 2012 at the 2009 auction clearing price

** LSE can be regulated utility or competitive retail supplier*

Step #2

The Regional Capacity Auction (3 Years "Forward")

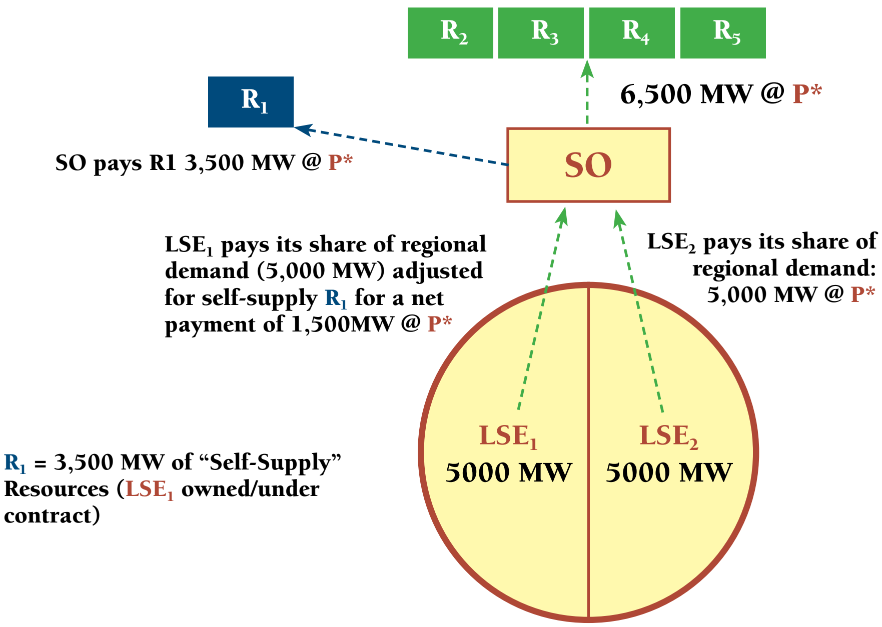


R_1-R_7 = Capacity offered by Supply-Side (New built, Existing, Uprates) and Demand-Side (Energy Efficiency, Demand Response, Distrib. Gen); Self-supply (R_1) bids in a "zero" price; ***New Resources set clearing price.***

Step #3

System Operator Pays Cleared Resources at P* and Bills LSEs

(Note: Self-Supply capacity is a "wash")



In 2010:

Total regional peak demand of 10,000 MW supplied by R_1 + R_2 + R_3 + R_4 + R_5. LSE_1 and LSE_2 are each responsible for 50% of regional peak demand.

APPENDIX 3

Eligibility Requirements for Demand-Side Resources in US Capacity Markets

PJM Eligibility Requirements

Eligibility of demand-side resources has changed significantly over the years in PJM's capacity markets. In particular, it was not until the most recent capacity auction (May 2009) for the 2012/2013 delivery year that energy efficiency became eligible to bid in PJM's Base Residual Auction. PJM is currently considering a tariff change to also allow energy efficiency to bid into incremental auctions.

Under PJM's eligibility rules, an energy efficiency resource must achieve a "permanent," continuous reduction in electric energy consumption. Examples of such a resource include lighting retrofit programs for residential, commercial, and industrial customers, and programs to retrofit buildings with heating and cooling systems that exceed current efficiency standards. To be eligible, an energy efficiency resource must meet the following criteria:

- It is fully implemented throughout the delivery year without any requirement of notice, dispatch, or additional customer action.
- It is not reflected as a reduction in the peak load forecast used for the Base Residual Auction for the proposed delivery year.
- It exceeds relevant standards (such as building codes or appliance standards) at the time of commitment.
- It achieves the specified load reduction (expected average demand in MW) during defined summer on-peak hours.[84]

Demand response, on the other hand, must be dispatchable — that is, customer demand must be reduced when instructed. For example, a large supermarket with coolers and freezers could install load management equipment that would cycle them on or off — and bid that demand response capability into the market.[85] More specifically, a demand response resource must meet the following criteria:

- It is able to reduce demand for electricity up to 10 times each year for up to six consecutive hours per interruption during defined periods.[86]
- It is fully implemented within one hour (short lead time) or two hours (long lead time) of notice from PJM.
- In a year without calls for demand reductions, it must demonstrate reliability through a test of reduction capability.
- It is registered in the Emergency Load Response Program and thus available for dispatch during PJM-declared emergency events.
- Compliance and status reports are filed as required.

Multiple end-use customers can be aggregated in order to submit a single demand response offer in the capacity auction if those customers share the same curtailment service provider, electric distribution company, and transmission zone.

In addition, customer-sited distributed generation may be offered into auctions as a demand resource. A hospital, for example, could offer to run its back-up generator on certain peak demand (e.g., hot summer) days to reduce its load on the system. Or an industrial plant could cut back on production on such days and continue to run its on-site combustion or steam-cycle turbine.

Currently, energy efficiency resources may participate

[84] Weekdays, excluding holidays, June through August between the hours ending 15:00 and 18:00 Eastern Prevailing Time (EPT).

[85] If instead, the supermarket replaced the existing coolers and freezers with more energy efficient ones, it would bid that proposal in as an energy efficiency resource. Or it could do both (replace and cycle) and bid in the capacity from the permanent savings (replacements) as energy efficiency and the dispatchable capacity (the cycling) as demand response.

[86] Weekdays, excluding holidays, from 12:00 to 20:00 EPT May through September, and 14:00 to 22:00 EPT October through April.

in Base Residual Auctions for up to four consecutive delivery years. In effect, this means that PJM limits capacity payments for efficiency measures to four years of their measure life (rather than for the full measure life).[87] In contrast, a demand response resource (including distributed generation) can participate in the PJM capacity market for as long as its ability to reduce demand continues.

ISO-NE Eligibility Requirements

Since the inception of ISO-NE's forward capacity market in 2006, energy efficiency has qualified as an eligible demand-side resource. ISO-NE defines demand resources as installed measures (products, equipment, systems, services, practices, and strategies) that result in verifiable reductions in end-use consumption of electricity in the New England power system. These are further categorized into "passive" (energy efficiency and non-dispatchable distributed generation) and "active" (demand response, emergency generation, and dispatchable distributed generation) resources. Passive demand resources are non-dispatchable but permanently reduce energy demand during peak hours. Active demand resources are designed to reduce peak loads and to reduce load based on real-time system conditions or ISO-NE instructions. Following are descriptions of eligible demand-side resources and performance requirements:[88]

Passive Demand Resources

- **On-Peak Demand Resources** are measures that are not weather-sensitive and reduce demand across a fixed set of on-peak hours, such as energy-efficient commercial lighting and motors.[89]
- **Seasonal Peak Demand Resources** are weather-sensitive measures that reduce load during high-demand conditions, such as energy-efficient heating and air conditioning systems. Seasonal Peak Demand Resources must reduce load when actual system load is equal to 90 percent of the most recent peak load forecast for the applicable summer or winter season.

Active Demand Resources

- **Real-Time Demand Response Resources** are measures including load management and distributed generation that can be dispatched by ISO-NE as needed. They must curtail electrical usage within 30 minutes of receiving a dispatch instruction and until receiving a release/recall dispatch instruction.
- **Real-Time Emergency Generation** is distributed generation whose state air quality permit limits operation to "emergency" conditions. Generators must curtail the customer's electrical usage within 30 minutes of receiving a dispatch instruction and until receiving a release/recall dispatch instruction. The amount of emergency generation that can be used to meet ISO-NE's capacity requirement is limited to 600 MW. If the amount of real-time emergency generation that clears the auction exceeds this level, payments to generators are reduced on a pro-rated basis. All real-time emergency generation is treated as existing capacity.

In contrast to PJM, all demand-side resources in ISO-NE are eligible to bid capacity for their full measure life, an approach that recognizes the full contribution of these resources to regional resource adequacy requirements and adds value to long-lived energy efficiency assets.

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[87] FERC has directed PJM to evaluate the impact of its capacity payment period for energy efficiency resources.

[88] Eric Winkler and Abimael Santana, ISO-NE, "New Demand Resource Qualification," May 5, 2009, at http://www.iso-ne.com/support/training/courses/fcm/fcm_forum_may_5.pdf.

[89] Summer on-peak hours are 13:00 to 17:00 non-holiday weekdays in June, July, and August; Winter on-peak hours are 17:00 to 19:00 non-holiday weekdays in December and January.

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