The Integration of Price Responsive Demand into PJM Wholesale Power Markets and System Operations

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I. Introduction

A number of states and utilities are pursuing demand response based on dynamic and time-differentiated retail prices and utility investments in Advanced Metering Infrastructure (AMI), often as part of Smart Grid initiatives.[2] These developments could produce large amounts of Price Responsive Demand, demand that predictably responds to changes in wholesale prices.[3] Through enabling technology and behavioral changes, consumers would modify their demand as prices change without being centrally dispatched or bidding demand reductions into RTO markets.

This rapid expansion of Price Responsive Demand will require significant investment in AMI and the development of innovative retail rate structures. It also requires coordination between the wholesale market and the retail rate design to maximize the benefit of Price Responsive Demand to consumers.

The deployment of AMI for small commercial and residential customers will enable dynamic and time–differentiated retail rate structures linked to wholesale prices. AMI can support dynamic retail rate structures, such as:

- Critical Peak Pricing that allows retail rates to rise when the wholesale market price exceeds a threshold level;

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[2] This can be characterized as a third generation of demand response. First generation demand response would include utility interruptible rates and direct load control, and RTO Demand Response programs would be a second generation of demand response.

[3] See for example: A. Faruqui and S. Sergici (2009). *Household Response to Dynamic Pricing of Electricity – A Survey of the Experimental Evidence.* The Brattle Group, San Francisco, CA.

- Critical Peak Rebate pricing which provides bill credits to consumers who reduce their usage below a baseline quantity during periods when the wholesale market price exceeds a threshold level and which can be attractive default tariff for residential consumers; or
- Real-Time Pricing which, in some cases, is the default tariff for larger customers and can be an option available to other consumers.

This will provide the necessary exposure to market prices to reduce consumption during high demand periods.

This paper addresses how Price Responsive Demand can be efficiently integrated into wholesale power markets and system operations in a manner consistent with reliability standards.

II. System Benefits of Price Responsive Demand

Significant penetration of Price Responsive Demand would provide substantial benefits. In a period of rising costs, it can defer the need for generation investment and delay the need for certain transmission upgrades by slowing the growth in peak demand. If properly incorporated into the regional market, Price Responsive Demand would reduce overall costs by improving existing asset utilization and risk by mitigating extreme price volatility. Price Responsive Demand will make the market more competitive during peak usage hours by introducing demand elasticity. It also will improve the predictability of demand requirements and power flows during the operating day and will provide rapid response to emergency shortage conditions to preserve short term system reliability. Investments in AMI and enabling technology also will permit demand response to provide operating reserves and potentially regulation services.

The presence and coordination of Price Responsive Demand will tend to improve reliability and facilitate meeting Loss of Load Expectation (LOLE) objectives. High demand periods and outages will increase prices in balancing markets, causing an offsetting demand reduction from Price Responsive Demand. Given this relationship, all else being equal, Price Responsive Demand will reduce the planning reserves required to meet LOLE based reliability standards. Moreover, unlike large customer demand response, mass market Price Responsive Demand is the sum of responses by hundreds of thousands or millions of consumers. While a single large demand responder or generator may fail on a given day, the response of large numbers of consumers and devices is statistically likely to exhibit less variance. And, AMI will provide access to far more load data, providing the opportunity to enhance forecasting methodologies and reduce the uncertainty associated with load forecasts.

Finally, Price Responsive Demand can facilitate the integration of intermittent renewable resources into power system operations.

III. Characteristics of Price Responsive Demand

The concept of Price Responsive Demand is to provide the opportunity for consumers, including residential and small commercial customers, to voluntarily reduce their consumption when prices rise in the regional wholesale electricity market. Historically, the development of Price Responsive Demand has been inhibited by the lack of infrastructure and appropriate retail rate structures. Since the investment required to deploy AMI is large, the value of Price Responsive Demand must be maximized in order to justify the investment for the benefit of consumers. The value of Price Responsive Demand includes: avoidance of capacity requirements, avoiding energy payments during high price conditions, reducing the frequency and magnitude of energy scarcity events, and incorporating a price/quantity demand relationship into short term operations. The investment in AMI will be enabled through support by retail regulatory authorities, but will be justified based on the avoidance of capacity and scarcity pricing payments.

Current demand forecast methods do not consider the development of Price Responsive Demand and are based on data from periods without dynamic retail pricing. Such forecasts would continue to produce resource and planning reserve requirements which would force LSEs with Price Responsive Demand to carry resources and reserves for demand that would not be present at higher spot prices. The requirement to hold this additional capacity both eliminates the opportunity to avoid capacity costs and dampens prices. With the additional capacity in place, energy and ancillary service prices rarely will reach a level that evokes a significant demand response. Avoided capacity costs can be the single largest cost savings in the business case for AMI. Undermining the realization of these savings would make significant AMI investments unlikely. As a result, it is not possible to simply wait until there is significant Price Responsive Demand before integrating its consideration into the determination of forward capacity and planning reserve requirements. Adjustments to these rules are needed to ensure that the benefits of making significant AMI investments and implementing retail rate reforms will flow through to consumers.

While Price Responsive Demand is not directly dispatchable, customer responses to price signals should produce a predictable demand curve as a function of price for an aggregate group of customers in a given transmission zone. This price responsive characteristic will require enhancements to operating tools which will improve the granularity and predictability of demand impacts on regional and local powerflow patterns.

Since Price Responsive Demand is primarily based on the responses of small customers, it is not feasible to treat it in the same manner as conventional, large customer, demand response. Price Responsive Demand may not be acting as a resource in either the energy or capacity markets. In the energy market, Price Responsive Demand will simply reduce demand in increasing amounts when prices continue to rise above the threshold level specified in the retail rate design.

IV. Price Responsive Demand and Reliability

Integration of Price Responsive Demand while maintaining reliability can be achieved with an approach that combines the following four elements:

- Use in system planning and operations of transparent forecast demand response curves that reflect a statistically predictable relationship between prices and demand;
- Reforming scarcity pricing by implementing an Operating Reserve Demand Curve with an appropriately high price, potentially reflecting the Value of Lost Load (VOLL) at minimum reserve levels, and with a sloping curve reflecting a declining loss of load expectation and value of expected unserved energy at increasing reserve levels;
- Requiring price responsive loads to have capacity and planning reserves for forecasted firm demand, after accounting for expected Price Responsive Demand, while providing the option for such loads to carry additional capacity; and
- Applying non-discriminatory procedures for dumping load in a capacity emergency based upon the extent to which the demands of price responsive and non-price responsive loads are capacity deficient.

Taken together these steps ensure system reliability, prevent price responsive consumers from leaning on the system, and promote an efficient balance of resource investment and demand response.

A. Forecast Demand Response Curve

Traditional forecasting treats demand as if it was not responsive to short-term prices. With Price Responsive Demand, a single MW quantity, irrespective of short-term prices, is not the best representation of forecast demand. Initially, the short term load forecasting approach can be adapted to reflect Price Responsive Demand by adding a locational Price Responsive Demand forecast modifier. The locational load forecast modifier will reflect the expected price-responsive behavior of the Price Responsive Demand at a particular location on the grid by adding a price-responsive demand curve to the base load characteristic which will ensure the composite load forecast used in grid operations will properly account for Price Responsive Demand.

The development and use of the Price Responsive Demand curve should be transparent, such that the actual demand of price responsive loads can be compared to forecast demand for the observed peak price.[4] Transparency and after the fact review of the forecast methodology will help avoid under forecasts and improve forecasting over time.

Longer term load forecasting also will need to evolve to reflect the development of Price Responsive Demand. As forecasters acquire sufficient data about the behavior of locational PJM price responsive loads, they will develop an integrated approach in which demand forecasting models include spot price terms statistically determined based on PJM customer class or market segment data. Such an integrated model will forecast firm load – the residual demand after taking account of Price Responsive Demand – for any given spot price.

Until an integrated forecasting model is developed, existing price elasticity data and accepted statistical tools can be used to develop credible forecasts of demand response.

Within PJM, price elasticity has been calculated for residential dynamic pricing experiments in Commonwealth Edison, GPU, and PSE&G.[5] The results of these experiments and other utility experience can be relied upon to develop the first elasticity estimates. However, as PJM LSEs implement dynamic and time-differentiated pricing, increasing weight would be given to the data from their experience.

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[4] Comparison of actual demand to long-term forecasts may require normalization for weather and other variables.

[5] A. Faruqui and S. Sergici (2009). *Household Response to Dynamic Pricing of Electricity – A Survey of the Experimental Evidence.* The Brattle Group, San Francisco, CA.

Using established statistical methods such data can be used to develop reliable estimates of price elasticity by:

- Comparing the load shapes of consumers with dynamic or time differentiated pricing to those of similar consumers on standard rates;
- Evaluating how consumers changed their load shapes with the introduction of dynamic or time-differentiated pricing; and
- Comparing load shapes of participating consumers across different otherwise comparable hours with varying prices.

These approaches can be used to estimate an "elasticity of substitution" – the percentage change in the ratio of usage between two periods based on the change in the ratio of prices between the periods, and "own price elasticity" – the percentage change in demand due to a percent change in price after controlling for all other factors, so as to accurately forecast the impacts of Price Responsive Demand.[6]

With the development of a Smart Grid communications infrastructure, it may become possible to directly sample the price response points programmed into consumer equipment, further reducing the uncertainty about consumer responses.

Price elasticity data can be input into models such as EEI's Pricing Impact Simulation Model (PRISM) to develop a transparent forecast demand response curve. [7]

A demand response curve represents the forecast of firm demand at different prices, after accounting for Price Responsive Demand. When the assumptions are documented, the representation of firm load as a demand response curve is consistent with reliability standards. The Reliability First Corporation (RFC)[8] Resource Adequacy Standard, BAL-502-RFC-02, Paragraph R1.3.1, requires documentation of "Load forecast characteristics" including "Daily demand modeling assumptions (firm, interruptible)." It is the view of RFC staff that, "PRD [Price Responsive Demand] and how its effects are determined based on historical experience and appropriate

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[6] For an illustration using the constant elasticity-of-substitution (CES) model, see: A. Faruqui and S. George, "Quantifying Response to Dynamic Pricing," *The Electricity Journal,* 2005.

[7] See: A. Faruqui and L. Wood (2008), *Quantifying the Benefits of Dynamic Pricing in the Mass Market.* Edison Electric Institute, Washington, D.C.

[8] RFC is the regional reliability organization for most of the PJM region, including all of the retail competition states that may have to rely more heavily on the market for the development of new resources. Parts of PJM are within SERC which does not appear to have a comparable resource adequacy standard.

extrapolation for future model years fits within the ‘demand modeling assumptions’ for ‘firm’ load. Since these analyses are for future years, ‘firm’ must always be calculated using some methodology such as econometric analysis and PRD can be a part of that methodology along with associated calculations and assumptions.”[9]

The investments required to support Price Responsive Demand are unlikely to be made if LSEs and consumers also are required to hold resources and reserves for demand that would not be present at higher energy and ancillary service prices. To appropriately recognize Price Responsive Demand, PJM would calculate resource and reserve requirements from a price/ quantity point on the forecast demand response curve. This point represents a 50/50 forecast of firm demand at the selected price after accounting for Price Responsive Demand. The selected price/quantity point necessarily would be less than VOLL.[10] This will ensure adequate resources are available to serve the remaining firm load and that price responsive customers are not “leaning on the system” financially or physically. Financially, both non-price responsive and, to the extent they so choose, price responsive loads would have the opportunity to avoid high spot prices through forward physical or financial hedges. To the extent price responsive loads do not curtail and have not hedged, these price responsive loads would pay the higher spot prices. From the physical perspective, peak requirements are the sum of non-price responsive demand, the remaining price responsive demand at peak prices, regulation, and operating reserves.[11] PJM will continue to be responsible for forecasting peak load and has no incentive to under forecast firm demand. PJM’s determination of planning reserves would continue to consider a range of forecasts to ensure that reserves adequately account for forecast uncertainty.

B. Scarcity Pricing Reform: Operating Reserve Demand Curve

An Operating Reserve Demand Curve helps ensure reliability and remove barriers to the recognition of Price Responsive Demand. An Operating Reserve Demand Curve will raise energy and ancillary service prices before available operating reserves reach minimum levels and result in the purchase of additional operating reserves, thereby improving efficiency and enhancing reliability.

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[9] Email communication from Bob Millard, RFC (December 7, 2008).

[10] At prices equal to VOLL, consumers would prefer to be curtailed and not include such prices in their rates (or in an equivalent forward power purchase agreement).

[11] See section IV (D) below for a discussion of capacity emergency procedures.

In Order 719, FERC found that rules which stop prices from rising sufficiently during an operating reserve shortage to match demand and supply are unreasonable. With respect to such RTO tariff provisions, the Commission said:

> "In particular, they may not produce prices that accurately reflect the value of energy and, by failing to do so, may harm reliability, inhibit demand response, deter entry of demand response and generation resources, and thwart innovation.
>
> When bid caps are in place, it is not possible to elicit the optimal level of demand or generator response, thereby forgoing the additional resources that are needed to maintain reliability and mitigate market power. This, in turn, increases the likelihood of involuntary curtailments and contributes to price volatility and market uncertainty. Further, by artificially capping prices, price signals needed to attract new market entry by both supply- and demand-side resources are muted and long-term resource adequacy may be harmed. Without accurate prices that reflect the true value of energy, we cannot expect the optimal integration of demand response into organized markets."[12]

The Commission directed the RTOs "to remove such barriers to demand response by requiring price formation during periods of operating shortage to more accurately reflect the value of such energy during such shortage periods."[13]

Currently PJM initiates scarcity pricing only when emergency conditions have actually occurred. The likelihood of a reserve shortage is not signaled in advance of an actual emergency event through increases in energy or reserve prices. Therefore, the current scarcity mechanism results in a rapid and large step-change increase in prices to signal scarcity to the market in a capacity emergency. However, the increase in prices may occur too late to allow resources, including demand, to respond efficiently. A more gradual increase in prices as scarcity approaches would be a more efficient approach. An Operating Reserve Demand Curve would raise energy and ancillary service prices by purchasing additional reserves before available operating reserves reach minimum, thereby improving economic efficiency, removing barriers to demand response, and enhancing reliability.

In response to Order 719, PJM has developed a straw proposal for an Operating Reserve Demand curve.[14] The proposed demand curve would allow higher price

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[12] *In the Matter of Wholesale Competition in Regions with Organized Electric Markets*, 125 FERC ¶61,071 (October 17, 2008) at 192 – 193.

[13] *Ibid.*

signals to be sent earlier, giving demand a longer time to respond to keep the system out of emergency conditions and avoiding a harsh switch from non-scarcity prices to much higher scarcity prices.[15]

In this section, we summarize the scarcity pricing provisions in PJM's current tariff and describe how an Operating Reserve Demand Curve would function to meet the objectives of Order 719.

In PJM's current scarcity pricing mechanism, market power mitigation is suspended in the scarcity region when the combination of load and reserve requirements may exceed available resources, more specifically when:

- Real-time demand is greater than the highest offer available for dispatch;
- There is no remaining generation in PJM to meet demand and emergency purchases are required;
- Operating reserves are below the 10 minute synchronous reserve target and the system experiences or is likely to experience a synchronous reserve event; or
- Reserves are less than the largest contingency and that contingency occurs.

In these circumstances, generators can increase their offer prices without market power mitigation. And, prices at all nodes in the scarcity region are based on the highest offer price by a generator providing energy or reserves.[16] This creates the possibility of a supply response and of market power increasing prices in excess of the level necessary to clear the triggering condition. Additionally, PJM's $1,000 offer cap remains in effect. By capping prices at $1,000 per MWh, PJM does not allow prices to reach an efficient market clearing price and limits the opportunity for demand response.

An Operating Reserve Demand Curve requires real-time operating reserve markets. Pricing in these markets should reflect simultaneous co-optimization of the operating reserve and real-time energy markets.[17] Simultaneous co-optimization provides the appropriate incentives for market participants to offer based on their expected costs and

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[14] P. Sotkiewicz, *PJM Scarcity Pricing Straw Proposal*, Task Force 719 Meeting (January 9, 2009).

[15] *Ibid.*

[16] Scarcity pricing may also apply to generators outside the region called upon to alleviate a constraint leading to the scarcity conditions.

[17] For a discussion of co-optimization, see for example: Affidavit of Michael Cadwalader, Attachment I, to the Midwest ISO Initial Ancillary Services Market Tariff Filing, FERC Docket No. ER07-550-000 (Feb. 15, 2007).

establishes prices in each market taking into consideration impacts on other co-optimized markets.

An operating reserve demand curve would be structured to procure at least the minimum level of reserves necessary to meet reliability standards and, in many hours, additional reserves to the extent such reserves provide value to consumers. In a capacity emergency when minimum operating reserves cannot be maintained, service is curtailed. Therefore, the price of operating reserves at the minimum reserve level should equal the estimated VOLL of the consumers who would be curtailed. Although VOLL is difficult to estimate and can vary significantly within and between customer classes, it is generally thought to be higher than PJM's $1,000 per MWh offer cap.[18] Some have suggested a VOLL operating reserve price of $10,000 per MWh, which arguably reflects an average of the VOLL for different types of consumers who might be impacted by involuntary curtailment.[19] The Australian National Electricity Market initiates curtailments when prices equal a VOLL level of $10,000AUD or about $6,800 in U.S. dollars.[20] The Midwest ISO selected $3,500 per MWh as "the average cost to consumers of an interruption of firm demand" and the highest price on its Ancillary Services demand curve.[21] This exceeds the estimated value of uninterrupted service for residential consumers. The New York ISO sets the 10-minute spinning reserve price under shortage conditions at zonal prices ranging from $850 per MWh to $1,750 per MWh. The VOLL is difficult to directly quantify, but it is important that the operating reserve shortage reference price should be set sufficiently high to elicit voluntary load

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[18] For MISO, the median residential VOLL for a one-hour interruption on a summer afternoon has been estimated to be less than $1.50 per kWh (or $1,500 per MWh) with the VOLL for approximately 95% residential consumers being at or below $2.50 per kWh (or $2,500 per MWh). The estimated VOLL for commercial and industrial customers is higher and more variable with the median VOLL for Service sector (SIC codes 70-89) consumers estimated at approximately $15,000 per MWh and for small Agricultural (SIC Codes 01-09), Mining (SIC Codes 10-14) and Wholesale / Retail (SIC Codes 50-59) end users approaching $50,000 per MWh. These estimates are within the range of VOLL values identified in other studies. P. Centolella, M. Farber-DeAnda, L. Greening, & T. Kim. 2006. *Estimates of the Value of Uninterrupted Service for the Midwest Independent System Operator,* (Carmel, IN: Midwest ISO).

[19] W. Hogan and S. Pope, "Comments on Wholesale Competition in Regions with Organized Electric Markets," *In the Matter of Wholesale Competition in Regions with Organized Electric Markets,* FERC Docket Nos. RM07-19-000 and AD07-7-000 (September 17, 2008).

[20] National Electricity Market Management Corporation, Ltd. *An Introduction to Australia's National Electricity Market* (June 2008).

[21] Schedule 28, Midwest ISO Open Access Transmission, Energy and Operating Reserve Markets Tariff (October 1, 2008).

reductions if minimum reserve levels are reached, minimizing the risk of involuntary curtailment for LSEs who have purchased adequate capacity.[22]

For reserves in excess of the minimum needed to meet reliability standards, the demand curve should reflect the marginal Value of Expected Unserved Energy (VEUE). This can be calculated as the product of VOLL times the conditional probability of lost load at these reserve levels given a selected event, such as a forced resource outage of 100 MW or greater.[23] Developed in this manner as a two-part curve, with fixed VOLL prices for minimum reserves and probabilistic value based pricing for additional reserves, the Operating Reserve Demand Curve would reflect the expected value to consumers of operating reserves.

The shape of such an Operating Reserve Demand Curve is illustrated in Figure 1. The marginal VEUE portion of the curve intersects the minimum reserve quantity at a point less than VOLL because the probability of loss of load, given that quantity of operating reserves, is less than one,

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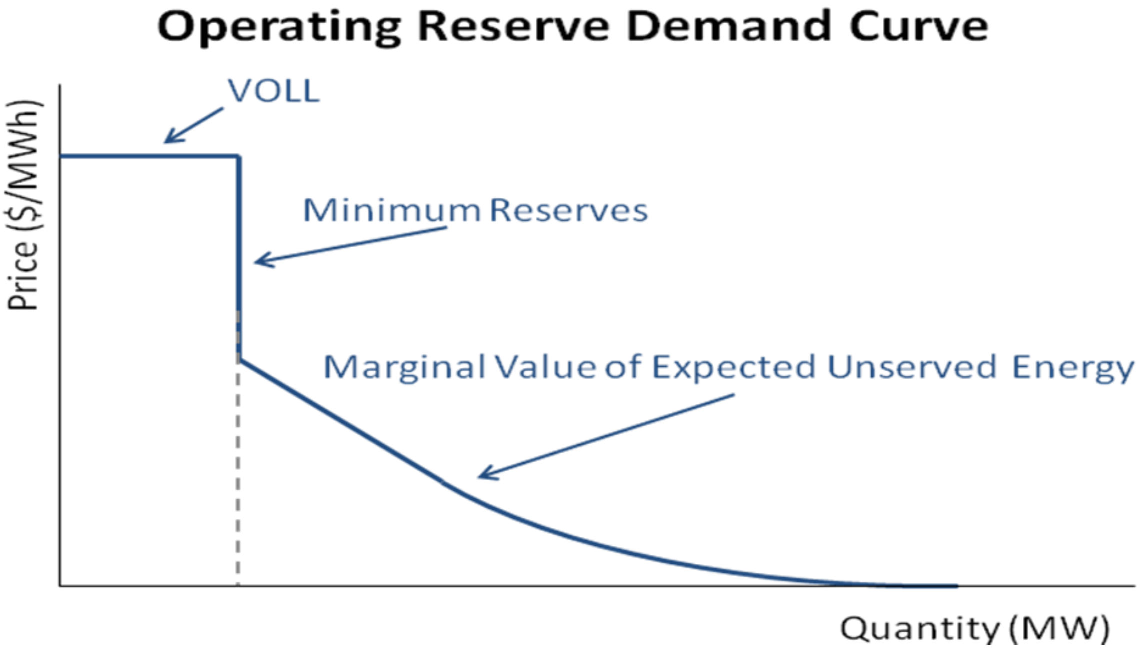
[22] In setting a VOLL price, it should be noted that a high VOLL price can be avoided by forward purchases or voluntary curtailment at a lower price.

[23] See, for example: Schedule 28, Midwest ISO Open Access Transmission, Energy and Operating Reserve Markets Tariff (October 1, 2008). A detailed description of a variation on this approach is presented in W. Hogan, *Electricity Market Hybrids: Mixed Market Design, Regulation and Investment* (January 17, 2008), available at: www.whogan.com.

Figure 1:



The combination of demand bidding in the real-time markets, Price Responsive Demand, and an Operating Reserve Demand Curve will create sloped demand curves. When resources are scarce, the intersection between the slope of these curves and available resources will set efficient, market clearing prices. It will be possible to have scarcity pricing that reflects the value of operating reserves without having to suspend market power mitigation or raise the offer cap on generators capable of exercising market power.

With this reform, energy and operating reserve prices may exceed the current $1,000 per MWh offer cap. However, as discussed in the following section, loads that are not price responsive would avoid these high prices through energy price offsets in the capacity price reference. Customers with price responsive load who wish to limit their exposure to high prices could do so through forward energy and capacity purchases.

In summary, a properly constructed Operating Reserve Demand Curve would enhance reliability, increase opportunities for Price Responsive Demand, and improve economic efficiency, because it would:

- Recognize that operating reserves in excess of minimum levels reduce the probability of service interruption and, consistent with the value of such reserves to consumers, increase the purchase of reserves before reaching minimum reserve levels;

- Reduce the price swings associated with the current scarcity pricing mechanism, in which scarcity conditions are either present or not present, by introducing a sloped demand curve for operating reserves;
- Create an efficient two-sided market, with the participation by supply and demand response, that reflects the expected economic value of reserves to consumers, by allowing prices to be set not only by generation offers, but also by real-time demand bids, Price Responsive Demand, and an Operating Reserve Demand Curve;
- Enhance price signals for the entry and operation of generation and demand response when and where it is needed by integrating market pricing into the operating procedures for scarcity conditions; and
- Ensure that market power is mitigated during operating reserve shortages by retaining market power mitigation and generator offer caps, while permitting prices to reach appropriate market clearing levels.

C. Coordination of Capacity Market and Scarcity Pricing

The Reliability Pricing Model design includes the Cost of New Entry (CONE) reference price with an Energy and Ancillary service revenue offset to establish the net CONE on the Variable Resource Requirement curve. The implementation of an operating reserve demand curve will establish more accurate price signals as the energy market approaches shortage conditions. The improvements in the scarcity pricing design will require adjustments to the energy revenue offset mechanism in the capacity market in order to synchronize the net CONE calculation with the operating reserve demand curve parameters and ensure that capacity purchases are an effective and timely hedge against scarcity prices in the operating reserve and energy markets.

D. Optional Hedging by Price Responsive Load

Price Responsive Demand should not have to purchase capacity for demand which would not be present at higher spot prices. And, price responsive loads should carry resources and reserves for their remaining firm demand, after accounting for predictable price response. A reasonable price/quantity ceiling may be applied in selecting a point on the forecast demand response curve, below the VOLL price, which represents the expected firm demand of price responsive loads.

A requirement that price responsive consumers meet resource and planning reserve requirements with respect to firm demand provides a floor on the capacity which must be maintained to serve these loads. In addition to this required capacity, price responsive customers will enter forward contracts and purchase capacity to hedge price risks. This will support additional investment.

The fact that such loads would respond to price does not mean that they will not hedge price risks. Hedging and bill protection strategies, which require forward contracts, will be important in the transition to dynamic pricing.[24] Likely rate designs for price responsive POLR loads include two-part tariffs and Critical Peak Rebate rates. For example, Georgia Power has two-part Real-time Pricing for large customers. Under two-part RTP, energy users purchase a baseline level of usage at a fixed price, pay a variable price for usage over the baseline, and receive a variably priced credit if their usage is below baseline quantities. Several utilities have tested residential Critical Peak Rebate or Peak Time Rebate rate designs. With a Critical Peak or Peak Time Rebate tariff, consumers are hedged at a fixed price for their full load and receive a rebate if they reduce their consumption during critical peak periods. A 2008 California Public Utilities Commission decision directs PG&E to implement Peak Time Rebate pricing as the default tariff for residential consumers.[25]

Moreover, lifting the price cap through the introduction of Price Responsive Demand and an Operating Reserve Demand Curve will provide an incentive for efficient long-term contracting and investment. If pricing matches supply and demand in the energy and operating reserve markets, market participants will know that the alternative to having or performing under a long-term contract is to turn to these markets. To the

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[24] See: Faruqui, A. and Ryan M. Heldik, *Transitioning to Dynamic Pricing* (January 27, 2009). Available at SSRN: http://ssrn.com/abstract=1336726

[25] *Application of Pacific Gas and Electric Company To Revise Its Electric Marginal Costs, Revenue Allocation, and Rate Design,* California Public Utilities Commission Decision No. 08-07-045, (August 1, 2008).

extent that energy and ancillary services are priced efficiently, market participants will take that into account when making investment and contracting decisions. However, to the extent energy and ancillary service prices do not reflect marginal costs and greater reliance is placed on administrative mechanisms to determine revenues and spread costs, this may bias their choice of investments and contracts.

E. Non-Discriminatory Curtailment in a Generation Emergency

Involuntary curtailment of load (manual load dump) is a final step taken to protect system security in a capacity emergency.[26] The system is planned and operated to minimize the risk of having to take this action. However, in the event of such an emergency, utility AMI investments would provide the capability to target, rapidly implement, and confirm load curtailments. Most new advanced meters include remote disconnection and rapid, on-demand reporting capabilities.

If a capacity emergency reaches this point, PJM should implement involuntary curtailments in a non-discriminatory manner. To the extent price responsive loads hold capacity, either for firm demand or to hedge risk, they should be treated in the same manner as non-price responsive loads with comparable capacity. This may require a capacity tracking program to capture the acquisition and transfer of capacity entitlements outside of RPM auctions and modifications to Control Zone curtailment procedures. Non-discriminatory curtailment would reflect the relative capacity deficiency of each Control Zone and, to the extent practicable, of price-responsive and non-price responsive loads within the zone. Curtailments would first address capacity deficiencies, equating the ratio of demand to the capacity registered with PJM, before curtailing on a pro-rata basis. In the event that a forecast price response has failed to materialize, the non-responding load would be subject to mandatory curtailment up to its relative capacity deficiency.[27]

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[26] PJM, *Emergency Operations Manual,* at Section 2, Capacity Emergencies (January 30, 2009).

[27] The specific mechanism by which curtailments will be implemented may vary based installed technology. Some utilities may install technology that enables control signals to be sent to end use devices, e.g. Programmable Communicating Thermostats. In other cases, advanced meters may include demand limiting devices.

V. Integration of Price Responsive Demand in Operational Tools

The price responsive characteristic of Price Responsive Demand will enable development of enhanced operational tools to take advantage of the predictable nature of short term consumption patterns that are related to wholesale price conditions. EDC operational centers can incorporate the Price Responsive Demand characteristic into the distribution operation models by modifying their short term load forecasts to account for the price responsive characteristic as operational experience is obtained. The regional security-constrained economic dispatch can be modified to incorporate the price responsive characteristic which may defer or avoid the need to deploy emergency operating procedures during peak demand periods. Well coordinated Price Responsive Demand could provide grid operators with more granular demand response information during critical periods that lead up to peak system conditions. Predictable Price Responsive Demand could enable regional grid operators to defer more expensive redispatch options and reduce transmission congestion costs. The development of these tools will require development of a more granular load forecast capability and enhanced visualization tools for system operators at the EDC and regional grid operator level.

VI. Integration of Price Responsive Demand in Regional Planning

The PJM regional Transmission Planning process and forward resource adequacy planning process are highly dependent on load forecasting. The development of Price Responsive Demand and its representation in a transparent Forecast Demand Response Curve, consistent with the approach described herein, will enable the regional load forecasting process to recognize the peak demand reduction that occurs in response to price. While the current load forecasting techniques recognize the impact of economic trends on future regional demand requirements, they do not consider the development of Price Responsive Demand that may occur due to installation of technologies such as AMI.

Price Responsive Demand will enter the regional Transmission Planning Process in two ways. First, the firm demand of price responsive customers, after accounting for their forecast response to prices, must be included in load forecasts used in planning to satisfy reliability standards and regional planning criteria. Second, a transparent Forecast Demand Response Curve will facilitate evaluating market efficiency driven transmission upgrades.

Price Responsive Demand will be reflected in PJM's resource adequacy planning through the development of forecasts that incorporate the firm demand of price responsive loads. The expected firm demand of these loads will be a selected price/quantity point on a transparent Forecast Demand Response Curve. The Forecast Demand Response Curve will be based on a predictable statistical relationship between Price Responsive Demand and LMP. Price responsive consumers would continue to carry capacity and reserves under RPM or FRR for their forecast firm demand.