

Assessment of Customer Response to Real Time Pricing

Task 1: Literature Search

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I. Introduction

The Center for Energy, Economic and Environmental Policy (CEEPP) has been engaged by the Retail Energy Supply Association (RESA) to perform an assessment of whether industrial and commercial customers placed on hourly rates take any specific actions to curtail load during high price periods or to shift load from high price periods to low price periods and to quantify the economic benefits and environmental impacts of such actions. This project has three primary tasks.

First, CEEPP will perform a literature search and review relevant reports on the topic. CEEPP will also assess the transferability of the findings in these reports to New Jersey. Second, if approved by RESA, CEEPP will interview customers in New Jersey that have been placed on hourly rates to determine what actions, if any, they have taken to reduce or shift load in response to hourly price signals. Third, if approved by RESA, CEEPP will quantify and assess the benefits of any load reductions or load shifting that occurred through the use of in-house production cost modeling capabilities. This report presents the findings from the first task.

II. Background

The Board of Public Utilities (the Board) has held a number of proceedings over the past few years and developed policies related to emerging competition in retail electricity markets. The Board has created a market structure that has placed the State's largest electric customers, approximately 1,900 customers with loads greater than 1,250 kW, on tariffs with hourly rates reflective of PJM's hourly spot market prices and has deliberated whether to move additional larger customers onto hourly rates. The Board has attempted to balance the potential benefits of competitive markets with ensuring that customers that are moved to hourly rates are not harmed.

One of the premises of moving customers onto hourly rates is that customers will act rationally in response to more precise price signals such that customers will shift load from high price periods to low price periods or otherwise reduce load whenever it makes economic sense to do so. In theory, such actions by hourly customers will benefit all customers by making the PJM market place more efficient, reducing market power, and improving reliability.

This research is intended to assess the impact of customer responses to being placed on hourly rates on the overall PJM market. Quantifying price impacts involves simulating what prices would have been had customers not responded to being placed on hourly prices by reducing or shifting demand. Supply models will be used to reconstruct market supply curves and estimate changes in hourly prices due to customers reducing or shifting load.

This research is also intended to assess any environmental benefits that result from customers reducing or shifting demand. Lowering demand reduces generation, which provides clear environmental benefits, assuming backup generation is not used to replace electricity generated by centralized power plants. Shifting demand may produce positive or negative environmental benefits depending on the generation units on the margin at the time the demand occurred and the time the demand would have occurred. The environmental impact also depends on existing regulatory policies. For example, under the cap-and-trade policies for sulfur dioxide and

nitrogen oxide, reductions in emissions by some generation units frees up allowances that others may purchase, resulting in no net reduction in emissions.

In this phase of the project CEEEP conducted a literature search related to customer response to being placed on hourly rates. This phase also entailed a review of related literature regarding the economic theory of real time pricing (RTP).

CEEEP has reviewed numerous reports and papers concerning how customers respond to being placed on real time prices, which are identified in the Appendix. The literature identifies a number of states with experience with real time pricing whose results may be relevant for New Jersey. Section III of this report provides a high-level summary of the literature review. Section IV summarizes the economic theory, which supports the movement towards real time pricing in retail electricity markets. Section V is a summary of experience in other states with real time pricing programs. Section VI provides a preliminary analysis of the applicability of policy options to New Jersey, and Section VII is a summary of conclusions.

III. Summary of Literature Review Regarding How Larger Electricity Customers Respond When Placed on Hourly Rates

Description of Literature Review

CEEEP reviewed approximately 40 papers and reports in the academic and industry literature over the past 10-15 years. This review included a number of studies performed by national energy laboratories, consulting firms, and academics. In addition, CEEEP discussed these issues with colleagues at the Lawrence Berkeley National Laboratory (LBNL) and contacted the Maryland Public Service Commission because it has been active in moving large customers to hourly rate schedules.

Key Findings

1. The literature mirrors the changing industry: earlier papers focus on time of use rates in the context of a vertically integrated utility, then shift to the theoretical benefits of real-time pricing with restructuring, and finally conduct some empirical work regarding price-responsive load, particularly in the context of ISO demand responsive programs and California's shortages in recent years (Grayson, 2001; Borenstein, 2002; Neenan, 2003; Goldman, 2004; Barbose, 2004).
2. The theoretical papers conclude that having more price responsive load (e.g., time-of-use tariffs, real-time pricing) improves efficiency, reduces market power, and increases reliability.
 - a. A number of analysts argue that RTP represents the most direct and efficient demand response mechanism, and therefore it should be the focus of policymakers' efforts, at least for large customers (e.g., Borenstein, 2002; Borenstein, 2005; Goldman, 2004).
 - b. There is some dispute in the literature regarding how beneficial price responsive load is and whether customers should receive payments for curtailing load in addition to

- foregoing paying the real-time price. This discussion hinges on the question to what extent non-price responsive customers benefit with lower prices and improved reliability from price responsive load (Barbose, 2004; Ruff, 2002).
- c. Part of this dispute relates to efficiency benefits versus transfers payments from producers to consumers. This distinction is well settled among economists and analysts but less understood and settled among those outside of this community (Borenstein, 2005).
 - d. As more and more customers switch to real-time or similar rates, there are cost shifting implications within and between rate classes and concerns regarding whether smaller customers are sophisticated enough to shop around.
3. The empirical papers examine particular utility programs, (e.g., Niagara Mohawk Power Corporation, which implemented RTP in the context of the transition to retail access in New York, Georgia Power, which has a long-standing and successful time-of-use program but does not have a wholesale market similar to PJM), ISO programs (e.g., PJM, NYISO) that provide payments for load reductions in addition to avoiding the real-time price or a proxy for it, and what-if analyses, (e.g., what if California had price responsive load during its summers of shortages) (Barbose, 2004; Goldman, 2004; Borenstein, 2002).
 4. Specific empirical findings are:
 - a. All customer types respond to the price that they pay but have very different price elasticities of demand, the amount of reduction of their consumption with a 1% increase in price.
 - b. In general, larger customers are more price-responsive than smaller ones.
 - c. The transaction costs (time, money, metering, obtaining information) can be large so unless electricity is a large component of a customer's business costs, or if aggregating with other similarly situated customers can reduce transaction costs, customers are unlikely to spend much effort in this area. The presence of transaction costs would suggest that there is a large amount of inertia, which may result in many customers continuing what they are doing, i.e., not switch to real-time rate options, and continue to pay for their electricity via retail rates.
 - d. Many customers facing real-time prices want some way to manage their exposure to price volatility. Some customers that are put on real-time rates will, however, not enter into bilateral or risk-management contracts.
 5. Coordinating RTP and associated educational and informational initiatives with traditional energy efficiency and DSM-related efforts such as marketing, customer education, technical assistance, and rebate programs, could capitalize on the natural synergies between RTP and energy efficiency yielding several benefits for customers and society (Barbose, 2002, page ES-9).

IV. Economic Theory

Rationale for Real Time Pricing

Under real time pricing (RTP) tariffs, electric consumers are charged prices that follow actual market prices such as PJM's hourly locational marginal price (LMP). RTP can also be based on other types of forward prices such as the day-ahead RTP offered by Georgia Power. These tariffs differ significantly from those typically used by electric utilities which are based on average costs, with little or no differentiation with respect to the timing of consumption. "Economists have long advocated for RTP on the basis of the gains in economic efficiency it could potentially engender, by more accurately signaling to consumers the time-varying costs of electric consumption" (Barbose and Goldman, 2004, page 1; Vickrey 1971; Schweppe et al. 1980).

In a number of states with retail choice including New Jersey, RTP has been designated as the default service for large customers that do not switch to a competitive supplier. "RTP is largely viewed as a tool for stimulating the development of competitive retail markets, with the belief that most customers will prefer some form of hedged service from a competitive supplier" (Barbose and Goldman, 2004, page 1).

RTP has also been identified as a potential strategy for developing demand response. "Economists and policy analysts engaged in efforts to improve the performance of competitive wholesale markets recognize that, by providing customers with an incentive to respond to high wholesale market prices, RTP could serve to mitigate market power, dampen wholesale price volatility, and bolster system reliability" (Barbose and Goldman, 2004, page 1; Lafferty et al. 2001). Thus, while the rationale for RTP in New Jersey and other states is to develop competitive retail markets, RTP will create additional benefits if customers reduce or shift peak demand in response to RTP.

Policymakers seeking to develop demand response must determine what combinations of mechanisms to use: RTP, emergency load reduction programs, demand bidding programs, or traditional load management programs such as interruptible tariffs and direct load control. "While other mechanisms can be used to induce price-responsive demand and/or reduce peak demand, many economists argue that RTP represents the most direct and efficient demand response mechanism, and therefore it should be the focus of policymakers' efforts to improve the performance of wholesale and retail electricity markets" (Barbose, page ES-1; Borenstein et al. 2002).

Price Elasticity and Substitution Elasticity

Price elasticity is a measure of how a customer reacts to a change in price. Economists measure how responsive consumers are to a change in the price of goods or services by the concept of elasticity. The degree of elasticity or inelasticity is the elasticity coefficient, which is equal to the percentage change in quantity demanded divided by the percentage change in price. For example, if the price increased by 100% and customers reduced demand by 10%, the elasticity coefficient would be negative 0.1. Electricity is relatively inelastic, meaning that large price percentage price increases are generally necessary to reduce demand substantially compared to

other goods or services. On the other hand, in many situations, a relatively small reduction in electricity demand may provide substantial efficiency and reliability benefits.

In the context of this report, substitution elasticity is used to define “the change in the ratio of peak/off-peak electricity consumption that results from a one percent change in the off-peak/peak prices. The computed substitution elasticity is a measure of how willing the customer is to shift usage given the relative prices of peak and off-peak electricity” (Goldman, 2004, page xviii). The Niagara Mohawk case study discussed below calculates the substitution elasticity for several types of customers that are served under RTP tariffs.

Demand Response Options

“The key element of demand response is that the price or contract conditions depend to some extent or under some conditions upon the state of the wholesale market. This means that the price paid by a customer can change at relatively short notice in contrast to the traditional fixed price tariff” (O’Sheasy, 2003, page 54). Long-term fixed price contracts can also have some benefit in making customers more responsive to wholesale market conditions because it requires customers to tradeoff between locking in a long-term price at a premium to buying from the real-time market. More importantly, long-term contracts do not reduce the strong incentive on marginal consumption of electricity (Borenstein, 2005). Specifically, even a customer with a long-term contract has the incentive when electricity prices are high to reduce consumption because it can sell its electricity purchased under the long-term contract into the market at a high price.

Pricing options that impact demand response include the following:

- Fixed price tariffs: based on average costs that include seasonal or time-of-use (TOU) rates
- Monthly tariffs: prices vary monthly based on the previous months market price
- Day-ahead pricing: customers learn the price a day in advance
- Critical period TOU pricing: consists of standard TOU prices and pricing periods but adds a critical peak period or periods
- Occasional real-time pricing: includes variable hourly prices during the critical hours
- Real-time pricing (RTP): customers pay hourly market based prices

The above list represents a continuum from no to little signaling of wholesale prices to customers to real-time changes in prices that customers pay. In theory, each of these pricing options will result in different levels of demand response since each sends a different price signal to end use customers. However, CEEEP was unable to identify any studies or literature that analyzed the different levels of demand response that could be expected from implementation of these various pricing options available.

In addition to the retail pricing options listed above, several ISO’s offer programs such as PJM’s Economic Load Response and Emergency Load Response Programs. These programs provide customers direct financial incentives for reducing load at times of high prices or capacity

shortages. Several of the papers reviewed indicate that RTP tariffs work best when offered in conjunction with these types of programs (Barbose, 2004; Goldman, 2004).

Offering RTP in conjunction with ISO demand response programs or peak shaving programs such as incentives for investments in energy efficiency and renewable energy can increase benefits to customers and society. Thus, RTP is not the only choice for regulators for achieving demand response but can be a critical component of a portfolio of programs aimed at achieving demand response. The following subsection discusses the potential benefits of RTP.

Benefits of RTP

“Markets require both a supply side and a demand side to function effectively. The demand side of wholesale electricity markets is severely underdeveloped. It is widely recognized that wholesale electricity markets will work better when a significant level of potential demand-side response is available in the market.”

2004 PJM State of the Market Report

“The major failure of electricity restructuring around the world and in the U.S. is the lack of a sophisticated and active demand side of the wholesale electricity market”

Market Surveillance Committee of the California ISO, September, 2000

“The main obstacle to tapping the potential of price responsive load in the PJM system is the fact that most end-use customers are not exposed to real time prices.”

Grayson C Heffner and Charles A. Goldman, August, 2001

“Perhaps nowhere is the disconnect between retail pricing and wholesale costs so great as in restructured electricity markets. In the last decade, it has become apparent that wholesale electricity price fluctuations can be extreme, but retail prices have in nearly all cases adjusted only gradually.”

Severin Borenstein and Stephen P. Holland, July, 2003

The above quotations represent the conclusions of the majority of the literature reviewed. All of the literature reviewed endorses the theory that for competitive electricity markets to function efficiently, demand response must participate in the energy and capacity markets.

The vast majority of the literature reviewed advocates that improving the ability of retail electric demand to respond to wholesale prices will reduce the overall cost of energy, improve reliability and reduce price volatility in wholesale markets. In recognition of this the Federal Energy Regulatory Commission, in its Standard Market Design stated that demand response is a

necessary element of standard market design that will allow demand resources to participate in the energy and capacity markets (Ruff, 2002).

PJM noted in its 2004 State of the Market Report that “a functional demand side of the electricity market does not mean that all customers curtail usage at specific levels of price”. It does mean, however, “that all or most customers will have the ability to see real-time prices and react to such prices”. PJM concluded that the “true goal of demand-side programs is to ensure that customers can make informed decisions about energy consumption. Customers can and will make investments in demand-side management technologies based on their own evaluations of those tradeoffs” (PJM 2004 State of the Market Report, page 86).

The economic benefits of reducing demand is explained as follows (Ruff, 2002, page 7): “The net economic benefit of an increase in demand response is the reduction in total supply-side plus demand-side costs of meeting customers demand. For example, if peak demand response is improved by making it easier and cheaper to run back up generation and turn off electricity using industrial processes when prices are high, demand and hence the need for costly supply during high priced periods will be reduced. The gross benefit of improvement in peak demand response will be the reduction in supply side costs because fewer peakers are running in the short run and needed in the long run.”

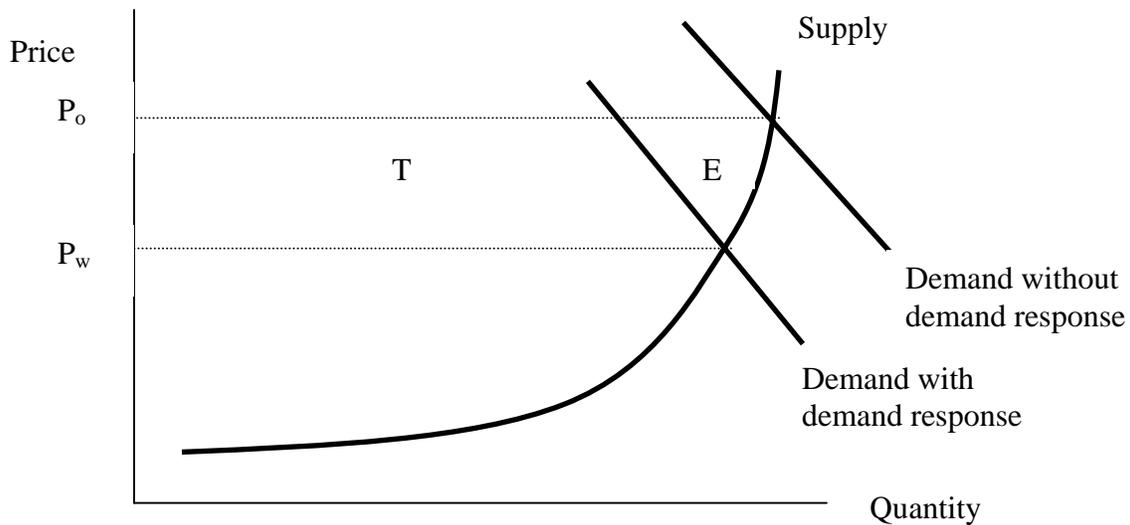
A series of wholesale market simulations makes several important conclusions (Borenstein, 2005). First, efficiency gains from RTP are likely to be significant even if demand is relatively inelastic. In other words, it does not take much reduction in demand or shifting demand to lower priced hours to result in substantial efficiency gains. Second, the efficiency gains from RTP applied to large customers outweigh the associated metering costs because the savings in the amount of resources society as a whole uses to produce electricity from RTP are a lot more than the costs of installing real-time meters. In contrast, a simple TOU pricing system that has a peak and off-peak periods is likely to only capture a small share of the efficiency gains of RTP. Finally, the incremental benefits of having more customers on RTP diminish as the percentage of RTP increases.

Efficiency Versus Transfer Benefits

An important distinction needs to be made between efficiency benefits of demand response to hourly wholesale electricity prices and transfers of value from producers to consumers. The discussion of this distinction, however, should not obscure the finding by economists that society and consumers in particular would benefit by having more price-responsive demand responding to wholesale market conditions.

If a customer can reduce load at a cost less expensive than the supply cost, that customer can reduce their energy costs and reduce total system costs, which benefits all customers. There are two consequences of this load reduction. One is an efficiency benefit and the other is a transfer from producers to consumers, as illustrated in Figure 1.

Figure 1: Reduction in Demand Results in Efficiency Benefits and a Transfer from Suppliers to Consumers



In Figure 1, the efficiency benefit is denoted by the triangle-like shape labeled E, which represents the reduction in total system costs or the societal benefits. The trapezoid-like shape T denotes the reduction in wholesale market prices that represents the transfer payment from suppliers to consumers.

The transfer from suppliers to consumers is not an efficiency gain because it does not result in a better use of society's limited resources, but only in the level of payment made for those resources. Policymakers and regulators concerned about consumers may want to count the transfer as a benefit, but whether it is an actual benefit to consumers is more complicated.

For example, if market power exists, then demand response reduces the ability of suppliers to exercise market power, which provides additional benefits. If the market is competitive, however, the reduction of payments to suppliers may result in some suppliers not being able to cover all of their fixed costs from the PJM capacity market alone, requiring them to exit the market or forego future investment, which may ultimately result in higher prices than P_w but still less than P_o to consumers. Thus, from a long-run theoretical perspective in a competitive market, E is viewed as the economic benefit to consumers and T is viewed as a short-term transfer from generators to consumers. In other words, in a competitive market, the transfer T produces a short-run benefit to consumers that may be lost in whole or in part in future periods due to the dynamic response of the market to changing prices.

Market Power Impacts

Experience in PJM, California and other states has demonstrated the potential for extreme price volatility in restructured electric markets. Although PJM price volatility has subsided in 2003 and 2004 compared to previous years, the potential for a reemergence of volatile prices exists if the current supply/demand balance changes or if the markets become less competitive. "Thus,

there is increasing interest in policies, programs and tariffs that encourage customer loads to provide demand response to help discipline wholesale markets. Conceptual studies and market simulations suggest that if a sufficient number of customers are exposed to and adjust their demand in response to wholesale electric prices, the resultant reductions in demand will limit the ability of suppliers to increase spot and long-term market clearing prices above competitive levels” (Goldman, 2004, page 1; Borenstein, 2002; Ruff, 2002).

PJM noted in its 2004 State of the Market Report that a functional demand side of the wholesale electricity market would tend to induce more competitive behavior among suppliers and limit their ability to exercise market power than without such participation. If customers had the essential tools to respond to prices, then suppliers would have the incentive to deliver power on a cost-effective basis.

Distributional Impacts

“Discussions of changes to greater price-responsiveness in demand have usually focused on who, among customers, would win or lose from such a change. While the distributional impact among customers is certainly important, price responsive demand is also very likely to affect the total cost of electricity and, especially, the allocation of the cost between customers and deregulated producers” (Borenstein, 2002, page 7).

Average price tariffs, such as the fixed price default tariff currently used in New Jersey, result in all customers in the same class paying the same price for electricity. Customers that use more electricity than the class average during high price periods are not paying the full costs they impose on the system and are being subsidized by customers that use less than the class average during these periods.

RTP or similar dynamic pricing methods eliminate intra-class subsidies for the commodity portion of customer bills by having all customers pay prices that reflect the costs each customer imposes on the system. Customers that consume less power when market prices exceed the average rate or more power when market prices are below the average rate will see bill reductions.

To the extent RTP results in customers reducing demand during high price periods or shifting load from high price to low price periods, it will improve the efficiency of the wholesale market, thereby reducing costs and prices for all customers. Customers that can reduce or shift peak usage can also reduce their bills.

While RTP exposes customers to additional volatility in prices, one should not assume switching a customer to RTP would necessarily result in an increase in costs, although this is possible for some customers. In fact, in the long run, RTP should lower costs to customers, both by improving the efficiency of the wholesale market and by reducing any risk premium suppliers include in their offers to customers if they are to offer a customer a fixed price. RTP will reduce costs for customers with “better” load profiles than the class average and conversely could increase costs for customers with “worse” than average load profiles, although these customers can reduce costs to the extent they can reduce or shift peak usage and will benefit from overall

reductions in system costs. All of the literature reviewed endorses the theory that RTP will, over the long run, result in lower system costs and reduce prices compared to what would occur without RTP.

V. Review of RTP Program Results

The focus of the review performed was to identify studies that assessed customer response to being placed on real-time pricing (RTP). CEEEP was asked to review the studies and assess their applicability to the New Jersey marketplace.

“About 40 utilities have experimented with RTP tariffs over the last two decades” (Barbose et al, 2002). “A few programs have persisted over multiple years, have managed to achieve and/or maintain substantial customer participation, and have reported elasticity estimates and aggregate demand response under various pricing conditions” (Goldman, 2004, page 1).

The market context for nearly all of the RTP programs that were reviewed, however, is different than the current situation in New Jersey. Nearly all of the RTP programs that have been reviewed, with the exception of the Niagara Mohawk study discussed below, have been voluntary programs implemented by vertically integrated, regulated utilities that operate in states without retail competition. By contrast, in New Jersey and Maryland, RTP is framed in the context of a default tariff for large customers. However, based on conversations with the staff of the Maryland Public Service Commission, no evaluation of customer response to RTP has been performed.

Customer response to RTP depends “upon assumptions regarding customers’ price elasticity, the level of price response by different customer groups, factors that affect customers’ ability to respond, identification of barriers to RTP, and customer preferences for physical and financial hedging products. Yet to date, relatively little information exists in the public domain about how these customers actually respond to RTP in the context of current prices and emerging competitive market and institutional structures” (Goldman, 2004, page 2). The literature review confirmed the finding that little information exists regarding how customers placed on RTP in the context of a competitive wholesale market respond to RTP. However, CEEEP was able to identify a number of RTP programs that have some relevance to how customers can be expected to respond to RTP in New Jersey.

State Experience with RTP as a Default Service

Several states including New Jersey have implemented RTP as the default service for large customers. The following table summarizes the status of such programs (Goldman, 2004, page 3):

Table 1: States/Utilities with RTP as Default Service (as of 2004)

State (Utility)	Large C/I Default Service	Number of Customers	Peak Demand (MW)
Niagara Mohawk.	Day-ahead hourly prices (>2 MW)	~ 140	550
Maryland (BGE)	Real-time hourly prices (>600 kw)	620	1540
New Jersey	Real-time hourly prices (>1.4 MW)	1696	2580
PA (Duquesne L&P)	Real-time hourly prices (>300 kw)	~1000	~1500
Ohio	Market based variable rate	All large GS	
Georgia Power	Day-ahead and hour ahead hourly prices (optional > 250 kw)	1600	5000

The following section summarizes the literature reviewed regarding how customers responded to being placed on RTP.

Summary of Case Studies

A number of reports and papers assessed actions taken by customers to reduce or shift peak load usage in response to RTP. One study of Niagara Mohawk Power Corporation's RTP program evaluated the response of customers placed on RTP tariffs in the context of the transition to retail access in New York. Most of the other studies involved customers that were placed on RTP tariffs voluntarily, which may introduce certain bias into the results because presumably those that volunteered for such programs were more able to adjust their demand profile than those that did not participate or had other motivations for participation. These studies, however, indicate opportunities that are available to different types and sizes of customers.

In 1998, as part of New York's transition to retail access, Niagara Mohawk Power Corporation (NMPC) placed customers with peak demand in excess of 2 MW on a tariff that priced the electric commodity at hourly-varying prices indexed to the NYISO day-ahead market. NMPC customers were also given a one-time choice in 1998 to sign up for TOU-based, fixed-rate contract for up to five years on a take-or-pay basis (Goldman, 2004).

CEEEP reviewed a case study that focused on the RTP tariffs offered by NMPC described above. The study assessed the issue of how customers respond to RTP and concluded that "price response is modest overall but individual customer response is extremely variable" (Goldman, 2004, page xiii).

The key findings of the NMPC case study are the following:

- “Over 30% of survey respondents say they can respond by foregoing discretionary usage; 15% say they can shift (and forego) usage from peak to off-peak periods when prices get high.
- The average substitution elasticity is 0.14 for all customers. [As discussed above, substitution elasticity is defined as the change in the ratio of peak/off-peak electricity consumption that results from a one percent change in the off-peak/peak prices.]
- There is substantial variation in substitution elasticity within and between customer groups. Average elasticities by customer group are: 0.11 for industrial customers (this is comparable to other RTP studies), 0.30 for government/education customers, and 0.00 for commercial customers” (Goldman, 2004, page xiii).

Based on an analysis of the 141 NMPC customers placed on the RTP tariff, the case study concluded that at a price of \$0.50/kWh, the customers on the RTP tariff could be expected to reduce demand by approximately 100 MW, or about 18% of these customers’ maximum demand (Goldman, 2004, page xiv). These numbers reflect what customers could do in the short run; over longer periods of time, customers have more options to reduce and shift electricity consumption and therefore smaller price increases would result in similar reductions and shifting of demand.

The case study also concluded that ISO-DR programs complement RTP, providing measurable increases in DR when events are called, particularly for industrial customers. NYISO-DR-program events increase the overall amount of load curtailed by the NMPC RTP customers by about 15% (Goldman, 2004, page xiv). This results in an increase in demand response from approximately 100 MW to 115 MW or from 18% to 21% of these customers maximum demand.

The NMPC case study results indicate that the ability and inclination of customers to respond varies widely:

- “Government/educational customers were most responsive to SC-3A [RTP] prices, not industrial customers as expected. Since these entities are common in virtually every jurisdiction, the potential for RTP is perhaps greater than previously envisioned” (Goldman, 2004, page xxiv).
- “A key challenge is in enhancing the price responsiveness of commercial sector customers. Because certain commercial customers (e.g., office buildings) have similar physical characteristics and end use loads (e.g., space conditioning and lighting) to government/education facilities, response from this sector is at least technically feasible. If institutional and other barriers can be overcome, the commercial sector may provide a rich source of price response” (Goldman, 2004, page xxiv).

A case study of commercial customers in California concluded that commercial buildings, primarily by controlling air conditioning and lighting load, could reduce peak demand by approximately 15 to 18% with minimal complaints from occupants. The study showed that the customers incurred costs to enable them to shed load that were in the range of \$20/kW curtailed for a building with 500 kW of load and \$30/kW curtailed for a building with 100 kW of load. These costs are significantly below the cost of installing a new peaking plant, which is above \$500/kW. The cost estimates do not include the costs of interval meters that were installed by

the utility. However, interval meters would add an additional \$20-30/kW curtailed so the cost would remain well below the supply side alternative (Borenstein et al, 2002, pages 57-64).

A third relevant study reviewed concerned customers of Georgia Power. It is important to note that these customers were placed on an RTP tariff on a voluntary basis and that Georgia Power does not operate in a state with retail access.

Georgia Power has, by far, the largest base of participants of any RTP tariff offered to large commercial and industrial (C&I) customers. Currently, about 1,540 customers are enrolled in the day-ahead tariff, and 60 in the hour-ahead tariff, which comprise 3,250 MW and 1,750 MW peak demand, respectively. Participants in the hour-ahead tariff primarily consist of large industrial and manufacturing customers, although several military bases, university campuses, and large office buildings are also enrolled. The day-ahead tariff is composed more or less equally of commercial and industrial customers (Barbose, 2004).

“The largest load reductions observed have been on the order of 800 MW, which occurred in 1999, when participants faced exceptionally high prices of \$1.50/kWh and \$6.50/kWh in the day-ahead and hour-ahead programs, respectively. Braithwait and O’Sheasy (2000) report that, over a period of high priced hours, participants in the hour-ahead tariff reduced their average demand by approximately 250 MW in aggregate, and those in the day-ahead tariff reduced their average load by approximately 500 MW. In summer 2000, when prices were less extreme than in the previous year, the maximum load reduction was 482 MW” (Barbose, 2004, pages 98-99). These demand reductions are equal to approximately 15% of peak-demand and are on par with the findings of the NMPC case study.

CEEEP also reviewed an evaluation of an RTP pilot program that targeted residential customers in Illinois (Summit Blue, 2005). The Community Energy Cooperative, a Chicago based nonprofit, launched the Energy-Smart Pricing Plan and enrolled more than 1,400 residential customers. Results of a study of the first year of the program showed that residential customers reduced demand by as much 20% in response to high prices and lowered their costs by 11% on average. While these results appear promising in demonstrating residential customer’s ability to respond to prices, it was a limited pilot program, and CEEEP was unable to ascertain the applicability of these results to residential customers in other states or the amount of savings due to rate design versus customers reducing or shifting peak demand.

VI. New Jersey Policy Analysis

For most of the last century, electricity was sold in regulated environments in which the retail prices did not vary based on the time it was used. While certain customers faced time of day or seasonal variations in prices, retail prices did not vary with wholesale market prices. Customers faced a constant price for electricity regardless of the supply/demand balance on the grid. As noted above, discussions of changes to price responsiveness in demand have focused on whom, among customers, would win or lose from such a change and that price responsive demand is also very likely to affect the total cost of electricity and the allocation of payments between customers and producers.

Pricing that reflects the cost of power during high price periods has existed in electric markets in New Jersey in various forms. Utilities experimented with time-of use tariffs in the 1980's and interruptible tariffs were used widely by integrated utilities as a tool to control peak loads and manage generation costs. More recently real time pricing is being utilized in New Jersey as a tool for stimulating the development of a competitive retail electric market.

New Jersey has recently mandated that the State's largest customers, currently those served at primary voltage and those with load of 1,250 kW or above, be exposed to real-time pricing. The default service for these customers includes energy rates based on PJM's spot market prices. These customers have the option of purchasing electric power from a third party supplier as a means of reducing their exposure to potentially volatile spot market prices.

The customers that have been placed on hourly rates in New Jersey have an aggregate peak demand of approximately 2,900 MW. If the demand response of these customers is comparable to the levels achieved in the case studies cited above, that is approximately 15% of peak demand, PJM could anticipate more than 400 MW of load response from these customers. However, additional research needs to be done to determine if the demand response from these customers is in fact similar to the levels achieved in the case studies reviewed.

Distributional Impacts/Cross Subsidy Issues

The large majority of customers that remain with their utility for electric supply are provided service pursuant to a fixed price tariff. These fixed priced tariffs include average cost based rates, some of which may vary by season or on and off-peak periods.

Average price tariffs, such as the fixed price default tariff currently used in New Jersey, result in all customers in the same class paying the same price for electricity. As discussed above, this results in customers that use more electricity than the class average during high price periods being subsidized by customers that use less than the class average. The rate subsidy issue highlights the disconnect between average utility tariff prices and volatile wholesale spot market prices. Customers do not receive accurate price signals that reflect the costs they are imposing on the system at times of high prices and therefore do not receive the information they need to make a decision as to whether they would continue purchasing electricity at specific price points or would choose to reduce demand at certain prices.

As set out in numerous rate decisions made by the Board over the past twenty years, New Jersey has had a long-standing policy of setting rates based on the costs to serve customers. In theory, all customers pay rates based on the average cost of serving the customer class. The Board's movement towards cost based rates has been tempered by its interest in rate stability such that certain customers or classes of customers were transitioned to a cost based rate over time to avoid rate shock.

All of the literature reviewed by CEEEP endorses the theory that RTP will, over the long run, result in lower system costs and reduced prices. Regulators are concerned about the short-term impacts on customers, primarily due to the potential for price volatility and that certain customers with "worse" than average load profiles will see price increases if they do not have the

ability to shift or reduce peak usage. RTP prices, however, would reflect the precise cost each customer is imposing on the system. This end result is consistent with the Board's policy of basing rates on costs but would need to be balanced with the Board's policy of favoring rate stability.

Policy Implications

The literature reviewed included a number of policy recommendations that New Jersey may wish to consider further. However, the recommendations should be considered preliminary in nature with additional research required prior to developing final recommendations.

LBNL concluded that customers need help understanding and managing price risk and that RTP implementation should be coordinated with other demand side activities. "Customers need technical assistance and training to help them understand market price formation and to identify physical and financial strategies for managing price risk. Financial incentives to accelerate adoption of technologies that simplify and/or automate price response may be warranted in some cases" (Barbose, 2004, page ES-8).

Although energy efficiency programs and RTP can both serve to induce demand response and share many overlapping technologies and customer education activities, these two pursuits have not been extensively coordinated in New Jersey. New Jersey should consider additional coordination of the marketing of New Jersey's Clean Energy Program that offers incentives for technologies that reduce or shift peak-demand with the Board's existing customer training related to the BGS auction. The Board should also consider new programs that offer financial incentives for technologies that simplify and/or automate price response.

"Integrating many of the programmatic initiatives needed to build participation in RTP with traditional energy efficiency and DSM-related efforts (e.g., marketing, customer education, technical assistance, and technology rebate programs) could capitalize on the natural synergies between RTP and energy efficiency, yielding several specific benefits for utilities and consumers." "Customers would be better positioned to evaluate investments in new end-use technologies (e.g., energy management and control systems and high efficiency air conditioning) in light of the benefits they provide for customers placed on RTP. Transaction and administrative costs could also be minimized (e.g., related to marketing materials, site audits, and customer load analyses)" (Barbose, 2004, page ES-9).

Likewise, RTP could also have positive impacts on the Board's long-standing policy of promoting investments in energy efficiency and renewable energy. RTP would most likely result in customers paying higher prices during peak demand periods thereby increasing the benefits of technologies that reduce or shift demand during these periods such as high efficiency air conditioning and photovoltaic systems. RTP would not be expected to deliver short-term results with regard to equipment purchases, i.e., customers would not be expected to discard functioning equipment. However, RTP could help modify a customer's purchasing decision if life cycle costs are taken into account and the cost of electricity saved exceeds the incremental cost of the equipment purchased.

LBNL also concluded that policymakers must account for the potential environmental and market impacts of increased use of distributed generation that may result from RTP. “Experience with existing RTP programs suggests that customers with on-site generation have been among those most receptive to RTP and, in some cases, the most price-responsive. Depending on the emissions characteristics and location of on-site generators relative to bulk power generation, the health and environmental consequences of increased operation of onsite generators may be negative or positive. If customers on RTP rates choose, or are allowed to, increase operation of existing diesel-fired generators as part of their price response strategy, adverse environmental consequences are likely to result. At the same time, a proliferation of distributed generation located in transmission-constrained load centers may help to reduced congestion, avoid the construction of new transmission facilities, and mitigate the exercise of market power, and therefore improve the efficiency of bulk power markets” (Barbose, 2002, page ES-10).

VII. Summary and Conclusions

The vast majority of the literature reviewed endorses real-time pricing as the most efficient approach to achieving demand response and recognizes that the performance of competitive wholesale markets is improved by providing customers with an incentive to respond to high wholesale market prices. RTP could serve to improve market efficiency, mitigate market power, dampen wholesale price volatility, and bolster system reliability. Demand response would eliminate intra-class subsidies on the energy portion of customers’ bills by having each customer pay an amount for electricity exactly equal to the costs imposed on the grid.

The literature reviewed indicates that some but not all customers can and will respond to price signals. LBNL’s case study of Niagara Mohawk’s RTP tariff, the most detailed and relevant study reviewed, showed that large customers responded as expected and were able to shift or reduce load. The average substitution elasticity for all customers was 0.14 meaning that if peak prices doubled relative to off-peak prices customers reduced peak usage by 14%.

LBNL’s study of Niagara Mohawk’s RTP customers also concluded that there is substantial variation in substitution elasticity within and between customer groups. Average substitution elasticities by customer group were found to be 0.11 for industrial customers, 0.30 for government/educational customers and 0.0 for commercial customers. Extrapolating from the modeling results, aggregate demand response that could be expected from customers at a price of \$0.50/kWh was approximately 100 MW or about 18% of those customers peak demand.

The literature reviewed also finds that in California small commercial and residential customers were able to shed load in response to price signals. One study concludes that commercial buildings, primarily by controlling air conditioning and lighting load, could reduce peak demand by approximately 15 to 18% with minimal complaints from occupants.

New Jersey has used RTP as the default tariff for large customers, primarily as a means of stimulating the development of a competitive retail electric market. However, if customers in New Jersey are responding to RTP in a manner similar to customers in other states and have reduced or shifted peak demand, New Jersey is receiving other benefits as discussed above. The

potential also exists for increasing these benefits by developing programs that increase demand response by other smaller customers. These benefits should be confirmed through additional research, quantified, and considered by the Board in future proceedings concerning the expansion of the class of customers served by RTP tariffs.

Conclusions

1. The theoretical papers conclude that having more price responsive load (e.g., time-of-use tariffs, real-time pricing) improves efficiency, reduces market power, and increases reliability.
2. Policymakers seeking to develop demand response must determine what combinations of mechanisms to use: RTP, emergency load reduction programs, demand bidding programs, or traditional load management programs (interruptible tariffs and direct load control).
3. Many argue that RTP represents the most direct and efficient demand response mechanism, and therefore it should be the focus of policymakers' efforts, at least for large customers.

With the exception of the Niagara Mohawk case study that involved customers with loads in excess of 2 MW, CEEEP did not find studies that answered the specific question of how industrial and commercial customers placed on RTP as a default tariff responded to being placed on RTP. We were unable to locate any empirical studies that might be indicative of how customers that the Board is considering placing on RTP, such as those with loads above 750 kW, may respond to RTP.

In the next phases of this study CEEEP will interview customers in New Jersey that have been placed on hourly rates to determine what actions, if any, they have taken to reduce or shift load in response to hourly price signals. CEEEP will quantify and assess the benefits of any load reductions or load shifting that occurred through the use of in-house production cost modeling capabilities.

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