IMPACTS OF RESPONSIVE LOAD IN PJM:LOAD SHIFTING AND REAL TIME PRICING

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Overview

In PJM, 15% of electric generation capacity ran less than 96 hours, or 1.1% of the time, over 2006[1]. If retail prices reflected hourly wholesale market prices, customers would shift consumption away from peak hours and installed capacity could drop. I use PJM data to estimate consumer and producer savings from a change toward real-time pricing (RTP) or time-of-use (TOU) pricing. Surprisingly, neither RTP nor TOU has much effect on average price under plausible short-term consumer responses. Consumer plus producer surplus rises 2.8%-4.4% with RTP and 0.6%-1.0% with TOU. Peak capacity savings are seven times larger with RTP. Peak load drops by 10.4%-17.7% with RTP and only 1.1%-2.4% with TOU. Half of all possible customer savings from load shifting are obtained by shifting only 1.7% of all MWh to another time of day, indicating that only the largest customers need be responsive to get the majority of the short-run savings.

Methods

I present a short-run analysis of a change to a more responsive demand-side market. I use one year of PJM data to build a supply model that implicitly accounts for dispatch constraints and varying conditions observed over a year. I use this model in three different simulations to estimate the impacts of responsive load. The first is an assumed load-shifting scenario that finds the effects of small changes in load profile on overall price. The load-shifting simulation does not consider customer time preference, but does show how quickly savings could be achieved. The final two simulations are discussed in this abstract and are more realistic; they use hourly demand curves to predict short-run impacts from change toward TOU or RTP from flat-rate pricing.

The data I use to build a wholesale supply-side model are system-wide hourly PJM market clearing results. I examine aggregate load and PJM average prices in the day-ahead and spot markets over 2006 [1]. In the final supply model, the adjusted R^2 is 0.949.

In order to model demand using the most realistic elasticities, I use estimates from the literature. The level of responsiveness that would be observed under RTP is uncertain and could depend on a variety of factors, but there are enough empirical estimates to place the plausible short-run elasticities of demand between 0 and -0.4 under RTP conditions [2-4]. I examine this full range.

Results

Market outcomes depend on the assumed demand elasticity. Table 1 summarizes impacts on consumption, expense, average price, and peak load with RTP rates. Although not shown, the impacts from TOU pricing on peak load shaved, consumption increase, and consumer expense saved are never more than 14.4%, 22.3%, and 21.9% respectively of the impacts from changing to RTP.

Table 1. Load increase, peak shaving, and price savings with RTP.

Elasticity of Demand	Peak Load, GW	Peak Load Saved	Total Energy, TWh	Consumption Increase	Total Expense, $Billion	Consumer Expense Saved	Average Price, $/MWh
0	145	0.0%	696	0.00%	$36.17	0.00%	$51.96
-0.05	137	5.7%	699	0.38%	$35.52	1.82%	$50.82
-0.1	130	10.4%	702	0.83%	$35.11	2.93%	$50.02
-0.15	126	13.3%	705	1.23%	$34.94	3.39%	$49.59
-0.2	123	15.1%	707	1.59%	$34.90	3.51%	$49.35
-0.25	121	16.6%	709	1.91%	$34.93	3.44%	$49.23
-0.3	119	17.7%	711	2.20%	$34.99	3.27%	$49.18
-0.35	118	18.7%	713	2.44%	$35.07	3.04%	$49.18
-0.4	117	19.5%	715	2.67%	$35.16	2.80%	$49.20

1 This is based on the entire PJM hourly load profile in 2006 [1]. The system had 17.5% excess available generation capacity. I do not include generation excess at coincident peak load in this calculation because some generation excess is necessary for reliability purposes.

Peak load reductions are extreme with a small amount of responsiveness but marginal savings taper with greater responsiveness. The large peak load savings under RTP have huge implications for the total system cost. Peak load determines the total capacity investment necessary for reliable operation. Although no savings will be made on peak capacity that has already been built, there will be savings via unneeded capacity investment as generators have to be replaced or load increases over time. At elasticity -0.2, peak load drops by 15.1% with RTP. At that level, an overnight capacity value of $600/kW or $1800/kW, corresponding roughly with the overnight capital costs of gas and coal generation, translates into a dollar savings of $13- $39 billion from a change to RTP. A change to TOU pricing would reduce $1.7 to $5.0 billion in capacity investments under the same conditions.

It is also important to know the impacts of RTP on a customer who cannot or will not respond to price. An unchanging typical customer saves less per unit than a responsive customer, but slightly more overall because she does not increase consumption[2]. More interesting is that a flat customer would save 7.0% of her annual electric bill even if *no one* responded to price. She would save the amount that currently goes to subsidize the excesses of more peaky customers. This savings highlights the issue of equity: under flat rates, moderate and counter-cyclical customers subsidize the consumption of customers with high coincident peak loads.

Before looking at these results, a regulator might be concerned about charging RTP for customers who have no ability to respond. It would seem unfair to charge customers high RTPs if they could not react, but these results indicate that even if customers had no means of knowing or responding to the RTP, the adverse effect of extremely high prices would not cause any problems on average over the year. Flat and countercyclical customers would benefit by not having to subsidize the excesses of others.

Conclusions

The traditional assumption that end users cannot vary their consumption as prices change has led to large, unnecessary investments in peaking plants. These under-utilized peak generation investments are a luxury that neither providers nor customers want to pay for. The good news is that the peak load problem can be mitigated by moving flat rate customers onto RTP tariffs. Even with little price responsiveness, surprisingly large peak load reductions can be achieved. Most other quantities of interest such as generator profitability, overall consumption, and average end user expense will not be affected greatly by a change toward RTP. However, policy makers will be disappointed with the short-term reduction in overall bills.

Under current conditions counter-cyclical end users subsidize the high coincident peak loads of others. When problematic, high-peak customers are confronted with higher bills, they will want to make small but important changes. If a peaky customer does not want to alter her consumption habits, then she will face the full price of her own load profile rather than having it subsidized by the rest of the system. Just as consumers have learned to respond to the volatile prices of gasoline, fruits, vegetables, and other commodities, so they can learn to respond to electricity prices. The largest difference is that customers purchase electricity every hour of the year and therefore some customers will want automated devices to react to changing prices.

Because only modest aggregate price elasticities are necessary for large peak capacity savings, most of the benefits can be achieved by shifting only large, responsive customers to RTP; from the experience in Niagara Mohawk, the “18% [of customers] with elasticities greater than -0.1 provide 85% of the aggregate price response” [2]. Further, 50% of all possible customer expense savings from load shifting could be achieved by shifting only 1.7% of all MWh to another time of day. Large, responsive users are the customers who would benefit the most by installing the equipment necessary for automated response to RTP. With RTP, each customer is free to react in the ways that best serve her interest.

References

[1] PJM Market Data. Available: http://www.pjm.com/markets/market-monitor/data.html

[2] Boisvert, Richard N, Peter Cappers, Charles Goldman, Bernie Neenan, and Nicole Hopper (2007). "Customer Response to RTP in Competitive Markets: A Study of Niagara Mohawk's Standard Offer Tariff," *The Energy Journal,* Vol. 28, No. 1.

[3] *Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them: A Report to the United States Congress Pursuant to Section 1252 of the Energy Policy Act of 2005*. US Department of Energy, February 2006. Available: http://www.oe.energy.gov/DocumentsandMedia/congress_1252d.pdf

2. At E = -0.2, the typical responsive customer saves 5.0% per unit and 3.5% overall; the typical unresponsive customer saves 3.6% although her quantity consumed is constant.

[4] King, Chris S, and Sanjoy Chatterjee. "Predicting California Demand Response: How do Customers React to Hourly Prices?" *Public Utilities Fortnightly*, July 1, 2003. Available: http://www.americanenergyinstitutes.org/research/CaDemandResponse.pdf