Power System Engineering, Inc.

Price Impacts on Peak Demand

Summary of Pilot Program Results

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Topics for Discussion

- Time-sensitive pricing vs. Dynamic pricing
  - Review of several pilot programs that test the different pricing programs.
- Questions for consideration:
  - Does this change the understanding of electricity demand by residential consumers?
  - Carrot or stick approach?
  - How does this apply to my utility?
  - How could this impact my forecast?

Review: Elasticity of Demand

- Defined as the % change in quantity demanded of a commodity in response to a change of price in that commodity.
- This can be calculated for either kW or kWh
- Could be price of electricity or LP gas
  - Own vs. Cross elasticity
- Conventional wisdom for electric price elasticity:
  - Residential: .1 to .2; Commercial: .3 to .5; LCI: .5 to 1.0
  - Peak elasticity is very low
- Emerging evidence: proper rate design can generate significant peak reduction, even for residential consumers.

How to send the signal to the consumer?

- A motivation: Convey dramatic cost difference by time periods to end users, which can guide decisions on use
- Different methods can be used:
  - Dynamic pricing: Real time costs passed to the consumer
  - Time sensitive pricing: different predetermined prices passed on to the consumer for different time periods

Different time sensitive programs

The following groups of pricing programs were evaluated:

- Time of Use (TOU)
- TOU with Technology
- Peak Time Rebates (PTR)
- Critical Peak Price (CPP)
- CPP with Technology

Technology used to send price signals

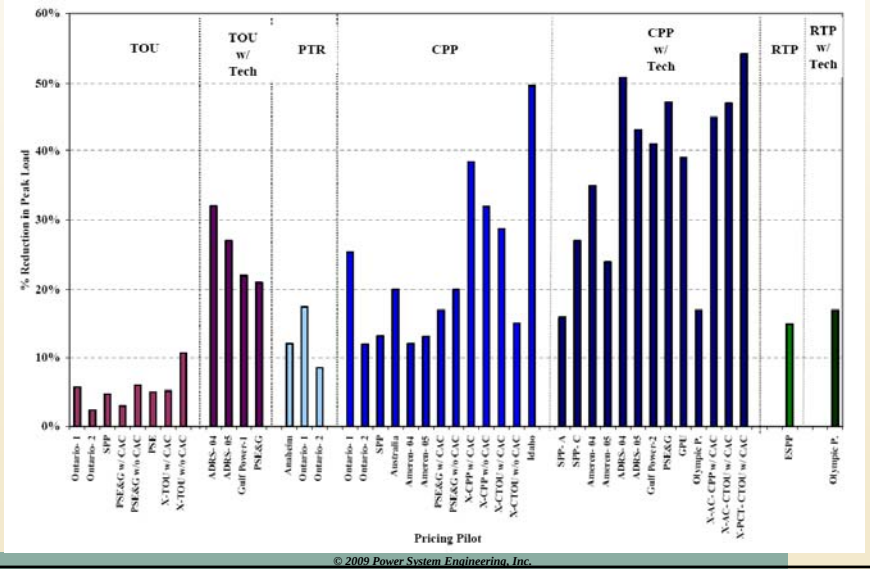
Technology

- Price information only
  - Email, text message, thermostat or other
- In home display device
  - Orb, color box, thermostat, or other
- Question to answer:
  - Customer control or utility control

How to set your Price

- Can you borrow from other studies or should you run a pilot?
  - The majority of available studies are dominated by large IOUs
  - Results indicate substantial potential
  - Different program design = big differences in results
  - Need pilots for smaller IOUs, municipals & cooperatives

Overview of Pilots and Goals



Overview of Pilots and Goals

- Different utility pilots have varied geographic locations.
  - An overview of the ones in this presentation.
    - Ontario: Energy Board
    - New Jersey: PSE&G
    - Illinois: Community Cooperative
    - California Statewide Pricing Pilot
    - New Jersey: GPU
    - Idaho: Idaho Power
    - Florida: Gulf Power
    - Colorado: Xcel

Ontario 1&2: TOU

- Ontario Energy Board's Smart Price Pilot
  - Tested TOU rates with a CPP component
    - The customer groups were broken into 3 pricing structures.
    - TOU customers followed the base TOU rates.
    - TOU customers with a CPP component were subjected to the same rates as TOU customers.
      - On-peak price to C$0.30 for the 93 highest hourly Ontario electric price from the previous year (Stick)
    - TOU customers with a CPR (critical peak reduction) were given a rebate of C$0.30 per kWh for each kWh reduction from the estimated baseline. (Carrot)
      - Baseline consumption was defined as the average usage during the same hours over the participants' last 5 non-event weekdays, increased by 25%.

Ontario 1&2: TOU

- TOU Base Rates

Season	Time	Charge	Applicable
Summer (Aug 1- Oct 31)	Off-peak	C$0.035/kWh	10 p.m.- 7 a.m. weekdays, all day on weekends, and holidays
Summer (Aug 1- Oct 31)	Mid-peak	C$0.075/kWh	7 a.m. - 11 a.m. and 5 p.m. - 10 p.m. weekdays
Summer (Aug 1- Oct 31)	On-peak	C$0.105/kWh	11 a.m. - 5 p.m. weekdays

- Results kW load shifted

	TOU	TOU-CPP	TOU-CPR	Control
Customers	124	124	125	125
Response to Price Structure (load shift in critical peak period)	5.7%	25.4%	17.5%	
Response to Price Structure (shift in all hours)	2.4%	11.9%	8.5%	

New Jersey - PSE&G Residential Pilot Program

- Residential TOU/CPP pilot
  - The customer groups were broken into 2 pricing structures:
    - myPower Connection customers were provided a free Programmable Communicating Thermostat (PCT) that received price signals from PSE&G and adjusted their air-conditioning setting based on previously programmed set points.
    - myPower Sense customers were educated about the TOU/CPP rates and notified on a day-ahead basis. This group was also divided between those that owned central air-conditioning and those that did not.
  - Total of 1,148 customers participated in the study: 379 in the myPower Sense, 319 in the myPower Connection , and 450 in the control group.

Period	Charge (June to September 2006)	Charge (June to September 2007)	Applicable
Base Price	$0.09/kWh	$0.087/kWh	All hours
Night Discount	-$0.05/kWh	-$0.05/kWh	10 p.m.-9 a.m. daily
On Peak Adder	$0.08/kWh	$0.15/kWh	1 p.m.-6 p.m. weekdays
Critical Peak Adder	$0.69/kWh	$1.37/kWh	1 p.m.-6 p.m. weekdays when called (Added to the base price when called)

New Jersey - PSE&G Residential Pilot Program

- Results
  - 2 CPP events in 2006 and 5 CPP events in 2007.
  - myPower Connection customers reduced their demand by 21% on TOU-only pricing and an additional 26% on CPP event days.
  - myPower Sense customers with CAC reduced their demand by 3% with TOU and 17% on CPP days. A very interesting finding was that those without CAC reduced their demand by 6% with TOU and 20% on CPP days.
  - It was clear that myPower Connection customers were able to reduce their demand more consistently because of the PCT technology.

Impact Substitution	Estimated Elasticity	90% Confidence Interval
myPower Connection	0.125	0.12 to 0.131
myPower Sense with CAC	0.069	0.063 to 0.075
myPower Sense without CAC	0.063	0.055 to 0.072

Illinois – Community Energy Cooperative's Smart Pricing Plan

First U.S. residential real-time pricing pilot

- Completed in ComEd territory in northern Illinois between 2003 and 2006.
- Started with 750 participants and expanded to almost 1,500 customers in 2005 and 2006.
- The focus of the experiment was to test if the major benefit may result from RTP without the adoption of expensive technology.

Illinois – Community Energy Cooperative's Smart Pricing Plan

Design:

- Day-ahead announcement of the hourly electricity prices for the next day.
- High-price day notification via phone or email when the price of electricity climbed over $0.10 per kWh (in 2006, the notification threshold was set to above $0.13 per kWh).
- A price cap of $0.50 per kWh for participants - the maximum hourly price is set at $0.50 per kWh during their participation in the program.
- From 2005 on, cycling switches for central air-conditioners were installed at participants' homes.
- In 2006, the Energy PriceLight, was distributed.
- Energy usage education was provided for participants.

Illinois – Community Energy Cooperative's Smart Pricing Plan

Results for 2005:

- The main goals:
  - determine the price elasticity of demand
  - Overall impact on energy conservation.
- Price elasticity in summer of 2005 was estimated to be -0.047.
  - With enabling technology during high-price periods (automatic cycling of the central air-conditioners) it was -0.069.
  - The largest response occurred on high-price notification days.
  - On the day with the highest prices in 2005, consumption was reduced by 15% compared to the flat ComEd residential rate.
- Price responsiveness varied over the course of a day.

Illinois – Community Energy Cooperative's Smart Pricing Plan

Results for 2005

Period	Elasticity
Daytime (8 am to 4pm)	-0.02
Late afternoon/evening hours (4 pm to 12am)	-0.03
Daytime: High Price notification	-0.02
Late afternoon/evening : High Price notification	-0.05

- Energy Smart Pricing Plan (ESPP) participants consumed 35.2 kWh less per month in summer months compared to base.
- These savings represented roughly 3 to 4% of summer electricity usage. Statistically significant savings were not found for winter usage, which is not surprising since most high-price days occur in the summer months in this area.
- Overall, ESPP resulted in a net decrease in monthly energy consumption. NOT Energy Neutral

Illinois – Community Energy Cooperative's Smart Pricing Plan

Elasticity results for 2006:

- Results in 2006 supported 2005.
- The price elasticity in summer of 2006 for hours when the price of electricity was at or below $0.13 per kWh was estimated to be -0.047.
- The price elasticity for the same period, but for hours when the price of electricity was above $0.13 per kWh, was estimated to be -0.082.
- The Energy PriceLight improved customer responsiveness, resulting in an elasticity of -0.067 across all hours. For customers with A/C cycling, the price elasticity for high price periods was estimated at -0.098.

Illinois – Community Energy Cooperative's Smart Pricing Plan

Energy impact results for 2006:

- ESPP participants consumed 16.7 kWh less per month, year round, relative to individuals not in the ESPP program.
  - This translates to approximately 3% of summer electricity usage, similar to the savings results of the 2005 program year.
  - ESPP resulted in a decrease in monthly energy consumption. (Not Energy Neutral)

California - Statewide Pricing Pilot

- Overview
  - California's three IOUs partnered with the two regulatory commissions for this pilot, which ran from July 2003 to December 2004 to test the impact of several time-varying rates.
  - It had about 2,500 participants including residential and small to medium C&I customers. Only residential results are presented here.

TOU -only rate		Time
On-Peak	0.22/kWh	12am -2pm and 7 pm - 12 am weekdays, all day on weekends
Off-Peak	0.09/kWh	2 pm - 7 pm weekdays
CPP	NA	NA
CPP-F		Time
On-Peak	0.22/kWh	12am -2pm and 7 pm - 12 am weekdays, all day on weekends
Off-Peak	.09/kWh	2 pm - 7 pm weekdays
CPP	.59/kWh	2 pm - 7 pm weekdays, when called
CPP-V		Time
On-Peak	0.22/kWh	12am -2pm and 7 pm - 12 am weekdays, all day on weekends
Off-Peak	0.09/kWh	2 pm - 7 pm weekdays
CPP	0.65/kWh	2 to 5 hours, 2 pm - 7 pm weekdays, when called

California - Statewide Pricing Pilot

Results for TOU

- The reduction in peak period energy use during the inner-summer months of 2003 (July-Sept) was estimated to be 5.9%.
  - However, this impact completely disappeared in 2004.

California - Statewide Pricing Pilot

Results for CPP-F

- On critical days, statewide average reduction in peak-period energy use was estimated to be 13.1%.
  - Impacts varied across climate zones from a low of 7.6% to a high of 15.8%.
- The average peak-period impact on critical days
  - Inner-summer months was 14.4%
  - Outer-summer months (May, June, Oct) was 8.1%.
- No change in total energy use across the entire year was found based on the average Statewide Pricing Pilot prices. Energy neutral
- The impact of different customer characteristics on energy use by rate period was also examined. Central AC ownership and college education are the two customer characteristics that were associated with the largest reduction in energy use on critical days.

California- Statewide Pricing Pilot

Results for CPP-V

- Divided into two groups: Track A and Track C.
  - Track A customers were drawn from a population with energy use greater than 600 kWh/month.
    - In this group, average income and central AC saturation was much higher than the general population.
  - Track A customers were given a choice of installing an enabling technology
    - about two-thirds of them opted for the enabling technology.

California- Statewide Pricing Pilot

Results for CPP-V (con't)

- Divided into two groups: Track A and Track C.
  - The Track C group was formed from customers who previously volunteered for a smart thermostat pilot.
  - All Track C customers had central AC and smart thermostats.
- This means that two-thirds of Track A customers and all Track C customers had enabling technologies.

California- Statewide Pricing Pilot

Results for CPP-V

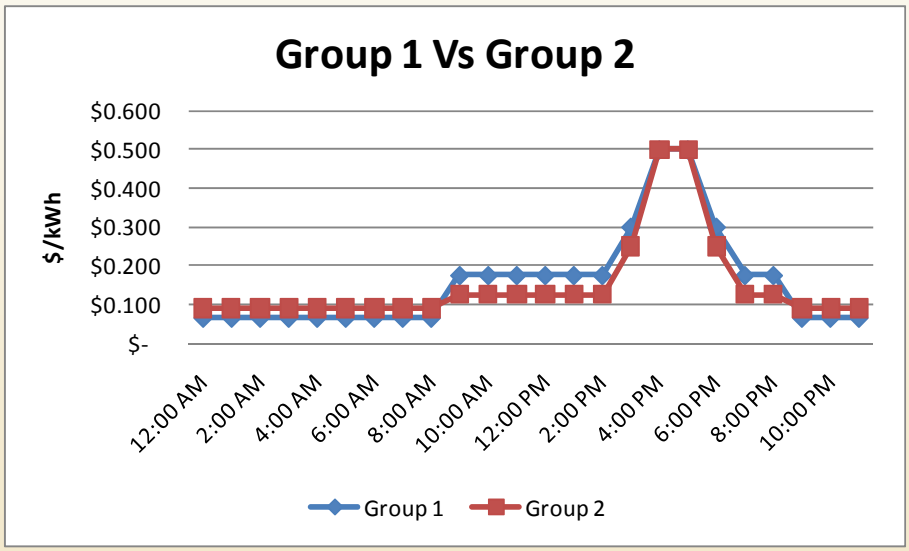
- Track A customers reduced their peak-period energy use on critical days by about 16% (about 25% higher than the CPP-F rate impact).
- Track C customers reduced their peak-period use on critical days by about 27%.
- Comparing the CPP-F and the CPP-V results suggests that usage impacts are significantly larger with an enabling technology than without it.

New Jersey - GPU Pilot

- In 1997, GPU offered a residential TOU/CPP pilot program with an enabling technology component.
  - The rate design involved 3 price tiers (peak, shoulder, and off-peak) and a critical peak price (limited number of high-cost summer hours).
- In addition, the pilot program tested the impacts from two sets of alternative rates by creating two groups and subjecting each group to one of the two sets of rates.

Control		Time
All hours	Standard increasing - Block residential tariff $0.12/kWh if consumption <=600 kWh per month; $0.153/kWh if consumption >600 kWh per month	All hours
Group 1		Time
Off-Peak	$0.065kWh	1am -8 am and 9 pm - 12 pm weekdays, all day on weekends
Shoulder	$0.175kWh	9am - 2 pm and 7 pm -8 pm weekdays
Peak	$0.30/kWh	3pm -6 pm weekdays
CPP	$0.50/kWh	When called
Group 2		Time
Off-Peak	$0.09kWh	1am -8am and 9 pm -12 pm weekdays, all day on weekends
Shoulder	$0.125kWh	9am - 2 pm and 7pm -8 pm weekdays
Peak	$0.25/kWh	3pm - 6 pm weekdays
CPP	$0.50/kWh	When called

New Jersey - GPU Pilot



New Jersey - GPU Pilot

- Results for non-critical weekdays
  - The largest usage reductions in the average hourly load were observed during the peak period and averaged 0.53 kW or 26% relative to the control group.
  - Load reductions were also observed during the late-morning shoulder period.
  - The high rate design reduced usage by roughly 50% more during each of the peak and shoulder periods than the treatment group with the low-rate design.

New Jersey - GPU Pilot

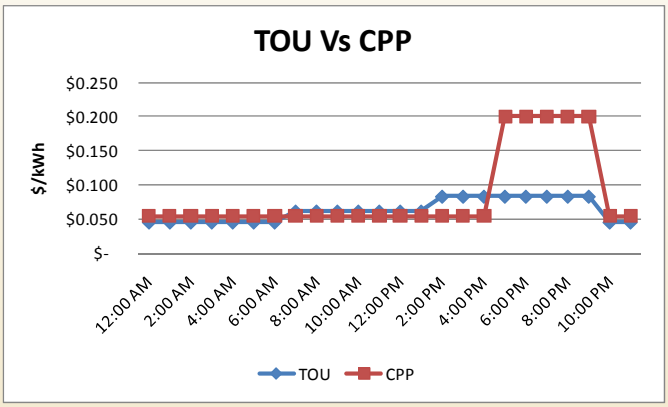
- Results for CPP weekdays
  - The results were similar to those on the non-CPP weekdays but larger in magnitude
  - In the first hour of the peak period, average load reduction was 1.24 KW or a 50 % reduction compared to the control group.
  - During the next two peak hours, the reduction was around 1 KW, later falling to 0.59 KW on the last peak hour.
  - The treatment group usage was substantially larger than the control group during the shoulder and off-peak periods following the critical peak hours.

Idaho - Energy Watch Pilot

- Idaho Power Company designed a CPP pilot which took place in the summer of 2006.
- Participants were notified of the CPP event on a day-ahead basis and a total of 10 events were called.
- The pilot divided the customers between 68 in the treatment group and 355 in the control group.

Control		Time
All hours	Standard increasing - Block residential tariff $0.054/kWh if consumption <=300 kWh/month; $0.061/kWh if	All hours
Treatment		**Time**
Off-Peak	$0.045/kWh	9 pm - 7 am weekdays, all day on weekends
Mid-peak	$0.061/kWh	7 am - 1 pm weekdays
Peak	$0.083/kWh	1 pm -9 pm weekdays
CPP-off peak	$0.054/kWh	All hours but CPP hours
CPP-on peak	$0.20/kWh	5 pm -9 pm on CPP days

Idaho - Energy Watch Pilot



- Average hourly demand reduction ranged from 0.64 kW (on June 29) to 1.70 kW (on July 27).
- Average hourly load reduction for all 10 event days was 1.26 kW. The average total load reduction for a 4-hour event was 5.03 kW.

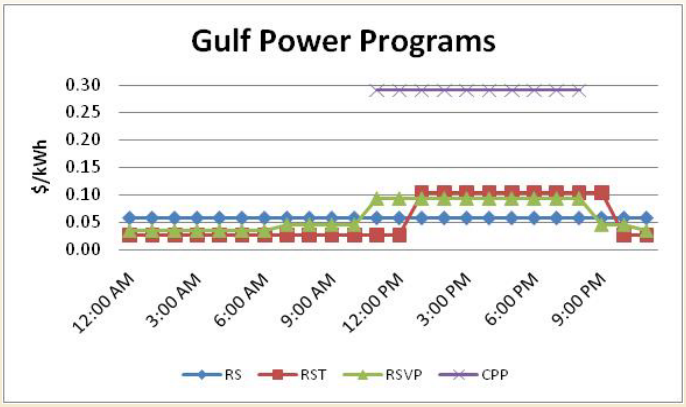
Florida - Gulf Power Select Program

- In 2000, Gulf Power offered a residential TOU/CPP pilot program with an enabling technology component. The rate design offered three different service options:
  1. The standard residential service (RS) pricing option, which involved a standard flat rate with no time varying rates.
  2. A conventional TOU pricing option, (RST) which is a two-period TOU tariff.
  3. The Residential Service Variable Price (RSVP) option, which is a three-period CPP tariff.

  The RSVP option also contained a technology component that allowed customers to modify their usage patterns through a combination of the price signals, advanced metering and appliance control.

Standard Service Rate		Time
Base	$0.057/kWh	All hours
RST		Time
Off-Peak	$.027/kWh	12 am - 12 pm and 9 pm to 12 am
Peak	$.104/kWh	12 pm - 9 pm
RSVP		Time
Off-Peak	$.035/kWh	12 am -6 am and 11 pm - 12 am
Mid-peak	$.046/kWh	6 am - 11 am and 8 pm -11 pm
Peak	$.093/kWh	11 am -8 pm
CPP	$.29/kWh	When called

Florida - Gulf Power Select Program



- Gulf Power reports the base coincident peak demand as 6.1 kW per household. RSVP program participants reduced their demand by 2.75 kW per household during the critical peak period. This corresponds to a 41% reduction in energy usage during the critical peak period.

Colorado - Xcel TOU/CPP Pilot

- The goal was to test both TOU and CPP rates.
  - In addition, some customers were provided enabling technologies: AC switching and programmable communications thermostats.
  - All the data in this program was collected via AMR meters.

Program 1: Time-of-use (RTOU)
Higher price during on-peak periods and a lower price during off-peak periods
Program 2: Critical peak (RCPP)
Critical peak prices up to 10 summer days; lower off-peak prices at all other times
Notification of the peak days by 4 pm the day before.
Program 3: Time-of-use+ critical peak (RCTOU)
Higher on-peak price (lower than the RTOU on-peak prices), lower off-peak prices, and critical peak prices up to 10 summer days

Colorado - Xcel TOU/CPP Pilot

Rate	Enabling Technology	Central AC	Critical Peak	On Peak	Off Peak
TOU	None	No	-	-0.1063	-0.0295
TOU	None	Yes	-	-0.0519	-0.0027
CPP	None	No	-0.3191	-	-0.0008
CPP	None	Yes	-0.3842	-	0.0059
CPP	AC Cycling Switch	Yes	-0.4481	-	0.0134
CTOU	None	No	-0.1512	-0.0251	0.0869
CTOU	None	Yes	-0.2875	-0.0821	0.0356
CTOU	AC Cycling Switch	Yes	-0.4686	-0.1063	0.04
CTOU	PCT	Yes	-0.5422	-0.1029	0.0296

- Participants subject to critical peak pricing reduced demand during peak hours substantially more than customers not subject to CPP.
- Important to note again, however, that self-selection may have played a role in the observed demand response impacts.

How do changes in price manifest themselves in demand?

The magnitude of price response depends on several factors:

- Magnitude of the price increase
  - What would it take on your system?
- Presence of central air-conditioning
  - Could you use electric heat or water heaters?
- Availability of enabling technologies
  - Would you want to add this to the mix on your system?
  - Do you have AMI or will you?

What did the most successful programs find?

Across the range of experiments studied:

- TOU rates induce a drop in peak demand that ranges between 3 and 6%.
  - California's State Wide Pricing Pilot
  - New Jersey's Public Service Electric and Gas w/o & w/ AC
  - Colorado's Xcel w/o & w/ AC
- CPP tariffs lead to a drop in peak demand of 13 to 20%.
  - New Jersey's Public Service Electric and Gas w/o & w/ AC
  - Colorado's Xcel w/o & w/ AC
- CPP tariffs accompanied with enabling technologies lead to a drop in peak demand in the 27 to 44% range.
  - Ameren 2004 & 2005
  - New Jersey's Public Service Electric and Gas w/o & w/ AC
  - Colorado's Xcel w/o & w/ AC

Who benefits?

Customers:

- Feeling of being in control
- Lower electric bills

Utilities:

- Better management of demand and supply resources
- Being good corporate citizens
- Higher earnings (rate decoupling)

Society:

- Cleaner environment
- Good legacy for children and grandchildren

Thank You

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