



The Impact of Dynamic Pricing on Low Income Customers

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EXECUTIVE SUMMARY

There is a rapidly growing literature which shows that dynamic pricing, by lowering peak demand during hours when the power system is critical, can provide substantial benefits to utilities and customers by avoiding expensive capacity and energy costs in the long term and lowering wholesale market prices in the short term. By now, there is little dispute about the impact of dynamic pricing on customers in the aggregate. However, there is much disagreement about the impact of dynamic pricing on certain customer segments, most notably low income customers.

Two competing forces are at work. Since low income customers use relatively less energy during the peak hours, their load profiles are flatter than those of the average residential customer. This would make them immediate beneficiaries of a rate that charges more during peak hours. And if they exhibit demand response, by curtailing their usage during peak hours or shifting their usage to off-peak hours, they would gain even more. Others suggest that low income customers have little discretion in their power usage. Thus, they have less to work with in terms of ability to shift load.

Ultimately, whether and how much low income customers respond to price signals is an empirical question that can be resolved on the basis of empirical evidence. This paper provides new information about how low income customers respond to dynamic prices. It draws upon results from three recent dynamic pricing programs in Connecticut, the District of Columbia, and Maryland: Connecticut Light & Power's (CL&P's) Plan-it Wise Energy Pilot (PWEP), Pepco's PowerCentsDC Program (Pepco DC), and Baltimore Gas & Electric's Smart Energy Pricing Pilot (BGE 2008). It also presents early results from a full scale program that is being rolled out by Pacific Gas & Electric Company (PG&E) in California, the SmartRate Tariff. For completeness, results are also summarized from California's widely cited Statewide Pricing Pilot (SPP), even though it was conducted over five years ago during the period from 2003 to 2005, as well as simulation results.

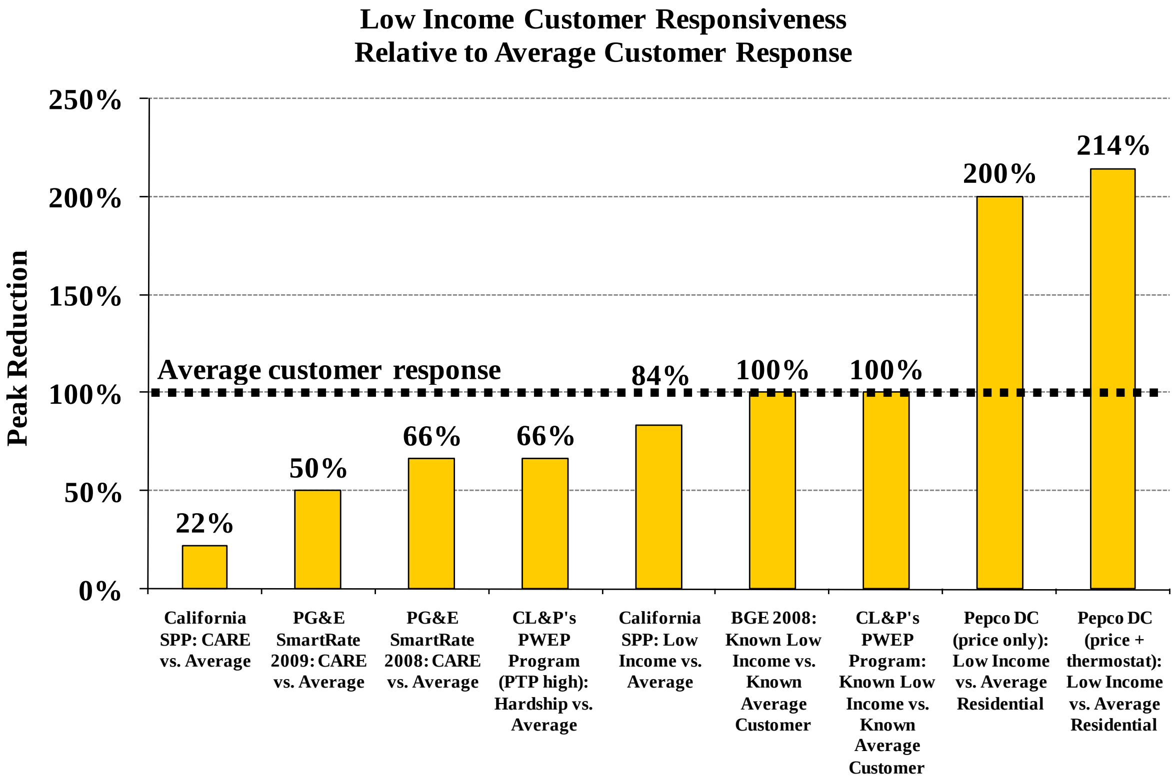
Our core finding is that low income customers are responsive to dynamic rates and that many such customers can benefit even without shifting load. These results are encouraging. Contrary to the arguments about the inability of low income customers to respond to price signals, these results show that low income customers do shift their load in response to price signals. Table 1 and Figure 1 summarize the findings. In Figure 1, if low income customers respond less than the average customer, the corresponding bars are lower than 100 percent. Conversely, if low income customers respond more than the average customer, the corresponding bars are higher than 100 percent. These results are further detailed in this paper.

Table 1. Summary of Low Income and Average Customer Response to Dynamic Prices[1]

Program Results	Low Income Peak Reduction	Average Peak Reduction	Low Income vs. Average
BGE 2008: Known Low Income vs. Known Average Customer	*Varies depending on rate type; low income customers respond similarly to average customer*		100%
CL&P's PWEP Program: Known Low Income vs. Known Average Customer	*Varies depending on rate type; low income customers respond similarly to average customer*		100%
CL&P's PWEP Program (PTP high): Hardship vs. Average	13%	20%	67%
Pepco DC (price only): Low Income vs. Average Residential[1]	10%	5%	200%
Pepco DC (price + thermostat): Low Income vs. Average Residential[1]	15%	7%	214%
PG&E SmartRate 2008: CARE vs. Average	11%	17%	66%
PG&E SmartRate 2009: CARE vs. Average	8%	15%	50%
California SPP: Low Income vs. Average	11%	13%	84%
California SPP: CARE vs. Average	3%	13%	22%

[1] In most of these cases, the low income result is compared to the result of the average customer, which includes low income customers. However, for the PepcoDC pilot, the average residential response excludes low income customers that qualify for the RAD program; in that case, the low income customers are compared to the average non-low income customers.

Figure 1. Summary of Low Income Customer Responsiveness to Dynamic Prices Relative to Average Customer Response

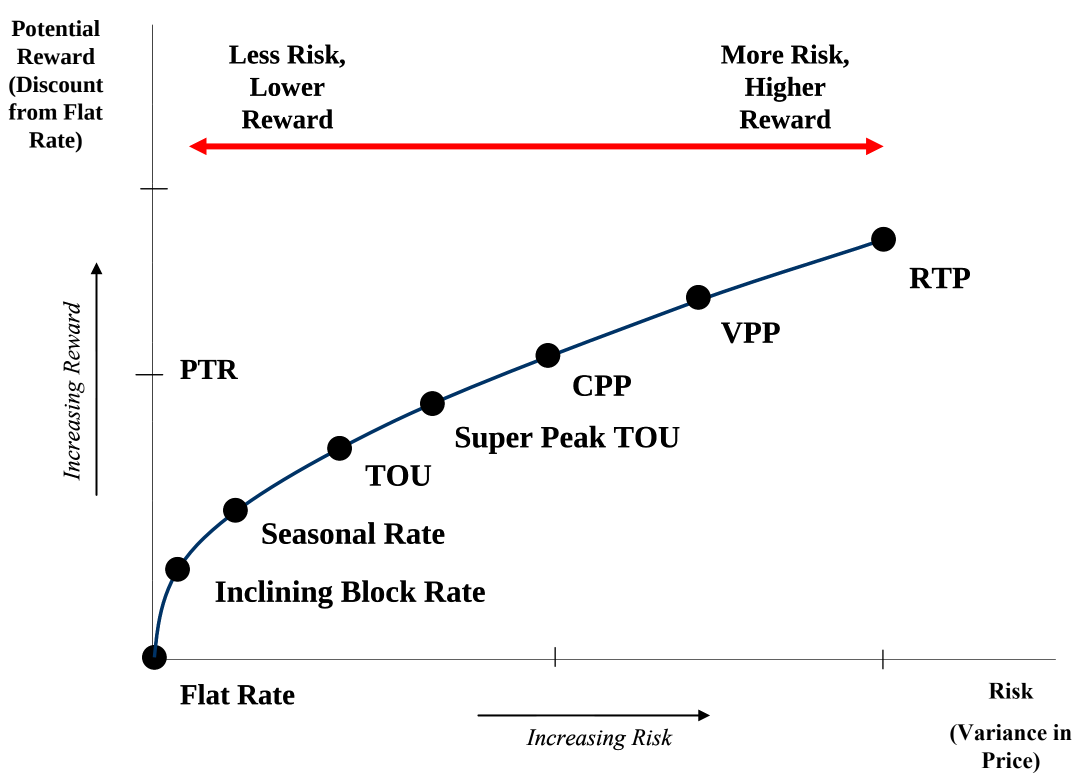


Note: For the PepcoDC pilot, the average residential response excludes low income customers that qualify for the RAD program.

DYNAMIC PRICING

Before examining the impact of dynamic pricing on low income customer response, we present background information. The majority of mass market customers today pay flat rates that do not vary with the hourly, daily, or seasonal variation in the cost of producing and delivering electricity. By contrast, time-varying prices reflect wholesale price volatility in varying degrees. Flat rates and time varying rates fall along the arc of risks and rewards shown in Figure 2. In the figure, a flat rate is shown at the lower left, reflecting the minimal risk of wholesale price volatility customers incur by paying the same retail rate regardless of the wholesale cost of electricity. Under flat rates, the utility assumes all of the risk of wholesale price volatility and factors this risk into the cost-to-serve customers. Hence, under flat rates customers pay a premium for the utility to hedge their risk. At the other end of the spectrum is real time pricing, where the customer assumes all of the risk and pays a retail rate that is directly linked to the marginal cost or the wholesale price of electricity. Under real time pricing customers pay the utility no hedging premium, and are rewarded with a lower cost of service. Other time-varying rates fall in between.

Figure 2. Risk and Reward Trade-off with Time-Based Rates



Time of use (TOU) rates are positioned next to the flat, or fixed, rates on this spectrum. TOU rates reflect the higher cost of supply during peak periods and lower cost during off-peak periods. However, TOU rates are not "dynamic" in that they are not dispatched based on the changes in actual wholesale market prices.

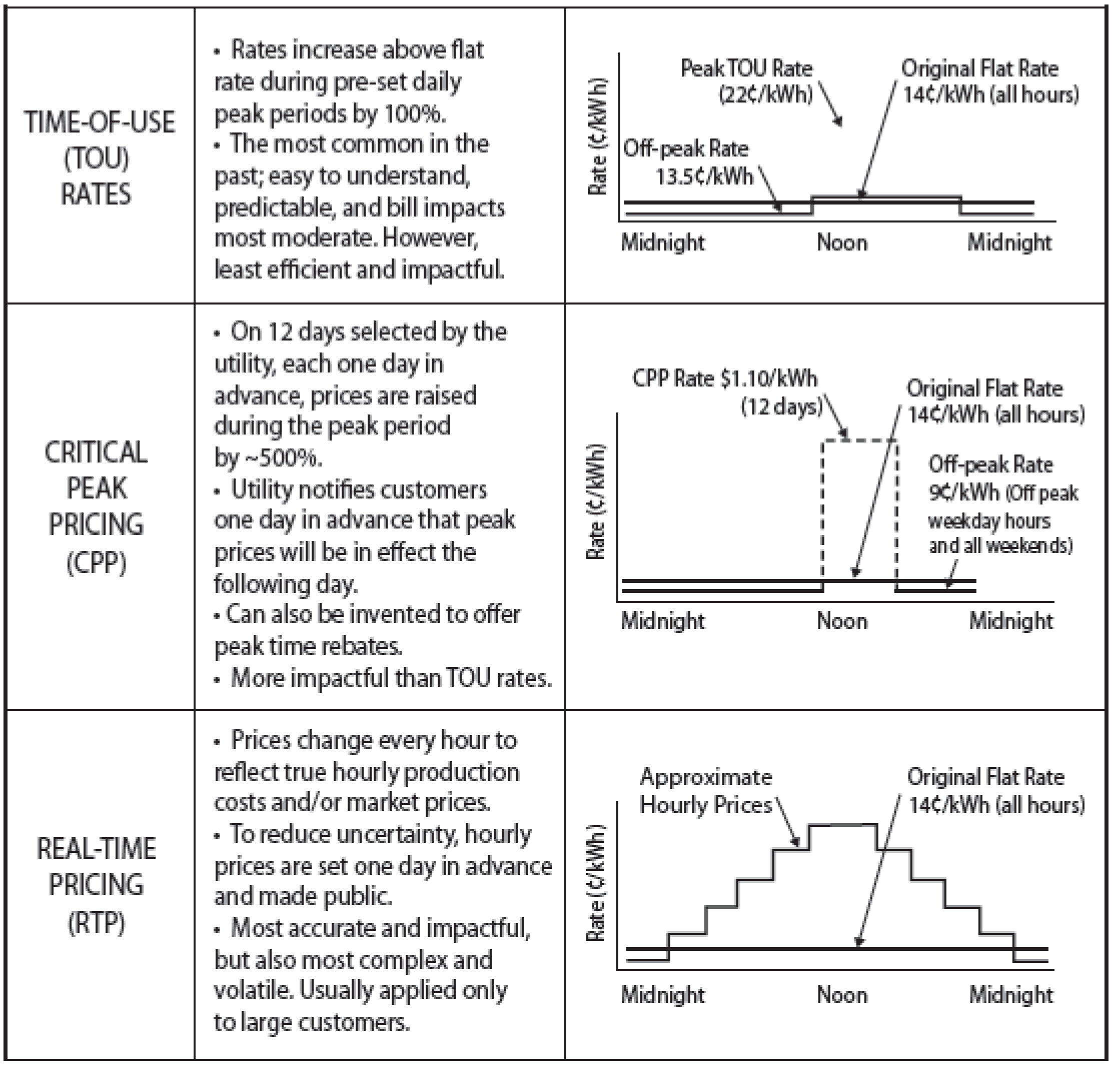
Real time pricing (RTP), on the other hand, constitutes the purest form of dynamic pricing. Customers pay electricity prices that are linked to the wholesale cost of electricity on an hourly (or sub-hourly) basis. Prices are provided on a day-ahead or hour-ahead basis and may apply to a customer's entire load or a portion of their load. Although RTP is the purest form of dynamic pricing and ideal from a price signal perspective, it may not be the best option for smaller mass market customers (e.g., residential and small commercial). For the majority of mass market customers, rates that approximate RTP make more sense. One such approximation is critical peak pricing which sits somewhere close to the center of the time varying price spectrum.

Critical peak pricing (CPP), attempts to convey the true cost of power generation to electricity customers by providing a price signal that more accurately reflects energy costs during a small percentage of all hours, the most critical 100 to 200 hours of the year. In exchange for paying very high prices during this small number of hours, customers receive a discounted rate for all remaining hours of the year. Under CPP rates, if customers can shift their electricity usage from the more expensive hours to the less expensive hours, they can reduce their electricity bills.

An alternative to the CPP rate is the *peak time rebate (PTR)* which is a mirror image of the CPP rate. In contrast to CPP rates, where customers pay higher rates during critical event hours and lower rates during other hours, under a PTR customers remain on their current flat rate but receive a cash rebate for each kWh of load that they reduce below their baseline usage during the CPP event hours. Under a PTR, no customer can be charged more than they would be on a corresponding flat rate if they do not respond, but customers who do respond can save on their monthly bill. However, PTR has a few drawbacks. First, a PTR requires the establishment of a baseline load for each customer from which the reductions can be computed. Second, since customers do not receive a higher price, per se, educating customers who are actually on this new rate can be challenging. With a PTR, customers who don't respond by shifting load wind up paying the rebates to those customers that do respond.

Figure 3 summarizes three time-varying rates – TOU, CPP, and PTR – and provides examples of typical rate levels.

Figure 3. Time Varying Electricity Pricing with Example Rates



TIME-OF-USE (TOU) RATES	• Rates increase above flat rate during pre-set daily peak periods by 100%. • The most common in the past; easy to understand, predictable, and bill impacts most moderate. However, least efficient and impactful.	
CRITICAL PEAK PRICING (CPP)	• On 12 days selected by the utility, each one day in advance, prices are raised during the peak period by ~500%. • Utility notifies customers one day in advance that peak prices will be in effect the following day. • Can also be invented to offer peak time rebates. • More impactful than TOU rates.	
REAL-TIME PRICING (RTP)	• Prices change every hour to reflect true hourly production costs and/or market prices. • To reduce uncertainty, hourly prices are set one day in advance and made public. • Most accurate and impactful, but also most complex and volatile. Usually applied only to large customers.	

Source: Fox-Penner (2009), page 41.

Most of the empirical evidence available on low income customer price responsiveness is based on the CPP or PTR (also called critical peak rebate [CPR]) rates. In addition, these two rates have gained the most attention and traction in the power industry and among state regulators. Therefore this paper focuses on these two rates.

IMPACT OF DYNAMIC PRICING ON LOW INCOME CUSTOMERS PRIOR TO DEMAND RESPONSE

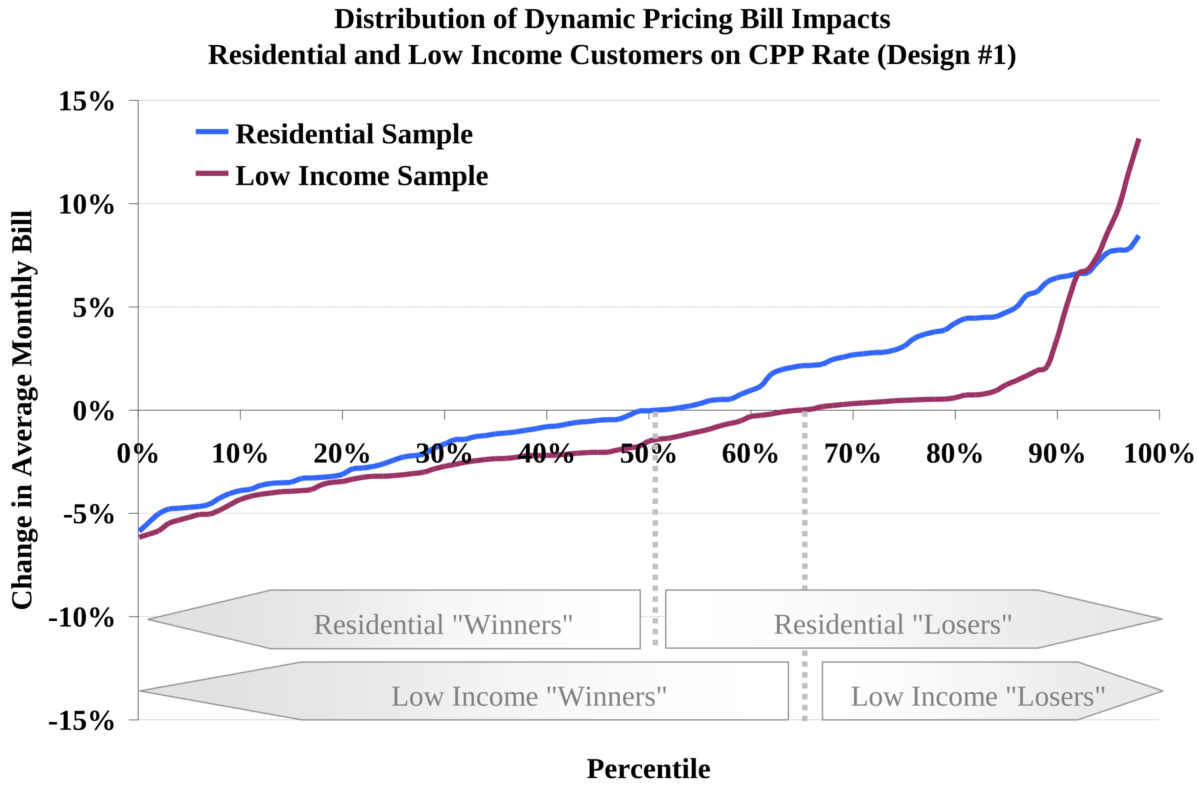
Before reviewing the empirical evidence on low income customer responsiveness to dynamic pricing, it is useful to examine how dynamic pricing will affect low income customers even if there is no demand response. To do this, we simulated two versions of a CPP rate and one version of a PTR rate for representative samples of residential and residential low income customers at a large urban utility. All rates were designed to be revenue neutral relative to the existing rate of 13 cents per kWh.

The first CPP we examined included a critical peak price of $1.25 per kWh during a four-hour peak period from 2 p.m. to 6 p.m. on fifteen critical days in the summer for a total of 60 hours. During the other 8,700 hours of the year, the rate was roughly 11 cents per kWh.

- For a revenue neutral dynamic pricing rate such as this, we might expect half the customers in a utility's service area to see immediately higher bills and the other half of customers to see immediately lower bills. For our sample of residential customers, roughly half was immediately better off and the other half was immediately worse off on this CPP rate, as shown by the blue curve in Figure 4. Note that with demand response, the curve will shift down and more customers will experience bill decreases.

- However, running the same simulation on the same rate for a sample of low income customers shows a different starting point. *Because the low income customers tend to have flatter load shapes (than average customers), roughly 65 percent of the low income customers were immediately better off on the CPP rate than on the flat rate even without demand response*, also shown in Figure 4. Again, demand response will create even more winners.

Figure 4. Residential and Low Income Bill Impacts Based on CPP Rate Design #1



Next, we simulated the impact of a Peak Time Rebate (PTR) which featured a rebate of $1.10 per kWh during the critical peak periods for low income customers. All customers continued on the existing rate of 13 cents per kWh.

- As shown in Figure 5, the Peak Time Rebate (PTR) rate has no impact on bills before demand response. Thus, when thinking about the immediate (that is, before demand response) beneficiaries of a dynamic pricing rate, the CPP may be superior in that it creates instant winners out of more than half of the low income customers. At the same time, the CPP rate also creates a smaller number of instant losers, whereas the PTR rate leaves all customers' bills unchanged in the absence of demand response.

- After low income customers change usage in response to the PTR rate, almost all customers are better off and no customers are worse off, since customers can only benefit from a rebate. The bill changes shown after demand response in Figure 5 assume a moderate level of demand response, as predicted by the PRISM software.[2]

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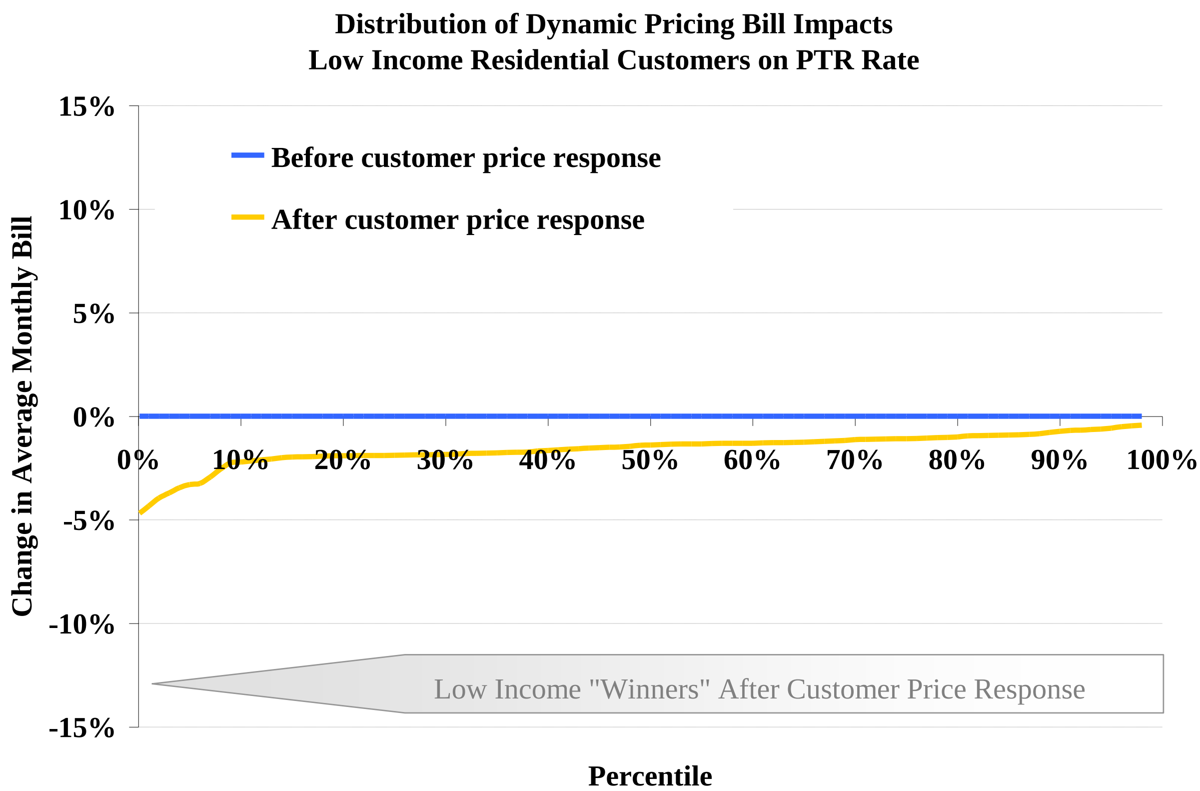
[2] PRISM or Price Impact Simulation Model, which forms the basis of FERC's *A National Assessment of Demand Response Potential* and which has been used in a variety of utility assessments, captures the actual

Figure 5. Low Income Bill Impacts on a PTR Rate Before and After Demand Response



As indicated by the prior examples, these results depend somewhat on the rate design itself. In order to test the sensitivity of these results, simulation results are also reported for different variations of the CPP rates. For Rate Design #2, we tested a CPP rate that was in effect during the four summer months (June through September) with seasonal revenue neutrality. The rate involved a critical peak rate of roughly 90 cents per kWh applied for a five-hour period from 2 p.m. to 7 p.m. during fifteen critical summer days. The off-peak rate was 10 cents per kWh during the four summer months. During the other months of the year, the current rate of 13 cents per kWh was in effect.

- As shown in Figure 6, the simulations showed that about 60 percent of residential customers would realize immediate bill decreases on this CPP rate.[3]

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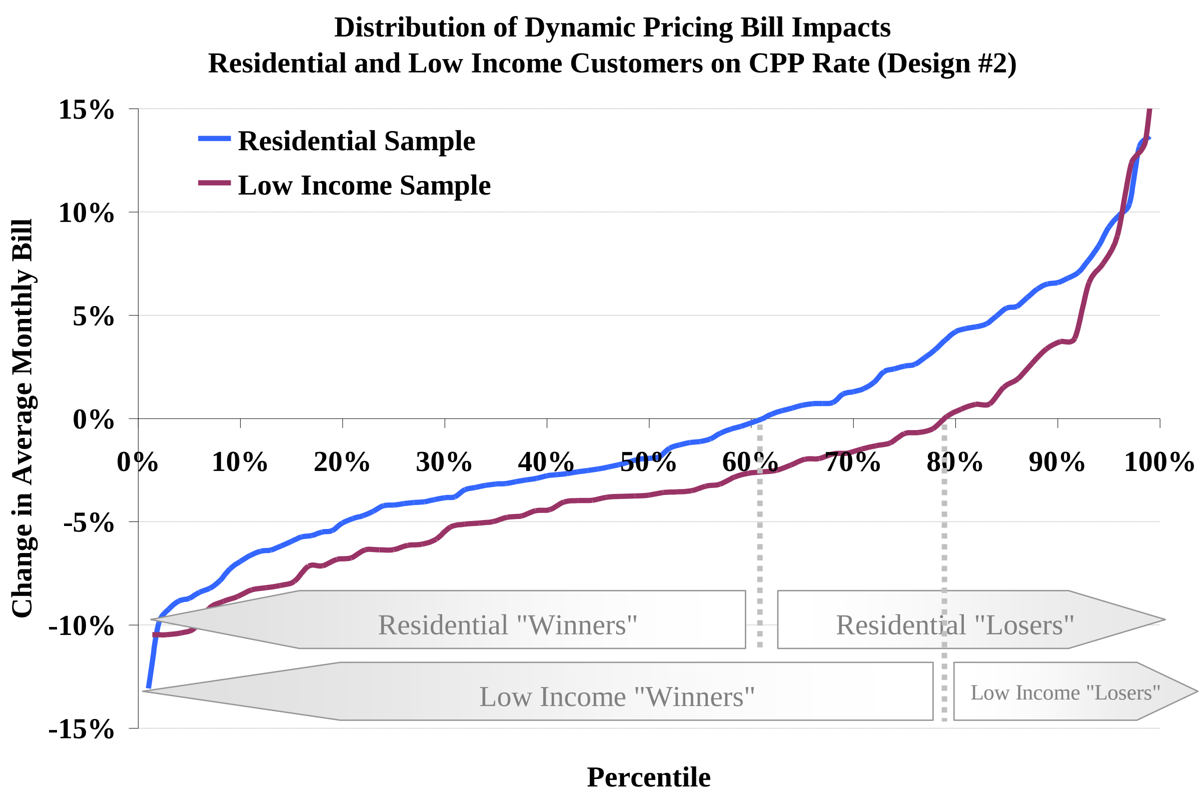
responses of thousands of customers during several residential dynamic pricing experiments and actual deployments for commercial and industrial customers.

3 In this sample, smaller customers tended to have flatter load shapes, and therefore also tended to experience immediate bill decreases. So, for the sample as a whole, the revenue change was close to zero, even though there were more winners than losers.

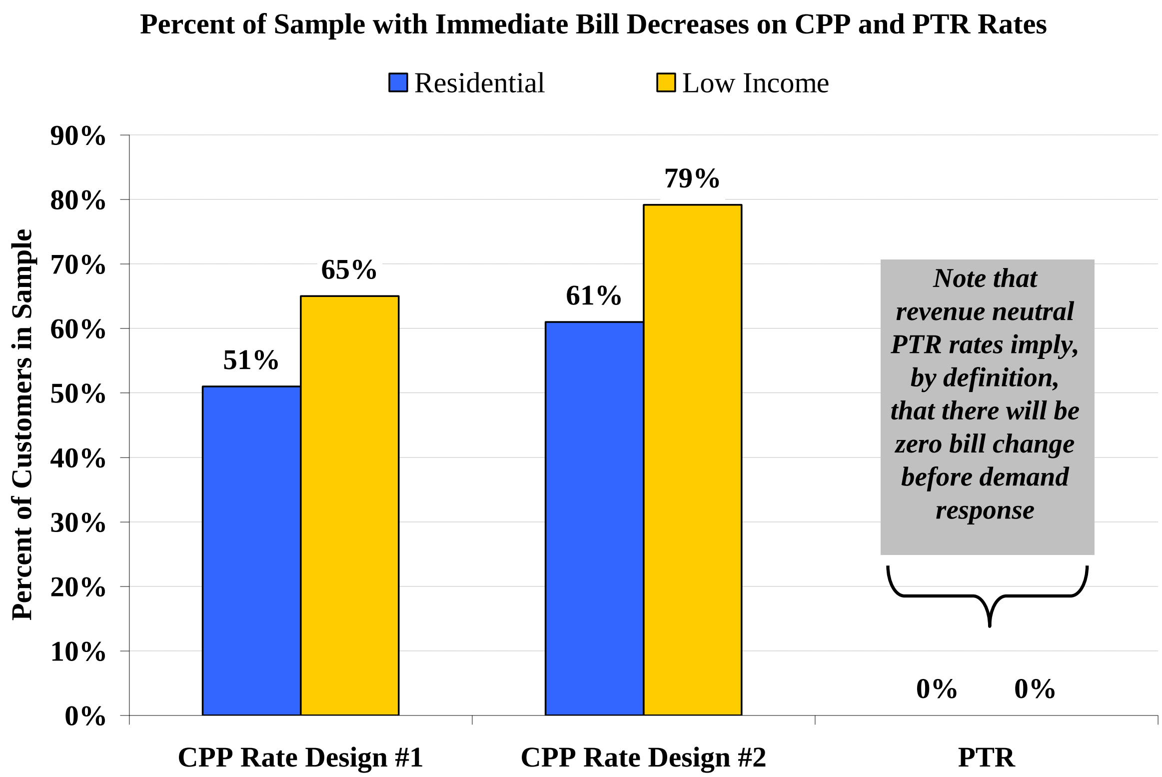
- For low income customers, even more are better off under this rate, with nearly 80 percent immediately better off on the CPP rate with no price response compared to on a flat rate. Remember, after demand response, the savings will be higher across the board.

Figure 6. Residential and Low Income Bill Impacts Based on CPP Rate Design #2



The results of the simulations, summarized in Figure 7, indicate that the exact percentage of low income customers who will immediately benefit from dynamic pricing depends on the rate design itself. On the whole, it is highly likely that more than half of low income customers will immediately benefit from a CPP rate. In any case, the dynamic rate can clearly be designed so that a large percentage of low income customers will realize savings.

Figure 7. Percent of Sample with Immediate Bill Decreases Before Demand Response



IMPACT OF DYNAMIC PRICING ON LOW INCOME CUSTOMERS AFTER DEMAND RESPONSE

In this section of the paper, we review the evidence from four dynamic pricing pilot programs and one full-scale program to assess the price responsiveness of low income customers. These programs span four states – Maryland, Connecticut, the District of Columbia, and California:

1. BGE Smart Energy Pricing (SEP) Pilot – Maryland
2. CL&P Plan-it Wise Energy Program – Connecticut
3. PEPCO PowerCentsDC Program – District of Columbia
4. PG&E SmartRate Tariff – California
5. California Statewide Pricing Pilot (SPP) – California

In order to assess the price responsiveness of low income customers, we first need to define the term “low income”. The US government defines poverty based on the notion of “money income thresholds” that vary by family size and composition. If a family’s total income is less than the threshold, then that family and every individual in it is considered to be living in poverty. In 2008, the poverty threshold for a family of four with two children under the age of 18 was $21,834. Approximately 13 percent of the U.S. population was under this threshold in 2008. The pilots reviewed in this paper, however, do not share a uniform definition of poverty. For purposes of comparing the results, we simply identify the definition used in each pilot. A summary of these definitions is shown in Table 2 with more detail about PG&E’s CARE eligibility shown in Table 3.

Table 2. Definitions of Low Income Status across Pilots

Pilot	Definition of Low Income	Source
BGE Smart Energy Pricing (SEP) Pilot	Income less than $25,000	Survey question
CL&P Plan-it Wise Energy Program (PWEP)	1. Income less than $50,000 2. "Hardship"	1. Survey question 2. Defined by the state of Connecticut
PEPCO PowerCentsDC Program	Residential Aid Discount (RAD) customers	Defined by utility
PG&E SmartRate Tariff	California Alternate Rates for Energy (CARE) customers	Defined by utility
California Statewide Pricing Pilot (SPP)	1. California Alternate Rates for Energy (CARE) customers 2. Income snapshots of $40,000 (low income) and $100,000 (high income)	1. Defined by utility 2. Customer data

Table 3. PG&E Eligibility for CARE Program

Number of Persons in Household	Annual Income*
1 or 2	$30,500
3	$35,800
4	$43,200
5	$50,600
6	$58,000
For each additional person, add:	$7,400

Source: pge.com/care/

Not all of the pilots reviewed in this paper provide percentage load reduction impacts that can easily be compared across low income and high income customers. In some cases, the evidence is only available in the form of price sensitivity (i.e., price elasticity) parameters. Nevertheless, price sensitivity parameters are sufficient to assess the differences in price responsiveness between low income and higher income customers.

Our review of these five programs reveals that low income customers are responsive to dynamic rates, that many such customers can benefit even without shifting load, and that their degree of responsiveness relative to that of average customers varies across the studies reviewed.

Some studies found that low income customers were equally price responsive as higher income customers (as in CL&P and BGE programs), others found they were half as responsive (SPP and PG&E programs), while others found that low income customers were twice as responsive (PEPCO DC program) as the higher income customers. In the rest of this paper, we discuss the findings from each of the five studies.

BGE SMART ENERGY PRICING (SEP) PILOT – MARYLAND

Background

BGE conducted a Smart Energy Pricing (SEP) pilot program during the summer of 2008.[4] In 2008, the SEP pilot included 1,375 residential customers. 1,021 customers received dynamic rates and 354 customers formed a control group which stayed on their current rate. BGE also tested the impacts of two different technologies, the Energy Orb and a switch for cycling air conditioners, in conjunction with the dynamic pricing options.

The pilot tested three dynamic pricing structures: a dynamic peak pricing (DPP) tariff, a "low" Peak Time Rebate (PTRL), and a "high" Peak Time Rebate (PTRH). The DPP rate consisted of a critical peak rate of $1.30 per kWh, peak rate of $0.14 kWh, and an off-peak rate of $0.09 per kWh. There were 12 critical days called during the pilot period, and the critical hours were between 2 p.m. and 7 p.m. With both the low and high Peak Time Rebate, customers remained on their existing rate of $0.15 per kWh. However, during critical peak hours from 2 p.m. to 7 p.m. on the 12 critical days, customers received a rebate of $1.16 per kWh (low) or $1.75 per kWh (high) for reducing their consumption below their baseline amount.[5] Detailed description of the DPP and PTR rate designs are shown in Table 4.

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[4] Another SEP pilot was carried out in summer 2009, but there are no separate low income results from the 2009 analysis.

[5] In this pilot, the baseline was calculated by identifying ten non-event non-holiday weekdays preceding an event day, choosing the three highest kWh days while omitting any days not within 10% of the THI for the event day, and using these remaining days to calculate an average 24-hour load profile for each PTR customer.

Table 4. BGE SEP 2008 Rate Designs

BGE DPP and PTR Rate Design (June 1, 2008 - September 30, 2008)

Time / Day	Category	DPP	PTR	
		Rate ($/kWh)	Rate ($/kWh)	Rebate
2 p.m. - 7 p.m Weekdays (Non-Critical Days)	Peak	0.140	0.150	
2 p.m. - 7 p.m Weekdays (Critical Days)	Critical Peak	1.300	0.150	1.160 (PTRL); 1.750 (PTRH)
Weekends, Holidays & 7 p.m - 2 p.m Weekdays	Off-peak	0.090	0.150	

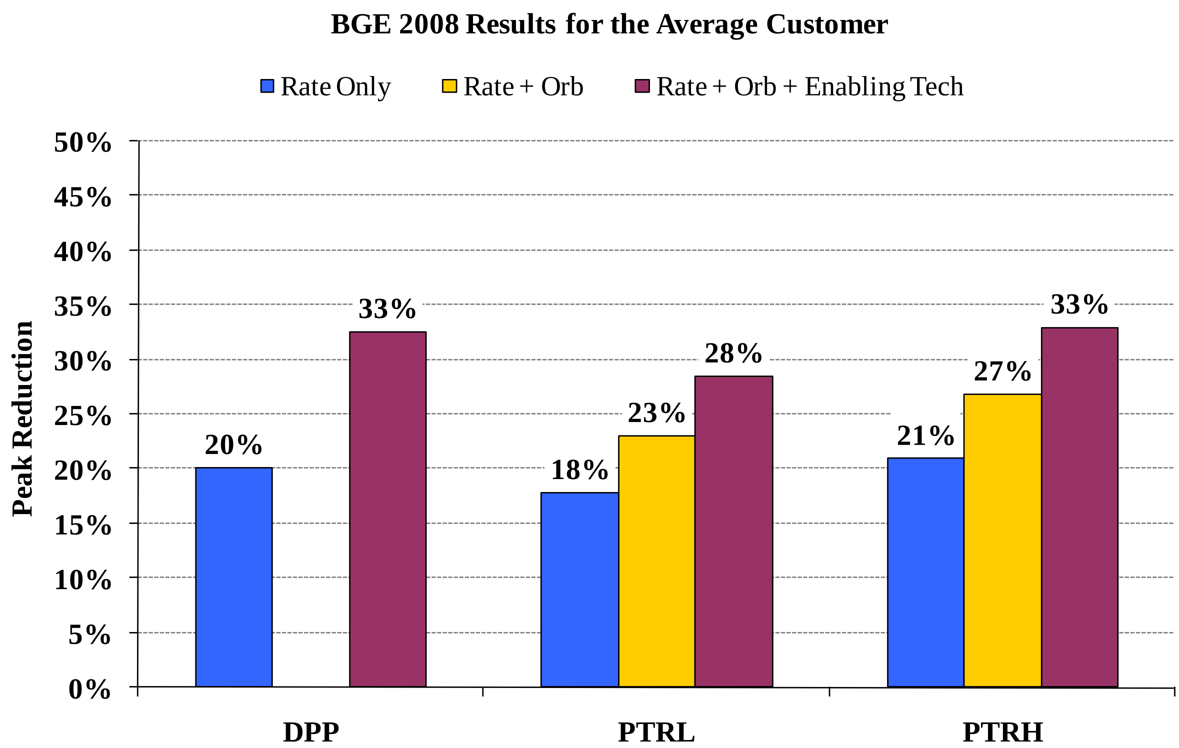
Notes:
The SEP DPP prices include generation, transmission, and distribution charges. They can be converted into all-in prices by adding the customer charge of $7.50 per month, which translates into $0.009/kWh for the average customer.
The PTR rate shown is the average all-in rate during the pilot period.

For the BGE analysis, a customer with an income level less than $25,000 was defined to be a low income customer, generally in line with the federal poverty threshold. This choice for the low income threshold was dictated by the income question in the enrollment survey.

Results

For the full sample of customers, the peak reductions varied across programs and enabling technology status. In the absence of enabling technologies, the peak reduction was 18 to 21 percent. With the Energy Orb, impacts ranged from 23 to 27 percent. With both the Energy Orb and a switch on the central air conditioner, the impacts ranged from 28 to 33 percent. *As expected, enabling technologies resulted in increased price response*. These results are shown in Figure 8.

Figure 8. Percent Peak Demand Reduction Based on BGE SEP 2008 Pilot



Note: The pilot did not test Rate + Orb for the DPP program.

Obtaining results for different income levels was more complicated. Since 368 out of 1,375 customers did not respond to the survey question on income; there were 1,007 customers whose income status was known. This subset of customers with known income status had different elasticities of substitution than the full sample; namely, the customers that responded to the survey question also tended to be more responsive to dynamic rates.

Within the subset of customers with known income status, we defined two groups – low income was defined as self reported income under $25,000 and high income was defined as self reported income over $75,000. The results show that a customer's income status did not have a measurable effect on their elasticity of substitution. *More explicitly, these results show that the elasticity of substitution of low income customers is not statistically different from that of other higher income customers whose income data is known*. However, we do not know how customers who did not respond to the survey question would have responded to dynamic rates.

CL&P PLAN-IT WISE ENERGY PROGRAM - CONNECTICUT

Background

CL&P conducted the Plan-it Wise Energy Program in the summer of 2009. The pilot included 1,251 residential customers, of whom 1,114 customers received dynamic rates and 137 customers constituted a control group that stayed on their current rate.

Plan-it Wise tested three different rate structures: Time of Use (TOU), Peak Time Pricing (PTP), and Peak Time Rebate (PTR), each with two different price levels (low and high). A total of 10 critical event days were called over the course of the pilot. The peak period was defined as between 2 p.m. and 5 p.m. for PTR and PTP, and between 12 noon to 7 p.m. for the TOU rate. The pilot also tested several different technologies including smart thermostats, A/C switches, Energy Orbs, and in-home displays (IHDs) in combination with the time-based rates. The rates tested in the pilot are detailed in Table 5.

Table 5. CL&P Plan-it Wise All-in Rate Designs

PWEP All-in Rate Designs, in $/kWh (June 1 2009 - August 31, 2009)

Period	Total Tariff Rate ($/kWh)	PTP Rate ($/kWh)		TOU Rate ($/kWh)		PTR Rebate ($/kWh)	
		Low	High	Low	High	Low	High
Peak	0.201	0.856	1.815	0.272	0.343	0.655	1.614
Off Peak	0.201	0.186	0.165	0.172	0.143	N/A	N/A

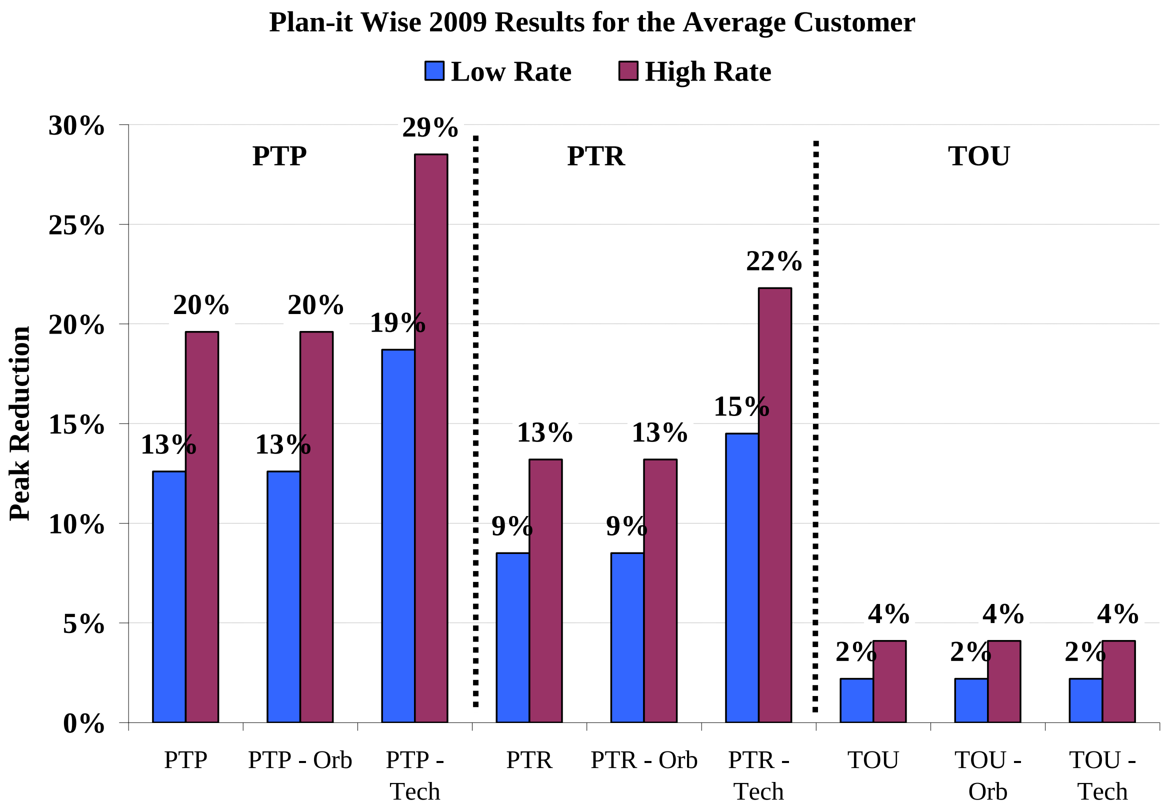
Note: The values shown in the table are weighted averages for Rate 1 and Rate 5 customers.

Two different definitions of low income customers were used for the purposes of this analysis. The first definition was based on the income question in the program enrollment survey, in which a customer was defined to be low income if her annual income was less than $50,000. The second definition was based on a customer being certified by the state as being in a state of hardship.

Results

First, the results were analyzed for the full sample. As shown in Figure 9, the PTP rate had the greatest impact, resulting in up to 29 percent peak reduction, while the TOU rates had the lowest impacts, between 2 and 4 percent peak reduction. As expected, the higher rates led to greater peak impacts. Note that these results are weather-normalized.

Figure 9. Percent Peak Demand Reduction Based on CL&P Plan-it Wise Pilot, 2009[6]



As with BGE, obtaining results for different income levels was more complicated. Only 552 out of 1,251 customers responded to the income question on the survey. However, within the subset of customers who did respond to the income question, the elasticities of substitution for low income customers were essentially the same as those for the average customer with known income data.

Using the second definition of low income—"hardship"—the results were slightly different. *In this case, results indicated that hardship customers responded slightly less than the average treatment customer to the PTP rate, although they did still respond. The incremental effect of the PTR rate was similar for hardship and non-hardship customers.* We estimate that where

[6] These results are based on the weather conditions of an average summer. The summer of 2009 was very mild and assessment of the impacts at the summer 2009 conditions would yield slightly lower peak reduction impacts.

average customers responded to the high PTP rate with a 20 percent peak reduction, hardship customers responded with a roughly 13 percent reduction, or about two-thirds as much.[7]

PEPCO POWERCENTSDC PROGRAM – DISTRICT OF COLUMBIA

Background

Pepco DC administered the PowerCentsDC pilot from July 2008 to February 2009. It involved nearly 900 treatment and 400 control group customers. One unique feature of the PowerCentsDC program is that it actively recruited a group of limited income customers to understand their responsiveness to dynamic pricing. All program participants were randomly selected and voluntarily recruited to the program.

Three rate designs were tested in the pilot: Critical Peak Pricing (CPP), Critical Peak Rebate (CPR) and Hourly Pricing (HP). The critical peak period was from 2 p.m. to 6 p.m. Customers with central air conditioners were also offered a smart thermostat. The prices are shown in Table 6.

Customers who had the Residential Aid Discount (RAD) status offered by Pepco were considered to be low income customers. The program design specified that low income participants could only be placed on the CPR, not the CPP rate.

Results

The results indicate that low income customers on the CPR (the only rate offered to the low income customers) exhibited, on average, greater peak reductions than the higher income customers. According to Wolak (2010), while this effect is partially explained by the higher critical peak rebate offered to RAD customers, that rebate difference does not fully explain the observed difference in impact. The impacts for low income customers were about twice that for other customers, yet their rebate amounts were only 30 to 38 percent higher. If both customer sets were responding equally, one would expect low income customer response greater than that for the average customer, but no greater than the amount by which the rebate levels differed. *The fact that low income customers responded by significantly higher margins than expected*

[7] In this case of hardship regressions, comparisons were made based on treatment customers only (excluding control customers), since there were no control customers with hardship status.

confirms that they did respond more than customers who were not low income. The results are shown in Figure 10.

Table 6. PowerCentsDC Rates

Increasing Block Prices for Control Group and CPR Customers

Price Plan	Summary	Tier 1 Size (kWh)	Tier 1 Price ($/kWh)	Tier 2 Size (kWh)	Tier 2 Price ($/kWh)	Tier 3 Size (kWh)	Tier 3 Price ($/kWh)
R	Applies to most residential customers	0-400	0.129	401+	0.147	N/A	N/A
AE	Customers with electric heating	0-400	0.128	401+	0.147	N/A	N/A
RAD	Limited income customers	0-400	0.054	401+	0.148	N/A	N/A
RAD-AE	Limited income with electric heating	0-400	0.055	401-700	0.123	701+	0.146

Block Prices and CPP Event Prices for CPP Customers

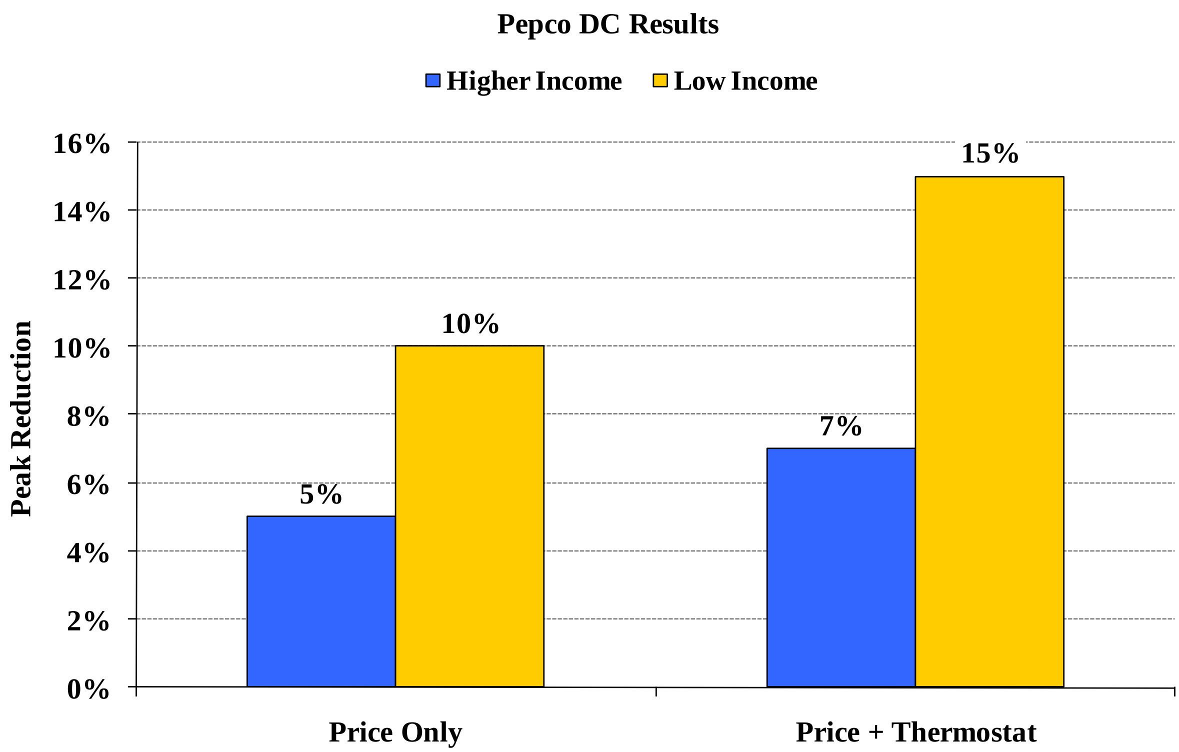
	Summer				Winter			
Price Plan	Tier 1 ($/kWh)	Tier 2 ($/kWh)	Tier 1 Critical Peak ($/kWh)	Tier 2 Critical Peak ($/kWh)	Tier 1 ($/kWh)	Tier 2 ($/kWh)	Tier 1 Critical Peak ($/kWh)	Tier 2 Critical Peak ($/kWh)
R	0.123	0.141	0.771	0.789	0.117	0.126	0.722	0.731
AE	0.123	0.142	0.775	0.769	0.116	0.121	0.702	0.707

Rebate Prices for CPR Customers

	Summer			Winter		
Price Plan	Tier 1 Rebate ($/kWh)	Tier 2 Rebate ($/kWh)	Tier 3 Rebate ($/kWh)	Tier 1 Rebate ($/kWh)	Tier 2 Rebate ($/kWh)	Tier 3 Rebate ($/kWh)
R	0.639	0.621	N/A	0.639	0.621	N/A
AE	0.649	0.631	N/A	0.649	0.631	N/A
RAD	0.821	0.790	N/A	0.821	0.790	N/A
RAD-AE	0.880	0.890	0.850	0.620	0.614	0.604

Source: Wolak, Frank A., *An Experimental Comparison of Critical Peak and Hourly Pricing:* The PowerCents DC Program, March 12, 2010 (Preliminary Draft prepared for 2010 POWER Conference)

Figure 10. Percent Peak Demand Reduction Based on PowerCents DC Pilot, 2008 - 2009



Source: Wolak, Frank A., An Experimental Comparison of Critical Peak and Hourly Pricing: The PowerCents DC Program, March 12, 2010 (Preliminary Draft prepared for 2010 POWER Conference)

PG&E SMARTRATE TARIFF - CALIFORNIA

Background

PG&E deployed the first large scale critical peak pricing program in North America in the summer of 2008 for the six months May through October. The SmartRate tariff was initially offered to residential (E-1 and E-8) and non-residential (A-1) customers in the Bakersfield and greater Kern County region. The SmartRate program was offered again in 2009. By the end of summer 2009, the program had roughly 25,000 active participants. Results for both 2008 and 2009 are reported below.

The SmartRate price was layered on top of PG&E's default tariff, with an incremental charge applying during critical hours on "SmartDays" and a credit to all other hours to maintain revenue neutrality. Up to 15 SmartDays could be called over the course of the summer; in 2008, 9 SmartDays were called. The critical peak period was from 2 p.m. to 7 p.m. For residential customers, the additional critical charge was $0.60 per kWh, with a credit of roughly 3 cents per kWh in all other hours. The incremental charge and credits were layered on top of the existing 5-Tier inclining block rate tariff, as detailed in Table 7.

Table 7. PG&E Default Prices, 2008[8]

PG&E E-1 CARE and Non-CARE Prices

Usage Tier	% of Baseline Usage	Approximate Maximum Monthly Usage in Tier (kWh)	E-1 Price ($/kWh)	Average E-1 Price Based on Mid-Tier Usage ($/kWh)	CARE Price (cents/kWh)	Average CARE Price Based on Mid-Tier Usage ($/kWh)
1	100%	582	0.116	0.116	0.083	0.083
2	130%	757	0.131	0.131	0.096	0.084
3	200%	1164	0.247	0.247	0.096	0.088
4	300%	1746	0.354	0.354	0.096	0.091
5	>300%	>1746	0.411	0.411	0.096	0.092

Source: Freeman, Sullivan & Co., *2008 Ex Post Load Impact Evaluation for* Pacific Gas and Electric Company's SmartRateTM Tariff, December 30, 2008

Low income customers are designated as those who qualify for California Alternate Rates for Energy (CARE), a program in which low income customers receive lower rates.

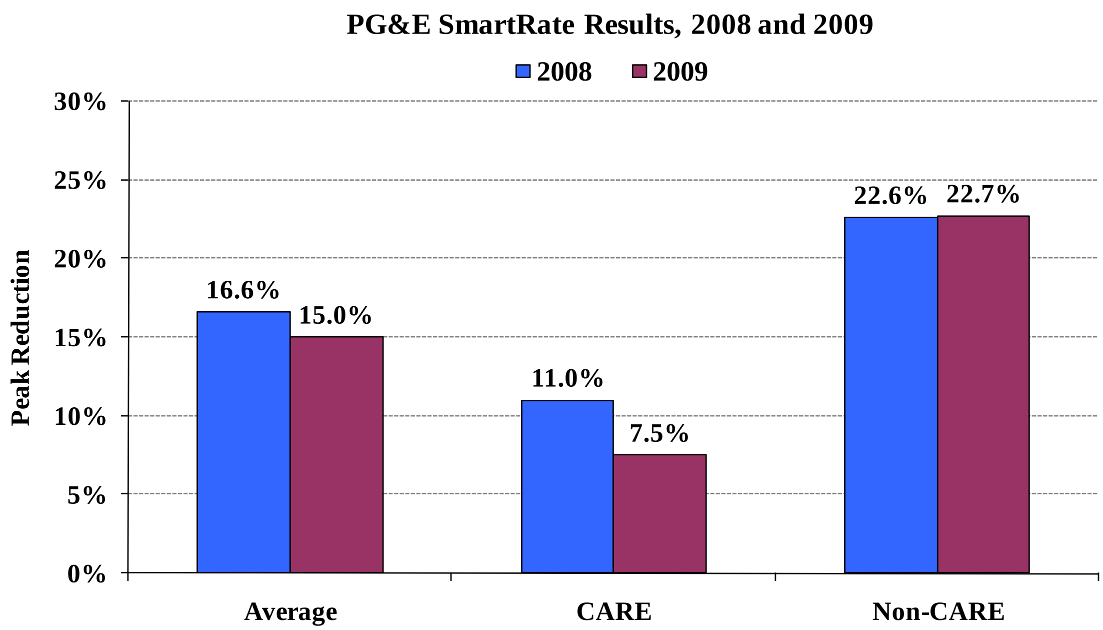
Results

Results for both 2008 and 2009 are shown in Figure 11. In 2008, the average residential customer across the sample reduced peak load by 16.6 percent across the 9 SmartDays. CARE customers reduced peak load by 11 percent and non-CARE by 22.6 percent on average. *The demand response of low income customers was lower than that of the higher income customers, but was still significant.*

In 2009, the average CARE peak reduction was 7.5 percent and the average non-CARE peak reduction at 22.7 percent, with an overall average customer response of 15 percent. *Thus, the CARE customers in 2008 responded half as much as non-CARE customers, while in 2009 they responded one-third as much.*

[8] The underlying rates in 2009 were slightly different, but the incremental SmartRate charges and credits were the same in 2008 and 2009.

Figure 11. Percent Peak Demand Reduction Based on PG&E SmartRate Program, 2008 and 2009



Sources:
Freeman, Sullivan & Co., 2008 Ex Post Load Impact Evaluation for Pacific Gas and Electric Company's SmartRateTM Tariff, December 30, 2008.
Freeman, Sullivan & Co., 2009 Load Impact Evaluation for Pacific Gas and Electric Company's Residential SmartRateTM -- Peak Day Pricing and TOU Tariffs and SmartAC Program; Volume 1: Ex Post Load Impacts; April 1, 2010.

California Statewide Pricing Pilot (SPP) – California

Background

In 2003, the California Statewide Pricing Pilot (SPP) was put into place to help quantify demand response to dynamic pricing. The SPP involved roughly 2,500 residential and small commercial and industrial customers and tested several different time-varying rates during the following three years. Although this pilot is several years old at this time, we include it because the results are widely cited and remain relevant.

The rates included a Time of Use (TOU) rate, in which the peak to off-peak price ratio was roughly 2:1 and a Critical Peak Pricing (CPP) tariff, in which the critical peak to off-peak ratio was 6:1. We focus the CPP-F rate in this paper, which had a fixed critical peak period and day-ahead notification. Detailed rate information for the CPP-F rate is shown in Table 8. Similar to the SmartRate program described earlier, the peak period was from 2 p.m. to 7 p.m.

Table 8. SPP Prices for CPP-F Rate

Average Prices for Residential CPP-F Tariff - Summer 2003, 2004

Customer Segment	Day Type	Period	Average Rate ($/kWh)
Control	All	All	0.130
Treatment	Critical	Peak	0.590
	Critical	Off-Peak	0.090
	Critical	Daily	0.230
	Normal Weekday	Peak	0.220
	Normal Weekday	Off-Peak	0.090
	Normal Weekday	Daily	0.120
	Weekend	Daily	0.090

Source: Charles River Associates, Impact Evaluation of the California Statewide Pricing Pilot, March 16, 2005.

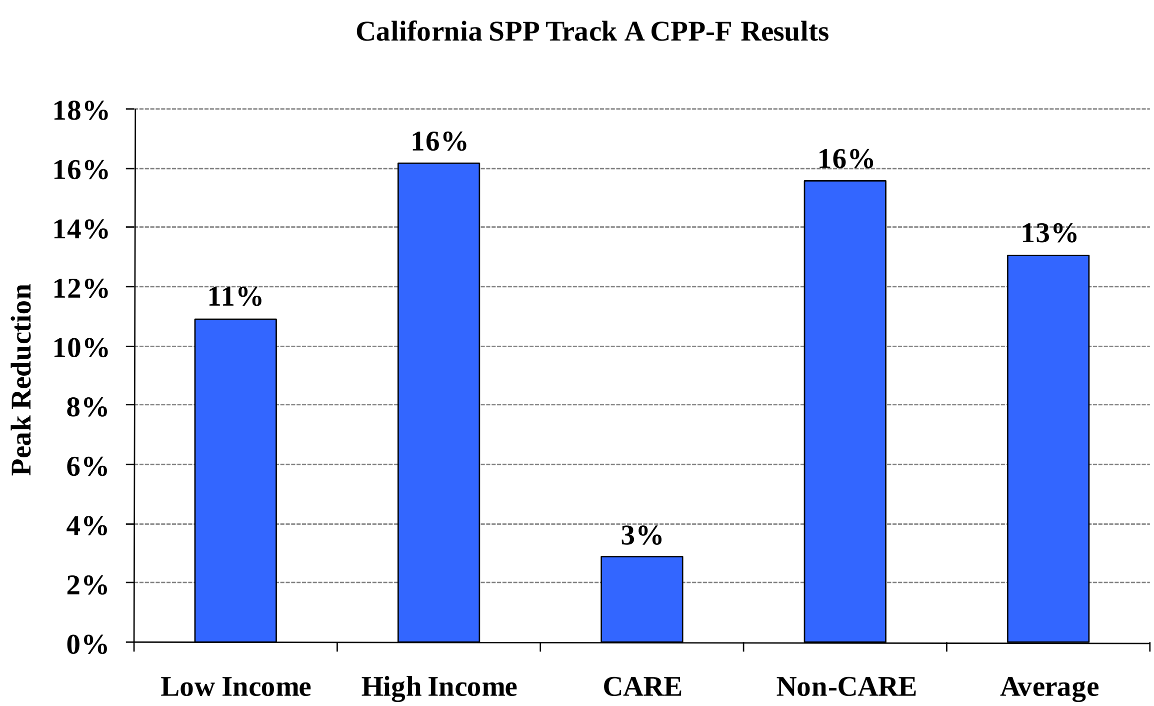
The experiment was divided into three tracks. Track A was designed to be representative of California's general population. Track B was designed to be representative of the members of a low income community housed in a part of San Francisco located in close proximity to a power plant. Track C focused on customers in San Diego that had volunteered for a prior smart thermostat program. Track A was spread over four climate zones while Tracks B and C focused on single climate zones. Tracks A and B allow inferences to be drawn about low income customers.

Track A investigated the price responsiveness of low income customers. It yielded results on two categories of low income customers. First, snapshots of low income and high income customers were compared, with low income customers represented by customers with an average income of $40,000 and high income customers represented by an average income of $100,000. Second, the price responsiveness of customers on the CARE program, who receive a discount on their electricity bill, was compared with the responsiveness of non-CARE customers.

Results

High income households were somewhat more price-responsive than low income households. However, the difference was not substantial and low income customers also exhibited demand response. Within Track B, designed to be representative of the low income community, customers that received only information reduced peak demand by 1.15 percent, while those that were also placed on the CPP-F rate reduced peak demand by 2.6 percent. Within Track A, we can compare the peak demand reductions of low income ($40,000) and high income ($100,000) customers as well as CARE vs. non-CARE customers. These results are shown in Figure 12. Customers with average incomes of $100,000 exhibited average peak reductions of 16 percent on the CPP-F rate, while customers with average incomes of $40,000 exhibited average peak reductions of 11 percent. Similarly, non-CARE customers exhibited average peak reductions of 16 percent while CARE customers only exhibited peak reductions averaging 3 percent.

Figure 12. Percent Peak Demand Reduction Based on SPP Results for Track A, CPP-F Rate



Source: Charles River Associates, Impact Evaluation of the California Statewide Pricing Pilot, March 16, 2005.

CONCLUSION

Based on bill impact simulations and the results reviewed from four pilots and one full-scale program, we conclude that low income customers will benefit from dynamic pricing.

- Bill impact simulations reveal that a large percentage of low income customers will benefit from dynamic pricing even without shifting load, as shown in Figure 13 and Figure 14. Based on our simulations, this ranges from 65 percent to 79 percent of low income customers. The reason for this is that a high percentage of low income customers have flatter than average load shapes.

- Two studies, the CL&P and BGE programs, found that low income customers were equally price responsive to the average customers, while the SPP and PG&E SmartRate programs found that they were less responsive. The Pepco DC results, on the other hand, showed that low income customers were much more responsive than other customers.

- To compare the magnitude of the response of different income groups, it is useful to compare the average low income customer response to the average customer (or in some cases, the average non-low income customer) response. For example, in the PG&E SmartRate program in 2009, CARE customers demonstrated a 7.5 percent peak reduction, while the average customer demonstrated a 15.0 percent peak reduction, meaning the CARE response was 50 percent of the average response. In the PepcoDC (price only) results, low income customers showed a 10 percent peak reduction, while higher income customers showed only a 5 percent reduction, meaning that the average low income response was 200 percent of (or twice as high as) the average non-low income response. A summary of the results is shown in Table 9.

In summary:

While there is mixed evidence on the magnitude of the responsiveness of low income customers relative to other customers, there is strong evidence across these five programs that low income customers do respond to dynamic rates and, in many cases, that response is a load reduction above 10%. Furthermore, even without responding to dynamic rates, a large percentage of low income customers will be immediate beneficiaries of dynamic rates due to their flatter than average load profiles. These results suggest that when evaluating dynamic pricing, it is important to recognize that such rates are not harmful, and, in fact, may be beneficial to a large percentage of low income customers.

Figure 13. Residential and Low Income Bill Impacts Based on CPP Rate Design #1

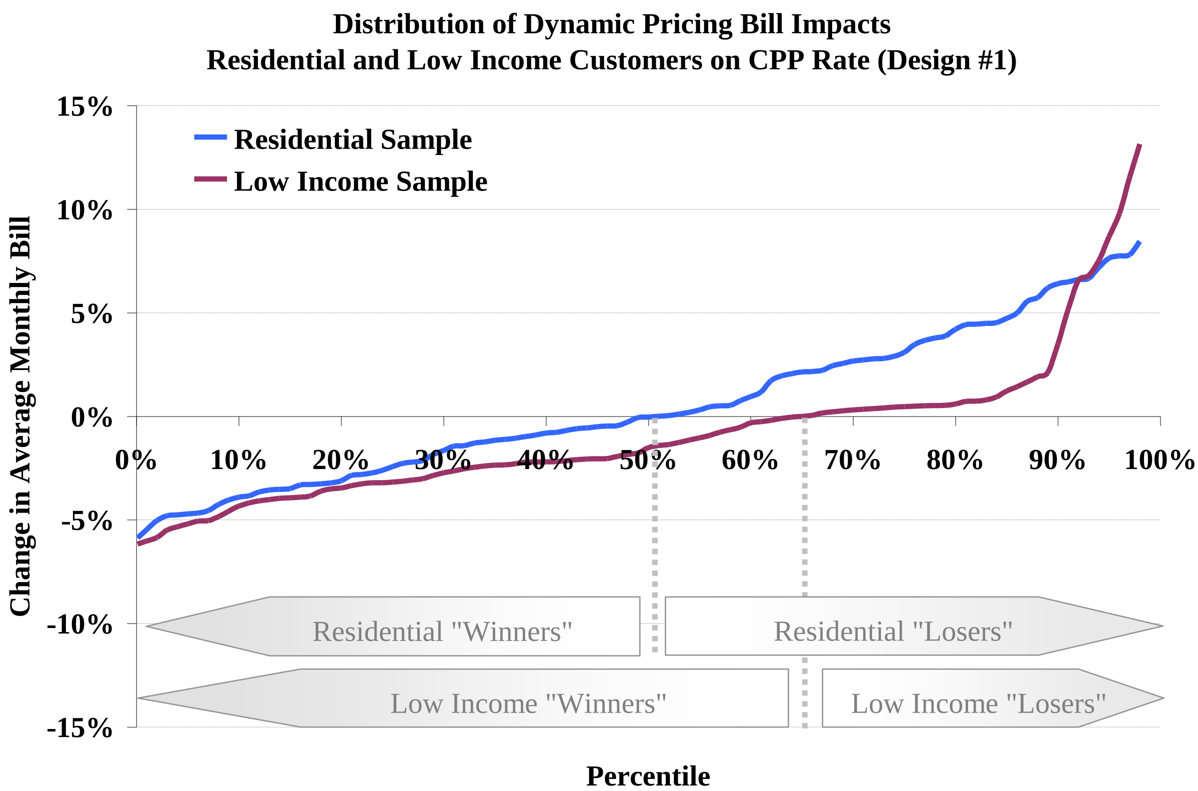


Figure 14. Residential and Low Income Bill Impacts Based on CPP Rate Design #2

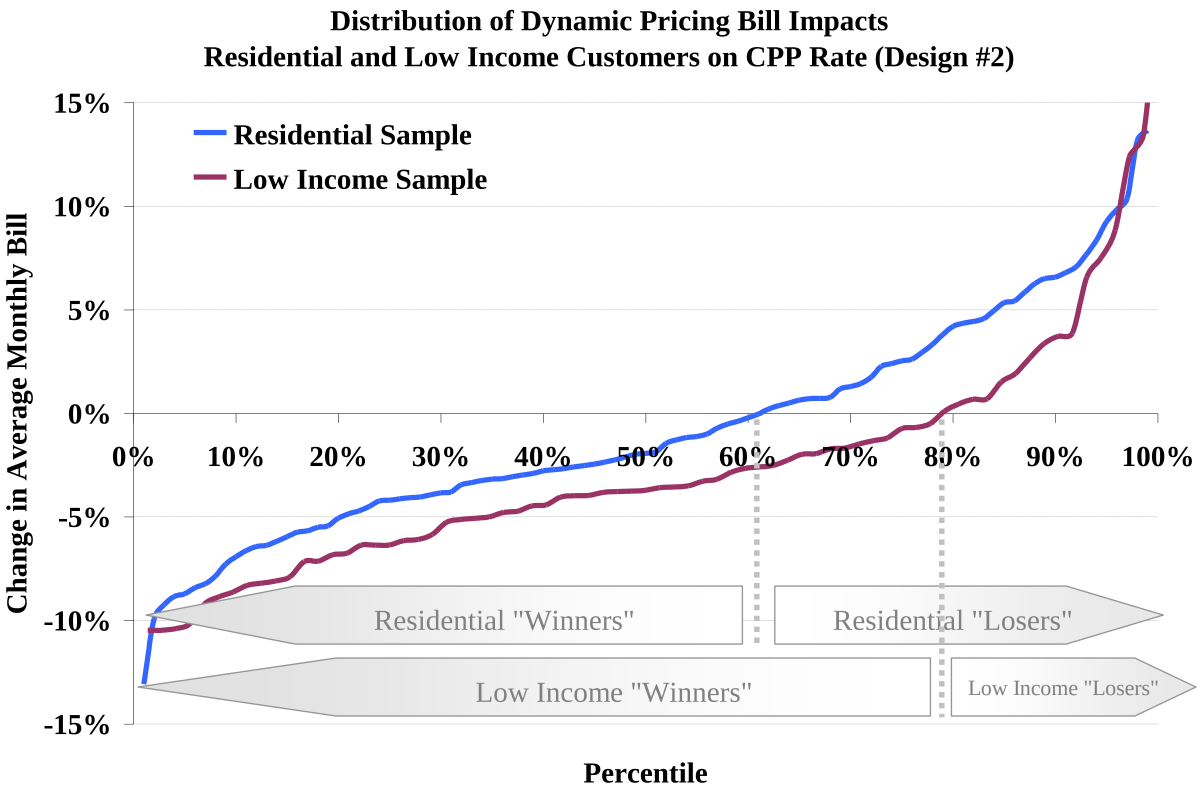


Table 9. Summary of Low Income and Average Customer Response to Dynamic Prices[9]

Program Results	Low Income Peak Reduction	Average Peak Reduction	Low Income vs. Average
BGE 2008: Known Low Income vs. Known Average Customer	*Varies depending on rate type; low income customers respond similarly to average customer*		100%
CL&P's PWEP Program: Known Low Income vs. Known Average Customer	*Varies depending on rate type; low income customers respond similarly to average customer*		100%
CL&P's PWEP Program (PTP high): Hardship vs. Average	13%	20%	67%
Pepco DC (price only): Low Income vs. Average Residential[1]	10%	5%	200%
Pepco DC (price + thermostat): Low Income vs. Average Residential[1]	15%	7%	214%
PG&E SmartRate 2008: CARE vs. Average	11%	17%	66%
PG&E SmartRate 2009: CARE vs. Average	8%	15%	50%
California SPP: Low Income vs. Average	11%	13%	84%
California SPP: CARE vs. Average	3%	13%	22%

[9] In most of these cases, the low income result is compared to the result of the average customer, which includes low income customers. However, for the PepcoDC pilot, the average residential response excludes low income customers that qualify for the RAD program; so in that case, the low income results are compared to the average non-low income results.

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