The Impact of Dynamic Pricing on Low-Income Customers: An Analysis of the IEE Whitepaper.

A report to the Maryland Office of the People's Counsel

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I. EXECUTIVE SUMMARY

Concerns about potential adverse impacts of critical peak pricing on large segments of the residential customer class, in particular low income customers, have been a factor in the opposition by some parties to the implementation of advanced metering infrastructure, and in particular to critical peak pricing on opt-out basis. In June, 2010, IEE[1] released a Whitepaper entitled *The Impact of Dynamic Pricing on Low Income Customers* authored by Ahmed Faruqui, Sanem Sergici, and Jennifer Palmer of the *Brattle Group*. In September 2010, IEE released an updated version of the paper.[2] As the paper observes, "there is much disagreement about the impact of dynamic pricing on certain customer segments, most notably low income customers." The paper states that it "provides new information about how low income customers respond to dynamic prices,"[3] with the goal of helping to resolve the ongoing dispute over the impact of dynamic pricing on low-income customers.

The IEE whitepaper attempts to assess the impact of dynamic pricing on low-income customers in two ways. First, the authors conduct simulations of dynamic pricing using assumptions drawn from a large urban utility. Second, the authors collect the results of evaluations of 4 pilots and one ongoing dynamic pricing offering, comparing what is known from these evaluations about the response of the average customer and that of the low-income customer.

The authors state that their "core finding" is that "low income customers are responsive to dynamic rates and that many such customers can benefit even without shifting load."[4] The two conclusions in this core finding are very general, they may or may not apply to various utilities, do not apply equally to all low-income customers and, in any case, they will vary in degree from utility to utility around the country. Our paper explains why the results reported in the IEE Whitepaper should not be directly applied to the varying situations of different utilities and different customers in different jurisdictions throughout the country.

The first major conclusion we explore, that many low income customers can benefit even from dynamic pricing without shifting load, should not be interpreted to mean that the majority of low income customers will always be better off under CPP even if they do not respond. In fact, the percentage of residential customers, in any utility (including low income customers) that would

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[1] The Institute for Electric Efficiency (IEE) is a program of the Edison Foundation, According to its web page, "IEE's mission is to advance energy efficiency and demand response among electric utilities. IEE is governed by a Management Committee of electric industry executives. IEE has a permanent Advisory Committee made up of representatives of the efficiency community, federal and state government agencies, and other informed stakeholders. IEE also has a Strategy Committee comprising senior energy industry executives that identify strategies and projects for IEE." Lisa Woods is the Executive Director..

[2] The updates were made to reflect the final evaluation of the PepcoDC PowerCentsDC pilot; when the paper was first released, only the interim results of that pilot were available

[3] As defined in the IEE Whitepaper, dynamic pricing refers to a rate structure in which price varies depending on changes in wholesale costs during a given period, rather than remaining static for the period regardless of changes in wholesale power costs. *IEE Whitepaper*, p. 5. Rate structures with this feature include real time pricing (RTP), critical peak pricing (CPP), and peak time rebates (PTR). The IEE Whitepaper focuses on critical peak pricing and peak time rebates. *IEE Whitepape*r , p. 6.

[4] *Id.*

be better off under mandatory CPP than under existing rates if they do not or cannot reduce critical peak demand will depend on the actual distribution of residential customer load shapes within that utility. Moreover, the amount by which some customers, including low income customers, may be better off even without shifting load will depend on the existing rates and the CPP rates at that utility, as well as the incremental costs incurred to implement CPP, such as the costs of smart meters and in home devices.[5]

The second major conclusion, that low income customers are responsive to dynamic rates, also should not be interpreted to mean that the majority of low income customers everywhere will respond to PTR or CPP with significant reductions in critical peak use. In fact, the percentage of residential customers at a given utility who will respond to CPP, and by how much, will depend on existing rates, the PTR or CPP rates, the penetration of central air conditioning, local weather conditions, and income levels, among other factors.

As the authors point out, "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."[6] Despite broad language in the IEE Whitepaper, however, the authors are not able to and do not assert that the pilots and programs examined in their report provide this evidence, nor that they are representative of every utility throughout the United States.[7] Instead, the authors state that "Other utilities should conduct pilots or market research to verify that these results also hold for their customers."[8]

Our paper explains why the IEE Whitepaper conclusions cannot be applied directly to the varying situations of different utilities and different jurisdictions throughout the country. We review the methods and data used in the IEE Whitepaper, to the extent they are known, to determine whether and to what extent they can be used elsewhere. We analyze what is known about the data used in the IEE Whitepaper, and attempt to draw together a list of the kinds of data that would be necessary to transfer the conclusions of the IEE Whitepaper to other utilities and jurisdictions.

[5] The IEE failure to offset bill reductions by the bill increases to pay for the ability to offer dynamic pricing is not unique among dynamic pricing evaluations. None of the dynamic pricing pilot evaluations take the incremental cost of the metering and related investments into account when estimating the bill impacts of the use of smart metering infrastructure to make such pricing possible.
[6] *Id.*
[7] Response to Question 2, personal communication from the authors ("Response to Question"). Drs. Faruqui and Sergici were kind enough to answer a set of Questions emailed to them in August 2010 about sources and methods of the IEE Whitepaper.
[8] Response to Question 4.

II. THE PERCENTAGE OF LOW INCOME CUSTOMERS WHO WILL BENEFIT FROM DYNAMIC PRICING WITHOUT SHIFTING LOAD WILL VARY FROM UTILITY TO UTILITY

The IEE Whitepaper begins by examining "how dynamic pricing will affect low income customers even if there is no demand response."[9] To do this, the authors start with a set of residential customer load data, including residential low income customers, for a large urban utility[10]. They then evaluate the impact of applying different forms of dynamic pricing to this hypothetical residential class under the assumption that none of the residential customers change their usage pattern in response to the dynamic pricing.[11]

According to the IEE Whitepaper, one would expect roughly half the residential customers of this hypothetical utility to have load shapes flatter than the residential class average load shape and the other half to have peakier than average load shapes.[12] This assumption undergirds the IEE analyses of hypothetical bill impacts of CPP and PTR rates.

We disagree with the blanket assumption that roughly half the residential customers of a utility will have load shapes flatter than the residential class average load shape and the other half will have peakier than average load shapes. In fact, some utilities have a residential class in which a relatively small percentage of customers have a large and peaky usage, for example 30% of customers with central air conditioning, and the majority of customers have relatively low, flat usage.

In addition, load profiles are not necessarily distributed evenly from low to high load factor in any class of customers, or in any particular group out of the class. This can be seen from the following distribution of peaks per customer for Jersey Central Power & Light, a New Jersey utility:[13]

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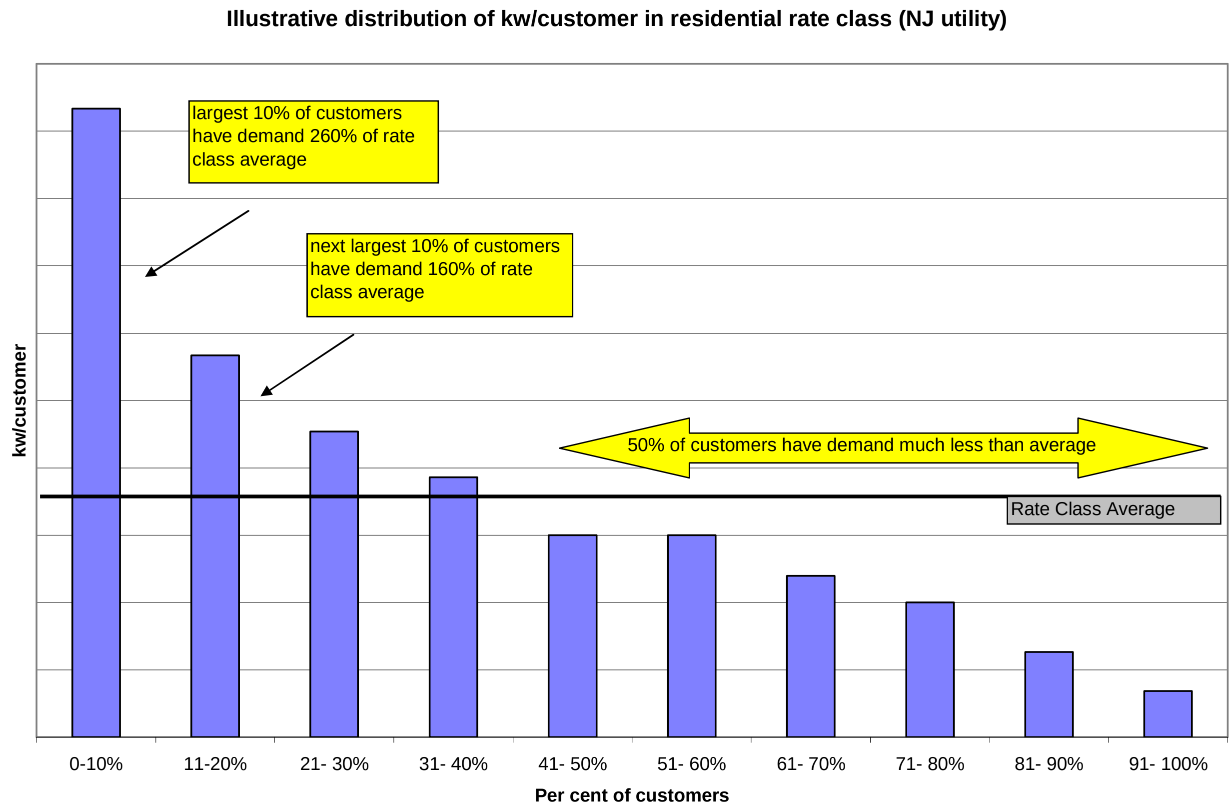
[9] *IEE Whitepaper,* p. 7.
[10] The utility is not identified in the paper. According to the IEE Whitepaper authors, the data are confidential. Response to Question 10.
[11] The pricing forms were used in the simulation were (a) a CPP rate of $1.25/kWh in 60 critical peak hours and $0.11 / kWh in the other 8,700 hours; (b) a CPP rate of $0.90/kWh in 75 critical peak hours, $0.10 / kWh in the other summer hours and $0.13 in the non-summer hours; and a (c) PTR of $1.10/kWh in 60 critical peak hours with no change in the existing all-hours rate of $0.13/kWh. *IEE Whitepaper,* p. 7.
[12] Load factor is the ratio of annual average hourly use and peak hourly use; as such it measures the shape of a customer’s load. For example, a relatively flat load might have a load factor of 70% to 80%, which would be considered very high; a relatively peaky load might have a load factor of 20% to 30%, which is considered relatively low.
[13] NJ BPU Docket Nos. EO08080542 and EO08050326. Attachment 3 to JCP&L response RC-JCPL-1.



Applying its assumption regarding load profile distributions, the IEE Whitepaper found that application of a PTR to its hypothetical residential class would have no impact on low income customers, or any other residential customers, even if those customers did not change their use in response to the PTR. The absence of an impact in this "no demand response" scenario is due to the fact that there is no change in the existing rates after introduction of a PTR. A customer can earn a rebate, but cannot experience higher rates just for maintaining its existing load profile. A low load factor customer will be no worse off, all other things equal, under PTR than under the existing rate.[14]

The IEE Whitepaper found that application of a CPP to the hypothetical residential class in the simulation would raise bills for all customers who did not reduce their critical peak usage in response, including low-income customers, This impact is due to the fact that under a CPP approach existing average rates are replaced with much higher critical peak prices during critical peak hours and by reduced prices in off-peak hours.

[14] They are identical, except for the fact that the customers now have to defray the cost of the advanced metering infrastructure, at least to the extent it is not offset by operational savings. There have been no business cases filed with public utility regulators in which the operational savings are claimed to completely offset the cost of the AMI.

The rates are designed to be revenue-neutral.[15] Thus, under CPP, customers with load shapes that are flatter than the residential class average will be better off under CPP even with no demand response. This segment of "higher than average load factor" customers will benefit because they purchase most of their power in non-critical-peak hours, when rates are lower, and relatively little power in the small number of very-high-priced critical peak hours. By contrast, customers with peakier-than-average load shapes (lower than average load factors) would see their bills go up as the result of the introduction of critical peak pricing, unless they were able to reduce their critical peak usage sufficiently to avoid the bill impact of the higher prices during those hours.

The actual number or percentage of customers who will better off under a CPP depends on the distribution of residential customers by load shape, and the design of the CPP. Therefore the impacts of the two CPPs modeled in the IEE Whitepaper on the hypothetical low income customers are a function of the distribution of their load shapes relative to those of the hypothetical residential class, and of the design of the two CPPs.

In the case of CPP variant #1, the authors say that "*[b]ecause 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*."[16] Applying the second version of a CPP rate to the same customer load data, the authors state: *[f]or 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*.[17]

The IEE Whitepaper provides no empirical evidence that low-income customers always and everywhere have flatter load profiles than the average residential customer. The fact that 65% of the low-income customers in the simulation were better off under the first CPP variant, and 80% were better off under the second, is particular to the load data used. These are not universal values. In fact, the authors do not maintain that low-income customers everywhere and always have better load factors than the average residential customer.[18] Thus the specific percentages of "winners" and "losers" claimed in the simulations must be recognized as an artifact of the particular load data (and rate structures) used.

It is true that, on average, low-income customers have fewer end-uses that draw high amounts of peak power, such as central air conditioning.[19] Indeed, those opponents of dynamic pricing who

[15] Revenue neutrality means that if customers did not change their load profiles in response to the change in rate design, the utility would receive no more and no less revenue than under the existing rates. If some rates for some portion of time is raised (e.g. the price for critical peak hours), then to achieve revenue neutrality rates applied in some other period must be lowered. To promote efficient usage of electricity, reductions in prices to achieve revenue neutrality under time-of-use rates like CPP are made to the off-peak rates.
[16] *IEE Whitepaper,* p. 7 (emphasis in original).
[17] *Id.*, p. 10.
[18] Response to Question 1.
[19] Figure 3-2, Percentage of low-income households nationwide with central air conditioning was at 42% in 2005, compared to 58% for all households. LIHEAP Home Energy Notebook for Fiscal Year 2007 (2009). Percentage of low income customers in Massachusetts with central AC was 23% vs. 40% for non-low-income customers. Opinion

express concern for the impact of such pricing on low-income customers make precisely this point. That is, they argue that *because* low-income customers on average have fewer discretionary loads on peak, they are less able to reduce their loads in response to prices.[20]

There is little hard data publicly available, however, on the actual load profiles of low-income customers (or of the average residential customer, for that matter). As noted, the IEE Whitepaper authors have not disclosed the load profile data used in their simulations. Consequently, it is impossible to assess how closely a given utility's low-income and average residential customer groups' load profiles match those assumed in the IEE Whitepaper simulation.

The calculations performed in the IEE Whitepaper of impacts of CPP, assuming no demand response by the hypothetical residential customers, will only be applicable to other utilities if, and to the extent, the load profiles of the low-income and average customers in the simulations are the same as the load profiles of the low-income [21]and average customers of the utility. No more can be said based on the information provided by the IEE Whitepaper. The IEE review of pilot results does not by itself support the introduction of dynamic pricing, nor the investment in smart metering and smart metering infrastructure required to offer such rates.

III. THE IMPACT OF DYNAMIC PRICING ON LOW INCOME CUSTOMERS AFTER DEMAND RESPONSE WILL VARY BY UTILITY

The IEE Whitepaper examines the demand response of low income customers to dynamic pricing in four dynamic pricing pilot programs and one full-scale program.[22] The evaluations were of the following pilots and ongoing rate offering:

1. BGE Smart Energy Pricing (SEP) Pilot – Maryland
2. CL&P Plan-it Wise Energy Program – Connecticut

Dynamics Corporation, *Massachusetts Residential Appliance Saturation Survey (MA RASS),* Vol. 1, Summary Results and Analysis, April 2009, Table 50. About twice the percentage of Massachusetts low-income households have no air conditioning of any kind as do non-low-income households (77% vs. 38%). *Id.* Low-income households in Massachusetts use their air conditioning less frequently at all times of day studied than non-low-income households. *Id.* See also William B. Marcus, Greg Ruszovan, JBS Associates, *"Know Your Customers": A Review of Load Research Data and Economic, Demographic, and Appliance Saturation Characteristics of California Utility Residential Customers ("Review of CA Load Research"),* filing by TURN with California PUC, in App. 06-03-005, Dynamic Pricing Phase, December 11, 2007.

[20] See, e.g., Hawiger andSchilberg, *Advanced Metering Infrastructure: What Happened to Demand Response?,* presentation to Joint Agency Workshop, September 30, 2004. See also Barbara Alexander, *Smart Meters, Real Time Pricing, and Demand Response Programs: Implications for Low Income Electric Customers (Smart Meters),* Update, May 30, 2007. Available at: http://www.pulp.tc/Smart_Meters_Real_Time.pdf. And see Gerald Norlander, *Not So Smart? High Tech Metering May Harm Low Income Electricity Customers,* (*Not So Smart)* Public Utility Law Project, April 16, 2007. Available at: http://pulpnetwork.blogspot.com/2007/04/not-so-smart.html.

[21] And assuming no incremental cost of the AMI needed to offer such a rate.

[22] *IEE Whitepaper,* at p. 12.

3. PEPCO PowerCentsDC Program – District of Columbia
4. PG&E SmartRate^{tm} Tariff – California
5. California Statewide Pricing Pilot (SPP) – California

The authors examined the observed price elasticities[23] or the percent demand reductions, reported by evaluators for low-income customers and for the average customer in these pilots or taking service under the SmartRate^{tm} Tariff. Their core conclusion from this review was that:

> *low income customers are responsive to dynamic rates, ... many such customers can benefit even without shifting load, and ... their degree of responsiveness relative to that of average customers varies across the studies reviewed.*[24]

As with the simulation exercise discussed above, this review of pilot results does not support the introduction of dynamic pricing, nor the investment in smart metering and smart metering infrastructure required to offer such rates.

A. THE WHITEPAPER ITSELF DOES NOT ATTEMPT TO PREDICT LOW -INCOME CUSTOMER RESPONSES TO DYNAMIC PRICING.

The core conclusion itself contains no actionable assertions. The IEE Whitepaper does not attempt to provide a percentage or a range of percentages of demand response likely from low-income customers in every utility.

First, the statement that "low income customers are responsive to dynamic rates" does not say how responsive[25] such customers are, and does not say what portion of all low-income customers are responsive.

Second, the statement that "many such customers can benefit even without shifting load" is actually a restatement of a conclusion drawn on the basis of the simulated application of dynamic prices to sample load data from the unnamed large urban utility. It is not a conclusion drawn

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[23] Elasticity is defined as the relative percent change in usage due to a percent change in price. For the IEE Whitepaper, the authors were particularly interested in the "elasticity of substitution" which, together with daily price elasticities, provides a measurement of the demand response of customers on a given day. As described by Charles River Associates in the evaluation of the CA SPP, "the constant elasticity of substitution (CES) demand system ... consists of two equations. The first equation models the ratio of peak to off-peak Quantities ... as a function of the ratio of peak to off-peak prices ... and other terms. The second equation models daily electricity consumption ... as a function of the daily price of electricity ... and other factors. The two equations constitute a system for predicting electricity consumption by rate period. By taking the shares of energy use by rate period that are predicted by the first equation and multiplying them by predictions of daily energy use from the second equation, one can generate predictions of the amount of energy used in each rate period given specific peak and off-peak prices and other determining factors.[23] *Impact Evaluation of the California Statewide Pricing Pilot*, at p. 33.
[24] *Id.* (emphasis in original).
[25] By "responsive," we mean taking actions to reduce critical peak loads in response to price signals, including using enhanced technology such as programmable thermostats to pre-set load reductions upon receipt of price signals.

from the review of the pilots and the PG&E rate. Even as such, the statement is qualified ("*many* such customers") so as to remove any assertion of a particular percentage or proportion of low-income customers for whom the statement is valid. Finally, the core conclusion does not purport to claim a universal degree of responsiveness for low-income customers relative to average customers.

The IEE Whitepaper does not attempt to provide a basis for calibrating the response of low-income customers of any of the pilots to low-income customers in other states. The authors of the IEE Whitepaper merely summarize the results of the five studies in broad terms:

> 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 slightly less responsive compared to higher income customers (Pepco DC and SPP programs), while others found that low income customers were half as responsive (PG&E) as the higher income customers..[26]

The IEE Whitepaper implicitly acknowledges that the results of the five dynamic pricing experiences cannot be used as predictors of the results of introducing such pricing in other areas.[27] Rather, the authors contend only that based on the results of their report, utilities and regulators should not accept the argument that is often put forward that dynamic pricing will necessarily harm low income customers.[28] That dynamic pricing will not necessarily hurt all low-income customers of every utility does not resolve the debate. The question remains what portion of low-income customers, if any, would experience what level of bill increases under dynamic pricing, in any given utility's situation.[29]

B. THE KEY FACTORS DRIVING PEAK DEMAND AND DEMAND RESPONSE VARY FROM ONE JURISDICTION TO ANOTHER.

Residential customer peak demand is driven by a number of variables. These include housing stock, income, climate (e.g., cooling degree days), and penetration of central air conditioning. As a result, average residential class peak demand, and likely demand responsiveness, varies over a wide range from state to state. The IEE Whitepaper authors themselves recommend that utilities other than those reviewed in the paper "should conduct pilots or market research to

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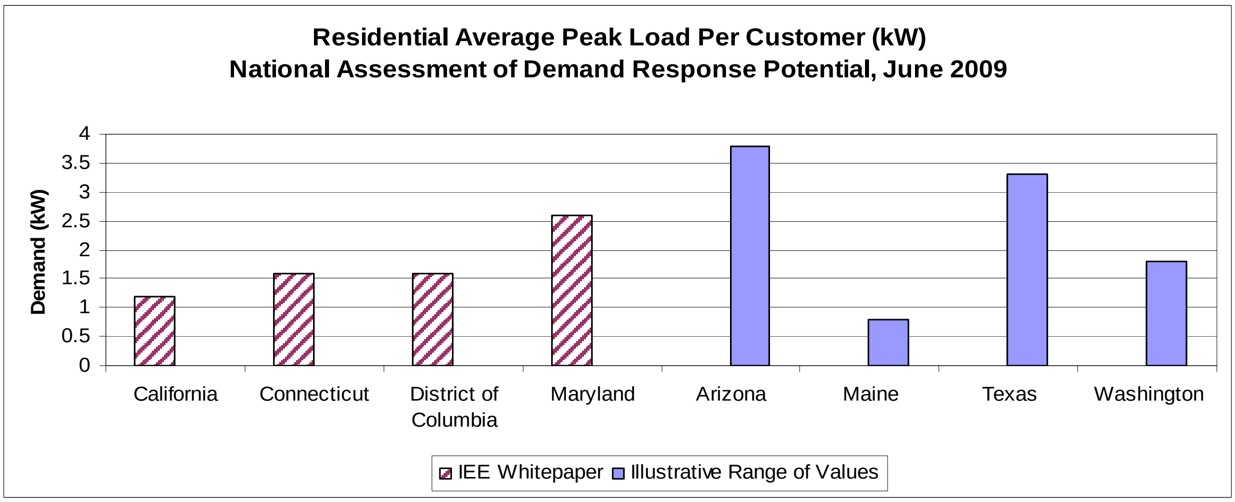
[26] IEE Whitepaper at 14. .
[27] Indeed, in response to Question 4, the authors state that "based on the best available data on the subject, low income customers do respond to price signals. *Other utilities should conduct pilots or market research to verify that these results also hold for their customers*." (emphasis supplied)
[28] Response to Question 4.
[29] Again, because by definition low-income customers do not have enough income to maintain a basic standard of living, any increase in electricity bills will make a bad situation worse,

verify that these results also hold for their customers.[30] The variability of these factors is discussed in this section.

1) Peak Loads, Climate, Air Conditioning, Extent of Poverty All Vary by State

Estimates of residential peak loads from the FERC Staff Report, *A National Assessment of Demand Response Potential*, June 2009, at p. 80, show marked differences:



In turn, there are clear differences in levels of the key drivers of peak load in the four states where the IEE Whitepaper authors reviewed dynamic pricing demand response results, and in other states. The IEE Whitepaper authors (and coauthors) explained in an earlier report on demand response generally that, in order to extrapolate the demand response results from the pilots and programs they reviewed to other utilities, one must make adjustments for differences in the values of those key drivers (in particular climate, CAC penetration and the level of the dynamic prices).[31]

> [Demand] responsiveness for residential customers varies across regions based in part on differences in the use of air conditioning. Climate differences can also impact price responsiveness, as can the presence or absence of enabling technology such as programmable communicating thermostats and other load control devices. ... The price elasticities summarized [in this study] for residential customers produce quite different percent reductions across states as a function of the variation in climate and air conditioning saturations.[32]

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[30] Response to Question 4. The authors do not explain how the results of the IEE Whitepaper can be applied to other utilities given the variation in the rate programs and customer load profiles reviewed.
[31] Response to Question 3.
[32] The Brattle Group, Freeman Sullivan & Co., Global Energy Partners, LLC, *A National Assessment of Demand Response Potential*, prepared for the Staff of the Federal Energy Regulatory Commission, June 2009, at 59.

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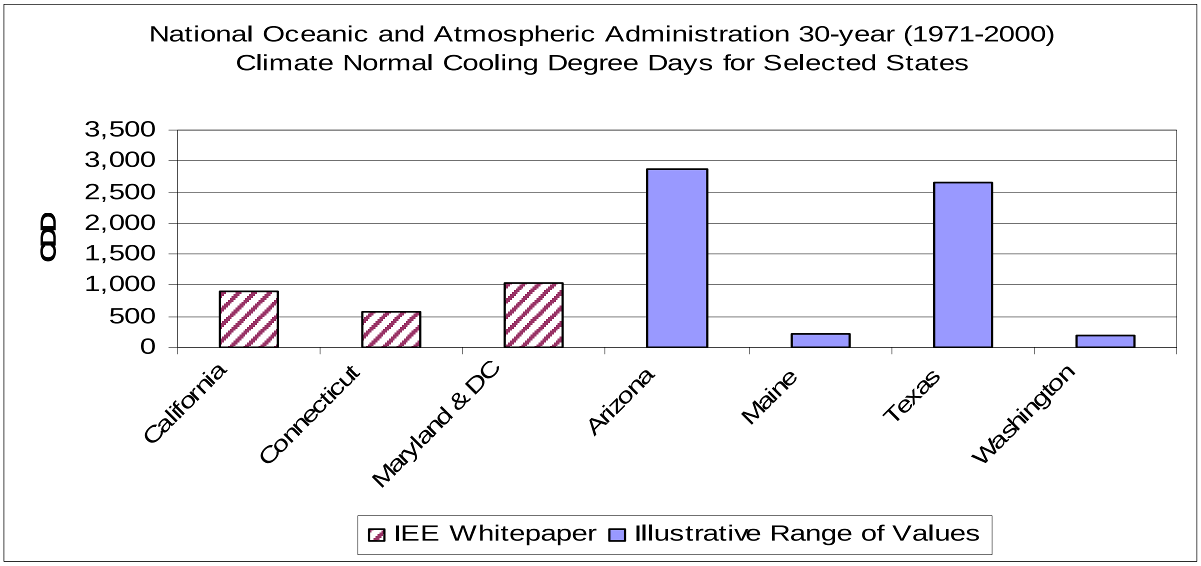
Looking at climate, for example, the four states[33] included in the IEE Whitepaper review have lower numbers of CDDs than Arizona and Texas, but higher numbers than Maine and Washington states. This variation in CDDs is illustrated in the chart below:



The penetration of central air conditioning[34] also varies greatly from state to state:[35]

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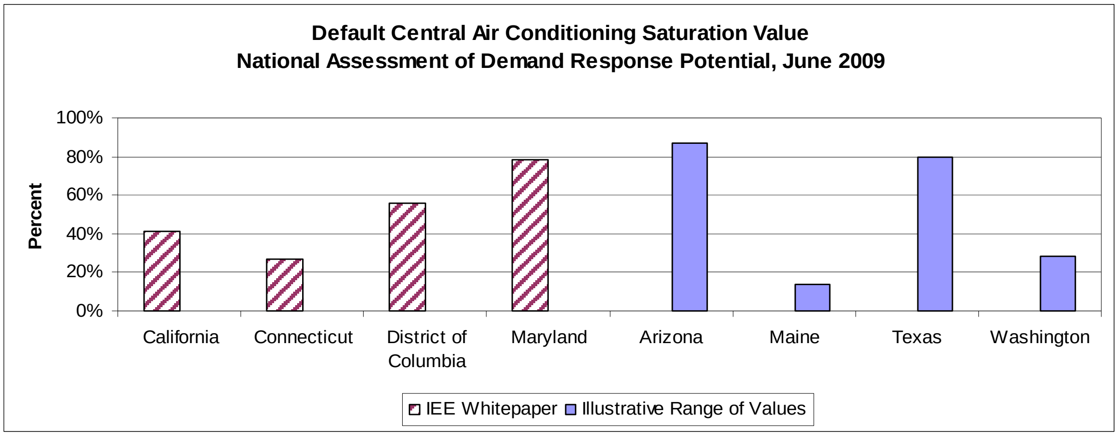
[33] Note that in the California Statewide Pricing Project, the state was divided into four climate zones; responses of pilot participants in one zone were different from those of participants in another zone. See, e.g., Charles River Associates, *Impact Evaluation of the California Statewide Pricing Pilot, Final Report (CA SPP Evaluation),* 2005, Table 4-17.

[34] Central air conditioning penetration values for all states were taken from the FERC's *National Assessment of Demand Response Potential* prepared by the Brattle Group, Freeman, Sullivan and Company, and Global Energy Partners, LLC. The authors of the FERC report collected central air conditioning penetration data from both primary and secondary sources, and then "professional judgment was used to determine the data that provided the closest approximation to the state level value in order to estimate the default saturation value for each state." (p.218, FERC)

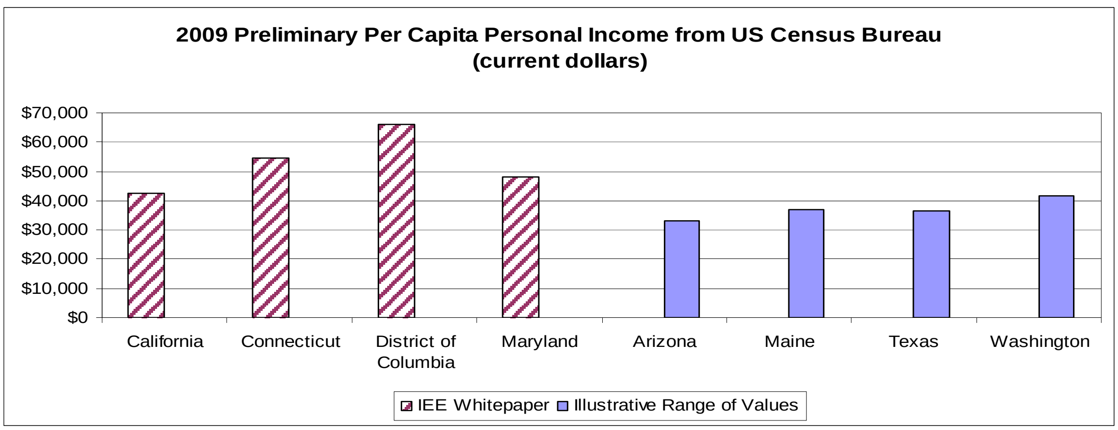
[35] The 2009 evaluation of the PG&E SmartRate^{tm} tariff results provides additional support for this observation, and shows that, at least in one service area in California, low-income participants had a lower penetration of CAC than non-low-income customers:

> [T]he estimated share of SmartRate customers with central air conditioning is 64% for non-CARE customers and roughly 53% for CARE customers. Customers with a high propensity of owning central air conditioning provide significantly greater load reductions than do customers who do not own central air conditioning. Evidence ... indicates that the average load drop for CARE customers with less than a 25% probability of owning central air conditioning is only one third as large as for CARE customers with a 75% probability of owning central air conditioning. For non-CARE customers, households with a greater than 75% probability of owning central air conditioning provide load reductions that are 4.5 times greater than households who have less than a 25% probability of owning central air conditioning.

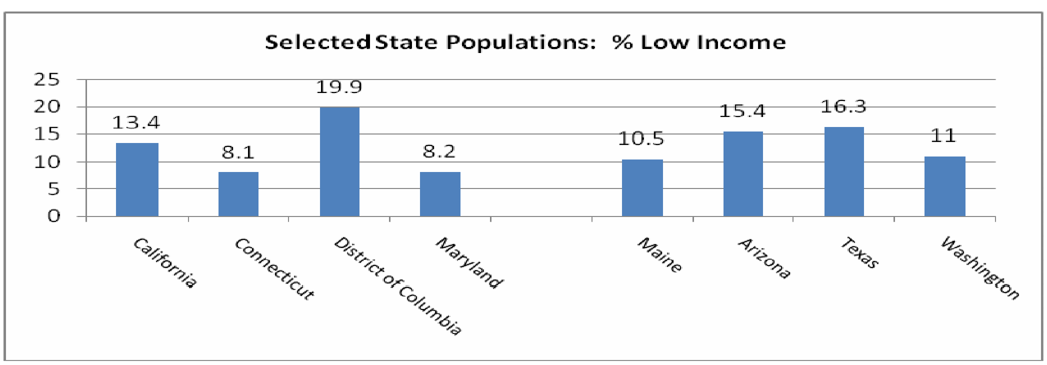
FSC., *2009 Load Impact Evaluation for Pacific Gas and Electric Company's Residential SmartRate^{TM}—Peak Day Pricing and TOU Tariffs and SmartAC Program: Ex Post Load Impacts*, Final Report, April 1, 2010, at p. 3.



Income varies from state to state:[36]



The portion of the population living at various levels of poverty[37] also varies from state to state:



[36] http://www.bea.gov/regional/spi/drill.cfm.

[37] Source: U.S. Census Bureau, 2003 American Community Survey, 2003, Ranking Tables, available at http://www.census.gov/acs/www/Products/Ranking/2003/R01T040.htm#top

2) The value of load response to CPP or PTR pricing will also vary from state to state, and in turn affect participation rates and responses.

The price differentials that drive demand response in dynamic pricing are based on the value of capacity in the wholesale market. If the market price goes up, the value of backing off critical peak load goes up, and vice versa. As the value of backing off critical peak load varies, the price differential between ordinary pricing and critical peak pricing (or variously the amount of the rebate in PTR pricing) should vary, at least over time.[38] As the price differential goes up and down, the customer responses may go up and down.[39]

The long-term marginal cost of capacity, which represents the value of demand response, varies as a result of numerous factors, including load forecasts, forecast plant retirements and additions, plant capacity factors, fuel costs, and the like. While there are exceptions, that long-term value is likely to be quite low through 2019 because the existing capacity in most regions is projected to exceed the quantity required for reliability according to the 2010 Long-term Reliability Assessment released by the North American Electric Reliability Corporation. For example, long-term projections of avoided capacity costs in New England are less than $20 per kW-year.[40] While current prices in congested zones can be and are much higher, such as $85 per kW-year in a congested zone of PJM,[41] those prices could drop sharply in the long-term as new transmission projects eliminate the congestion. For example, capacity prices in the non-congested zones of PJM are dramatically less than those in the congested southeastern area.[42]

The Maryland Commission in its review of BG&E's AMI investment proposal found that capacity values in the Southwest MAAC varied over a wide range, making it difficult to predict what the value of critical peak reductions would be over a ten or fifteen year period.[43] In that

[38] Some utilities, such as BG&E, have elected to choose a value for their dynamic pricing (in its case, its peak time rebates) and leave it in place for more than a season, regardless of the changes in the value to the system of responses to the price differential.

[39] There is no long-term experience with critical peak pricing or peak time rebates. The Energy-Smart Pricing Plan[tm], a version of real-time pricing for energy cooperative members in Greater Chicago, ran four summers. The evaluators of the last summer's pilot concluded that "ESPP participants continue to respond to hourly electricity prices in a manner similar to prior years. They reduce electric consumption during high priced hours." Summit Blue Consulting, *Evaluation of the 2006 Energy-Smart Pricing Plan[SM]: Final Report,* p. 2. BGE continued its SEP pilot for a third summer (2010) but only partial results are available after the first year.

[40] Direct Testimony of J. Richard Hornby, *In the Matter of the Application of Baltimore Gas and Electric Company for Authorization to Deploy a Smart Grid Initiative and to Establish a Surcharge for the Recovery of Cost,* (Hornby BGE Direct) Maryland Public Service Commission, Case No. 9208, October 13, 2009, at p. 27.

[41] *In the Matter of the Application of Baltimore Gas and Electric Company for Authorization to Deploy a Smart Grid Initiative and to Establish a Surcharge for the Recovery of Cost*, Maryland Public Service Commission, Order No. 83410 (BGE-Maryland PSC Order No. 83410), Case No. 9208, June 21, 2010, p. 50, fn. 194 ($266.15 mw-day * 365 days/year all divided by 1000 kW per mW).

[42] *Hornby BGE Direct* , at p. 27.

[43] *Id.*, p. 51, fn. 194.

proceeding BG&E did not provide any analyses to support is assumption that the current high capacity costs in its zone would continue for fifteen years. If fact, if the likelihood of future congestion relief is factored in, the future values of demand response for BGE customers could easily decline to as low as $100 per MW-day ($36 per kW-year).[44]

The differences in the value of avoided capacity between wholesale markets, and the fluctuation in such values over time, both put in question the applicability of the results of the pilots and the PG&E SmartTariff[tm] to another place or even another time.

C. PILOT RESULTS MIGHT BE SKEWED BY SELF-SELECTION BIAS.[45]

It is notoriously difficult to eliminate self-selection bias[46] in pilots with humans as "subjects." Self-selection bias may have occurred for a number of reasons in the pilots, including incentives to participate that would not apply in a utility-wide dynamic pricing implementation, and recruitment and participant attrition that may render the participant population unrepresentative.

For example, prospective participants in the BGE SEP and CA SPP pilots were given financial incentives for participating.[47] Some participants in the CA SPP pilots may have been enticed to participate by the utility's invitation to help address the energy problems in the state. Low-income customers in the PEPCO DC pilot were also given a higher rebate for demand response during critical peak hours than non-low-income customers, in an effort to attract such customers to participate in that pilot. Customers electing to take service under PG&E's SmartRate[tm] tariff were offered a $50 Visa card during the 2008 promotion of the rate, and all customers signing up for the tariff all receive bill protection for their first year on the rate.[48] These inducements likely

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[44] *Hornby BGE Direct*, at pp. 26-27.

[45] Self-selection bias refers to the possibility that the members of the participant group (or for that matter, the control) are not representative of the larger population from which they are drawn, because some factor in the recruitment of participants (or controls) attracts some types of customers and not others. It does not refer to any intent to skew the results. "Bias", in statistical terms, merely refers to the extent to which the sample studied is not representative of the larger population. For example, self-selection bias was likely the reason that a telephone poll, used by the Chicago Tribune to predict that presidential candidate Dewey was the winner over President Truman in the 1948 election, was wrong. Truman voters were simply less likely to have telephones at the time.

[46] There are statistical analyses that can be performed to observe whether certain possible contributors to the results are skewed between participants and control. See, e.g., James Heckman, "Sample Selection Bias as a Specification Error," *Econometrica*, Vol. 47, pp. 153-161 (1979). Tests following Heckman's method are commonly known as "Heckman" procedures. Heckman's insight has spawned a large literature on various ways to use participation factors and other statistical tools to try to correct for self-selection bias. The difficulties in the application of these methods can be appreciated by reference to the following articles, among many: Raymond S. Hartman, "A Monte Carlo Analysis of Alternate Estimators in Models Involving Selectivity," *Journal of Business & Economic Statistics*, Vol. 9, No. 1. (Jan. 1991): 41-49, available at http://links.jstor.org/sici?sici=0735-0015%28199101%299%3A1%3C41%3AAMCAOA%3E2.0.CO%3B2-G; and François Bourguignon, Martin Fournier, Marc Gurgand, *Selection Bias Corrections Based on the Multinomial Logit Model: Monte-Carlo Comparisons*, September 6, 2004.

[47] In the PEPCO DC case, low-income customers and other peak time rebate customers were given a $25 'thank-you" payment for completing the post-pilot survey.

[48] 2009 Evaluation, p. 14.

will not be available in full-scale implementation of dynamic pricing tariffs. Responses of customers not provided these inducements may be different from those of any such pilot or other cohort.

Another source of concern about the representativeness of the samples relates to the numbers of customers who declined the invitation to participate, or left the pilots. For example, only 3.1 percent of the residential customers solicited by CL&P for the Plan-It-Wise pilot enrolled.[49] Of these, 6 percent left the pilot before it started because they changed their mind.[50] After completing the enrollment process, 13.2 percent of residential participants were disqualified from the program.[51] The primary reasons for "unenrollment" were move-outs, the inability to get into the residence to install the smart meter or the lack of customer response to Company requests to schedule an enabling technology installation.[52] In all, 20 percent of all CL&P Plan-It-Wise pilot enrollees (residential and small C&I) left the pilot or were disqualified by the end of the rate pilot.[53] Over the three month duration of the pilot, 2.9 percent of residential customers left the pilot.[54]

The Maryland Commission openly questioned whether attrition rendered pilot results unrepresentative in the BGE pilot. During the second summer of the BGE SEP pilot, almost 300 out of 6-700 first-year participants did not return.[55] The lead evaluator of the BGE pilots, Dr. Faruqui, attributed this nearly one-third decline in enrollment to "natural attrition."[56] The Maryland PSC expressed concern that "this decline could indicate that (1) fewer residential customers have an interest in exploring dynamic pricing options when they are not paid to do so[57], or (2) a significant number of BGE customers simply lost interest in the program after only one summer."[58]

In the Interim Evaluation of the PEPCO DC pilot, the evaluator noted that certain parameter estimates were not very precisely estimated, probably on account of the fact that there were fewer than 20 RAD-AE customers[59] in the treatment group and a very small number of them had

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[49] *Impact Evaluation of Cl&P's Plan-It Wise Energy Program*: *Final Results,* prepared by the Brattle Group, APPENDIX C, p. 3. Note also that residential participant solicitation was by mail only, an approach that might explain the preponderance of college graduates and those with graduate degrees (54%) among the participants. *Id.*, p. 4. By contrast, according to the Census Bureau, 24% of adults over 25 in Connecticut had a bachelor's degree or higher. *Educational Attainment in the United States: 2007, Population Characteristics,* June 2009, at p. 1. See www.**census**.gov/prod/2009pubs/p20-560.pdf.

[50] *CL&P Impact Evaluation,* Appendix C, p. 3.

[51] *Id.*, at p. 5.

[52] *Id.*

[53] *Id.*, p. 5.

[54] *Id.* According to the CL&P evaluators, this rate of "unenrollment" is consistent with experiences of other utility rate pilots. Participants in the Connecticut pilot with central air conditioning who were given enabling technology left the pilot or were disqualified at a higher rate than customers without the enabling technology.

[55] *In the Matter of the Application of Baltimore Gas and Electric Company for Authorization to Deploy a Smart Grid Initiative and to Establish a Surcharge for the Recovery of Cost*, Maryland Public Service Commission, Order No. 83410 (BGE-Maryland PSC Order No. 83410), Case No. 9208, June 21, 2010, p.14.

[56] *Id.*, p.14, fn. 50.

[57] BGE offered incentives for customers to participate in the 2008 pilot, but did not offer such incentives in 2009.

[58] BGE-Maryland PSC Order No. 83410, p.14.

[59] Households with electric heating.

a smart thermostat.[60] The interim report stated that the evaluator, Dr. Frank Wolak of Stanford University, was doing further work on data for these customer groups, to see if it were possible to obtain usable results. The caveats about the precision of estimates were not included in the final report.
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D. The Pilots Reviewed Do Not Use Consistent Definitions of Low Income

One can readily hypothesize that income will have an effect on drivers of electricity usage, such as use of central air conditioning, size of dwelling, efficiency of appliances and the like, as well as on access to tools such as web portals. The IEE Whitepaper attempts to quantify the effects, positive and negative, of low income on a customer's response to dynamic pricing. As the authors say, "In order to assess the price responsiveness of low income customers, we first need to define the term "low income."[61]

The authors begin their review of the chosen pilots and rates with a discussion of what they call the test for "low income" published by the United States government, the Federal Poverty Guidelines. Having put forward one definition of poverty, the IEE Whitepaper then does not employ it in the analysis. The authors explain that the pilots reviewed in the paper "do not share a uniform definition of poverty." Rather than attempt to rationalize the definitions used in the various pilots, the analysts state that, for purposes of comparing the results, they "simply identify the definition used in each pilot."

The IEE Whitepaper lists the various definitions of low-income status as follows:

Definitions of Low Income Status Across Pilots[62]		
Pilot	**Definition of Low Income**	**Source**
BGE Smart Energy Pricing Pilot	Income less than $25K	Pilot survey question
CL&P Plan--it Wise Energy Program	1. Income less than $50K 2. Hardship	1. Survey question 2. Statute[63]
PEPCO PowerCents DC	1. Residential Aid Discount	Means-tested rate
PG&E SmartRate[tm] Tariff	California Alternate Rates for Energy (CARE)	Means-tested rate

[60] Frank A. Wolak, *An Experimental Comparison of Critical Peak and Hourly Pricing: The PowerCentsDC Program*, Very Preliminary Draft Prepared for 2010 POWER Conference, March 13, 2010, p. 26.
[61] IEE Whitepaper at 12.
[62] Source: IEE Whitepaper, Table 2.
[63] According to Connecticut utility statutes, "(B) 'hardship case' includes, but is not limited to: (i) A customer receiving local, state or federal public assistance; (ii) a customer whose sole source of financial support is Social Security, Veterans' Administration or unemployment compensation benefits; (iii) a customer who is head of the household and is unemployed, and the household income is less than three hundred per cent of the poverty level determined by the federal government; (iv) a customer who is seriously ill or who has a household member who is seriously ill; (v) a customer whose income falls below one hundred twenty-five per cent of the poverty level determined by the federal government; and (vi) a customer whose circumstances threaten a deprivation of food and the necessities of life for himself or dependent children if payment of a delinquent bill is required." 12 CA 499, section 16-262c.

California Statewide Pricing Pilot	1. CARE 2. Income under $40K (low-income) vs. income above $100K ("high income") *3. $25,000*[64]	1. Means-tested rate 2. Survey *3. Pre-SPP survey .*

As can be seen from the listing above, in three cases the definition of "low income" is a flat dollar limit ($25,000, $50,000 and $40,000). In four other cases, the definition is set at the eligibility for protections afforded to low-income utility customers by the tariff or state law.[65] Those eligibility rules take into account household size in addition to annual income.

Flat dollar income limits are only very imprecise markers of high or low household income in a pilot. Also, the three definitions of low-income based on standards of eligibility for certain protections are not identical. Customers who meet the definition in one case may not in another.

There is a substantial literature on the question of how to identify a household's income (or wealth) status.[66] In general, low-income refers to a household income so low that the household cannot afford the basic necessities of daily living, such as housing, food, utilities, clothing, medical care, transportation and the like. One conclusion from the literature is clear: almost no government agency or utility uses the Federal Poverty Guidelines *per se* to define eligibility for means-based programs.[67]

In any event, we know that different states and utilities that have defined the status of "low income customer" use a variety of income limits to identify low-income customers. Pilot program designers also have used different income levels, and do not consistently include any other variables, such as household size. The reliability of income designations varies as well. To the extent eligibility is a function of participation in a means-tested program such as LIHEAP, the household's eligibility may be verified by the LIHEAP agency, not the utility. To the extent an evaluator uses surveys of participants, there are no means of verification.

It is thus a practical necessity for a report such as the IEE Whitepaper to make reference to the designations of low (or high) income used in each study reviewed. At the same time, inability to

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[64] The evaluations based on income band data from the pre-SPP survey, shown in italics here, were not referenced in the IEE Whitepaper. At least two were published based on analyses done at the California Energy Commission, using data on income from the pre-SPP survey. See Karen Herter, Patrick McAuliffe and Arthur Rosenfeld, "An exploratory analysis of California residential customer response to critical peak pricing of electricity," *Energy*, 32 (2007):25-34; and Karen Herter, "Residential Implementation of critical-peak pricing of electricity," *Energy Policy* 35 (2007) 2121–2130. Available at: www.elsevier.com/locate/energy

[65] Hardship - Connecticut Light & Power, RAD - PEPCO PowerCentsDC, and CARE-California utilities.

[66] See links at http://aspe.hhs.gov/poverty/contacts.shtml.

[67] Governments, including the United States government, usually use adjusted values for the FPG to identify families in poverty. For example, the Low Income Home Energy Assistance Program (LIHEAP), funded by the federal government and administered locally, allows states to limit eligibility to 150 percent of the poverty guidelines, except where 60 percent of a state's median income is higher. For some states, that means fuel poverty is defined as a household income of 200% of the FPG or more. Among experts in low-income energy issues, these higher levels are understood to be better guidelines for identifying households with insufficient income to meet basic needs of daily living in the United States.

rationalize the definitions of low income across any of the pilots makes it impossible to translate the results noted as applying to "low income customers" to customers of another utility or in another state. The most that can be said with regard to the behavior of participants in the four pilots and one tariff is that those participants defined as "low-income" in that pilot showed such and such behavior in response to dynamic pricing during that pilot or evaluation period. We cannot definitively apply those results to any other utility or jurisdiction to obtain a solid basis for justifying the investments needed to offer dynamic pricing to low-income customers.

E. Some Pilots Lacked Enough Data to Segregate and Compare Low-Income and Non-Low-Income Responses.

In two cases, BGE and CL&P, it was not possible to identify differences in the responses of all low-income participants versus all non-low-income participants. In two other cases, the small number of low-income participants in some pilot treatments made it difficult to develop reliable statistics on such customers' use.

In the BGE case, 368 of 1375 participants (27%) did not respond to the survey question on income. As a result, the income status of only three quarters of all the pilot participants was known.[68] The subset of customers with known income status had different elasticities of substitution than the full sample. The authors note however, that "we do not know how customers who did not respond to the survey question would have responded to dynamic rates."[69]

As with BGE, obtaining results by income level was complicated in the CL&P pilot. Only 552 out of 1,251 participants (44%) responded to the income question on the survey.[70] The conclusions of the comparison of these low-income and non-low-income customers were valid then, only for this subset of customers who responded to the income question.[71] More reliable results were obtained for CL&P participants identified as "hardship" customers, who were qualified for certain consumer protections. CL&P was presumably able to identify hardship customers with specificity, as they would be tagged on company billing records as such.[72]

A somewhat different problem is presented by the so-called Track B portion of the California SPP. The IEE Whitepaper describes Track B as "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."[73] The Whitepaper reports that "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." This conclusion does not precisely describe the results of Track B.

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[68] BGE Evaluation at 16.
[69] *Id.*
[70] IEE Whitepaper at 18.
[71] Those customers who self-identified as below the income limit in the survey had demand responses "essentially eQually" to those self-identified as higher income.
[72] *Id.* Comparing hardship participants with the average non-hardship participant "*indicated that hardship customers responded slightly less than the average treatment customer to the [CPP] rate ..*" *(Emphasis in original).*
[73] *Id.*, p. 24.

The comparison to be made based on Track B results is not that low-income customers reduced load by a particular amount. Rather, the Track was intended to allow a comparison of the results for three otherwise similar groups of low-income customers, one receiving only information and two placed on the CPP rate. Further, average Track B results were likely pulled in the direction of lower load reductions by the demand response of a few participants: four of the Track B participants cut their usage 50% in response to CPP calls, and one of these reduced household demand by two-thirds during the winter period.[74]

As noted, the interim evaluation of the PowerCentsDC reported that it was difficult to estimate the demand response of customers identified as low-income.[75] In the Final Report, estimates are provided, without explanation as to what further analysis was done to obtain usable results.[76]

F. THE IEE WHITEPAPER ACKNOWLEDGES THERE MAY BE LOW-INCOME CUSTOMERS WHO EXPERIENCE SHARP PRICE INCREASES UNDER DYNAMIC PRICING

The IEE Whitepaper highlights the experience of low-income customers who are said to have enjoyed lower bills under dynamic pricing. It does not focus on the experience of low-income customers in the simulations and in the pilot evaluations who were observed to experience adverse bill impacts (even without including the cost of the AMI). Both the simulations and the pilot evaluations show that some low-income customers experienced serious adverse impacts from dynamic pricing.

For example, as shown in Figure 4 of the Whitepaper, the hypothetical low-income customers include at least 10% who would experience high bill impacts just because of the change to dynamic pricing. These impacts range as high as 10% or more. By definition, such bill increases are unsustainable for customers who are identified as low-income.[77]

There is evidence from at least one actual pilot that some low-income customers experienced adverse bill impacts from their switch to the piloted critical peak pricing.[78] These were high-use

[74] M Cubed, et al, *Statewide Pricing Pilot, Track B,* presentation slides April 26, 2005, at slide 8. Note also that for the group from the Richman, CA area, only the information plus dynamic pricing was piloted, without an information-only control. For this reason, these results are not statistically valid. *Id.*, slide 5.
[75] PowerCentsDC Interim Report at 2.
[76] The author of the Final Report forwarded a request for this information to Professor Wolak, who had not replied by the date of this paper.
[77] The IEE Whitepaper asserts that most adverse impacts on low-income customers can be averted by the choice of dynamic rate design. *IEE Whitepaper* at 10. It is not clear what compromises to the initial purpose of the dynamic rate would need to be made to accomplish this result, particularly if the aim is to protect all low-income customers from harm resulting from the switch to dynamic rates.
[78] "[S]ome customer types are more likely to see a bill increase due to CPP implementation. In particular, the insignificant bill savings for the low-income ($0–$24,999) and middle income ($25,000–$49,999) customer segments in the high use category warranted further investigation. A closer look at the individual billing data

low-income customers in the California Statewide Pricing Pilot. The evaluator who called out these adverse bill impacts suggested that efforts be made before introducing critical peak pricing to identify customers who would experience such effects, and target services including energy efficiency assistance to them.[79] The effectiveness of such an approach has not been tested.

G. The IEE Whitepaper Does Not Take Into Account the Costs of the Advanced Metering Used to Support the Dynamic Pricing

None of the bill impacts in the evaluations, simulated or otherwise, reflects the cost of installing the advanced metering infrastructure used to support the critical peak tariffs. Depending on the items included in the metering implementation (e.g. enhanced technology for central air conditioning control, in-home displays, etc.), the extent of operational savings that are achieved via the AMI (particularly elimination of manual meter reading costs), and rate design for recovery of the AMI investments (e.g. per customer or volumetric), some or all of the bill reductions enjoyed by low-income customers will be eroded by the offsetting cost of the investments. The IEE Whitepaper does not discuss these considerations.

H. Results of the Pilots Are Not Consistent and Not Calibrated.

As the authors state in their conclusion, 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 slightly less responsive compared to higher income customers (Pepco DC and SPP programs), while others found that low income customers were half as responsive (PG&E) as the higher income customers.". The authors do not attempt to determine the drivers of these different results. It is thus difficult to look at these results and understand which of them, if any, are predictors of likely relationships between average low-income and non-low-income responses to dynamic pricing.

I. Customers With Medical or Other Needs for Electricity Should Not Be Penalized for Critical Peak Usage.

Among the persons who would qualify for the designation "vulnerable" in the context of critical peak pricing are those who have a medical or similar need for electricity. Such customers include those requiring pumped oxygen, air conditioning or filtering, refrigerated medicines, and similar electricity-powered aides. Even if the utility offers only peak time rebates, which do not penalize a customer for failure to reduce demand at the critical peak hours, such customers may feel that they must reduce demand.

Others who may suffer in a dynamic pricing regime are those who feel the need to save money and do so at the expense of their health and safety. As the IEE Whitepaper points out, there are

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showed that 5.0% of these customers saw bill increases of more than 10%." K. Herter, *Residential implementation of critical-peak pricing of electricity*, Energy Policy 35 (2007) 2121–2130, 2126.
[79] *Id.*

no studies that confirm this concern. Energy advocates who have worked with vulnerable people for decades remain concerned that such customers may stint themselves at the expense of health and safety. Two examples illustrate this problem.

In a brutal heat wave some years ago in California, at least one person died of the heat because although she could well afford to pay for air conditioning, she had been raised in a situation requiring great frugality, and could not bring herself to pay for what she considered a luxury.[80] In the other example, a 76-year old woman in California signed up for the PG&E SmartRate[tm] critical peak pricing plan to save money. A utilities-analyst neighbor reported that she was "absolutely miserable – in part because she thought she had to turn off everything in her house but a couple of lights and her computer or TV in order to save anything."[81]

IV. CONCLUSION

The authors of the IEE Whitepaper on the impact of dynamic pricing on low-income customers state that their "core finding" is that "low income customers are responsive to dynamic rates and that many such customers can benefit even without shifting load."[82] The two conclusions in this core finding are very general ,they may or may not apply to various utilities and, in any case, they will vary in degree from utility to utility around the country. Our paper explains why the results reported in the IEE Whitepaper are not directly applicable to the varying situations of different utilities and different jurisdictions throughout the country.

The first general conclusion addressed in the paper, that many low income customers can benefit even from dynamic pricing without shifting load, should not be interpreted to mean that the majority of low income customers will always be better off under CPP even if they do not respond. In fact, the percentage of customers, including low income customers, in any utility who would be better off under mandatory CPP than under existing rates will depend on the distribution of residential customer load shapes within that utility. Further, the amount by which some customers (including low-income customers) may be better off will depend on the existing rates and the CPP rates at that utility, as well as the incremental costs incurred to implement CPP, such as the costs of smart meters and in home devices

The second general conclusion addressed in the IEE Whitepaper, that low income customers are responsive to dynamic rates, also should not be interpreted to mean that the majority[83] of low income customers will respond to PTR or CPP with significant reductions in peak use. In fact,

[80] Jennifer Steinhauer, "California Heat Wave Ends With a Death Toll Near 25," *The New York Times*, September 7, 2007, available at http://www.nytimes.com/2007/09/07/us/07heat.html; Hank Shaw, "Victims of S.J.'s fatal heat wave had so many things in common," August 20, 2006, *The Record OnLine*, available at http://www.recordnet.com/apps/pbcs.dll/article?AID=/20060820/NEWS01/608200331/-1/a_special07. Last viewed September 3, 2010.
[81] William B. Marcus, *Residential Rate Design and Energy Efficiency*, a presentation to the NRRI Teleseminar on Rate Design, February 11, 2010, available at http://www.jbsenergy.com/Energy/Papers/papers.htm.
[82] *Id.*
[83] Much less the great majority, and definitely not 100% of low-income customers.

the percentage of residential customers at a given utility who will respond to CPP, and by how much, will depend on many factors, including the existing rates, the financial penalty imposed on maintaining critical peak usage,, the percentage of central air conditioning, local climate conditions and income levels, and perhaps other key variables. The authors do not maintain that the pilots and programs examined in their report are representative of every utility throughout the United States[84]. Instead, they state that “Other utilities should conduct pilots or market research to verify that these results also hold for their customers”[85]

In the debates over the value of smart metering and dynamic pricing for customers of various utilities, the IEE Whitepaper has been and will be cited as proof that low-income customers have nothing to fear from the implementation of such policies. A closer look at the paper reveals that, however much the general conclusions of the IEE Whitepaper may approximate reality in some situations, the Whitepaper does not lay to rest the concern for impacts on low-income customers.

[84] Response to Question 2
[85] Response to Question 4.

Appendix

ESTIMATING DEMAND RESPONSE VIA THE PRISM MODEL

PRISM (or the Price Impact Simulation Model) uses price elasticity estimates derived from the California Statewide Pricing Pilot in 2003-2004 to develop elasticity estimates for application in other localities:

> The California Statewide Pricing Pilot (SPP) produced estimates of price elasticity for residential customers that captured variations in customer price responsiveness across four different climate zones in the state. These estimates were codified in the Pricing Impact Simulation Model (PRISM) which allows price elasticities to vary as a function of a zone's saturation of central air condition (CAC) equipment and weather conditions. Specifically, it was found that zones with higher CAC saturation (which were also the hotter climate zones) were more price elastic than zones with low CAC saturations (which were also the milder climate zones). *CAC saturation was found to be a key driver of differences in price responsiveness across the zones. These findings made it possible to express price elasticity as a function of CAC saturation, allowing the PRISM results to be projected to other regions of the country.*[86]

PRISM[87] calls for the following inputs from the analyst seeking to use it to estimate demand responses from a dynamic pricing pilot or tariff:

- Breakdown of average kWh per month usage, for residential customers on average, for residential customers with central air conditioning, for residential customers without central air conditioning, and for residential customers with central air conditioning who received an enabling technology such as a programmable communicating thermostat, all by critical day peak hours, critical day non-peak hours, and non-critical day peak and non-peak hours.
- Residential all-in rates on average, expressed in $/kWh, and broken down by critical peak pricing, peak pricing, and off-peak pricing.
- Residential customer charge.
- Non-energy variable charges (if any).
- Number of hours in the four periods in question, critical day peak hours, critical day non-peak hours, and non-critical day peak and non-peak hours.
- Average central air conditioning saturation.
- Average daily cooling degree hours per hour (at 72^{o} F - about 22^{o} C), and excess of cooling degree hours per hour, for peak and off peak periods, broken down by critical peaks and otherwise.

[86] FERC Demand Response Assessment, Appendix D, pp. 233-234.

[87] This list of inputs is from a 1997 version of PRISM available to the authors of this review. According to emailed answers to Questions put by the reviewers to the IEE Whitepaper authors, the most recent version of the PRISM model "is the Company's Intellectual Property and not publicly available." Brattle Group Response to Reviewers' Response to, Question 15. The Brattle Group noted that one "can refer to the publicly available version [of PRISM through the EEI."

- Ratio of impacts of customers with both central air conditioning and an enhanced technology to central air conditioning impacts.

To this data, the PRISM model applies substitution elasticities and daily price elasticities, drawn from the results of the California Statewide Pricing Pilot. The model allows the analyst to use different substitution elasticities if they have been re-estimated using other data. The model then takes the inputs and the given elasticities and uses them to estimate a per customer demand response for both CPP and Non-CPP days for the sample load profiles.[88]

We do not know what elasticity assumptions are in the particular version of the PRISM model used in the IEE Whitepaper. The authors do not provide an explanation of any adjustments they may have made to the PRISM elasticities to make them more reliable predictors of likely demand responses of customers of the "large urban utility." In addition, we are not told what "large urban utility" was used as the exemplar in the simulations, and cannot gauge the relevance of the experience of customers of that utility to the experience of customers elsewhere.

As used in the IEE Whitepaper, the PRISM simulations model is a black box. The specific model of PRISM used has not been described nor made available by the IEE Whitepaper authors. Nor have the IEE Whitepaper authors shared the inputs used in the IEE Whitepaper simulations using the model are provided in the paper.[89] The IEE Whitepaper does not reveal what is assumed regarding the relative elasticities of low-income and non-low-income customers, for the simulated demand response exercise.

The IEE Whitepaper authors do agree, however, that "in order to extrapolate the results from their report to other utilities one must make adjustments for differences in the values of various key independent variables, in particular the level of the dynamic rate, weather and CAC penetration."[90] Accordingly, it is not possible to verify the usefulness of the Whitepaper's assumptions regarding low-income customers' demand responsiveness, as reflected in the bill impacts estimated for the two critical peak pricing scenarios.[91]

The need to make adjustments to PRISM for application outside California is described more fully in the methodology and data section of the FERC Demand Response Assessment, also authored by a Brattle Group team. The FERC Demand Response Assessment used the PRISM model to estimate likely demand responses around the country. The Assessment authors attempted to calibrate outcomes based on the PRISM model against a number of other pilot results.

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[88] The analyst can then go on to the benefits explanation portion of the PRISM model, where data on forecast loads and resource costs are used to develop the value estimated as above of the load reduced via the dynamic pricing.
[89] Response to Questions 10, 11.
[90] Response to Question 3.
[91] To the extent the elasticities used in the PRISM model are based on the California Statewide Pricing Pilot, the results for customers of different income levels are only rough suggestions of direction and magnitude of response of California low-income customers. The evaluations used a cut-off for lower income ($40,000) that is not tied to household size, which makes it an unreliable identifier of poor households. As discussed further below, however, there is no consistent data from pilots or actual rate offerings with regard to differences in results based on income.

The PRISM model failed to predict the observed demand response. In a number of cases, using input data from the utility in question, PRISM's California-based elasticity estimates over-predicted the demand response that was actually observed.[92] This was so despite the fact that the Statewide Pricing Pilot was run in four separate and different climate zones in California, a state with a wide variation in climate as a result of its great size.

The authors of the FERC Assessment acknowledged that "some judgment must be exercised in determining whether to extrapolate their findings to a larger population beyond the participants of the pilot."[93] Presumably judgment would also have to be applied to extrapolate the PRISM results in the IEE Whitepaper to other geographic areas and other residential customer populations.

The FERC Demand Response Assessment authors speculate that the inability to translate the California elasticities directly to other states is a function of the relative lack of humidity in the California climate zones, even the hottest zones.[94] To estimate likely demand responses more closely, given this inadequacy of the CA SPP elasticities, the FERC Assessment authors applied two adjustments. In the pilot states with observed results lower than those predicted by PRISM, the authors scaled back PRISM-simulated peak demand reductions to equal the lower impacts that were observed in these three pilots. In addition, the analysts derated PRISM-simulated impacts by 20% for all states east of the Rocky Mountains, to account for the humidity effect observed in the three pilots.[95]

From the adjustments that had to be made to provide usable results from PRISM in the FERC Demand Response Assessment, it is clear that, as acknowledged by the IEE Whitepaper authors, PRISM runs with elasticities based on the California Statewide Pricing Pilot cannot simply be used in other jurisdictions. At the same time, there is no publicly-available critique of the methods used in the FERC Demand Response Assessment to adapt the California elasticity findings to other areas in the United States.[96] Even as to the 20% deratings, it is not possible to know how the adaptations were made. For the other adjustments, we cannot know what the adaptations were, how well the adaptations work in a variety of situations, and accordingly whether and to what extent the PRISM model, even as adapted, can be used with confidence to predict demand responses from any other set of residential customers.

As the authors confirm, one can state with confidence that adjustments must be made to the PRISM model approach outside of California to achieve usable results. In addition, the model's predictions explicitly vary with variations in the climate (cooling degree days), underlying rates, dynamic pricing rate structure, and penetration of central air conditioning (and enhancing technologies).

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[92] This error occurred in applying PRISM to the results of pilots in Maryland (BGE), Missouri (Ameren) and New Jersey (PSE&G).
[93] FERC Demand Response Assessment, at p. 234.
[94] *Id.*, at p. 235.
[95] *Id.*
[96] FERC did not study impacts in Canada.