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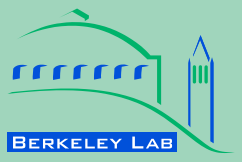

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Evaluation of evolving residential electricity tariffs

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Disclaimer

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Abstract

Residential customers in California's Pacific Gas and Electric (PG&E) territory have seen several electricity rate structure changes in the past decade. A relatively simple two-tiered pricing system (charges by usage under/over baseline for the home's climate zone) was replaced in the summer of 2001 by a more complicated five-tiered system (usage below baseline and up to 30%, 100%, 200%, and 300%+ over baseline). In 2009, PG&E began the process of upgrading its residential customers to Smart Meters and laying the groundwork for time of use pricing, due to start in 2011. This paper examines the history of the tiered pricing system, discusses the problems the utility encountered with its Smart Meter roll out, and evaluates the proposed dynamic pricing incentive structures. Scenario analyses of example PG&E customer bills will also be presented. What would these residential customers pay if they were still operating under a tiered structure, and/or if they participated in peak hour reductions?

Introduction

PG&E is an investor owned utility (IOU) that encompasses most of northern and central California and serves approximately five million residences. PG&E is regulated by the California Public Utilities Commission (CPUC), a state agency that oversees the utility rates and certain business practices. As mandated by CPUC, PG&E has began preparations for transitioning its residential customers from the current 5-tiered tariff to time variable pricing, due to be completed by 2014, and with the ultimate goal of real-time pricing in 2020 (CPUC 2010a).

PG&E residential tariff structure

Brief history of PG&E residential tariffs and explanation of baseline

Until the middle of 2001, PG&E employed a two-tiered pricing structure for residential electricity with a baseline allowance and usage above baseline costing more. Usage for electricity up to and over baseline hovered around 11.5 US cents per kWh, and 13.3 US cents per kWh, respectively. Starting in June 2001, a five-tiered rate structure was introduced that increased the cost of electricity at 101%, 131%, 201%, and 301% of baseline. **Figure 1** shows the tier structure and costs starting from 2000. The baseline amount (kWh/day x days/month) differs depending on season and location, meaning that weather and climatic differences are roughly taken into account. Baseline is calculated to be roughly 60% of the average usage within each area. This means that if the majority in an area do not

conserve, then the baseline allowance will, in theory[1], raise to account for this group behavior, which in time will reward those who do conserve energy.

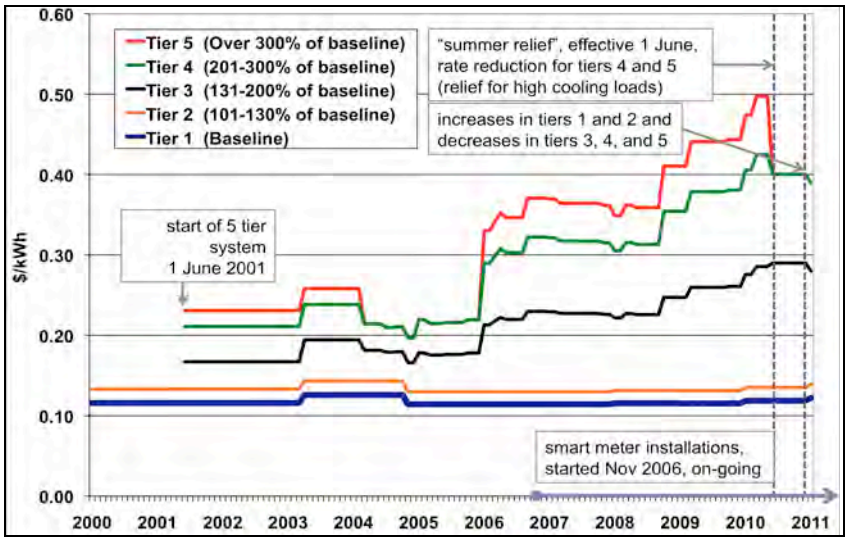

Figure 1. History of PG&E residential electricity tier pricing, year 2000 to present.

Figure 2 shows the PG&E territory baseline map, the percent and number of customers, and the baseline for each area for summer and winter. Note that the allowances shown are for "basic" customers who receive both electric and natural gas service. Customers who receive only electric (no natural gas for cooking or heating), have a medical need for more electricity, and those on reduced rates have more generous allowances[2].

Base-line Area	Residential Customers %	Residential Customers 1000's	Baseline Quantity (kWh/day) summer	Baseline Quantity (kWh/day) winter
P	3.58%	179	16.5	12.9
Q	0.08%	5	8.3	12.6
R	10.63%	532	18.1	12.3
S	16.45%	823	16.5	12.7
T	24.05%	1203	8.3	9.8
V	1.08%	54	9.6	11.1
W	5.10%	255	19.4	11.4
X	37.62%	1881	12.1	12.6
Y	1.28%	64	12.2	13.3
Z	0.14%	7	8.8	11.6

Figure 2. PG&E baseline map, customers as of 2010, and electricity baseline quantities for those who receive both electric and natural gas service. Source: PG&E and own work, number of customers rounded to the thousand.

Historical analysis

The ten baseline territories shown in **Figure 2** are aggregated into four areas that share similar climate and other characteristics: coastal, hills/mountain, valley-inner, and valley-outer. Table 1 below shows a summary of the electricity usage from 2006 through 2009 for the average, normalized customer of these four areas[3], and **Figure 3** shows graphically the behavior of customers in coastal and valley-inner areas. The tariff (values rounded) at each tier is included; if multiple tariffs were in effect during a year, the last applicable rate is shown. For each baseline area normalized customer, the kWh/a consumption and % change from one year to the next is shown. For any given year, the sum of the usage in all tiers multiplied by the number of customers in the aggregated baseline area equals the total amount of electricity sold to the residential sector.

[1] The baseline amounts shown in this paper are current and were last updated by PG&E in May 2006.
[2] Analysis of non-basic customers is out of scope for this paper.
[3] The normalized customer usage is calcuated as the total usage consumed in each tier (kWh/a) in each of the four aggregated areas divided by the number of customers in the same areas.

		Tier 1 (T1)			Tier 2 (T2)			Tier 3 (T3)			Tier 4 (T4)			Tier 5 (T5)			*Total Ann. Usage*	
Baseline Area	yr	Tariff	Usage		Tariff	Usage		Tariff	Usage		Tariff	Usage		Tariff	Usage			
		$/kWh	kWh/a	% Δ	$/kWh	kWh/a	% Δ	$/kWh	kWh/a	% Δ	$/kWh	kWh/a	% Δ	$/kWh	kWh/a	% Δ	*kWh/a*	*% Δ*
Coastal	06	$0.114	2680	-	$0.130	488	-	$0.230	687	-	$0.322	390	-	$0.371	312	-	*4557*	*-*
(Q, T, V)	07	$0.114	2655	-1.0	$0.130	486	-0.5	$0.226	687	0.0	$0.315	391	0.5	$0.362	331	6.2	*4550*	*-0.1*
	08	$0.116	2653	-0.1	$0.131	480	-1.2	$0.247	674	-1.9	$0.354	378	-3.4	$0.411	333	0.6	*4518*	*-0.7*
	09	$0.115	2672	0.7	$0.131	484	0.8	$0.261	678	0.6	$0.381	376	-0.6	$0.443	340	2.2	*4550*	*0.7*
Hills/	06	$0.114	3793	-	$0.130	707	-	$0.230	986	-	$0.322	565	-	$0.371	427	-	*6479*	*-*
Mount.	07	$0.114	3760	-0.9	$0.130	700	-1.0	$0.226	969	-1.7	$0.315	540	4.5	$0.362	393	-8.0	*6361*	*-1.8*
(X, Y, Z)	08	$0.116	3782	0.6	$0.131	705	0.7	$0.247	976	-0.7	$0.354	544	0.7	$0.411	396	0.8	*6402*	*0.6*
	09	$0.115	3814	0.8	$0.131	712	1.0	$0.261	979	0.3	$0.381	531	-2.4	$0.443	372	-6.1	*6408*	*0.1*
Valley-	06	$0.114	4386	-	$0.130	855	-	$0.230	1256	-	$0.322	753	-	$0.371	450	-	*7700*	*-*
Inner	07	$0.114	4350	-0.8	$0.130	836	-2.2	$0.226	1203	-4.2	$0.315	678	-10.0	$0.362	360	-19.9	*7427*	*-3.6*
(P, S)	08	$0.116	4439	2.1	$0.131	856	2.3	$0.247	1226	1.9	$0.354	677	-0.1	$0.411	340	-5.7	*7537*	*1.5*
	09	$0.115	4527	2.0	$0.131	874	2.2	$0.261	1238	1.0	$0.381	657	-2.9	$0.443	309	-9.0	*7606*	*0.9*
Valley-	06	$0.114	4604	-	$0.130	879	-	$0.230	1304	-	$0.322	802	-	$0.371	448	-	*8036*	*-*
Outer	07	$0.114	4542	-1.3	$0.130	868	-1.3	$0.226	1278	-2.0	$0.315	754	-5.9	$0.362	386	-13.7	*7829*	*-2.6*
(R, W)	08	$0.116	4633	2.0	$0.131	885	1.9	$0.247	1290	0.9	$0.354	743	-1.4	$0.411	361	-6.6	*7912*	*1.1*
	09	$0.115	4736	2.2	$0.131	916	3.5	$0.261	1327	2.9	$0.381	740	-0.4	$0.443	337	-6.7	*8056*	*1.8*

Table 1. Summary of tier prices, normalized customer usage in different tiers, and % changes for 2006-2009.
Source: PG&E and own calculations.

For all four areas, the normalized customer's annual consumption from 2006 to 2009 has remained fairly constant: changing by just -0.2% for coastal, -1.1% for hills/mountain, -1.2% for valley-inner, and 0.2% for valley-outer; however, the behavior when faced with tiers differs from year to year and between the baseline areas.

Coastal: even with increasing tier pricing over time, the tiered consumption of the average coastal customer remained relatively stable, and with the largest percent change in T5. One possible explanation for this is that since the coastal climate is mild and assigned a lower baseline than the other areas (8.3 kWh/day summer, 9.8 kWh/day winter in area T, where 24% of PG&E customers live), that the usage cannot be easily reduced, i.e., demand is inelastic. **Figure 3**-left demonstrates the lack of response from these customers when faced with higher prices.

Hills/Mountain: similar to the coastal example, the largest consumption reduction happens in T5, however, the gains in the lower tiers are inconsistent.

Valley-Inner and Valley-Outer: the usage noticeably declines as the T4 and T5 prices increase between 2006 and 2009; and during the same period, usage increases in T1 and T2. **Figure 3**-right shows the correspondence between higher prices and decreasing consumption for the Valley-Inner case.

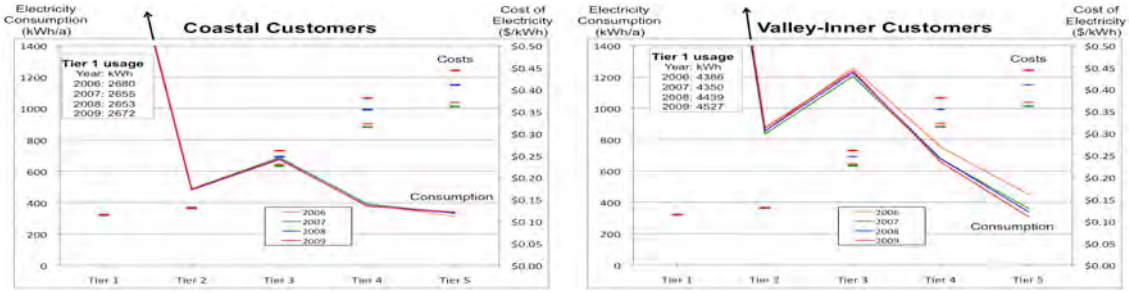

Figure 3. Comparing the behavior of Coastal and Valley-Inner customers between 2006 and 2009

Limitations and caveats of historical analysis

Several assumptions had to be made as part of the analysis. The lack of long-term data precluded in-depth look at customer behavior. In addition, since no seasonal or monthly data was available, the usage can only be examined at the yearly level. This meant that the potential summer cooling peaks and behaviour volatility were not visible. Special customer classes (for example, those with medically necessary increased baselines, those who qualify for discounted rates, etc) were included as part of the examined population. Their electricity usage may be quite different than a basic user, but due to the nature of the raw consumption data, no disaggregation was performed.

The future of residential tariff, beyond the five-tiered system

The tariffs are undergoing major changes as PG&E switches from the five-tiered system to time of use (TOU) pricing as mandated by the CPUC. It is believed that this move will enhance overall electric system reliability, reduce the need for utilities to purchase power during peak hours, reduce customers' electricity bills, and help to protect the environment (CPUC 2006).

The introduction of Smart Meters

One of the necessary steps towards the implementation of TOU for the residential sector is the installation of Smart Meters, or the retrofitting of existing meters with network communications infrastructure.

Customer discontent with Smart Meters

There are currently 3.8 million electrical residential Smart and 1.3 million analog meters in service in the PG&E territory. The Smart Meter program complaints generally fall into three broad categories (Structure 2010):

- Smart Meters are inaccurate and lead to higher bills.
- Sub-par installation experience and unsatisfactory customer service experience. These has little to do with the Smart Meters but rather with PG&E employees and their perceived lack of professionalism or expertise.
- Safety and privacy issues. Some customers believe Smart Meter EMFs and/or RFs are harmful (EMF Network 2010); some customers also believe their electricity usage information will be hacked/illegally accessed.

Figure 4 shows the preliminary analyses of ~2700 complaints regarding PG&E's Smart Meter program that were filed with the CPUC. Approximately half of the complaints were decided in favor of the utility or to be resolved at the discretion of the utility.[4] Approximately a quarter of the complaints were decided in favor of the customer; these mostly consisted of high and inaccurate bill complaints. While preliminary, the analyses suggest that despite the vocal complaints from thousands of customers, the Smart Meters are accurate.

	2008	2009	2010
Utility	12	258	1021
Customer	0	65	604
Compromise	1	32	86
Unresolved	2	1	85
Unrelated	3	98	436
Total	18	454	2232

Figure 4. Summary of PG&E's Smart Meter complaints. Source: CPUC and own calculations.

In addition to these individually filed complaints, the EMF Safety Network, on behalf of concerned businesses and individuals, has challenged the CPUC's decision to allow for Smart Meters (CPUC 2010b). Several cities and counties in California have also enacted (or are proposing) laws to ban the installation of Smart Meters (stopsmartmeters.org 2011). Despite these oppositions, CPUC has thus far maintained its support and time variable pricing will still be instituted in the future.

PG&E's current and proposed residential pricing incentive structures

SmartAC and SmartRate are two of the current opt-in energy saving programs that a customer may be served under in addition to their otherwise applicable residential tariff. Future pricing incentive structures include Peak Day Pricing (PDP) and Peak Time Rebate (PTR). The current five-tier structure will add time variability, starting with voluntary "opt-in" to PDP in February 2011, or default transitioning into PTR between May 2011 and 2012, followed by default into PDP in 2013 or 2014. Refer to **Figure 5** for graphical representation.

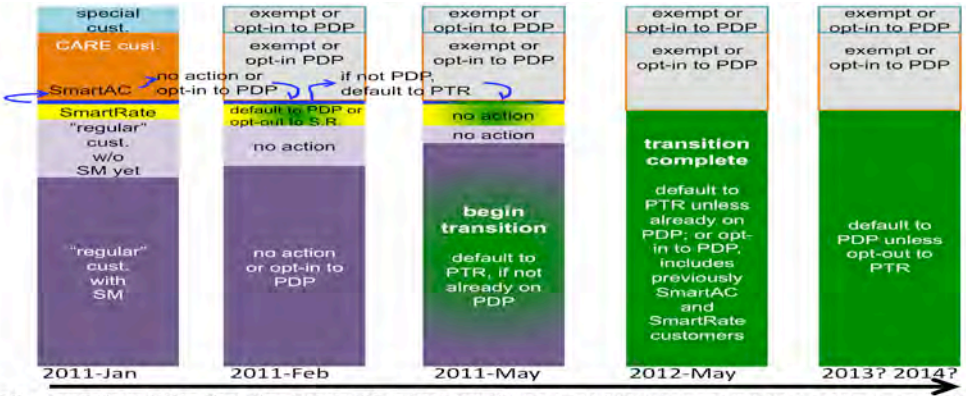

Figure 5. The progression of residential tariffs.

[4] Included in PG&E's favor were complaints from unresponsive customers, i.e., those who were unresponsive when the utility or CPUC tried to follow up with the complaint. An example of a case that could be marked as utility discretion would be a customer whose meter installation coincided with an especially high, but correct, bill and who sought relief from PG&E. Additionally, complaints of "I don't want a Smart Meter installed" or "I want my Smart Meter removed" were counted in the Utility's favor since there is currently no opting-out of the program.

SmartAC and Smart Rate

These are two of the current optional programs for residential customers. SmartAC customers agree to allow PG&E to temporarily adjust the AC temperature setting or cycle the AC unit for 50% less over any 30 min interval, for no more than 6 hours per day or 100 hours per season (PGE SmartAC 2010). SmartRate is a time differentiated summer-only rate that charges $0.60/kWh (all tiers) for usage between 14:00h to 19:00h on upto 15 "Smart Days" from May through October, while offering a reduced rate of $0.02992/kWh (all tiers) between June and September for all other hours, and with the added bonus of a $0.01/kWh credit for tiers 3-5 for usage anytime between 1 June and 30 September (PG&E SmartRate 2010). Approximately 2% of customers participate in these programs, and they will be transferred onto the new TOU rates along with the rest of the customers.

Peak Day Pricing (PDP)

The PDP has as its basis the 5-tiered rate, in addition to TOU charges, as well as charges and credits for peak days. The TOU charges fall under five categories: summer on/mid/off peak and winter mid/off peak. Usage during each of those five TOU periods will still be influenced and accounted by the 5-tiered rate structure. "Peak days" are days when the electrical system is seriously strained, when the electrical wholesale market price is extremely high, or when the average temperature of four key locations in the state exceeds 36.6 C (weekday) or 40.6 C (weekend). They may occur any day of the year, but can only be "called" between 9 and 15 times, and only between 14:00h and 19:00h. Peak days have to be called by 14:00h a day prior so that customers have time to prepare and react.

Peak Time Rebate (PTR)

PTR is yet another pricing structure with both a TOU and "peak" condition. However, unlike PDP, there are no charges/penalties if the customer does not shed load during an event. In other words, PTR has only an incentive component; customers' bills will either be the same or lower while on PTR compared to their otherwise applicable tariff, but never higher. Referring back to Figure 5, it is shown that between May 2011 and 2012, PG&E will transfer most of its customers to PTR unless they have already previously opted into PDP. PTR is expected to become the default tariff in 2013 or 2014 for those who opt-out of PDP.

Example calculation for summer on peak using 5-Tiers and PDP[5]

The effects of PDP can be demonstrated by taking an Area R and an Area T customer and assuming both use above their baseline during a summer peak day. Table 2 contains the hourly kWh of the R and T customers; total usage is 20.17 kWh/day and 14.97 kWh/day, respectively. In Table 3 through Table 5, *italicized values* are part of the tariff/rate; regular text values are calculated; **bold values** are the charges, total bill[6], and average cost of electricity.

Table 3 shows the cost that customers in R and T would pay on the traditional 5-Tiers system. In R, the 20.17 kWh/day is distributed to T1 and T2, and in T, the 14.97 kWh/day is distributed to T1 through T3 (recall that R has a lower baseline). This example shows that the average $/kWh for R and T is $0.12 and $0.17, respectively. Thus, even though R uses more, its higher baseline means that its usage manages to stay within the lower two tiers. On the other hand, T uses less, but with a lower baseline, the overall lower amount is distributed over three tiers.

	H 1	H 2	H 3	H 4	H 5	H 6	H 7	H 8	H 9	H 10	H 11	H 12
Area R	0.59	0.53	0.50	0.48	0.48	0.52	0.57	0.62	0.70	0.78	0.86	0.93
Area T	0.46	0.43	0.42	0.42	0.45	0.53	0.57	0.57	0.58	0.60	0.62	0.63

	H 13	H 14	H 15	H 16	H 17	H 18	H 19	H 20	H 21	H 22	H 23	H 24	Total
Area R	1.01	1.08	1.14	1.18	1.20	1.19	1.13	1.13	1.10	0.97	0.81	0.68	20.17
Area T	0.64	0.64	0.67	0.70	0.72	0.76	0.84	0.92	0.88	0.76	0.62	0.53	14.97

Table 2. Example hourly kWh usage of customers in R and T areas during the summer
(Peak hours = 12:00-18:00, off-peak = 21:30-8:30, mid-peak = all others).

	Total	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
$/kWh		*$0.12233*	*$0.13907*	*$0.28011*	*$0.38978*	*$0.38978*
Area R (kWh/day)	20.17	18.1	2.07	-	-	-
Charges by Tier		**$2.21**	**$0.29**			
Total ($)	**$2.50**					
Average ($/kWh)	**$0.12**					
$/kWh		*$0.12233*	*$0.13907*	*$0.28011*	*$0.38978*	*$0.38978*
Area T (kWh/day)	14.97	8.3	2.49	4.18	-	-
Charges by Tier		**$1.02**	**$0.35**	**$1.17**		
Total ($)	**$2.54**					
Average ($/kWh)	**$0.17**					

Table 3. Cost of electricity based on the traditional 5-Tiered pricing (TOU/peaks not considered).

[5] PTR example calculation not possible; tariff rates are not yet available on the PG&E website.
[6] Total bill excluding fees/surcharges, taxes, etc.

Table 4 and Table 5 show PDP calculations for R and T. As can be seen, the PDP calculations are significantly more complicated than those of the traditional 5-Tier system. Such a pricing structure may prove to be difficult for customers to decipher. The average kWh costs in the PDP calculation are almost 4x higher, with the PDP Event Charge of $0.50/kWh playing a prominent role in the bill. Table 6 shows a comparison of the 5-Tiered method with PDP on a monthly level. In these two particular examples, the PDP bills run slightly higher, under 5%. However, it should be noted that these are just two load shapes, and that there certainly are combinations where the customer will receive bill savings. The PG&E projected range of increases/decreases for the customers on PDP is shown in Figure 6. Overall, 53% are estimated to have PDP bills within ± 2% of the bill as calculated by the 5-Tiered system.

		Time-of-Use (TOU) Periods		
		Peak	Mid Peak	Off Peak
R area summer baseline allowance (kWh/day)	*18.1*	12:00-18:00	8:30-12:00, 18:00-21:30	21:30-8:30
PDP Event Charge ($/kWh, applicable on PDP days)	*$0.50*	-	-	-
PDP Adjustments ($/kWh, applicable on all days)		*-$0.01331*	*-$0.01331*	*-$0.01331*
Residential E1 TOU rate ($/kWh, all days)		*$0.14211*	*$0.12164*	*$0.10943*
Adder: Tier 1 (Tier 1 Adder + TOU rate + PDP Adj.)	-	$0.12880	$0.10833	$0.09612
Adder: Tier 2 (Tier 2 Adder + TOU rate + PDP Adj.)	*$0.01625*	$0.14505	$0.12458	$0.11237
Actual usage (kWh/day); usage by TOU	20.17	6.54	7.67	5.96
TOU usage breakdown (%)	-	32%	38%	30%
Usage at baseline/Tier 1 (kWh/day)	18.1	5.9	6.9	5.4
Usage in Tier 2 (kWh/day)	2.07	0.7	0.8	0.6
Charges:				
Tier 1 charges (Tier 1 kWh/day * TOU rate with adder and Adj.)		**$0.75542**	**$0.74579**	**$0.51429**
Tier 2 charges (Tier 2 kWh/day * TOU rate with adder and Adj.)		**$0.09745**	**$0.09824**	**$0.06887**
PDP Event Charge ($.50/kWh * Actual usage)	**$10.09**	-	-	-
Total bill on a PDP day (sum of all charges)	**$12.37**			
Average $/kWh for electricity on a PDP day for area **R**	**$0.61**			

Table 4. R area customer PDP day calculation (PG&E 2010b and own calculations)

		Time-of-Use (TOU) Periods		
		Peak	Mid Peak	Off Peak
T area summer baseline allowance (kWh/day)	*8.3*	12:00-18:00	8:30-12:00, 18:00-21:30	21:30-8:30
PDP Event Charge ($/kWh, applicable on PDP days)	*$0.50*	-	-	-
PDP Adjustments ($/kWh, applicable on all days)		*-$0.01331*	*-$0.01331*	*-$0.01331*
Residential E1 TOU rate ($/kWh, all days)		*$0.14211*	*$0.12164*	*$0.10943*
Adder: Tier 1 (Tier 1 Adder + TOU rate + PDP Adj.)	-	$0.12880	$0.10833	$0.09612
Adder: Tier 2 (Tier 2 Adder + TOU rate + PDP Adj.)	*$0.01625*	$0.14505	$0.12458	$0.11237
Adder: Tier 3 (Tier 3 Adder + TOU rate + PDP Adj.)	*$0.17185*	$0.30065	$0.28018	$0.26797
Actual usage (kWh/day); usage by TOU	14.97	4.00	5.86	5.11
TOU usage breakdown (%)	-	27%	39%	34%
Usage at baseline/Tier 1 (kWh/day)	8.3	2.2	3.2	2.8
Usage in Tier 2 (kWh/day)	2.49	0.7	1.0	0.9
Usage in Tier 3 (kWh/day)	4.18	1.1	1.6	1.4
Charges:				
Tier 1 charges (Tier 1 kWh/day * TOU rate with adder and Adj.)		**$0.28539**	**$0.35197**	**$0.27251**
Tier 2 charges (Tier 2 kWh/day * TOU rate with adder and Adj.)		**$0.09642**	**$0.12143**	**$0.09557**
Tier 3 charges (Tier 3 kWh/day * TOU rate with adder and Adj.)		**$0.33528**	**$0.45816**	**$0.38237**
PDP Event Charge ($.50/kWh * Actual usage)	**$7.48**	-	-	-
Total bill on a PDP day (sum of all charges)	**$9.88**			
Average $/kWh for electricity on a PDP day for area **T**	**$0.66**			

Table 5. T area customer PDP day calculation (PG&E2010b and own calculations)

	Monthly Comparisons			
	5 Tiers		PDP	
	R	T	R	T
daily usage (kWh/a)	20.17	14.97	20.17	14.97
tiered charge ($/kWh)	$2.50	$2.54	-	-
PDP day charge ($/kWh)	-	-	$12.37	$9.88
non-PDP day ($/kWh)	-	-	$2.28	$2.40
monthly tiered (daily $/kWh *30)	**$75.00**	**$76.20**	-	-
monthly charge for month w/1 PDP day (PDP day charge + 29 * non-PDP day charge)	-	-	**$78.49**	**$79.48**
Increase (%)			**+4.7%**	**+4.3%**

Table 6. Comparison of 5-Tiered tariff and PDP tariff.

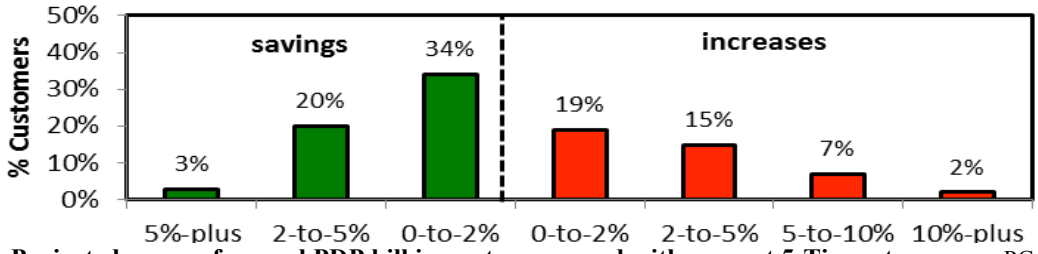

Figure 6. Projected range of annual PDP bill impacts compared with current 5-Tier rates. source: PG&E 2010b.

Summary and Conclusions

Residential PG&E customers have been paying for electricity based on a tiered system since 2001, and are currently in the transition period towards a time variable pricing structure, due to be implemented later this year. Using yearly data from 2006 to 2009, it is possible to see the tiers "at work" as a normalized customer shifts his consumption from the upper to the lower priced tiers or decrease usage all together to avoid paying higher costs. In addition, it is possible to see when a normalized customer does not, or cannot, meaningfully alter his tier profile.

Going forward, the installation of Smart Meters will play an integral part in the planned TOU pricing structure. Unfortunately, the Smart Meter rollout has faced opposition from not only individuals, but also non-profit umbrella organizations and city/county governments. A preliminary review of the complaints that have been filed and of the 3-rd party Smart Meter report suggests that while the meters on the whole are accurate and secure, some customers have a deep seated belief they are being overcharged, that the meters are affecting their health, and that their privacy will be compromised. Despite antagonism from several fronts, the CPUC and PG&E both stand by the program.

Two example bill calculations have been completed to demonstrate the variable pricing structure that will be implemented in the not too distant future. At first glance, the PDP day energy prices are not only complicated to calculate but also severely punishing, at 4x the rate the same customer would otherwise pay on the regular tiered schedule. However, when the comparison is done at the monthly level and lowered non-PDP day savings are factored in, the customer's bill becomes much more reasonable, in these examples, within 5% of the tiered pricing. It should also be noted that PG&E's own projections estimate that with PDP pricing, 52.4% of customers will be within ± 2% of their tiered pricing.

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