CHRISTENSEN ASSOCIATES ENERGY CONSULTING

The Effects of Critical Peak Pricing for Commercial and Industrial Customers for the Kansas Corporation Commission
Final Report

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1. Introduction and Purpose of the Study

Commercial and industrial (C&I) customers of Kansas City Power & Light (KCP&L) and Westar Energy (Westar) currently pay rates that do not vary with system conditions. Instead, the Small and Medium General Service (SGS and MGS, respectively) rates encourage customers to flatten their load profile (i.e., minimize the variation in their usage level across hours) and increase overall usage levels by reducing the per-kWh rate as customers use more electricity.[1]

The incentives provided by the SGS and MGS tariffs are associated with the *average cost* to serve customers, for example by varying rates seasonally. However, when high levels of electricity demand (e.g., a hot day with high levels of air conditioning usage) lead to increases in wholesale energy prices and/or the probability of a power outage, the existing rate structures do not provide customers with any additional incentive to reduce usage. Because customers do not have any added financial incentive to reduce usage on high-demand days, system planners must compensate by having access to additional peaking generating units or peak-period wholesale power contracts.

Dynamic retail pricing structures, or those in which prices can change with system conditions, provide customers with the incentive to reduce usage levels during hours with high demand. The resulting *demand response,* or reductions in customer usage levels, replaces the need for additional generating resources, instead utilizing the existing plants more efficiently.

In this report, Christensen Associates Energy Consulting (CA Energy Consulting) examines the outcomes associated with implementing Critical Peak Pricing (CPP) rates for the small- and medium-sized C&I customers of KCP&L and Westar. The study focuses on the following effects:

- Customer-level bill impacts;
- The amount of demand response; and
- The potential for the utility to lose revenues if rates are designed without accounting for customer choice or customer demand response.

After this introductory section, Section 2 describes the CPP program. Section 3 describes the methods used to set the rates to be simulated. Section 4 presents the estimated bill impacts for each utility. Section 5 contains estimates of the customer load reductions and/or load shifting in response. Section 6 provides a summary and conclusions.

2. Description of the Pricing Programs Included in the Study

When considering the adoption of a dynamic pricing program, there are two fundamental design issues to be determined: the rate structure's design (e.g., whether to use a CPP design or hourly real-time pricing design); and the method of enrolling customers. These issues are described in depth below.

[1] This is accomplished through declining block rates or hours-of-use rates. While Westar's MGS tariff does not employ either of these structures, it does have very low energy rates, which also acts as an incentive to increase usage levels.

2.1 Enrollment Method

Customers may be enrolled in a new rate in one of three ways:

- **Mandatory**: customers are placed on the new rate structure with no options from which to choose.
- **Voluntary opt-in**: the new rate structure is made available to customers, who must take action to move from their current rate structure to the new rate structure.
- **Voluntary opt-out, or default**: customers are automatically enrolled in the new rate structure and must take action to move to an alternative rate.

Mandatory enrollment has the advantage of maximizing participation in the new pricing program, but may upset customers. *Opt-in* enrollment is not upsetting to customers, but may not result in a very high adoption rate for the dynamic pricing structure (e.g., because of *status quo bias*, or the tendency for people to continue previous actions). *Opt-out*, or *default* enrollment lies in between the extremes of mandatory and opt-in enrollment. Because customers must take action to leave the dynamic pricing program, opt-out enrollment tends to lead to a higher participation rate. While customers may be angered by the perception of having been "slammed",[2] the anger may be mitigated by using transitional mechanisms such as a 1-year "bill guarantee" program, which ensures that customers pay no more under the dynamic pricing program than they would have under their previous tariff.

In this study, we use customer-level hourly usage data to simulate each customer's bill impact under a proposed dynamic pricing program. This allows us to analyze outcomes under a variety of enrollment scenarios. Mandatory enrollment is simulated by simply adding up outcomes across all customers. Voluntary enrollment (opt-in or opt-out) is simulated by adding up outcomes across sub-sets of customers. The voluntary enrollment scenarios analyzed here represent the outcome when each customer selects the rate option that has the lowest bill. This method allows us to determine an upper bound on the potential for utility revenue loss due to customer choice.

2.2 Rate Structures

A variety of dynamic pricing programs exist, with varying degrees of customer exposure to high prices. In this study, we examine Critical Peak Pricing (CPP), in which customers receive a discount on their peak-period rate in exchange for providing the utility the ability to declare "critical days", during which the peak-period price is much higher than it is on non-critical days.

As described in Section 2.1, default CPP programs offer customers the opportunity to select an alternative to the CPP rate.[3] For example, Pacific Gas and Electric Company (PG&E) has a default CPP program called Peak Day Pricing (PDP), in which rates vary by time of use. Customers may opt out of PDP to a TOU rate that has a higher peak-period price on non-critical days, but no exposure to critical prices. We adopt this overall program design

[2] This term, which is typically used in a telecommunications context, refers to having one's service conditions changed without consent.

[3] Pacific Gas and Electric, Southern California Edison, and San Diego Gas and Electric have used this enrollment method, with a TOU rate serving as the opt-out alternative.

for this study. The sections below describe three rate structures: the current SGS and MGS rate structures for KCP&L and Westar customers; the TOU rate to which customers may opt-out; and the CPP program.

2.2.1 Current rates

Existing utility-specific C&I rates are used as the basis for all bill and load impact analyses in the study.

KCP&L's Small General Service (SGS) tariff has the following properties:

- Hours-of-use (HOU) with declining block energy charges (with blocks defined as the first 180 hours of use, the next 180, and over 360);
- Facilities charge on annual maximum demand > 25 MW;
- Customer charge, which varies based on annual maximum demand; and
- Seasonally differentiated energy charges.

In an HOU rate, the price varies by "block" of energy, where the size of the block is determined by the customer's maximum demand. The rate goes down for blocks with higher usage levels. This rate structure produces lower average rates for customers with high load factors, where load factor is defined as a customer's average usage divided by its maximum usage.

Westar's SGS tariff contains the following features:[4]

- Declining block energy prices, with the block set at 1,200 kWh per month;
- Demand charge on monthly maximum demand > 5 MW;
- Customer charge; and
- Seasonally differentiated demand charges.

The declining block structure used in this tariff resembles the HOU structure used in KCP&L's SGS tariff, but in Westar's case the block size is fixed at 1,200 kWh per month and does not vary with the customer's demand level.

KCP&L's Medium General Service (MGS) tariff has the following properties:

- HOU with declining block energy charges (first 180, next 180, over 360);
- Demand charge on monthly maximum demand (with a minimum demand of 25kW);
- Facilities charge on annual maximum demand, (with a minimum demand of 25kW);
- Customer charge; and
- Seasonally differentiated energy and demand charges.

Fuel cost adjustments are included in each tariff. For Westar, we used the value that was in effect from June 30, 2011 through September 28, 2011 ($0.021671 per kWh). For KCP&L, we used the average ECA value from May through September 2011, or $0.015038.

[4] Because we do not have information about customer voltage levels, we bill all Westar customers under the assumption that they are secondary voltage customers.

2.2.2 Time-of-use (TOU) rate

TOU rates contain prices that vary across the hours of the day in a manner that reflects the average cost to serve customers. These rates are fixed within a time-of-use period and do not respond to changing system cost conditions. The primary motivation for TOU rates is that electricity costs vary across the hours of the day in reasonably predictable ways. By establishing different rates for different periods of the day, it is possible for rates to be more reflective of average differences in the cost to serve.

TOU rates provide customers with an incentive to reduce peak-period usage, perhaps by shifting it to lower-cost hours. For this study, the TOU rates have two pricing periods (peak and off-peak) per season (summer is defined as June through September for Westar and May 16 through September 15 for KCP&L). Section 3.2.1 describes the methods used to set the TOU pricing periods and rates.

2.2.3 Critical Peak Pricing

As described above, CPP offers participating customers a discount on the peak-period TOU rate on non-critical days in exchange for the possibility of facing "critical periods", in which the rate increases by 5 to 10 times its typical level. Typical features of CPP programs include:

- Day-ahead notification of event days from the utility;
- Critical prices that apply during peak hours of the day (i.e., summer afternoon hours);
- Prices on non-critical days vary by time of use; and
- There is a limit to the number of critical days that the utility may call each season and/or year (we simulated 5 days in our study).

Because critical periods tend to occur during hot summer weather, we restrict the analysis to summer months only.

3. Rate Design Methodology

3.1 Prepare customer usage data

KCP&L and Westar provided us with 2007 hourly usage data from their SGS and MGS load research samples.[5] We examined the usage data to ensure that they provided a reasonable basis for bill comparisons under the potential alternative rate designs. In some cases for the hourly customer data, we could "clean" a relatively small number of observations (i.e., to remove data missing because of service outages or metering error) and retain the customer's data. In other cases, we excluded the customer's data entirely, typically because it appeared that the customer closed its account during the sample timeframe.

[5] Midwest Energy is excluded from this study because they do not have a load research sample, and hourly customer data are required to conduct the analyses.

Table 3.1 provides a summary of the number of customers by utility and tariff. We used utility-provided sample weights to ensure that each customer was given the proper weight in the study.[6]

Table 3.1: Number of Customers used in the Analysis, by Utility

Utility	SGS	MGS	Total
KCP&L	105	77	182
Westar	225	133	358

3.2 Rate design summary

The TOU and CPP rates are set to produce the same total revenue as the existing C&I rates (in Section 2.2.1) for the available sample customers. Therefore, the first step in the rate design process is to calculate the total revenue (accounting for the sample weights) from the current rates. The assumptions used when setting the rates are a) all customers are on the rate (i.e., there is no customer selection issue), and b) the historical load profiles are retained (i.e., we ignore the potential effect of demand response on customers' usage and bills). The analysis considers only summer months.

We simulate a range of CPP and TOU rates, with variations in how we handle the demand charges in the current tariffs. One set of rates retains the full demand charge for each tariff. A second set removes the demand charges, so that the TOU and CPP rates consist entirely of energy and customer charges. Removing the demand charges has the effect of increasing the energy rates.[7] In practice, the utilities may want to retain smaller demand charges for the recovery of transmission and distribution (but not generation) costs. For KCP&L's MGS tariff, we simulate this by retaining only the "facilities" demand charge. Westar does not separate its demand charge into similar components.

3.2.1 Time-of-use rate

For consistency, we retained the TOU period definitions developed for our previous study of residential rates in Kansas. In that study, we used 2007 hourly data on Southwest Power Pool (SPP) prices to design TOU rates under the assumption that TOU rates should reflect expected differences in marginal costs by time period, and that wholesale market prices signal those marginal costs. We combined those data with the load research sample data to determine the TOU seasons, pricing periods, and price ratios across pricing periods. The goal is to create pricing periods that contain hours that are most alike in terms of marginal costs (e.g., hours of high costs and low costs), and therefore produce peak to off-peak price ratios that reflect the greatest difference between costs by time period.

The summer season corresponds to definitions used in the relevant tariffs: June through September for Westar and May 16 through September 15 for KCP&L. The peak hours are defined as 11:00 a.m. to 7:00 p.m. Weekends are defined as all off-peak hours.

[6] For example, utilities often over-sample high-use customers in their load research samples, to ensure that their profile is represented in the limited number interval data that can be obtained. When using the data to calculate a class load profile, these over-sampled customers are given less weight than other customers to ensure that the profile properly represents the average class usage pattern.

[7] The SGS and MGS customer charges are retained throughout the analysis.

The TOU rates were set to be revenue neutral to the current rate, prior to any demand response. To do this, we assumed that the price ratios across TOU pricing periods equal the ratio of SPP prices across pricing periods (using 2007 SPP data). We then solved for the set of rates (given the ratios) that obtains revenue neutrality.[8] Tables 3.2 and 3.3 show the resulting TOU energy rates for each utility, with variations in how the demand charges are handled.

As the tables show, the energy rates are higher when the demand charges are omitted from the rate. Notice that the omission of demand charges makes very little difference in the TOU (and CPP) rates for KCP&L's SGS customers. This is because the demand charge only applies to customers with maximum demands over 25 kW, and there are relatively few such customers.

Table 3.2: TOU Prices by Period ($/kWh), *KCP&L*

Customer Group	Include Demand Charge?	Pricing Period	
		Peak	Off-peak
SGS	No	$0.156	$0.097
	Yes	$0.155	$0.096
MGS	No	$0.131	$0.082
	Yes	$0.104	$0.065
	Facilities Only	$0.118	$0.074

Table 3.3 TOU Prices by Period ($/kWh), *Westar*

Customer Group	Include Demand Charge?	Pricing Period	
		Peak	Off-peak
SGS	No	$0.102	$0.064
	Yes	$0.077	$0.049
MGS	No	$0.097	$0.060
	Yes	$0.062	$0.038

3.2.2 CPP rate

CPP rates are based on the TOU rates developed in Section 3.2.1, in that we retain the TOU pricing periods and off-peak prices. To complete the CPP design, we designate critical days, set the critical price, and set the peak price on non-critical days.

Critical days were selected as the days with the five highest average peak-period SPP prices. For most scenarios, the critical price was set to $0.50 per kWh. While this value exceeds even the highest market prices observed in the 2007 SPP data, it is actually quite low by the standards of critical prices in other CPP programs, which may exceed $1.00 per kWh. The critical price was selected to be high enough to provide customers with a significant incentive to reduce usage, but lower than observed in other CPP programs due to the low SPP prices we observed in the data.

[8] This is not the only method that can be used to create revenue neutral TOU rates. For example, the peak rate could be set at the expected market marginal cost with the off-peak rate set to obtain revenue neutrality.

In order to complete the rate design, we calculated the peak-period price charged on non-critical days that obtains revenue neutrality with the current (and TOU) rate. This peak price is lower than the peak price calculated for the TOU rate in Section 3.2.1 because the revenues collected during critical hours reduce the amount of revenue that must be recovered during the remaining peak hours of the summer.

For Westar scenarios that retain the demand charge, the critical price was reduced to $0.30 per kWh. Because the energy prices are relatively low when the demand charges are included, the discount on the peak price at a $0.50 per kWh critical price reduced the non-critical day peak price below the off-peak price. Therefore, we reduced the critical price to a level at which the peak price remained reasonable.

Tables 3.4 and 3.5 contain the CPP rates that resulted from implementing this methodology for each utility, with variations in how the demand charges are handled. Notice that the difference between the peak and off-peak prices on non-critical days is quite a bit lower than it is in the TOU rates, particularly for Westar customers.

Table 3.4: CPP Prices ($/kWh), *KCP&L*

Customer Group	Include Demand Charge?	Pricing Period		
		Critical	Peak	Off-peak
SGS	No	$0.500	$0.131	$0.097
	Yes	$0.500	$0.129	$0.096
MGS	No	$0.500	$0.104	$0.082
	Yes	$0.500	$0.076	$0.065
	Facilities Only	$0.500	$0.090	$0.074

Table 3.5: CPP Prices ($/kWh), *Westar*

Customer Group	Include Demand Charge?	Pricing Period		
		Critical	Peak	Off-peak
SGS	No	$0.500	$0.073	$0.064
	Yes	$0.300	$0.061	$0.049
MGS	No	$0.500	$0.069	$0.060
	Yes	$0.300	$0.046	$0.038

4. Bill Impacts

We calculated customer-level bills using the available customer-level load data, the current SGS and MGS rates, and the TOU and CPP rates described in Section 3. We then calculated bill impacts at the customers' historical usage patterns, before accounting for any possible modification in customers' load profiles in response to the new price signals.

The bill impacts are displayed as scatter plots against each customer's average monthly usage (in kWh). This allows for an easy examination of both the distribution of the bill impacts and how they vary with customer usage. Because the current rates (with the exception of Westar's MGS rate) have a declining block structure, low-use customers tend to benefit from the TOU or CPP rates.

The sub-sections below present bill impacts for three rate changes: current rate to TOU rates; current rates to CPP rates; and TOU rates to CPP rates.

4.1 Current tariff to TOU rate

This section examines customer-level bill impacts as customer move from the current SGS and MGS tariffs to the TOU rate. The results are described separately for each rate class.

4.1.1 Small General Service

Figures 4.1 through 4.4 illustrate the customer-level bill impacts for SGS customers as they transition from their current tariff to the TOU rate. The KCP&L SGS rates are very similar with and without the demand charge, so the bill impacts in Figures 4.1 and 4.2 are not substantially different. The scatter plots show a tendency for larger customers to experience bill increases and smaller customers to experience bill decreases on the TOU rate. This is because the declining block structure in the SGS tariff reduces the average rate paid for high-use customers, whereas this structure is not present in the TOU rate.

Figure 4.1: TOU Rate Bill Impacts, *KCP&L, SGS, No demand charge*

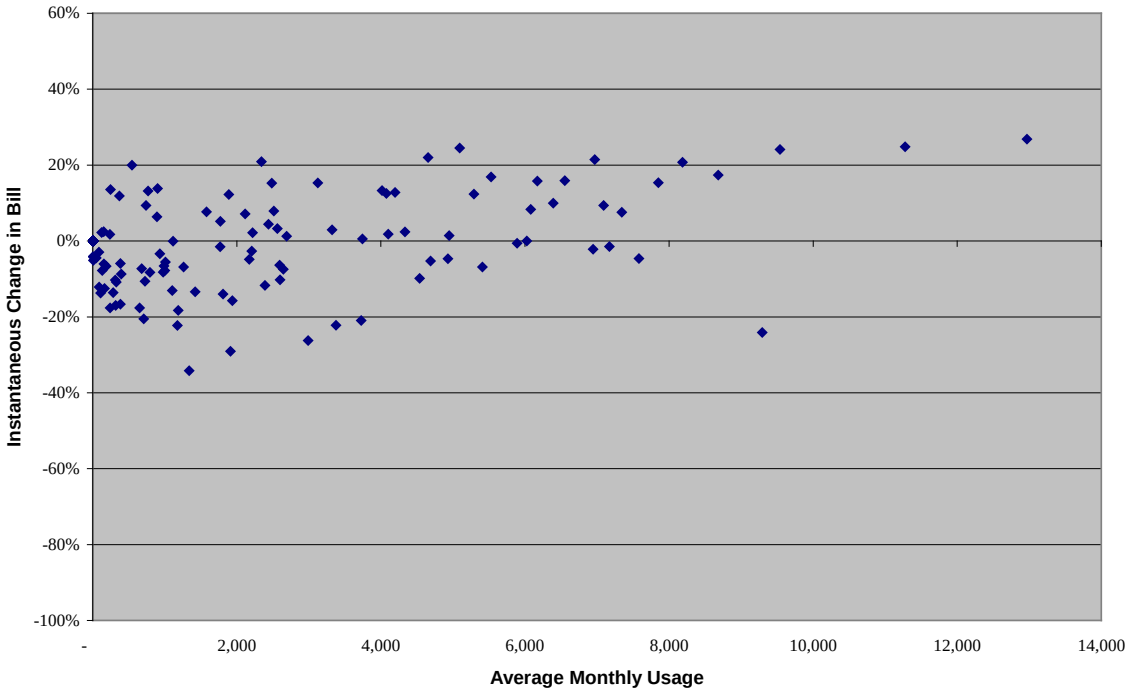
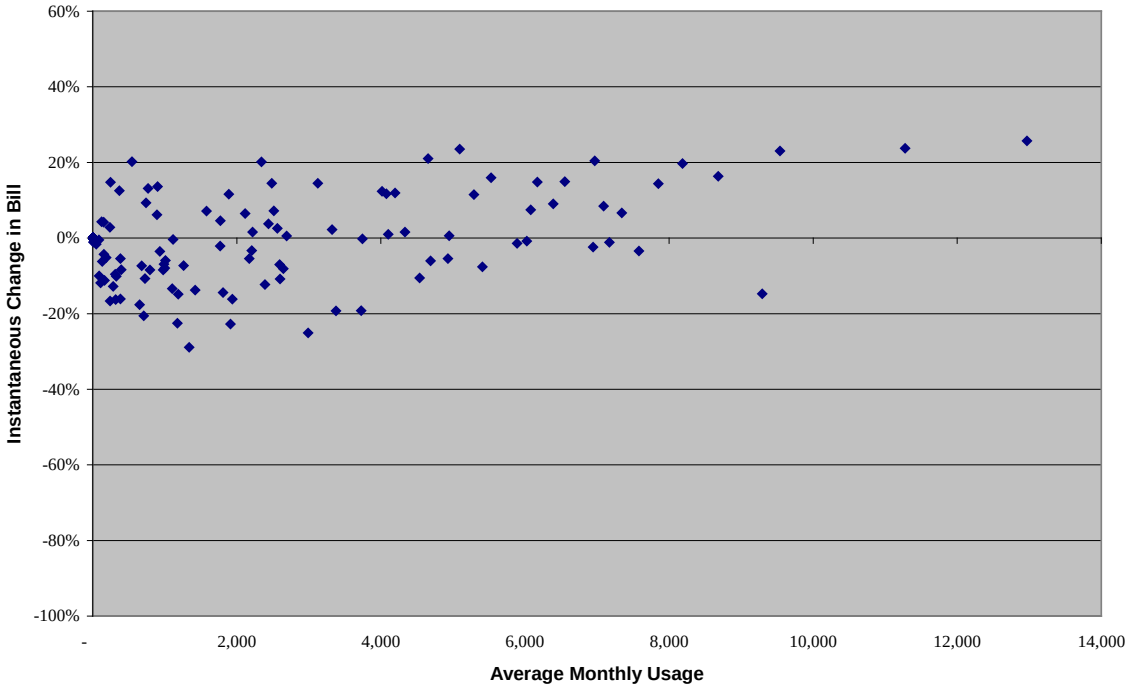


Figure 4.2: TOU Rate Bill Impacts, *KCP&L, SGS, Including demand charge*



Westar's SGS customer-level bill impacts show an even more pronounced relationship with average usage, as shown in Figures 4.3 and 4.4. The bill impacts are somewhat larger without the demand charge (in Figure 4.3), but the pattern across customers is the very similar in the two scenarios.

Figure 4.3: TOU Rate Bill Impacts, *Westar, SGS, No demand charge*

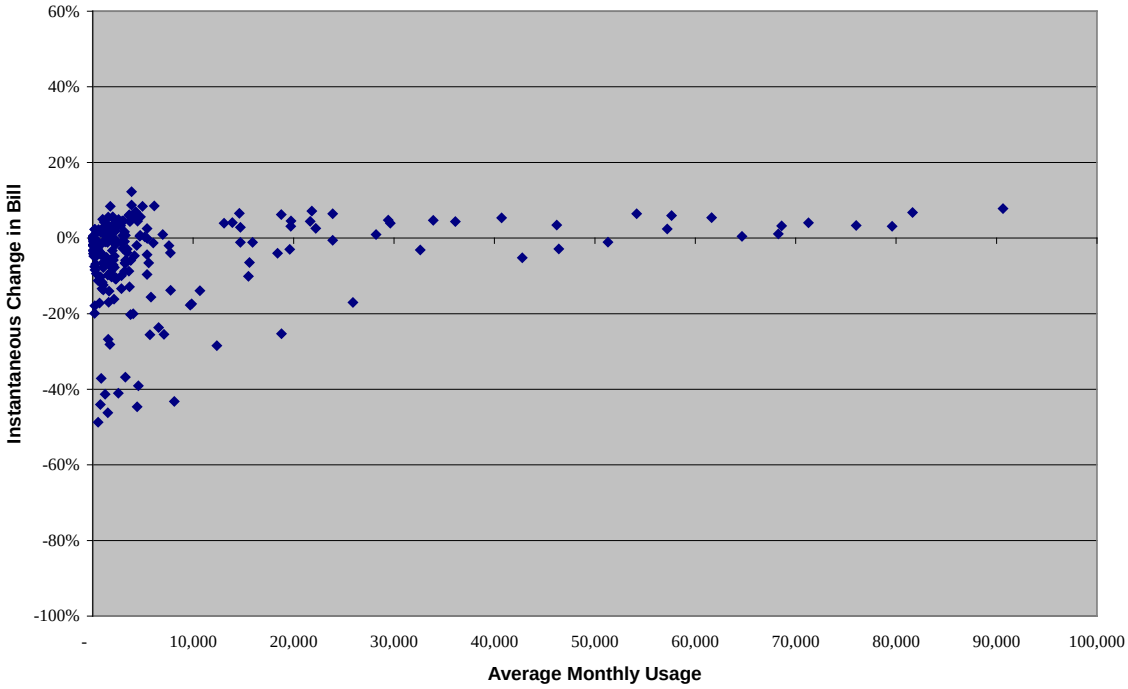
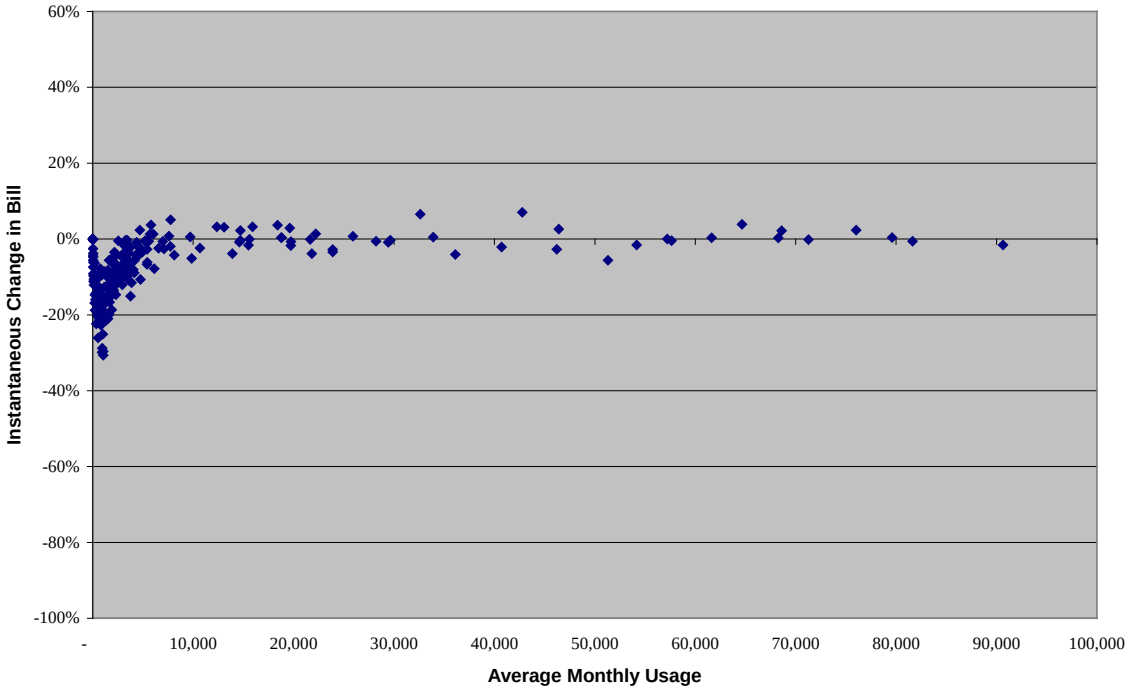


Figure 4.4: TOU Rate Bill Impacts, *Westar, SGS, Including demand charge*



4.1.2 Medium General Service

Figures 4.5 through 4.9 show the customer-level bill impacts for MGS customers as they move from the current rate to the TOU rate. Three variations are shown for the KCP&L

customers (Figures 4.5 through 4.7): TOU rates with no demand charge, the full MGS tariff demand charge (including the facilities charge), and the facilities charge only. The bill impacts become more pronounced (i.e., larger in the extremes), as the demand charges are smaller, or as more revenue recovery occurs through the energy charges.

Figure 4.5: TOU Rate Bill Impacts, *KCP&L, MGS, No demand charge*

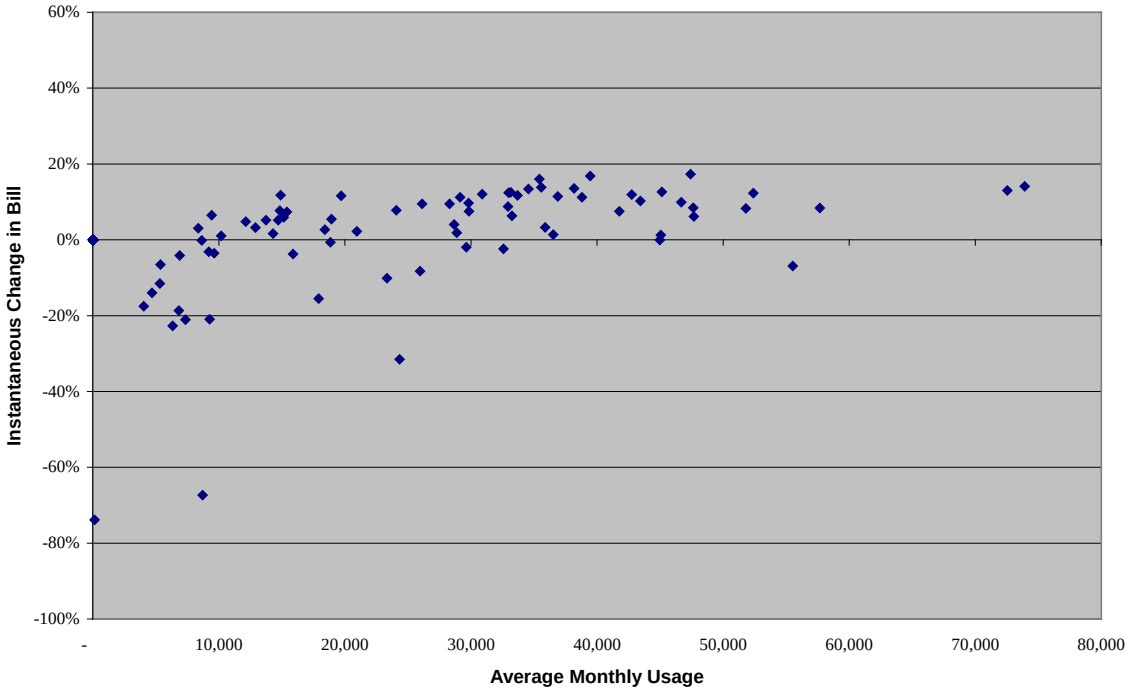


Figure 4.6: TOU Rate Bill Impacts, *KCP&L, MGS, Including demand charge*

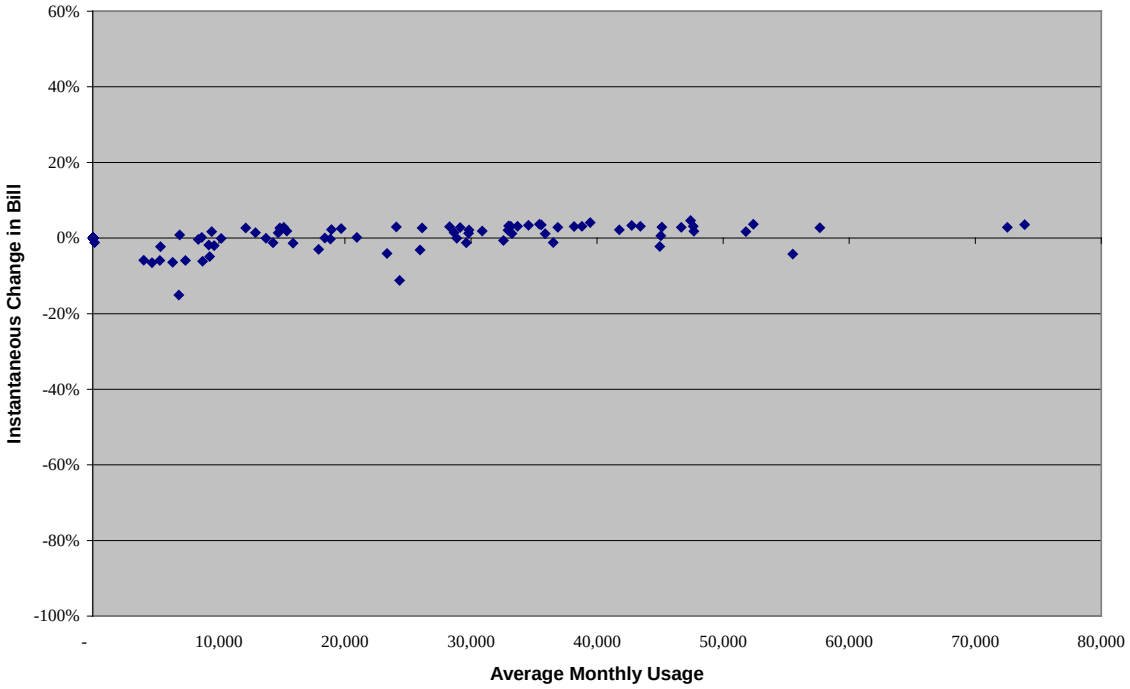
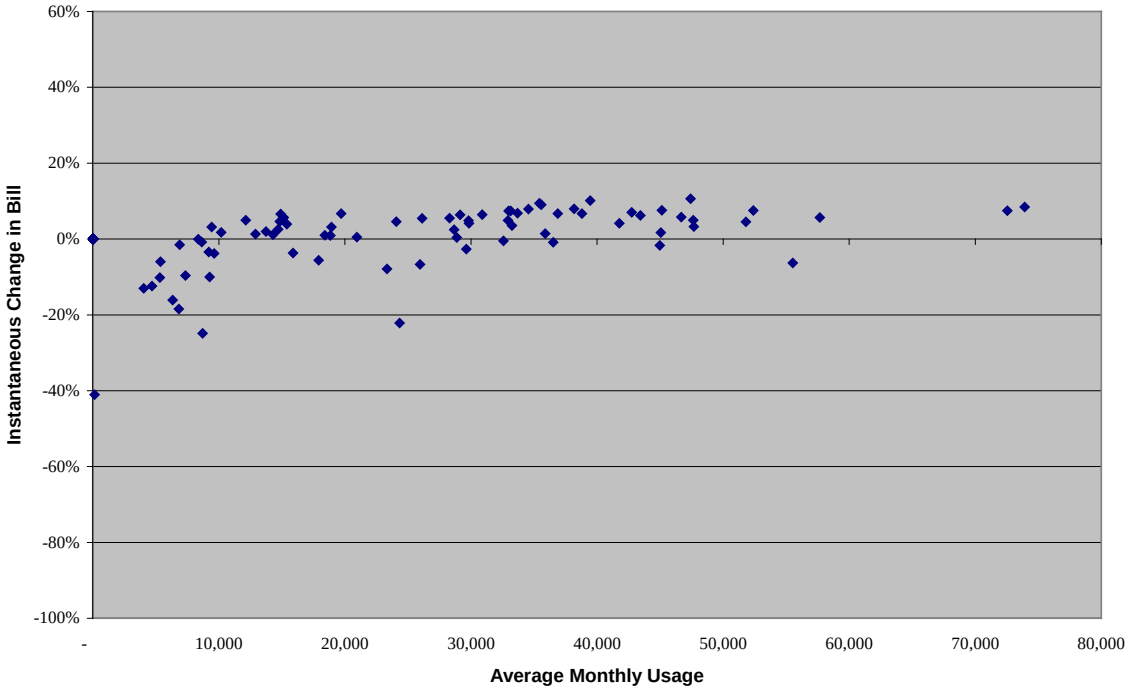


Figure 4.7: TOU Rate Bill Impacts, *KCP&L, MGS, Facilities demand charge only*



For Westar, the MGS bill impacts without demand charges are both larger and more related to customer size than the bill impacts with the demand charge. In this case, the demand

charge is a large component of the total bill, so when it is present, the effect on the bill of modifying the energy charges is small.

Figure 4.8: TOU Rate Bill Impacts, *Westar, MGS, No demand charge*

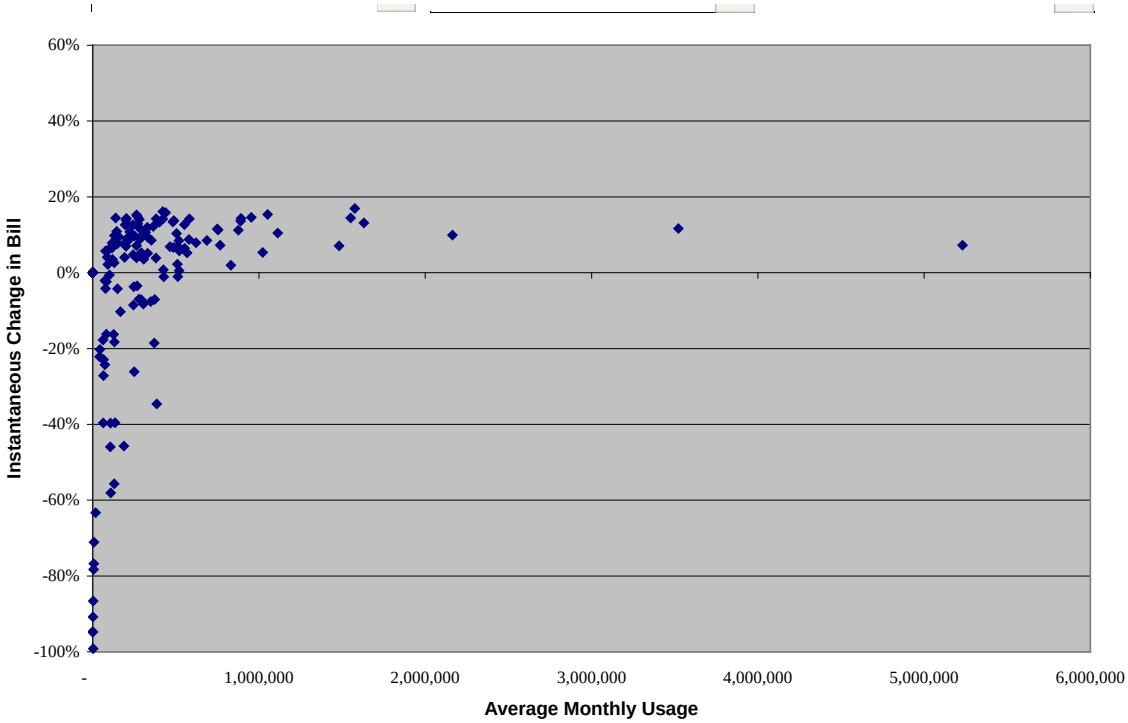
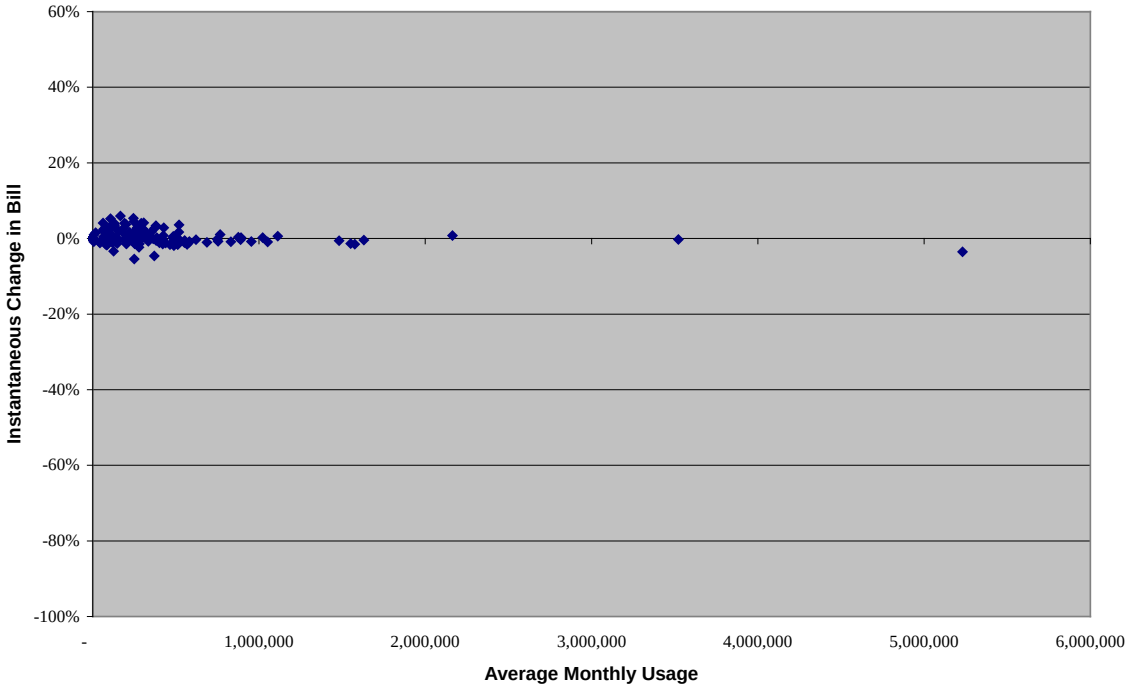


Figure 4.9: TOU Rate Bill Impacts, *Westar, MGS, Including demand charge*



4.2 Current tariff to CPP rate

In this section, we present the bill impacts associated with moving from the current SGS and MGS tariffs to the CPP rate. As with the previous section, the results are presented by utility, tariff, and the presence of demand charges. The bill impacts across scenarios are very similar to the results for the TOU rates, indicating that the effect of introducing critical prices and non-critical day discounts is small relative to the total bill.

4.2.1 Small General Service

Figures 4.10 and 4.11 show the bill impacts for KCP&L's SGS customers. Figures 4.12 and 4.13 show the results for Westar's SGS customers.

Figure 4.10: CPP Rate Bill Impacts, *KCP&L, SGS, No demand charge*

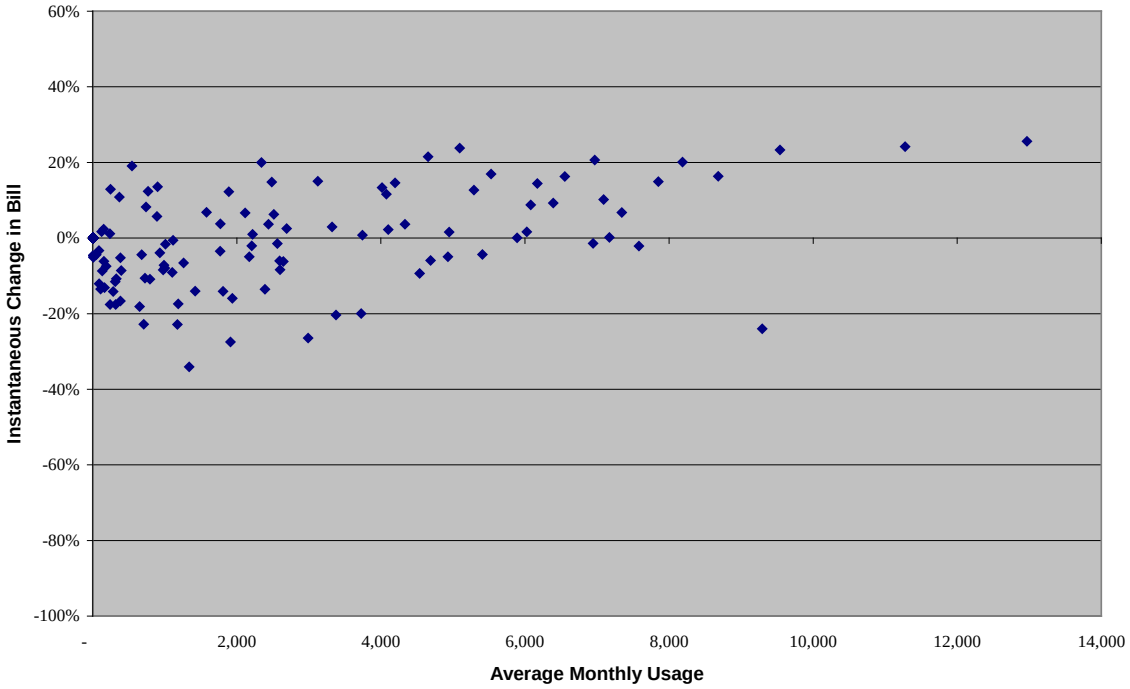


Figure 4.11: CPP Rate Bill Impacts, *KCP&L, SGS, Including demand charge*

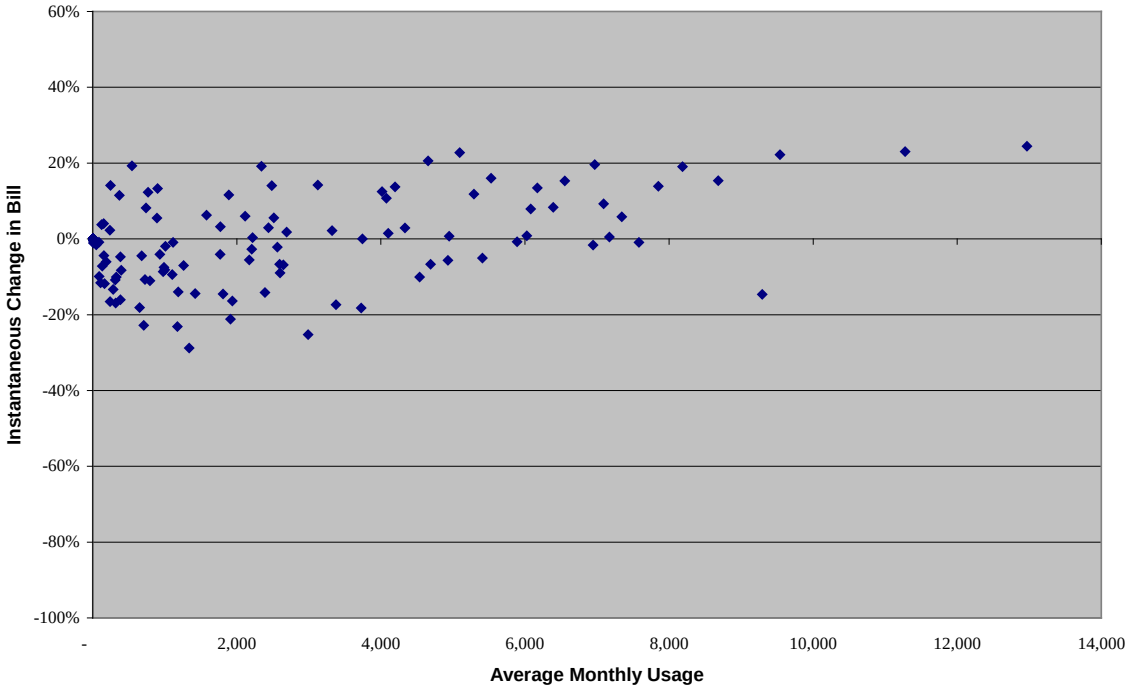


Figure 4.12: CPP Rate Bill Impacts, *Westar, SGS, No demand charge*

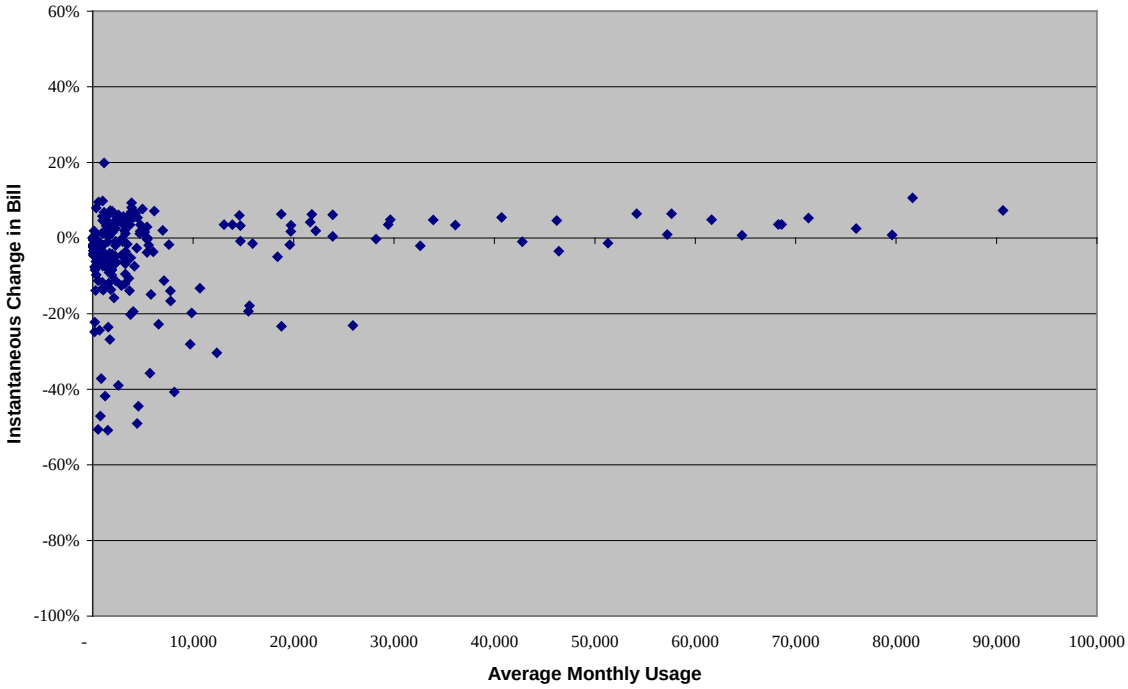
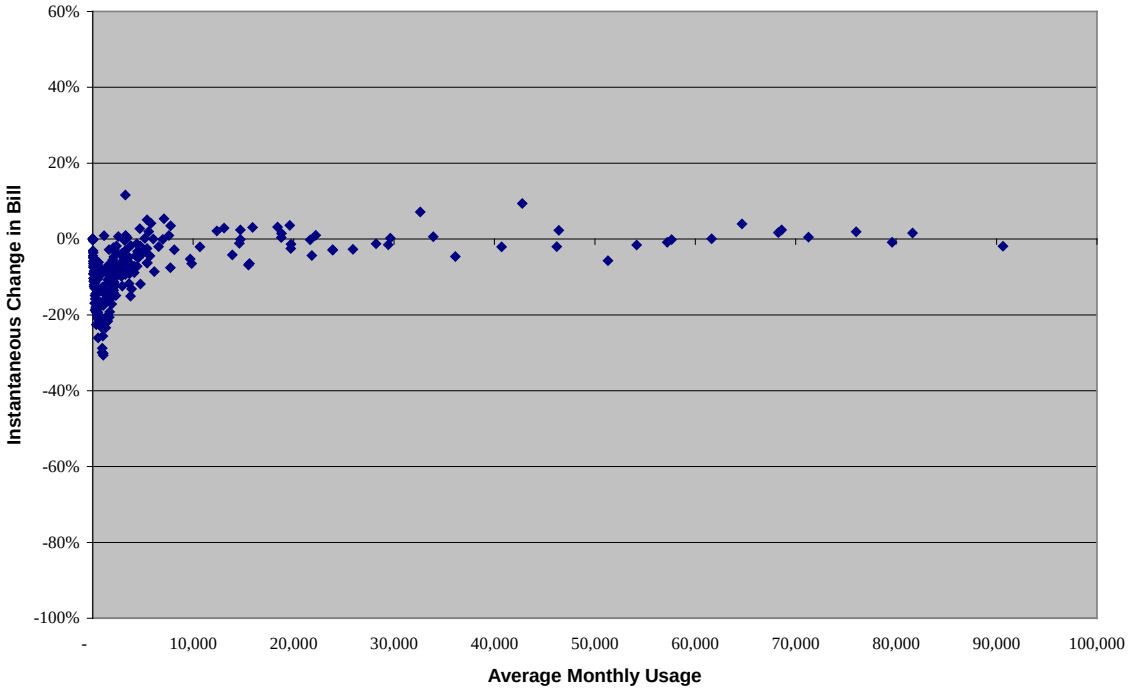


Figure 4.13: CPP Rate Bill Impacts, *Westar, SGS, Including demand charge*



4.2.2 Medium General Service

Figures 4.14 through 4.18 show the bill impacts for MGS customers at KCP&L and Westar. As with the SGS customers, the bill impacts as customers are migrated to a CPP rate are very similar to the bill impacts associated with adopting a TOU rate.

Figure 4.14: CPP Rate Bill Impacts, *KCP&L, MGS, No demand charge*

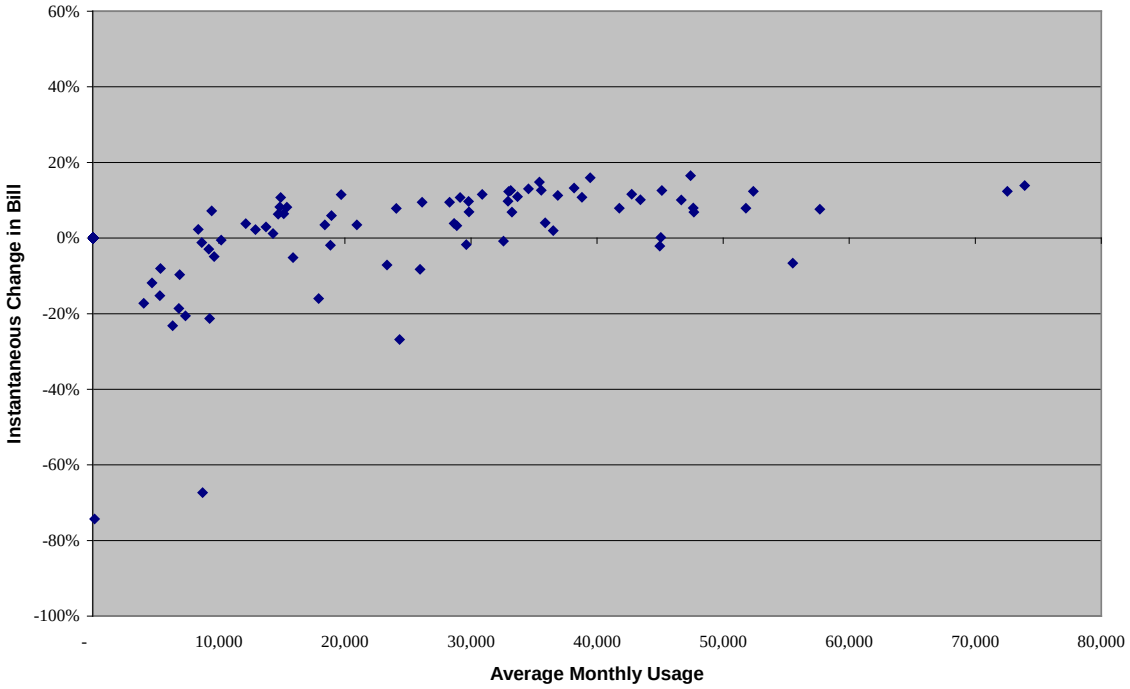


Figure 4.15: CPP Rate Bill Impacts, *KCP&L, MGS, Including demand charge*

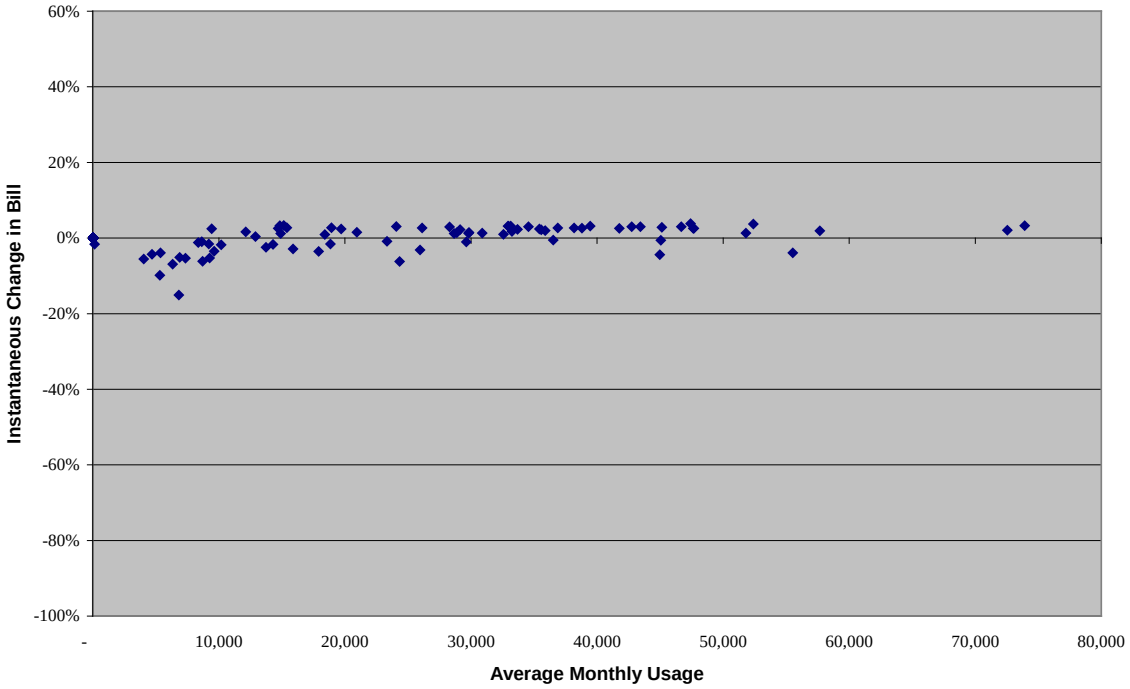


Figure 4.16: CPP Rate Bill Impacts, *KCP&L, MGS, Facilities demand charge only*

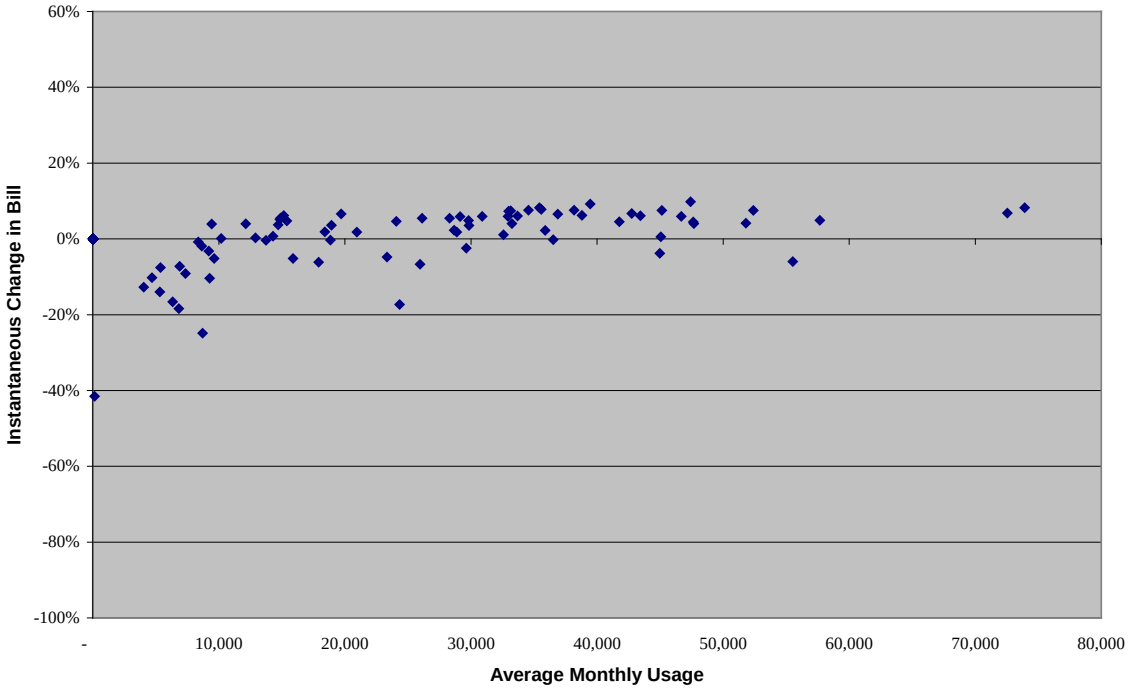


Figure 4.17: CPP Rate Bill Impacts, *Westar, MGS, No demand charge*

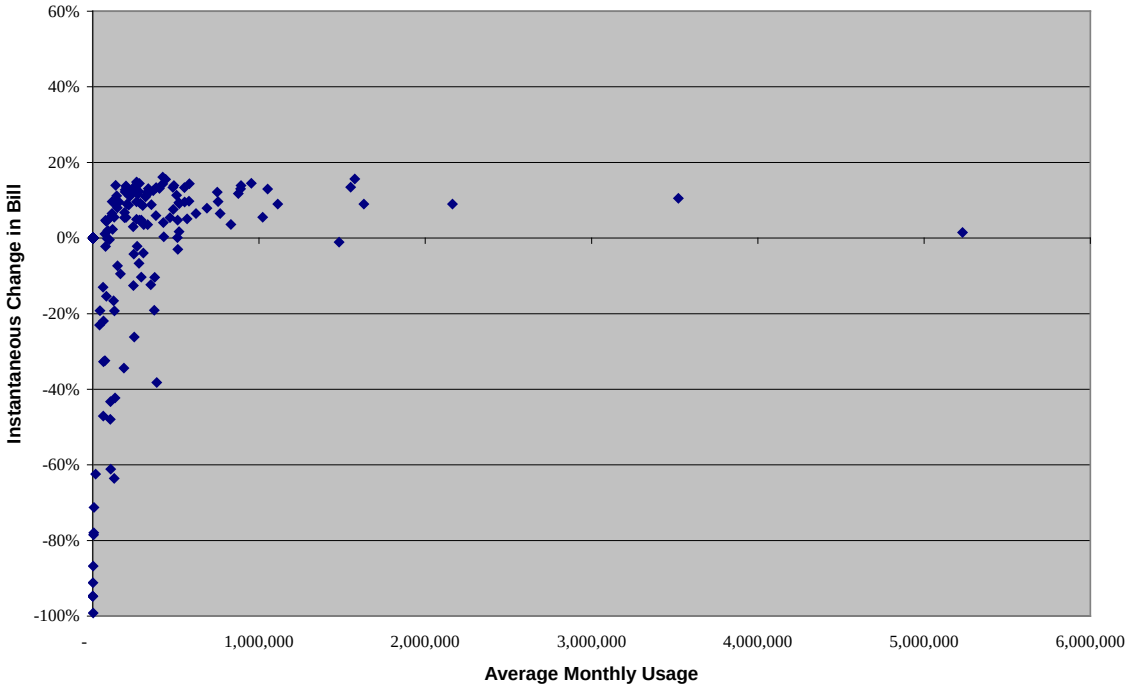
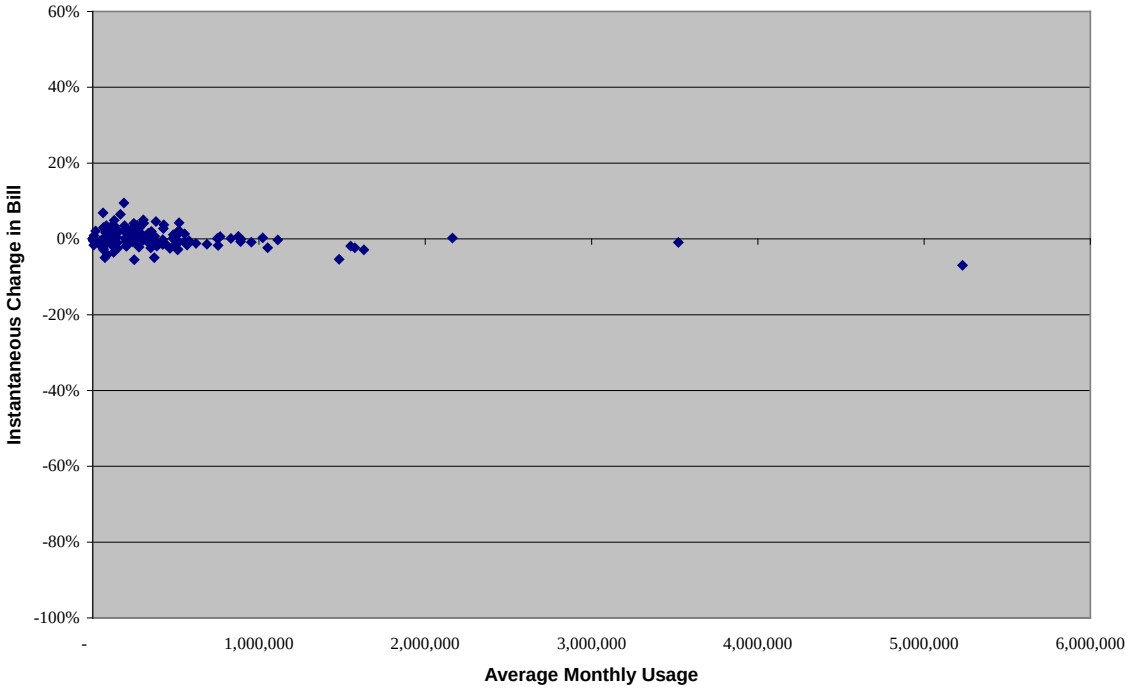


Figure 4.18: CPP Rate Bill Impacts, *Westar, MGS, Including demand charge*



4.3 TOU rate to CPP rate

This section shows the bill impacts as customers move from TOU to CPP rates. The previous two sections showed that the differences between TOU and CPP bill impacts (relative to the SGS and MGS tariffs) are small. The results in this section directly illustrate those small differences. The bill impact associated with moving from the TOU to CPP rate rarely exceeds 10 percent.

4.3.1 Small General Service

TOU to CPP bill impacts for SGS customers are shown in Figures 4.19 through 4.22.

Figure 4.19: TOU to CPP Rate Bill Impacts, *KCP&L, SGS, No demand charge*

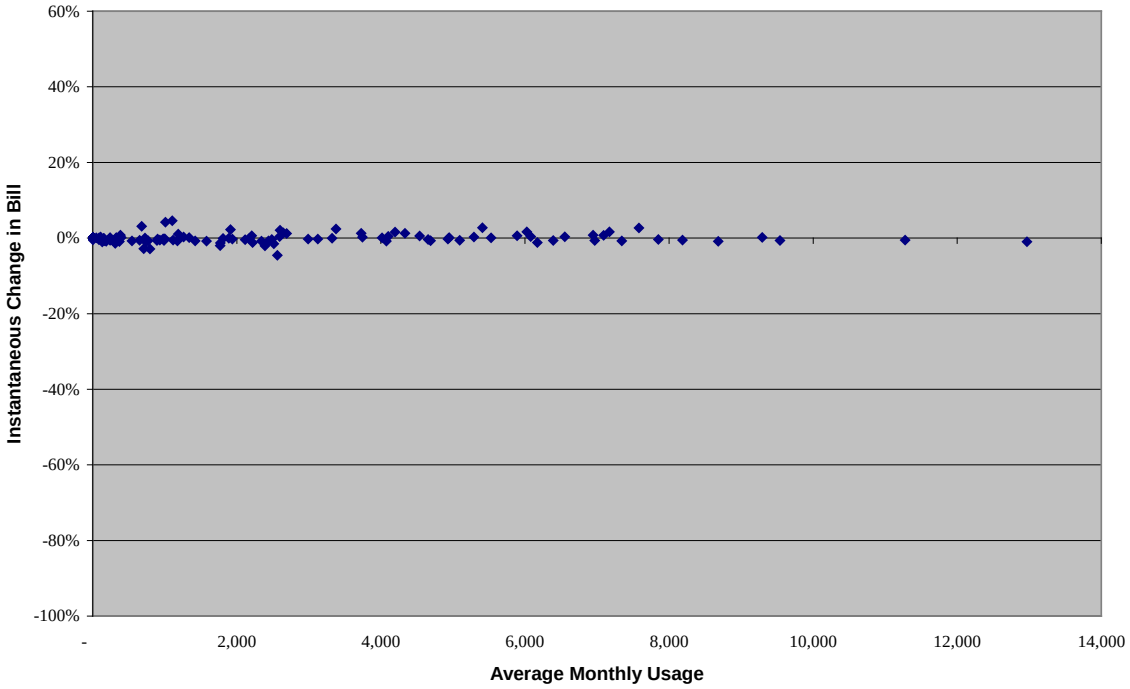


Figure 4.20: TOU to CPP Rate Bill Impacts, *KCP&L, SGS, Including demand charge*

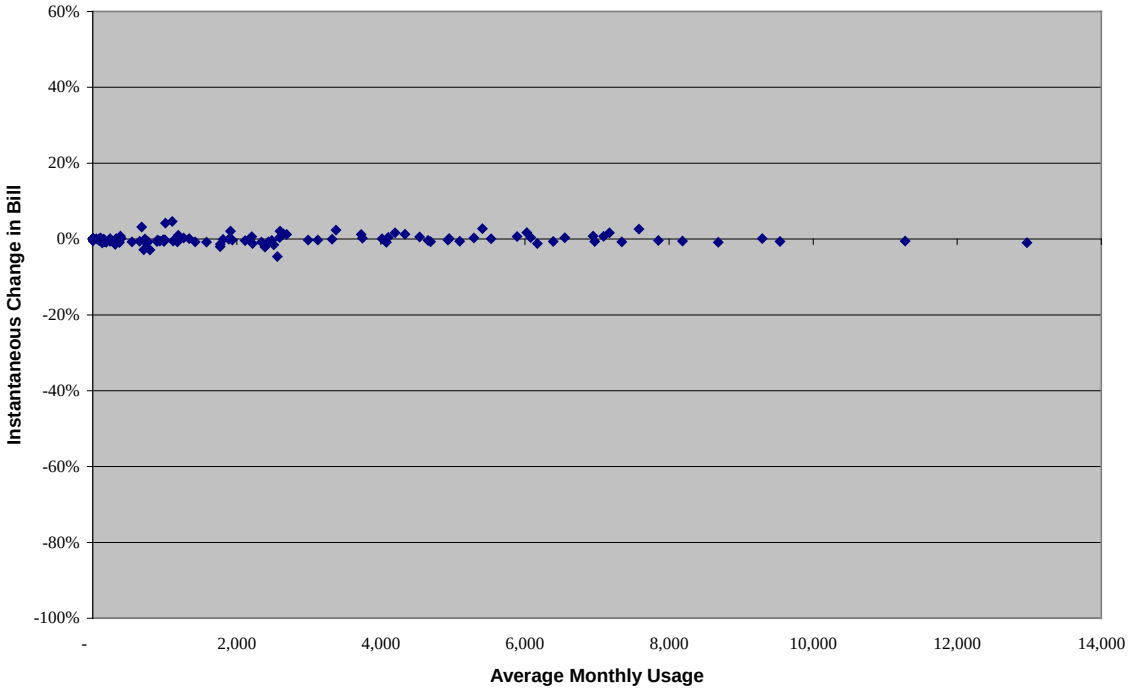


Figure 4.21: TOU to CPP Rate Bill Impacts, *Westar, SGS, No demand charge*

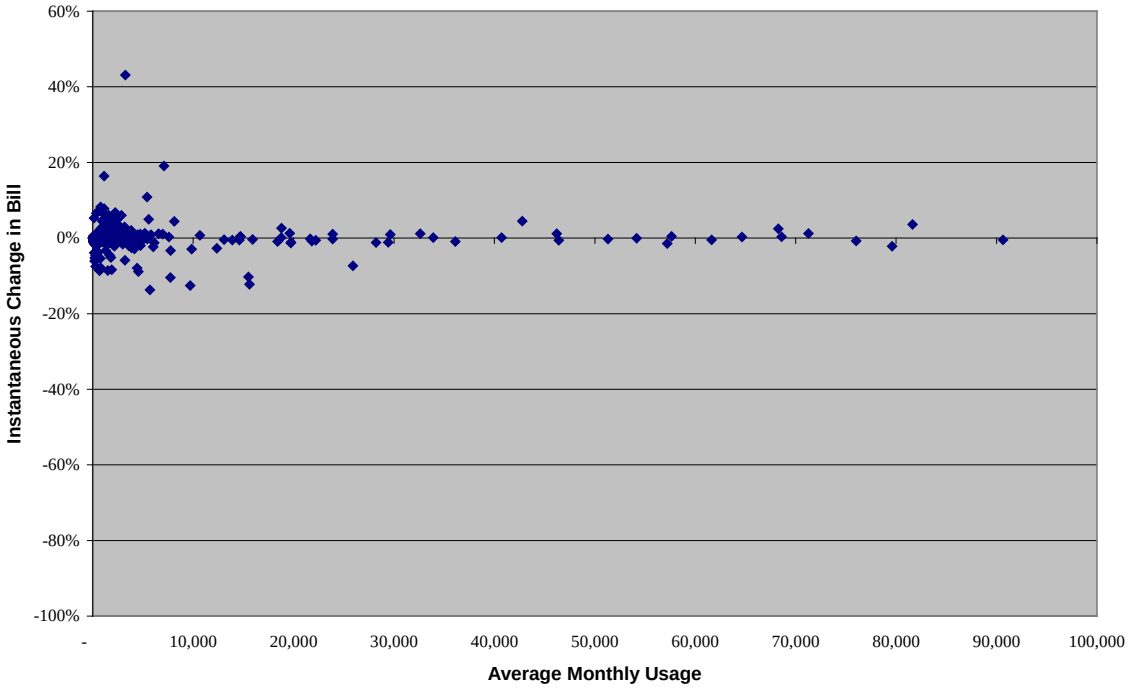
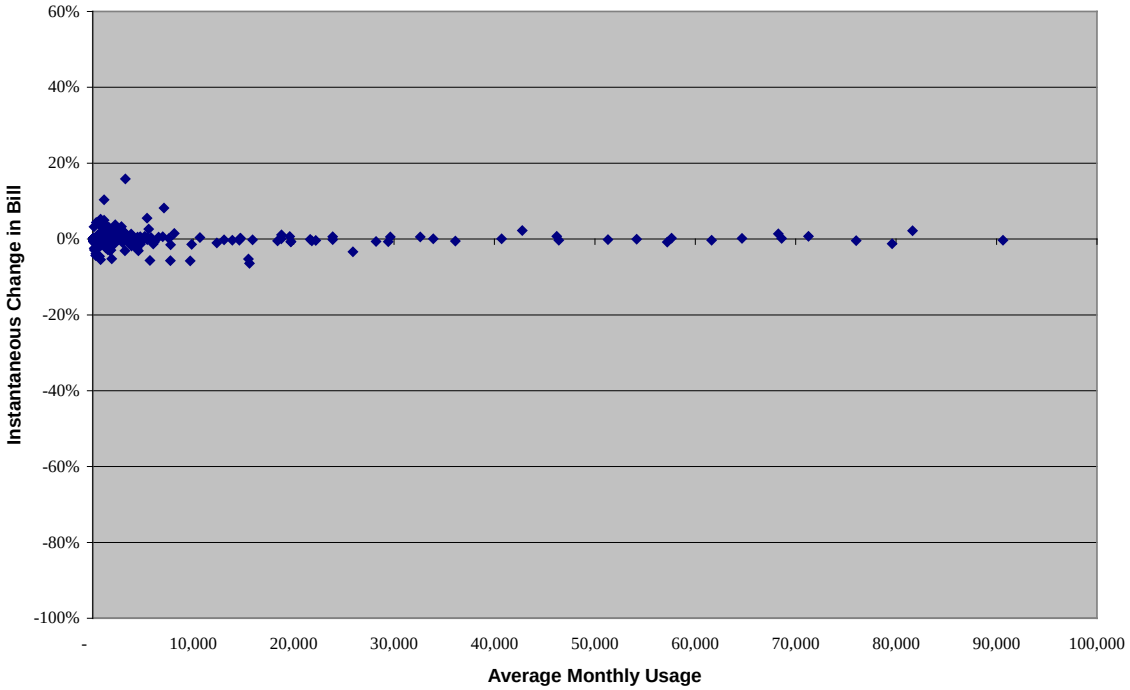


Figure 4.22: TOU to CPP Rate Bill Impacts, *Westar, SGS, Including demand charge*



A handful of the smaller Westar SGS customers experience significant bill impacts as they move from the TOU to CPP rates, but overall the magnitude of the bill impacts is quite small.

4.3.2 Medium General Service

The TOU to CPP rate bill impacts for the MGS customers are shown in Figures 4.23 through 4.27. As with the SGS customer results, the MGS bill impacts are small.

Figure 4.23: TOU to CPP Rate Bill Impacts, *KCP&L, MGS, No demand charge*

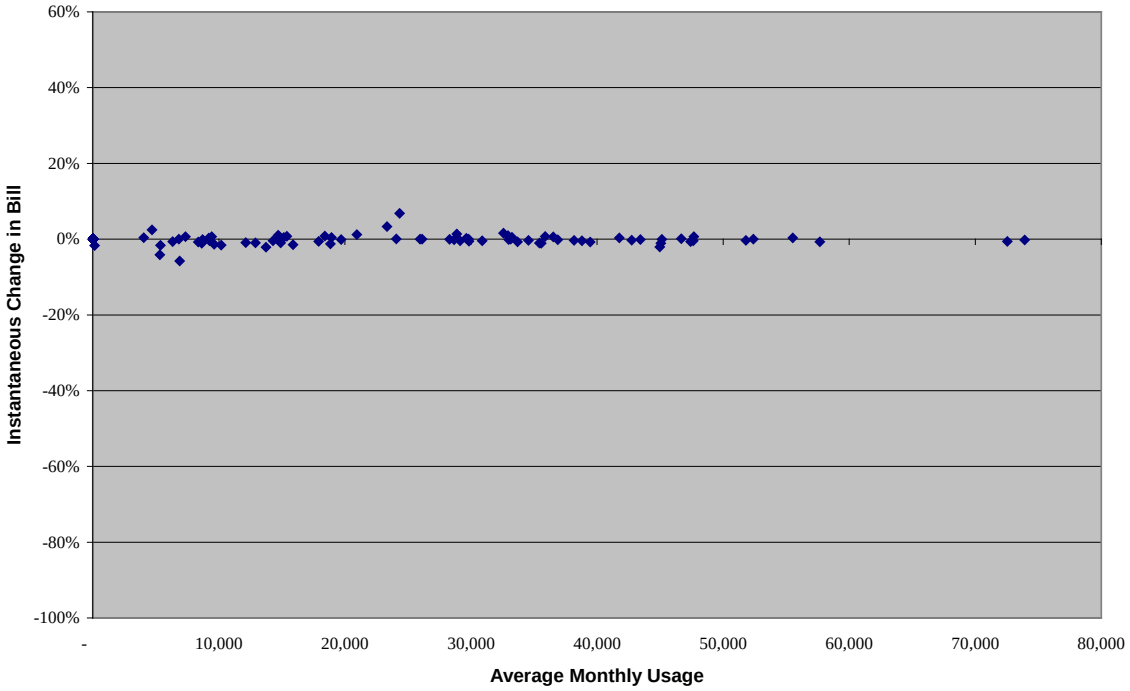


Figure 4.24: TOU to CPP Rate Bill Impacts, *KCP&L, MGS, Including demand charge*

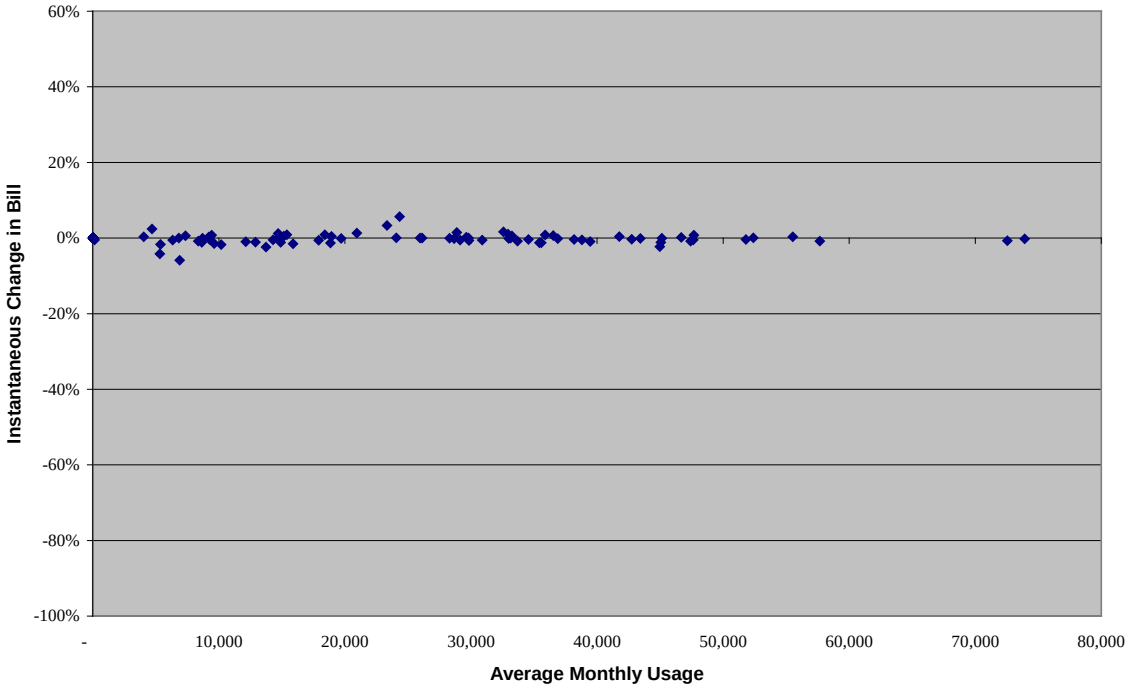


Figure 4.25: TOU to CPP Rate Bill Impacts, *KCP&L, MGS, Facilities demand charge*

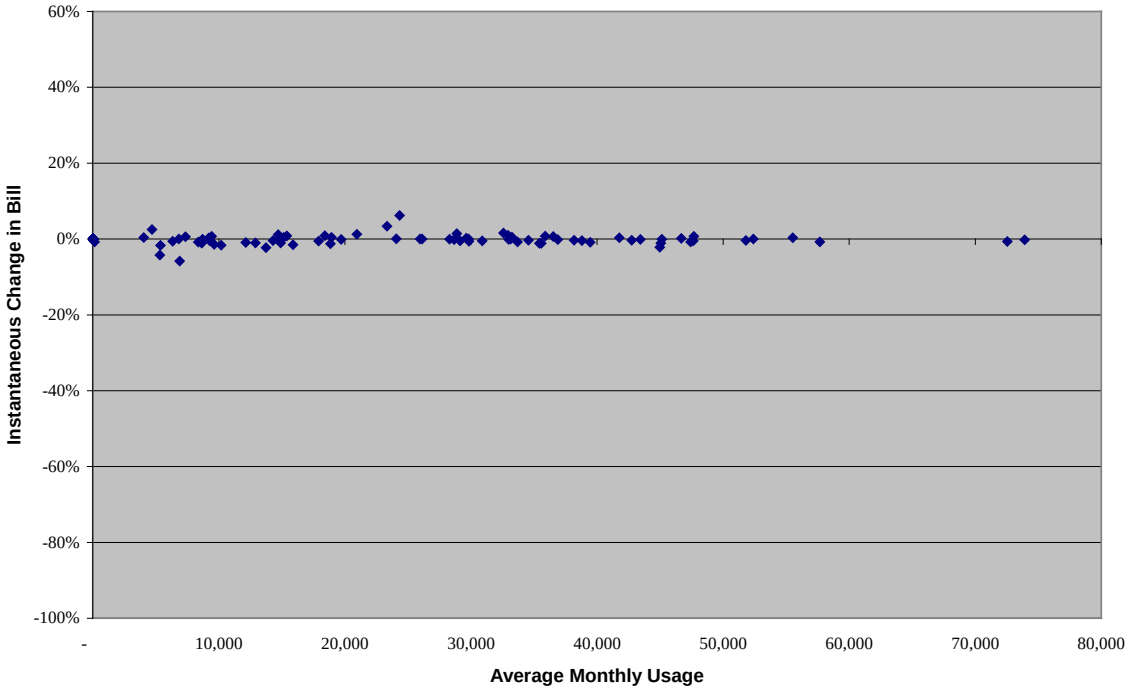


Figure 4.26: TOU to CPP Rate Bill Impacts, *Westar, MGS, No demand charge*

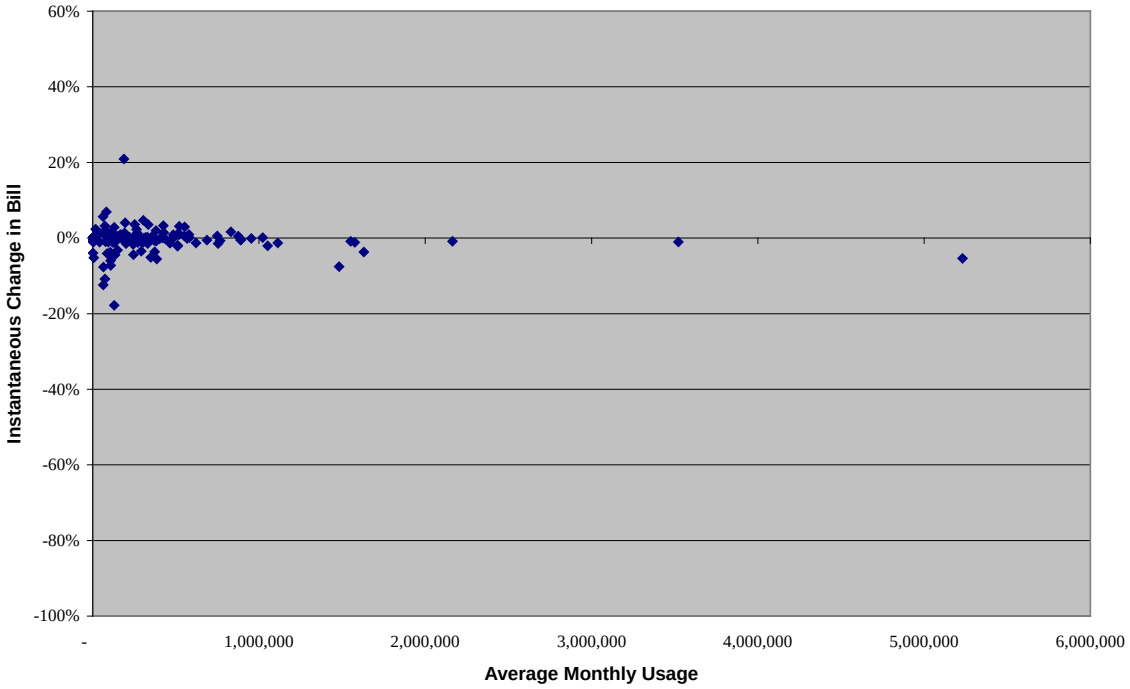
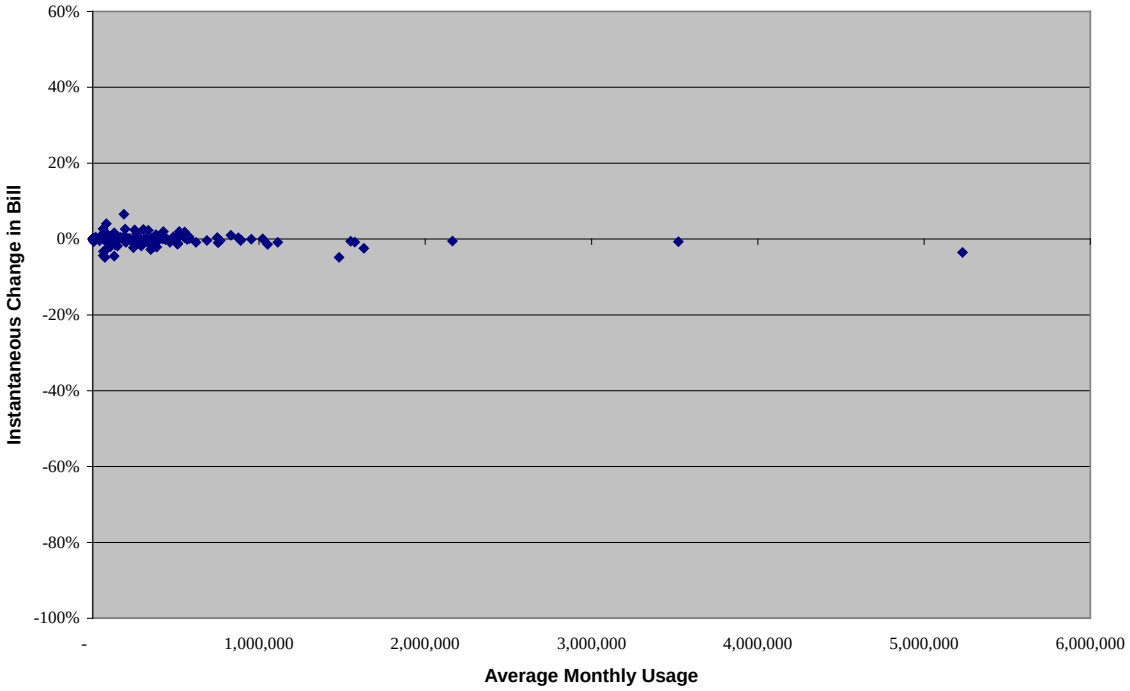


Figure 4.27: TOU to CPP Rate Bill Impacts, *Westar, MGS, Including demand charge*



4.4 Summary of bill impacts

Tables 4.1 through 4.3 provide information that summarizes the figures presented in the previous sub-sections. Four statistics are provided for each utility and rate structure:

- The share of customers that experienced a bill increase of 10% or more on the new rate structure;
- The share of customers that experienced a bill decrease of 10% or more on the new rate structure;
- The average percentage bill impact for low-use customers; [9] and
- The average percentage bill impact for high-use customers.[10]

These statistics are intended to facilitate comparisons of bill impacts across rate structures and utilities. Recall that, on average, the bill impact is zero (when appropriately weighted by revenue). Therefore, the goal of this exercise is to examine the *distribution* of bill impacts. Even though the rates are designed to be revenue neutral for the entire class, individual customers may experience rather large bill impacts.

The tables suggest the following observations:

- Larger bill impacts occur where more of the revenue is collected through energy charges (i.e., when demand charges are reduced or eliminated);
- Even in instances with more dispersed bill impacts (e.g., KCP&L's SGS customers moving to TOU or CPP rates), approximately half of the customers experience a bill impact less than 10 percent in magnitude (positive or negative);
- The bill impacts associated with moving from TOU to CPP rates is small. There were not any scenarios in which more than 5 percent of the customers experienced a bill impact greater than +/- 5 percent.

Table 4.1: Summary of Bill Impacts, *Current Tariff to TOU Rates*

Rate Class	Utility	Include Demand?	Share of Customers by Bill Impact Amount		Average Bill Impact by Customer Usage	
			Greater than 10%	Less than -10%	Low Use	High Use
SGS	KCP&L	No	24%	25%	-6%	10%
		Yes	24%	24%	-5%	10%
	Westar	No	0%	20%	-3%	2%
		Yes	0%	37%	-9%	0%
MGS	KCP&L	No	27%	16%	-17%	8%
		Yes	0%	3%	-4%	2%
		Facilities	3%	12%	-11%	5%
	Westar	No	29%	23%	-85%	11%
		Yes	0%	0%	0%	-1%

[9] Low-use customers are defined as: 500 kWh per month for KCP&L SGS; 500 kWh per month for Westar SGS; 10,000 kWh per month for KCP&L MGS; and 20,000 kWh per month for Westar MGS.

[10] High-use customers are defined as: 5,000 kWh per month for KCP&L SGS; 25,000 kWh per month for Westar SGS; 40,000 kWh per month for KCP&L MGS; and 1,000,000 kWh per month for Westar MGS.

Table 4.2: Summary of Bill Impacts, *Current Tariff to CPP Rates*

Rate Class	Utility	Include Demand?	Share of Customers by Bill Impact Amount		Average Bill Impact by Customer Usage	
			Greater than 10%	Less than -10%	Low Use	High Use
SGS	KCP&L	No	25%	24%	-7%	10%
		Yes	24%	24%	-5%	10%
	Westar	No	1%	20%	-4%	2%
		Yes	0%	36%	-10%	0%
MGS	KCP&L	No	29%	14%	-18%	8%
		Yes	0%	1%	-5%	2%
		Facilities	0%	12%	-11%	4%
	Westar	No	29%	25%	-85%	9%
		Yes	0%	0%	0%	-2%

Table 4.3: Summary of Bill Impacts, *TOU to CPP Rates*

Rate Class	Utility	Include Demand?	Share of Customers by Bill Impact Amount		Average Bill Impact by Customer Usage	
			Greater than 10%	Less than -10%	Low Use	High Use
SGS	KCP&L	No	0%	0%	0%	0%
		Yes	0%	0%	0%	0%
	Westar	No	2%	2%	-1%	0%
		Yes	1%	0%	0%	0%
MGS	KCP&L	No	0%	0%	-1%	0%
		Yes	0%	0%	-1%	0%
		Facilities	0%	0%	-1%	0%
	Westar	No	1%	2%	-1%	-2%
		Yes	0%	0%	0%	-2%

4.5 The effect of customer self-selection on utility revenues

When customers are offered the choice between the TOU and CPP rates, their rate selection may be influenced by any number of factors, including their *willingness* to face critical prices (i.e., risk aversion), *ability* to respond to critical peak prices (i.e., price responsiveness), or whether they are an *instant winner* because they use relatively less energy during critical periods than other customers, even in the absence of demand response.

The assumptions the utility uses when designing a rate may be violated as customers select rates, because the customer types and aggregate load profile served by a rate may differ from the assumed values. This can produce *revenue attrition*, which is a loss of utility revenues due to customer rate choices that persists until the next rate case, at which time the utility can price each rate correctly based on the actual, instead of expected, participants.

Our analysis attempts to provide an upper bound of the revenue attrition that KCP&L and Westar may experience due to customer self selection under a default CPP program. The assumptions we use to price the TOU and CPP rates are as follows:

- All applicable customers adopt the rate; and
- Customers do not engage in demand response (i.e., historical loads are used).

Customer choice is simulated assuming that each customer selects the rate option (TOU or CPP) that provides them with the lowest bill, after accounting for demand response.

In practice, the utility can improve upon the two pricing assumptions by basing rates on its *expectation* of customer enrollments and demand response (provided that the assumptions and modeling are accepted by the Commission). In addition, the customer choice assumption is extreme because customers may not select the lowest-cost rate. For example, customers who may save on a CPP rate on average may nevertheless select the TOU rate because of an aversion to critical prices. For these reasons, the results presented here provide an overestimate of revenue attrition due to customer self selection. However, we believe that the results are instructive regarding the potential scale of the issue from a utility perspective.

The results of implementing the methods described above are presented in Table 4.4, with the revenue attrition expressed in both percentage and dollar terms.[11]

Table 4.4: Revenue Attrition Due to Customer Self-Selection

Rate Class	Utility	Include Demand?	% Revenue Attrition	Revenue Attrition ($000)
SGS	KCP&L	No	0.46%	$168
		Yes	0.46%	$168
	Westar	No	0.95%	$2,221
		Yes	0.53%	$1,239
MGS	KCP&L	No	0.45%	$297
		Yes	0.49%	$324
		Facilities	0.47%	$310
	Westar	No	0.89%	$1,675
		Yes	0.53%	$997

The reductions in utility revenues from customer self selection are fairly small as a percentage of total revenues. The highest value contained in our simulations indicates that Westar would recover 0.95 percent too little revenue from its SGS customers (in the scenario in which no demand charge is used). Many of the results indicate less than one-half percent revenue attrition. Given that these results are based on conservative assumptions (in that they imply an overestimate of the revenue attrition), revenue attrition does not appear to be a significant issue for default CPP programs.

[11] The revenue attrition in dollars is calculated using class-level revenues from each utility's most recent rate case. The revenue values in millions of dollars are: KCP&L SGS = $36.5; KCP&L MGS = $66.0; Westar SGS = $233.8; Westar MGS = $188.2.

5. Load Response

5.1 Load response modeling

The previous section examined the customer-level bill impacts that occur before customers take actions to adapt to the new rate structures (e.g., by shifting or reducing load). Because the primary motivation for offering TOU and CPP rates is to provide customers with incentives to change their usage behavior, we now examine the load response that customers can be expected to undertake in response to the proposed rates.

The model used to simulate load response as customers move from TOU to CPP rates contains two steps. In the first step, customers shift load from peak or critical periods to off-peak periods. The extent to which customers shift load depends on two factors: the ratio of peak or critical to off-peak prices; and the customer's assumed *elasticity of substitution*.[12] In this step, we assume that the overall quantity of energy used remains constant.

In the second step, customers increase or decrease their entire load profile (i.e., change the total amount of energy consumed) in response to a change in their overall expenditure level. An increase in overall energy expenditures causes customers to use less energy. The amount that customers change their usage level depends upon the size of the change in energy expenditures and the customer's *overall elasticity* value.[13]

The elasticity values used in the analysis are taken from the Commercial and Industrial portion of the California Statewide Pricing Pilot (CSPP).[14] This is one of the few existing studies of small and medium C&I customer response to CPP rates. We use an elasticity of substitution of 0.0412 and an overall elasticity of -0.025. The elasticity of substitution value implies that doubling the peak to off-peak *price ratio* leads to a 4.12 percent reduction in the peak to off-peak *usage ratio*. The overall elasticity value implies that a doubling of the overall price level (or expenditures) leads to a 2.5 percent reduction in total usage. While these values represent a fairly modest amount of demand response, the Statewide Pricing Pilot actually found that small C&I customers without enabling technology did not exhibit any statistically significant demand response. For this study, we supplant that result with an assumption that the SGS customers have the same level of price responsiveness as medium C&I customers.

While we do not know of any studies of CPP load response for Midwestern C&I customers, some evidence of regional differences in *overall* price responsiveness (i.e., changes in overall usage levels in response to changes in the average price level) comes

[12] The elasticity of substitution is defined as (the negative of) the percentage change in the quantity ratio divided by the percentage change in the price ratio. That is, as the peak price increases relative to the off-peak price, we expect that customers will reduce usage in the peak period relative to the off-peak period.
[13] The overall elasticity is an own-price elasticity of demand, defined as the percentage change in usage divided by the percentage change in price (expenditures in this case).
[14] Stephen George, Ahmad Faruqui, and John Winfield, "California Statewide Pricing Pilot: Commercial and Industrial Analysis Update", 2006.

from a 2005 RAND study.[15] In this study, the authors estimate regional short- and long-run price elasticity values for commercial electricity customers, with results differentiated by census region. The results show that elasticity of demand for commercial customers in the Pacific Coast region (which includes California) is approximately twice as high as it is for commercial customers in the West North Central region (which includes Kansas).

While these estimates are not directly applicable to our analysis of CPP rates, they do indicate the potential for regional differences in price responsiveness. Therefore, we also simulated models using elasticity values half as high as those derived from the CSPP, or a 0.0206 elasticity of substitution and a -0.0125 overall elasticity. The results were as we expected, with the simulated percentage load impacts and revenue attrition values scaling linearly with the assumed elasticity values. That is, if the elasticities are reduced by half, the resulting load response percentages and revenue attrition amounts are also reduced by half.

Tables 5.1 and 5.2 show the percentage load changes by pricing period and scenario for KCP&L and Westar (respectively) using the CSPP elasticity values.

Table 5.1: TOU to CPP Usage Changes, *KCP&L*

Customer Group	Include Demand Charge?	Pricing Period		
		Critical	Peak	Off-peak
SGS	No	-8.7%	-2.3%	-0.2%
	Yes	-8.7%	-2.3%	-0.2%
MGS	No	-9.1%	-1.5%	0.4%
	Yes	-10.1%	-1.0%	0.2%
	Facilities Only	-9.5%	-1.3%	0.3%

Table 5.2: TOU to CPP Usage Changes, *Westar*

Customer Group	Include Demand Charge?	Pricing Period		
		Critical	Peak	Off-peak
SGS	No	-10.0%	-0.5%	0.6%
	Yes	-8.7%	-1.0%	0.7%
MGS	No	-11.4%	-0.7%	0.5%
	Yes	-10.8%	-0.9%	0.6%

Usage reductions in the critical hours range from 8.7 to 11.4 percent (or 4.4 to 5.7 percent assuming the halved elasticity values). KCP&L customers reduced peak-period usage by 1.0 to 2.3 percent (depending on scenario), which is larger than the range of peak-hour load usage reductions for Westar customers, which ranged from 0.5 to 1.0 percent. This result is due to the fact that the peak to off-peak price ratio is smaller for Westar customers than it is for KCP&L customers.

Off-peak period usage tends to increase, with the results indicating 0.2 to 0.7 percent usage increases. The exception is KCP&L's SGS customers, who reduced usage in the off-peak

[15] Mark A. Bernstein and James Griffin, "Regional Differences in the Price-Elasticity of Demand for Energy", 2005.

hours by 0.2 percent. This is due to the fact that the increase in overall expenditures caused these customers to reduce usage in all hours.

5.2 The effect of customer demand response on utility revenues

In Section 4.5, we examined the potential for utility revenue attrition due to customer self selection. This section examines a different source for potential utility revenue attrition: customer demand response.

If the utility sets its rates using historical loads instead of loads that anticipate the load response of the customers, the utility may lose revenues as customers shift usage from high-priced to low-priced periods. For this analysis, we assume that all customers are on the CPP rate and examine the utility revenues lost as customers shift load out of the critical pricing periods. This can be thought of as an analysis of the potential for lost revenues under a *mandatory* CPP program, in which all customers are on the CPP rate, but they may change their loads such that they no longer match the loads that the utility used when setting the rates.

The results are presented in Table 5.3, with the revenue attrition expressed in both percentage and dollar terms using the California SPP elasticity values.

Table 5.3: Revenue Attrition Due to Customer Demand Response

Rate Class	Utility	Include Demand?	% Revenue Attrition	Revenue Attrition ($000)
SGS	KCP&L	No	1.26%	$460
		Yes	1.25%	$457
	Westar	No	0.67%	$1,566
		Yes	0.36%	$842
MGS	KCP&L	No	0.79%	$522
		Yes	0.72%	$475
		Facilities	0.75%	$495
	Westar	No	0.73%	$1,374
		Yes	0.38%	$715

Revenue attrition due to demand response is slightly larger than the revenue attrition we found for customer self selection, with utility losses ranging from 0.36 to 1.26 percent (or 0.18 to 0.63 percent assuming the halved elasticity values) across the rate classes. Even so, the overall magnitude of the revenue attrition is rather small, particularly given that the analysis assumes that *all* SGS and MGS customers are on the CPP rate and that the utility does nothing to account for expected customer load response when setting rates. Therefore, the results indicate to us that revenue attrition may not be a significant consideration when considering the adoption of a CPP program.

6. Summary and Conclusions

This report analyzed the effects associated with adopting time-of-use (TOU) and critical peak pricing (CPP) rates for Small and Medium General Service customers at KCP&L and Westar. CPP programs provide customers with incentives to reduce usage during the hours

of greatest need (e.g., hot summer days when increased customer demand increases the cost to serve customers). The usage reductions can replace the need for additional peaking generation, allowing for the most efficient use of existing generating resources. TOU rates provide the foundation for the CPP program, serving as both the basis for the CPP rates on non-critical days and the alternative rate for customers who do not want to be exposed to critical prices.

The study uses customer-level hourly usage data to examine the following types of results:

- The distribution of customer-level bill impacts;
- The extent to which the utility can lose revenue (revenue attrition) because of customer self-selection (or the tendency for customers to select the rate that is best for them); and
- The extent to which the utility can lose revenue because of customer demand response (or customers modifying their load profiles in response to the price signals contained in the TOU and CPP rates).

The analysis of customer-level data provides a means of analyzing the outcomes that may occur under default CPP pricing, in which customers are automatically placed on the CPP rate, but allowed to switch to an alternative TOU rate instead.

We examined scenarios that varied in the handling of demand charges (a billing component that relates to the customer's maximum usage during a period of time). Some scenarios eliminated the demand charge entirely, shifting a significant amount of revenue recovery to the energy prices. The results for these scenarios typically had the broadest range of bill impacts across customers. Other scenarios included the full demand charge (including the facilities charge) contained in the SGS and MGS tariffs. For the KCP&L MGS customers, we were able to examine an intermediate scenario in which customers are charged only the facilities charge. In all cases, the proposed rates were designed to be revenue neutral at the class level (relative to the SGS and MGS rates). However, the bill impacts will vary within each customer class. We examine the distribution of bill impacts to determine whether sub-sets of customers experience especially large bill changes as they adopt new rates.

The key findings are as follows:

- Customer usage reductions during critical hours range from 8.7 to 11.4 percent (or 4.4 to 5.7 percent assuming more conservative price response, or elasticity values). These reductions can replace the need for peaking generation used to serve the peak demand hours.[16]
- Relatively low-use customers tend to experience bill decreases, while higher use customers tend to experience bill increases as they move from SGS or MGS to TOU or CPP. This is because the SGS and MGS tariffs tend to provide lower average rates to lower-use customers, and the rate structures that produce this effect are not carried over into the TOU and CPP rates.

[16] The study does not consider the extent to which the CPP load impacts serve as a substitute or complement for KCP&L's or Westar's current demand response programs.

- Bill impacts for TOU and CPP rates (as customers migrate from the SGS and MGS tariffs) are very similar and tend to be relatively small in magnitude. Even in the scenarios with the most dispersed load impacts, approximately half of the customers experience a bill change of less than 10 percent.
- Bill impacts as customers move from TOU to CPP rates are very small, rarely exceeding 5 percent. This means that, despite their high prices, the critical hours contribute relatively little to the bill impacts.
- Utilities do not have a high percentage of rate class revenue at risk by pricing new rate options in a manner that fails to account for customer choice or demand response. That is, the tendency for customers to select the most beneficial rate and then change their load shape to reduce their bill may cause the utility to only lose on the order of 1 percent of class revenues, even under assumptions intended to reflect a worst case scenario.

The results have shown the benefit of introducing CPP rates, in the form of approximately 5 to 10 percent usage reductions during critical hours, depending on the assumed level of customer price responsiveness. The costs appear to be relatively small. The largest portion of the bill impact is due to removing incentives to grow (and/or flatten) loads in the SGS and MGS rates. The critical prices themselves do not have a large effect on customer bills. In addition, utility revenue attrition does not appear to be a significant barrier to the adoption of CPP.