

Final Results from SMUD's SmartPricing Options Pilot¹

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ABSTRACT

The Sacramento Municipal Utility District's (SMUD) SmartPricing Options (SPO) pilot is widely recognized as one of the best designed and most valuable pricing pilots ever conducted in the electricity industry. This pilot examined customer acceptance of and load impacts from time-of-use (TOU) and critical peak pricing (CPP) pricing plans under both default and opt-in enrollment. A combination TOU/CPP plan was also offered on a default basis. The SPO also offered in-home displays (IHDs) to a subset of treatment customers to determine whether the offer of an IHD increases enrollment and/or demand response. The SPO pilot ran for two summers, 2012 and 2013. Customers were allowed to remain on the SPO pricing plans at the end of the official pilot period and most did.

In addition to testing default and opt-in enrollment, a unique experiment to date in the industry, SMUD's SPO also rigorously adhered to the strict rules of sound experimental design. Some treatments were examined using a randomized control trial (RCT) design with recruit and delay for those chosen for the control group. Other treatments used a randomized encouragement design (RED). Both experimental methods have equal internal validity.

This paper provides a high level overview of key findings from the study. Following a brief summary of the pilot design and the rate options that were tested, average and aggregate load impacts and customer acceptance rates are presented. The results of a conjoint survey are also discussed showing how changes in rate characteristics would affect customer acceptance of opt-in tariffs. Results from an end-of-pilot survey focused on customer satisfaction and perceptions about the rates are summarized. Finally, the relative cost-effectiveness of opt-in and default rate options is discussed.

Introduction

This paper summarizes the final evaluation results for Sacramento Municipal Utility District's (SMUD) SmartPricing Options (SPO) pilot. SPO was a multi-year pricing pilot that tested the three time-variant rates summarized below:

- **TOU Rate Option:** Participants were charged an on-peak price of \$0.27/kWh between the hours of 4 PM and 7 PM on weekdays, excluding holidays. For all other hours, participants were charged \$0.0846/kWh for the first 700 kWh in each billing period, with any additional usage billed at \$0.1660/kWh.
- **CPP Rate Option:** Participants were charged a price of \$0.75/kWh during CPP event hours, when temperatures and SMUD's system loads are expected to be unusually high. This rate option was designed under the assumption that 12 CPP events would be called each year, between the hours of 4 PM and 7 PM on weekdays, excluding holidays. Customers were notified 24 hours in advance of an event day. For all other hours, participants were

¹ The final report can be found at
https://www.smartgrid.gov/files/SMUD_SmartPricingOptionPilotEvaluationFinalCombo11_5_2014.pdf

charged \$0.0851/kWh for the first 700 kWh in each billing period, with any additional usage billed at \$0.1665/kWh.

- TOU-CPP Rate Option:** The third and final SPO rate combines the pricing structures of the TOU and CPP rate options. The TOU-CPP off-peak electricity rate was \$0.0721/kWh for the first 700 kWh in each billing period, with any additional off-peak usage billed at \$0.1411/kWh. Participants were charged an on-peak price of \$0.27/kWh between the hours of 4 PM and 7 PM on weekdays, excluding holidays. A CPP price of \$0.75/kWh was charged to participants between the hours of 4 PM and 7 PM on CPP event days, which were planned to be called 12 times during the summer months. The 12 days are the same as those called for the CPP-only rate.

To our knowledge, the SPO is the only pilot in the industry that has compared enrollment and load impacts on a side-by-side basis for identical customer segments based on both opt-in and default recruitment. The SPO also tested the impact of the offer of an in-home display (IHD) on customer enrollment for opt-in recruitment. The pilot research design involved both randomized control trials (recruit and delay) and randomized encouragement designs. Figure 1 summarizes the treatment groups tested in the SPO.

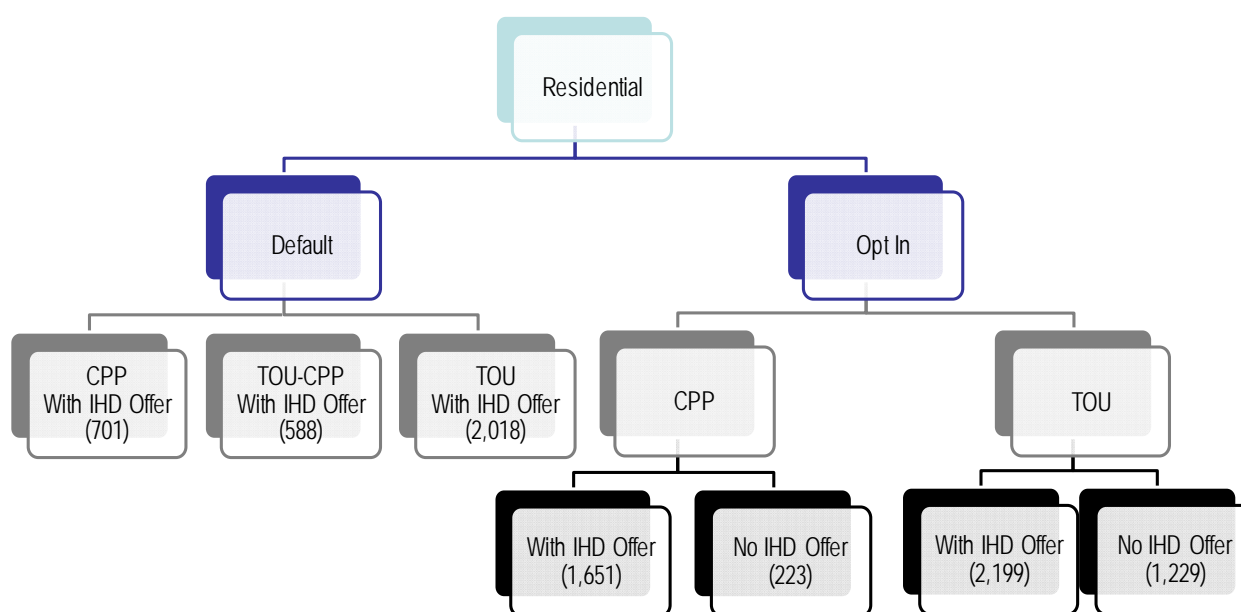


Figure 1. Overview of SPO Treatments²

Opt-in recruitment began in October 2011 and marketing continued until June 1, 2012, when the new pricing plans went into effect. Default treatment groups were notified in early April 2012 that they would be placed on a new, time-variant pricing plan by June 1 unless they contacted SMUD indicating that they did not wish to be placed on the new plan. Time-variant rates were effective from June 1 through September 30

² Total enrollment including deferred groups = 12,027; Total # of customers receiving offers (including deferred groups) = 53,798; Total # of customers in SPO including controls = 99,661

for the summers of 2012 and 2013. In between the two summers, customers reverted to their otherwise applicable SMUD tariff.

In addition to analyzing customer enrollment and load impacts, this paper summarizes the results from two surveys. A conjoint survey was conducted to examine the likely impact of changes in rate attributes (e.g., price ratios, the number of rate periods, the number of event days for CPP pricing plans, etc.) on customer enrollment for opt-in pricing plans. An end-of-pilot survey was conducted to assess customer satisfaction, awareness of the attributes of each pricing plan, customer perceptions, reasons that customers stayed on the new pricing plans, IHD use and other topics of interest. The cost-effectiveness of various pricing plans under the assumption that SMUD would offer the plan to the entire residential population is also discussed.

Customer Acceptance and Attrition

Customer acceptance rates for opt-in pricing plans were high by industry standards and much higher than expected for default plans. Opt-out rates were low for all plans. Table 1 shows the number of offers made to customers for each pricing plan, the number of customers who accepted each offer and enrollment at various points during the two year pilot. Figures 2 and 3 show the acceptance and attrition rates for each pricing plan.

As seen in Figure 2, acceptance rates across the four opt-in treatment groups were between 16% and 19%, which is quite high when compared with most other utility rate programs and pilots (especially considering that all recruitment was done over roughly an 8 month period, not over multiple years). Differences in acceptance rates across the four pricing plans are small. The offer of an IHD has no apparent influence on acceptance rates for CPP plans and only a slight impact for TOU plans. Acceptance rates for CPP plans are slightly higher than for TOU plans and the difference for the CPP and TOU plans that did not include the offer of an IHD was statistically significant at the 95% confidence level. However, customers were not given a choice of multiple time-variant pricing plans, so this difference should not be interpreted as a preference for one plan over the other. Indeed, the conjoint survey that was done included choice exercises where both pricing plans were offered simultaneously. Results from this survey show that, when given a choice of both plans, customers prefer TOU to CPP by a factor of roughly 2 to 1.

Table 1. Offers Made and Customers Enrolled by Pricing Plan

Recruitment Approach	Rate	IHD Offer	# of Offers Made	# of Customers Accepting	# of Customers Enrolled on Date		
					6/1/12	6/1/13	9/30/13
Opt-in	CPP	No	1,187	223	212	161	147
		Yes	9,060	1,651	1,569	1,265	1,172
	TOU	No	7,500	1,229	1,157	941	877
		Yes	12,554	2,199	2,092	1,664	1,554
Default	CPP	Yes	846	701	701	566	536
	TOU	Yes	2,410	2018	2,018	1,628	1,508
	TOU-CPP	Yes	729	588	588	465	431

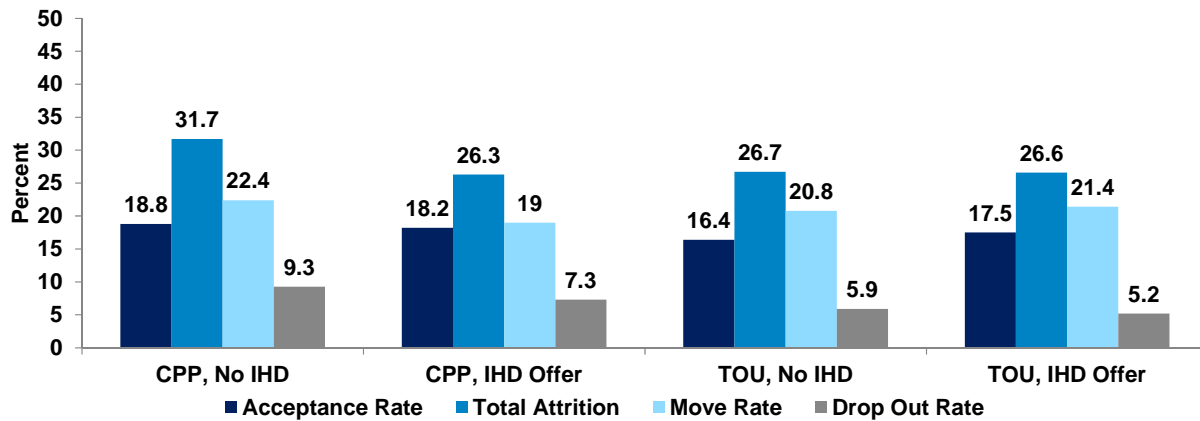


Figure 2. Customer Acceptance and Attrition for Opt-in Pricing Plans

The attrition, move rates and dropout rates shown in the figure cover the period from June 1, 2012 to September 30, 2013. Total attrition ranged from roughly 26% to 32%. However, the majority of this attrition was due to customers moving. Dropout rates represent the percent of customers who actively de-enrolled over the two summers and range from a low of 5.2% for the TOU plan that included an IHD offer to a high of 9.3% for the CPP plan with no IHD offer.

Figure 3 summarizes the acceptance and attrition rates for the default pricing plans. The acceptance rate equals the percent of customers who were notified that they would be placed on the new pricing plan and who did not notify SMUD that they wished to opt-out prior to being placed on the plan. As seen, only roughly 3% to 7% of customers chose not to go on the new pricing plan. This acceptance rate was much higher than the 50% rate that SMUD had planned for. Over the next two summers, an additional 4% to 8% of enrolled customers dropped out, and between 18% and 22% moved. The dropout rates for opt-in plans were actually higher than for the default plans. This likely reflects a lower level of awareness and engagement by default customers compared with opt-in customers, as evidenced by findings from the end-of-pilot survey reported later.

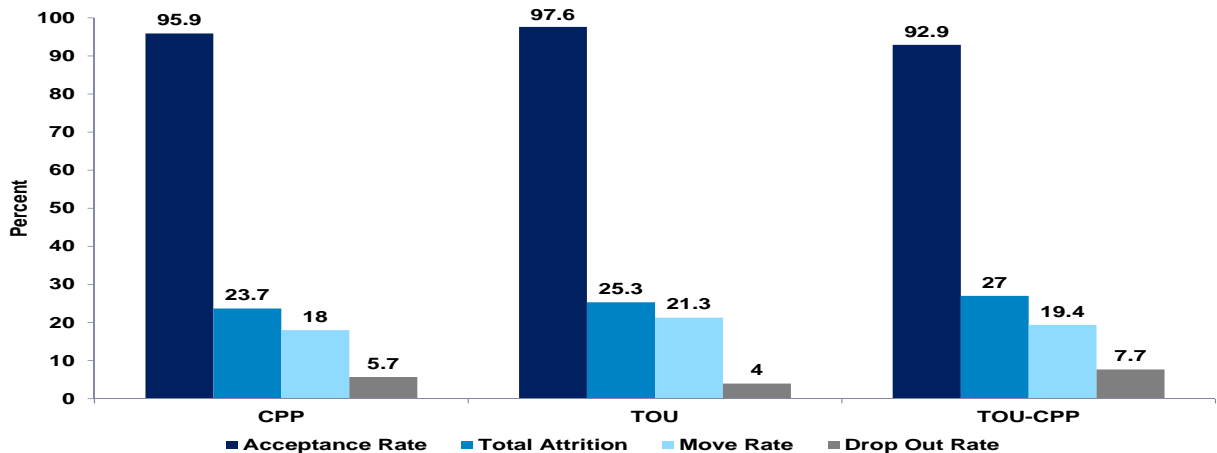


Figure 3: Customer Acceptance and Attrition for Default Pricing Plans

Load Impacts

Table 2 summarizes the average peak-period load reductions across the two summers for each pricing plan. The first three numerical columns show the impacts averaged across the 23 days on which critical peak prices were in effect. Values for CPP days are shown for both CPP and TOU pricing plans so that an apples-to-apples comparison can be made for those two rate options under the same set of weather conditions. The last three columns in the table show the peak period load reductions across the average weekday for both summers for the TOU pricing plans. These values include impacts on days when events were and were not called for the CPP pricing plans.

Table 2. Peak Period Load Reductions for All Pricing Plans

Group	CPP Day Impacts			Average Weekday Impacts		
	Impact	Reference Load	% Impact	Impact	Reference Load	% Impact
Opt in TOU, IHD Offer	0.32	2.38	13.3%	0.21	1.79	11.9%
Opt in TOU, No IHD Offer	0.23	2.24	10.1%	0.16	1.72	9.4%
Opt-in CPP, IHD Offer	0.64	2.53	25.1%	n/a	n/a	n/a
Opt-in CPP, No IHD Offer	0.49	2.33	20.9%	n/a	n/a	n/a
Default TOU, IHD Offer	0.15	2.47	5.9%	0.11	1.86	5.8%
Default CPP, IHD Offer	0.36	2.56	14.0%	n/a	n/a	n/a
Default TOU-CPP, IHD Offer	0.31	2.54	12.3%	0.17	1.91	8.7%

A key conclusion is that the absolute and percent impacts per customer are roughly half as large for default plans compared with the same opt-in pricing plans. Another key conclusion is that, under CPP event-day weather conditions, average load reductions for CPP pricing plans are roughly twice as large as for TOU pricing plans. Importantly, the fact that average impacts are roughly half as much under default plans compared with opt-in plans does not mean that aggregate impacts would be smaller under default plans. Indeed, quite the opposite is true. When the differential enrollment rates are factored into the equation, default plans offered to the same population of customers as opt-in plans are likely to produce much higher aggregate load reductions. For example, the aggregate load reduction in the initial summer of an opt-in CPP pricing plan that included the offer of an IHD would equal 11.6 MW if offered to 100,000 customers.³ The same plan offered on a default basis would produce 34.5 MW of load reduction, nearly three times more than for the opt-in plan. Similarly, if the TOU plan with an IHD offer was marketed to 100,000 customers on an opt-in basis, the load reduction on the average weekday would be 3.7 MW (and 5.6 MW on the average CPP day). When offered on a default basis, the estimated load reduction is 10.8 MW, once again roughly three times as large as for the opt-in plan.

Other key findings from the load impact analysis include the following:

- For 6 of the 8 pricing plans, average load reductions per customer were not statistically significantly different across the two summers – that is, load impacts persisted over two

³ 11.6 MW = (100,000x.18.2x.64kW)/1,000

years – after controlling for movers. For the opt-in TOU plan with the IHD offer, impacts fell from 0.26 kW in the first summer to 0.20 kW in the second and this difference was statistically significant. For the default CPP pricing plan, impacts increased from 0.31 kW to 0.42 kW, and this difference was statistically significant.

- For default TOU pricing plans, EAPR and non-EAPR customers produced very similar absolute and percent reductions. EAPR stands for Energy Assistance Program Rate and is a rate offered to qualifying low income consumers that is significantly less than the non-EAPR rate. For default CPP and for all opt-in pricing plans, average load reductions for EAPR customers were less than for non-EAPR customers.
- Absolute load reductions increased by as much as a factor of 10 across customers segmented into quartiles based on summer usage. This suggests that any opt-in program will likely be much more cost-effective if it markets primarily to large users.
- Energy savings were statistically insignificant for all but three pricing plans. Savings for the default TOU plan equaled 1.3%, for the opt-in CPP plan (with IHD offer) savings equaled 3.5% and for the default CPP plan, savings equaled 2.6%.
- A structural economic model of demand was estimated so that load impacts could be predicted for prices other than those tested in the SPO. The estimated price elasticities were comparable to those found through other pricing pilots, including California's Statewide Pricing Pilot. Based on the estimated demand model, increasing critical peak prices by roughly 60% over SPO price levels (from \$0.75/kWh to \$1.20/kWh) would increase the percent load reduction during the peak period by roughly 20% for both opt-in and default CPP pricing plans. For TOU pricing plans, a 55% increase in peak period prices, all other things equal, would increase the percent load reduction by 30 to 40%.

The Influence of IHDs

The SPO was designed to assess the impact of the offer of an IHD on customer acceptance of opt-in pricing plans. As discussed above, the offer of an IHD did not have a material impact on acceptance rates.

Another useful investigation concerns the acceptance of and connection rates for IHDs among treatment groups that received an IHD offer. What percent of customers who received an IHD offer accepted it and what percent of those customers receiving an IHD connected the device with their meter?

Two of the opt-in treatment groups were offered a free IHD if they enrolled on the rate. Acceptance of the IHD was not a condition of going on the pricing plan. Opt-in customers could indicate at the time of enrollment whether or not they wanted an IHD. If they did, the IHD was mailed to them pre-commissioned, so that when they unpacked it and turned it on, it was supposed to automatically connect with their meter and start displaying information. All customers in the default treatment groups were offered a free IHD. Because customers were automatically enrolled unless they opted-out, there was not the same opportunity to simply "check a box" at the time of enrollment to indicate whether or not they wanted an IHD. Instead, those who wanted an IHD had to take a proactive step to request it.

In summer 2012, SMUD was able to determine from the meter data management system the number of IHD devices that were connected to meters at any point in time but was not able to link those devices to individual customer accounts. However, in summer 2013, data became available that provided a daily log for each customer indicating whether or not their IHD was connected to their meter. As such, for the second year of the pilot, it was possible to identify customers who had their IHDs connected during the entire summer, those who never had it connected during summer 2013, and those who were connected on some days and not others.

For each treatment group, Table 3 shows the number of customers who requested an IHD at the beginning of the pilot, the IHD acceptance rate (the number accepting divided by the number offered), the

number of customers who accepted the IHD that were still enrolled at the beginning of the summer period in 2013 and, of those, the percent that had their device connected with their meter during the entire summer, the percent that were connected at some point in time during summer 2013 and the percent that were never connected in 2013.

Table 3: IHD Acceptance and Connection Rates

Group	Enrolled 6/1/12	# That Accept IHD	Acceptance Rate	# of Customers With IHDs Still Enrolled as of 6/1/13	% Connected All the Time	% Connected Some of the Time	% Never Connected
Opt-in CPP, IHD Offer	1,569	1,498	95%	1,195	11.6%	27.4%	61.0%
Opt-in TOU, IHD Offer	2,092	2,017	96%	1,597	11.6%	22.8%	65.6%
Default TOU- CPP, IHD Offer	588	136	23%	112	18.8%	39.3%	42.0%
Default CPP, IHD Offer	701	167	24%	140	14.3%	42.9%	42.9%
Default TOU, IHD Offer	2,018	418	21%	363	18.2%	23.1%	58.7%

As seen in the table, roughly 96% of opt-in customers requested an IHD whereas fewer than 25% of default customers did so. As seen in the last three columns in the table, roughly two thirds of opt-in customers who accepted the IHD and who were still enrolled at the beginning of the 2013 summer never had their device connected in 2013. This “never connected rate” was much lower for two of the three default groups, equal to roughly 42% for the default TOU-CPP and CPP groups. The higher connection rate for default customers compared with opt-in customers is consistent with a hypothesis that, since default customers had to take a proactive step to request the device compared with the passive “check the box” approach for opt-in customers, they were more invested in using the device once it arrived. Why the “never connected rate” for default TOU customers is closer to that of opt-in customers than it is to that of the other default groups is unclear.

The SPO was not designed to assess the impact of an IHD on demand response. However, careful observers will note in Table 2 that load impacts for opt-in treatments that include an IHD offer are larger than for those that don’t include an IHD offer. However, it is not appropriate to attribute these differences to the offer or use of the IHD. After correcting for pre-treatment differences across treatment groups, the load impact differences are not statistically significant. Put another way, there is no evidence from the SPO indicating that IHDs significantly increase load impacts associated with time-variant pricing plans.

The Impact of Rate Attributes on Customer Acceptance

A conjoint survey was conducted to assess the impact of changes in rate attributes on customer acceptance. A conjoint survey asks respondents to select their preferred choice from among several options that vary according to selected attributes, such as peak to off-peak price ratios, the length and number of rate

periods, the number of event days for CPP plans, and others. Because most rate plans implemented by utilities are revenue neutral for the average customer, when selected attributes were changed across options, prices also changed. For example, as the length of the peak period increased, the average peak period price fell since the avoided capacity costs underlying peak period prices are spread over more hours.

In order to avoid survey fatigue and so as not to influence customer behavior, the conjoint survey was not administered to SPO treatment customers. Rather, it was administered to SPO control group customers, to those who were ineligible for the SPO because they were participants in SMUD's balanced billing or direct load control programs, and to customers who were eligible for the SPO but were not included in the study. These groups were segmented and analyzed separately. 1,142 surveys were completed and the survey response rate was almost 40%. Each respondent was given 9 groups of 3 choices, for a total of 27 observations per respondent that could be used for analysis purposes. Key findings from the survey included the following:

- Pricing plan acceptance rates fell as the length of the peak period increases. The estimated percent of customers who opt-in fell by roughly 3 to 5 percentage points (from a value of 16 to 19% for a length of 3 hours depending on the rate option) as the peak period length grew from 3 to 6 hours.
- Acceptance rates were essentially the same for pricing plans that were based on 6 and 12 event days, but increasing the number of events days beyond 12 decreases acceptance rates.
- Increasing the peak-to-off-peak price ratio had only a modest impact on acceptance rates for TOU plans but had a stronger, negative impact on acceptance rates for CPP plans.
- Respondents preferred time-variant rates that do not also have a tiered structure in which prices increase as usage increases.
- Customers preferred TOU plans over CPP plans by a factor of nearly 2 to 1.
- Almost 60% of respondents said they preferred some type of time-variant rate over the standard tiered rate.
- Almost 30% of respondents would take any time-variant rate over the standard rate and another 30% would choose one time-variant option over the standard rate but not another.

Cost Effectiveness Analysis

The cost-effectiveness of each of the 7 pricing plans tested in the SPO was estimated based on the assumption that the plans were offered to SMUD's entire residential population (about 540,00 customers) and the two-year average enrollment rates and load impacts found in the SPO were observed for this larger population. Recruitment, notification and other variable costs from the SPO were used and startup and other costs were adjusted where appropriate to reflect changes that might be needed to support a larger scale operation. The primary benefit included in the analysis was avoided capacity costs resulting from lower peak period usage. Estimates were also developed for three non-SPO scenarios in which customers were defaulted onto the CPP, TOU or TOU-CPP rates but without the offer of an IHD. Given the fact that there were no measurable incremental load reductions associated with an IHD for opt-in treatments, we assumed that enrollment rates and load reductions would be the same with and without the IHD offer. The present value of net benefits was calculated over a 10 year period.

Table 4 shows the NPV of benefits, costs and net benefits over a ten year period for each pricing plan. It also shows the benefit-cost ratio for each plan, based on the inputs and methods described above. The values in the table are for overall cost-effectiveness, which includes both start-up and ongoing costs, and addresses the policy question of which plan would be most cost effective if it were to be implemented from scratch.

As seen in the table, all but one of the pricing plans, opt-in TOU with an IHD offer, are cost effective, but the magnitude of net benefits vary by almost a factor of 60 between the plans with the lowest

and highest positive net benefits. Of the 7 pricing plans tested in the SPO, if they were to be extended to SMUD's entire residential population, the net benefits over 10 years would range from a low of roughly -\$5.5 million for the opt-in TOU plan with the IHD offer to more than \$86 million for the default TOU-CPP plan with an IHD offer. Default plans are significantly more cost effective than opt-in plans and pricing plans that include the offer of an IHD are all much less cost effective than the equivalent plan that does not offer an IHD. For simulated default plans without an IHD offer, the TOU plan has the lowest net benefits but still exceeds \$50 million. The TOU-CPP plan is estimated to deliver net benefits that are more than twice as large as the TOU plan. In general, all CPP plans deliver net benefits that are roughly twice as large as the equivalent TOU plan.

Table 4: NPV of Benefits and Costs by Pricing Plan (\$ millions)

Scenario Type	Scenario	Benefit/Cost Ratio	10 Year NPV for SMUD Territory		
			Benefits	Costs	Net Benefits
Opt-in Tested	TOU, No IHD Offer	1.19	\$12.1	\$10.2	\$2.0
	TOU, IHD Offer	0.74	\$15.5	\$21.0	-\$5.5
	CPP, No IHD Offer	2.05	\$29.7	\$14.4	\$15.2
	CPP, IHD Offer	1.30	\$34.3	\$26.3	\$7.9
Default Tested	TOU, IHD Offer	2.04	\$66.9	\$32.8	\$34.1
	CPP, IHD Offer	2.22	\$142.1	\$63.9	\$78.2
	TOU-CPP, IHD Offer	2.49	\$144.8	\$58.1	\$86.7
Default Simulated	TOU, no IHD Offer	4.48	\$66.9	\$15.0	\$52.0
	CPP, no IHD Offer	4.28	\$142.1	\$33.2	\$109.0
	TOU-CPP, no IHD Offer	4.53	\$144.8	\$32.0	\$112.9

End-of-Pilot Survey Summary

A survey was conducted in the fall of 2013, after the end of the second summer period, to obtain input among pilot participants on the following topics:

- Customer satisfaction with SMUD and with the pricing plan customers were on;
- Awareness of the attributes of each pricing plan;
- Perceptions about the pricing plan;
- Reasons for staying on the pricing plan;
- Awareness of events for the CPP pricing plans; and
- IHD use.

The survey was sent to all customers who were enrolled on a pricing plan (including those who actively dropped out but not those who moved) as well as a sample of control group and deferred customers. The survey was conducted using both online and hard copy questionnaires. The overall response rate was 40%. Key survey findings include the following:

- Satisfaction ratings for respondents in all treatment cells, including the deferred treatment cell, were equal to or greater than satisfaction levels in the control group. Put another way, defaulting customers onto time-variant rates or using recruit and delay research methods in some cases did not negatively impact satisfaction with SMUD services.
- Customers on time variant pricing plans, including default plans, report greater agreement with the statement, “My current pricing plan is easy to understand” than do customers on the standard rate. Opt-in customers showed greater actual (not perceived) understanding of rate attributes than did customers on the standard rate and default customers showed about the same level of understanding as customers on the standard rate.
- Significantly more customers on time-variant pricing plans agreed with the statement, “My current pricing plan provides me with opportunities to save money” than did customers on the standard rate. More time-variant pricing plan customers also felt that their pricing plan was fair than did customers on the standard rate.
- Roughly 40% of customers on default time-variant pricing plans and about 57% of those on opt-in plans strongly or somewhat agreed with the statement, “My current pricing plan is better than my old pricing plan” and roughly half of all default respondents and three quarters of opt-in respondents strongly or somewhat agreed with the statement, “I want to stay on my pricing plan.”
- Almost half of default and roughly two thirds of opt-in respondents strongly or somewhat agreed with the statement, “I think the Sacramento community would be better off if everybody was on my pricing plan.”
- Almost 60% of default and 80% of opt-in respondents strongly or somewhat agreed with the statement, “I believe that I did something good for Sacramento by participating in my pricing plan.”