Making Decisions Regarding New Technology Upgrades Within Existing Load Management Programs

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ABSTRACT

Emerging technologies for load management offer greater demand savings, enhanced features and more customer choices. Utilities with existing load management programs must decide whether, when and how to upgrade to these new technologies. Sacramento Municipal Utility District (SMUD) is faced with such a choice regarding its Peak Corps residential air conditioning load management program. In partnership with the California Energy Commission (CEC), SMUD is evaluating as pilot programs two state-of-the-art load management technologies based on Internet gateway and "smart thermostat" technology. One program, called PowerStat℠, is a utility-controlled air conditioner cycling program, while the other, called Power Choice, is a customer-controlled time-of-use program.

In this paper, issues surrounding the upgrade decision are examined, using PowerStat℠ and Power Choice as examples. Results from the evaluation of the 2002 PowerStat℠ program are presented in a framework of questions and answers, which derive from the issues and inform the upgrade decision. Based on findings, recommendations are made for whether and how to migrate the technology to Peak Corps or to proceed with a roll out of a separate PowerStat℠ program.

Introduction and Background

Critical decisions facing managers of energy efficiency and load management programs are when and how to upgrade to new technology with enhanced features. These new technologies have the potential for greater demand savings, offer managers enhanced features for gathering information and managing program operations, and offer customers more choices for how they participate in the program. However, these new technologies are also more costly and difficult to install, have greater constraints or requirements around their usability, and can be difficult to integrate into existing information systems infrastructures.

SMUD is at a decision-point with regard to moving forward with the use of new load management technologies. For over 20 years, SMUD has operated a very successful residential air conditioning load management program, called Peak Corps, which serves approximately 100,000 customers. This program has shown relatively low turnover and high customer satisfaction. However, this program is based on old style controllers placed directly on the air conditioner compressor. Currently, Peak Corps is dispatched under emergency-only conditions where system voltage or capacity shortages are threatened or imminent.

To provide SMUD and other utilities with information necessary to make decisions regarding new technologies, SMUD and the CEC are jointly investigating two new technologies for residential use. One technology, called PowerStat℠, allows SMUD to radio-dispatch a signal to a thermostat that cycles off the customer's air conditioner for a programmed percentage of time, in the same way as the Peak Corps. An additional feature of the PowerStat℠ thermostat is a proprietary Adaptive Algorithm™, which is designed to overcome the loss of load savings that occurs when the duty cycles of air conditioners synchronize with the uncontrolled cycle time.

The second technology, called Power Choice, is a time-of-use (TOU) energy management system, which allows customers to control the operation of their HVAC and other equipment remotely through a gateway. Curtailment is voluntary on the part of participants and in response to price signals from a tiered TOU rate structure. The Power Choice technology has two elements: a programmable thermostat, which can be set to automatically control the HVAC and other specified end uses during peak and non-peak periods, and a data networking technology for collecting and reporting to participants interval load data of controlled end uses. Both the thermostat and the interval load data are remotely accessible. Unlike the Peak Corps controller and the PowerStat℠ thermostat, the Power Choice thermostat can detect if and when the air conditioner and other controlled end uses are running. The gateway technology selected for the pilots was developed by Comverge; the thermostats were developed by Honeywell for Comverge.

In 2002, SMUD and the CEC implemented pilot programs to evaluate the new technologies. Summit Blue Consulting, an independent contractor, was selected by SMUD to conduct impact and market evaluations of both programs. SMUD project staff is conducting process evaluations of the programs. The objectives of the evaluations are to estimate unit demand and energy savings, estimate the potential markets for the technologies, measure participant satisfaction, determine field performance of the technologies and identify best practices for implementing and administering programs using the technologies.

Customers were solicited to participate in the PowerStat℠ pilot program in the spring of 2002, and equipment was installed by mid-summer. To control for the effects of pricing, the PowerStat℠ pilot offered the same incentive structure and cycling options as Peak Corps. Also, in order to test the functioning of the equipment in comparison with the Peak Corps equipment, the Adaptive Algorithm™ feature was not deployed. The PowerStat℠ pilot will be continued through summer 2003 to test the potential additional load savings of this feature. Customers were solicited for the Power Choice program in winter 2002, and installations began in spring 2003.

SMUD management has asked the Research and Evaluation group to identify the critical decisions that need to be made around deployment of new technologies for demand response, and to provide information to make those decisions. Results of the pilot studies can inform these decisions and help formulate a strategic vision for SMUD's load management programs. Defining these decisions and providing answers to some of the questions raised may also provide a roadmap for other utilities facing the same dilemma. Results from the Power Choice pilot program will not be available until 2004. Results from the 2002 PowerStat℠ pilot study are presented here in the context of the issues surrounding the decisions of whether to migrate to the new technology, and how to position that technology in relation to the existing Peak Corps program.

Considerations in Migrating to New Technologies

There are several key issues that need to be addressed when considering migration to a new load management technology. These are:

- current and future costs, both initial and ongoing;
- difficulty in implementing the new technology;
- potential for penetration of both technologies into existing and new markets, and the comparative rates of attrition;
- impacts, satisfaction and other benefits of the new and old technologies; and
- conditions for deployment of both technologies once implemented.

Each of these issues has ramifications for policy regarding the new and old programs.

The fixed costs of infrastructure acquisition and maintenance among the three technologies being employed at SMUD (Peak Corps, PowerStat℠ and Power Choice) are similar, ranging between $300,000 and $500,000. However, both the features of the technologies and the variable costs of materials, installation and maintenance differ considerably. To provide some perspective, the per-unit cost today for radio controllers is approximately $100, compared with $300 for radio-controlled thermostats and $1,300 for time-of-use management systems. Maintenance costs are also expected to be greater for the new technologies than for the old, because the new technologies are housed inside customers' dwellings and control the daily operation of their air conditioners and other equipment.

Problems and associated added costs of installing the new technologies, both as they integrate with the existing IT infrastructure of the utility and with customers' HVAC systems, also need to be considered. At least $100k of the fixed costs, and between one-third and two-thirds of variable costs, is in-house labor associated with configuring, customizing and troubleshooting installations.

The costs and structure of incentives is another chief consideration, particularly in relation to deployment strategy and valuation of avoided load. PowerStat℠ has the same incentive structure as Peak Corps, which includes a fixed seasonal payment and a variable (per event) payment, both of which vary with maximum cycling strategy. The Power Choice rate varies both by season and time-of-use, with two winter and three summer TOU periods, plus a critical summer period tied to temperature and system load. The rate is designed to be revenue neutral while encouraging conservation. Peak Corps and PowerStat℠, however, are not revenue neutral. Incentives were designed based more on customer needs than marginal costs and market prices of power. As a result, a minimum number of events need to occur at any given marginal price to achieve break-even or better from a utility perspective.

Offsetting the higher costs of the new technologies is the potential for greater benefits, both from load and energy impacts and from increased customer satisfaction. With Peak Corps there is no way to determine whether and which controllers or air conditioners are operating properly. Although controllers are field-tested and maintained on a regular schedule, at any point in time there may be as many as 10% that are malfunctioning, as well as a smaller portion of air conditioners that are not working. Like the Peak Corps controller, the PowerStat℠ thermostat also cannot detect whether the air conditioner or control mechanism is working. However, because the control unit is the thermostat itself, customers are much more likely to report problems, resulting in the thermostats being repaired. The Power Choice thermostat can detect and report if signals are received and end uses are operating, so any faulty equipment is easily identified and repaired.

In addition to avoiding losses from broken equipment, the new technologies offer other ways to increase load impacts. The Adaptive Algorithm™ of the PowerStat℠ technology monitors the run time of the air conditioner during an hour block, and adapts the cycle time during the following hour to ensure that the air conditioner is cycled off during the time that it otherwise would have ordinarily been operating, rather than during the time when it would have been off. Comverge claims "maximum" load savings from this feature.[1]

Although it is more difficult to determine the economic value of participant satisfaction than of impacts, participant satisfaction is equally important to SMUD management in the decision to migrate to new technologies. Peak Corps surveys repeatedly reveal three primary needs of participants: more choice, more control and more money. The advanced features of the new technologies provide abundant choices and control, as well as the potential for substantial bill savings. The Power Choice technology can be programmed for varying degrees of air conditioning curtailment by resetting the temperature or shutting the unit off entirely during peak periods. It also provides online viewing of monthly energy usage, as well as on-line programming and control of curtailment. PowerStat℠ provides the ability to

[1] A discussion of this feature can be found at http://www.comverge-tech.com/dcusupswitch.html.

use an immediate one-time opt out via the Internet rather than giving 24-hour notice by telephone. Customers can also consult the Internet to see when and whether they are being cycled, or look at their thermostats.

Potential for penetration into existing and alternate markets has a bearing on whether to migrate the qualifying existing program participants to the new technology, to grow the existing program or to develop and grow a separate program. Studies indicate that Peak Corps is close to saturation. (SMUD 1994 and Wood, Sambandan & Kolodziej 2001) For this reason, the current policy toward the Peak Corps is to maintain the participant base and resource by recruiting to offset attrition rather than to grow the program. Due to the advanced features of PowerStat℠, simply migrating current Peak Corps participants who qualify to the new technology has the potential to increase both satisfaction and impacts. If these new features also attract customers who are not presently interested in participating in Peak Corps, or encourage existing Peak Corps participants to move up to higher cycling strategies, then the potential exists to grow the Peak Corps program or develop and grow a separate PowerStat℠ program.

The rate of attrition of programs based on the old and new technologies affects not only penetration but also costs. Peak Corps controllers are left in place when customers leave the program. However, PowerStat℠ and Power Choice equipment is removed when customers leave. Current inventory of Peak Corps equipment is sufficient for some time to come, so there are no marginal costs to leaving controllers in the field, and only the cost of installation for new customers. PowerStat℠ and Power Choice, on the other hand, require purchase of equipment for new customers, as well as removal of equipment for departing customers.

Finally, the conditions under which the new and old programs are deployed affects the decision to grow the existing program or promote the new technology as its own program. SMUD has been operating the Peak Corps as an emergency-only program since 1998. As a result, even during periods of market volatility and power shortages, the program has not been dispatched as often as it had been in previous years. From 1988 through 1997, the annual average number of cycling events was ten. Since then, Peak Corps was dispatched twice in 1998, six times in 2000, and not at all in 2001 and 2002. The PowerStat℠ program, on the other hand, is dispatched at its contractual limit of ten events per season. The Power Choice critical peak is declared whenever system load, temperature and day-ahead price all reach certain thresholds.

With the stabilization of the California energy markets and SMUD having become its own control area, the likelihood of emergency dispatch today is very small. Thus the increased program costs related to the new equipment require that the program be dispatched more often than under emergency conditions in order to be cost effective. SMUD management has decided, at least for the moment, to continue to deploy Peak Corps as an emergency program. For this reason, in SMUD's case at least, the choice for PowerStat℠ is to offer it as a separate program that is dispatched for peak load reduction in normal conditions, or not to offer it at all.

Summer 2002 PowerStat℠ Pilot Study

The summer 2002 PowerStat℠ pilot study was designed to answer many of the questions that arise regarding the market potential into existing and new markets, impacts, and implementation issues of the PowerStat℠ technology, particularly in relation to the Peak Corps program. In order to extrapolate evaluation results to both potential new programs and Peak Corps, pilot participants were randomly solicited from three groups: current Peak Corps participants, former Peak Corps participants who dropped out in 2000, and customers who have never been Peak Corps participants. Solicited customers were asked screening questions to determine if they belonged to the qualifying population of

customers living in single-family dwellings with home computers and Internet access. The market research firm, JD Franz Research, solicited approximately half of the pilot participants from a list of 3,500 customers. The other half was solicited by mail in two batches of 1,000 customers per stratum. From these efforts 178 customers agreed to participate in the PowerStat℠ pilot.

Estimates of savings from Peak Corps are based on a 1994 study using a sample of 238 Peak Corps participants with interval meters, and pooling 1991 and 1992 summer data. (SMUD 1994) A lagged regression model was developed using load and temperature data from cycled and uncycled days. Estimates from this model are accurate at ±6.6% at a 95% level of confidence. This same model was used to develop an engineering estimate of unit savings of the Peak Corps program given the new maximum cycling options. (Customers on the old 33% option were placed on the 50% option, those on the 50% option were placed on the 67% option, and those on the 67% and 100% options remained.)

To estimate load and energy impacts of PowerStat℠, nested samples were randomly selected for a variety of load measurements. Site and equipment characteristic data and spot Watt measurements were collected for all participants. Data loggers collected running-state data for 50 air conditioners, of which 14 also collected interval load data. A fixed-effects panel regression model was developed leveraging and reconciling the interval data to the run-time data on cycled and uncycled days. Estimates of impacts from the model are accurate at ±5% at a 90% level of confidence. (Violette & Ozog 2003)

To identify customer groups, estimate market potential and measure customer satisfaction, several surveys were administered to PowerStat℠ participants and non-participants containing subsets of identical questions. Customers who agreed to participate were asked demographic questions in addition to screening questions during recruitment. Customers who declined were asked only demographic questions. Information on Peak Corps participants and non-participants was obtained from a general Residential Appliance Saturation Survey (RASS) conducted in 2001, which included questions regarding dwelling and equipment characteristics, air conditioner usage patterns and demographics. PowerStat℠ participants completed a web-based survey that addressed these same issues as well as program satisfaction. Where possible among the surveys, responses of PowerStat℠ and Peak Corps participants were compared with PowerStat℠ and Peak Corps non-participants on the same questions to measure differences and similarities between the groups. All estimates from the surveys are accurate within ±10% at a 95% confidence level.

To determine how well the technology functions in the field and to identify practices that minimize problems and maximize efficiencies, detailed records were kept of all contacts with participants, from installation and training to reported problems to resolution. From these records databases were developed to enable summary reporting.

Findings from these analyses are discussed below in response to questions that arise surrounding the issues of new technology migration, in particular migration of Peak Corps technology to PowerStat℠ technology.

Market Results of Pilot

What is the likelihood of having the required characteristics for participation in the new technology program? Based on the recruitment survey and RASS, three-fourths of SMUD's 480,000 residential customers live in single-family dwellings. Of these 60% have computers, and of these 80% have Internet access, yielding a technical potential of approximately 36% of residential customers, or 170,000 customers.

What are the characteristics of customers who qualify for the new technology program compared to those who do not? Based on RASS responses and results from the recruitment survey, customers who qualify to participate in PowerStat℠ compared to those who do not qualify:

- Are more likely to have children—50% vs. 33% have children
- Have more education—50% vs. 43% have college degrees
- Have higher incomes—29% vs. 5% make over $100k
- Live in newer homes that use more electricity—28 vs. 38 years and 759 vs. 733 monthly kWh
- Are more likely to already have an automatic set-back thermostat, not necessarily electronic—73% vs. 40%
- Are equally likely to be home during peak hours (59%), but more likely to use their air conditioning when home—93% vs. 87%
- Are less likely to have recently experienced an increase in electricity usage—14% vs. 24%

What proportion of customers who qualify for the new technology program is willing to participate? Unfortunately, the design of the recruitment survey precludes being able to answer this question, because only customers who agreed to participate were asked the screening questions to determine if they qualify. Declining customers were only asked the demographic questions. However, we can say that 45% of all customers are willing to participate.

Are there differences between customers agreeing and those declining to participate in the new technology? Based on the recruitment survey, customers who agree to participate in PowerStat℠, compared to those who decline:

- Are more likely to have children—40% vs. 27%
- Are younger—16% vs.23% are 60 or over
- Are not as educated—46% vs. 66% have college degrees
- Make less money—50% vs. 32% make under $50k
- Live in older homes that use less electricity—34 vs. 29 years and 744 vs. 799 monthly kWh

Clearly, customers who are willing to participate are not the same as those who are qualified, which suggests that the subset of the willing and qualified is probably quite small. This is borne out by the fact that only 2.6% of the 9,600 customers who were solicited by phone or mail agreed to participate, and ultimately, only 1.6% of the qualified population actually participated. This rate was confirmed while recruiting to replace customers who did not rejoin at the end of their 2002 contract period, where a participation rate of 1.5% was achieved. Based on these rates, a reasonable estimate of the market potential of PowerStat℠ is between 3,000 and 5,000 customers.

Table 1. Qualification for and Willingness to Join PowerStat℠

Peak Corps Participation	% Qualify	% Willing
Non-Participants	35%	41%
Participants	71%	70%
50% Strategy	33%	50%
67% Strategy	55%	62%
100% Strategy	83%	78%

Does the likelihood to qualify differ between those participating and those not participating in the old technology? The answer to this question will determine the technical potential for PowerStat℠ within and without Peak Corps. As shown in Table 1, recruitment survey results reveal that Peak Corps participants are much more likely to qualify for the PowerStat℠ program than Peak Corps non-participants (71% vs. 35%). In addition, the higher the selected Peak Corps cycling strategy, the more likely Peak Corps participants are to qualify.

Does the willingness to participate in a program using the new technology differ between those participating and those not participating in the old technology program? In terms of market potential, Table 1 shows that Peak Corps participants are also much more willing to join PowerStat℠ than Peak

Corps non-participants (70% vs. 41%). Furthermore, willingness to join is directly related to maximum cycling strategy—the higher their selected Peak Corps strategy, the more willing they are to join.

Are there differences between customers participating in the new technology program compared with qualifying participants in the old technology program? Based on the PowerStat℠ and RASS surveys, participants in the PowerStat℠ program, compared to participants in the Peak Corps program who qualify for PowerStat℠:

- Are more likely to have children—50% vs. 40%
- Make more money—30% vs. 21% make more than $100k
- Use less electricity—a monthly average of 790 kWh vs. 1,010 kWh (compared with 814 kWh for the general population of residential customers)
- Are less likely to have an automatic set-back thermostat—60% vs. 71%
- Are more likely to have increased electricity usage recently—30% vs. 14%

Are there differences between customers migrating from the old technology program to the new technology program and customers who did not participate in the old technology program? The PowerStat℠ survey shows no demographic, dwelling or behavioral differences between participants and non-participants in Peak Corps who enrolled in PowerStat℠, even though the originating populations are very different.

What is the attrition rate of the new technology program compared with the old technology? One third of PowerStat℠ participants elected to quit the program at the end of 2001, whereas the Peak Corps has had an annual gross attrition rate of less than 1%.

Are there any differences between those who remain in the new technology program and those who quit the program? According to the PowerStat℠ survey, participants who stayed in the PowerStat℠ program compared with those who left:

- Are more satisfied with PowerStat℠—78% vs. 56%
- Are less likely to have kids—44% vs. 65%
- Are older—14% vs. 0% are 60 or over
- Are more likely to have been Peak Corps participants vs. non-participants—81% of participants stayed vs. 57% of non-participants

How satisfied are participants with the new technology program? As shown in Table 2, the majority of participants are satisfied with the PowerStat℠ program, and this is the same regardless of whether they were in the Peak Corps program when they joined PowerStat℠ or not. Dissatisfaction is greater with the thermostat than with the program. Also, more participants find the PowerStat℠ thermostat more comfortable than their old thermostat, but more participants are uncomfortable than comfortable during cycling.

Table 2. Satisfaction and Comfort of PowerStat℠ Participants

Satisfied vs. dissatisfied with PowerStat℠ program	71% vs. 10%
Satisfied vs. dissatisfied with PowerStat℠ thermostat	70% vs. 19%
Peak Corps participants vs. non-participants satisfied with PowerStat℠ program	71% vs. 71%
Recommend vs. not recommend PowerStat℠ to friends and family	59% vs. 25%
PowerStat℠ thermostat vs. old thermostat is more comfortable	33% vs. 12%
Comfortable vs. uncomfortable during cycling	30% vs. 50%

Are there differences between participants in the new technology program who are satisfied and those who are not? Satisfied PowerStat℠ participants are:

- More likely to have signed up for the 67% and 100% cycling strategies—80% and 76% satisfied among those who opted for 67% and 100% strategies respectively vs. 36% satisfied among those who opted for the 50% strategy
- Are much more likely to remain in the program—90% vs. 25% of dissatisfied participants; 50% of dissatisfied participants returned to Peak Corps, while 25% dropped out entirely
- Much more likely than dissatisfied participants to recommend PowerStat℠ to family and friends—69% vs. 0%
- Much more likely than dissatisfied participants to be satisfied with the thermostat—85% vs. 25%

How easy is the new technology to use? As shown in Table 3, although more participants thought the thermostat was easy to program than thought it difficult, 44% of participants had some difficulty with the thermostat. Of these customers, only half had their problem corrected.

Table 3. Ease of Use of PowerStat℠ Thermostat

Easy vs. difficult to program the thermostat	48% vs. 30%
Thermostat training was helpful vs. unhelpful	59% vs. 12%
Reprogrammed the thermostat at least once	50%
Had trouble with the thermostat	44%
Thermostat did not work	6%
Had trouble programming the thermostat	13%
Had trouble operating the thermostat	13%
SMUD helped with or corrected the trouble with the thermostat	51% (of 44%)

What is the relative value to participants of the features or potential features of the new technology program? Table 4 shows the percentage of participants who think the program is or would be improved with the described feature. Although increasing the incentive per event was rated highly by most people, conjoint studies have shown that reducing the cycling intensity is actually the most highly valued attribute. (Wood, Sambandan & Kolodziej 2001) The second most valued feature is a larger display on the thermostat. The least valued feature is the ability to program over the Internet. As shown above in Table 3, only 50% of participants have ever programmed the thermostat, so it is not surprising that this attribute has little value.

Table 4. Relative Value of PowerStat℠ Program Features

Program Feature	Would Improve Program
Increase the payment per cycling event	78%
Provide a larger display on the thermostat	77%
Provide the ability to immediately opt out of one cycling event per season	64%
Provide a backlight display on the thermostat	64%
Reduce the minutes per hour the air conditioner is off (reduce cycling intensity)	62%
Increase the set point of the thermostat rather than cycle the air conditioner	62%
Provide color options for the thermostat	60%
Provide a two-year warranty on the thermostat	51%
Reduce the hours per day cycling is allowed	50%
Increase the flat monthly payment	44%
Reduce the number of days cycling is allowed	42%
Provide the option of cycling both the compressor and fan or just the compressor	42%
Provide the ability to program times and temperatures over the Internet	32%

Impact Results of Pilot

What is the difference in demand and energy savings between the old and the new technologies? A comparison of savings from Peak Corps and PowerStat℠ technologies by cycling strategy and temperature is shown in Table 5. As can be seen, unit load savings from PowerStat℠ are almost double the savings from Peak Corps. There are no significant energy savings from either program.

Table 5. Unit Load Savings by Program

Temperature Bin	Peak Corps Savings			PowerStat℠ Savings		
	50%	67%	100%	50%	67%	100%
<90° F	*	*	*	0.85	1.13	1.71
90° F - <95° F	0.51	0.70	1.01	0.98	1.29	1.95
95° F - <100° F	0.59	0.77	1.18	1.06	1.40	2.12
100° F – <105° F	0.66	0.84	1.35	*	*	*
105° F & >	0.78	0.96	1.68	*	*	*

This considerable difference in load savings estimates may have several sources: it may be due to differences in technology, differences in population, and/or differences in estimating methodology. This last possibility is the least likely and outside the scope of this paper. Differences in technology have been discussed above, and may well account for some or all of the load savings difference. However, the impact of technological differences can only be determined by eliminating population differences. Differences in population can be due to differences in dwelling and equipment characteristics, differences in demographics, and/or differences in preferences.

The fixed-effects panel model that was used to estimate PowerStat℠ load savings controlled for differences in dwelling and equipment characteristics. Therefore, only differences in demographics and preferences were analyzed as possible explanations. Because the pilot sample was stratified by Peak Corps participation, it was possible to determine if PowerStat℠ load savings differs between Peak Corps participants and non-participants.

Do savings differ between participants and non-participants in the old technology program who have enrolled in the new technology program? As shown in Table 6, the difference between load savings of customers who migrated from Peak Corps and those who did not is striking. On average, Peak Corps participants in PowerStat℠ have six times the load savings that Peak Corps non-participants in PowerStat℠ have.

Table 6. Comparison of Savings Between Peak Corps Groups Within PowerStat℠

Outdoor Temperature Bin	PowerStat℠ Peak Corps Participants			PowerStat℠ Peak Corps Non-Participants			All PowerStat℠ Participants		
	50%	67%	100%	50%	67%	100%	50%	67%	100%
<90° F	1.28	1.69	2.56	0.21	0.28	0.43	0.85	1.13	1.71
90° F - <95° F	1.36	1.80	2.73	0.23	0.30	0.45	0.98	1.29	1.95
95° F & >	1.51	2.00	3.03	0.25	0.33	0.50	1.06	1.40	2.12
All Observations	1.46	1.93	2.94	0.24	0.32	0.49	1.02	1.34	2.04

This difference may be explained in part by comparing the maximum cycling strategies that Peak Corps participants select as they migrate from Peak Corps to PowerStat℠. As can be seen in Table 7, PowerStat℠ participants as a whole select both lower and higher strategies than Peak Corps participants, because Peak Corps participants in the lower strategies were automatically moved to higher strategies when the program was redesigned. Generally, however, PowerStat℠ participants select higher strategies than Peak Corps, and PowerStat℠ participants who migrate from Peak Corps select higher strategies than Peak Corps non-participants.

Table 7. Peak Corps and PowerStat℠ Maximum Cycling Strategies

Group	Maximum Cycling Strategy		
	50%	67%	100%
Peak Corps	9%	54%	37%
PowerStat℠ Total	25%	17%	58%
PowerStat℠ Peak Corps	17%	12%	71%
PowerStat℠ Non-Peak Corps	32%	22%	46%

In addition, as seen in Table 8, the majority of Peak Corps participants elect to increase cycling strategy when they move to the PowerStat℠ program, and non-Peak Corps participants who join PowerStat℠ elect higher strategies than those who join Peak Corps.

Table 8. Peak Corps vs. PowerStat℠ Cycling Strategies

Peak Corps Strategy	PowerStrat℠ Strategy		
	50%	67%	100%
Non-Participants	32%	22%	46%
50% Strategy	50%	25%	25%
67% Strategy	36%	14%	50%
100% Strategy	7%	10%	83%
Net Migration from Peak Corps	-7%	-51%	+58%
Final Distribution	25%	17%	58%

This propensity of PowerStat℠ customers to elect higher cycling strategies, particularly the 100% strategy, probably accounts for the greater share of savings difference between programs. However, there may still be other reasons for the difference, in particular the assurance that all the thermostats and air conditioners in the PowerStat℠ program are operating, unlike some controllers and air conditioners in the Peak Corps program.

What is the additional load savings attributable to new technology features? Because the Adaptive Algorithm™ technology was not deployed in the 2002 pilot, this question cannot be answered by the 2002 study. In 2003, the pilot will test the potential additional load savings of this feature. To control for its effects, other program features and the evaluation methodologies of the 2003 program will remain the same; only the deployment of the Adaptive Algorithm™ will differ.

PowerStat℠ Process Evaluation Findings

What are the utility infrastructure barriers to installation of the new technology? There were two major barriers to installation of the PowerStat℠/Power Choice gateway technology. The most problematic barrier was that the standard employed by PowerStat℠ technology proved to be

incompatible with the standard adopted by SMUD's Business Technology Department. As a result, the PowerStat℠ code was unsupportable. Considerable effort was required on the part of both SMUD and Comverge to reconfigure SMUD's Internet gateway and network for communication to work. The second problem was that some customization of SMUD's billing system was required for proper billing of Power Choice. There were no billing issues with PowerStat℠ because the rate structure is the same as for Peak Corps, and SMUD's billing system already accommodates Peak Corps billing.

What are the customer barriers to installation of the new technology compared with the old, and what proportion of the participant population has these barriers? Compared with Peak Corps, it is more difficult to get PowerStat℠ and Power Choice equipment installed on customers' premises. An appointment with the customer is necessary, because installation of the thermostat requires the installer to be inside the home and to operate the HVAC equipment. In addition, the PowerStat℠ thermostat is incompatible with zoned HVAC systems or systems that have variable speed blower fans. Also, because the PowerStat℠ thermostat is a power-stealing device, it needs some power from the HVAC circuit to operate. In some instances, it was difficult to get enough power to operate the thermostat, even with a relay/coil installed on the circuit, resulting in the unit not operating at all. Installation of the relay was also difficult and time consuming, increasing installation costs.

The Power Choice technology poses a more difficult barrier to overcome. The Power Choice monitoring equipment is a C-shaped collar that fits over the meter, which can only be fitted with the ends pointing down. If the panel box opens to the left, right or above the meter, the device will obstruct the panel door, and thus cannot be installed. It is estimated that only approximately 20% of SMUD's residential customers have compatible panel boxes.

What are the operational problems associated with the new technology compared with the old? Both the PowerStat℠/Power Choice and the Peak Corps technologies are radio-controlled, which can result in "dead zones" where signals cannot reach. Peak Corps controllers receive signals from SMUD relay stations that provide comprehensive coverage, but PowerStat℠ thermostats receive paging signals, and coverage depends on the quality of the paging service. The operation of the Peak Corps controller is, for the most part, transparent to the customer, but the PowerStat℠ and Power Choice thermostats are not. As shown in Table 3 above, almost half of PowerStat℠ participants had difficulty programming or operating the thermostat, or both.

What are the issues of troubleshooting with the new technology, and how are they different from troubleshooting the old technology? Programming and operational problems related to the PowerStat℠ thermostat were handled over the telephone by SMUD technicians. Only half of customers with problems were able to overcome those problems with SMUD's assistance. Another 23% of PowerStat℠ customers had technical problems with the thermostat, ranging from the HVAC system not working with the thermostat, to the thermostat display not working. SMUD technicians handled these problems by conducting a home visit, and virtually all of them were corrected.

Many of these problems would have been eliminated if the HVAC system had been tested for proper operation after the new thermostat was installed. There is a trade-off between testing and maintenance: extensive testing increases the costs of installation, but reduces the follow-up and maintenance costs considerably.

Implications of Research Findings for New Technology Program Development

The results from the summer 2002 PowerStat℠ pilot have strong implications for the direction of a full-scale program at SMUD, and how it integrates or coexists with the Peak Corps program. The large difference in load savings between customers migrating from Peak Corps and those not

participating in Peak Corps makes clear that Peak Corps customers are the primary target market for the PowerStat℠ program.

Furthermore, the market potential for PowerStat℠ is much greater in the Peak Corps population. They sign up at a higher rate than non-participants, in addition to signing up at higher maximum cycling strategies than they elect in Peak Corps. Participants electing the higher cycling strategies also have the greatest satisfaction with the program and are more likely to remain. For this reason, SMUD should consider offering only the 67% and 100% cycling strategies for any full-scale program. This would minimize the risk and costs associated with attrition, which primarily occurs within the 50% strategy.

The program feature that customers are most concerned about is the thermostat itself. The research suggests that the thermostat should be modified to make it easier to program, to include a larger, backlit display and to operate reliably without a relay. To minimize technical problems with the thermostat and the HVAC system, it is recommended that SMUD implement a process that assures that testing is performed at the time of installation. In addition, SMUD should implement a process that ensures that customers having problems with their thermostat, particularly programming problems, have a dedicated person within the company who is charged with solving those problems to satisfaction and closure.

A major difficulty for the viability of the PowerStat℠ program, however, is the absolute size of the potential market. Recruitment efforts have shown it to be a maximum of approximately 5,000 participants. Assuming that a majority of participants migrate from Peak Corps, the program could achieve a total of approximately 10 MW at market saturation. However, these are gross, not net savings. Subtracting the savings achieved from these customers as participants in Peak Corps, the total net savings are estimated to be approximately 4.5 MW.

In order to cover the additional program costs of PowerStat℠ over Peak Corps, a completely separate program should be developed and marketed, one that allows for more frequent and economic dispatch. The research indicates that the number of cycling days is not a major concern of most PowerStat℠ participants, and that the flat payment is less important than the payment per event (see Table 4 above). Participants expect to experience cycling events, and are satisfied as long as they feel they are adequately compensated based on the cycling strategies they have chosen. Further study should be undertaken to determine the economic value to SMUD of a separate PowerStat℠ program, including analysis of break-even at current and reduced seasonal incentives and various market prices of power.

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