AUTOMATED DEMAND RESPONSE SYSTEM PILOT

Final Report
Volume 3

Future Program Recommendations

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In this volume of the report, we explore the Super Peak and peak period load reductions at the individual household level, to test the hypothesis that a minority of high performance households contributes to the majority of load reductions. From this finding and from the load impact results presented in volume 2 of this report, we describe our recommendations for future program design. The recommendations include targeting strategies that utilities can use to recruit in to the program likely high performing customers. We identify and present physical and behavioral characteristics that can help utilities screen and target customers during the recruiting process. Additionally, we make some recommendations for how utilities can implement ADRS programs in the future to enhance program performance.

Introduction

One of the primary conclusions from the 2004 and 2005 Automated Demand Response System (ADRS) pilot program is that CPP-F customers in the Statewide Pricing Pilot (SPP) with ADRS technology in climate zone 3 successfully achieved additional load reductions during the Super Peak Period, compared to both CPP-F customers without ADRS technology and control customers on standard tiered rates. The load reductions were substantial and stable across a range of days and temperatures, with the technology appearing to be an important driver in reducing energy usage, especially during the Super Peak Period.

In particular, “high consumption” CPP-F customers with ADRS technology in the pilot consistently produced more than twice the load reduction of “low consumption” CPP-F customers with ADRS technology, compared to their respective control groups. Furthermore, high consumption ADRS customers reduced more than twice the load of residential customers in other demand response programs who do not have technology[1]. High consumption ADRS customers are defined as customers with average daily usage (ADU) during the summer season greater than or equal to 24 kWh per day. Homes with an ADU of less than 24 kWh per day on average were designated as low consumption homes.

Since the cost-effectiveness of a demand response program is a function of the magnitude of the peak demand reduction achieved per home and the number of homes participating in the program, these conclusions from the ADRS pilot suggest a strategy of targeting residential demand response enabling technology to higher-usage customers. This leads to the question of whether there are other characteristics of high consumption customers that would help utilities better identify them as high-performance customers in terms of potential to deliver relatively large peak demand reductions. For this information to be most useful in programs design, it should be obtainable during the program recruiting process. If so, it could be used to screen in customers that would benefit the most from an ADRS-like program.

This report examines in more detail the load reduction performance of specific high consumption customers in the ADRS pilot. Using these results, we attempt to identify characteristics of high performing ADRS customers for purposes of screening and targeting in future ADRS programs.

[1] Ibid.

This report also makes recommendations for the implementation and operation of future ADRS programs to maximize load reduction benefits.

ADRS high consumption ADRS homes segmentation

In the ADRS pilot, high consumption homes are defined as those customers with summer average daily usage (ADU) greater than 24 kWh. In our opinion, this is still a rather low threshold. The range of ADU for high consumption ADRS homes in the pilot was actually between 24 kWh to 150 kWh, a 750% difference. As will be evident in the analysis discussed herein, the population of high consumption homes is diverse, resulting in different potentials and ability to reduce on-peak loads using technology.

To segment the high consumption ADRS homes in more detail, RMI studied the relative performance of high consumption ADRS customers against each other. The objective of this analysis was to determine the types of homes that comprise the bulk of the Super Peak and peak period load reductions. We wanted to test the hypothesis that the largest ADRS homes contributed most to Super Peak and peak period reductions on event and non-event days, respectively.

Determining the portion of homes that contributed the most to Super Peak and peak period reductions requires a measurement of ADRS load impact at an individual household level. This is problematic, because control homes cannot be matched with ADRS homes on a one to one basis. In all of the load impact analyses we've conducted in this report, RMI compared the average load of all control homes with that of ADRS homes for each time interval, by consumption stratum. Comparing an individual ADRS home with the average load of all control homes at a given time interval is not informative either, as we would be comparing an average control load that includes both large and small homes to one ADRS home that may have large or smaller loads than the average control load.

Given the data available, we decided to determine household level performance according to each home's immediate load drop at 2 p.m. compared to the period immediately prior, at 1:45 p.m. Furthermore, the 2 p.m. load drop would be scaled to the ratio of adjusted statewide average load reduction to the average 2 p.m. load drop. We judged this to be the best compromise to determining individual household performance, given the inability to compare against a control group at the individual household level. This "pre-curtailment" approach has been studied as an approach for automated demand response baseline calculations for individual customer accounts[2].

Thus for each ADRS customer, we began with the calculation of immediate load drop relative to 1:45 p.m. to 2:00 p.m. load on event and non-event days, for each month from July 2004 through September 2005. The ADRS homes and their load impact results were then segregated by high and low consumption strata. RMI calculated the average initial load drop between 2:00 p.m. and 2:15 p.m. and between 2:15 p.m. and 2:30 p.m. for each ADRS customer during every weekday

[2] "Development of Uniform Protocols for Demand Response "Peak Savings" Calculations: A Review of Existing Methods and Recommendations for Uniform Protocols" Miriam L. Goldberg, CEC Staff Workshop, August 15, 2002

from June 2004 through September 2005. The two time intervals were chosen because the first half hour of the 2:00 p.m. to 7 p.m. period generally produces the largest load drop on event and non-event days. The larger of the two values, percent load drop during the first fifteen minutes and percent load drop during the second fifteen minutes of the peak period, was used as the representative performance value for each ADRS participant.

An average 2 p.m. load drop was then calculated for all homes combined, according to high and low consumption strata. Next, we calculated the ratio of the adjusted statewide average load reduction, which is based on the results of our 2004 and 2005 load impact evaluation, to the average 2 p.m. load drop of all ADRS homes. A separate ratio was calculated for each month from July 2004 through September 2005 for event and non-event days. This ratio was then multiplied by the immediate load drop at 2 p.m. for each individual household by consumption stratum. Once the adjusted immediate load drop at 2 p.m. for each household was calculated, RMI calculated the percentage of homes in each stratum whose load drop equaled or exceeded a given level on average.

Estimates of load impact at the individual household level[3] revealed that 14% of high consumption ADRS customers who remained on the program from July 2004 through September 2005 were "supersavers" (Table 1). These homes consistently reduced their load at 2 p.m., the start of the Super Peak and peak periods, by 30% or greater, compared to their load immediately prior at 1:45 p.m. Supersavers contributed 19% of Super Peak reduction and 20% non-Super Peak reduction across the summer months from 2004 to 2005, in terms of instantaneous load shed at 2 p.m.

Table 1: Summary of house level performance based on 2 p.m. load drop July 2004-September 2005

	High consumption stratum	Low consumption stratum
Supersavers		
No. of Homes	14	2
% of Homes	15%	13%
Improved Performers		
No. of Homes	5	0
% of Homes	5%	0%
Program Cruisers		
No. of Homes	11	5
% of Homes	12%	16%
Not categorized		
No. of Homes	62	23
% of Homes	67%	24%
Opt outs/Incomplete data		
No. of Homes	36	15
% of Homes	N/A	N/A

[3]Description of analysis methodology for household level analysis is included in Appendix A to this report, Household Level Analysis Methodology.

While Supersavers consistently reduced 2 p.m. load every event day during both years of the pilot program, another one-third (35%) of high consumption ADRS homes reduced their 2 p.m. load by 30% or greater on a majority of event days from July 2004 through September 2005. An additional 15% of high consumption ADRS homes reduced their 2 p.m. load by 20% or greater on most Super Peak days from July 2004 through September 2005. While we did not segment these two groups of customers into specific categories with names, they were also good to high performing customers.

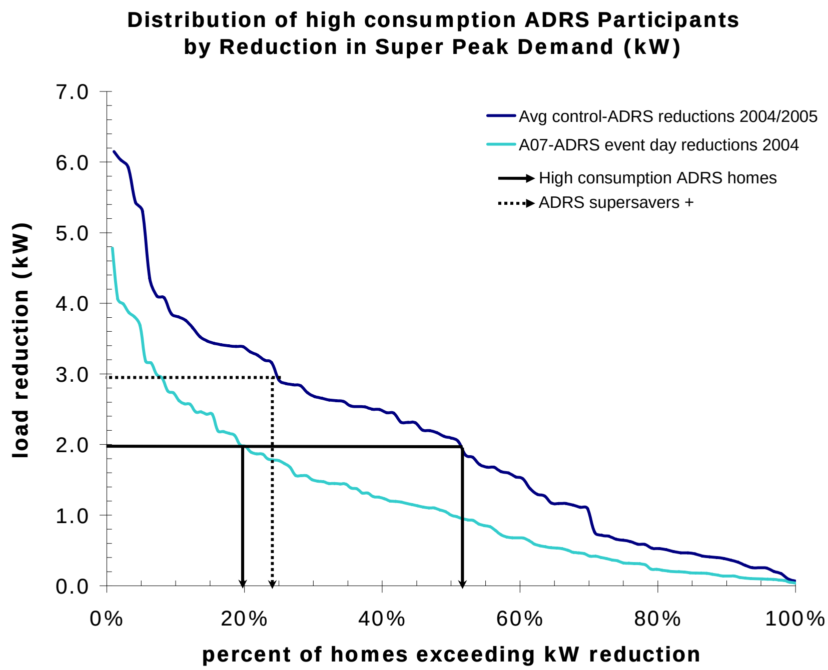
Twelve percent of all ADRS homes were “program cruisers”. These customers consistently reduced their 2 p.m. load on event and non-event days by less than 20%, and did not appear to experiment very much with the technology.

Approximately 5% of high consumption ADRS homes gradually improved their 2 p.m. percent load drop performance from July 2004 to September 2005, which we categorized as “improved performers”. These homes initially reduced Super Peak and peak period load by 20% or less during 2004 but increased their load reductions to 30% or more by the end of 2005. Finally, about 2% of homes saw their performance decline from July 2004 through September 2005 on both event and non-event days.

Load drop distribution among high consumption ADRS homes

Figure 1 plots the estimated, individual-household level Super Peak period reductions relative to control homes on standard, tiered rates without ADRS technology, averaged across July 2004 and September 2005. Also plotted are estimated individual ADRS household Super Peak reductions relative to SPP A07 customers (customers who are on the CPP-F rate but do not have ADRS technology) from July through September 2004.

Figure 1: Distribution of high consumption ADRS load reduction on event days, July 2004-September 2005



Also indicated in Figure 1 is the percentage of high consumption ADRS homes reducing 2 kW or more load compared to control and A07 customers on event days, as well as the percentage of homes represented by supersavers. Thus on event days, over half or 51% of all high consumption ADRS homes statewide reduce Super Peak period load by 2 kW or more, compared to control homes. Furthermore, these same ADRS homes made up 80% of the total load shed during Super Peak periods. However, just 19% of high consumption ADRS homes statewide reduce load by 2 kW or more compared to A07 customers. These same homes made up 46% of the total load shed during Super Peak periods.

Supersavers reduced load compared to control homes by an average of 3.0 kW during Super Peak periods. Compared to A07 customers, supersavers reduced load by 2.3 kW during Super Peak periods. As reported above, supersavers represent 15% of the high consumption ADRS population and contribute about 20% of total load reduction on event and non-event days. Note in Figure 1, however, that the percent of homes reducing Super Peak load by 3.0 kW or more is 24%, slightly greater than the population of supersaver homes. This is because there are other large, high consumption homes reducing significant load but this load is not 30% or more of their off-peak load at 1:45 p.m. This implies that the relationship between available load and load reduction is not as strong as one would hope, as further revealed by Figure 2 and Figure 3 below.

The results for non-event days are similar, with the exception that we used a lower load reduction threshold of 1.0 kW (graph not shown). Almost 40% of all high consumption ADRS homes statewide reduced peak period load by 1.0 kW or more, compared to control homes. Furthermore, these same homes made up 66% of the total load shed during peak periods.

However, just 15% of high consumption ADRS homes statewide reduce load by 1.0 kW or more compared to A07 customers. These same homes made up 43% of the total load shed during peak periods. Supersavers reduced peak period load by an average of 1.5 kW, compared to control homes. Compared to A07 customers, supersavers reduced load by 1.2 kW during Super Peak periods.

Figure 2 and Figure 3 look at this issue from a slightly different perspective, in terms of size of high consumption ADRS homes (as measured by summer average daily usage) and amount of load drop during event and non-event days, respectively. We make two observations from the figures. First, that the population of high consumption ADRS homes is quite diverse, as the range of ADU varies 750% between 24 kWh to 150 kWh. Second, it is not consistently true that the highest energy consuming homes will reduce the most loads, particularly on non-event days. The figures show that the relationship between Super Peak or peak period load drop and energy consumption is rather weak, with r-squared (r^2) values close to zero[4].

While these results support our hypothesis that even within the high consumption ADRS sample, a subset of homes contributed to the majority of Super Peak and peak period load reductions compared to control homes, they are not particularly compelling because the "subset" consists of the majority of high consumption homes. This suggests that targeting high consumption homes during program recruiting is adequate, and is an economical way of implementing the program. Monthly consumption data on customers are readily available and easily accessible, so that utilities can screen for this parameter if so desired during program recruiting.

[4] A strong relationship would have r-squared values close to 1.0.

Figure 2. Correlation study of event day, Super Peak period load drop and 2003 summer average daily usage, high consumption ADRS homes

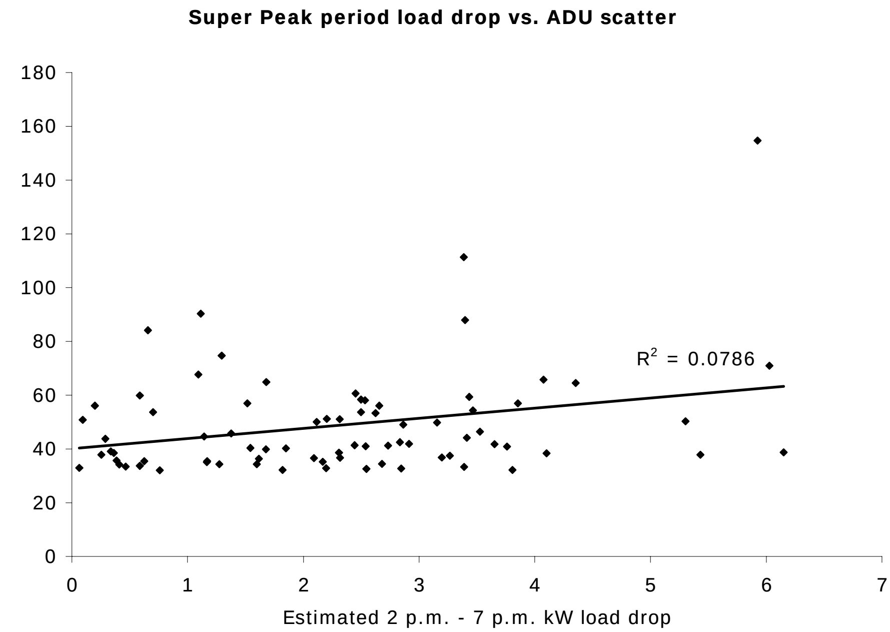
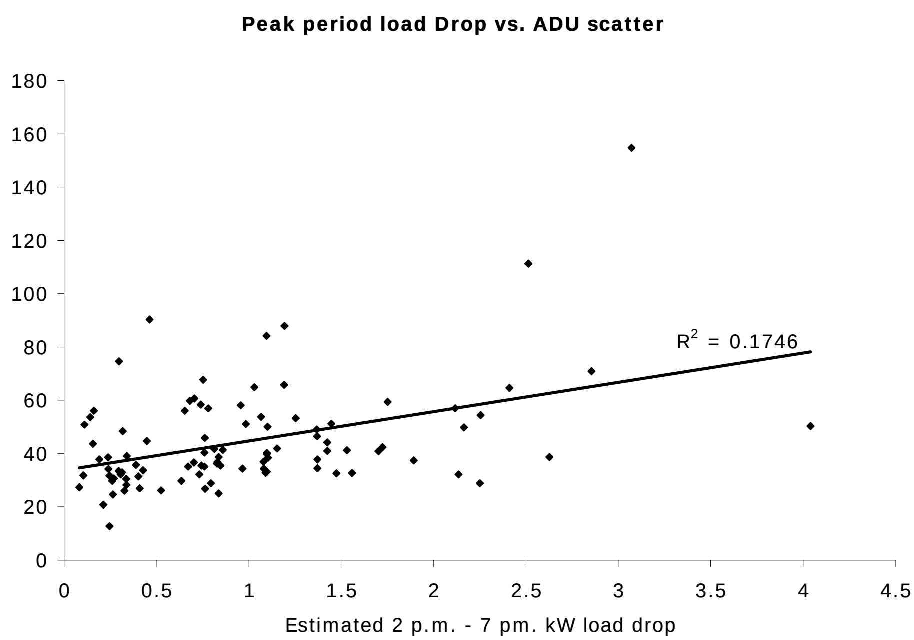


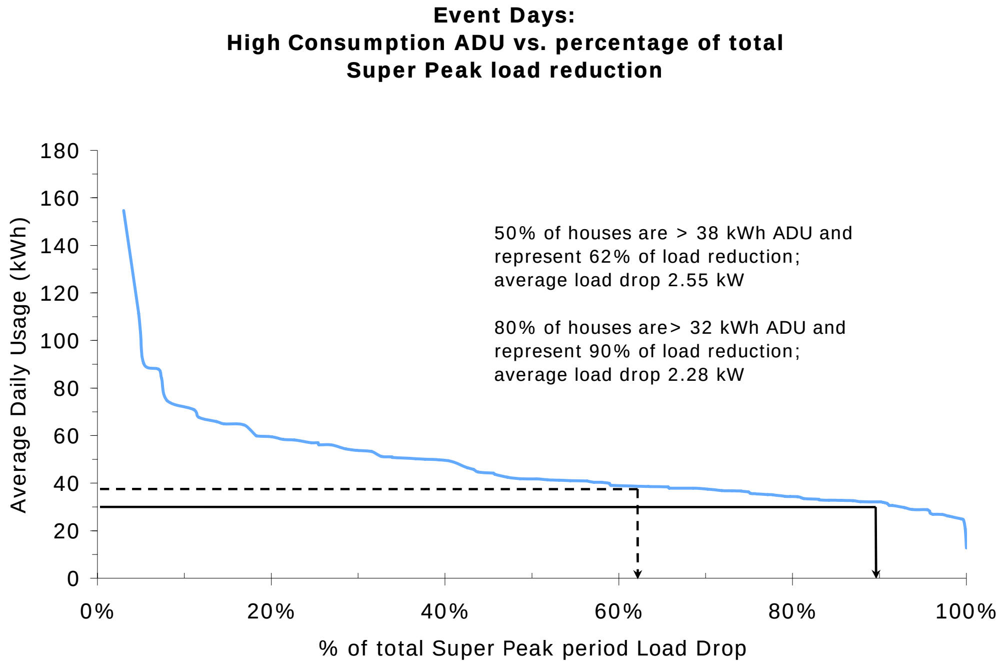
Figure 3. Correlation study of non-event day, peak period load drop and 2003 summer average daily usage, high consumption ADRS homes



<u>We recommend, however, that the threshold between low and high consumption homes is raised slightly from its current 24 kWh ADU to 32 kWh ADU.</u> As illustrated in Figure 4, 90% of total Super Peak period load drop in summers 2004 and 2005 was achieved by ADRS homes with ADU greater than 32 kWh, which made up 80% of total high consumption population. These

homes have ADU greater than 32 kWh, and achieved an average (unadjusted, household-level estimate) load drop of 2.3 kW from 2004 to 2005. An ADU study for non-event days produced identical results, with homes achieving an average (unadjusted, household-level estimate) load drop of 1.1 kW across the peak period.

Figure 4. Distribution of high consumption ADRS homes on event days by summer 2003 average daily usage, July 2004-September 2005



The fact that there are a number of particularly high consuming households (> 50 kWh ADU) in Figure 2 and Figure 3 that reduce load by 1.5 kW or less on event and non-event days suggests that there is a behavioral element to participation. Predicting behavior based on observable data, however, is harder and therefore, more difficult to use as a targeting strategy. However, if utilities can cost effectively identify and target these homes when implementing ADRS programs in the future, they can potentially capture most of the potential benefits of the program while reducing their costs of running the program. The key, then, is determining how these high performing homes can be identified.

Targeting high performance homes to maximize program benefits

Given that high performing, high consumption ADRS homes were identified in the summer 2004 and summer 2005 pilot program, we next attempted to outline some physical and behavioral characteristics for use in screening for potentially high performing customers in future ADRS programs. We also looked into elements of pilot implementation that could be improved in the future to further increase program effectiveness. The following section specifies guidelines for maximizing load reduction performance of homes using ADRS technology.

Screening for desired household physical characteristics during recruitment

High consumption homes tend to have higher demands on the hottest summer days. The ADRS pilot defined high consumption homes as customers with summer ADU greater than 24 kWh. As discussed in the above section, however, 90% of total Super Peak period load drop in summers 2004 and 2005 was achieved by 80% of high consumption ADRS homes. These homes have ADU greater than 32 kWh, and achieved an average (unadjusted, household-level estimate) load drop of 2.28 kW from 2004 to 2005. We thus recommend that utilities raise the high consumption threshold to 32 kWh in future ADRS programs. Locating customers with ADU greater than 32 kWh is relatively straightforward, as monthly consumption data on customers are readily available and easily accessible, so that utilities can screen for this parameter if so desired during program recruiting.

Evaluation results showed that load reductions were stable and consistent for high consumption ADRS homes experiencing peak temperatures greater than 90^{o}F. The exception was ADRS participants in SDG&E territory, where temperatures rarely exceed 95^{o}F during the summer. However, SDG&E homes also exhibited stable load reductions during event days greater than 85^{o}F. This leads to the hypothesis that what is considered "hot" is relative, and suggests that homeowners use ADRS technology to help them maintain comfort while minimizing energy expenditures. Furthermore, ADRS customers in this pilot were located in climate zone 3 only, in the California inland areas. RMI recommends that climate zone 4 customers located in desert climates be included in future programs in addition to climate zone 3 homes that were recruited for the pilot.

Pilot evaluation results showed that where present, pool pumps made a significant contribution to reduction of Super Peak and peak period load. The 2005 load impact evaluation revealed that residents shifting pool pump operation contribute 32% of the total Super Peak reduction for an average home with a pool. On non-event days, residents shifting pool pump operation contributed over 50% of the total peak period reduction for an average home with a pool.

Additional in-home interviews and focus groups conducted by Boice Dunham Group (BDG) as part of the ADRS pilot further uncovered that many homeowners with pools abstained from use of pool pumps completely in anticipation of Super Peak days[5]. Other homeowners reschedule pool pumps well outside the Super Peak hours, for example beginning at noon rather than at 2 p.m. These load shifting strategies were thus not clearly captured by measurement of load drop only during the peak period between 2 p.m. and 7 p.m. Nevertheless, these homeowners with pools contribute to overall peak period reductions.

As such, ADRS programs should target communities with a high incidence of pool ownership to maximize opportunities for significant load shifting during Super Peak and peak periods. Utilities implementing ADRS programs in the future should try to employ technology with additional end use control capability for other large customer loads such as pool pump operation in addition to air conditioning. The ADRS technology has the ability to schedule the use of

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[5]Boice Dunhame Group. 2006. *Customer Satisfaction Report, ADRS pilot program,* and *Customer Super Peak Behavior Report, ADRS pilot program.*

electric water heating as well, though this capability was not employed for this pilot. We surmise control of electric water heating could also increase the effectiveness of future ADRS programs in the manner that pools did in the pilot.

Another primary conclusion from the summer 2005 and 2004 ADRS pilot load impact evaluation is that load reduction performance for ADRS customers varied between utilities across the state. SCE high consumption ADRS customers achieved on average about 2 kW reductions on event days across a range of temperatures[6]. PG&E and SDG&E high consumption ADRS customers achieved substantial, but lower reductions, close to 1 kW on event days on average.

While both PG&E and SCE ADRS homes in the pilot program experienced similar temperatures on event and non-event days, the different performance between the two utilities suggests that additional factors other than temperature contribute to load reduction performance. On one hand, we cannot compare the results of one utility relative to another because each utility operated the pilot within their service territories independently of each other. As such, there were too many variables to consider in the process of explaining why one utility achieved higher reductions. On the other hand, we wish to suggest some factors based on qualitative evidence that appear to contribute to significant load reduction performance among ADRS participants. We feel that these factors warrant further study for future ADRS program design.

One of the factors that appear to provide a strong link to better program performance is targeting specific geographic regions. ADRS homes in SCE territory were selected from zip codes[7] where homes tended to be larger than ADRS homes from zip codes targeted in PG&E and SDG&E territory, on average. About 40% of SCE customers owned homes with floor areas larger than 2,000 sq.ft., compared to about 30% and 20% for ADRS customers in PG&E and SDG&E service territories, respectively (Table 2). These homes also tended to have larger air conditioning units, on average 4 tons cooling capacity per unit. Furthermore, the majority of ADRS participants in SCE territory had household incomes greater than $100,000 per year.

Table 2
Some Summary Characteristics of ADRS Homes*

	SCE	**PG&E**	**SDG&E**
Average air conditioner size (tons)**	4.25	3.25	3.3
% of homes > 1,500 sq. ft	80%	68%	64%
% of homes > 2,000 sq. ft.	42%	29%	23%
Avg. # of bedrooms	3.8	3.3	3.3
Household income > $100,000-yr	59%	10%	41%

*Source for all data with exception of average a/c size from Utility Home Energy Survey for ADRS pilot and Statewide Pricing Pilot programs.
**Source for a/c sizing data from ADRS Installer Survey conducted April-May 2004 based on respondents

[6]This result is consistent with RMI's evaluation of ADRS technology in another pilot program conducted by Nevada Power Corp during summers of 2003 and 2004.
[7] The ADRS technology utilized cable TV for broadband connectivity, and cable providers for the GoodWatts system were identified by zip code

Given the number of residential customers that PG&E and SDG&E serve and the geographical diversity of the two utility service territories, we are confident that there are subsets of customers within PG&E and SDG&E service territories located in zip codes with similar household size and income profiles that SCE recruited into the ADRS pilot. It is highly plausible then, that utilities that target larger customers in zip codes with relatively newer and higher income residential developments will have a better chance of achieving 2 kW load reduction performance. These customers will likely have larger homes (>2,000 ft^2), and thus likely to have air conditioning units along with other end uses such as swimming pool pumps.

Another factor that can contribute to maximizing overall program benefits of load reduction of homes using ADRS technology is if the homes are located in zip codes with relatively high avoided capacity and energy costs. In general, a demand response program such as ADRS will be worthwhile to implement if avoided generation capacity and energy costs, avoided distribution capacity costs, and avoided environmental costs accrued to utilities and society are greater than the costs to implement and operate the program[8].

In California, the California Public Utilities Commission (CPUC) adopted a methodology in October 2004 for calculating area-specific total avoided cost values based on the specific hour of a typical year and by planning areas and climate zones within the state[9]. Transmission and/or distribution capacity and line losses, the marginal cost of ancillary services, and the price effect of demand reduction on energy consumers are also accounted for in the total avoided costs. The utilities can consult this methodology and the corresponding cost model to identify high avoided cost areas within their service territory in order to concentrate recruiting of ADRS participants there[10]. The load impact evaluation has shown that ADRS customers can successfully relieve statewide and utility-specific system Super Peak period loads when called upon to do so. At an even smaller scale, ADRS has the potential to help utilities relieve peaks at the local distribution level and defer distribution capacity on a planning area basis.

Screening for desired household behavioral characteristics during recruitment

As suggested by BDG, high consumption customers who are customarily away from home during the day are good enrollment targets as they can more readily reduce significant load between 2 p.m. and 7 p.m. on both event and non-event days. The remote programmable feature of ADRS technology is highly appropriate in this case, as homeowners can program their desired preferences to respond automatically to price signals.

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[8]Benefits from the customer perspective includes utility bills savings resulting from lower consumption during peak hours.

[9]California Public Utilities Commission. 2004. R. 04-04-025. Order Instituting Rulemaking to Promote Consistency in Methodology and Input Assumptions in Commission Applications of Short-run and Long-run Avoided Costs, Including Pricing for Qualifying Facilities.

[10] The avoided cost valuation model designed by Energy and Environmental Economics, Inc. (E3) for the CPUC was originally for energy efficiency programs specifically. Currently, there is a module that allows users to allocate energy reductions to specific hours of the year and to locate hours when avoided costs are greatest by planning area. This gives it some flexibility for evaluating avoided cost benefits of demand response programs. There are plans for updating the avoided cost valuation model to more accurately calculate value for demand response programs such as ADRS specifically, but no new versions of the valuation model have been issued to date.

While this behavioral characteristic is relatively easy to screen for, it also makes for difficult (and potentially uneconomic) recruiting given that these homeowners are hard to reach during the day, and hard to schedule appointments with during the week to handle equipment installations or customer service calls. This is not an absolute screen, furthermore, as other pilot participants have expressed appreciation of ADRS technology's sophisticated capability to flexibly control energy consumption to help minimize energy bills even when customers are regularly at home.

During various interviews with existing ADRS participants, BDG discovered a group of customers who enjoy the "set and forget" capability that the ADRS technology allows them. These customers feel that the automation makes it easy and relatively effortless for them to participate in the program. These customers may experiment with the technology's features and settings, but will restore the technology programming during Super Peak days to maximize performance. This is a set of high consumption customers who are receptive to automation, and are not limited to technophiles who tend to be early adopters of new technology. Unlike the customers who are regularly away from home, this set of customers is harder to identify prior to their participation. However, this is a characteristic which we have identified as helpful for achieving high load reductions in future ADRS programs.

A third chief behavioral characteristic that BDG identified as useful for targeted marketing is the set of high consumption customers who are receptive to learning about ADRS technology. This tends to be the group of customers who read program materials carefully, who attend informational workshops, and who will invest the time and attention to learn about the ADRS program. Like the customers who enjoy automation, this set of customers are difficult to target, but possess a characteristic we have identified as useful for achieving high load reductions in future ADRS programs.

We do not claim that the behavioral elements just discussed are complete or exhaustive. However, we feel that they are the chief behavioral characteristics that can be relatively easily (and therefore economically) screened for during targeted marketing and that would increase the chances of recruiting high performance participants.

We also caution that these behavioral elements should be screened in conjunction with the physical characteristics described above, to avoid conflicting results. For example, there is little program benefit to identifying a customer who's not usually home during the day but has average daily usage less than 32 kWh, indicating that the household does not have much load available to curtail. In this case, a utility would be recruiting based on behavioral characteristics that we recommended while ignoring the physical characteristics of many high performing ADRS customers, thereby potentially reducing the effectiveness of the program.

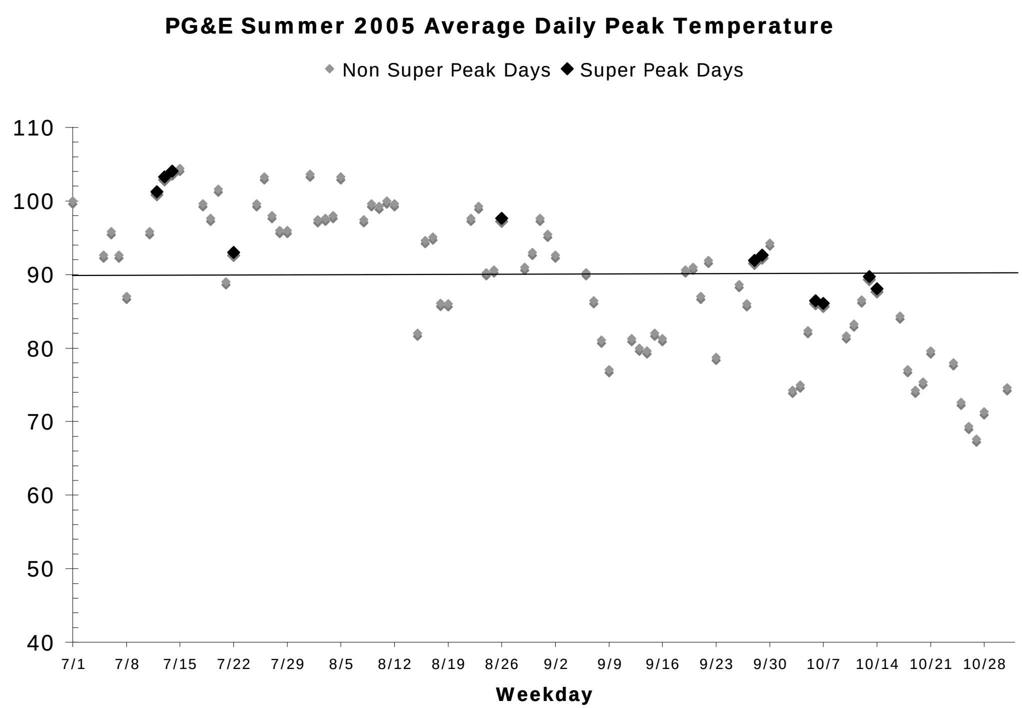
Other Recommendations for Program Implementation

The remainder of this section discusses recommendations for implementation and operating ADRS programs to maximize program benefits. First, RMI's evaluation results showed that load reductions were stable and consistent for high consumption ADRS homes experiencing peak temperatures greater than 90°F, as mentioned above. This suggests that utilities should call event days when temperatures are predicted to be highest for the summer.

As Figure 5 illustrates using PG&E service territory as an example, a Super Peak event day was not always the hottest day in the ADRS pilot. The black dots in Figure 5 are the peak temperatures recorded for ADRS homes in PG&E's territory on event days called statewide, and the gray dots are the remaining non-event days between July and October 2005. ADRS homes in PG&E's service territory experienced about 32 days in the early summer that were hotter than average peak temperatures on six Super Peak event days called statewide. Only one event day in August was called, though there were many hot days that were higher than 95°F.

Four event days were called statewide in October 2005, when average peak temperatures in PG&E territory regularly fell below 90°F. According to BDG's in-home interviews and focus group sessions, ADRS customers from all utility service territories did not understand why late September and October events during 2005 were necessary when summer was essentially over and temperatures had become mild.

Figure 5. PG&E Summer 2005 Average Daily Peak Temperature



While we agree that there will be occasions when event days need to be called for other reasons such as unexpected plant shutdowns, we recommend that utilities create a separate category for event days when outside temperatures are less than 90°F. We recommend that utilities call these exceptional event days as "emergency" days, for example, rather than "Super Peak" events that customers associate with high summer temperatures.

Given that the ADRS technology has the capability of reporting outside temperatures of ADRS participants by zip code, utilities have the ability to check this data point against weather forecasts and tailor notification of Super Peak events by zip code. For ADRS homes located in zip codes that will experience temperatures on Super Peak days lower than 90°F, utilities may recast the notification as emergency events, or refrain from triggering Super Peak for those homes altogether. In this way, customers receive more consistent messages on the calling of events and may more likely perceive that the program is simple, straightforward, and effective.

Figure 5 also supports the conclusion that peak temperatures experienced by ADRS customers within each utility territory do not always coincide with days when statewide Super Peak events are called. Calling event days statewide for a pilot program that is operated on a statewide basis makes sense in terms of system requirements and allows for easier program evaluation. However, it may not be the best approach for maximizing program performance. Because of temperature differences by utility, and because utility system electrical peaks do not always coincide, RMI recommends that event days should be called by each utility separately.

Results from the load impact evaluation revealed that homes with ADRS technology produce a consistent and predictable load profile during Super Peak and peak periods. Load reductions are at their maximum at the start of the period, then gradually increase as homes warm up and air conditioners pulse on to maintain indoor temperatures at the higher setpoint. For some homes, such as those observed in SCE territory, load reductions are sustained over the first two or three hours of the peak period but decline noticeably during the fourth and fifth hours[11].

As a second implementation recommendation, then, ADRS load reductions should be called closer to actual utility system peaks. Currently, Super Peak and peak periods are defined as 2 p.m. to 7 p.m. on weekdays excluding holidays from July through September. However, utility system loads in California tend to peak around 4 p.m. on weekdays during the summer, which also corresponds to the hottest hour of the summer day[12]. <u>Thus, utilities may want to consider starting Super Peak and peak periods shortly prior, at 3 p.m.</u>

<u>As a second alternative, we recommend that utilities end the peak period earlier than 7 p.m.</u> While shifting the start of the peak period on event and non-event days one or two hours later in the afternoon benefits utility operators, ending the peak period earlier may further increase customer satisfaction with the program. According to BDG interviews, customers felt that extending the peak period to 7 p.m. was inconvenient for them because most customers were home during that time and wanted to be comfortable while they make dinner or else relax at home.

As a third alternative, <u>we recommend putting ADRS customers on the CPP-V rate, as oppose to the CPP-F rate used for this pilot</u>. The difference between the rates is that Super Peak price

[11] This behavior is potentially problematic if the recovery period coincides with the local distribution system peak, and utilities should take note. The sharp increase in load following the end of the designated peak period would not, however, affect the utility system-wide peak given that utilities schedule ADRS homes to reduce load during these system peaks, such that the recovery period occurs after the system-wide peak occurs.

[12] Rufo, Michael and Fred Coito. 2002. *California's Secret Energy Surplus: The Potential for Energy Efficiency*. Final Report. Prepared for the Energy Foundation and the Hewlett Foundation. Figure A-8, page A-6.

signals can be sent during any hour of the peak period under the CPP-V rate, and duration of the Super Peak period varies between the hour the price signal is sent and 7 p.m. Under the CPP-F used for the ADRS pilot, the Super Peak period is fixed, always beginning at 2 p.m. and always ending at 7 p.m. We conclude that the CPP-V rate should be a better fit for homes with ADRS technology, given the transient nature of load reductions observed in this pilot[13].

Finally, we recommend that utility managers may sometimes be able to call on homes with ADRS technology to reduce load alternately at different times throughout the Super Peak period to help sustain load reductions through a five hour period, as opposed to "dispatching" all ADRS homes at the same time at 2 p.m. For example, utilities may try sending the Super Peak price signal at 2 p.m. to half of the ADRS homes and another Super Peak price signal at 4 p.m. to the remaining half. Utilities may also consider dividing the Super Peak period customer participation into thirds. Additionally, customers could alternate between being the first group to be dispatched on alternate event days, such that the same homes are not always dispatched to 7 p.m. over the course of a summer.

This last alternative is not likely to be effective as the standard method of calling Super Peak events, however. While this strategy would smooth out the average kW reduction over a longer (5 hour) peak period, it also reduces the total load available for curtailment (since utilities are only calling ½ of customers at a time, for example). The reduced load performance per household thus reduces program cost effectiveness. Furthermore, the jump in load during the recovery period for the group called first may coincide with when the utility is still trying to get other customers to curtail, and risks negating the overall savings. Utilities can mitigate this effect by further staggering the homes for the end of the peak period to control the magnitude of the recovery. Because of these issues with recovery period load, we recommend this as a strategy only some times.

In addition to the timing and length of peak and Super Peak events that are called only on the warmest days or else during emergencies, we recommend that future ADRS program limit the number of consecutive event days to those absolutely necessary, to minimize opt outs or program churn. We understand that multiple, consecutive event days were called in 2004 and 2005 to test the efficacy of ADRS technology. However, customer responses based on BDG research have indicated that calling too many consecutive event days have caused them to consider opting out of the program.

Furthermore, our observation is that either automated technology or dynamic pricing can deliver significant demand response in large residential houses, but that the combination of both technology and dynamic pricing might not be necessary for the average home. The following rationale explains this observation.

In the summer 2005 pilot, ADRS load impact was evaluated against a control group without enabling technology or dynamic rates. The results show a substantial load drop during Super Peak Periods with larger homes. However, in the summer 2004 pilot, ADRS load impact was

[13] The reason why the CPP-V rate was not used for the ADRS pilot was because only two utilities had filed the rate application with the CPUC when the pilot began in 2004. PG&E still does not have a CPP-V tariff at time of this writing.

evaluated against a group of average homes that were on the CPP-F rate but did not possess ADRS technology ("A07" homes). Particularly for low-consumption homes, the 2004 load impact report revealed that the critical peak pricing rate captured the majority of load benefits, and the additional load reduction resulting from enabling technology was small to negligible[14].

Assuming that dynamic rates are adopted in California statewide, future ADRS load reduction performance would be comparable to statewide results reported compared against A07 customers in the 2004 ADRS load evaluation study[15]. Residential customers without enabling technology would already reduce some Super Peak and peak period loads as a result of the dynamic pricing tariff, and the incremental impact (and therefore cost effectiveness) of enabling technology would be reduced.

If dynamic pricing tariffs do not become the default tariffs, then the average residential customers generally would be similar to the control group studied in the pilot. In this case, the ADRS program is more likely to be cost effective, and utilities could further optimize the program by targeting high consumption homes as described above.

Finally, <u>we recommend that residential demand response programs for high consumption households should include automated technology regardless of whether dynamic pricing is in place</u>. In this way, utilities would have the ultimate flexibility to induce reductions in air conditioning and other residential end use loads in response to system needs, or for reliability purpose. Automated technology and could also improve price responsiveness in the absence of tariffs, or for customers that opt out of default dynamic tariffs, using either messaging or pricing signals.

Summary

The results of the 2004-2005 ADRS pilot evaluation concluded that high consumption (>24 kWh ADU) customers with ADRS technology and subject to CPP-F rates in climate zone 3 successfully achieved load reductions compared to control customers without ADRS technology on standard tiered rates, and compared to customers in climate zone 3 subject to CPP-F rates only, without ADRS technology. This report examines in further detail the distribution of load reduction performance among high consumption customers, explores and recommends strategies for maximizing program cost effectiveness by targeting only those customers that can reduce the most load (≥ 2 kW) when implementing ADRS programs in the future.

Examination of ADRS customers at the household level for Super Peak and peak period load reductions confirmed that 51% of the ADRS high consumption homes produced the vast majority of savings (80%). This suggests that simply targeting high consumption homes during program recruiting is adequate to enhance customer program benefits, and is an economical way of implementing the program.

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[14]Rocky Mountain Institute. 2005. *Residential Automated Demand Response System (ADRS) Pilot Load Impact Final Report*. March 25. Downloadable from http://www.energy.ca.gov/demandresponse/documents/index.html

[15]Refer to statewide high consumption load impact results in this report, *Automated Demand Response System Pilot, Restatement of 2004 Summer Load Impact Analysis.*

However, we recommend that utilities raise the threshold between low and high consumption homes slightly from its current 24 kWh ADU to 32 kWh ADU, and to target homes with ADU 32 kWh or greater. Our analysis reveals that 90% of total Super Peak period load drop in summers 2004 and 2005 was achieved by ADRS homes with ADU greater than 32 kWh, which made up 80% of total high consumption ADRS population.

In addition to ADU > 32 kWh as a screen for potential ADRS participants, we recommend a number of additional physical and behavioral characteristics that utilities can use to target future ADRS customers to help maximize future program performance. The additional physical characteristics are:

- Customers located in geographical sub-regions within the service territory that experience hottest summer temperatures, preferably above 90°F on average during the hours of 2 p.m. to 7 p.m.
- Customers possessing end uses in addition to air conditioning, such as swimming pool pumps and hot water heaters.
- Customers in regions that have similar home construction and demographics to ADRS pilot participants in SCE service territory: larger, newer (post 1985) homes that are more likely to have central air and developments with higher income households >$100,000 per year.
- Customers located in areas with high total avoided costs[16].

The behavioral characteristics of ADRS customers we could most decisively identify as contributing to large load impact include the following:

- Customers who are away from home during the day.
- Households receptive to automation of appliance operation and control settings.
- Customers who are receptive to learning about new technology.

While these behavioral characteristics are more difficult to identify ahead of time, particularly the last two, we consider these household characteristics helpful for achieving high load reductions in future ADRS programs. These observations were developed by BDG, which is evaluating customer satisfaction levels with and willingness to pay for ADRS technology during the summer 2005 and summer 2004 pilot programs[17]. Rocky Mountain Institute has been coordinating our research efforts with BDG to develop a cohesive set of results and recommendations for future ADRS programs.

Also, we propose some guidelines for program design and implementation of future ADRS programs to maximize load reductions and therefore program effectiveness. Utilities will likely achieve maximum program performance and benefits when they:

- Call Super Peak event days when summer temperatures are highest (*minimum* of 90°F in regions for ADRS customers). Else, reserve a separate category for event days

[16] *i.e.*, avoided capacity, energy, transmission and distribution, and environmental costs

[17] Boice Dunhame Group. 2006. *Customer Satisfaction Report, ADRS pilot program,* and *Customer Super Peak Behavior Report, ADRS pilot program.*

called when temperatures are merely warm or moderate, and call event days separately by utility.

- Shift start of peak period to 3 p.m.
- Shift end of peak period to 5:30 p.m. from 7 p.m.
- Place ADRS customers on the CPP-V (day of) rate instead of CPP-F (day ahead) to maximize flexibility, since the ADRS is automated.
- In limited situations, stagger calls to subsets of participants rather than all participants at once to even out the load reduction through the Super Peak period.
- Call consecutive event days only when absolutely necessary (avoid customer fatigue).

Furthermore, our observation is that either automated technology or dynamic pricing can deliver significant demand response in large residential houses, but that the combination of both technology and dynamic pricing might not be necessary for the average home.

Finally, we recommend that residential demand response programs for high consumption households should include automated technology regardless of whether dynamic pricing is in place. In this way, utilities would have the ultimate flexibility to induce reductions in air conditioning and other residential end use loads in response to system needs, or for reliability purpose. Automated technology and could also improve price responsiveness in the absence of tariffs or for customers that opt out of default dynamic tariffs.