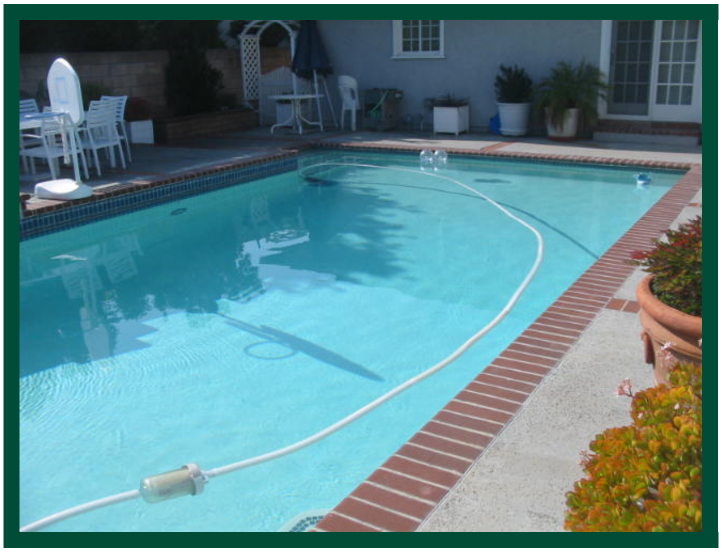
POOL PUMP DEMAND RESPONSE POTENTIAL

DEMAND AND RUN-TIME MONITORED DATA

DR 07.01 Report



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ABBREVIATIONS AND ACRONYMS

hp	Horsepower
kW	Kilowatt
MW	Megawatt
psi	Pounds per square inch
RMS	Root-mean-squared
TOU	Time of use

FIGURES

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EQUATIONS

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EXECUTIVE SUMMARY

This report presents the results of research into a potential Southern California Edison (SCE) single family residential pool circulation pump (pool pump) demand response program. These results will be used by SCE to assess the feasibility of offering a pool pump demand response program to single family residential customers with swimming pools. Only pool pumps providing pool circulation are a part of this study. All studies indicate that pool pump operation varies minimally by day of week.

A site survey collected data on the characteristics of 152 single family residential outdoor swimming pools in three regions revealing the following:

- All pools surveyed were in-ground.
- Forty-seven percent of the sites visited have a spa.
- Pool pumps ranged in size from ½ to 3 hp, with an average nameplate rating of 1.31 hp.
- Pool pump demand ranged from 0.44 to 2.28 kW, with an average demand of 1.364 kW.
- Forty percent of pools were heated with a gas-fired heater, and 2% were heated with a solar heater. The remaining 58% were not heated.

One hundred forty six pool pump motors from the site survey were monitored for at least seven days during the winter period. The site monitoring data revealed the following:

- Pool pumps in SCE's service territory are operated an average of 5.18 hours per day, including 5.14 hours in the coastal region, 5.81 hours in the desert region, and 4.59 hours in the inland valley region.
- In the desert region, average pool pump operating times are 1.7 hours or 32% longer for contractor-maintained pools than for owner-maintained pools, while in the other regions there is no statistically significant difference in operating times.
- The percentage of pool pumps on varies by time of day. Figure 1 shows 24-hour profiles of pool pump use for the three regions in SCE's service territory. Coastal and desert region profiles were similar. The inland valley profile varied from the other two regions.

Figure 2 presents the estimated cumulative maximum and likely potential impacts of a pool pump demand response program. The likely impact is calculated by taking the average hourly kW demand profile for households that expressed interest in a pool pump demand response program during a telephone interview, and factoring these values by the estimated number of pools in the SCE territory and the percentage of all telephone interview respondents who expressed interest in a demand response program.

The estimated maximum cumulative electric demand load from swimming pool pumps in SCE's service territory between the on peak hours of 12 PM and 6 PM is 248 MW, measured between 12 PM and 1 PM, based on an estimated 385,722 number of Single Family Residence (SFR) pools in the SCE service area, 46.7% pool pumps operating between 12 PM and 1 PM.

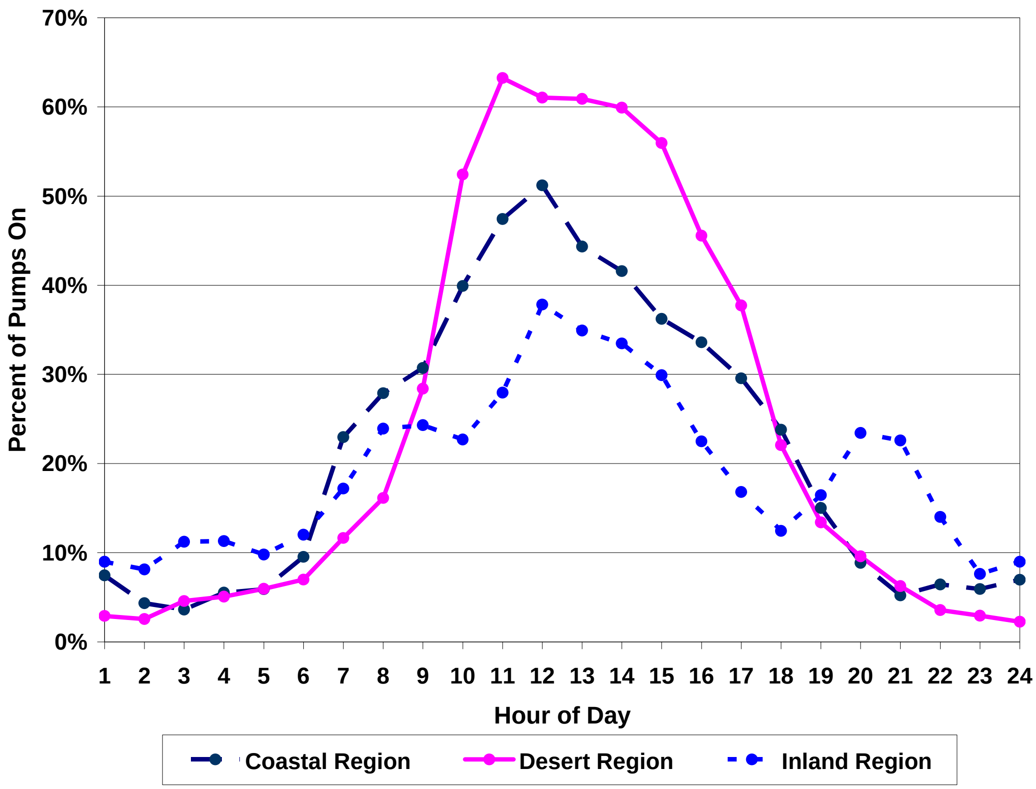

FIGURE 1. POOL PUMP PERCENTAGE ON PROFILES BY SCE REGION

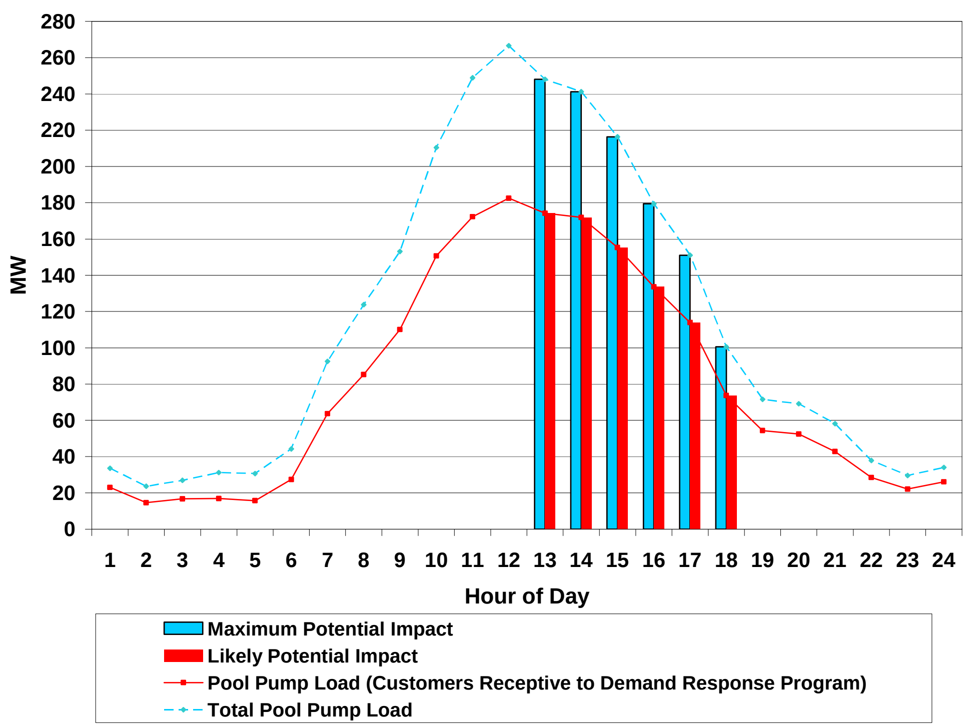

FIGURE 2. MAXIMUM AND LIKELY POTENTIAL PROGRAM MW DEMAND IMPACTS

RECOMMENDATION

Given the positive demand reduction opportunities shown by this phase of the project, it is recommended to continue to explore and test the technology aspect of pool pump controls including, communications with ZigBee and possible connectivity to the SmartConnect meters. This will require working with pool pump manufacturers to promote and develop ZigBee communications to pool pump controls.

INTRODUCTION

PURPOSE OF REPORT

This report presents the results of research into a potential Southern California Edison (SCE) single family residential pool circulation pump (pool pump) demand response program. Only pool pumps providing pool circulation are a part of this study. These results will be used by SCE to assess the feasibility of offering a residential pool pump demand response program to single family residential customers with swimming pools.

Topics covered include:

- Description of pool equipment and operating conditions (e.g., percent of heated pools, distribution of pool pumps by motor size);
- Monitored operating hours and load profiles of pool pump motors; and
- Assessment of the potential for peak demand reduction and demand reduction overall.

STUDY METHODOLOGY

This study was designed to review pool pump operations in three different geographic regions of the SCE territory. The coastal region included Long Beach, Westminister, Newport Beach, and cities and communities located between those three cities. The inland valley region included several cities and communities located in the San Gabriel Valley from Temple City eastward to Azusa and Covina. The desert region included several cities and communities located in the Coachella Valley from Palm Springs southeastward to Palm Desert.

SCE acquired a list of pool owners in each of the three regions, and matched households on the list against information in the customer database to identify a Source Population of 22,619 eligible single family residences with pools. A computer program randomly selected 500 potential interviewees from this Source Population. A Telephone Survey of the 500 potential interviewees was conducted and detailed in a separate report titled *Pool Pump Telephone Survey Research for Demand Response.*[1]

During the Telephone Survey, pool owners were asked if they would like to participate in a site survey and site monitoring of their pool pumps. Of those who elected to participate, site-specific data on pool pump run-times and power load profiles were collected for 152 outdoor residential swimming pools (Site Survey). One hundred forty six residents of the Site Survey agreed to allow site monitoring of the operation of the pool pumps (Site Monitoring); six residents declined site monitoring. One hundred forty six pool pump motors were monitored for a minimum period of seven days to detect time of operation. These 146 sites were monitored at various weeks from January to March of 2008.

Table 1 presents the distribution by geographic region and by type of data collected for Source Population, Telephone Survey, Site Survey, and Site Monitoring.

TABLE 1. SAMPLE SITES BY GEOGRAPHICAL REGION AND TYPE OF DATA COLLECTED

TYPE OF DATA COLLECTED	COASTAL	INLAND VALLEY	DESERT	TOTAL
Source Population	9,552	8,779	4,288	22,619
Telephone Survey	175	175	150	500
Site Survey	54	48	50	152
Site Monitoring	53	46	47	146

Table 2 presents the disposition of the sample for the Telephone Survey, and reports the number of survey respondents who were aware of and reported their pool pump hours of operation. Of the 500 Telephone Survey interviewees, only 362 reported pool pump operating hours.

TABLE 2. DISPOSITION OF TELEPHONE SURVEY SAMPLE

DISPOSITION OF SAMPLE	NUMBER OF HOUSEHOLDS	NUMBER OF RESPONDENTS REPORTING POOL OPERATING HOURS
Site Survey and Site Monitoring	146	114
Site Survey Only	6	4
Site Survey Scheduled but Not Completed	9	8
Could Not Be Contacted to Schedule Site Survey	184	138
Declined Site Survey	155	98
Total	500	362

The data set was analyzed using standard statistical methods, including calculation of means, standard deviations, and correlations. Where appropriate, regression analysis was used to determine relationships between different variables. Appendix A describes these methods used in the analysis of the data collected during the interviews and on-site measurements.

A separate telephone survey of businesses providing pool services to SCE residential customers (Provider Survey) was also part of this project. The Provider Survey assessed pool service provider interest and support for a potential pool pump demand response program. Eleven total telephone interviews were completed: four providers serving the coastal region, three providers serving the inland valley region, and four providers serving the desert region. More information about the Provider Survey is available in the *Residential Pool Service Provider Summary Report*[2].

SUMMARY OF MAJOR FINDINGS

Data collected in the Site Survey revealed the following:

- All pools surveyed were in-ground.
- Forty-seven percent of the sites visited also have a spa.
- Pool filtration pumps ranged in size from ½ to 3 hp, with an average rating of 1.31 hp.
- Pool pump demand ranged from 0.44 to 2.28 kW, with an average demand of 1.364 kW.
- Forty percent of pools were heated with a gas-fired heater, and 2% were heated with a solar heater. The remaining 58% of pools did not have heaters.

The data collected through the Site Monitoring revealed the following:

- Pool pumps in SCE's service territory are operated an average of 5.18 hours per day, including 5.14 hours in the coastal region, 5.81 hours in the desert region, and 4.59 hours in the inland valley region.
- Percentage of active pool pumps varies by time of day.
  - Across all regions, the highest percentage (50%) of active pool pumps occurs between 11 AM and 12 PM.
  - In the coastal region, the highest percentage (51%) of active pool pumps occurs between 11 AM and 12 PM.
  - In the desert region, the highest percentage (63%) of active pool pumps occurs between 10 AM and 11 AM.
  - In the inland valley region, the highest percentage (38%) of active pool pumps occurs between 11 AM and 12 PM.
- In the desert region, average pool pump operating times are 1.7 hours longer for contractor-maintained pools than for owner-maintained pools, while in the other regions there is no statistically significant difference in operating times.

The maximum estimated electric demand load from swimming pool pumps in SCE's service territory between the on peak hours of 12 PM and 6 PM is 248 MW, measured between 12 PM and 1 PM.

Key findings of the Telephone Survey include:

- Seventy six percent of customers surveyed are interested in an incentive-based pool pump demand response program
  - The main benefits customers mention about the program include: saving energy or energy costs, and the cash incentive.
  - The main concerns include: water quality degradation, not being in control of the pump, level of trust in SCE, and skepticism about cost savings.
- Sixty-two percent of customers surveyed have a pool maintenance service.
- Sixty percent of all customers surveyed control the pool pump timer themselves.

Key findings of the Provider Survey include:

- Fifty-five percent of surveyed pool service providers expressed no concerns about a sixteen week demand response program (Sixteen Week DR) under which single family residential pool pumps would be remotely shut off once a week for 2 to 6 hours over 16 weeks. These providers maintain 54% of the pools serviced by all respondents.

- Thirty-six percent of respondents expressed no concerns about a three day peak demand response program (Three Day Peak DR) under which single family residential pool pumps would be remotely shut off for 4 hours on three consecutive days during a heat wave. These pool service providers maintain 50% of the pools serviced by all respondents.

The hypothetical Sixteen Week DR program raised fewer concerns than the hypothetical Three Day Peak DR program. The 11 pool service providers maintain an average of 130 pools each, and when their responses are weighted by the number of pools maintained by each respondent, the discrepancy is largely mitigated. Concerns about remote pool pump shut off include algae growth and inadequate filtration for high-use pools.

DATA COLLECTION METHODOLOGY

This section describes the sample design and the procedures used to collect the data on which this report is based.

SAMPLING PLAN

The sampling design for the study used a two-stage process. In the first stage, a sample was developed for conducting the Telephone Survey to collect market characterization data. The data analyses were presented in a separate report.[1] In the second stage, a sample was developed for on-site collection of data on pool pump performance characteristics. The analysis of the on-site data is presented in this report.

In the first stage of the sample design, SCE provided a list of pool owners to develop a sample of 500 households located in three different regions of SCE's service territory to conduct the Telephone Survey. Interviews were completed with 150 households in the desert region and 175 households each in the coastal and inland valley regions. Each region was stratified into three geographical subregions based on zip code. Each region's sample points were equally distributed across subregions. Table 3 summarizes the population used as a basis for sampling or "sampling frame" and households sampled or "sample points" by region, subregion, and zip code.

The second stage of the sample design involved selecting a subset of houses for on-site pool pump inspection and collection of data on pool pump operating hours. On-site inspections were conducted for 54 households in the coastal region, 50 households in the desert region, and 48 households in the inland valley region. The sample points for each region were randomly selected from households that previously completed a telephone survey. This sample of 152 households included pool owners who maintain their own pools as well as those who use pool service or maintenance contractors. This enabled the identification of any operating characteristics that are different between self-serviced and contractor-serviced pools. Pool pump monitoring was conducted at 146 of the 152 sites that were inspected, as shown in Table 3.

Table 3. Summary of Sampling Frame and Sample Points by Zip Code

Zip Code	Subregion	Sampling Frame	Telephone Survey	Site Survey	Site Monitoring
Coastal					
90803	A	650	4	0	0
90804	A	37	2	0	0
90808	A	1,024	30	10	10
90814	A	131	5	1	1
90815	A	1,012	18	5	5
92625	B	374	6	4	4
92627	B	277	5	0	0
92646	B	1,467	26	11	10
92660	B	731	19	4	4
92663	B	159	2	1	1
92683	C	1,373	18	4	4
92840	C	833	19	3	3
92841	C	703	13	7	7
92843	C	436	4	2	2
92844	C	345	4	2	2
Subtotal		9,552	175	54	53
Desert					
92234	A	1,381	50	12	11
92264	B	1,317	50	21	21
92270	C	1,590	50	17	15
Subtotal		4,288	150	50	47
Inland Valley					
91731	A	196	4	3	3
91732	A	523	9	6	6
91775	A	814	28	5	4
91776	A	394	4	1	1
91780	A	793	14	5	5
91745	B	2,249	50	16	16
91746	B	579	8	1	1
91790	C	1,624	22	1	1
91791	C	1,607	36	10	9
Subtotal		8,779	175	48	46
Grand Total					
Total		22,619	500	152	146

SITE SURVEY DATA COLLECTION PROCEDURES

Pool owners were telephoned to arrange times for the Site Survey on-site data collection. Upon agreement of the pool owner, a mutually acceptable time for data collection was arranged, based on the convenience of the household and the travel schedule of the field staff.

Site Survey information included:

- If a pool heater is used
- Type of fuel used to heat pool (e.g., gas or solar)
- Filtration pump size (hp)
- Hours during which the pool pump operates (i.e., 24-hour profile of pump use)

Nameplate data on pool pump motor size, manufacturer, and model number was collected using a Pool Pump Data Collection Form shown in Appendix B. One-time pool pump power measurements were made, where feasible. The electric load of the pool pump motor was measured with a portable wattmeter. If the pool pump was off, it was turned on to measure the kW demand. Although the current waveforms of pump motors are very sinusoidal, true-RMS wattmeters (EMC Model 3910 TRMS Power Meter) were used to make the measurements.

Because head pressure on the pump impacts the motor power requirement, the pressure at the pool filter was recorded on the data collection form. A reading from the existing pressure gauge on the pool filter was used to document the system pressure. Operation of the gauge was confirmed by turning the pump off and verifying that the gauge needle returned to zero. Calibration of the existing pressure gauge cannot be confirmed. The gauge reading was made after the pump was running for at least two minutes and the system stabilized.

Onset Computer’s HOBO Motor ON/OFF (U9-004) loggers were used to make continuous measurements of pool pump motor operation over a period of time in order to develop hourly operating profiles. These are Time of Use (TOU) loggers that record a date and time stamp when a motor is turned on or off. The loggers work by detecting the 60 hertz electromagnetic fields generated by operating pool pump motor windings. As shown in Figure 3, TOU loggers were attached to the pool pump motor housing. The loggers were placed inside zip lock bags to protect them from water damage. No interruption of the customer’s equipment was necessary. The site address, serial number, and installation date were recorded for each logger installation.

Pool pump timers are 24-hour clocks that can cycle a pump on and off one or two times a day. Loggers were typically installed to collect seven to ten days of data for each monitored pump motor.

Upon retrieval of the loggers, monitored data was processed so as to correspond to an integral number of 24-hour, daily intervals. The logger software was used to calculate the on/off time stamp recordings as average percent on times for 15-minute and hourly intervals. The analyses presented in this report are based on the hourly averages. Hourly averages over multiple, full days of data collection were averaged into a single, 24-hour daily operating profile for each pool pump. The average percent on time for a given hour represents the previous hour’s average; for example, the percent on time for hour 13 is the average percent on time from 12:00:01 to 13:00:00.

FIGURE 3. TIME OF USE LOGGER ATTACHED TO POOL PUMP MOTOR HOUSING

CHARACTERISTICS OF SWIMMING POOLS AND PUMP SYSTEMS

This section provides information on the characteristics of the pools and pump motors for the on-site sampling program.

CHARACTERISTICS OF FILTRATION POOL PUMPS

Nameplate information on the horsepower of motors for pool filtration pumps was collected during on-site inspections of 152 households in the SCE service territory. Table 4 reports the number of pools inspected and the average nameplate horsepower of filtration pump motors in each sample region in SCE's service territory for the sample with a total and an average for the entire sample. The percentages of total pools with filtration pump motors of different horsepower are reported in Table 5.

TABLE 4. AVERAGE HORSEPOWER OF FILTRATION POOL PUMP BY SCE REGION

	COASTAL	DESERT	INLAND VALLEY	TOTAL
Number of Pools	54	50	48	152
Average hp of Pump	1.171	1.462	1.307	1.310
Standard Deviation, hp of Pump	0.495	0.493	0.456	0.494

TABLE 5. PERCENTAGE DISTRIBUTIONS OF FILTRATION PUMP MOTORS BY PUMP MOTOR HORSEPOWER BY SCE REGION

	COASTAL	DESERT	INLAND VALLEY	TOTAL
Number of Pool Sites Surveyed	54	50	48	152
Percent with 1/2 hp Motors	3.7%	0.0%	0.0%	1.3%
Percent with 3/4 hp Motors	24.1%	8.0%	10.4%	14.5%
Percent with 1 hp Motors	38.9%	34.0%	45.8%	39.4%
Percent with 1.5 hp Motors	22.2%	22.0%	22.9%	22.4%
Percent with 2 hp Motors	7.4%	34.0%	18.8%	19.7%
Percent with 2.5 hp Motors	1.9%	0.0%	2.1%	1.3%
Percent with 2.6 hp Motors	0.0%	2.0%	0.0%	0.7%
Percent with 3 hp Motors	1.9%	0.0%	0.0%	0.7%
Total	100.0%	100.0%	100.0%	100.0%

KW DEMAND PER HORSEPOWER FOR FILTRATION PUMP MOTORS

For the 152 pools inspected, the kW demand of the filtration pump motor was measured. A true RMS wattmeter (AEMC Model 3910 TRMS Power Meter) was used to make the measurements.

One-time measurements of pump motor kW demand values versus nameplate horsepower ratings are shown graphically in the scatter plot in Figure 4. Table 6 provides the average measured kW demand for motors of different horsepower ratings. The standard deviation for each average value, which is a measure of the dispersion of the kW demand values contributing to each average value, is also reported. Figure 5 shows the distribution of pool pump motor sizes by region. The correlation between pump motor horsepower and measured kW demand is 0.42, indicating a moderate linear relationship between the two variables. Equation 1, shown in Appendix A, presents the formula for deriving the correlation. The average pool pump kW demand during pump operation across all regions is 1.364 kW, which is similar to the average pool pump kW demand of 1.374 reported in the baseline and market characterization report for the 2001 Summer Initiative Pool Pump Program.[3]

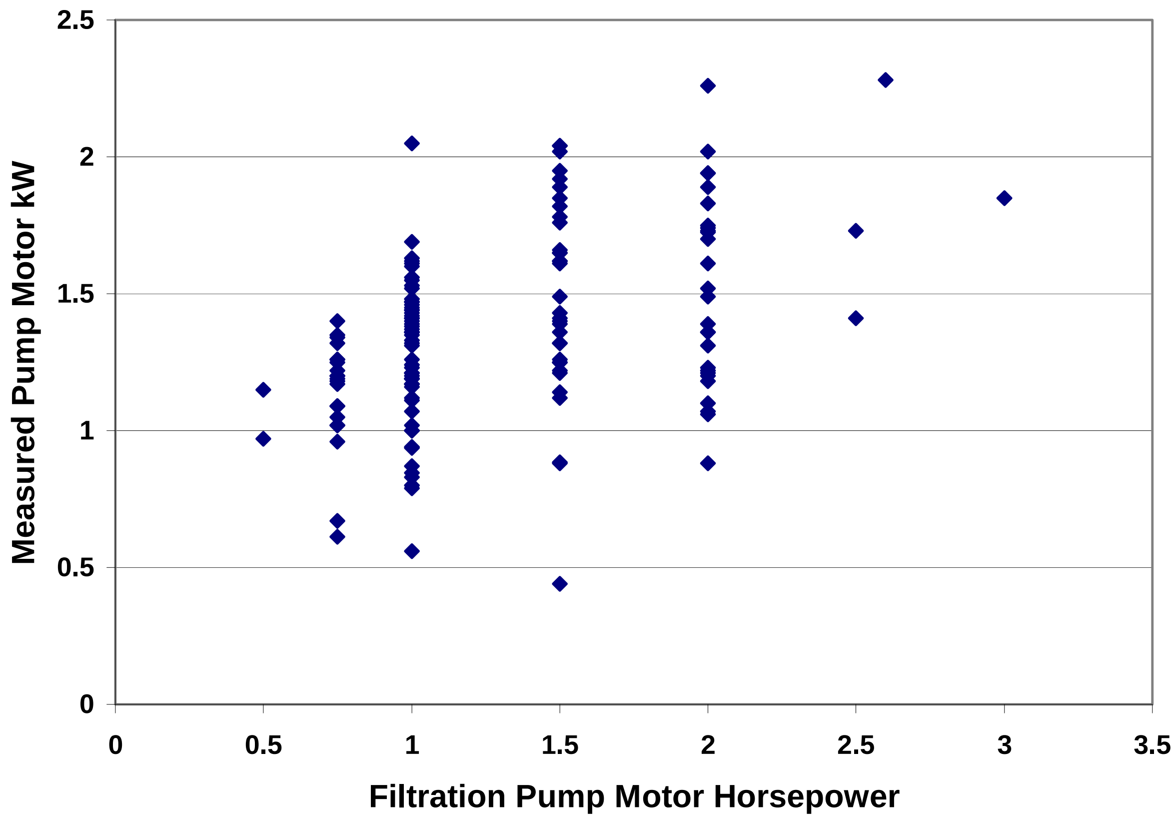

FIGURE 4. ONE-TIME MEASUREMENT OF FILTRATION PUMP MOTOR KW DEMAND VERSUS MOTOR HORSEPOWER

Table 6. kW Demand for Filtration Pool Pump Motors by Motor Horsepower by SCE Region

	Number of Pumps Measured	Measured Pump Population Percentage	Average Measured kW Demand	Standard Deviation of kW Demand
Coastal				
1/2 hp Motors	2	3.7%	1.060	0.127
3/4 hp Motors	13	24.1%	1.197	0.216
1 hp Motors	21	38.9%	1.376	0.198
1.5 hp Motors	12	22.2%	1.539	0.317
2 hp Motors	4	7.4%	1.678	0.490
2.5 hp Motors	1	1.9%	1.730	N/A
3 hp Motors	1	1.9%	1.850	N/A
Subtotal	54	100.0%	1.395	0.301
Desert				
3/4 hp Motors	4	8.0%	0.990	0.230
1 hp Motors	17	34.0%	1.281	0.282
1.5 hp Motors	11	22.0%	1.494	0.397
2 hp Motors	17	34.0%	1.466	0.317
2.6 hp Motors	1	2.0%	2.280	N/A
Subtotal	50	100.0%	1.387	0.363
Inland Valley				
3/4 hp Motors	5	10.4%	1.146	0.091
1 hp Motors	22	45.8%	1.208	0.295
1.5 hp Motors	11	22.9%	1.433	0.418
2 hp Motors	9	18.8%	1.467	0.351
2.5 hp Motors	1	2.1%	1.410	N/A
Subtotal	48	100.0%	1.306	0.338
Combined Regions				
1/2 hp Motors	2	1.3%	1.060	0.127
3/4 hp Motors	22	14.5%	1.148	0.205
1 hp Motors	60	39.5%	1.287	0.267
1.5 hp Motors	34	22.4%	1.490	0.369
2 hp Motors	30	19.7%	1.495	0.346
2.5 hp Motors	2	1.3%	1.570	0.226
2.6 hp Motors	1	0.7%	2.280	N/A
3 hp Motors	1	0.7%	1.850	N/A
Total	152	100.0%	1.364	0.334

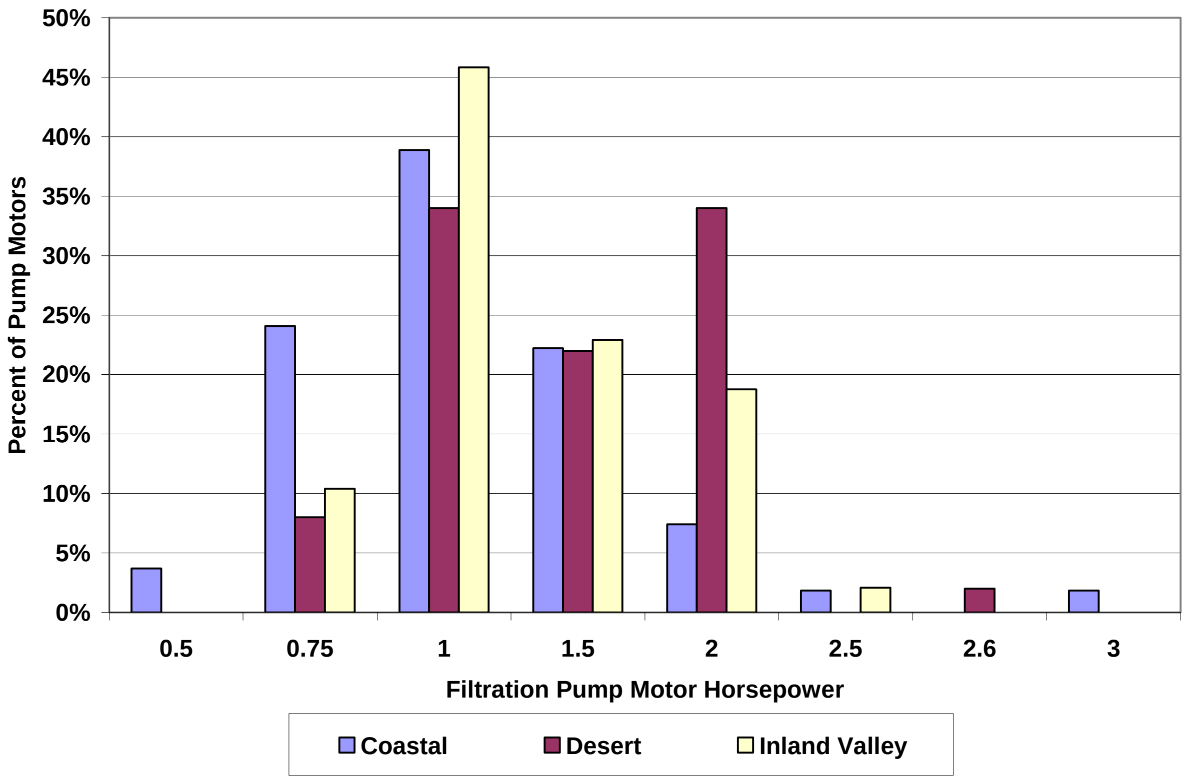

FIGURE 5. DISTRIBUTION OF POOL PUMP MOTOR SIZES BY REGION

EFFECTS OF HEAD PRESSURE ON KW DEMAND

As shown in Table 6, the kW demand varies even for motors of a given horsepower. This occurs in part because of variations in head pressure, which affect the pump and thereby impact the motor energy requirement. Pressure readings were made at the pool filter using the existing system pressure gauge. Readings were performed with the system running at a stable equilibrium. These pressure readings were analyzed to determine the impact of pressure on kW demand.

Average pressure reading values for pool pump motors of different horsepower are summarized in Table 7. The standard deviation for each average value, which is a measure of the dispersion of the pressure reading values contributing to each average value, is also reported. The relationship between pressure readings in pounds per square inch (psi) and measured kW demand is shown graphically by the scatter plot in Figure 6. There is a correlation of 0.262 between the two variables, indicating a low-to-moderate linear relationship. Equation 1, shown in Appendix A, presents the formula for deriving the correlation.

TABLE 7. PRESSURE READINGS BY MOTOR HORSEPOWER

	Number of Pump Motors Measured	Pressure Reading, psi: Average	Pressure Reading, psi: Standard Deviation
1/2 hp Motors	2	14.0	5.7
3/4 hp Motors	20	15.8	4.7
1 hp Motors	57	15.7	5.6
1.5 hp Motors	33	18.4	5.9
2 hp Motors	29	17.1	6.4
2.5 hp Motors	1	10.0	
2.6 hp Motors	1	15.0	
3 hp Motors	1	15.0	
Total	144	16.5	5.7

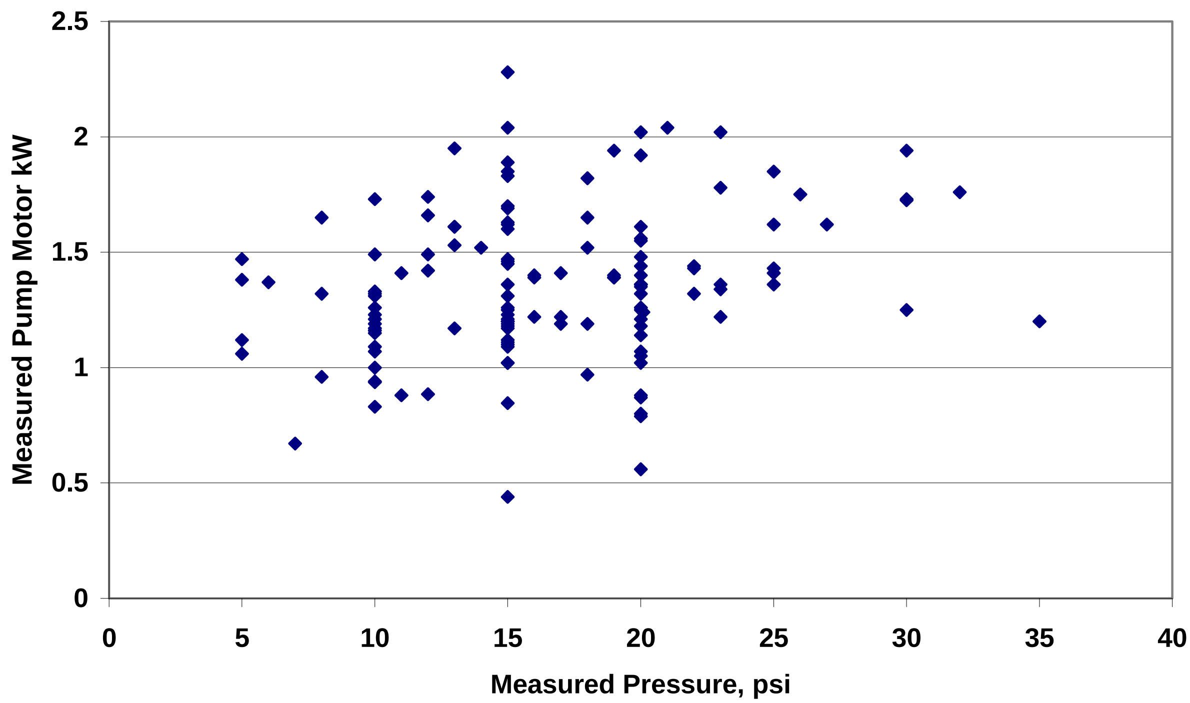

FIGURE 6. SCATTERPLOT OF MEASURED KW DEMAND VERSUS MEASURED PRESSURE

Multiple regression analysis, a statistical procedure for developing a linear equation to predict the value of a dependent variable from the values of several explanatory variables, was conducted to assess the effects of pool pump motor horsepower and pool filter pressure on motor kW demand.

The regression results are reported in Table 8. The usual test of the statistical significance of a coefficient is to calculate the ratio of a coefficient to its standard error. This ratio is expressed in terms of a "t-statistic." Because the t-statistics for motor horsepower and pool filter pressure reading are greater than 1.96, the coefficients are statistically significant at the 95% confidence level. A variable coefficient indicates the value by which pool pump kW demand is expected to vary from the intercept value of 0.796 for each 1.0 unit of the respective variable. The positive coefficient for pool filter pressure readings indicates, as expected, that higher pressure at the pool filter results in higher kW demand for a motor of a given horsepower. The "r-squared" value of 0.239 indicates that the values of the explanatory variables are moderately predictive of the value of the dependent variable in the regression equation.

TABLE 8. RESULTS OF MULTIPLE REGRESSION ANALYSIS OF EFFECTS OF PRESSURE ON KW DEMAND FOR FILTRATION PUMP MOTORS

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T- STATISTIC	PROBABILITY
Intercept	0.796	0.094	8.458	0.000
Motor Horsepower	0.281	0.050	5.597	0.000
Pool Filter Pressure Reading	0.012	0.004	2.795	0.006

R-squared = 0.239

OTHER POOL CHARACTERISTICS

As shown in Table 9, less than half of the pools monitored had heaters. Of those pools with heaters, gas-fired pool heaters were common. Solar heated pools were rare.

TABLE 9. PERCENTAGES OF POOLS WITH HEATERS BY SCE REGION

	COASTAL	DESERT	INLAND VALLEY	TOTAL
Percent of Pools with Gas-Fired Heater	39.6%	56.0%	30.6%	42.1%
Percent of Pools with Solar Heater	3.8%	0.0%	2.0%	2.0%
Percent of Pools with No Heater	56.6%	44.0%	67.3%	55.9%

Pool water condition was also assessed during pool inspection. Table 10 presents a summary of these findings. Figure 7 shows an example of a very clean pool and Figure 8 shows an example of a very dirty pool.

TABLE 10. WATER CONDITION BY VISUAL INSPECTION BY PERCENTAGE

POOL WATER CONDITION	COASTAL	DESERT	INLAND VALLEY	TOTAL
Very Clean	20.4%	16.0%	8.5%	15.2%
Clean	38.9%	50.0%	59.6%	49.0%
OK	24.1%	22.0%	23.4%	23.2%
Dirty	11.3%	16.7%	10.0%	11.3%
Very Dirty	1.3%	0.0%	2.0%	1.3%

FIGURE 7. EXAMPLE OF VERY CLEAN POOL

FIGURE 8. EXAMPLE OF VERY DIRTY POOL

Other key findings include the following:

- All pools surveyed were in-ground and none were indoor pools.
- Forty-seven percent of the sites inspected have a spa.
- All inspected sites but one had a single speed pump motor; one site had a 3.0 horsepower variable speed pump motor.

ANALYSIS OF HOURS OF POOL PUMP OPERATION

Data about the hours of pool pump operation was gathered through telephone and in-person interviews and through on-site inspection and monitoring time of pool pump operation. The information collected was analyzed to determine (1) average hours of operation for pool pumps and (2) profiles showing the percentage of pool pumps on and the kW demand during different hours of the day. Monitoring of pool pump operation occurred during the months of January, February, and March. The results of these analyses are presented in this section.

HOURS OF POOL PUMP OPERATION FROM ON-SITE MONITORING DATA

According to both the Telephone Survey responses and the Site Monitoring data, pool pump operation varies minimally by day of the week. Therefore, all analyses presented in this section are based on average daily pool pump operation.

Table 11 shows the average monitored hours of operation for 146 pool pumps in different regions in SCE service territory. The standard deviation for each average value, which is a measure of the dispersion of the pool pump operating hours contributing to each average value, is also reported.

TABLE 11. HOURS OF POOL PUMP OPERATION BY SCE REGION

	COASTAL	DESERT	INLAND VALLEY	TOTAL
Number of Pools	53	47	46	146
Average Hours On	5.140	5.810	4.585	5.181
Standard Deviation, Hours On	3.666	2.378	2.612	2.995

For 114 sites, two estimates of operating hours are available: the self-reported hours from the Telephone Survey and the observed hours from pool pump Site Monitoring. Paired t-tests, which are performed to compare the values of means from two related samples, were performed for the 114 sites. The results of these t-tests, reported in Table 12, show that differences between the mean hours of operation for interviewee responses versus inspection results are not statistically significant at the 90 percent confidence level. The absolute values of the t-statistics, reported in Table 12, convey the degree of statistical significance of the differences in average operating hour estimates developed from interviewee responses and those developed from pool pump monitoring.

TABLE 12. RESULTS OF T-TESTS FOR DIFFERENCES IN AVERAGE OPERATING HOUR ESTIMATES DEVELOPED FROM INTERVIEWEE RESPONSES AND MONITORING

		Pool Pump Hours of Operation					
		Telephone Survey		Site Monitoring			
Region	N	Mean	Standard Deviation	Mean	Standard Deviation	T-Statistic	Probability
Coastal	44	4.840	3.682	5.250	3.883	-0.51	0.61
Desert	35	5.478	1.863	5.429	2.768	0.09	0.93
Inland Valley	35	4.789	2.709	4.200	2.784	0.90	0.37
Total	114	5.020	2.916	4.982	3.264	0.09	0.37

HOURS OF POOL PUMP OPERATION BY MAINTENANCE ARRANGEMENT

Swimming pool owners can either maintain pools themselves or contract with a pool service provider to maintain pools. Interviewees were asked which arrangement they used. Statistical t-tests were performed to determine whether average hours of operation differed because of differences in pool maintenance arrangements. The results of these tests, which are reported in Table 13, show that differences in average operating hours for owner-maintained and contractor-maintained pools in the coastal and inland valley regions are not statistically significant at the 90% confidence level. However, in the desert region, the difference is statistically significant. In the desert region, average pool pump operating times are 1.7 hours longer for contractor-maintained pools than for owner-maintained pools.

TABLE 13. RESULTS OF T-TESTS FOR DIFFERENCES IN MONITORED AVERAGE OPERATING HOURS RELATING FROM DIFFERENT POOL MAINTENANCE ARRANGEMENTS

	Hours Operated							
	Owner Maintained Pools			Contractor Maintained Pools				
Region	N	Mean	Standard Deviation	N	Mean	Standard Deviation	T-Statistic	Probability
Coastal	23	5.000	2.645	30	5.248	4.332	-0.24	0.81
Desert	34	5.339	2.009	13	7.044	2.880	-2.30	0.03
Inland Valley	20	3.982	1.545	25	4.938	3.167	-1.39	0.17
Total	77	4.885	2.165	68	5.477	3.716	-1.19	0.24

HOURS OF POOL PUMP OPERATION BY DISPOSITION OF SAMPLE

Pool pump operating hours reported by Telephone Survey respondents are compared for respondents who agreed to a site survey, respondents who declined a site survey, and respondents who could not be contacted to schedule a site survey. Excluding respondents who did not report their pool pump start and stop times, average reported operating hours were compared for 114 sites also site monitored, 138 sites for which the customer expressed willingness to allow a site survey during the telephone interview but could not be contacted, and 98 sites for which the customer declined scheduling a site survey.

Table 14 reports the results of a statistical t-test to assess differences in respondent estimates of pool pump operating hours for the 114 sites also site monitored and the 98 sites for which the customer declined scheduling of a site survey. The results show that the difference between the average customer-reported hours of operation for these two groups is statistically significant at the 90% confidence level. On average, respondents who declined a site survey reported operating their pool pumps for 0.75 hours per day longer than reported by those respondents who later participated in Site Monitoring.

TABLE 14. RESULTS OF T-TESTS FOR DIFFERENCES IN AVERAGE REPORTED OPERATING HOURS RELATING TO CUSTOMER APPROVAL OF ON-SITE INSPECTION

DATA ON HOURS OPERATED							
REPORTED BY RESPONDENTS ALSO SITE MONITORED			REPORTED BY RESPONDENTS WHO DECLINED SITE SURVEY				
N	MEAN	STANDARD DEVIATION	N	MEAN	STANDARD DEVIATION	T-STATISTIC	PROBABILITY
114	4.982	3.264	98	5.735	4.075	-1.49	0.07

Table 15 reports the results of a statistical t-test to assess differences in respondent estimates of pool pump operating hours for the 114 sites also site monitored and the 138 sites for which the customer expressed willingness to allow a site survey during the telephone interview but could not be contacted. The results show that the difference between the average customer-reported hours of operation for these two groups is not statistically significant.

TABLE 15. RESULTS OF T-TESTS FOR DIFFERENCES IN AVERAGE REPORTED OPERATING HOURS RELATING TO SUCCESS IN CONTACTING CUSTOMER TO SCHEDULE ON-SITE INSPECTION

DATA ON HOURS OPERATED							
REPORTED BY RESPONDENTS ALSO SITE MONITORED			REPORTED BY RESPONDENTS WHO COULD NOT BE CONTACTED TO SCHEDULE SITE SURVEY				
N	MEAN	STANDARD DEVIATION	N	MEAN	STANDARD DEVIATION	T-STATISTIC	PROBABILITY
114	4.982	3.264	138	4.899	2.958	0.21	0.42

HOURLY PROFILES FOR PERCENTAGE OF POOL PUMPS ON

Pool pump operating profiles were developed from monitored pool pump starting and stopping times. As shown in Table 16, the profiles show the percentage of pool pumps operating during each hour of the day. The data is also shown graphically in Figure 9 and Figure 10. Figure 9 shows a representative 24-hour profile for all regions, while Figure 10 shows representative 24-hour profiles for each of the three regions (coastal, desert, and inland valley) within SCE territory.

The 24-hour profile for the coastal region, desert region, and combined regions can generally be described as a bell curve with peak usage at 11 am or 12pm. The inland valley 24-hour profile is significantly different from the other curves. This curve indicates that a significant number of SCE customers in the inland valley are still operating their pool pumps between 8 pm and 10 pm.

TABLE 16. PERCENTAGES OF POOL PUMPS ON DURING GIVEN HOUR OF DAY BY SCE REGION

HOUR OF DAY	COASTAL	DESERT	INLAND VALLEY	TOTAL
0-1	7.4%	2.9%	9.0%	6.5%
1-2	4.3%	2.6%	8.1%	5.0%
2-3	3.6%	4.6%	11.2%	6.3%
3-4	5.5%	5.1%	11.3%	7.2%
4-5	5.9%	6.0%	9.8%	7.1%
5-6	9.5%	7.0%	12.0%	9.5%
6-7	23.0%	11.6%	17.2%	17.5%
7-8	27.9%	16.1%	23.9%	22.9%
8-9	30.7%	28.4%	24.3%	28.0%
9-10	39.9%	52.4%	22.7%	38.5%
10-11	47.4%	63.2%	28.0%	46.4%
11-12	51.2%	61.0%	37.8%	50.2%
12-13	44.3%	60.9%	34.9%	46.7%
13-14	41.6%	59.9%	33.5%	44.9%
14-15	36.2%	55.9%	29.9%	40.6%
15-16	33.6%	45.5%	22.5%	33.9%
16-17	29.6%	37.7%	16.8%	28.2%
17-18	23.8%	22.1%	12.5%	19.7%
18-19	15.0%	13.4%	16.5%	15.0%
19-20	8.9%	9.6%	23.4%	13.7%
20-21	5.2%	6.3%	22.6%	11.0%
21-22	6.4%	3.6%	14.0%	7.9%
22-23	5.9%	2.9%	7.6%	5.5%
23-24	7.0%	2.3%	9.0%	6.1%

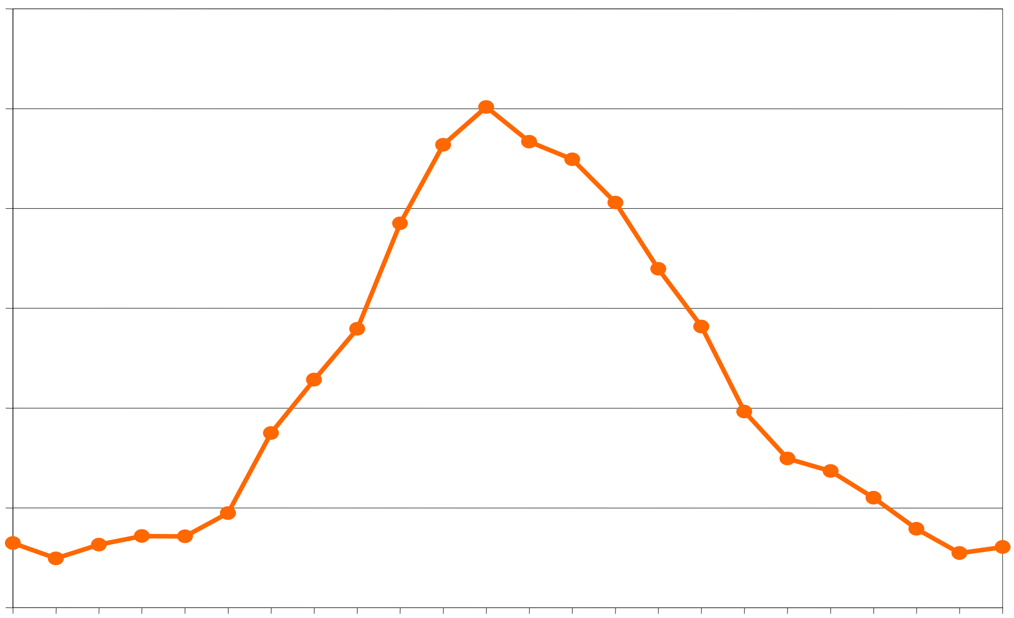

FIGURE 9. PERCENT OF POOL PUMPS ON

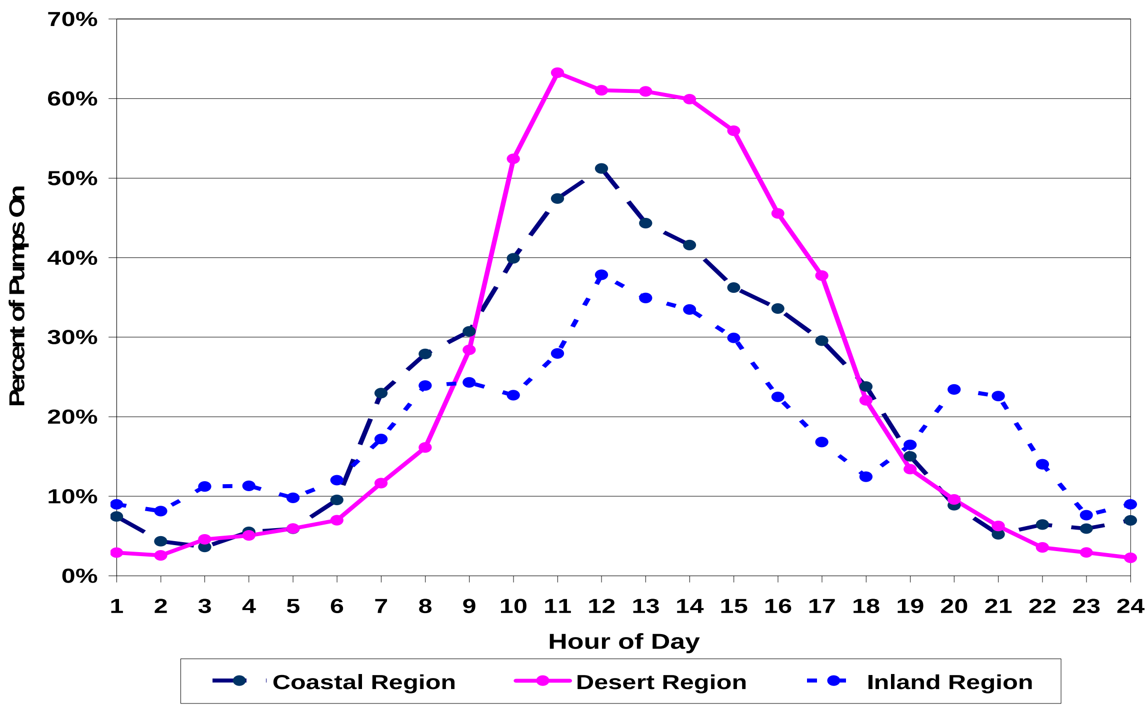

FIGURE 10. POOL PUMP OPERATING PROFILES BY SCE REGION

Pool pump operating profiles developed from Site Monitoring data are compared with those developed from the Telephone Survey in Table 17 and Figure 11. The data shown is based on a subset of 114 sample sites for which pool owners both reported pool pump start and stop times in the Telephone Survey and permitted site monitoring.

TABLE 17. MONITORED VS. REPORTED PERCENT OF POOL PUMPS ON

HOUR OF DAY	MONITORED	REPORTED	HOUR OF DAY	MONITORED	REPORTED
0-1	7.2%	8.8%	12-13	46.9%	43.0%
1-2	6.1%	8.8%	13-14	43.5%	36.8%
2-3	7.0%	8.8%	14-15	38.2%	30.7%
3-4	7.9%	6.1%	15-16	31.0%	25.4%
4-5	7.2%	7.0%	16-17	24.7%	19.3%
5-6	9.4%	7.0%	17-18	13.8%	18.4%
6-7	18.1%	15.8%	18-19	10.6%	11.4%
7-8	23.5%	26.3%	19-20	12.9%	14.0%
8-9	28.2%	27.2%	20-21	12.0%	12.3%
9-10	37.3%	38.6%	21-22	8.6%	11.4%
10-11	45.1%	50.0%	22-23	5.9%	7.0%
11-12	49.9%	54.4%	23-24	6.7%	9.6%

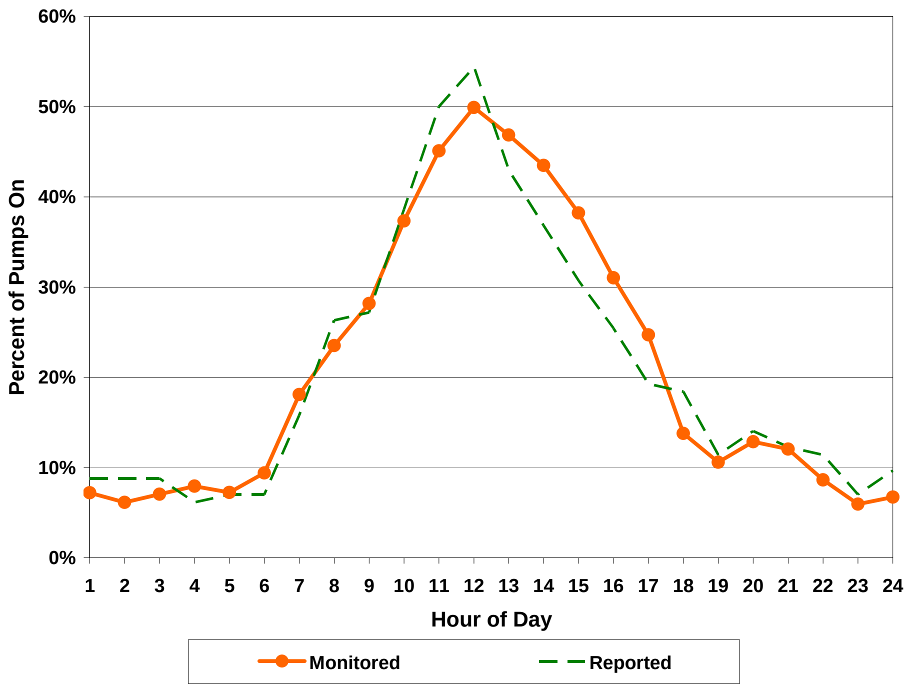

FIGURE 11. COMPARISON OF MONITORED AND CUSTOMER-REPORTED PERCENT OF POOL PUMPS ON

Using the previous sample data subset, Figure 12 shows the percentage difference between the number of operating pool pumps from Site Monitoring and the number of operating pool pumps reported by Telephone Survey. During the average hour of a day, monitoring indicated 1% more pool pumps were operating than were reported. However, during peak demand hours of 12 PM to 6 PM, monitoring indicated 14% more pool pumps were operating than were reported. This percentage increases to 22% between the hours of 1 PM and 5 PM.

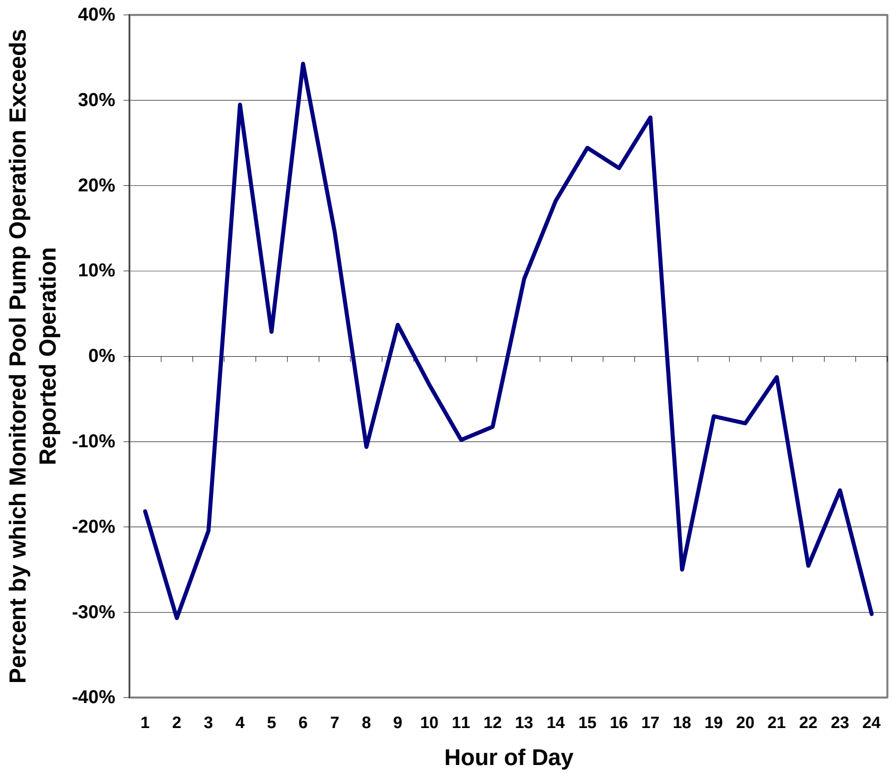

FIGURE 12. PERCENT DIFFERENCE BETWEEN MONITORING VS. CUSTOMER-REPORTED NUMBER OF POOL PUMPS ON

A comparison of average Telephone Survey reported pool pump operating times is presented in Table 18 and plotted in Figure 13 for:

- 114 sites that participated in the Telephone Survey and that were site monitored,
- 138 sites for which the customer expressed willingness to allow a site survey but could not be contacted, and
- 98 sites for which the customer declined to schedule a site survey.

On average, respondents who declined the site survey stated that they operated their pool pumps more frequently than residents who could not be contacted to arrange a site survey or who agreed to a site survey.

TABLE 18. CUSTOMER-REPORTED PERCENTAGE OF POOL PUMPS ON BY DISPOSITION OF CUSTOMER CONTACT FOR SCHEDULING A SITE SURVEY

HOUR OF DAY	SITE MONITORED	HOUSEHOLD COULD NOT BE CONTACTED	SITE SURVEY DECLINED
0-1	8.8%	5.8%	11.2%
1-2	8.8%	6.5%	10.2%
2-3	8.8%	6.5%	10.2%
3-4	6.1%	8.0%	9.2%
4-5	7.0%	7.2%	8.2%
5-6	7.0%	5.8%	11.2%
6-7	15.8%	13.0%	18.4%
7-8	26.3%	21.7%	25.5%
8-9	27.2%	33.3%	40.8%
9-10	38.6%	42.8%	49.0%
10-11	50.0%	55.1%	62.2%
11-12	54.4%	52.2%	57.1%
12-13	43.0%	51.4%	48.0%
13-14	36.8%	44.2%	42.9%
14-15	30.7%	31.2%	35.7%
15-16	25.4%	24.6%	26.5%
16-17	19.3%	17.4%	21.4%
17-18	18.4%	13.8%	16.3%
18-19	11.4%	13.8%	15.3%
19-20	14.0%	11.6%	12.2%
20-21	12.3%	8.7%	11.2%
21-22	11.4%	8.0%	10.2%
22-23	7.0%	3.6%	10.2%
23-24	9.6%	3.6%	10.2%

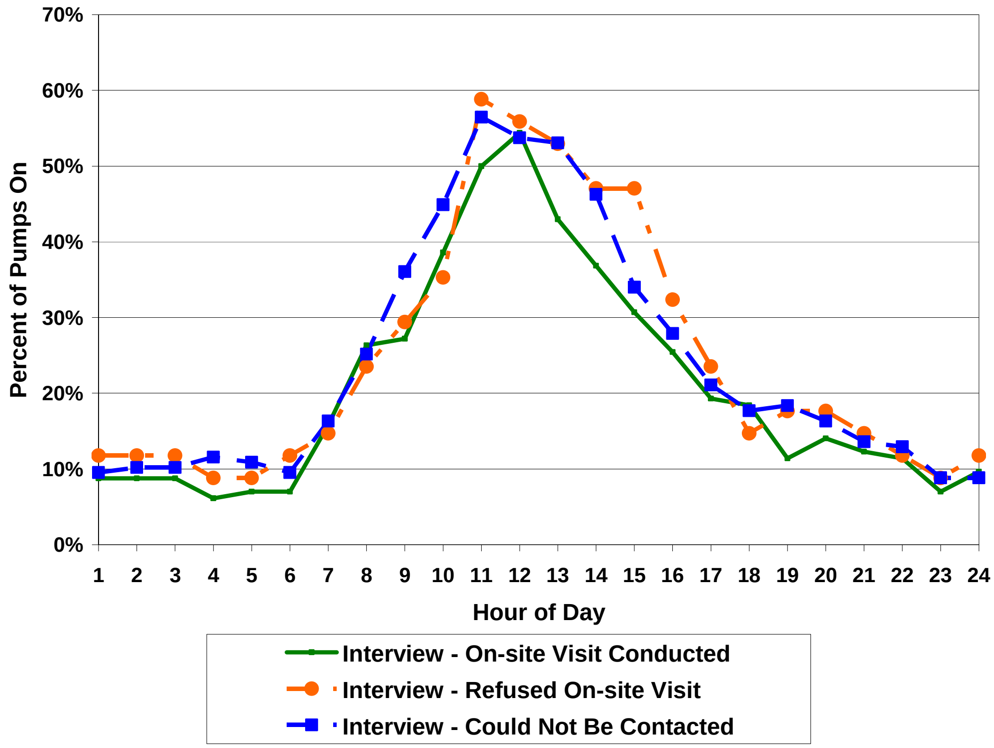

FIGURE 13. COMPARISON OF CUSTOMER-REPORTED PERCENT OF POOL PUMPS OPERATING BY DISPOSITION OF CONTACT FOR SCHEDULING A SITE SURVEY

HOURLY PROFILES FOR AVERAGE POOL PUMP KW DEMAND

One-time kW demand power measurements allowed development of hourly profiles of average pool pump motor kW demand. Average measured kW demand values for pool pump motors during each hour of the day are reported in Table 19. For instance, the value 0.08 for hour 5 indicates that the average pool pump kW demand for all regions in SCE territory is 0.08 kW from 4:00:00 AM to 4:59:59 AM. The aggregate data is then plotted in Figure 14 and are shown for each region in Figure 15.

TABLE 19. AVERAGE HOURLY KW DEMAND PROFILES BY SCE REGION

HOUR OF DAY	COASTAL	DESERT	INLAND VALLEY	TOTAL
0-1	0.107	0.034	0.117	0.087
1-2	0.062	0.030	0.093	0.061
2-3	0.053	0.047	0.113	0.070
3-4	0.081	0.051	0.111	0.081
4-5	0.087	0.059	0.092	0.080
5-6	0.142	0.079	0.119	0.115
6-7	0.333	0.155	0.218	0.240
7-8	0.410	0.230	0.311	0.321
8-9	0.451	0.419	0.311	0.397
9-10	0.578	0.751	0.298	0.545
10-11	0.682	0.880	0.363	0.645
11-12	0.731	0.847	0.486	0.691
12-13	0.618	0.846	0.465	0.643
13-14	0.582	0.833	0.462	0.625
14-15	0.502	0.772	0.413	0.561
15-16	0.467	0.626	0.299	0.465
16-17	0.417	0.526	0.225	0.392
17-18	0.337	0.271	0.162	0.261
18-19	0.216	0.147	0.190	0.186
19-20	0.131	0.120	0.295	0.179
20-21	0.079	0.094	0.292	0.151
21-22	0.095	0.043	0.159	0.098
22-23	0.088	0.037	0.104	0.077
23-24	0.101	0.027	0.135	0.088

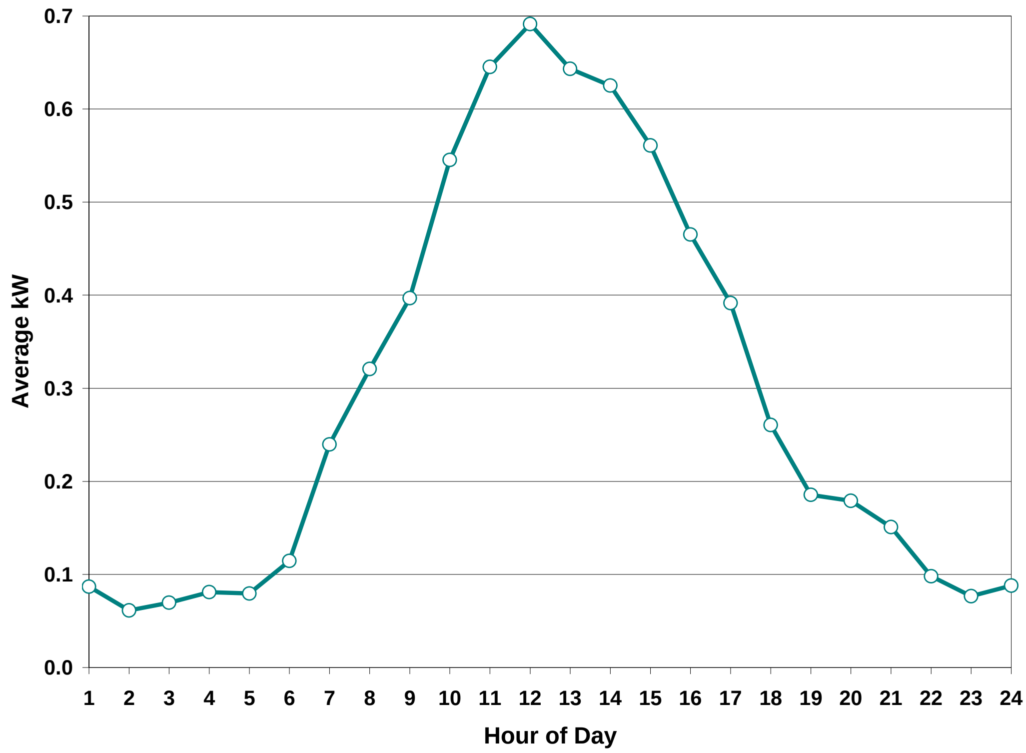

FIGURE 14. AVERAGE POOL PUMP KW DEMAND

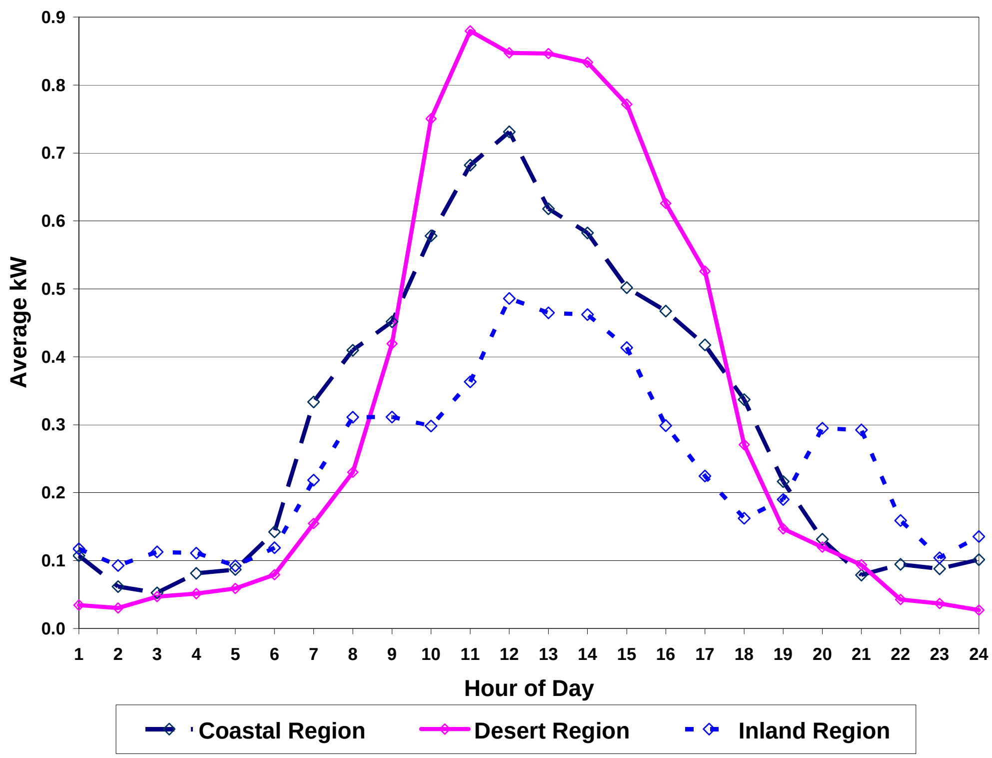

FIGURE 15. AVERAGE POOL PUMP KW DEMAND BY SCE REGION

There is a strong relationship between the percentage of pool pumps operating during a given hour and the corresponding average kW demand.

Figure 16 shows the relationship between average kW demand and operating profiles. The correlation between average kW demand and percentage of pumps operating is 0.999.

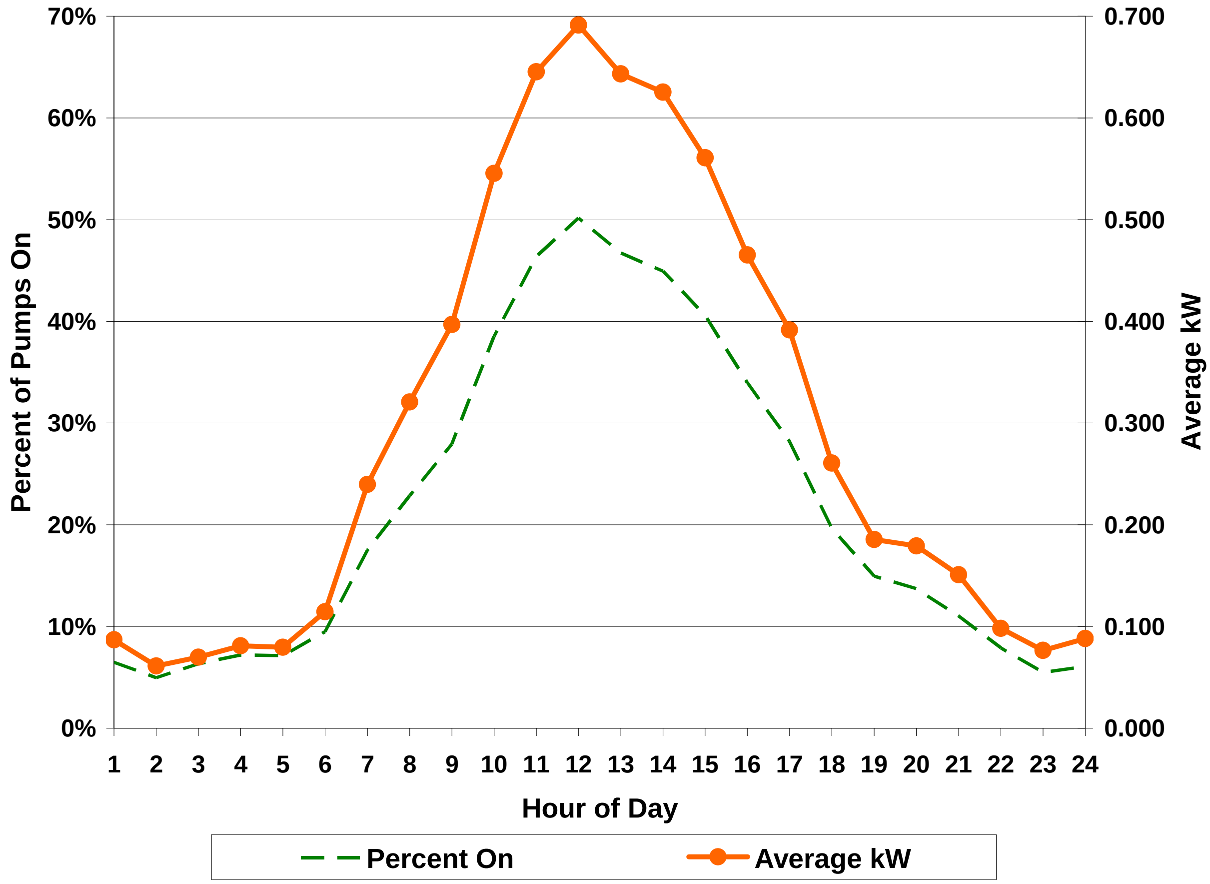

FIGURE 16. COMPARISON OF HOURLY AVERAGE KW DEMAND AND OPERATING PROFILES

Table 20 presents information about the number of pool pumps operating for at least one half hour during peak demand hours of 12 PM to 6 PM. Across all SCE regions, 69% of pool pumps operated for at least one half hour during peak demand times. In the desert region, 81% of pool pumps operated for at least one half hour during peak demand times.

TABLE 20. POOL PUMPS OPERATING FOR AT LEAST ONE HALF HOUR DURING PEAK DEMAND TIMES FOR WINTER OPERATION

	COASTAL	DESERT	INLAND VALLEY	TOTAL
Total Number of Pools	53	47	46	146
Number of Pools with Pumps Operating for At Least One Half Hour during Peak Demand Times	34	38	27	100
Percent of Pools with Pumps Operating for At Least One Half Hour during Peak Demand Times	64%	81%	59%	69%

Because this sample subset is more representative of the population of potential pool pump demand response program participants, hourly profiles in terms of average kW demand are also presented for those sites at which pool pumps were operating for at least one half hour during peak demand times. The average kW demand during an hour for the subset of 100 pool pumps is reported in Table 21. The data is then plotted in Figure 17 and Figure 18.

TABLE 21. AVERAGE HOURLY KW DEMAND PROFILES BY SCE REGION: POOL PUMPS OPERATING FOR AT LEAST ONE HALF HOUR DURING PEAK DEMAND TIMES

HOUR OF DAY	COASTAL	DESERT	INLAND VALLEY	TOTAL
0-1	0.048	0.011	0.108	0.050
1-2	0.048	0.006	0.051	0.032
2-3	0.048	0.026	0.064	0.044
3-4	0.048	0.032	0.060	0.044
4-5	0.056	0.041	0.073	0.054
5-6	0.139	0.072	0.098	0.101
6-7	0.166	0.130	0.203	0.161
7-8	0.229	0.203	0.247	0.224
8-9	0.363	0.349	0.266	0.338
9-10	0.555	0.726	0.292	0.557
10-11	0.738	0.955	0.364	0.726
11-12	0.920	0.997	0.560	0.857
12-1	0.938	1.040	0.649	0.901
1-2	0.900	1.029	0.699	0.889
2-3	0.776	0.950	0.649	0.800
3-4	0.722	0.769	0.507	0.674
4-5	0.647	0.642	0.379	0.566
5-6	0.520	0.324	0.275	0.374
6-7	0.301	0.171	0.246	0.233
7-8	0.151	0.092	0.291	0.165
8-9	0.059	0.026	0.261	0.100
9-10	0.048	0.018	0.164	0.068
10-11	0.048	0.011	0.113	0.051
11-24	0.048	0.011	0.108	0.050

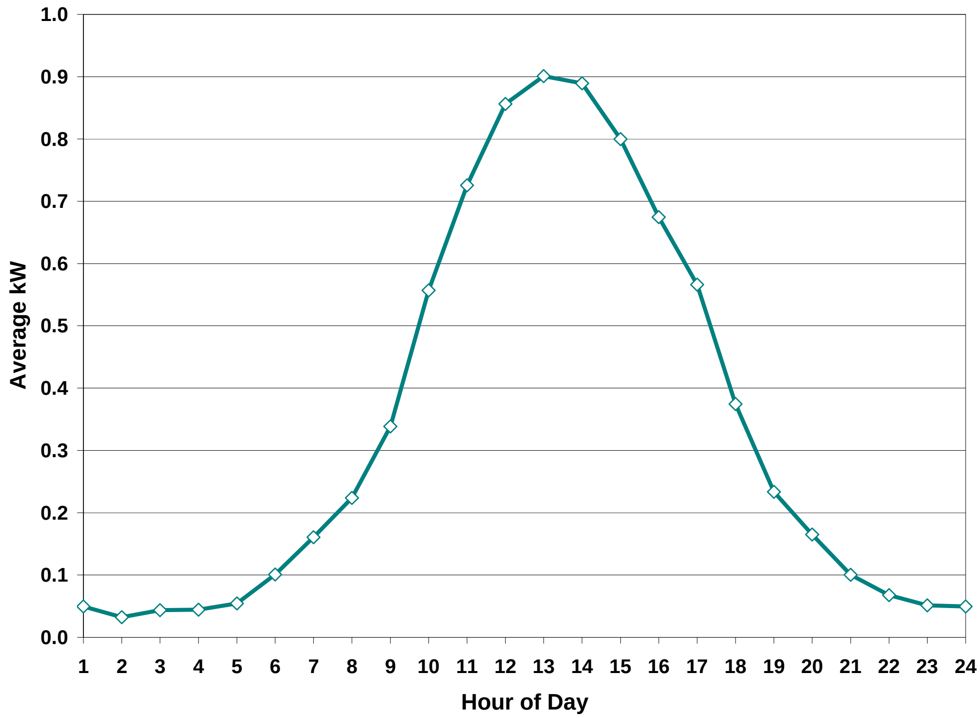

FIGURE 17. AVERAGE POOL PUMP KW DEMAND: POOL PUMPS OPERATING FOR AT LEAST ONE HALF HOUR DURING PEAK DEMAND TIMES

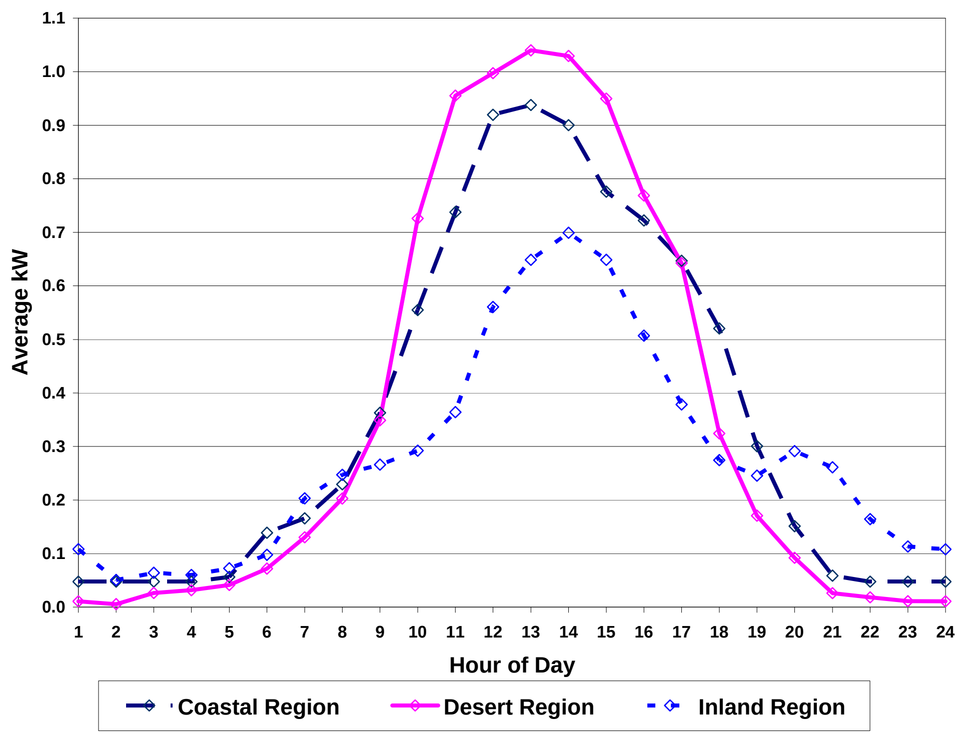

FIGURE 18. AVERAGE POOL PUMP KW DEMAND BY SCE REGION: POOL PUMPS OPERATING FOR AT LEAST ONE HALF HOUR DURING PEAK DEMAND TIMES

A profile of the average hourly kW demand for swimming pool pumps in the SCE territory was developed from monitored data collected during baseline analysis for the Summer Initiative Pool Pump Program in 2001.[3] Table 22 compares the average hourly kW demand for 146 pool pumps as presented in this report with the average hourly kW demand developed during 2001. Figure 19 provides a graphic comparison of these average kW demand profiles. The average hourly kW demand values for the current report are 12% higher during peak demand hours of 12 PM to 6 PM than those developed in 2001. The kW demand values for the current report are, on average, 11% lower during off peak demand hours than those developed in 2001.

TABLE 22. DATA ON HOURLY AVERAGE POOL PUMP KW DEMAND FROM THIS STUDY AND FROM ANALYSIS OF 2001 SUMMER INITIATIVE POOL PUMP PROGRAM

HOUR OF DAY	THIS STUDY	2001 BASELINE
0-1	0.087	0.117
1-2	0.061	0.106
2-3	0.070	0.124
3-4	0.081	0.136
4-5	0.080	0.077
5-6	0.115	0.120
6-7	0.240	0.224
7-8	0.321	0.270
8-9	0.397	0.470
9-10	0.545	0.546
10-11	0.645	0.654
11-12	0.691	0.729
12-13	0.643	0.735
13-14	0.625	0.674
14-15	0.561	0.546
15-16	0.465	0.379
16-17	0.392	0.223
17-18	0.261	0.073
18-19	0.186	0.128
19-20	0.179	0.196
20-21	0.151	0.201
21-22	0.098	0.192
22-23	0.077	0.186
23-24	0.088	0.132

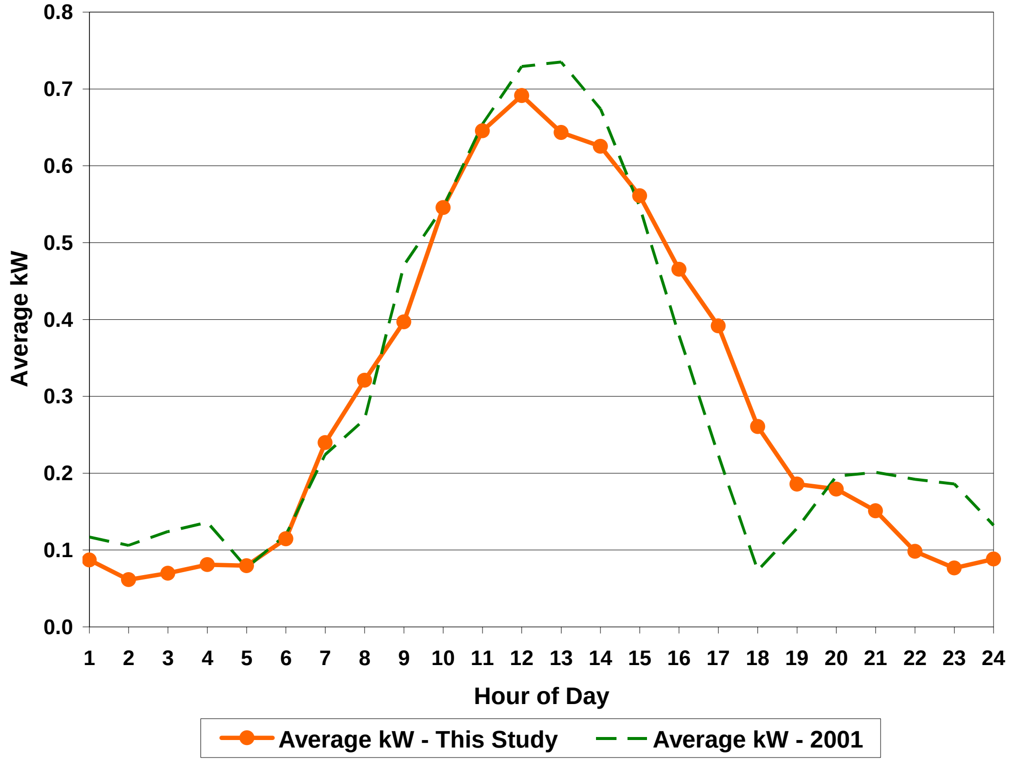

FIGURE 19. COMPARISON OF SCE AVERAGE HOURLY POOL PUMP KW DEMAND PROFILES FROM THIS STUDY AND FROM ANALYSIS OF 2001 SUMMER INITIATIVE POOL PUMP PROGRAM

ASSESSMENT OF DEMAND REDUCTION POTENTIAL

To assess the potential for reducing electricity demand associated with pool pump operation, aggregate pool pump load (kW) for each hour of the day is estimated as the product of three factors:

- Number of pool pumps;
- Percentage of pool pumps operating during each hour; and
- Estimated operating pool pump kW demand.

In February 2008, the SCE billing system reports a total of 4,175,386 residential service accounts. The California Statewide Residential Appliance Saturation Study[4] (RASS) estimates 62 percent of the residential service accounts in SCE's service territory are detached single-family homes, and 14.9 percent of single family homes in SCE's service territory have swimming pools. These values resulted in an estimate of 385,722 (4,175,386 * 0.62 * 0.149) single family residential swimming pools in the SCE service territory at the time of the Site Survey and Site Monitoring. Aggregate electric load was calculated by multiplying average pool pump kW demand by the percentage of pool pumps operating during each hour by the estimated number of single family residential swimming pools in the SCE service territory.

The estimated demand associated with pool pump operation at different hours of the day is shown in Table 23. The demand attributable to pool pump operation varies across the hours of the day. The highest demand occurs between 11 AM and noon. The demand between the hours of noon and 6 PM represents the maximum demand reduction potential for the entire SCE service territory. The values for these hours appear in bold in Table 23, which varies from just below 250 MW to just above 100 MW. The estimated pool pump demand within SCE territory developed during baseline analysis of the 2001 Summer Initiative Pool Pump Program[3] is also presented. The maximum demand reduction potential of a residential pool pump demand response program has grown considerably since 2001. Figure 20 presents the difference between the aggregate electric load from swimming pool pumps from this study and from calculation of data presented in the 2001 report. The number of pools in place in the SCE service area in 2001 was provided by SCE for use in analyzing the 2001 Summer Initiative Pool Pump Program.[3] It was estimated that there were 323,403 pools in the SCE service territory. Aggregate electric load during 2001 was calculated by multiplying average pool pump kW demand by the percentage of pool pumps operating during each hour by the estimated number of single family residential swimming pools in the SCE service territory.

Table 23. Aggregate Electric Load from Swimming Pool Pumps from This Study and from Analysis of 2001 Summer Initiative Pool Pump Program

	Percent On		Demand Load (MW)	
Hour of Day	This Study	2001	This Study	2001
0-1	6.5%	8.5%	33.6	37.8
1-2	5.0%	8.5%	23.7	34.3
2-3	6.3%	9.8%	26.9	40.1
3-4	7.2%	11.0%	31.2	44.0
4-5	7.1%	7.3%	30.7	24.9
5-6	9.5%	9.8%	44.2	38.8
6-7	17.5%	19.5%	92.4	72.4
7-8	22.9%	20.7%	123.7	87.3
8-9	28.0%	35.4%	153.1	152.0
9-10	38.5%	40.2%	210.4	176.6
10-11	46.4%	46.3%	248.9	211.5
11-12	50.2%	53.7%	266.6	235.8
12-13	**46.7%**	**53.7%**	**248.1**	**237.7**
13-14	**44.9%**	**46.3%**	**241.2**	**218.0**
14-15	**40.6%**	**37.8%**	**216.3**	**176.6**
15-16	**33.9%**	**26.8%**	**179.4**	**122.6**
16-17	**28.2%**	**17.1%**	**151.0**	**72.1**
17-18	**19.7%**	**7.3%**	**100.5**	**23.6**
18-19	15.0%	11.0%	71.6	41.4
19-20	13.7%	14.6%	69.1	63.4
20-21	11.0%	15.9%	58.2	65.0
21-22	7.9%	14.6%	37.8	62.1
22-23	5.5%	13.4%	29.5	60.2
23-24	6.1%	11.0%	34.0	42.7

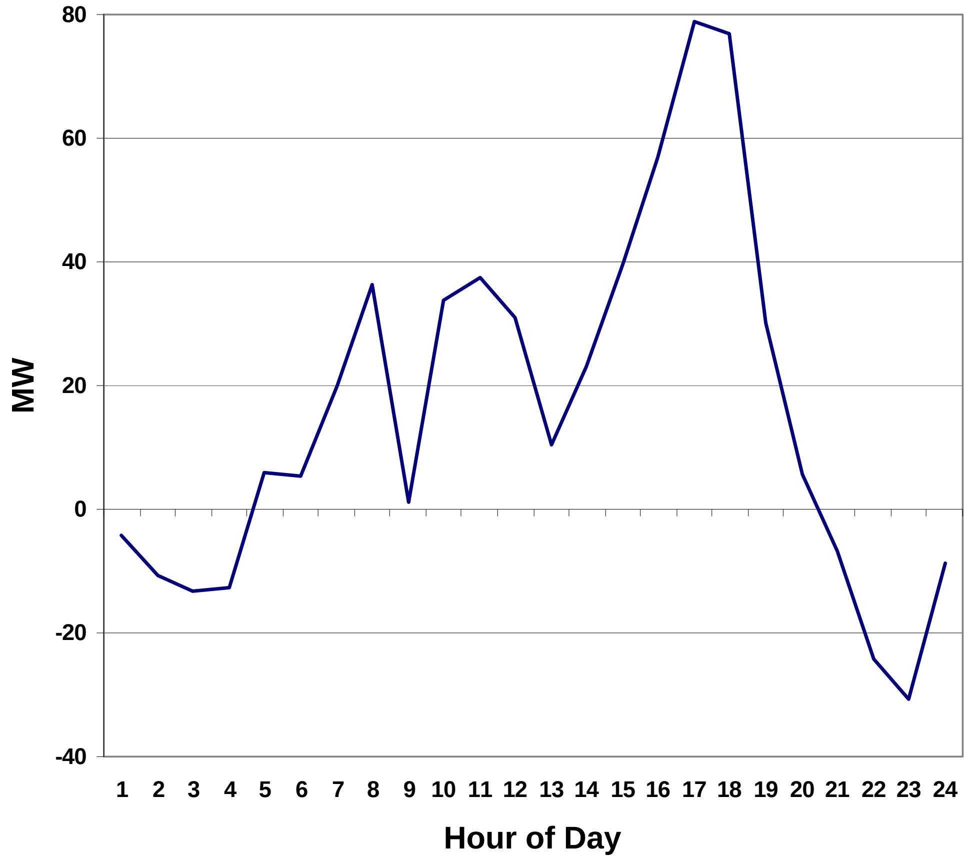

FIGURE 20. DIFFERENCE BETWEEN AGGREGATE ELECTRIC LOAD FROM SWIMMING POOL PUMPS FROM THIS STUDY AND FROM ANALYSIS OF 2001 SUMMER INITIATIVE POOL PUMP PROGRAM

Table 24 presents the number of households in the sample expressing either interest or lack of interest in a pool pump demand response program offering cash incentives to participating customers. The data set was used to assess whether there were differences in pool pump operation that were related to the level of customer interest in a pool pump demand response program.

TABLE 24. NUMBER OF HOUSEHOLDS IN SAMPLE EXPRESSING INTEREST OR NON-INTEREST IN POOL PUMP DEMAND RESPONSE PROGRAM

	COASTAL	DESERT	INLAND VALLEY	TOTAL
Interested in Pool Pump Demand Response Program	42	41	37	120
Not Interested in Pool Pump Demand Response Program	11	6	9	26

The likely impact, which is presented in Table 25, is calculated by taking the average hourly kW demand profile for households that expressed interest in a pool pump demand response program, and factoring these values by the estimated number of pools in the SCE territory and the percentage of all telephone interview respondents who expressed interest in a demand response program.

TABLE 25. LIKELY POTENTIAL PROGRAM MW DEMAND IMPACTS

HOUR OF DAY	LIKELY MW IMPACT	MAXIMUM MW IMPACT
0-1	23.0	33.6
1-2	14.6	23.7
2-3	16.7	26.9
3-4	16.9	31.2
4-5	15.7	30.7
5-6	27.4	44.2
6-7	63.7	92.4
7-8	85.3	123.7
8-9	110.0	153.1
9-10	150.6	210.4
10-11	172.3	248.9
11-12	182.5	266.6
12-13	**174.2**	**248.1**
13-14	**172.0**	**241.2**
14-15	**155.3**	**216.3**
15-16	**133.6**	**179.4**
16-17	**113.9**	**151.0**
17-18	**73.7**	**100.5**
18-19	54.3	71.6
19-20	52.5	69.1
20-21	42.7	58.2
21-22	28.5	37.8
22-23	22.1	29.5
23-24	26.1	34.0

Figure 21 presents the maximum and likely potential impacts of a pool pump demand response program.

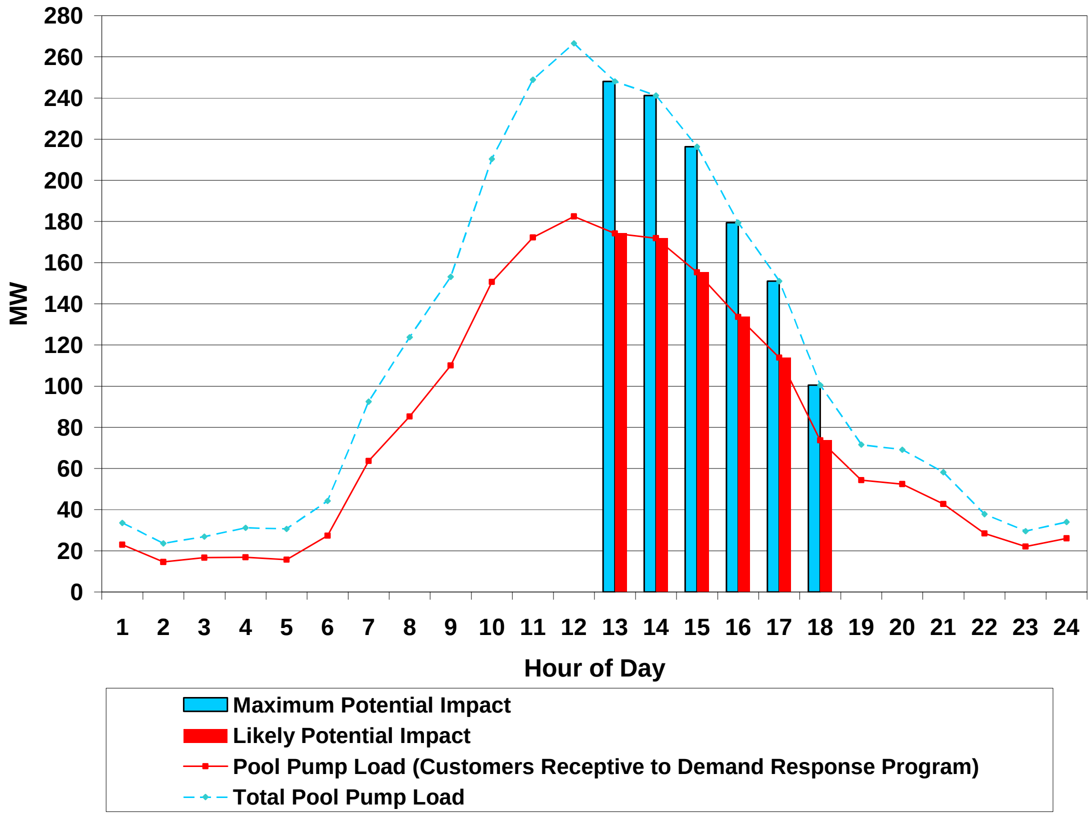

FIGURE 21. MAXIMUM AND LIKELY POTENTIAL PROGRAM MW DEMAND IMPACTS

Table 26 shows, by region, the average hourly kW demand profiles for swimming pool pumps for households that expressed interest in a pool pump demand response program and for those that did not express interest in such a program. This data is also graphically presented in Figure 22, Figure 23, and Figure 24. Across SCE territory, average peak demand is 25% higher for households that expressed interest in a pool pump demand response program than for households that did not express interest in such a program. Among households in the inland valley region, average peak demand is 57% higher for households expressing interest in the program than for households that did not express interest.

TABLE 26. AVERAGE HOURLY POOL PUMP KW DEMAND FOR HOUSEHOLDS EXPRESSING INTEREST OR NON-INTEREST IN A POOL PUMP DEMAND RESPONSE PROGRAM

	Coastal		Desert		Inland Valley		Total	
Hour of Day	Interest	No Interest	Interest	No Interest	Interest	No Interest	Interest	No Interest
0-1	0.1	0.0	0.0	0.0	0.1	0.3	0.1	0.1
1-2	0.1	0.0	0.0	0.0	0.0	0.3	0.1	0.1
2-3	0.1	0.0	0.0	0.0	0.1	0.3	0.1	0.1
3-4	0.1	0.1	0.0	0.1	0.1	0.3	0.1	0.2
4-5	0.1	0.1	0.0	0.1	0.0	0.3	0.1	0.2
5-6	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.2
6-7	0.4	0.2	0.1	0.1	0.2	0.4	0.2	0.3
7-8	0.4	0.4	0.2	0.0	0.3	0.5	0.3	0.3
8-9	0.5	0.4	0.3	0.2	0.3	0.4	0.4	0.3
9-10	0.6	0.6	0.5	0.6	0.3	0.3	0.6	0.5
10-11	0.6	0.8	0.6	0.8	0.4	0.4	0.6	0.7
11-12	0.7	0.8	0.6	0.8	0.5	0.6	0.7	0.8
12-13	**0.6**	**0.7**	**0.6**	**0.7**	**0.5**	**0.5**	**0.6**	**0.6**
13-14	**0.6**	**0.6**	**0.6**	**0.8**	**0.5**	**0.4**	**0.6**	**0.6**
14-15	**0.5**	**0.5**	**0.5**	**0.8**	**0.5**	**0.2**	**0.6**	**0.5**
15-16	**0.5**	**0.4**	**0.5**	**0.5**	**0.4**	**0.1**	**0.5**	**0.3**
16-17	**0.4**	**0.4**	**0.4**	**0.2**	**0.3**	**0.1**	**0.4**	**0.2**
17-18	**0.3**	**0.3**	**0.2**	**0.1**	**0.2**	**0.2**	**0.3**	**0.2**
18-19	0.2	0.1	0.2	0.0	0.2	0.2	0.2	0.1
19-20	0.2	0.0	0.1	0.0	0.3	0.3	0.2	0.1
20-21	0.1	0.0	0.1	0.0	0.3	0.3	0.2	0.1
21-22	0.1	0.0	0.0	0.0	0.2	0.2	0.1	0.1
22-23	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1
23-24	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0

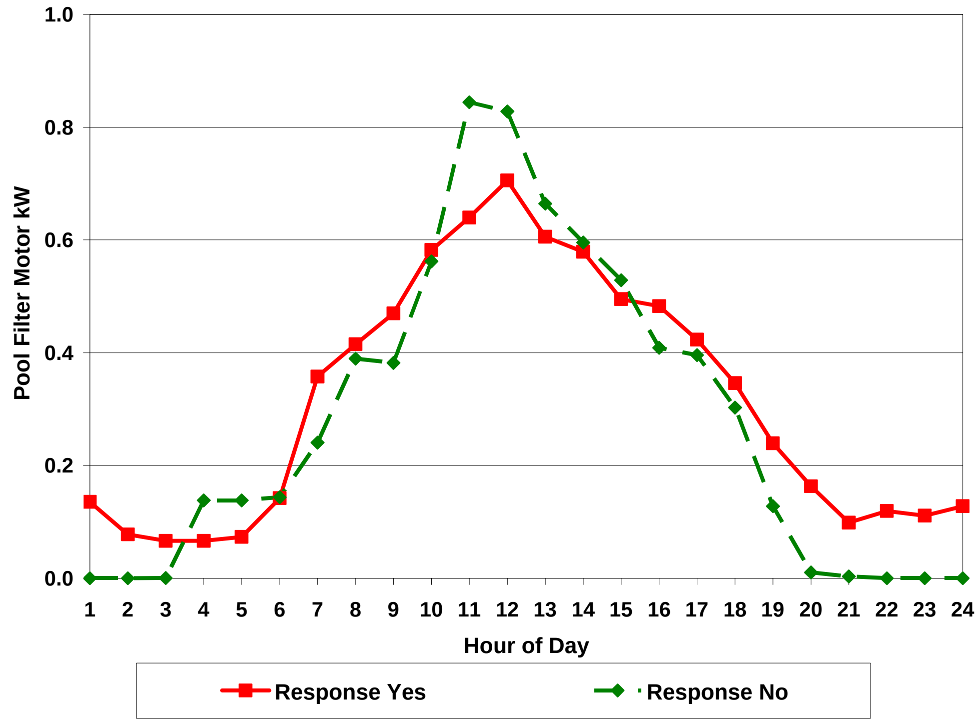

FIGURE 22. COMPARISON OF AVERAGE HOURLY POOL PUMP KW DEMAND PROFILES FOR HOUSEHOLDS EXPRESSING INTEREST OR NON-INTEREST IN A POOL PUMP DEMAND RESPONSE PROGRAM – COASTAL REGION

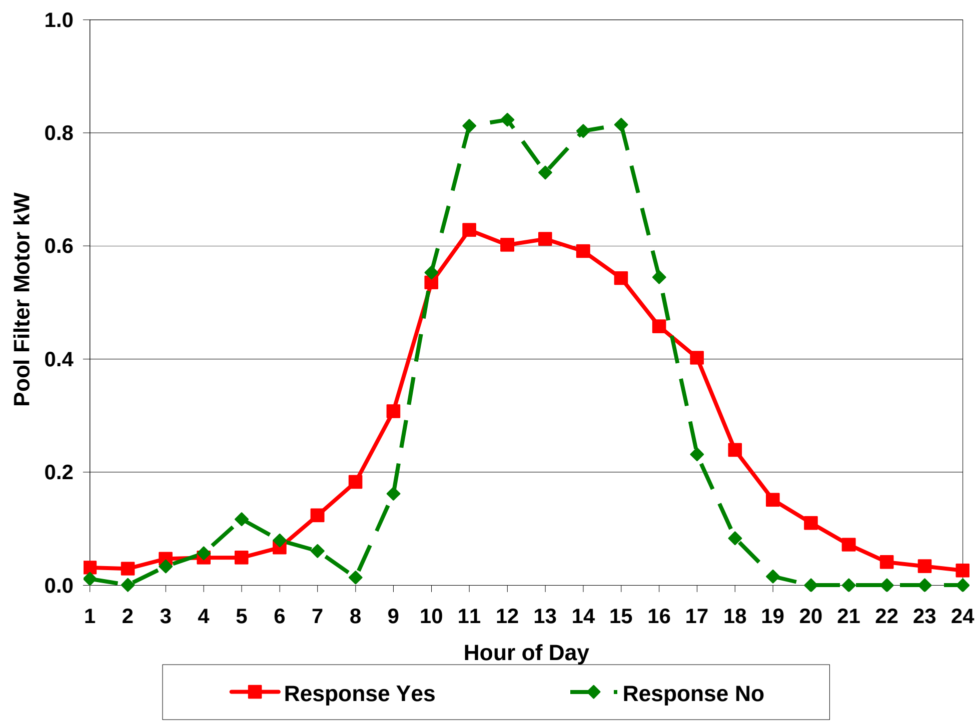

FIGURE 23. COMPARISON OF AVERAGE HOURLY POOL PUMP KW DEMAND PROFILES FOR HOUSEHOLDS EXPRESSING INTEREST OR NON-INTEREST IN A POOL PUMP DEMAND RESPONSE PROGRAM – DESERT REGION

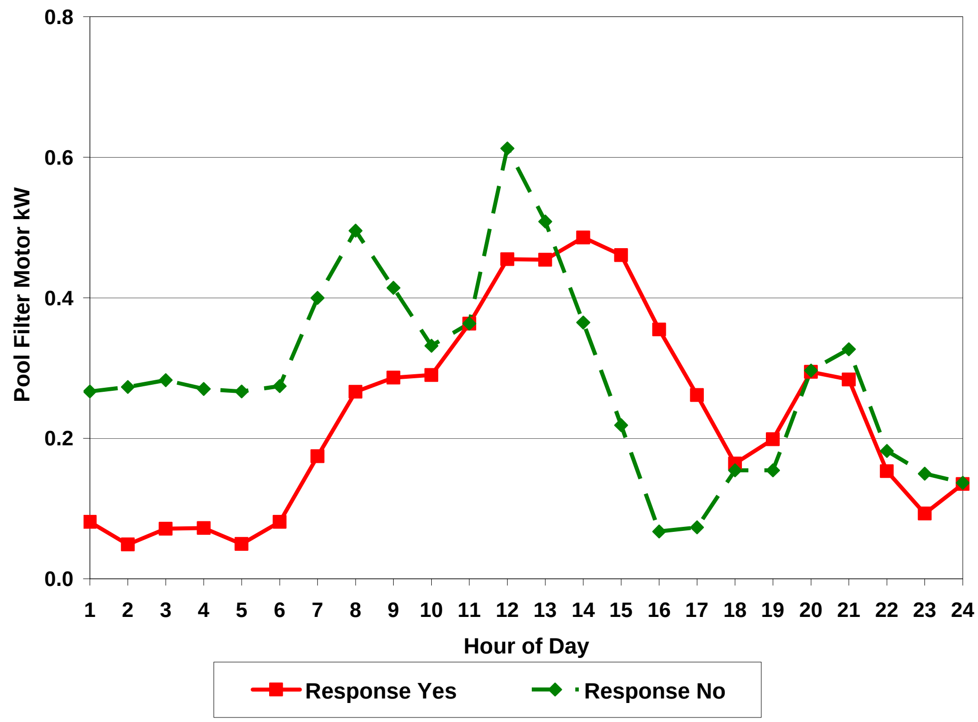

FIGURE 24. COMPARISON OF AVERAGE HOURLY POOL PUMP KW DEMAND PROFILES FOR HOUSEHOLDS EXPRESSING INTEREST OR NON-INTEREST IN A POOL PUMP DEMAND RESPONSE PROGRAM – INLAND VALLEY REGION

APPENDIX A. ANALYSIS PROCEDURES

This appendix briefly describes the methods used in the analysis of the data collected during the interviews and on-site measurements.

MEANS AND STANDARD DEVIATIONS

Means and standard deviations were calculated for different data collected, including measured kW demand.

- The mean of a variable is the average value, calculated by summing all the values for that variable and dividing by the number of values.
- The standard deviation represents how spread out numbers are from the mean. It is calculated by taking the square root of the arithmetic average of the squares of the deviations from the mean in a frequency distribution.

When graphed, data that is normally distributed looks like Figure 25.

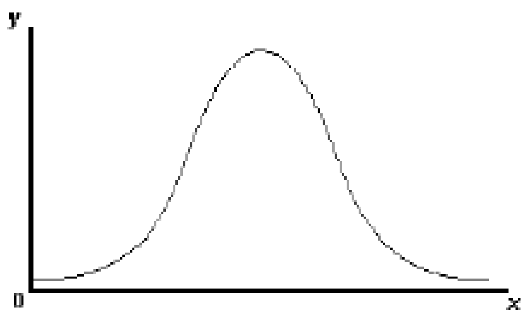

FIGURE 25. NORMAL DISTRIBUTION FOR DATA VALUES

The x-axis (horizontal) measures the values of the variable. The y-axis (vertical) measures the number of data points for each value on the x-axis. The standard deviation is a statistic that tells how tightly all the various values are clustered around the mean in a set of data. When the values are bunched together and the bell-shaped curve is steep, the standard deviation is small. When the values are spread apart and the bell curve is relatively flat, the standard deviation is relatively large.

CORRELATION ANALYSIS

Correlation analysis measures the strength of the linear relationship between the values of two variables (e.g., kW demand and pump pressure). The correlation coefficient can range between ±1.0 (plus or minus one). A coefficient of +1.0, a "perfect positive correlation," means that changes in the values of one variable will result in identical changes in the other variable. A coefficient of -1.0, a "perfect negative correlation," means that changes in the values of one variable will result in identical changes in the values of the other variable, but the change will be in the opposite direction. A coefficient of zero means there is no relationship between the two variables and that a change in the values of one variable will have no corresponding changes in the values of the other variable. Equation 1 shows the formula for deriving the correlation between two variable ("x" and "y").

EQUATION 1. CORRELATION EQUATION

$$Correl(X,Y) = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

A low correlation coefficient (e.g., less than ±0.10) suggests that the relationship between two variables is weak or non-existent. A high correlation coefficient (i.e., closer to plus or minus one) indicates that the values of the two variables change in similar fashion. The direction of the change depends on the sign of the correlation coefficient. If the coefficient is a positive number, then the two variables move in the same direction. If the coefficient is negative, then the two variables move in opposite directions.

MULTIPLE REGRESSION ANALYSIS

Multiple regression analysis is a statistical procedure for developing a linear equation to predict the value of a dependent variable from the values of several independent variables. The mathematical model for a multiple regression analysis with, for example, two independent variables is shown in Equation 2.

EQUATION 2. REGRESSION EQUATION

$$Y = a + bX1 + cX2$$

In this equation, Y denotes the dependent variable, X1 and X2 are the independent variables, and a, b, and c are regression coefficients. The "a" is an intercept term for the regression, while the "b" and the "c" are slope coefficients that show how the value of the dependent variable changes when the values of the independent variables change.

The purpose of a multiple regression analysis is to estimate the values of the regression coefficients (i.e., "a", "b", and "c"). The values of these coefficients can be estimated by the method of least squares, in which values of the coefficients are chosen so as to minimize the sum of the squares of the "n" differences between the actual and predicted values for the dependent variable. Standard computer programs are available for performing this minimization and estimating the values of the regression coefficients.

The extent to which the value of the dependent variable in a regression equation can be predicted from the values of the independent variables is summarized by the multiple correlation coefficient (denoted as R) and its square (denoted by R-squared). The R-squared value gives the proportion of the variance in the dependent variable that can be explained by all of the independent variables acting together according to a linear equation.

The statistical significance of each regression coefficient can also be tested by using the value of the standard error of a coefficient. The standard error of each coefficient is provided by the computer program. The usual test of the statistical significance of a coefficient is to calculate the ratio of a coefficient to its standard error. This ratio is expressed in terms of a “t-statistic.” For example, assuming that we are willing to tolerate a 5 percent chance of error, then the t-statistic for a regression coefficient should be at least 2 for the value of the coefficient to be considered statistically different from 0. (That is, the coefficient should be at least twice its standard error.) The tables for regressions discussed in this report provide data showing the probabilities that t-statistics higher than the calculated t-statistics might be obtained. The lower this probability, the more confidence we can have that a regression coefficient is different from 0.

APPENDIX B. DATA COLLECTION FORM

POOL PUMP AUDIT FORM

Auditor _______________ Date ___________

Name ____Site ID ___________________

Address ____City ____________________________________

Filter Motor Hp ______ Mfg __________________ Model ____________________________

Sweep Motor Hp ______ Mfg __________________ Model ____________________________

GPM ________ @ _________ Other ____

Filter Pump	On	Off	On	Off
Time Clock Schedule	_______	_______	_______	_______
Real Time	_______	_______	_______	_______

Sweep Pump	On	Off	On	Off
Time Clock Schedule	_______	_______	_______	_______
Real Time	_______	_______	_______	_______

Filter Clamp-on Measurement kW _____________ Sweep Clamp-on Measurement kW ____________

Filter Type: ________ Diatomaceous Earth _________ Cartridge ______ Sand Filter Pressure (psi) ________

1. Did you have to change your pool pump time clock settings as a result of participation in the pool pump rebate program? Yes ____ No ____ Don't Know ____

2. If Yes, What time were the pump time clock settings prior to the change? ON ________ OFF _______

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