DNV·GL

Impact Evaluation of 2013-2014 SDG&E Residential VSD Pool Pump Program

California Public Utilities Commission

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1 EXECUTIVE SUMMARY

This report presents DNV GL's energy impact evaluation of San Diego Gas & Electric's (SDG&E) 2013-14 Variable-Speed Drive (VSD) Pool Pump Program. The California Public Utilities Commission (CPUC) determined that the expected (ex ante) savings from VSD pool pumps were uncertain and required an evaluation under the 2014 Efficiency Savings and Performance Initiative (ESPI) review. DNV GL focused its evaluation on metering VSD pool pumps and surveying the customers who received rebates. The evaluation estimated the energy and demand impacts of rebated VSD pool pumps in SDG&E single-family homes only. Other territories and multifamily installations were not included in this evaluation. This evaluation is also part of the CPUC 2013-14 Residential Research Roadmap, which is part of the 2013-14 Energy Efficiency Evaluation, Measurement, and Verification (EM&V) Plan.[1]

The primary objectives of this evaluation were to first determine the ex post gross and net savings impacts for both energy (kWh) and demand (kW) achieved from the 2013-14 SDG&E VSD Pool Pump Program. While gross savings estimate the difference between the incentivized VSD pool pump and a minimally code-compliant two-speed pump, net energy savings consider the difference between the incentivized equipment and the equipment efficiency level that would have been installed in the absence of the program. The evaluation also sought to update key parameter assumptions SDG&E used in their workpaper that documented their methodology and calculations for expected savings. Key parameters DNV GL highlighted in the 2013 ESPI review as having a high degree of uncertainty, included run time and power draw in different power mode settings. Lastly, a third objective for the evaluation was to establish a more appropriate load shape for pool pumps.[2]

1.1 Evaluation activities

To achieve the primary evaluation objective of determining ex post gross and net savings impacts for both energy and demand, DNV GL performed the following evaluation activities:

- Review SDG&E's VSD pool pump workpaper to document the key parameters and assumptions used to estimate ex ante savings – Completed for 2013 ESPI
- Review program participation tracking records from SDG&E
- Conduct on-site data collection to document site and measure characteristics
- Conduct end-use metering to analyze the typical energy consumption and load shape of installed VSD pool pumps
- Estimate the baseline energy consumption using data collected during on-site surveys and end-use metering
- Conduct participant phone survey to assess program influence, attribution, and ultimately update the net-to-gross (NTG) ratio.

1.2 Gross impacts

As mentioned above, the primary goal of the evaluation was to determine gross and net savings impacts for both energy and demand for the SDG&E VSD Pool Pump Program during the 2013-14 cycle. To estimate

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[1] CPUC. 2013-2014 Energy Efficiency EM&V Plan. http://www.energydataweb.com/cpuc

[2] SDG&E workpaper used the load shaped associated with residential central air conditioning as the closest available load shape as a load shape specific to residential pool pumps was not available in the PG&E E3 calculator.

gross savings, the evaluation team used both on-site survey and end-use metering to gather data on VSD pool pump energy usage. The SDG&E workpaper assumed savings are achieved by the VSD pump running at a lower wattage for a longer time period compared to a standard pump with two speeds. The workpaper also assumed the entire volume of the pool runs through the filter daily. The evaluation's metering effort suggests that on average, 152% of the entire pool volume is filtered daily. The metering effort also suggests that the average power draw of VSD pumps in high speed mode is much less than assumed in the workpaper and that the pump runs in both high and low speed modes for longer than assumed. These findings produced ex post energy savings that were very close to the ex ante estimates, but ex post demand savings that were much higher than the ex ante estimate.

The gross realization rate is the ratio of the ex post (achieved) gross savings relative to the ex ante (expected savings) estimates from the workpaper. DNV GL established population-level gross savings estimates by extrapolating the sample level results to the population.

Table 1 shows VSD Pool Pump unit-level (i.e. per pump) expected and achieved gross energy savings. The evaluation successfully sampled 49 sites and achieved a 15.9% relative precision at 90% confidence. As indicated, the average annual unit-level gross savings was 1,230 kWh/year. This estimate indicates a 105% gross savings realization rate compared to the expected savings estimate.

Table 1. Unit-level gross energy savings summary

Ex ante energy savings (kWh/ yr)	Ex post energy savings (kWh/ yr), N=49	Energy savings realization rate	Ex post energy savings standard deviation	Ex post energy savings standard error	Ex post energy savings error bound (90% CI)	Ex post energy savings relative precision (90% CI)
1,169	1,230	105%	830	119	±195	±15.9%

Program-level gross expected and achieved energy savings estimates are shown in Table 2. As shown, the VSD Pool Pump Program achieved a gross energy savings realization rate of 105% across all program years. In 2013 and 2014, the program achieved gross energy savings of 2.87 million kWh/year and 2.99 million kWh/year, respectively.

Table 2. Program-level gross energy savings by program year

Program year	Ex ante UES (kWh/yr)	Ex post UES (kWh/yr)	Measure quantity	Ex ante gross savings (kWh/yr)	Ex post gross savings (kWh/yr)	Gross savings realization rate
2013	1,169	1,230	2,333	2,727,277	**2,869,590**	**105%**
2014	1,169	1,230	2,433	2,844,177	**2,992,590**	
Total (2013-2014)	1,169	1,230	4,766	5,571,454	**5,862,180**	

Table 3 shows site-level ex post gross coincident demand savings.[3] The evaluation found that coincidence of

[3] Gross coincident demand reduction was calculated as the average of demand reduction across all sites during the evaluation defined peak window time period within the logging period. Since the logging period did not include the DEER-defined peak periods for the climate zones within the geographical area of the study, the evaluation developed a peak window time period for the logging period that utilized the DEER peak period definitions. The evaluation peak window constraints are as follows: afternoon hours from 2-5 PM on the three hottest consecutive weekdays within the logging period for which all sites had a logger deployed.

operation is slightly lower than the expected estimate, while the measured delta watts per mode is greater than the expected estimate. The achieved gross coincident demand reduction was more than twice as much as the expected estimate, resulting in a gross demand realization rate of 273%.

Table 3. Site-level gross coincident demand savings summary

Source	Coincident demand reduction (kW)	Demand savings realization rate
Ex-ante	0.166	**273%**
Ex-post, n=49	0.453	

Table 4 shows the program-level gross ex post demand savings by program year. Overall, the evaluation found annual demand savings of 1,056 kW/year in 2013 and 1,101 kW/year in 2014, or 273% of the annual ex ante demand savings estimates.

Table 4. Program-level gross demand savings by program year

Program year	Ex ante UES (kW/yr)	Ex post UES (kW/yr)	Measure quantity	Ex ante gross savings (kW/yr)	Ex post gross savings (kW/yr)	Gross savings realization rate
2013	0.166	0.453	2,333	387	**1,056**	**273%**
2014	0.166	0.453	2,433	404	**1,101**	
Total (2013-2014)	0.166	0.453	4,766	791	**2,157**	

1.3 Net impacts

In their work paper, SDG&E used the CPUC Database for Energy Efficient Resources (DEER) default NTG value of 0.55 in the net savings calculations, since an impact evaluation of VSD pool pumps had not been undertaken in California before this study. To inform the NTG ratio and consequently the estimate of net savings impacts, DNV GL conducted a phone survey with participants to determine what they would have done in absence of the program as well as the pool contractor’s influence on their installation decision.

As shown in Table 5, the results of the participant survey and NTG analysis yielded an achieved NTG ratio of 0.61. This resulted in a net energy savings realization rate of 117%. Overall, the 2013-14 VSD Pool Pump Program achieved energy savings of over 3.5 million kWh/year on a net basis.

Table 5. Program-level net energy savings by program year

Program Year	Ex Ante Gross Savings (kWh/yr)	Ex Ante NTG Ratio	Ex Ante Net Savings (kWh/yr)	Ex Post Gross Savings (kWh/yr)	Ex Post NTG Ratio	Ex Post Net Savings (kWh/yr)	Net Savings Realization Rate
2013	2,727,277	0.55	1,500,002	2,869,590	0.61	**1,750,450**	**117%**
2014	2,844,177	0.55	1,564,297	2,992,590	0.61	**1,825,480**	
Total (2013-2014)	5,571,454	0.55	3,064,300	5,862,180	0.61	**3,575,930**	

Table 6 shows the program-level achieved net demand savings using the evaluated NTG ratio of 0.61. As shown, the VSD Pool Pump Program had a net demand savings realization rate of 253% compared to the ex ante net demand savings estimate. Overall, the 2013-14 program achieved 1,100 kW/year of demand savings.

Table 6. Program-level net demand savings by program year

Program Year	Ex Ante Gross Savings (kW/yr)	Ex Ante NTG Ratio	Ex Ante Net Savings (kW/yr)	Ex Post Gross Savings (kW/yr)	Ex Post NTG Ratio	Ex Post Net Savings (kW/yr)	Net Savings Realization Rate
2013	387	0.55	213	866	0.61	**644**	**302%**
2014	404	0.55	222	903	0.61	**672**	
Total (2013-2014)	791	0.55	435	1,768	0.61	**1,316**	

1.4 Conclusions and recommendations

After completing the evaluation of SDG&E's 2013-14 VSD Pool Pump Program, DNV GL's conclusions and recommendations are as follows:

Energy savings. The ex post gross and net energy savings found by DNV GL's evaluation were very close to the ex ante estimates used in SDG&E's ESPI workpaper, with 105% gross savings realization rate and 117% net realization rate. While the program achieved high realization rates, the evaluation suggests that updates to the workpaper assumptions for high-speed power draw, daily pool turnover, and run time in both high and low-speed are warranted. The high realization rates found by this evaluation should help alleviate some of the uncertainty that was initially associated with VSD pool pump savings estimates.

Demand savings. The ex post demand savings, both gross and net, were more than double the ex ante estimates for demand savings. The workpaper simply averaged the demand reduction in high and low speed (which assumed equal time in both modes); whereas the evaluation found that during peak times VSD pumps do not run in both modes equally. DNV GL used the actual run time in each mode to calculate average site-level demand. Additionally, DNV GL believes that there is an opportunity to achieve additional demand savings with a program or outreach initiative focused on encouraging customers to shift their programmed VSD pump schedule to operate off-peak.

Customer education. Anecdotally, through talking with on-site contacts, DNV GL field staff found that the majority of program participants were not well informed about their pool pump operation, schedule, or how to maintain the pump to achieve the expected energy savings. While the program already provides training to contractors and program marketing materials to participants, there is an opportunity to further educate program participants through a simple flyer or leave behind provided by the pool pump contractor focused on pump operation and maintenance that could help participants and the program achieve the desired level of energy savings.

Future evaluation. To improve on the precision achieved by this evaluation and further reduce the uncertainty around VSD pool pump energy and demand savings, DNV GL recommends a larger and more robust evaluation of VSD pool pumps in the future. DNV GL recommends that any future evaluation should attempt to measure consumption of non-participants or code-compliant two-speed pool pumps in order to improve the baseline estimate. Additionally, DNG GL recommends a larger sample for future evaluations, which is necessary to improve precision given the large degree of variability of savings on a site by site basis. Lastly, DNV GL recommends a much longer monitoring period to better capture seasonal changes and timing across sites.

2 INTRODUCTION

This report presents DNV GL's energy impact evaluation of San Diego Gas & Electric's (SDG&E) 2013-14 Variable-Speed Drive (VSD) Pool Pump Program that is part of the California Public Utilities Commission (CPUC) 2014 Efficiency Savings and Performance Initiative (ESPI) review. This evaluation is also part of the CPUC 2013-14 Residential Research Roadmap, which is part of the 2013-14 Energy Efficiency Evaluation, Measurement, and Verification (EM&V) Plan.[4] DNV GL focused its evaluation on rebated VSD pool pumps in SDG&E single-family homes only. Other territories and multifamily installations were not included in this evaluation.

For the 2013-14 program cycle, Southern California Edison (SCE) and SDG&E both implemented residential VSD pool pump programs. However, this evaluation only focused on the SDG&E program since pool pumps in SDG&E territory were deemed an ESPI measure.[5]

The SDG&E VSD Pool Pump Program provided rebates to customers who purchased an eligible VSD pool pump instead of a two-speed pump that meets minimum code regulations. Eligible participants received a one-time incentive payment of $200 per pump installed, regardless of pump size.

2.1 Objectives

The primary objectives of this evaluation were to first determine the ex post (achieved) gross and net savings impacts for both energy and demand (in kWh and kW) achieved by the 2013-14 SDG&E VSD Pool Pump Program. The evaluation also sought to update key input parameters used by SDG&E per their workpaper, previously highlighted by DNV GL as having a high degree of uncertainty. These parameters include, run time and power draw in different power mode settings. Lastly, the evaluation had a third objective of establishing a more appropriate load shape for pool pumps.[6]

DNV GL determined gross program impacts using information collected from the following five research activities:

- Review of SDG&E's VSD pool pump workpaper to document the key parameters and assumptions used to estimate ex ante savings
- Review of program participation tracking records from SDG&E
- On-site data collection to document site and measure characteristics
- End-use metering to analyze the typical energy consumption and load shape of installed VSD pool pumps
- Estimation of baseline energy consumption using data collected during on-site surveys and end-use metering.

DNV GL determined net program impacts using results from a phone survey with participants to determine what they would have done in absence of the program and how influential the program was in their decision to purchase a VSD pool pump.

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[4] CPUC. 2013-2014 Energy Efficiency EM&V Plan. http://www.energydataweb.com/cpuc

[5] CPUC. Final 2015 ESPI Uncertain List. http://www.cpuc.ca.gov/NR/rdonlyres/9F79154A-065B-4E80-B1AC-58A6E7223F91/0/Final_2015_ESPI_Uncertain_List.pdf

[6] SDG&E workpaper used the load shaped associated with residential central air conditioning as the closest available load shape as a load shape specific to residential pool pumps was not available in the PG&E E3 calculator.

2.2 Claimed savings

Table 7 lists the 2013-14 claimed savings for the VSD Pool Pump Program implemented under the Plug Load and Appliances program (SDG&E 3203). The VSD pool pump measure has expected deemed energy savings estimate of 1,169 kWh/year and expected demand savings estimate of 0.166 kW/year. Program participation was almost identical between 2013 and 2014, with 2,333 and 2,433 rebated VSD pool pumps, respectively. Because this measure is not temperature-dependent, savings do not vary by climate zone. This measure is only applicable to single family homes and should not be used for multifamily dwellings.

Table 7. 2013-14 Claimed VSD pool pump program savings

Program year	Ex ante UES (kWh/yr)	Ex ante UES (kW/yr)	Measure quantity	Ex ante gross savings (kWh/yr)	Ex ante gross savings (kW/yr)	NTG ratio	Ex ante net savings (kWh/yr)	Ex ante net savings (kW/yr)
2013	1,169	0.166	2,333	2,727,277	387	0.55	1,500,002	213
2014	1,169	0.166	2,433	2,844,177	404	0.55	1,564,297	222
Total (2013-2014)	1,169	0.166	4,766	5,571,454	791	0.55	3,064,300	435

3 METHODS

This section describes the methods used to derive ex post gross and net savings for both energy and demand.

3.1 Gross impact evaluation

As stated in the research plan, the primary goal of the evaluation was to determine gross and net savings impacts for both energy and demand of the SDG&E VSD Pool Pump Program during the 2013-14 cycle. To estimate gross savings, the evaluation team used both an on-site survey and end-use metering to gather data on VSD pool pump usage. DNV GL updated inputs to the parameters used in the workpaper calculations that included; the site-observed characteristics, end-use metering data, and installation rate; to calculate the achieved gross savings. The team then compared the achieved gross savings to the expected savings estimates from the workpaper to determine a gross savings realization rate. DNV GL established population-level gross savings estimates by extrapolating the sample level results to the population.

3.1.1 Sample design

The goal of the sample design was to support estimates of installation rates and program savings for the 2013-14 program cycle with a minimum of 10% precision at 90% confidence, as recommended in the California Energy Efficiency Evaluation Protocols.[7] Site-level energy savings estimates from SDG&E's program tracking data indicated that 99% of participants installed one VSD pump and had the same expected savings estimate. DNV GL stratified the program participants by program year only since expected savings across all participants were the same.

The method used for sampling adhered to the following distinct steps:

1. Review program tracking records and use project level (i.e., site address) ex ante energy savings estimates to draw a sample from 2013 and 2014 program participants.
2. Use model-based statistical sampling to optimize and select the actual sample for on-site monitoring.
3. Contact selected participants to schedule on-site visits, deferring to backup sites only when participants selected for the primary sample declined to participate in the evaluation or could not be reached after reasonable effort.

The sample design originally called for installing and monitoring equipment at 70 participant sites. Due to the tight schedule and recruiting challenges, DNV GL was only able to conduct 60 site visits, which resulted in 49 sites with useable consumption data. Table 8 shows the number of visits and the sample disposition and final metered sample.

7 California Public Utilities Commission. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. April 2006. http://www.cpuc.ca.gov/nr/rdonlyres/27629e7a-f01a-48ca-8b2c-b07ecee7dd5a/0/caenergyefficiencyevaluationprotocols.doc

Table 8. Achieved sample

Site explanation	Number of sites
Total sites visited (VSD pump verified)	60
Could not install logger	4
Logger equipment failure (no data)	1
Logger installed (bad data)	3
Logger installed (short time series)	3
Achieved sample (logger installed, good data)	**49**

Table 9 shows the planned sample size, expected relative precision and estimated coefficient of variance compared to the achieved sample.

Table 9. Comparison of planned sample and achieved sample

Sample	Sample Size	Ex Post Energy Savings Relative Precision (90% CI)	Coefficient of Variance (Gross)	Coefficient of Variance (Net)
Planned sample	70	10.0%	0.5	0.7
Achieved sample	49	15.9%	0.68	0.44

Based on experience with similar studies, DNV GL anticipated an error ratio (or coefficient of variation) of 0.5 for gross energy savings and 0.7 for the NTG ratio. The error ratio is a summary statistic of variability of the ratio of verified to tracking system energy savings. Mathematically the error ratio is the standard deviation of the realization rate divided by the mean realization rate. The error ratio is expressed as:

$$er = \frac{\sqrt{\sum_{i=1}^{n} w_i \left(e_i^2 / x_i^{\gamma} \right) \sum_{i=1}^{n} w_i x_i^{\gamma}}}{\sum_{i=1}^{n} w_i y_i}$$

Where,

n is the sample size
w_i is the population expansion weight associated with each sample point i
x_i is the program reported savings for each sample point i
y_i is the evaluated gross savings for each sample point i
ɤ (gamma) is a constant with a value of 0.8
$e_i = y_i - bx_i$ is an error for each sample point where b is the program realization rate, expressed as:

$$b = \frac{\sum w_i \; y_i}{\sum w_i \; x_i}$$

At the conclusion of the pool pump program evaluation, DNV GL was able to calculate an updated coefficient of variation (CV) to use in future evaluation sampling.[8] The gross energy savings had a CV of 0.68 while the net savings had a CV of 0.44.

3.1.2 Expansion of sample results to the population

DNV GL used ratio estimation techniques to expand estimates of achieved (ex post) savings from the sample sites to a program-level estimate of adjusted gross savings. The ratio estimation leveraged the statistical sample design described earlier to quantify program savings with measures of statistical precision and confidence intervals.

In addition, DNV GL included tracking system or the "expected" estimates of savings for the sample sites to calculate an adjustment factor (R_v) that can be applied to ex ante savings estimates program-wide in order to determine achieved savings. DNV GL used appropriate weights to determine the G_I and G_V for each site corresponding to the sampling rate within each stratum. As the ex ante savings was the same for all sites, each sampled site received an equal weight. The formula for this factor is:

$$R_V = \frac{\sum_{j \varepsilon A} G_{Vj}}{\sum_{j \varepsilon A} G_{Ij}}$$

Where,

G_{Ij} is the tracking estimate of gross savings for project j, adjusted for non-installation
G_{Vj} is the achieved gross savings for project j based on simulation modeling
A denotes the sample

3.1.3 Data collection

DNV GL collected data primarily through site visits, equipment monitoring, and participant surveys.

Table 10 provides a high-level description of the data DNV GL field staff collected through direct measurements, observations, and questions to program participants. The on-site data collection instrument is presented in APPENDIX B. Table 11 lists the metering and test equipment DNV GL used for field data collection. DNV GL also collected information on the type of pump that was previously installed (single speed/two speed/VSD).

The monitoring period was limited to the evaluation schedule. Ideally, pool pumps should be metered for an entire year to gather data on seasonal changes. DNV GL launched on-site data collection and equipment monitoring in mid-September and retrieved the monitoring equipment in December. This allowed for a minimum of 45 days of monitoring and a maximum of 94 days, depending on when each logger was installed and retrieved. In some cases, we were able to observe the beginning of a seasonal adjustment (summer operations to winter operations) but had to rely on participant survey responses to capture when

[8] An estimate of variability (error ratio or coefficient of variation) is always necessary to determine the desired sample size. Since we had not done a VSD pool pump evaluation before, we did not know what the error ratio would be. We estimated an error ratio of 0.5 for gross energy savings and 0.7 for the NTG ratio based on our experiences with other evaluations. At the conclusion of this study, we produced an updated error ratio that can be used to inform future evaluations. This is not a number that will affect savings claims, but rather a value that informs future evaluations of the sample required for a study to be statistically significant.

they would revert back to normal (summer) operations. Regardless of what was observed onsite, the onsite evaluator also asked the participants if they changed the schedule of their pool pumps for different seasons. DNV GL used the data collected to produce site-level savings estimates and then extrapolated the estimates to the program population.

Table 10. Summary of collected data

Data	Description
Measure type	Residential VSD pool pump
Workpaper	WPSDGEREWP0002 (SDG&E)
EM&V scope	60 participating residential sites in SDG&E service area; one pool pump per site
Operation	Operating hours and power draw at all programmed speeds
Pump motor rated power	From nameplate
Unit information	Manufacturer, model, rated power, service factor, efficiency, installation date, previous motor type, and rated power
Unit measurements	Tests: Voltage, current, power, and power factor (spot measurements and data loggers)
Contextual information	Supplemental cleaning equipment and cleaning schedule, booster pumps, water features, pool dimensions and volume, water heating, solar power for pump, filtering system, and contractor/maintenance firm's frequency of visits
Measurement equipment	See Table 11: Field data collection equipment

Table 11 lists the sensor-based measurements used to determine pump power consumption.

Table 11. Field data collection equipment

Parameter to measure	Parameter range	EM&V equipment brand and model	Rated full scale accuracy	Accuracy of expected measurement	Planned metering duration	Planned metering interval
Volts, amps, kilowatts, kilowatt hours, power factor	0 kW–5 kW	Amprobe ACD-50NAV or equivalent clamp meter	± 2.0% logged value	± 2.0% logged value	Average of 2 tests	N/A
True power pulse transducer	0 kW–30 kW	CCS Wattnode (WNB-3D-240/480-P)	N/A	± 0.5% of logged value	2-4 months	1 minute

3.1.3.1 Data Collection Issues

DNV GL identified potential data collection issues that could arise during the study in the work plan. However, there were some unanticipated issues that came up that required mitigation in order to complete the objectives.

As mentioned earlier, there was the issue of not being able to observe VSD pool pump operations from season to season. In an ideal scenario, the evaluation would have monitored pool pump energy consumption for a full year to document if and when a seasonal adjustment is made. Additionally, with a full year of monitoring, we would be able to quantify the exact difference in energy consumption between the summer and winter, if a seasonal adjustment was made. This evaluation had to rely on self-reporting of study participants to document if and when seasonal adjustments to pump operations were made and what those adjustments were. In some cases, the on-site data collection may have been able to capture the beginning of the winter schedule and associated consumption; however, the evaluation had to rely on self-reporting for when the pump reverted to summer (normal) operations.

In addition to seasonal adjustment, there were other timing related issues that impacted the evaluation. Recruitment and on-site data collection was launched in mid-September and logger installations were completed in mid-October. As a result of this relatively late launch period, the evaluation missed the DEER-defined peak demand days[9] and had to select the hottest consecutive 3-day period after all of the sampled sites had loggers installed.

Due to the late launch, we had a short duration window on how much monitoring could occur to capture the summer season. Unfortunately, this resulted in having to cut short the recruiting time and number of sample points since any latter recruited sites would most likely be outside of the summer season for data collection.

Lastly, DNV GL learned that some sites were not compatible with logger installations due to a number of reasons (e.g., logger equipment would not fit in control box) that were not apparent until field staff were on-site and attempting to install the data logger. These issues impacted our ability to measure VSD pump energy consumption for a handful of sites and reduced the evaluation's achieved sample.

3.1.4 Gross savings analysis

This section provides a description of the methods used to estimate gross energy and demand savings, as well as the load profile. To estimate gross energy savings DNV GL took the following steps:

1. Determine if and when a seasonal operating adjustment occurred at each site
2. Determine the daily operating scheme of the installed VSD pump at each site
3. Estimate the daily volume of water pumped by the installed VSD pump at each site
4. Estimate the baseline (i.e. two-speed) pump operating scheme for each site based on site specific data collected
5. Calculate the average daily energy consumption of the baseline and VSD pump for each site
6. Calculate the average annual energy savings for each site
7. Aggregate the site-level results to estimate program-level annual energy savings

3.1.4.1 **Seasonal operating adjustments**

For each site where pool pump consumption data was collected, DNV GL had to determine whether participants made a seasonal adjustment to their pool pump operations and whether that adjustment

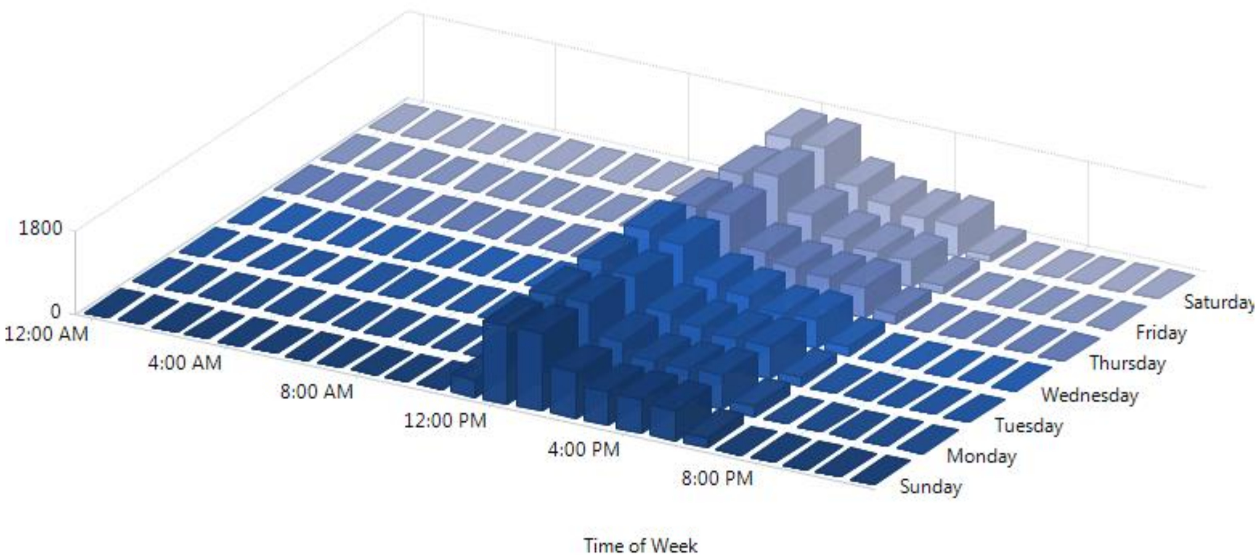
[9] DEER defines peak period as the nine-hour window (from 2pm to 5 pm) over a three-day "heat wave" which is determined for each climate zone. The three-day peak demand period within each climate zone is based on the following criteria: occurs between June 1st and September 30th, does not include weekends or holidays, and has the highest value for average temperature over the three-day period, the highest value for the average temperature from noon to 6 p.m. over the three-day period, and the highest value for the peak temperature over the three-day period.

occurred during metering. For sites that participated in the evaluation, pool pump consumption was measured from mid-September to December.[10] Site contact responses to seasonal adjustment survey questions and the logger data time series plots of pump motor watt draw were examined to determine if seasonal operating adjustments were performed at each site. For sites where the data illustrated a change to the pump operating schedule during the logging period, the data was segmented into summer and winter operational periods and analyzed separately. The duration of the winter operating schedule was determined from the period reported by the site contact. If no reliable estimate of duration was obtained, the duration of the winter operating scheme was assumed to be six months.

3.1.4.2 Daily average hourly operating scheme of installed VSD pump

The logger data was processed in Universal Translator 3[11] software to create an hourly day-of-the-week data table and plot from the time series in order to identify daily operation schemes for each operational period (summer or winter). An example day-of-the-week plot for a typical operating scheme is shown below in Figure 1. The vertical axis of the plot represents the pump watt draw, ranging from 0 -1800 watts for this site.

Figure 1. Typical VSD pool pump operation scheme



Daily average hourly pump motor watt draw was calculated for each operating scheme by averaging the power draw across all days of the week for each hour of the day. Using this hourly data, high and low speed mode watt draw and daily operational hours were derived using a threshold of 425 watts to separate high and low speed operation and a lower threshold of 10 watts to separate low speed operation from non-operational periods.[12] The daily average operating hours were then calculated as the summation of hours in each mode while the watt draw was calculated as the average hourly watt draw in each mode.

[10] Data loggers were installed from mid-September to mid-October and collected in early to mid-December.

[11] Universal Translator 3 <www.utonline.org> A PIER-funded collaboration between Pacific Gas & Electric, the U.S. Department of Energy, et al.

[12] One sampled site exhibited three distinctly different operating modes (569, 265, and 94 watts) and hours of operation (6, 5, and 12 hours, respectively). For the purposes of accurately representing the average daily power draw and volume of water pumped, a medium speed mode was included in the energy savings calculation for this site.

3.1.4.3 **Daily volume of water pumped by installed VSD pump**

To calculate the volume of water pumped in each operating mode, the evaluation team leveraged the 2014 Pennsylvania Technical Reference Manual (TRM) flow rate-watt draw regression formula identified in the 2013 VSD Pool Pump ESPI Review memo. The evaluation team back calculated flow rate in gallons-per-minute (gpm) from average hourly watt draw. For reference, the regression expression is presented as:

$$Watts = 0.0978 \times (flow\ rate)^2 + 10.989 \times (flow\ rate) + 10.281$$

The total daily volume of water pumped was calculated as the summation of the product of flow rates and hours of operations in each operating mode. The daily percent of pool volume turnover was then calculated by dividing the daily volume of water pumped by the total pool volume.

3.1.4.4 **Baseline pump operation**

To calculate gross energy savings relative to the baseline code compliant two-speed pool pump, a theoretical two-speed pump operating scheme was developed for each site. This operating scheme was derived from the workpaper assumptions in conjunction with the observed operating characteristics and logger data. The analysis retained the baseline pump motor high and low speed watt draw and flow rate assumptions from the workpaper (1883 watts/64 gpm for the high speed operating mode and 425 watts/33 gpm for the low speed operating mode) while deviating from the workpaper approach to determine the baseline pump hours of operation.

The evaluation team's approach to determine the baseline pump hours of operation modified the methodology utilized in the workpaper to achieve the same daily volume turnover rate as calculated for the installed variable pump, in place of the workpaper assumed 100% daily turnover for both installed and baseline pumps. The workpaper assumed that the baseline pump would operate in high speed for the same amount of time as the installed VSD pump, under the logic that the high speed run time was dictated by the time it takes to run suction powered pool cleaning devices such as a sweep. The workpaper then assumed that the baseline pump would run in low speed mode for a sufficient duration so as to achieve 100% turnover of the pool volume daily. However, the evaluation approach to calculate volume of water pumped with the installed VSD pump produced site level turnover rates that varied widely from this assumption. Of the 49 successfully sampled sites, 26 sites exhibited a calculated summer period daily turnover rate that fell outside the range of 75-125%. The evaluation-level average turnover rate was 152%. Table 12 lists the distribution of the daily percent of volume turnover for calculated average, summer period, and winter period for the installed VSD pump.

Table 12. Daily pumped volume

Percent of pool water volume pumped daily	Average	Summer period	Winter period
25-50%	1	0	1
50-75%	9	10	10
75%-100%	18	17	19
100-125%	5	5	5
100-150%	5	4	6
150-175%	3	1	1
175-200%	1	4	0
200-400%	5	6	5
>400%	2	2	2
Total	**49**	**49**	**49**

Applying the workpaper calculation approach for the two-speed motor operating hours to the evaluation site data led to overstated savings for sites where the VSD pump turned over less than 100% of the pool volume, and understated savings for sites where the VSD pump tuned over more than 100% of the pool volume.

To arrive at a baseline pump operation scheme comparable to the installed VSD pump operation, the evaluation team altered the calculation of operating hours for both high and low speed modes of the baseline two-speed pump. This resulted in the same daily volume of water pumped as in the observed VSD pump. For the high speed operation, the daily high speed operating hours from the installed VSD pump was carried over to the baseline case, unless the calculated volume of water pumped—using these hours and the workpaper-assumed high speed flow rate (64 gpm)—was greater than the calculated total daily volume of water pumped in all modes by the installed VSD pump. For these cases, the high speed operating hours were calculated to provide the same daily volume of water pumped as the installed variable speed pump motor. For the low speed operation, the baseline pump low speed hours of operation was calculated to match the total volume of water pumped by the installed VSD pump, instead of the 100% turnover that was assumed in the workpaper. Table 13 shows the ex ante and ex post baseline two-speed pump run time logic.

Table 13. Ex ante and ex post baseline pump run time logic

Baseline	High speed time (hrs)	Low speed time (hrs)
Ex ante	Hours = VS pump high speed hours	Hours = 100% turnover
Ex post	Hours = VS pump high speed hours unless this produces turnover rate > VS pump, in which case hours = time required for turnover rate = VS pump	Hours = time required for turnover rate = VS

3.1.4.5 Site-level average daily kWh consumption

The site-level average daily kWh consumption of the installed VSD and baseline pumps was calculated as the product of average watt draw of a mode, converted to kilowatts, and daily average hours of operation of that mode, summed across all modes of operation, for each operating scheme. For reference, this expression is presented as:

$$Average\ kWh_{daily} = \sum_{all\ modes} \frac{Average\ Ddaily\ Watts_{mode}}{1000 \frac{W}{kW}} \times Average\ dDaily\ Hhours_{\ mode}$$

3.1.4.6 Annual energy savings

To arrive at site-level annual energy savings, the evaluation calculated the average daily kWh savings from the difference in average daily kWh consumption for installed and baseline pumps for each operating scheme, and then multiplied this daily kWh savings value by the expected annual duration of operation for that operating scheme. This paralleled the workpaper approach of deriving annual savings from daily kWh consumption for each pump, but incorporated the addition of separate summer and winter operational schedules. Gross annual energy savings was calculated from the average of the site level annual gross savings estimates.

3.1.4.7 Coincident Demand reduction

The ex ante workpaper demand reduction value of 0.166 kW was calculated as the product of average demand reduction and coincidence factor. This average demand reduction value of 0.670 kW was calculated as the average of high speed and low speed demand reduction, 1.045 kW and 0.296 kW respectively. These high or low speed demand reductions were calculated as the difference between averaged the high or low speed power demand for Title-20-approved two-speed pumps and the variable speed pump high or low speed power demand from the CEC Appliance Database, which is based on manufacturer’s claims. The workpaper calculates a coincidence factor of 0.247 based on daily operating times as reported by pool contractors and pool owners in a 2009 PG&E/KEMA study.[13] The hourly average of the two reported numbers during the peak period from 2-5 PM was calculated based on the weighted average between the contractors and pool owners.

The ex post gross coincident demand reduction was calculated as the average demand reduction across all sites during the evaluation defined peak window time period within the logging period.

Since the logging period did not include the DEER-defined peak periods for the climate zones within the geographical area of the study, the evaluation developed a peak window time period for the logging period that utilized the DEER peak period definitions. The evaluation peak window constraints are as follows: afternoon hours from 2-5 PM on the three hottest consecutive weekdays within the logging period for which all sites had a logger deployed. Using this definition and actual 2015 weather data for the climate zones within the geographical area of the study, October 28-30th was selected as the peak window to calculate the coincidence demand reduction.

Site-level hourly watt draw data was pulled for the nine hours of the study’s peak window period. This data was used to calculate the hourly delta watts, or difference between the baseline watt draw in either high or low speed mode and the hourly watt draw in the corresponding mode. The same watt draw thresholds were employed for the demand reduction delta watts calculation as for the energy savings calculation: 425 watts as a threshold for determining high vs. low speed mode, and a lower limit of 10 watts for determining low

[13] Process Evaluation of 2006-2008 PG&E Mass Markets Program Portfolio and CFL, Swimming Pool Market Characterizations Final Report, December 11, 2009

speed vs. off modes. To arrive at a site-level demand reduction value, the hourly delta watts values for each site were averaged and converted to kilowatts.

$$Coincident\ Demand\ Reduction\ (kW)_{site} = \frac{Average\ \langle Baseline\ Watts_{mode} -\ Hourly\ Watts\rangle_{all\ peak\ hours}}{1000\frac{W}{kW}}$$

The evaluation-level coincident demand reduction value was calculated as the average of all site-level coincident demand reduction values.

3.1.4.8 Coincidence factor

An evaluation-level ex post VSD pool pump coincidence factor was developed from the peak window watt draw data for reference and for comparison to the ex ante coincidence factor value.

The watt draw data pulled for the nine hours of the study's peak window period was averaged to arrive at site-level average peak period load. The evaluation-level coincidence factor was then calculated as the sum of all site-level average peak period load values, divided by the sum of the total connected load for all sites.

$$Coincidence\ factor = \frac{Sum\big(\ Average\langle Hourly\ Watts\ \rangle_{all\ peak\ hours}\big)_{all\ sites}}{Sum(Total\ Connected\ Load)_{all\ sites}}$$

3.1.4.9 Load profile

The ex ante workpaper load shape claims to have utilized a residential air conditioning load shape as an approximation for a VSD pump load shape. However, examination of the program tracking data shows a residential time-of-use (TOU) measure load shape, 19-RES-AllResidential-POOL_PMP, was adopted for this measure. The measure load shape is the difference between the baseline and measure load profiles and, as the workpaper explains, "indicates what fraction of annual energy savings occurs in each time period of the year. A time-of-use load shape indicates what fraction occurs within five or six broad time-of-use periods." The TOU values for the pool pump measure load share are presented in Table 14.

Table 14. Ex ante TOU load shape for residential pool pumps used by SDG&E

	Summer			Winter		
	On-peak	Par-peak	Off-peak	Peak	Par-peak	Off-peak
kW	0.260	0.377	2.380	1.822	0.298	0.792
kWh	0.156	0.138	0.153	0.013	0.353	0.188

To develop an ex post VSD pool pump load shape, normalized daily average hourly profiles were calculated for each site, for each operating season (summer and winter). The load normalization was accomplished by dividing the daily average hourly watt draw by the total connected load (in watts), where the total load was calculated as the product of the nameplate motor horsepower, service factor, and horsepower to watts conversion factor, all divided by the motor efficiency. This calculation is presented as:

$$Total\ Load\ (W) = \frac{HP_{pump} \times SF\ \times 746\frac{W}{HP}}{\eta_{pump}}$$

Where,

HP_{pump} = pump motor nameplate horsepower, collected onsite

SF = service factor, assumed to be 1.3

η_{pump} = pump efficiency, assumed to be 0.91.

The evaluation-level load profile was calculated by taking the average of site-level normalized hourly loads across all sites, for each hour of the day, to arrive at an evaluation-level average hourly load profile for both summer and winter operating schemes.

For purposes of comparison to the ex post load profile, the ex ante TOU load shape values were leveraged to approximate an ex ante load profile. This was accomplished in three steps. The first step was normalizing the summer kW TOU values by the total of summer kW TOU values. The second step was to calculate 1 minus the normalized summer kW TOU value to approximate a load profile from the savings fraction. The final step involved scaling this TOU load by quotient of the ex ante demand reduction value (0.670 kW) over the evaluation-level average total connected load (3.02 kW).

3.2 Net impact evaluation

While gross savings estimate the difference between the incentivized VSD pool pump and code minimum 2-speed pump, net savings consider the difference between the incentivized equipment and the equipment efficiency level that would have been installed in the absence of the program. The SDG&E workpaper used the CPUC DEER default NTG value of 0.55 in its net savings calculations, since an impact evaluation of VSD pool pumps had not been undertaken in California before this study. This study utilized a phone survey with participants to determine what they would have done in absence of the program, which informed the NTG ratio and consequently the estimate of net savings impacts. The evaluation applied a basic level of rigor to the NTG ratio.

3.2.1 Participant survey objectives

The participant survey guide is presented in APPENDIX C. The primary objectives of the participant survey were to determine why people chose the VSD option, what they would have done in the absence of the program, and provide the information required to determine the NTG ratio. In addition to determining an updated NTG ratio, the participant survey was used to assess:

- Program awareness, knowledge, and decision to participate
- Customer satisfaction with all aspects of the program:
    - Interactions with the program and program contractors
    - Satisfaction with the VDS pump installation process
    - Satisfaction with the outcome
- Contractor impact on choosing a VSD pump
- Recruit appropriate sites for on-site, field surveys.

3.2.2 Participant survey implementation

DNV GL conducted the participant survey in-house and coordinated survey implementation with site recruitment for the impact evaluation. Once the on-site measurement and data collection recruitment was complete, DNV GL continued to survey program participants exclusively for the NTG portion of the survey. The participant survey sample design followed the design of the impact evaluation: a random sample of 2013-14 program participants. The participant survey had a target of 140 completes; however, DNV GL was able to complete only 105 participant surveys due to timing and participation rates.

3.2.2.1 Contractor survey

While not part of the original scope, DNV GL conducted a short survey (questions are presented in APPENDIX D) with two program affiliated installation contractors to gain an understanding of the contractor's role in promoting VSD pumps to their customers. We probed contractors about the impact of the program incentive for VSD pumps, if and why they promoted VSD pumps, and what type of pump they thought their customers would have installed without the program's incentive.

3.2.3 NTG analysis

As part of the participant survey, DNV GL asked a series of NTG-related questions designed to assess program influence and attribution. The NTG battery consisted of four main questions that assessed the influence of the program and the program's rebate (NTG1-NTG4) on participant's decision to install a VSD pool pump and two questions (M2 and M4) that assessed the influence of the installation contractor on participant's decision making.

- **NTG1.** In particular, how important was the rebate in your decision to install the VSD pump?
- **NTG2.** Are you aware of different levels of efficiency in pool pumps?
- **NTG3.** Without the pool pump rebate program, would you have installed the same type of pool pump that you installed or installed a different efficiency type?
- **NTG4.** Without the pool pump rebate, would you have replaced your pool pump at the same time as you did, earlier than you did, later than you did, or never?
    - **NTG4a**. [Only ask if NTG4 = "Later"] Approximately how many months later would you have completed the project?
- **M2.** How did you first hear about the variable speed pool pump rebate?
- **M4.** How important was your contractor's recommendation in choosing what pump to install?

DNV GL completed surveys with 105 program participants and assigned a score for program attribution to each respondent, ranging from 0-100%, depending on their responses to the NTG questions outlined above. The six NTG questions were split into two categories, program influence (NTG1-NTG4) and contractor influence (M2 and M4), and separate program attribution scores for each category were assigned to every respondent. DNV GL assigned an equal weight (50/50) to both the program influence and contractor influence scores when determining the final program attribution for each respondent. To estimate an ex post NTG ratio for the program, DNV GL averaged the program attribution score of all 105 survey respondents.

For the program influence questions, DNV GL delegated NTG3 and NTG4 as the primary NTG questions for assigning program attribution and used NTG1 and NTG2 as secondary questions to probe for response consistency. First, DNV GL calculated program attribution using only the two primary questions. Next, DNV GL calculated program attribution using the secondary questions. If there was a discrepancy between the primary responses and secondary responses, DNV GL took the average of the two program attribution scores. Table 15 to Table 18 below summarizes how DNV GL estimated program attribution for each survey respondent for the program influence portion of the NTG analysis which contributes half of the overall program attribution. Table 15 shows the NTG assignment for each potential response to NTG3, one of the two primary NTG questions.

Table 15. NTG assignment decision based on response to NTG3

Response to NTG3	NTG assignment
Would not have replaced pump	100% attribution (0% free-rider)
Other type	100% attribution
Same type	0% attribution (100% free-rider), proceed to NTG4
Don't know	0% attribution, proceed to NTG1

The program received full attribution (0% free-rider) for respondents who indicated that they would not have replaced their pump or who would have installed a different type (i.e., other) without the pool pump rebate program. For participants who did not know whether or not the program influenced the type of pump that they installed, we used the consistency questions (NTG1 and NTG2) as the primary means to assess program influence and assign program attribution. If a participant indicated that they would have installed the same type of pump, then we asked them NTG4 to assess whether the program influenced the timing of their replacement.

Table 16 shows the NTG assignment for each response to NTG4 and NTG4a.

Table 16. NTG assignment decision based on response to NTG4

Response to NTG4	NTG assignment
At the same time	0% attribution, proceed to NTG 1
Don't know	0% attribution, proceed to NTG 1
Earlier	0% attribution, proceed to NTG 1
Later	100% attribution, proceed to NTG4a
Never	100% attribution, proceed to NTG 1
Response to NTG4a	**NTG assignment**
1-2 years	100% attribution
5 or more years	100% attribution
6 months	50% attribution
6 months to a year	75% attribution
Don't know	50% attribution
Less than 6 months	25% attribution

DNV GL added the NTG assignment of NTG3 and NTG4 (NTG4 response was multiplied by NTG4a response when applicable) to get a primary program influence attribution score for each respondent. DNV GL then used the secondary program influence questions (NTG1 and NTG2) to assess the consistency of participant responses. If there was a significant discrepancy between the primary and secondary responses, DNV GL averaged the two scores. However, if a respondent was consistent in their responses, we did not average the scores and deferred to the primary score. Table 17 shows the NTG assignment for each response to NTG1, one of two NTG questions used in the participant survey to probe for consistency on the influence of the program on participant's decision making.

Table 17. NTG assignment decision based on response to NTG1

Response to NTG1	NTG assignment
Very important	100% attribution
Somewhat important	50% attribution
Neither	0% attribution
Somewhat unimportant	0% attribution
Very Unimportant	0% attribution
Don't know	0% attribution

After assessing the program attribution for each respondent using the primary questions, DNV GL adjusted the attribution using the secondary questions when there was a response discrepancy. For example, if a respondent indicated that they would have installed the "same type" of pump without the rebate (NTG3) but then indicated that the rebate was "very important" in their decision to install a VSD pump, then we would average the primary and secondary scores. In this case, the respondent received 0% program attribution (100% free-rider) from NTG3 but received 100% attribution from NTG1, which would result in average program attribution score of 50%.

Table 18 shows the NTG assignment for each response to NTG2, which was used to adjust inconsistent responses to NTG3. For example, if a respondent indicated that they would have installed the "same type" of pump without the program but then indicated that they were "not aware" of different efficiency levels; we estimated that the program had some influence over their efficiency decision and averaged the scores.

Table 18. NTG assignment decision based on response to NTG2

Response to NTG2	NTG assignment
Yes	0% attribution
No	50% attribution
Don't know	0% attribution

DNV GL adopted a similar approach to assigning program attribution for the contractor influence on participant's decision making, where a primary question established an initial score and a secondary question was used to probe for consistency. The scores of the two questions were averaged only when there was a discrepancy between responses, otherwise DNV GL deferred to the score from the primary question. Again, the program influence attribution score and the contractor influence attribution score were equally weighted to establish a final program attribution score for each respondent. Table 19 shows the NTG assignment for each response to survey question M4, the primary question used to establish contractor influence for each respondent.

Table 19. NTG assignment decision based on response to M4

Response to M4	NTG Assignment
Very important	100%
Somewhat important	50%
Neither	0%
Somewhat unimportant	0%
Very Unimportant	0%
Don't know, N/A	0%

Table 20Table 18 shows the NTG assignment for each response to M2 that was used to adjust inconsistent responses to M4. For example, if a respondent indicated that their contractor's recommendation was "very unimportant" in M4 (0% attribution) but responded that they first heard about the program from their "contractor recommendation" in M2 (100% attribution) we would average the two scores and assign 50% attribution for the contractor influence portion of the NTG analysis. For question M2, we treated pool store the same as contractor recommendation as they largely act in the same manner in educating potential participants about the benefits of VSD pumps and recommending the VSD pump over other options.

Table 20. NTG assignment decision based on response to M2

Response to M2	NTG Assignment
Contractor recommendation	100% attribution
Own research	0% attribution
Pool store	100% attribution
Other	0% attribution
Don't know	0% attribution

4 FINDINGS

This section presents our findings for ex post gross and net savings for both energy and demand, as well as an updated load shape for residential pool pumps.

4.1 Gross savings results

DNV GL used the data collected through on-site measurement[14] and participant surveys to update the key parameters used in SDG&E's workpaper, such as run time and power draw in different operating modes. We followed the gross savings methodology outline in section 3.1.3.1 to estimate unit-level ex post gross energy and demand savings for VSD pool pumps. DNV GL applied the unit-level ex post gross savings estimate to the program tracking data to estimate program-level ex post gross energy and demand savings.

4.1.1 SDG&E workpaper assumptions

Table 21 shows power draw and run time assumptions used in the SDG&E workpaper to estimate gross savings for VSD pool pumps. The workpaper assumes savings from VSD pumps result from operating just fast enough to produce proper flow rates. Since code-minimum two-speed pumps have fixed high-speed and low-speed settings, they are likely to operate at higher speeds (and consume more energy) longer than necessary. As shown in the table, the ex ante gross savings was estimated to be 1,169 kWh/year.

Table 21. Ex Ante comparison of two-speed and variable-speed pool pump[15]

Brand name	Curve-A flow (gpm)	Curve-A power (watts)	High speed time (hrs)	Low speed time (hrs)	High speed energy used (kWh)	Low speed energy used (kWh)	Annual energy used (kWh/yr)	Energy savings (kWh/yr)
Average (High Speed)	64	1,883	2.55		4.80		2,259	**1169**
Average (Low Speed)	33	425		3.26		1.39		
Pentair VS (High Speed)	50	838	2.55		2.14		1,089	
Pentair VS (Low Speed)	22	130		6.52		0.85		

4.1.2 Unit-level gross energy savings

As described in the gross savings methodology, the evaluation had to determine whether or not a seasonal adjustment to VSD pump operations was made at each site. If the logger data or on-site survey response indicated that a seasonal adjustment was made at a particular site, DNV GL then had to estimate what was done and when the seasonal adjustment started and ended. Through pump monitoring and on-site surveys with participants, DNV GL found that 35 out of the 49 successfully sampled sites did not display any

14 Additional site and measures characteristic data collected by DNV GL field staff can be found in APPENDIX F

15 Table 21 was taken directly from SDG&E's Variable-Speed Pool Pump Workpaper (WPSDGEREWP0002)

seasonal adjustments and operated their pump in the same manner year round. Table 22 shows the average power draw and run time of VSD pool pumps that were operated on year-round schedules. DNV GL estimated the energy consumption of a similar size two-speed pump (baseline) turning over the same amount of water daily for each site. As shown in the table, VSD pumps operating on year-round schedules produced gross energy savings of 1,132 kWh/year.

Table 22. Ex post energy consumption and savings of two-speed and VSD pool pumps on year-round operating schedules (n=35)

<table>
<tr><th>Year-round schedule</th><th>Curve-A flow (gpm)</th><th>Curve-A power (watts)</th><th>High speed time (hrs/ day)</th><th>Low speed time (hrs/ day)</th><th>High speed energy used (kWh/day)</th><th>Low speed energy used (kWh/day)</th><th>Days per year operated</th><th>Energy used (kWh/ season)</th><th>Energy savings (kWh/ yr)</th></tr>
<tr><td>High speed, baseline pump</td><td>64</td><td>1,883</td><td>3.47</td><td></td><td>6.54</td><td></td><td rowspan="4">365</td><td rowspan="2">2726</td><td rowspan="4">1132</td></tr>
<tr><td>Low speed, baseline pump</td><td>33</td><td>425</td><td></td><td>2.19</td><td></td><td>0.93</td></tr>
<tr><td>High speed, variable pump</td><td>36</td><td>573</td><td>4.17</td><td></td><td>2.87</td><td></td><td rowspan="2">1594</td></tr>
<tr><td>Low speed, variable pump</td><td>11</td><td>147</td><td></td><td>10.89</td><td></td><td>1.46</td></tr>
</table>

Sample size is denoted as "n"

Comparing the measured values in the table above to the estimated values in Table 21, one can see that the high speed change in wattage or "delta wattage"; is much greater for the measured values and that the measured high speed run hours are notably longer than the 2.55 hours used in the estimated savings analysis. Low speed delta wattage is similar between estimated and measured, however measured low speed VSD pump run hours are significantly longer than the estimate, while the measured low speed baseline pump hours are slightly lower than the estimate.

Overall, the achieved daily energy consumption estimates for the VSD and two-speed pumps were greater than the expected estimates, but the difference in daily energy consumption between the VSD and two-speed pumps remained similar, producing a measured annual energy savings value similar to that of the estimate.

The remaining 14 sites in the achieved sample were found to have distinct seasonal operation schemes compared to the 35 sites that operated on a year-round schedule. Table 23 shows the average power draw and daily operating hours for high speed and low speed modes for the 14 sites that had a distinct summer schedule. DNV GL found gross achieved summer-only savings of 875 kWh/year.

Table 23. Ex post energy consumption and savings of two-speed and VSD pool pumps on summer operating schedules (n=14)

<table>
<tr><th>Summer schedule</th><th>Curve-A flow (gpm)</th><th>Curve-A power (watts)</th><th>High speed time (hrs/ day)</th><th>Low speed time (hrs/ day)</th><th>High speed energy used (kWh/ day)</th><th>Low speed energy used (kWh/ day)</th><th>Days per year operated, summer</th><th>Energy used (kWh/ season)</th><th>Energy savings (kWh/ yr)</th></tr>
<tr><td>High speed, baseline pump</td><td>64</td><td>1,883</td><td>5.99</td><td></td><td>11.27</td><td></td><td rowspan="4">182</td><td rowspan="2">2185</td><td rowspan="4">875</td></tr>
<tr><td>Low speed, baseline pump</td><td>33</td><td>425</td><td></td><td>1.70</td><td></td><td>0.72</td></tr>
<tr><td>High speed, variable pump</td><td>55</td><td>932</td><td>6.50</td><td></td><td>6.27</td><td></td><td rowspan="2">1310</td></tr>
<tr><td>Low speed, variable pump</td><td>8</td><td>113</td><td></td><td>7.36</td><td></td><td>0.92</td></tr>
</table>

Table 24 shows the energy consumption and savings associated with the winter schedule for the 14 sites that did not operate on a constant year-round schedule. The total annual gross ex post energy savings for sites with distinct seasonal schedules was 1,499 kWh/year, the sum of the summer and winter savings.

Table 24. Ex post energy consumption and savings of two-speed and VSD pool pumps on winter operating schedules (n=14)

<table>
<tr><th>Winter schedule</th><th>Curve-A flow (gpm)</th><th>Curve-A power (watts)</th><th>High speed time (hrs/ day)</th><th>Low speed time (hrs/ day)</th><th>High speed energy used (kWh/ day)</th><th>Low speed energy used (kWh/ day)</th><th>Days per year operated, winter</th><th>Energy used (kWh/ season)</th><th>Energy savings (kWh/ yr)</th></tr>
<tr><td>High speed, baseline pump</td><td>64</td><td>1,883</td><td>4.17</td><td></td><td>7.86</td><td></td><td rowspan="4">183</td><td rowspan="2">1564</td><td rowspan="4">624</td></tr>
<tr><td>Low speed, baseline pump</td><td>33</td><td>425</td><td></td><td>1.64</td><td></td><td>0.70</td></tr>
<tr><td>High speed, variable pump</td><td>57</td><td>885</td><td>4.50</td><td></td><td>4.13</td><td></td><td rowspan="2">940</td></tr>
<tr><td>Low speed, variable pump</td><td>12</td><td>127</td><td></td><td>7.21</td><td></td><td>1.01</td></tr>
</table>

Table 25 shows the energy savings per season, per schedule, and finally the average unit-level annual energy savings.

Table 25. Ex post gross energy savings per season, schedule, and annual

Schedule	Quantity	Energy savings per season (kWh/yr)	Energy savings per schedule (kWh/yr)	Energy savings quantity weighted average (kWh/yr)
Year-round	35	1,132	1,132	1,237[16]
Summer	14	875	1,499	
Winter	14	624		

Table 26 presents the average unit-level gross ex post energy savings across all 49 sites included in the evaluation. DNV GL found gross energy savings of 1,230 kWh/year with 15.9% precision at 90% confidence. The evaluation found slightly more savings than the ex ante estimate which resulted in a 105% gross realization rate.

Table 26. Ex post unit-level gross energy savings summary

Ex ante energy savings (kWh/ yr)	Ex post energy savings (kWh/ yr)	Energy savings realization rate	Ex post energy savings standard deviation	Ex post energy savings standard error	Ex post energy savings error bound (90% CI)	Ex post energy savings relative precision (90% CI)
1,169	1,230	105%	830	119	±195	±15.87%

4.1.3 Site-level gross demand savings

Table 27 shows the evaluation findings for site-level ex post demand reduction. DNV GL found an average coincident demand reduction of 0.453 kW with 22.8% precision at 90% confidence.

Table 27. Ex post site-level ex post coincident demand reduction

Ex ante coincident demand reduction (kW)	Ex post coincident demand reduction (kW), n=49	Ex post coincident demand reduction standard deviation	Ex post coincident demand reduction standard error	Ex post coincident demand reduction error bound (90% CI)	Ex post coincident demand reduction relative precision (90% CI)
0.166	0.453	0.440	0.063	±0.103	±22.8%

The frequency distribution of site-level coincident demand reduction values are presented below in Figure 2.

[16] The discrepancy in annual energy savings values between this value and reported value of 1,230 kWh/ yr is because Tables 18-20, which were created to resemble the ex ante table, did not include the data on the one site that operated in a medium speed mode.

Figure 2. Ex post site-level coincident demand reduction distribution

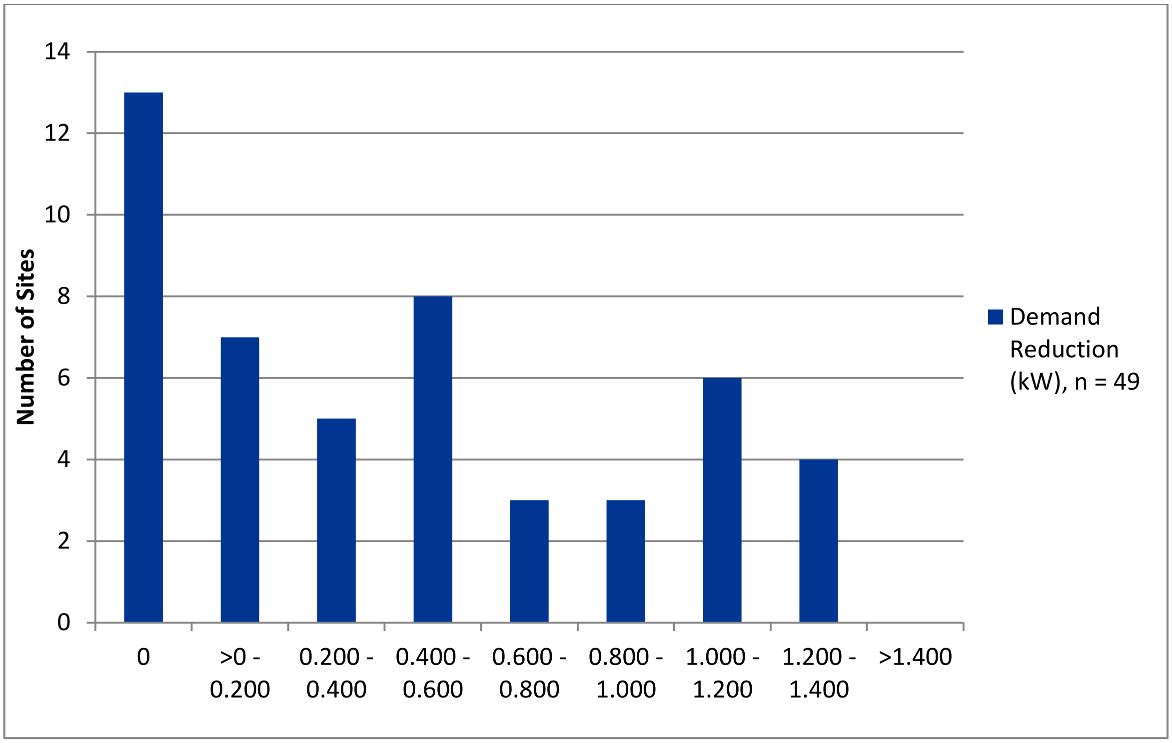


Table 28 shows the achieved site-level gross demand savings compared to the expected estimate of demand savings. The evaluation found greater average coincident demand reduction (0.453 kW) compared to the expected estimate (0.166 kW). Interestingly, the evaluation also found a smaller coincidence factor (0.161) than the estimated coincidence factor value of 0.247 which was based on responses from site contacts and pool contractors. This suggests that while the coincidence of operation is slightly lower than the expected estimate, the measured delta watts per mode is greater than the expected estimate. The achieved gross coincident demand reduction was more than twice as much as the expected estimate, resulting in a gross demand realization rate of 273%.

Table 28. Ex post site-level gross coincident demand savings summary

Source	Coincident demand reduction (kW)	Demand savings realization rate
Ex-Ante	0.166	**273%**
Ex-Post, n=49	0.453	

4.1.4 Program-level gross energy savings

DNV GL applied the ex post site-level gross savings estimate to the 2013-14 program activity to estimate gross ex-post program savings. Table 29 shows annual program activity along with ex ante and ex post program savings. As shown, the evaluation found slightly more gross savings (105%) than originally estimated by the VSD Pool Pump Program.

Table 29. Program-level ex post gross energy savings by program year

Program year	Ex ante UES (kWh/yr)	Ex post UES (kWh/yr)	Measure quantity	Ex ante gross savings	Ex post gross savings	Gross savings realization
2013	1,169	1,230	2,333	2,727,277	**2,869,590**	**105%**
2014	1,169	1,230	2,433	2,844,177	**2,992,590**	
Total (2013-2014)	1,169	1,230	4,766	5,571,454	**5,862,180**	

4.1.5 Program-level gross demand savings

Table 30 shows program-level achieved demand savings compared to the expected estimate. As shown, the evaluation found 2,157 kW of demand savings for the 2013-14 program compared to only 791 kW, or 223% of the expected estimate.

Table 30. Program-level ex post gross demand savings by program year

Program year	Ex ante UES (kW/yr)	Ex post UES (kW/yr)	Measure quantity	Ex ante gross savings (kW/yr)	Ex post gross savings (kW/yr)	Gross savings realization rate
2013	0.166	0.453	2,333	387	**1,056**	**273%**
2014	0.166	0.453	2,433	404	**1,101**	
Total (2013-2014)	0.166	0.453	4,766	791	**2,157**	

4.2 Net savings results

While the gross savings was calculated largely from the measurement data collected on site, net savings was estimated using the participant survey responses to the evaluation's NTG questions. The methodology used to calculate a NTG ratio from survey responses is detailed in section 3.2.3. DNV GL applied the ex post NTG ratio to the ex post gross energy and demand savings to arrive at ex post net program energy and demand savings.

4.2.1 NTG ratio

DNV GL used a series of survey questions to assess participant free-ridership and assign program attribution. Complete participant survey responses are presented in APPENDIX E. As described in the methodology section, the evaluation assessed both the influence of the program and the contractor on participant decision making, giving each component equal weight when scoring program attribution. Both program influence and contractor influence attribution scoring started with primary NTG questions that were used to calculate a program attribution score and then tested the consistency of respondent answers with secondary questions. If the evaluation team found conflicting responses to the primary questions and the secondary questions, they averaged the scores to arrive at a final program attribution score. In general, DNV GL found many discrepancies in participant responses. As shown in Table 31, 86% of respondents (n=105) indicated that the program's rebate was "very important" or "somewhat important" in their decision to install a VSD pool pump. Based on that response, one could deduce that the program was quite influential and free-ridership was low. However, Table 32 completely contradicts Table 31 as 76% of respondents indicated that they would have installed the same type of equipment without the VSD rebate program which would point to a high level of free-ridership.

Table 31. Importance of rebate in participants' decision to install the VSD pump (NTG1)

Response	Percent of respondents, n=105
Very important	36%
Somewhat important	50%
Neither	6%
Somewhat unimportant	6%
Very Unimportant	2%
Don't know, N/A	1%

Table 32. Type of pool pump equipment participants would have installed without the VSD rebate program (NTG3)

Response	Percent of respondents, n=105
Same type	76%
Other type	11%
Would not have replaced pump	3%
Don't know	10%

In addition to surveying 105 program participants about the program's influence on their decision to install a VSD pool pump, DNV GL conducted a short interview with two program affiliated pool pump installation contractors in an effort to better understand the contractor's influence on participant decision making. Both contractors indicated that they actively promoted VSD pumps to their customers because of the energy savings and most of their customers choose the VSD option. They also thought that the majority of their customers first heard about the VSD pump rebate from them. This was corroborated by the participant survey, which found that 61% of respondents heard about the VSD rebate from their contractor and another 18% from a pool supply store. Contractors also stated that the rebate was "very helpful" (both contractors gave it a 5 on a 1-5 scale of not at all helpful to very helpful) when they were trying to close a sale. Lastly, the contractors both suggested that they would not get nearly as many VSD customers without the rebate and would likely sell more two-speed pumps as a result.

Table 33 shows the ex post NTG ratio found by using the approach detailed in section 3.2.3. DNV GL found an ex post NTG ratio of 0.61 with 6.96% relative precision at 90% confidence. This is slightly higher than the ex ante NTG ratio of 0.55.

Table 33. NTG ratio summary

Ex Ante NTG Ratio	Ex Post NTG Ratio, n=105	Ex Post NTG Ratio Standard Deviation	Ex Post NTG Ratio Standard Error	Ex Post NTG Ratio Error bound (90% CI)	Ex Post NTG Ratio Relative Precision (90% CI)
0.55	0.61	0.27	0.026	±0.043	6.96%

4.2.2 Program-level net energy savings

DNV GL applied the ex post NTG ratio of 0.61 to the achieved gross savings to estimate net savings. Table 34 shows program-level net energy savings compared to the estimated net program savings. Based on the evaluation findings for gross savings and NTG ratio, the VSD Pool Pump Program achieved a net energy savings realization rate of 117%.

Table 34. Program-level ex post net energy savings by program year

Program Year	Ex Ante Gross Savings (kWh/yr)	Ex Ante NTG Ratio	Ex Ante Net Savings (kWh/yr)	Ex Post Gross Savings (kWh/yr)	Ex Post NTG Ratio	Ex Post Net Savings (kWh/yr)	Net Savings Realization Rate
2013	2,727,277	0.55	1,500,002	2,869,590	0.61	**1,750,450**	**117%**
2014	2,844,177	0.55	1,564,297	2,992,590	0.61	**1,825,480**	
Total (2013-2014)	5,571,454	0.55	3,064,300	5,862,180	0.61	**3,575,930**	

4.2.3 Program-level net demand savings

Table 35 shows the estimated and achieved net demand savings. On a net basis, the VSD Pool Pump Program achieved a demand savings realization rate of 302%.

Table 35. Program-level ex post net demand savings by program year

Program Year	Ex Ante Gross Savings (kW/yr)	Ex Ante NTG Ratio	Ex Ante Net Savings (kW/yr)	Ex Post Gross Savings (kW/yr)	Ex Post NTG Ratio	Ex Post Net Savings (kW/yr)	Net Savings Realization Rate
2013	387	0.55	213	866	0.61	**644**	**302%**
2014	404	0.55	222	903	0.61	**672**	
Total (2013-2014)	791	0.55	435	1,768	0.61	**1,316**	

4.3 Load shape

To develop an ex post VSD pool pump load shape, we used normalized daily average hourly profiles for each site, for each operating season (summer and winter).

Figure 3 shows the variable speed pump load profile during the summer period for all sites, and the subset of non-seasonally adjusted sites. For comparison, the estimated load profile is also included in

Figure 3. Comparing the estimated load profile to the measured profile of all sites, we can see from the figure that the ex post load peak is slightly below the ex ante peak and is much more narrow than the ex ante. This ex post profile shows the potential for shifting the pump load peak earlier in the day to reduce coincidence with the peak time periods.

Figure 3. Ex ante and ex post pool pump load profiles

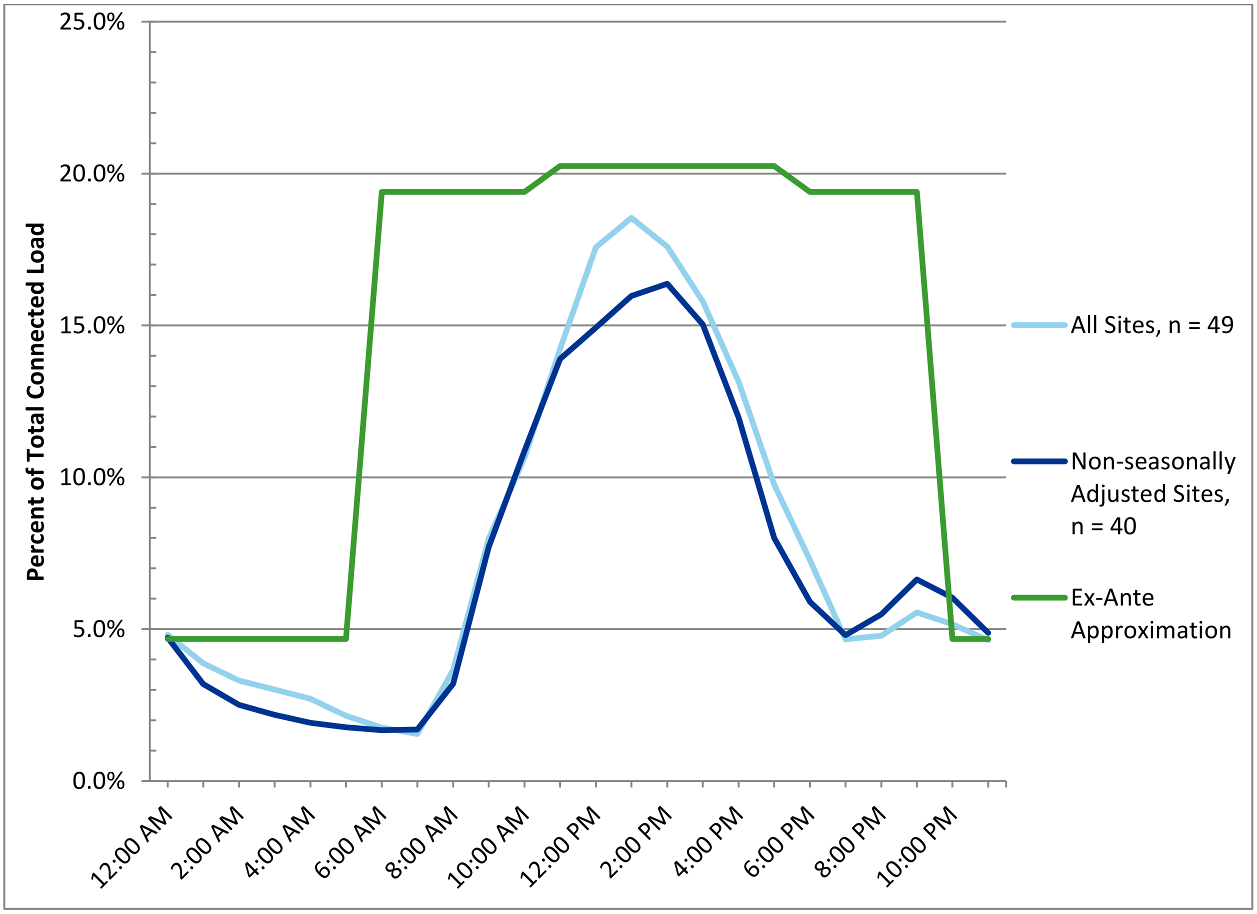
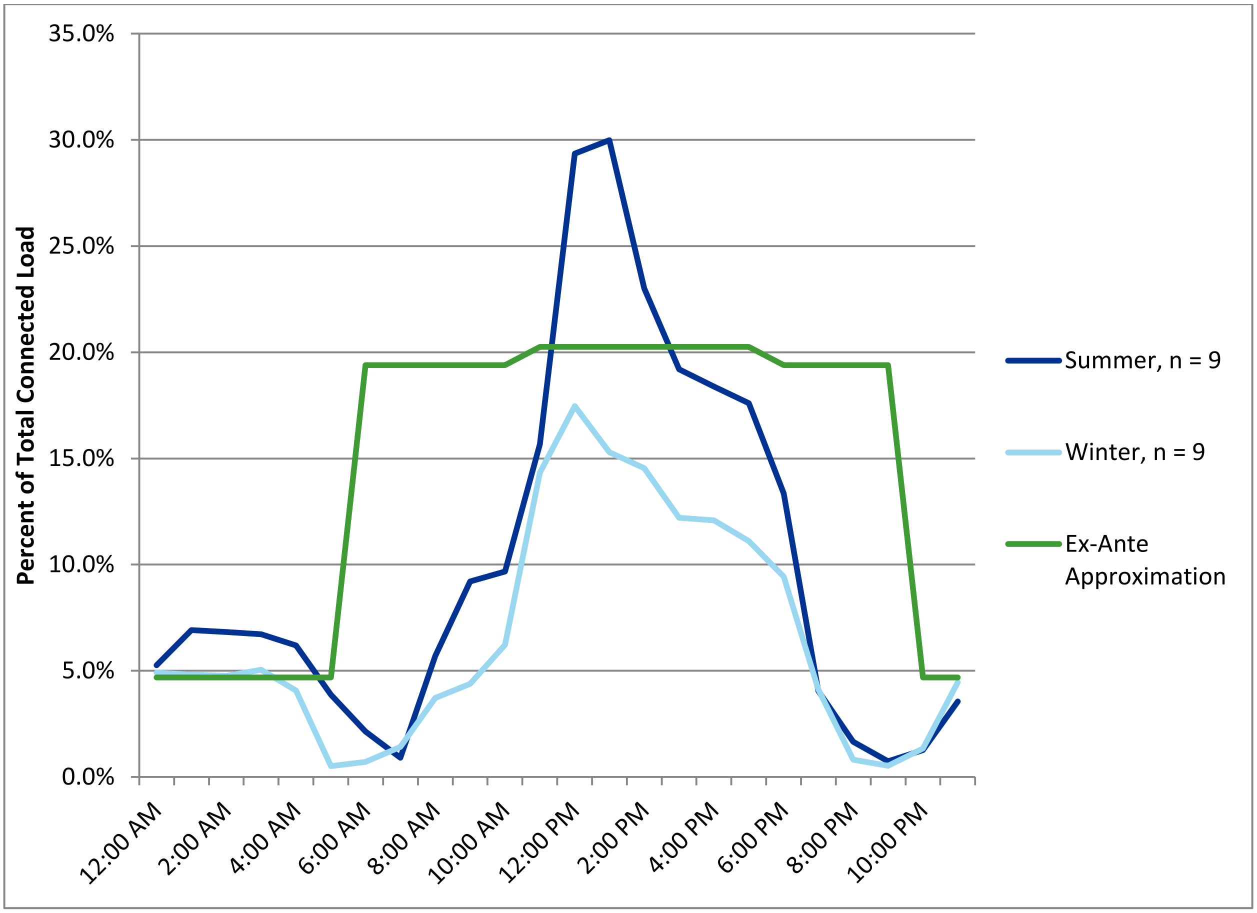


Figure 4 shows the summer and winter load profiles for the nine sites that performed seasonal operating adjustements, and again for reference, the approximated ex ante load profile. Of note in this figure is the high maximum load for the ex post summer profile and the low maximum load for the ex ante winter profile, relative to the load profile of all sites seen in

Figure 3. This suggests that there could be additional savings achieved through more widespread practice of seasonally adjusting pumping opeartions.

Figure 4. Ex ante and ex post seasonally adjusted pool pump load profiles



5 CONCLUSIONS AND RECOMMENDATIONS

After completing the evaluation of SDG&E's 2013-14 VSD Pool Pump Program, DNV GL's conclusions and recommendations are as follows:

Energy savings. The ex post gross and net energy savings found by DNV GL's evaluation were very close to the ex ante estimates used in SDG&E's ESPI workpaper, with 105% gross savings realization rate and 117% net realization rate. While the program achieved high realization rates, the evaluation suggests that updates to the workpaper assumptions for high-speed power draw, daily pool turnover, and run time in both high and low-speed are warranted. The high realization rates found by this evaluation should help alleviate some of the uncertainty that was initially associated with VSD pool pump savings estimates.

Demand savings. The ex post demand savings, both gross and net, were more than double the ex ante estimates for demand savings. The workpaper simply averaged the demand reduction in high and low speed (which assumed equal time in both modes) whereas the evaluation found that during peak times VSD pumps do not run in both modes an equal amount of time and used the actual run time in each mode to calculate average site-level demand. Additionally, DNV GL believes that there is an opportunity to achieve additional demand savings with a program or outreach initiative focused on shifting the programmed VSD pump schedule to operate off-peak.

Customer education. Anecdotally, through talking with on-site contacts, DNV GL field staff found that the majority of program participants were not well informed about their pool pump operation, schedule, or how to maintain the pump to achieve the expected energy savings. While the program already provides training to contractors and program marketing materials to participants, there is an opportunity to further educate program participants through a simple flyer or leave behind provided by the pool pump contractor focused on pump operation and maintenance that could help participants and the program achieve the desired level of energy savings.

Future evaluation. To improve on the precision achieved by this evaluation and further reduce the uncertainty around VSD pool pump energy and demand savings, DNV GL recommends a larger and more robust evaluation of VSD pool pumps in the future. DNV GL recommends that any future evaluation should attempt to measure consumption of non-participants or code-compliant two-speed pool pumps in order to improve the baseline estimate. Additionally, DNV GL recommends a larger sample for future evaluations, which is necessary to improve precision given the large degree of variability of savings on a site by site basis. Lastly, DNV GL recommends a much longer monitoring period to better capture seasonal changes and timing across sites.

Appendix AA. Standardized High Level Savings

The tables in Appendix AA summarizing natural gas savings make use of the unit MTherms – 1,000 Therms – rather than MMTherms – 1,000,000 Therms – for formatting purposes.

Gross Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0	0			
SDGE	Pool Pump	55,715	58,622	1.05	0.0%	1.05
SDGE	**Total**	**55,715**	**58,622**	**1.05**	**0.0%**	**1.05**
	Statewide	***55,715***	***58,622***	***1.05***	***0.0%***	***1.05***

Net Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0	0						
SDGE	Pool Pump	30,643	35,759	1.17	0.0%	0.55	0.61	0.55	0.61
SDGE	**Total**	**30,643**	**35,759**	**1.17**	**0.0%**	**0.55**	**0.61**	**0.55**	**0.61**
	Statewide	***30,643***	***35,759***	***1.17***	***0.0%***	***0.55***	***0.61***	***0.55***	***0.61***

Gross Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0.0	0.0			
SDGE	Pool Pump	7.9	21.6	2.73	0.0%	2.73
SDGE	**Total**	**7.9**	**21.6**	**2.73**	**0.0%**	**2.73**
	Statewide	***7.9***	***21.6***	***2.73***	***0.0%***	***2.73***

Net Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0.0	0.0						
SDGE	Pool Pump	4.4	13.2	3.03	0.0%	0.55	0.61	0.55	0.61
SDGE	**Total**	**4.4**	**13.2**	**3.03**	**0.0%**	**0.55**	**0.61**	**0.55**	**0.61**
	Statewide	***4.4***	***13.2***	***3.03***	***0.0%***	***0.55***	***0.61***	***0.55***	***0.61***

Gross Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0	0			
SDGE	Pool Pump	0	0			
SDGE	**Total**	**0**	**0**			
	Statewide	***0***	***0***			

Net Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0	0						
SDGE	Pool Pump	0	0						
SDGE	**Total**	**0**	**0**						
	Statewide	***0***	***0***						

Gross First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0	0			
SDGE	Pool Pump	5,571	5,862	1.05	0.0%	1.05
SDGE	**Total**	**5,571**	**5,862**	**1.05**	**0.0%**	**1.05**
	Statewide	***5,571***	***5,862***	***1.05***	***0.0%***	***1.05***

Net First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0	0						
SDGE	Pool Pump	3,064	3,576	1.17	0.0%	0.55	0.61	0.55	0.61
SDGE	**Total**	**3,064**	**3,576**	**1.17**	**0.0%**	**0.55**	**0.61**	**0.55**	**0.61**
	Statewide	***3,064***	***3,576***	***1.17***	***0.0%***	***0.55***	***0.61***	***0.55***	***0.61***

Gross First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0.0	0.0			
SDGE	Pool Pump	0.8	2.2	2.73	0.0%	2.73
SDGE	**Total**	**0.8**	**2.2**	**2.73**	**0.0%**	**2.73**
	Statewide	***0.8***	***2.2***	***2.73***	***0.0%***	***2.73***

Net First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0.0	0.0						
SDGE	Pool Pump	0.4	1.3	3.03	0.0%	0.55	0.61	0.55	0.61
SDGE	**Total**	**0.4**	**1.3**	**3.03**	**0.0%**	**0.55**	**0.61**	**0.55**	**0.61**
	Statewide	***0.4***	***1.3***	***3.03***	***0.0%***	***0.55***	***0.61***	***0.55***	***0.61***

Gross First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0	0			
SDGE	Pool Pump	0	0			
SDGE	**Total**	**0**	**0**			
	Statewide	***0***	***0***			

Net First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	0	0						
SDGE	Pool Pump	0	0						
SDGE	**Total**	**0**	**0**						
	Statewide	***0***	***0***						

Appendix AB. Standardized Per Unit Savings

Per Unit (Quantity) Gross Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
SDGE	Pool Pump	0	0.0%	0.0%	10.0	12,300.0	1,230.0	1,230.0
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	1	0.0%		0.0	0.0	0.0	0.0
SDGE	Pool Pump	1	0.0%		10.0	0.0	0.0	0.0

Per Unit (Quantity) Gross Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
SDGE	Pool Pump	0	0.0%	0.0%	10.0	0.0	0.0	0.0
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	1	0.0%		0.0	0.0	0.0	0.0
SDGE	Pool Pump	1	0.0%		10.0	0.0	0.0	0.0

Per Unit (Quantity) Net Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
SDGE	Pool Pump	0	0.0%	0.0%	10.0	7,503.0	750.3	750.3
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	1	0.0%		0.0	0.0	0.0	0.0
SDGE	Pool Pump	1	0.0%		10.0	0.0	0.0	0.0

Per Unit (Quantity) Net Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
SDGE	Pool Pump	0	0.0%	0.0%	10.0	0.0	0.0	0.0
SDGE	Passthrough: Pool Pump - Incentive to Contractor/Installer	1	0.0%		0.0	0.0	0.0	0.0
SDGE	Pool Pump	1	0.0%		10.0	0.0	0.0	0.0

Appendix AC. Recommendations

Study ID	Study Type	Study Title	Study Manager
tbd	Impact Evaluation	Impact Evaluation of 2013-14 SDG&E Residential VSD Pool Pump Program	CPUC

ommendat	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recommendation Recipient	Affected Workpaper or DEER
1	Res. VSD Pool Pump Program - Single Family	*Energy savings.* The ex post gross and net energy savings found by DNV GL's evaluation were very close to the ex ante estimates used in SDG&E's ESPI workpaper, with 105% gross savings realization rate and 117% net realization rate..	Gross and net savings results can be found in section 4	While the program achieved high realization rates, the evaluation suggests that updates to the workpaper assumptions for high-speed power draw, daily pool turnover, and run time in both high and low-speed are warranted. DNV GL recommends adopting the gross unit energy savings (UES) and NTG ratio found by the evaluation for VSD Pool Pumps installed at single family homes.	SDG&E	WPSDGEREWP0002
2	Res. VSD Pool Pump Program - Single Family	*Demand savings.* The ex post demand savings, both gross and net, were more than double the ex ante estimates for demand savings.	Gross and net savings results can be found in section 4	The workpaper simply averaged the demand reduction in high and low speed (which assumed equal time in both modes); whereas the evaluation found that during peak times VSD pumps do not run in both modes equally. DNV GL used the actual run time in each mode to calculate average site-level demand. DNV GL recommends adopting the gross demand savings and NTG ratio found by the evaluation for VSD Pool Pumps installed at single family homes.	SDG&E	WPSDGEREWP0002

3	Res. VSD Pool Pump Program - Single Family	*Customer education.* Anecdotally, through talking with on-site contacts, DNV GL field staff found that the majority of program participants were not well informed about their pool pump operation, schedule, or how to maintain the pump to achieve the expected energy savings.	Anecdotal information	While the program already provides training to contractors and program marketing materials to participants, there is an opportunity to further educate program participants through a simple flyer or leave behind provided by the pool pump contractor focused on pump operation and maintenance that could help participants and the program achieve the desired level of energy savings.	SDG&E	WPSDGEREWP0002
4	Res. VSD Pool Pump Program - Single Family	*Future evaluation.* To improve on the precision achieved by this evaluation and further reduce the uncertainty around VSD pool pump energy and demand savings, DNV GL recommends a larger and more robust evaluation of VSD pool pumps in the future.	Achieved sample precision can be found in Section 3.1	DNV GL recommends that any future evaluation should attempt to measure consumption of non-participants or code-compliant two-speed pool pumps in order to improve the baseline estimate. Additionally, DNG GL recommends a larger sample for future evaluations, which is necessary to improve precision given the large degree of variability of savings on a site by site basis. Lastly, DNV GL recommends a much longer monitoring period to better capture seasonal changes and timing across sites.	SDG&E	WPSDGEREWP0002

APPENDIX B. ON-SITE DATA COLLECTION FORM

Site ID:	
Owner Name:	
Occupant Name:	
Address 1:	
Address 2:	
City:	
Zip:	
Owner Phone:	
Tenant Phone:	
Mo/Yr replacement pool pump installed:	
Inspector Initials:	
Site Visit Date:	
Site Visit Time:	
SITE NOTES	
Previously Installed Pump Nameplate Info	
Type of pump that was previously installed (circle)	**Single speed Two speed VSD**
Previously Installed Pump MANUFACTURER	
Previously Installed Pump MODEL NUMBER	
Previously Installed Pump Rated Power	
Power Rating Units (circle)	**HP kW**
Age of pump previously installed (at time of replacement)	
Condition of previous pump at time of replacement (circle)	**Good (no problems) Fair (some problems) Broken**
Previously Installed Pump EFFICIENCY	
Currently Installed Pump Nameplate Info (TAKE PHOTO)	
TYPE of Pump Unit Currently installed (circle)	**Single speed Two speed VSD**
Currently Installed Pump MANUFACTURER	
Currently Installed Pump MODEL NUMBER	
Currently Installed Pump SERIAL NUMBER	
Currently Installed Pump Rated Power	
Rated Power Units (circle)	**HP kW**

Currently Installed Pump Service Factor		
Currently Installed Pump EFFICIENCY		
Currently Installed Pump Installation date		
Pump Controller Information:		
Controller Manufacturer		
Controller Model Number		
Controller Type (circle)	**Programmable Mechanical Other:_____________**	
Was the controller replaced when the pump was?		
Winter schedule--Currently Installed Pump		
Cleaning (high speed) flow, GPM		
Filtering (low speed) flow, GPM		
Weekend Hours at high speed	**(___:___ to ___:___)**	
Weekend Hours at low speed	**(___:___ to ___:___)**	
Weekday Hours at high speed	**(___:___ to ___:___)**	
Weekday Hours at low speed	**(___:___ to ___:___)**	
Dates at this schedule		
Pump controller Schedule Notes:		
Summer Schedule--Currently Installed Pump		
Cleaning (high speed) flow, GPM		
Filtering (low speed) flow, GPM		
Weekend Hours at high speed	**(___:___ to ___:___)**	
Weekend Hours at low speed	**(___:___ to ___:___)**	
Weekday Hours at high speed	**(___:___ to ___:___)**	
Weekday Hours at low speed	**(___:___ to ___:___)**	
Dates at this schedule		
Pump controller Schedule Notes:		
Is there a holiday or vacation schedule for the current pump outside of what is defined above? If yes, describe.		
Winter schedule--Previous Pump		
Cleaning (high speed) flow, GPM		
Filtering (low speed) flow, GPM (N/A if single speed pump)		
Weekend Hours at high speed	**(___:___ to ___:___)**	
Weekend Hours at low speed	**(___:___ to ___:___)**	
Weekday Hours at high speed	**(___:___ to ___:___)**	
Weekday Hours at low speed	**(___:___ to ___:___)**	

Dates at this schedule		
Pump controller Schedule Notes:		
Summer Schedule--Previous Pump		
Cleaning (high speed) flow, GPM		
Filtering (low speed) flow, GPM (N/A if single speed pump)		
Weekend Hours at high speed	**(___:___ to ___:___)**	
Weekend Hours at low speed	**(___:___ to ___:___)**	
Weekday Hours at high speed	**(___:___ to ___:___)**	
Weekday Hours at low speed	**(___:___ to ___:___)**	
Dates at this schedule		
Pump controller Schedule Notes:		
Is there a holiday or vacation schedule for the current pump outside of what is defined above? If yes, describe.		
Pool Characteristics		
Has homeowner altered the settings of the pool pump after the initial set up by the installer? (If yes, explain why/how.)		
Primary HEATING FUEL TYPE	**None Gas Propane Electric Solar Other:________**	
Secondary HEATING FUEL TYPE	**None Gas Propane Electric Solar Other:________**	
Heating set points:	**Spring: _____ Summer:_____ Fall:_____ Winter:_____**	
Describe any supplemental cleaning equipment:		
Cleaning schedule (hours/week)		
Booster pump present? If yes, record rated power		
Water features present?		
Site contact reported pool volume		
Calculated pool volume		
Filtering system type		
Pressure at filter (as found)		
Pressure at filter (after cleaning)		

Dedicated solar power for pump? (Not whole house.)	
Is there a pool cover present?	
If pool cover is motorized, does it use the pump motor?	
If there is a spa present, does it utilize the pool pump?	
Contractor/maintenance firm's frequency of visits	

Logger Information	
Hobo MicroStation Serial #	
Does the Hobo have fresh batteries? (If no, replace before install.)	
Pulse Input Adaptor Serial #	
CT size (Amps)	
Wattnode Model Number	
Wattnode Serial Number	
Filtering setting (low pump speed) counts	
Cleaning setting (high pump speed) counts	
Other pump speed (special features) counts	
Description of other pump speed uses (water features, spa, heater, etc.)	

Spot Power Measurements	**Field**	**Value**	**Time**
Filtering setting (low speed)	Volts1 Ph-Gnd V1		
	Volts2 Ph-Gnd V2		
	Amps1 A1		
	Amps2 A2		
	Power 1 W1		
	Power 2 W2		
	Power Factor1 PF1		
	Power Factor2 PF2		
	Field	**Value**	**Time**
Cleaning setting (high speed)	Volts1 Ph-Gnd V1		
	Volts2 Ph-Gnd V2		
	Amps1 A1		
	Amps2 A2		

	Power 1 W1		
	Power 2 W2		
	Power Factor1 PF1		
	Power Factor2 PF2		
Other setting (note)	**Field**	**Value**	**Time**
	Volts1 Ph-Gnd V1		
	Volts2 Ph-Gnd V2		
	Amps1 A1		
	Amps2 A2		
	Power 1 W1		
	Power 2 W2		
	Power Factor1 PF1		
	Power Factor2 PF2		

APPENDIX C. PARTICIPANT SURVEY

Database Variables

Variable	Description
<CONTACT NAME>	Program participant's full name
<ADDRESS>	Program participant address
<DATE>	Month and year Pool Pump was installed
<PHONE>	Telephone number

Introduction/Screener

I0 Hello, my name is _________, and I'm calling on behalf of the California Public Utilities Commission. May I speak with <CONTACT NAME>?

I1. Are you familiar with this household's decisions about pool equipment purchases in the past year? IF "YES" GO TO CELL1 **[IF NO, ARRANGE FOR CALLBACK]**

[IF NECESSARY:
We are conducting a survey on behalf of the Commission to better understand more about your recent pool pump purchase.

This is NOT a sales call and the information that you provide will be kept strictly confidential

The utility will use your input to improve the programs they offer to residential customers.

You may validate the legitimacy of this study by contacting Peter Franzese of the CPUC via phone at 415-703-1926]

CELL1 Great, I just need to ask a few questions before we can get started on the survey, have you received this call on a wireless phone or on a landline phone?

1	WIRELESS	GOTO CELL2
2	LANDLINE	GOTO I2
98	DON'T KNOW	CALLBACK
99	REFUSED	CALLBACK

CELL2 Are you driving a vehicle or using any equipment or machinery that requires your attention?

[INTERVIEWER: IF RESPONDENT SAYS YES, READ] Due to safety reasons we will need to call you back at a more convenient time. Thank you very much.

1	YES	CALLBACK
2	NO	I2
98	DON'T KNOW	CALLBACK
99	REFUSED	CALLBACK

I2. According to our records, your household <**ADDRESS**> received a rebate for a variable speed pool pump in <**DATE**>. Is that correct?
The SDG&E Pool Pump program provides a $200 rebate for installing a variable speed drive (VSD) pool pump.

1	Yes	PE1
2	No, different address	TT

2	No, different program date	[CORRECT DATE, PROCEED TO PE1]
98	DON'T KNOW	Find other contact/ Reschedule/TT
99	REFUSED	Find other contact/ Reschedule/TT

Previous Equipment

PE1. Before you installed the VSD pool pump, what kind of pool pump, if any, did you use?
[If needed: There are three basic kinds of pool pumps:

- Single speed pumps that only pump at one speed
- Two speed pumps that pump at two pre-set speeds
- Variable speed pumps that can pump at a range of speeds]

1	No pool pump	PE2
2	Single speed	PE2
3	Two speed	PE2
4	VSD	PE2
98	DON'T KNOW	PE2
99	REFUSED	PE2

PE2. How old was your previous pool pump when you replaced it?

1	Less than one year old	PE3
2	1 – 5 years	PE3
3	6-10 years	PE3
4	11-20 years	PE3
5	20+ years	PE3
98	DON'T KNOW	PE3
99	REFUSED	PE3

PE3. What condition was the previous pump in when it was replaced?

1	Good, still running.	M0
2	Fair, had issues.	M0
3	Poor, broken.	M0
98	DON'T KNOW	M0
99	REFUSED	M0

Rebated VSD Pump

M0 Now I have a few questions about the pool pump you installed as part of the Pool Pump program.
M1. Is the variable speed pool pump you purchased still installed?

1	Yes	M2
2	No	M1a

M1a. If no, why not?
M2. How did you first hear about the variable speed pool pump rebate?

1	Own research	M3
2	Contractor recommendation	M3
77	Other, SPECIFY	M3
98	DON'T KNOW	M3
99	REFUSED	M3

M3. What was your main reason for buying a VSD pool pump instead of another kind of pump?

1	Rebate for pool pump	M4

2	Save money on the electric bill	M4
3	Save energy	M4
4	Contractor recommended	M4
77	Other, SPECIFY	M4
98	DON'T KNOW	M4
99	REFUSED	M4

[ASK IF M2=2 OR M3=4. OTHERWISE SKIP TO NTG0]
M4. How important was your contractor's recommendation in choosing what pump to install?

1	Very unimportant	NTG1
2	Somewhat unimportant	NTG1
3	Neither important/unimportant	NTG1
4	Somewhat important	NTG1
5	Very important	NTG1
98	DON'T KNOW	NTG1
99	REFUSED	NTG1

Program Impact

NTG1. In particular, how important was the **rebate** in your decision to install the VSD pump? (*READ 5-1 IF NEEDED*)

1	Very unimportant	NTG2
2	Somewhat important	
3	Neither	
4	Somewhat important	
5	Very important	
98	DON'T KNOW	
99	REFUSED	

NTG2. Are you aware of different levels of efficiency in pool pumps?

1	Yes	NTG3
2	No	
98	DON'T KNOW	
99	REFUSED	

[If NTG2=2, 3, 98 or 99: There are three basic kinds of pool pumps:

- Single speed pumps that only pump at one speed
- Two speed pumps that pump at two pre-set speeds
- Variable speed pumps that can pump at a range of speeds]

NTG3. Without the Pool Pump rebate program, would you have installed the same type of pool pump as what you installed or different efficiency type?
IF NECESSARY: *The SDG&E Pool Pump program provides a $200 rebate for installing a variable speed drive (VSD) pool pump*.]

1	Same type	NTG4
2	Other type	NTG3a
3	Would not have replaced pump	NTG4
77	OTHER, SPECIFY____	NTG4
98	DON'T KNOW	NTG3a
99	REFUSED	NTG4

NTG3a. What type of pump would you have installed?

1	Single speed	NTG 4
2	Two speed	NTG 4
77	OTHER, SPECIFY___	NTG 4
98	DON'T KNOW	NTG 4
99	REFUSED	NTG 4

NTG4. Without the pool pump rebate, would you have replaced your pool pump at the same time as you did, earlier than you did, later than you did, or never?

1	At the same time	**SATIS0**
2	Earlier	**SATIS0**
3	Later	NTG4a
4	Never	**SATIS0**
98	DON'T KNOW	**SATIS0**
99	REFUSED	**SATIS0**

NTG4a ***[Only ask if NTG4 = "Later"]*** Approximately how many months later would you have completed the project?
[*PROMPT: IF NECESSARY, TRY FRAMING THE TIME AS BEGINNING WITH MORE OR LESS THAN TWO YEARS LATER*.]

1	Less than 6 months
2	6 months to a year
3	1-2 years
4	3-4 years
5	5 or more years
98	Don't know
99	Refused

Satisfaction

SATIS0. Next I have a few questions about how satisfied you were with different aspects of this rebate program. Did you apply for the rebate or did your contractor apply on your behalf?

1	Customer applied	SATI1
2	Contractor or other individual applied	SATI3
97	[Don't know]	SATI3
98	[Refused]	SATI3

SATIS1 For each of the following program components, please tell me how satisfied or dissatisfied you were, using a scale from one to five, where one is very dissatisfied and five is very satisfied.

		Very dissatisfied				Very satisfied	Don't know	Refused	N/A
1	The program paperwork	1	2	3	4	5	97	98	96
2	The rebate or incentive application form	1	2	3	4	5	97	98	96
3	The rebate timeliness	1	2	3	4	5	97	98	96
4	The contractor who completed the job	1	2	3	4	5	97	98	96
5	The pool pump	1	2	3	4	5	97	98	96
6	Your overall experience with the pool pump program	1	2	3	4	5	97	98	96

SATIS2a - [Only ask if SATIS1a < 3 ASK FOR EACH]
Why were you not satisfied with <PROGRAM COMPONENT>? [DO NOT READ. SELECT ALL THAT APPLY]

1	[RECORD]	SATI3
97	[Don't know]	SATI3
98	[Refused]	SATI3

SATIS3 What change, if any, have you noticed in your electric bill after the pool pump installation?

1	Increase	SATI3a
2	Decrease	SATI3a
3	No change	SATI4
97	[Don't know]	SATI4
98	[Refused]	SATI4

SATI3a Roughly how much has the bill <increased/decreased> a month?

1	[RECORD]	SATI5
97	[Don't know]	SATI5
98	[Refused]	SATI5

SATI5 What suggestions, if any, do you have for improving the program?

1	[RECORD]	
97	[Don't know]	
98	[Refused]	

SATI6 How many days per week do you use your pool in the…?

		Days/week	Don't know	Refused
1	Spring		97	98
2	Summer		97	98
3	Fall		97	98
4	Winter		97	98

On-site recruitment

R1. To better understand how the Pool Pumps use energy, we need to study how they operate. This study will involve a visit to your home sometime in September or October, and we'll pay you $100 in appreciation of your time and cooperation. Are you interested in participating in this upcoming study?
[IF ASKED FOR ADDITIONAL DETAILS: The visit should take about an hour and we will install a power meter that will monitor when the pump is running. This meter will stay in for about two months and then we will return to remove it. The second visit will take about half an hour.
IF NECESSARY: Unfortunately I don't have any more details at this time. If you have any interest in helping with the next part of the study, I'd suggest agreeing now and when someone calls to schedule the appointment, they'll be able to provide more details at that time. If you decide at that point that you're no longer interested, you're under no obligation to participate in the study.]
[IF ASKED ABOUT TIMING OF VISIT: We'll call you within the next couple weeks to set up a visit to your home.]

1	Yes	R2
2	No (ATTEMPT TO CONVERT)	T&T
98	Don't know (ATTEMPT TO CONVERT)	T&T
99	Refused (ATTEMPT TO CONVERT)	T&T

R2. Great, just to confirm – we have your address listed as **<ADDRESS>.** Is that right? *[IF NECESSARY: The researcher will use this information to find your home when he or she visits you.]*

1	Yes	R3

2	No, [SPECIFY]	R3
98	DK	T&T
99	REF	T&T

R3. We currently have your phone number listed as **<PHONE>.** Is this the best number to reach you?

1	Yes	T&T
2	No, [SPECIFY]	T&T
98	DK	T&T
99	REF	T&T

R4. We have **<day/time>** available for a one hour site visit. Will that **<day/time>** work for you? Reconfirm **<day/time>** again and provide **<your phone number>** should the participant need to cancel or change their site visit.

T&T. Those are all of the questions I have for you today. Thank you for your time, and have a great [day/evening].

APPENDIX D. Installation Contractor Survey Questions

1) How did you first learn about the SDG&E rebate program for VSD pumps?

2) What type of pool pump do your customers typically choose? (VSD or 2-speed?)

3) Do you promote VSD pumps to your customers? If so, why?

4) On a scale of 1-5 (1 being not at all helpful and 5 being very helpful), how helpful is the SDG&E rebate to you when you're closing a sale on a pool pump replacement?

5) From your perspective;
    a. Do potential customers first learn about the VSD pool pump rebates from you?
    b. Do you think customers would have installed the VSD pump if there was no rebate?
    c. Would customers have decided to install/replace their pool pump later if there was not a rebate available?

APPENDIX E. Participant survey responses

Table 36. Prior pool pump equipment type (PE1)

Response	Percent of respondents, n=105	Percent of respondents who answered / remembered, n=86
Single speed	77%	94%
No pool pump	4%	5%
VSD	1%	1%
Don't know	18%	

Table 37. Prior pool pump equipment age (PE2)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=94
1 – 5 years	19%	21%
6-10 years	36%	40%
11-20 years	29%	32%
20+ years	6%	6%
Don't know, N/A	10%	

Table 38. Prior pool pump equipment condition (PE3)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=99
Fair, had issues	34%	36%
Good, still running	36%	38%
Poor, broken	24%	25%
Don't know, N/A	6%	

Table 39. VSD pump installation verification (M1)

Response	Percent of Respondents, N=105
Yes	100%
No	0%
Don't know	0%

Table 40. How participants heard about VSD pump rebate (M2)

Response	Percent of Respondents, N=105
Contractor recommendation	61%
Own research	13%
Pool store	18%
Other	6%
Don't know	2%

Table 41. Primary reason for purchasing VSD pump (M3)

Response	Percent of Respondents, N=105
Contractor recommended	11%
Other	4%
Rebate for pool pump	1%
Save energy	17%
Save money on the electric bill	67%

Table 42. Importance of contractor's recommendation on decision to install VSD pump (M4)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=89
Very important	57%	67%
Somewhat important	22%	26%
Neither	2%	2%
Somewhat unimportant	3%	3%
Very Unimportant	1%	1%
Don't know, N/A	15%	

Table 43. Importance of rebate on decision to install VSD pump (NTG1)

Response	Percent of Respondents, N=105
Very important	36%
Somewhat important	50%
Neither	6%
Somewhat unimportant	6%
Very Unimportant	2%
Don't know, N/A	1%

Table 44. Awareness of different pool pump efficiency levels (NTG2)

Response	Percent of Respondents, N=105
Yes	69%
No	29%
Don't know	3%

Table 45. What participants would have installed without the pool pump rebate program (NTG3)

Response	Percent of Respondents, N=105
Same type	76%
Other type	11%
Would not have replaced pump	3%
Don't know	10%

Table 46. When participants would have installed the VSD pump without the pool pump rebate program (NTG4)

Response	Percent of Respondents, N=105
At the same time	67%
Later	27%
Earlier	1%
Never	1%
Don't know, N/A	5%

Table 47. [For respondents that answered “later” for NTG4] Number of months later (NTG4a)

Response	Percent of Respondents, N=29
Less than 6 months	7%
6 months	3%
6 months to a year	45%
1 to 2 years	34%
5 or more years	3%
Don't know	7%

Table 48. Who applied for the rebate (SATIS0)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=78
Contractor or other individual applied	10%	13%
Customer applied	65%	87%
Don't know	11%	
(blank)	14%	

Table 49. Participant satisfaction with program paperwork (SATIS1.1)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=80
Very dissatisfied	1%	1%
Dissatisfied	1%	1%
Neither	2%	3%
Satisfied	16%	21%
Very Satisfied	56%	74%
Don't know, N/A	24%	

Table 50. Participant satisfaction with rebate application (SATIS1.2)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=81
Very dissatisfied	1%	1%
Dissatisfied	1%	1%
Neither	4%	5%
Satisfied	12%	16%
Very Satisfied	59%	77%
Don't know, N/A	23%	

Table 51. Participant satisfaction with rebate timeliness (SATIS1.3)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=88
Very dissatisfied	1%	1%
Dissatisfied	1%	1%
Neither	7%	8%
Satisfied	18%	22%
Very Satisfied	57%	68%
Don't know, N/A	16%	

Table 52. Participant satisfaction with pool pump contractor (SATIS1.4)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=102
Very dissatisfied	3%	3%
Dissatisfied	2%	2%
Neither	4%	4%
Satisfied	8%	8%
Very Satisfied	81%	83%
Don't know, N/A	3%	

Table 53. Participant satisfaction with VSD pool pump (SATIS1.5)

Response	Percent of Respondents, N=105
Very dissatisfied	1%
Dissatisfied	0%
Neither	0%
Satisfied	12%
Very Satisfied	87%

Table 54. Participant satisfaction with overall experience (SATIS1.6)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=103
Very dissatisfied	0%	0%
Dissatisfied	0%	0%
Neither	2%	2%
Satisfied	15%	16%
Very Satisfied	81%	83%
Don't know, N/A	2%	

Table 55. Change in electric bill since installation of VSD pool pump (SATIS3)

Response	Percent of Respondents, N=105	Percent of Respondents Who Answered / Remembered, N=87
Decrease	75%	91%
No Change	8%	9%
Increase	2%	2%
Don't know	15%	

APPENDIX F. Site and Equipment Characteristics

Table 56. Previously installed pool pump equipment type

Type of Pump that was Previously Installed	Quantity of Pumps	Percent of Pumps
Single Speed	51	85%
Two Speed	3	5%
Variable Speed	2	3%
None, new pool	1	2%
Don't Know	3	5%
Total	**60**	**100%**

Table 57. Size of installed VSD pump

Currently Installed Pump Rated Power, HP	Quantity of Pumps	Percent of Pumps
3	51	85%
2	7	12%
1.5	2	3%
Total	**60**	**100%**

Table 58. Condition of previously installed pumped

Condition of Previously Installed Pump at Time of Replacement	Quantity of Pumps	Percent of Pumps
Good	23	38%
Fair	18	30%
Broken	12	20%
Don't Know	6	10%
N/A	1	2%
Total	**60**	**100%**

Table 59. Sites with heated pools

Pool Heated	Quantity of Pools	Percent of Pools
Yes	40	67%
No	15	25%
Rarely	5	8%
Total	**60**	**100%**

Table 60. Sites with supplemental cleaning equipment

Supplemental Cleaning Equipment Present?	Quantity of Sites	Percent of Sites
Yes	38	63%
No	21	35%
Don't Know	1	2%
Total	**60**	**100%**

Table 61. Pool size

Pool Volume Ranges (thousands of gallons)	Frequency	Percent
0-10	9	15%
20-30	28	47%
20-30	17	28%
30-40	3	5%
40-50	2	3%
50-60	0	0%
60-70	0	0%
70-80	1	2%
≥80	0	0%
Total	**60**	100%

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