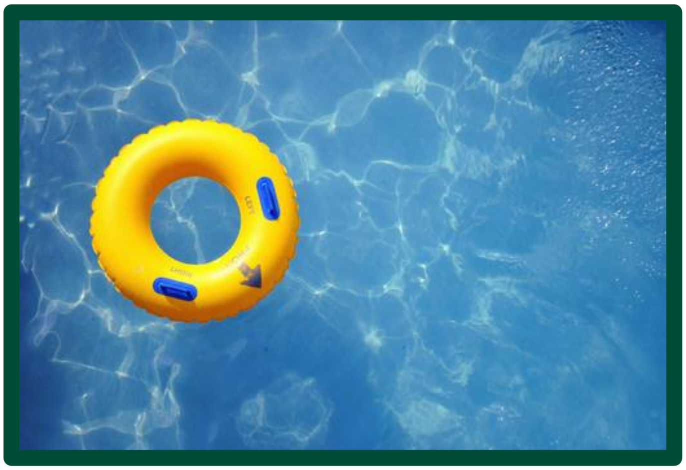
Commercial Variable Speed Pool Pump Market Characterization and Metering Study

ET13SCE1170/ET13SCE1171



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EXECUTIVE SUMMARY

This study assesses the energy savings benefits of installing pool pumps equipped with Variable Speed Drives (VSD) for commercial customers. To do this, market information was gathered from several sites across the Hotel/Motel, Education, and Assemblies market sectors to develop an estimate of operating characteristics that can be generalized across these market segments. In addition, five hotel/motel sites were selected to receive new VSD-equipped pool pumps for a metering study to measure the actual energy savings from a device to support and further validate energy savings estimates for potential inclusion into SCE incentive programs.

Pool pumps equipped with VSDs allow the owner to control the speed of the pump motor in order to save energy. Rather than run the pool pump at full motor speed for 24 hours each day, which is the way most single-speed pumps are operated, a VSD pump can operate at the minimum speed required to meet local health code requirements, saving energy in the long term. Additionally, pumps come in various sizes and increments, and may be over-sized in order to ensure the pool's turnover rate meets local health code requirements. VSD pumps afford the opportunity to "right-size" the pump for the given pool characteristics. This results in potential on-peak demand reduction.

Table 1 summarizes the energy savings and demand reduction from the five hotel/motel sites metered in this study. The values are averages for the pumps/motors monitored.

Table 1. Summary of Monitored Energy Savings and Demand Reduction

	Annual Energy Consumption (kWh/yr)	Annual Energy Savings (kWh/yr)	On-Peak Demand (kW)	On-Peak Demand Reduction (kW)
Baseline	16,017	-	2.10	-
New Technology	12,086	3,931	1.53	0.57

Table 2 normalizes the field results per unit horsepower (hp). The values are weighted averages based on nameplate hp for the motors monitored.

Table 2 Summary of Monitored Energy Savings and Demand Reduction per hp

Data Source Measured or Calculated	Average Energy Savings / hp (kWh/hp)	Average Demand Reduction / hp (kW/hp)
Measured	1,747	0.25

While three of the five field sites benefitted from energy savings by installing VSD-equipped pool pumps, it is clear from the comparison to the calculated energy savings that customer interference with the VSD controls during the metering phase did not allow for a true measurement of the savings potentials. This suggests a need to educate the customer to help them understand how to use the speed settings to achieve energy savings. The wide variability in results suggests this measure is not ready for deemed incentives for the commercial sector.

ABBREVIATIONS AND ACRONYMS

A	Amps
CEC	California Energy Commission
E	Energy Usage
gpm	Gallons per minute
hp	Horsepower
I	Current
kW	kilowatt
kWh	kilowatt-hour
P	Power
RMS	Root-mean-square
rpm	Revolutions per minute
V	Volts
VSD	Variable Speed Drive

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INTRODUCTION

The goal of this study is to assess the market characteristics and energy saving potential of retrofitting single-speed commercial pool pumps with variable speed commercial pool pumps. Researchers conducted surveys of 150 sites from three different market segments: hotels/motels, education, and assemblies. The surveys were used to obtain market penetration data and develop an estimate of operating characteristics that can be generalized across these market segments.

Five sites from the hotel/motel market segment were selected for more detailed evaluation. A new variable speed drive (VSD) was installed and monitored to determine energy savings and on-peak demand reduction potential.

BACKGROUND

Pool pumps have been outfitted with VSDs for many years. SCE currently offers incentives to residential customers to install VSD pool pumps. Commercial customers can also receive incentives, but only through a customized solution application process. Because customers typically only replace pool pumps when the unit fails, they often cannot afford to wait for the custom solution process since the process requires pre-installation and post-installation monitoring. As a result, customers often opt for the quickest and cheapest replacement option. The goal of this study is to collect data to support a prescriptive approach for incentivizing variable speed pool pumps.

ASSESSMENT OBJECTIVES

This project seeks to collect market characterization and field data for commercial VSD pool pumps. Ultimately, the intent is to gather sufficient data to develop prescriptive incentives for commercial pool pumps. Specifically, the assessment objectives are:

- Identify 50 customer sites within SCE's service territory with pools in each of the hotel/motel, education, and assembly market segments.
- Collect data to characterize the market, including operating hours, turnover rate, pump nameplate data, pump settings, filtration medium, and pool size.
- Calculate energy savings and demand reduction potential using market characteristics.
- Install a VSD pool pump and measure energy savings and demand reduction.
- Compare market characterization and field data results.
- Recommend whether or not a prescriptive incentive approach is possible.

TECHNOLOGY/PRODUCT EVALUATION

This project evaluated the energy savings and demand reduction potential of installing VSD pool pumps in hotel/motel, education, and assembly market segments. Single speed pool pumps were used as the baseline measure. To conduct the evaluation, SCE contracted an engineering firm to survey 50 sites within each segment, monitor five field installations, and then analyze the results. Field monitoring was conducted for a minimum of two weeks before and after the installation of the new VSD pump.

TECHNICAL APPROACH/TEST METHODOLOGY

The project is divided into two tasks:

- Market Characterization Survey
- Field Installation and Monitoring of Five Customer Sites

TASK 1: MARKET CHARACTERIZATION SURVEY

The project team methodically approached the survey using the following steps:

1. Select 50 survey sites from each of the market segments: hotels/motels, education, and assembly.
2. Develop on-site survey procedures.
3. Pilot on-site survey procedures on 15 customer sites and revise survey as needed.
4. Perform site surveys on remaining 135 sites.
5. Analyze survey results to characterize each market segment.

SITE SELECTION

The project team randomly selected potential survey sites for Hotels/Motels, Education, and Assemblies market segments from a customer database. Fifty sites were selected for each of the three market segments and Google Earth was used to provide an initial scan of each site. Sites were selected that had a visible pool with a volume of water that would require a pump between 2 and 5 hp. The team was able to find the requisite number of sites for the Hotels/Motels market segment, but ran into issues trying to find the needed sites for the other two segments. This is because many pools in the Education market segment tend to be larger, which require pumps larger than 5 hp, and many sites in the Assemblies segment simply do not have pools. The SCE project team and their consultant agreed to use sites from the Education segment with pumps larger than 5 hp to gain a better understanding of the typical setup for that market segment.

DEVELOP ON-SITE SURVEY PROCEDURES

For this task, the project team created an on-site questionnaire to gather the data for the market characterization, including pool and pump hours of operation, pool size (gallons), nameplate data from the pump, and measurements taken with a true Root Square Meter (RMS) meter.

Specifically the survey collected the following information:

- The annual pool operating schedule, year-round, or for specific months.
- The turnover rate required by local regulations and the actual turnover rate of the pool pump. There was no way to measure this during the survey, so it was strictly an interview question.
- The operating hours of the pool and the operating hours of the pump itself.
- The pool pump’s manufacturer and model number, according to the pump nameplate. Our survey technicians were also instructed to record whether the pump was single speed, two-speed, multi-speed, or variable speed. For this survey, multi-speed was any pump that had three or more distinct speed settings, while variable speed was any pump equipped with a VSD.
- The pool volume in gallons, if available. If the pool operator did not know how many gallons the pool held, our survey technicians were instructed to measure the length and width of the pool, and estimate the average depth.
- The pool pump’s rated flow rate (gallons per minute (gpm)) according to the pool operator or nameplate information. This is another factor that could not be directly measured because the time it takes to accurately measure flow rate was not considered cost effective for the purposes of this survey.
- The pool pump’s rated horsepower (hp), age (years), efficiency (%), service factor, and motor speed (revolutions-per-minute (rpm)) according to the pump’s nameplate information.
- Information regarding the pool’s filtration system, including the type of filters used and the pressure drop across the filters. Survey technicians were instructed to obtain both the clean pressure drop, right after the filter was changed, as well as the dirty pressure drop when the head pressure was greatest so that an average pressure drop could be calculated between both clean and dirty pressures.
- The pool pump’s current (amps) and voltage (volts) using a true RMS meter.

See *Appendix A On-site Questionnaire*, for a copy of the questionnaire.

PILOT SURVEYS

Field technicians piloted the On-site Questionnaire on 15 customer sites. The project team used the feedback from these first 15 sites to refine the survey. The primary recommendation identified was to contact the selected sites before the survey visit to increase the customer’s likelihood of participation.

COLLECT SURVEY DATA

After making adjustments to the on-site procedures and the survey questionnaire based on the results of the pilot, the remaining 135 site surveys were completed. Unfortunately, many of the selected assemblies’ locations recently closed down or were not open or staffed during the time the survey technicians visited them. Due to the low number of Assemblies with pools within SCE's service territory, less than 50 sites were surveyed for this segment.

DATA ANALYSIS AND MARKET CHARACTERIZATION

The base case power consumption is calculated using voltage (V) and current (I) with an assumed power factor of 0.8. Since a power factor was not available from the meters fielded, a value of 0.8 was assumed.[1]

Equation 1 shows the baseline annual energy usage (E) calculation.

Equation 1. Baseline Annual Energy Usage Calculation

$$E_{base}[kWh] = P_{base}[kW] * PumpHours\left[\frac{hours}{day}\right] * AnnualSchedule\left[\frac{days}{year}\right]$$

The measure case power consumption is determined from a regression analysis of data from the California Energy Commission (CEC) Appliance Efficiency Database, for Residential Pool Pumps. Since there is no significant distinction between residential and commercial pool pumps, the use of residential data is considered acceptable.

CEC SYSTEM CURVES

For each pool pump in the CEC database, flow rates and Watt draws at each of the three CEC system curves (A, B, C) are provided. Each VSD pump has several entries because they are tested at multiple speed (rpm) settings. Figure 1 shows a sample pump curve and the CEC curves and equations.

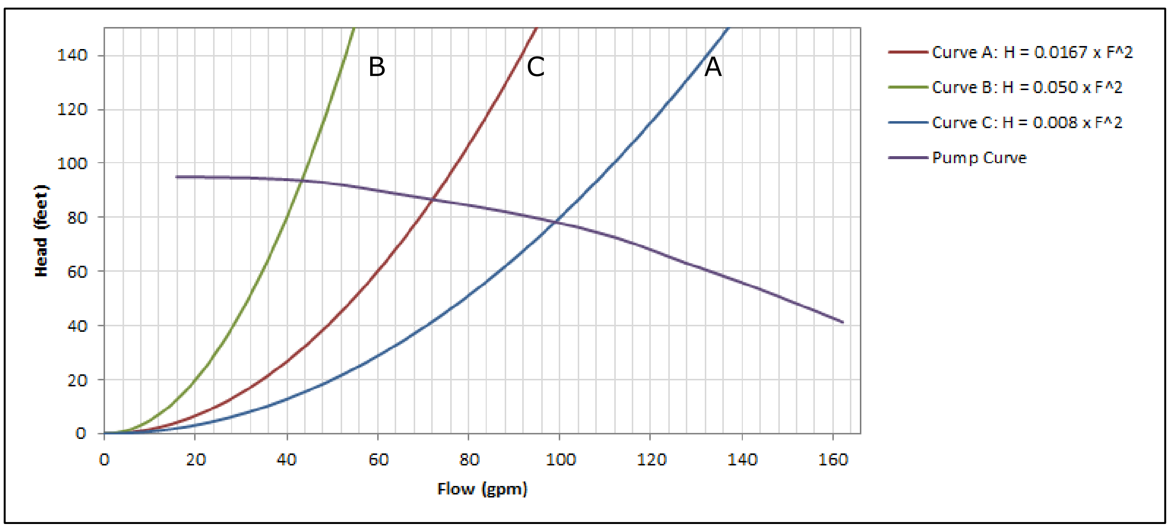

Figure 1. Sample Pump Performance Curve and CEC System Curves

Since pool plumbing head losses are site-specific, the CEC curves are used to represent three typical plumbing scenarios:

- Curve A corresponds to a system with high head losses. This is typical of a new pool with 2" PVC pipes.

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[1] The Handbook of Pumps, full load for 0.75–7.5 kW

- Curve B corresponds to an older system with very high head losses. This is typical of a pool with 1 ½" copper pipes.
- Curve C corresponds to a system with medium head losses. This is typical of a new pool with 2 ½" PVC pipes.

For the VSD pool pump measure, Curve C is used because it is assumed to be the most representative of VSD pump installations. The Los Angeles County Department of Public Health issued guidelines for the installation of VSD pumps, which state:

> *"For existing pools, installation will be allowed only when plumbing and equipment is sized to accommodate the maximum flow of the pump at 60 feet of head at the highest rpm."*

The guidelines also include specific requirements for a particular VSD pump model:

> *"Installation of this pump will only be allowed when the plumbing size of the suction line is at least 3" and the plumbing size of the return line is at least 2 ½". These are the pipe sizes needed to accommodate the maximum flow rate of this pump."*

Figure 2 shows a plot of the polynomial regression.

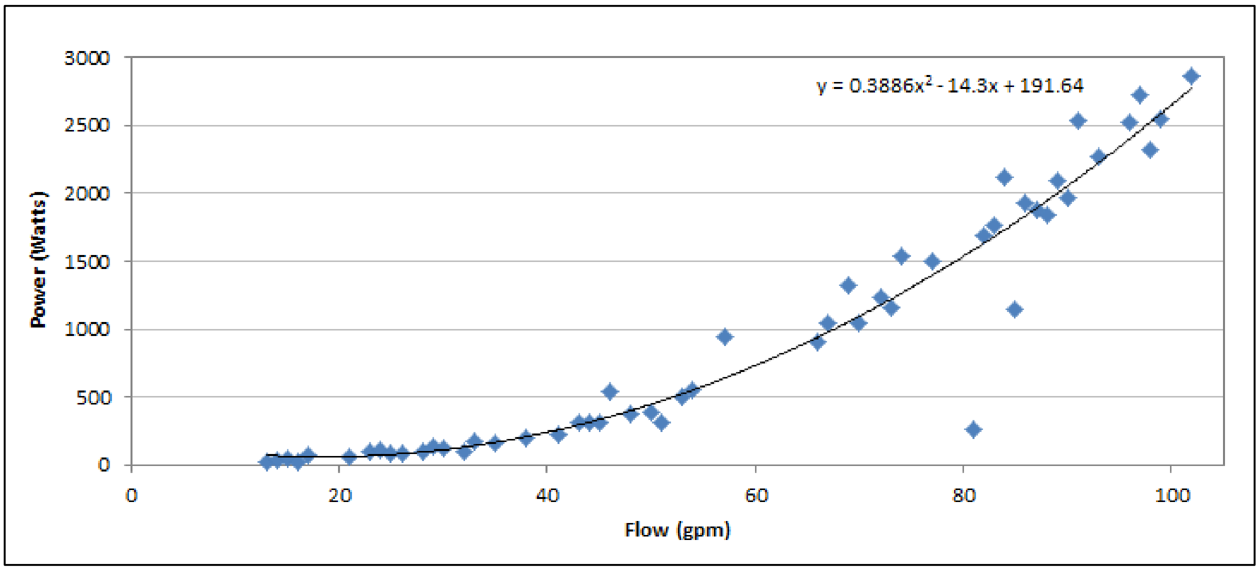


Figure 2. CEC Curve C Flow vs Power for VSD Pool Pumps

To use the regression equation presented in Figure 2, the minimum flow rate is required. Before applying the regression results, the following analysis provides a method of determining the minimum flow rate used in the regression.

Determining Minimum Flow Rate

The following equations were used to determine minimum flow rate.

The Title 24 6-hour turnover requirement for public pools is used to determine the minimum flow rate (Q_{open}) during pool open hours.

Equation 2. Minimum Flow Rate During Open Hours

$$Q_{open}[gpm] = \frac{PoolVolume[gal]}{TurnoverRate\left[\frac{hours}{turnover}\right] * 60\frac{min}{hour}}$$

Consider a typical pool that has a volume of 27,000 gallons, and a standard turnover rate of 6 hours per turnover. Equation 2 shows a solution where 75 gpm satisfies the minimum flow requirements for this example site.

$$75\ [gpm] = \frac{27{,}000\ [gal]}{6\ \left[\frac{hours}{turnover}\right] * 60\frac{min}{hour}}$$

Using the regression results shown in Figure 2, the expected power draw of a VSD pump providing 75 gpm is calculated as follows:

$$P_{measure,open} = (0.3886 * 75^2 - 14.3 * 75 + 191.64) * \frac{1\ kW}{1{,}000\ W} = \mathbf{1.31\ kW}$$

There are no regulations that specify minimum flow rates for public pools during closed hours. Pool pumps can be run at any speed during closed hours as long as the water passes health code water quality criteria (including pH, disinfectant concentration, and clarity/turbidity). Since residential pools have a suggested turnover rate of 24 hours/turnover, or 25% of the commercial pool requirement, this study uses that turnover rate for commercial pools during closed hours.

Annual Energy Usage

The following assumptions are used in the annual energy usage calculations:

- Non-filtration tasks such as pool cleaning, backwashing filters, and water features may require a pool pump to run at high speed. Typically when a residential VSD pool pump is programmed, a high speed serves these non-filtration tasks, and a low speed is used for filtration. However, the Title 24 6-hour turnover time for public pools requires that, in many cases, commercial VSD pool pumps operate at a high speed for filtration during open hours. Therefore, it is assumed that the open hours flow rate Q_{open} is sufficient to perform non-filtration tasks.
- Approximately 10% of a pool pump's operation time is used for non-filtration tasks. Therefore, the open hours are extended by applying a factor of 1.1.

Equation 3 shows how the annual energy usage (E) is calculated.

Equation 3. Annual Energy Usage for VSD Pool Pump

$$E_{measure}[kWh] = \left(P_{measure,open}[kW] * AdjustedOpenHours\left[\frac{hours}{day}\right] + P_{measure,closed}[kW] * ClosedHours\left[\frac{hours}{day}\right]\right) * AnnualSchedule\left[\frac{days}{year}\right]$$

To become a deemed measure, the VSD pool pump measure requires savings to be consolidated to one value per permutation of building type, climate zone, and program type. This was done using the following methodology:

1. Assemble initial data set

The schools' data were removed from consideration since most pumps were greater than 5 hp. This left 81 sites total for Lodging (50) and Assembly (31).

2. Remove ineligible sites

   Fifty of the 81 sites were removed from consideration for one or more of the following reasons:

   - The existing pump was not single-speed and therefore ineligible for this measure.
   - The existing pump was greater than 3 hp and not within the scope of the measure.
   - The pool required a larger pump or multiple pumps:

     The highest Curve C flow recorded in the CEC database, for any type of pool pump, is 102 gpm (except for 1 outlier at 170 gpm). Assuming a 6-hour turnover, this corresponds to a pool size of approximately 36,000 gallons. This implies that sites with a pool greater than 36,000 gallons need a pump greater than 3 hp or multiple pumps in parallel. Additionally, filter type and pipe size will limit maximum flow rate (a 2" pipe can accommodate 70-80 gpm, while a 2.5" pipe can accommodate 110-120 gpm).

     All sites meeting this criterion were removed from consideration. There will be cases where the plumbing system has less head than specified by Curve C and allows flows greater than 102 gpm, but those are not considered in this analysis.

Of the remaining eligible sites, 26 are lodging, and five are assembly; many of the assembly sites had large pools greater than 36,000 gallons. Because of the low representation of assembly sites, all 31 remaining sites were treated as a single group for analysis.

This measure is assumed to be unaffected by climate zone, so no further adjustments were made.

TASK 2: FIELD INSTALLATION AND MONITORING

Five sites from the hotel/motel market segment were selected to participate in the field monitoring task. ElitePro Recording Poly-Phase Power Meters were installed on each pool pump circuit to record a minimum of two weeks pre-installation and post-installation data. Licensed contractors were hired and instructed to install the new pumps and set the VSD to control the pumps per industry standard practice for installing such devices. Table 3 shows the power meter specifications.

Table 3. Power Meter Specifications

METER TYPE	MODEL	MEASUREMENT TYPE	SAMPLING FREQUENCY	ACCURACY
Power	Dent ElitePro	True RMS	7.28 kHz	< 1.0%

These metering devices have four input channels of current (0-6,000A), three channels of voltage (0-600V), and a sampling frequency of 7.28 kHz. The power meters were set to record current, voltage, and power every 15 minutes. This measurement was taken before and after the hotel's original pumps were replaced. The pumps were replaced with new VSD-equipped pumps and monitored for a minimum period of 14 days.

SURVEY RESULTS

HOTEL/MOTEL MARKET SEGMENT

This project focused primarily on the hotel/motel market segment due to its similarities with existing multi-family programs at SCE. The 50 sites selected in the hotel/motel market segment included 23 small roadside motels, 18 mid-sized hotels, and 9 larger resorts. For a more detailed breakdown of the results, see *Appendix B Detailed Survey Results*.

Table 4. Hotel/Motel Results Summary

SEGMENT SUBTYPE	PERCENTAGE WITH 24-HOUR OPERATION	MAJORITY OF POOL PUMP SIZE	PUMP TYPE	FILTRATION TYPE
Hotels	83%	2 hp (39%)	Single Speed (87%)	Diat. Earth (65%)
Motels	86%	< 5 hp (78%)	Single Speed (92%)	Diat. Earth (44%)

MOTELS

YEARLY OPERATING SCHEDULE AND HOURS OF OPERATION

All 23 motels are operated on a year-round basis, and while the pool hours of operation vary, the pool pumps are almost always on 24 hours a day, 7 days a week. In terms of pool pump operation, 19 of the 23 sites keep their pool pump running 24 hours a day, while the other 7 operate their pumps during the day while the pool is in use.

POOL TURNOVER RATE

In addition to hours of operation, survey technicians asked motel operators about the pool turnover rates, both those required by local counties and the actual turnover rate of the pool itself. Survey technicians found most local regulations required a turnover rate between 4 and 6 hours. However, when survey technicians asked for the actual turnover rates, they found that most motel operators did not know the current turnover rate for their pools. Of the 23 motels surveyed, only 1 motel knew that their actual turnover rate is 6 hours.

PUMP SIZE (HORSEPOWER)

The 23 motel pumps surveyed fall within the 0 to 5 hp. Figure 25, in Appendix B, displays the pool pump sizes in the motel market segment surveys.

POOL PUMP SPEED TYPE

According to the Motel segment survey results, all but three pumps are single speed. This lines up with another finding from the surveys; the operators of many surveyed sites keep the pumps running constantly 24 hours a day, 7 days a week. This is done to preserve the pools' water quality and cleanliness.

FILTRATION MEDIUM

During the survey, survey technicians found that most motels use diatomaceous earth filters with high-rate sand filters making up the next most popular group. In general, it seems that customers with smaller pumps tend to use diatomaceous earth filters.

HOTELS

YEARLY OPERATING SCHEDULE AND HOURS OF OPERATION

All 27 hotel sites surveyed operate on a year-round basis. While the pool hours of operation vary, the pool pumps are almost always on 24 hours a day, 7 days a week, with the exception of one site that only runs during summer months. In terms of pool pump operation, 23 of the 27 sites keep their pool pump running 24 hours a day, while the other four operate their pumps during the day while the pool is in use.

POOL TURNOVER RATE

In addition to hours of operation, survey technicians asked hotel operators about the pool turnover rates required by local codes and the actual turnover rate of the pool itself. Survey technicians found that most local regulations required a turnover rate between 4 and 6 hours. When asked for the actual turnover rates, most hotel operators do know the current turnover rate for their pools. However, there is still an opportunity to educate the 30% that do not know the current turnover rate for their pools. Most that did know fell between rates of 4 to 6 hours.

PUMP SIZE (HORSEPOWER)

Survey technicians found that 21 of the 27 pumps fall within the 5 hp limit set by the SCE project team. Judging from the dimensions of the pools with larger pumps, most tend to be larger lap pools for large resort hotels, rather than the typical hotel pool. In general, pump sizes are slightly larger than what was projected during Task 1. This could be due to designs for high head pressures that can come from dirty filters, or that the numbers projected in Task 1 were based on the minimum size pump needed to achieve a turnover rate of 6 hrs. Customers with larger pumps may have needed to achieve a higher turnover rate or simply opted to get pumps larger than the minimum pump size as a safety factor.

POOL PUMP SPEED TYPE

According to the Hotel segment survey results, all but two pumps are single speed. This lines up with another finding from the surveys; the operators of many surveyed sites keep the pumps running constantly 24 hours a day, 7 days a week. This is done to preserve the pools water quality and cleanliness.

FILTRATION MEDIUM

The hotels surveyed mainly use diatomaceous earth filters and high-rate sand filters, with rapid sand filters making up the next most popular group. In general, it seems that customers with smaller pumps tend to use diatomaceous earth filters.

EDUCATION MARKET SEGMENT

The education market segment consists of universities, colleges, high schools, and primary schools. The 50 selected sites in the education market segment included 36 high schools, 6 colleges, and 8 universities. Primary schools were not included in this survey as most do not have swimming pools. The findings for the education segment were somewhat different from the other two market segments. This was due to the size of the pools involved. This is because most university pools are competitive lap pools, which tend to be far larger than pools in both the hotel and assembly market segments. Therefore, many of the pumps associated with these pools were larger in comparison with the other market segments. Table 5 shows the Education results summary.

Table 5. Education Results summary

SEGMENT SUBTYPE	PERCENTAGE WITH 24-HOUR OPERATION	MAJORITY OF POOL PUMP SIZE	PUMP TYPE	FILTRATION TYPE
Universities	100%	>5 hp (66%)	Single Speed (83%)	Sand (67%)
Colleges	80%	>5 hp (80%)	Single Speed (100%)	Sand (40%)
High Schools	93%	>5 hp (93%)	Single Speed (90%)	Sand (97%)

UNIVERSITIES

YEARLY OPERATING SCHEDULE AND HOURS OF OPERATION

All six of the universities surveyed operated on a year-round basis, and similarly all eight pool pumps operated on a 24 hour a day basis, 7 days a week, even when the pools are only open for use during varying hours of the day. This may be due to the fact that university maintenance would rather have the pumps running constantly to keep the pool water clean and clear than risk shutting down the pumps to save energy.

POOL TURNOVER RATE

Unlike hotels and motels, many universities seemed to be aware of their actual turnover rate. Again the most common turnover rates were either four or six hours.

PUMP SIZE

Nearly all the pools found in the universities were competitive-size lap pools, used in school swimming competitions, water polo, and other aquatic sports. The smaller pools found were usually much shallower wading pools used for swimming lessons and similar activities.

POOL PUMP SPEED TYPE

Five out of the six pumps from the Universities surveyed are single speed. As many of these pumps are potentially older, large motors, it is likely not feasible to install a VSD without doing a complete retrofit that would involve removing the old large motor and replacing it with several smaller motors. The prevalence of single speed pumps brings up another finding from the surveys; the operators of most surveyed University pools keep the pumps running 24 hours a day, 7 days a week. This is done to preserve the pools water quality and cleanliness.

Filtration Medium

Universities surveyed mainly use high rate sand filters, with only a few using diatomaceous earth or rapid sand filters. There is an evident correlation between larger size pumps and high rate sand filters.

Colleges

Yearly Operating Schedule and Hours of Operation

Most colleges operate on a year-round basis, although the schedules for the pools often depend on school schedules, which vary more than a typical public pool schedule. Like universities, most colleges keep their pool pumps running on a 24/7 schedule. This may be due to the fact that the operation of the pool pumps is handled primarily by the school district rather than the school itself.

Pool Turnover Rate

Also in contrast to our survey of hotels and motels, the majority of colleges seemed to be aware of what their actual turnover rate was, which again may be due to the fact that the school district often appeared to handle pool maintenance. Once again, the most common turnover rates were either 4 or 6 hours.

Pump Horsepower

As stated earlier in this report, most of the pumps found at these locations were significantly larger than 5 hp, due to the size of pools they served. Survey technicians reported that nearly all the pools found in the college surveys were competitive-size lap pools, used in school swimming competitions and other aquatic sports. The smaller pools found were usually much shallower wading pools used for swimming lessons and similar activities.

Pool Pump Speed Type

All five pumps surveyed at colleges were single speed. As many of these pumps are potentially older, large motors, it is likely not feasible to install a VSD without doing a complete retrofit that would involve removing the old large motor and replacing it with several smaller motors. The prevalence of single speed pumps brings up another finding from the surveys; the operators of most surveyed Education sites keep the pumps running 24 hours a day, 7 days a week, likely in order to preserve the water quality and cleanliness of their pools.

Filtration Medium

During the pool pump survey, survey technicians found that colleges use high rate sand filters or diatomaceous earth filters, with only a few using rapid sand filters. It appears that schools with larger-size pumps use high rate sand filtration more often.

HIGH SCHOOLS

YEARLY OPERATING SCHEDULE AND HOURS OF OPERATION

Most of these sites are operated on a year-round basis, although the schedules for the pools often depend on school schedules, which vary more than a typical public pool schedule. Compared to hotels, a much higher percentage of pools keep their pumps running 24 hours per day. This may be because the operation of the pool pumps are handled primarily by the school district rather than the school itself.

POOL TURNOVER RATE

Also in contrast to our survey of motels, more high schools are aware of their actual turnover rate, which again, may be because the school district handles the maintenance of the pools. The most common turnover rates are between four and six hours.

PUMP HORSEPOWER

As stated earlier in this report, most of the pumps found at these locations were significantly larger than 5 hp, because of the size of pools they served. ASWB survey technicians reported that nearly all the pools found in the education surveys where competitive-sized lap pools, used in school swimming competitions and other aquatic sports. The smaller pools were usually much shallower wading pools used for swimming lessons and similar activities.

POOL PUMP SPEED TYPE

All but four pumps from the education market segment are single speed. As many of these pumps are potentially older, large motors, it is not feasible to install a VSD without doing a complete retrofit that would involve removing the old large motor and replacing it with several smaller motors. The prevalence of single speed pumps brings up another finding from the surveys; the operators of most surveyed education sites keep the pumps running 24/7. This is done to preserve the pools water quality and cleanliness.

FILTRATION MEDIUM

During the pool pump survey, survey technicians found schools and colleges use high rate sand filters or rapid sand filters, with only a few using diatomaceous earth filters. It appears that schools with larger sized pumps use high rate sand filtration more often.

ASSEMBLIES MARKET SEGMENT

This market segment covers a wide variety of public sites from fitness centers to amusement parks. This survey includes 8 gyms and fitness centers, 7 recreational parks, 4 amusement parks, 26 sports and recreation clubs, 2 religious retreats, and 3 public pools. Assembly sites showed the most variety among the data collected, mostly due to the wide variety of facility types within this market segment.

Table 6. Assemblies Results Summary

Segment Subtype	Percentage with 24-Hour Operation	Majority of Pool Pump Size	Pump Type	Filtration Type
Assemblies	84%	<5 HP (86%)	Single Speed (84%)	Diat. Earth 45%

Yearly Operating Schedule and Hours of Operation

Assemblies have roughly the same amount of partial schedules during specific months of the year compared to both the hotels/motels and education market segments. Of the three segments, Assemblies are also slightly more likely to run their pumps only during hours when the pool is open. Compared to the other market segments, Assemblies appear to be most similar to Hotels in terms of their operating schedules. The majority of sites still operate 24 hours a day, but there is a larger percentage of the population that shuts down their pumps after the pool closes.

Pool Turnover Rate

Similar to hotels/motels, most pool operators for assemblies do not know their actual turnover rate, so a similar opportunity to educate the customer exists here. Turnover rates between four and six hours appear to be the most common rates for these customers, which lines up with the required rates for these regions.

Pump Horsepower

Although most of the pumps the survey technicians encountered at Assemblies fall between 1.5 and 3 hp, there appears to be a greater range of pump horsepower compared to the hotel/motel market segment. This may be due to the wider range of pools used in Assemblies, ranging from smaller recreational pools found at hotels, to larger lap pools at gyms and other physical fitness centers within the Assemblies segment. A single 50 hp pump was surveyed at an aquatics center in Thousand Oaks, California, which serves an Olympic size lap pool. While most pumps for Assemblies fall within smaller motors, it is not uncommon to encounter pools that are closer to those found within the Education market segment.

Pool Pump Speed Type

Similar to the hotel/motel and education segment survey results, nearly all of the pumps are single speed. However, Assemblies had the largest percentage of variable speed pumps already installed; 4 out of the 31 surveyed. The owners of most surveyed Assemblies' sites keep the pumps running 24/7 to preserve the pools' water quality and cleanliness.

Filtration Medium

For Assemblies, diatomaceous earth filters are again the most popular type of pool filter, followed by High-Rate and Rapid Sand filters. One site was marked down as "unknown" because access to the filtration system was not possible at the time of the survey.

SUMMARY OF FINDINGS

Five lodging sites were selected for pre- and post-installation metering to measure the potential energy savings and demand reduction from the new VSD-equipped pool pumps. These five hotels are identified in Table 7.

Table 7. HOTEL/MOTEL Information

SITE NUMBER	HOTEL/MOTEL	HOTEL LOCATION	ORIGINAL PUMP	REPLACEMENT PUMP
1	Hotel	Palmdale	2 HP	2 hp Variable Speed
2	Hotel	Palm Springs	2.0 HP / 0.75 HP	3 hp / 3 hp Variable Speed
3	Motel	Palm Springs	1.5 HP	3 hp Variable Speed
4	Hotel	Buena Park	2 HP	2 hp Variable Speed
5	Hotel	Claremont	3 HP	2 hp Variable Speed with Suction and Discharge Flow Indicators

All five hotels received pool pumps with VSDs. Several of these sites received larger pumps and the installers set the maximum power draw to limit the loading to match the baseline/existing equipment. In some cases, the energy consumption increased as a result of excessive allowable power through the operator interface. The fifth hotel was retrofitted with a new pool pump equipped with a VSD and supplemental flow read-outs. The flow readouts for the fifth site were specified due to issues with the previous sites; in some cases, the hotel/motel management set the speed on the VSDs back up to the highest speed after the pool pumps had been installed and configured, negating potential savings.

MONITORED DATA ANALYSIS

Table 8 shows a summary of the average pre- and post-installation energy consumption measured at each site. The fourth column of the table shows the energy savings for each monitored site, calculated as the difference between the pre- and post-installation energy consumption measurements.

Table 8. Summary of kWh Savings

SITE NUMBER	AVERAGE ANNUAL ENERGY CONSUMPTION PRE-INSTALL (KWH)	AVERAGE ANNUAL ENERGY CONSUMPTION POST-INSTALL (KWH)	AVERAGE ANNUAL ENERGY SAVINGS (KW)
1	10,804	8,906	1,898
2	25,730	21,321	4,409
3	16,752	17,054	- 302
4	7,870	11,322	-3,452
5	18,927	1,826	17,101
AVERAGE	16,017	12,086	3,931

Table 9 shows a summary of the average pre- and post-installation power (demand) measured at each site. The fourth column of the table shows the demand reduction for each monitored site, calculated as the difference between the pre- and post-installation average on-peak demand measurements.

Table 9. Summary of On-Peak kW Demand Reduction

SITE NUMBER	AVERAGE ON-PEAK* DEMAND PRE-INSTALL (KW)	AVERAGE ON-PEAK DEMAND POST-INSTALL (KW)	ON-PEAK DEMAND REDUCTION (KW)
1	1.72	1.30	0.42
2	2.96	2.69	0.27
3	1.89	1.95	- 0.06
4	1.01	1.35	- 0.34
5	2.90	0.36	2.54
AVERAGE	2.10	1.53	0.57

*On-Peak period is Noon to 6 PM

CALCULATED DATA ANALYSIS

Survey results were used to calculate energy savings and demand reductions for the Lodging sector. The following results were calculated utilizing the survey data collected from the Lodging sector during the field investigation phase of the project. Some of the surveyed sites were eliminated from the calculations because they have two speeds or VSD pumping systems in place.

Table 10 shows the calculated value for the average pre- and post-installation energy consumption for a reduced sample of the surveyed Lodging sites. The sample of surveyed lodging sites was confined to those whose baseline pumps were at a constant speed and there was sufficient information for a reasonably accurate calculation. The third column of the table shows the energy savings for the reduced population of hotels. The energy savings are calculated as the difference between the pre- and post-installation energy consumption estimates.

Table 10. Summary of Calculated kWh Savings

Average Annual Energy Consumption Pre-Install (kWh)	Average Annual Energy Consumption Post-Install (kWh)	Average Annual Energy Savings (kWh)
13,488	5,417	8,071

Table 11 shows a summary of the average pre- and post-installation power (demand) measurements calculated at a reduced sample of the surveyed Lodging sites. The sample of surveyed Lodging sites was confined to those whose baseline pumps that were at a constant speed and there was sufficient information for a reasonably accurate calculation. The third column shows the demand reduction for the reduced sample population of hotels. The demand reduction is calculated as the difference between the pre- and post-installation demand estimates.

Table 11. Summary of On-Peak kW Demand Reductions

Average Demand Pre-Install (kW)	Average Demand Post-Install (kW)	Demand Reduction (kW)
1.65	0.95	0.69

AVERAGE ENERGY AND POWER DENSITIES

Table 12 shows the energy and power densities for the estimated and measured data summarized in the preceding tables. The horsepower used for these calculations is the nameplate hp on the motor. The values in Table 12 are weighted averages based on nameplate hp of the motors surveyed and monitored.

Table 12. Summary of On-Peak Energy and Demand Reductions

Data Source Measured or Calculated	Average Energy Savings / hp (kWh/hp)	Average Demand Reduction / hp (kW/hp)
Measured	1,747	0.25
Calculated	4,528	0.38

FIELD MONITORING RESULTS

POOL PUMP RETROFIT – SITE 1

Site 1 was equipped with a 2 hp single-speed pump while conducting their on-site survey. The contractor for this site replaced the original pump with a 2 hp pool pump equipped with VSD, programmed the speed setting to 2,500 rpms during the day, and then turned the pump off during non-operational hours.

Figure 3 and Figure 4 show the daily energy consumption recorded at the site during the pre- and post-installation metering periods. The horizontal axis provides the day of the month during the monitoring periods and the vertical axis provides the daily energy consumption during the monitoring periods.

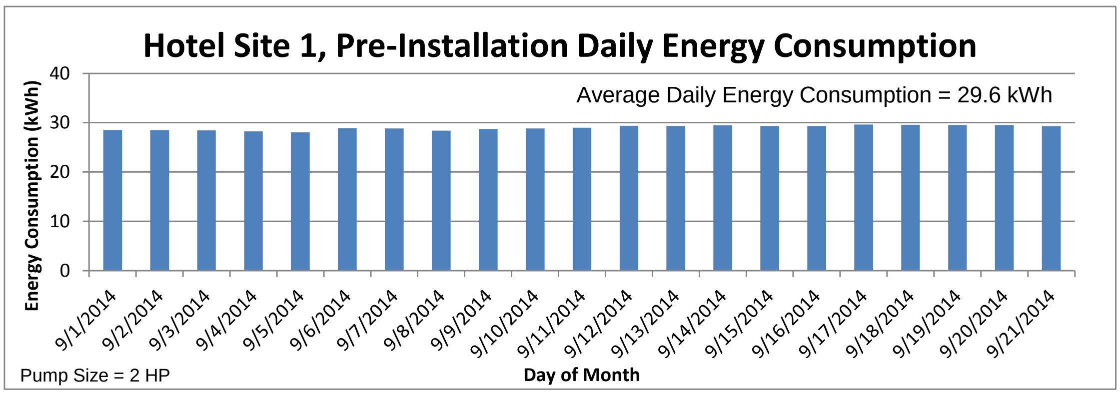


Figure 3. Hotel Pre-Installation Daily Energy Consumption – Site 1

The representative baseline monitoring period was maintained for 20 days. Logging recorded an average daily energy consumption of 29.6 kWh during the baseline/pre-installation monitoring period.

The post-installation monitoring period was also maintained for 20 days. Figure 6 shows the post-installation monitoring data for Site 1. The usage was consistent throughout this period and represents the settings that the customer intends to use.

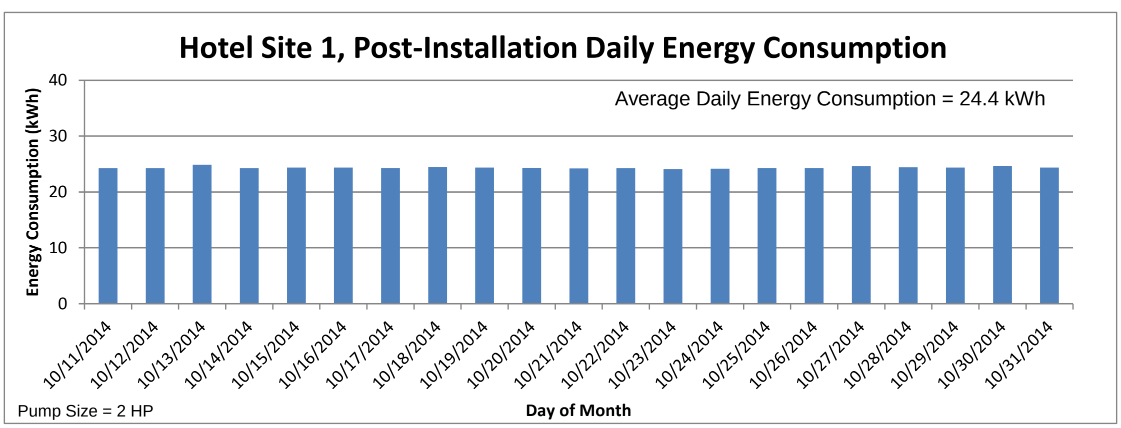


Figure 4. Hotel Post-Installation Daily Energy Consumption – Site 1

Post-installation logging recorded an average daily energy consumption of 24.4 kWh. The average daily energy savings was calculated as 5.2 kWh.

The pump operates all days of the year. Multiplying the average daily baseline energy consumption by 365 days in a year provides the annual baseline energy consumption for this pump. Equation 4calculates the annual energy usage and savings for the VSD pool pump for Site 1.

Equation 4. Annual Energy Usage and Savings for VSD Pool Pump –Site 1

$$E_{Base}[kWh] = \left(E_{Baseline,Daily}[kWh] * AnnualSchedule\left[\frac{days}{year}\right]\right)$$

Baseline annual energy consumption:

$$10{,}804_{\mathrm{Baseline,Annual}}[\mathrm{kWh}] = \left(29.6_{\mathrm{Baseline,Daily}}[\mathrm{kWh}] * 365\left[\frac{\mathrm{days}}{\mathrm{year}}\right]\right)$$

Post-installation annual energy consumption:

$$8{,}906_{\mathrm{Post,Annual}}[\mathrm{kWh}] = \left(24.4_{\mathrm{Post,Daily}}[\mathrm{kWh}] * 365\left[\frac{\mathrm{days}}{\mathrm{year}}\right]\right)$$

Annual energy savings:

$$1{,}898_{\mathrm{Savings,Annual}}[\mathrm{kWh}] = \left(10{,}804_{\mathrm{Base,Annual}}[\mathrm{kWh}] - 8{,}906_{\mathrm{Post,Annual}}[\mathrm{kWh}]\right)$$

Figure 5 and Figure 6 show the pre- and post-installation hourly load profiles averaged over the course of their respective periods. The horizontal axis provides the time of day during the monitoring periods and the vertical axis provides the average load on the pump, in kW, for each hour of the day during the respective monitoring periods.

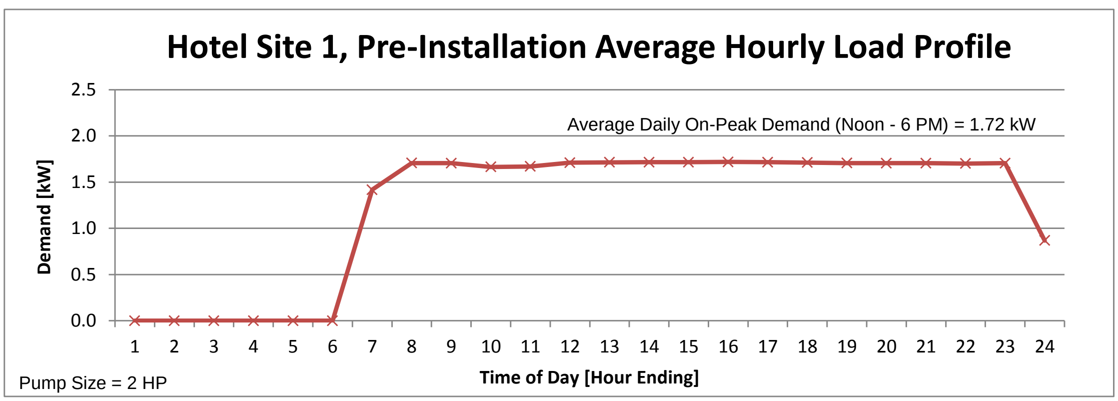


Figure 5. Hotel Pre-Installation Hourly Average Load Profile Site – 1

Logging recorded an average demand during the on-peak period (noon to 6 PM) of 1.72 kW in the baseline/pre-installation period.

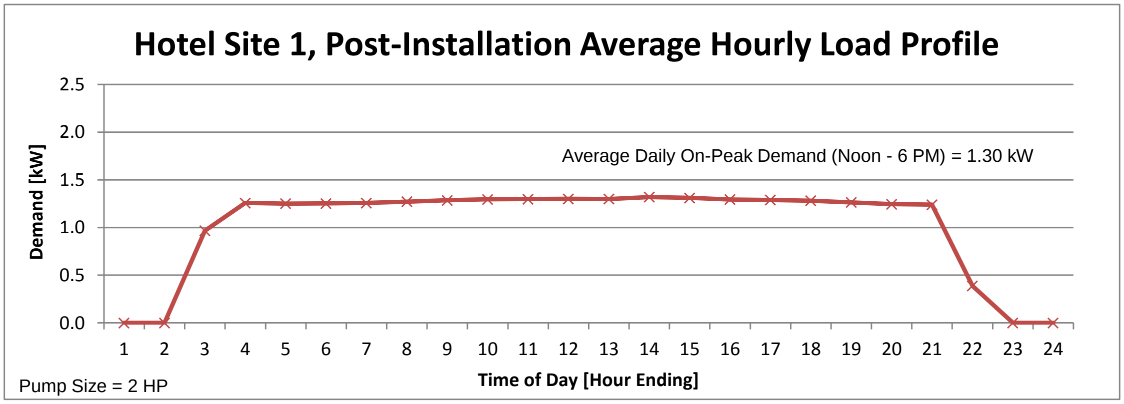


Figure 6. Hotel Post-Installation Hourly Average Load Profile – Site 1

Post-installation monitoring recorded an average demand of 1.30 kW during the same noon to 6 PM timeframe of the post-installation period. The difference of 0.42 kW represents the average daily demand reduction during the on-peak period.

Pool Pump Retrofit – Site 2

Site 2 was equipped with two pumps:

- A 2 hp single-speed pump
- A 0.75 hp single-speed pump

Two pumps are used in this pool because of the unique wading shelf. The wading shelf covers a section of the pool and separates the shallow section from the deeper sections of the pool. The wading shelf section of the pool requires its own circulation feed to ensure that it gets adequate water flow from the filter. Instead of tapping directly off of the main circulation loop, the designers included a separate pump and plumbing loop to supply filtered water to this section of the pool.

The installation contractor for this site replaced the original pumps with two 3 hp VSD pool pumps that were set to provide the required flow for the separate sections of the pool.

Figure 7 and Figure 8 show the daily energy consumption recorded at the site during the pre- and post-installation metering periods. The horizontal axis provides the day of the month during the monitoring periods and the vertical axis provides the daily energy consumption of the pump during the monitoring periods.

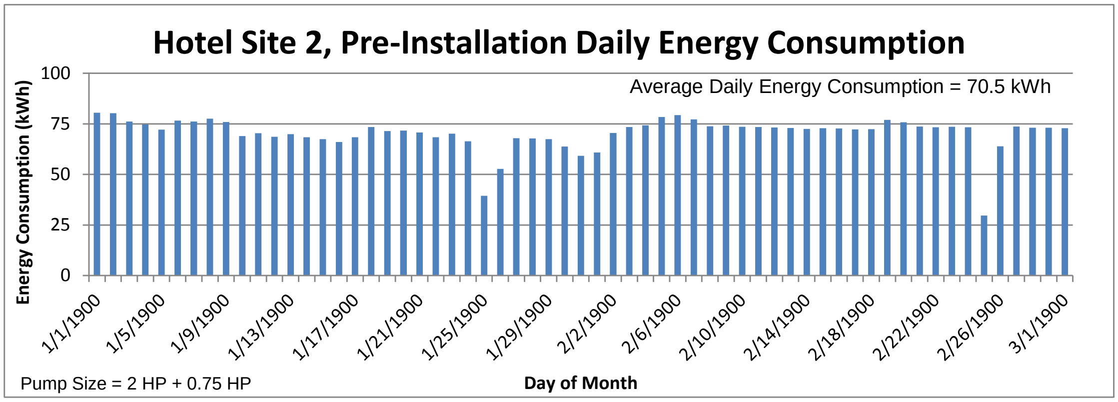


Figure 7. Hotel Pre-Installation Daily Energy Consumption – Site 2

The average daily energy consumption was 70.5 kWh during the pre-installation monitoring period.

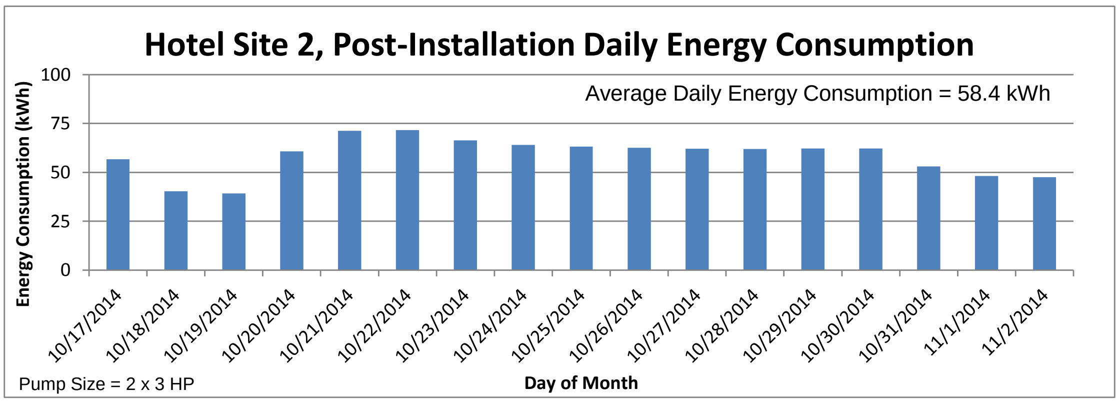


Figure 8. Hotel Pre-Installation Daily Energy Consumption – Site 2

Equation 5 shows that the average daily energy consumption was 58.4 kWh during the post-installation monitoring period. The daily average energy savings was recorded as 46.9 kWh for this site.

Equation 5. Annual Energy Usage and Savings for VSD Pool Pump – Site 2

$$E_{Base}[kWh] = \left(E_{Baseline,Daily}[kWh] * AnnualSchedule \left[\frac{days}{year}\right]\right)$$

Baseline annual energy consumption:

$$25{,}730_{\text{Baseline,Annual}}[\text{kWh}] = \left(70.5_{\text{Baseline,Daily}}[\text{kWh}] * 365 \left[\frac{\text{days}}{\text{year}}\right]\right)$$

Post-installation annual energy consumption:

$$21{,}321_{\text{Post,Annual}}[\text{kWh}] = \left(58.4_{\text{Post,Daily}}[\text{kWh}] * 365 \left[\frac{\text{days}}{\text{year}}\right]\right)$$

Annual energy savings:

$$4{,}410_{\text{Savings,Annual}}[\text{kWh}] = \left(25{,}730_{\text{Base,Annual}}[\text{kWh}] - 21{,}321_{\text{Post,Annual}}[\text{kWh}]\right)$$

Figure 9 and Figure 10 show the pre- and post-installation hourly load profiles averaged over the course of their respective periods. The horizontal axis provides the time of day during the monitoring periods and the vertical axis provides the average load on the pump, in kW, for each hour of the day during the respective monitoring periods.

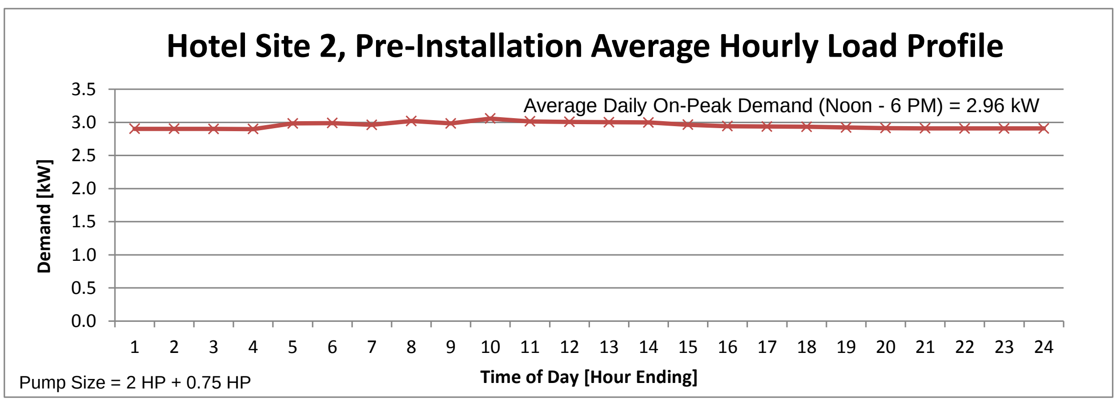


Figure 9. Hotel Pre-Installation Hourly Average Load Profile – Site 2

Logging recorded an average demand during the on-peak period (noon to 6 PM) of 2.96 kW in the baseline/pre-installation period. It should be noted that it is not unusual for this combination of motors to draw this much power. In the pool pump industry, the motors are sized with high service factors allowing them to use significantly more power than what is typically expected from a standard motor. A typical ¾ hp motor can have a service factor of 1.65, which allows the motor to be driven to the equivalent of a 1.25 hp motor with respect to Watt draw. Some motors are being installed with service factors of 1.87, which makes their nameplate hp less significant.

The installation contractor installed two identical 3 hp pumps equipped with VSDs at this site. Even though the baseline pumping system included a 2 hp pump and a ¾ hp pump, the installation of a combined 6 hp in pumping capability is acceptable based on the configuration of the VSD. Each individual pump with VSD has been installed to operate within the parameters required to serve the specific sections of the pool that are assigned to the pump. By limiting the pump’s maximum power draw, the installation contractor has effectively installed the equivalent pumping scenario as was installed prior to the retrofit to the VSD pumping system.

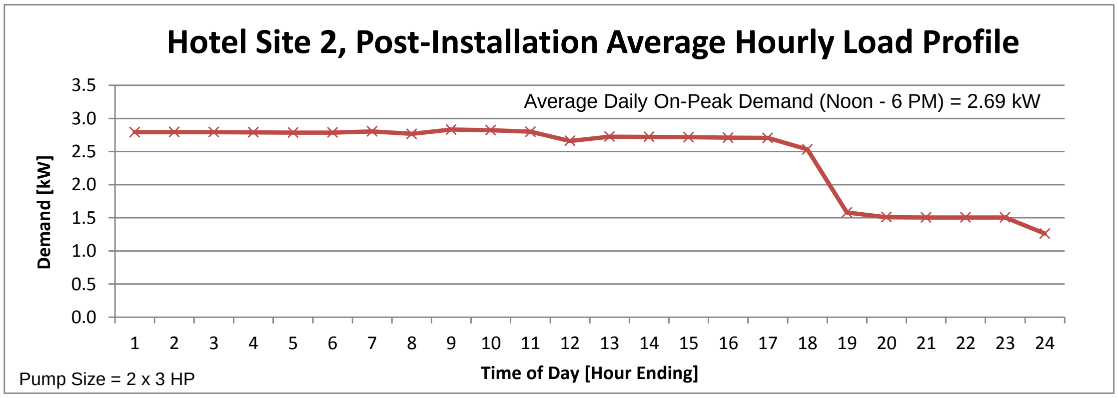


Figure 10. Hotel Post-Installation Hourly Average Load Profile – Site 2

The new system provides the operators the opportunity to reduce the speed of the pumps during the latter hours of each day, which saves energy on a daily basis. There has been a reduction of the on-peak demand provided by the new system due to increased pumping efficiency. Post-installation monitoring recorded an average demand of 2.69 kW during the same noon to 6 PM timeframe of the post-installation period. The difference of 0.28 kW represents the average daily demand reduction during the on-peak period (noon to 6 PM).

It appears, from the data, that this customer continues to tune the system and the energy savings may improve over time due to these continued tuning efforts.

Pool Pump Retrofit – Site 3

Site 3 was equipped with a 1.5 hp single-speed pump. The contractor for this site replaced the original pump with a 3 hp VSD pool pump. The settings for this pump were matched to the pool’s required flow rates at the time of the installation. The contractor set the maximum power draw to closely match the settings measured from the existing circulation pump.

However, when picking up the metered data, the field engineer found that the speed settings had been set back to the highest setting. The project team believes that the customer adjusted the speed settings after the contractor installed the new pump. This may have been due to a lack of education on the customer’s part about the speed calculations the contractor did during the installation.

Figure 11 and Figure 12 show the daily energy consumption recorded at the site during the pre- and post-installation metering periods. The horizontal axis provides the day of the month during the monitoring period and the vertical axis provides the daily energy consumption of the pump during the monitoring period.

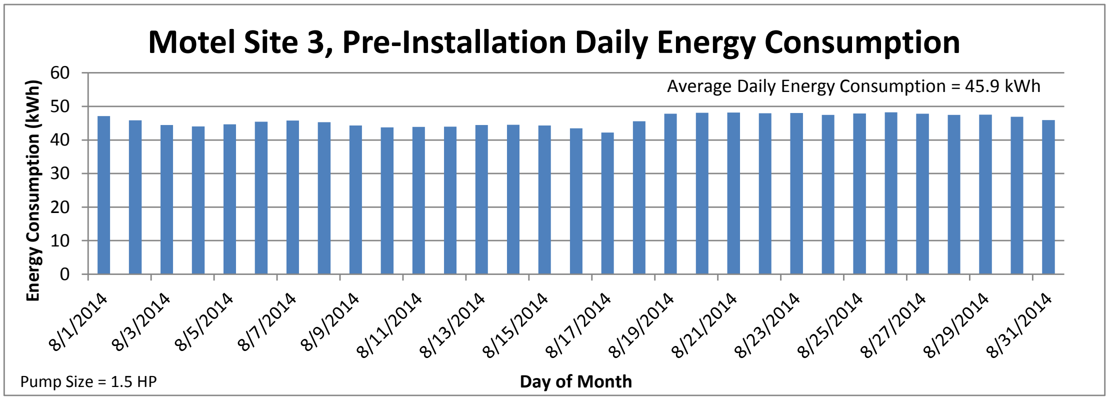


Figure 11. Motel Pre-Installation Daily Energy Consumption – Site 3

The average daily energy consumption was 45.9 kWh during the pre-installation monitoring period.

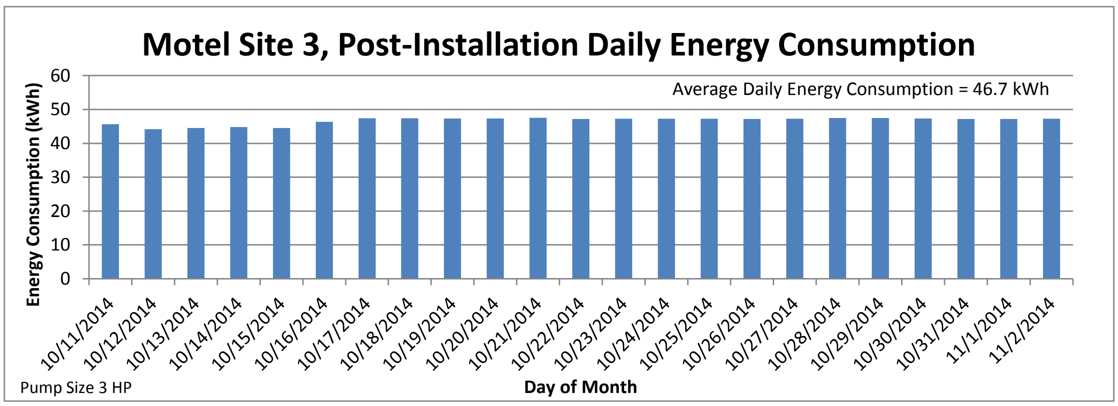


Figure 12. Motel Post-Installation Daily Energy Consumption – Site 3

Equation 6 shows that the average daily energy consumption was 46.7 kWh during the post-installation monitoring period. This installation did not register energy savings. In fact, this site used more energy during the post-installation phase of the monitoring period than during the pre-installation phase. The daily average energy increase was recorded as 0.8 kWh for this site.

Equation 6. Annual Energy Usage and Savings for VSD Pool Pump – Site 3

$$E_{Base}[kWh] = \left(E_{Baseline,Daily}[kWh] * AnnualSchedule\left[\frac{days}{year}\right]\right)$$

Baseline annual energy consumption:

$$16{,}752_{\mathrm{Baseline,Annual}}[\mathrm{kWh}] = \left(45.9_{\mathrm{Baseline,Daily}}[\mathrm{kWh}] * 365\left[\frac{\mathrm{days}}{\mathrm{year}}\right]\right)$$

Post-installation annual energy consumption:

$$17{,}054_{\mathrm{Post,Annual}}[\mathrm{kWh}] = \left(46.7_{\mathrm{Post,Daily}}[\mathrm{kWh}] * 365\left[\frac{\mathrm{days}}{\mathrm{year}}\right]\right)$$

Annual energy savings:

$$-310_{\mathrm{Savings,Annual}}[\mathrm{kWh}] = (\ 16{,}752_{\mathrm{Base,Annual}}[\mathrm{kWh}] - \ 17{,}054_{\mathrm{Post,Annual}}[\mathrm{kWh}]\ )$$

Figure 13 and Figure 14 show the pre- and post-installation hourly load profiles averaged over the course of their respective periods. The horizontal axis presents the time of day during the monitoring period and the vertical axis presents the average load on the pump, in kW, for each hour of the day during the respective monitoring period.

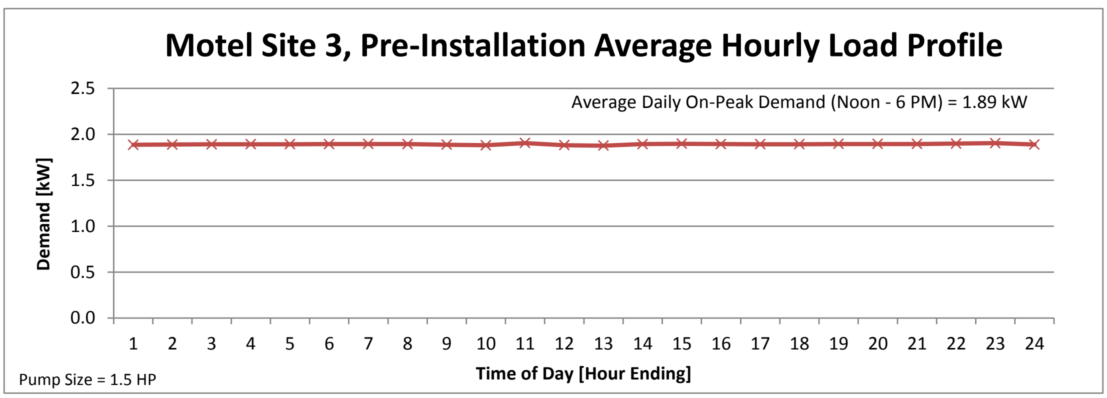


Figure 13. Motel Pre-Installation Hourly Average Load Profile – Site 3

Logging recorded an average demand during the on-peak period (noon to 6 PM) of 1.89 kW in the baseline/pre-installation period. It should be noted that it is not unusual for a motor of this size to draw this much power. In the pool pump industry, the motors are sized with high service factors allowing them to use significantly more power than what is typically expected from a standard motor. A typical 1.5 hp motor can have a service factor of 1.65 that allows the motor to be driven to the equivalent of a 2.5 hp motor with respect to Watt draw. Some motor installations have a service factor of 1.87, which makes their nameplate hp less significant.

The installation contractor installed a 3 hp pump equipped with a VSD at this site. Even though the baseline pumping system used a nameplate 1.5 hp pump, the installation of a 3 hp pump is acceptable due to the configuration of the VSD. Each individual pump with VSD is installed to operate within the parameters required to serve the specific pool. By limiting the pump's maximum power draw, the installation contractor has effectively installed the equivalent pumping scenario as was installed prior to the retrofit to the VSD pumping system.

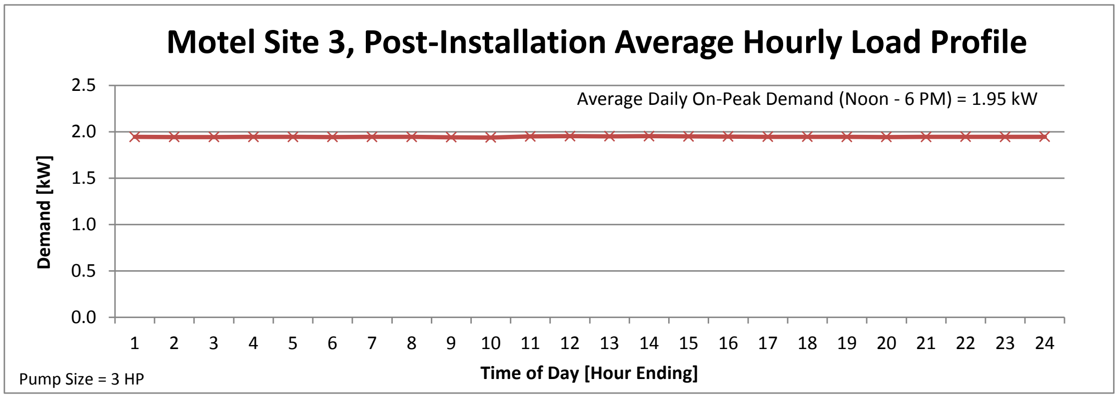


Figure 14. Motel Post-Installation Hourly Average Load Profile – Site 3

It appears from the data that the site service manager altered the pump settings shortly after the installation was complete. The alteration appears to have set the pump to maximum operating capacity. The settings were not adjusted after this initial setting increase. This pump installation is not expected to save energy as long as these settings remain in place.

POOL PUMP RETROFIT – SITE 4

Site 4 was equipped with a 2 hp single-speed pump. The contractor for this site replaced the original pump with a 3 hp VSD pool pump, programming the speed setting to the appropriate power levels and turnovers per day.

However, when collecting the metered data, the field engineer found that the speed settings had been re-programmed to the highest setting. The project team believes that the customer, worried about meeting local code requirements for pool turnover rates, turned up the speed setting to meet local codes. This may have been due to a lack of education on the hotel management or operator's part about the tuning the contractor did during their installation.

Figure 15 and Figure 16 show the daily energy consumption recorded at the site during the pre- and post-installation metering periods. The horizontal axis presents the day of the month during the monitoring period and the vertical axis presents the daily energy consumption of the pump during the monitoring period.

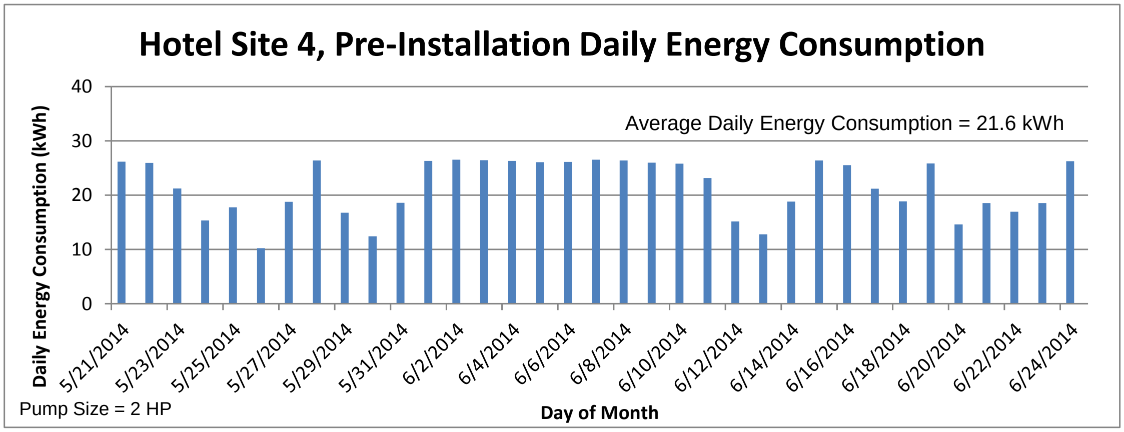


Figure 15. Hotel Pre-Installation Daily Energy Consumption – Site 4

The average daily energy consumption during the course of the pre-installation metering period was 21.6 kWh. Figure 15shows the energy consumption over the course of the entire pre-install period. The customer tends to shut off their pool pump for several hours during this period, or there is significant cavitation, which can be seen in the variability of the daily energy consumption.

The logger that was installed during the pre-installation phase of the monitoring period filled its memory and had to be restarted after the installation of the VSD pump. The data set that corresponds to the timeframe immediately after the pump installation was not recorded. By the time the logger was reset and began recording data during the post-installation monitoring period, the motor was operated continuously.

Figure 16 shows the post-installation daily energy consumption over the post-installation monitoring period. It appears from the data that the original settings were reset to maximum flow by the operating staff. By resetting the flow up to maximum, the site personnel removed the opportunity for energy savings.

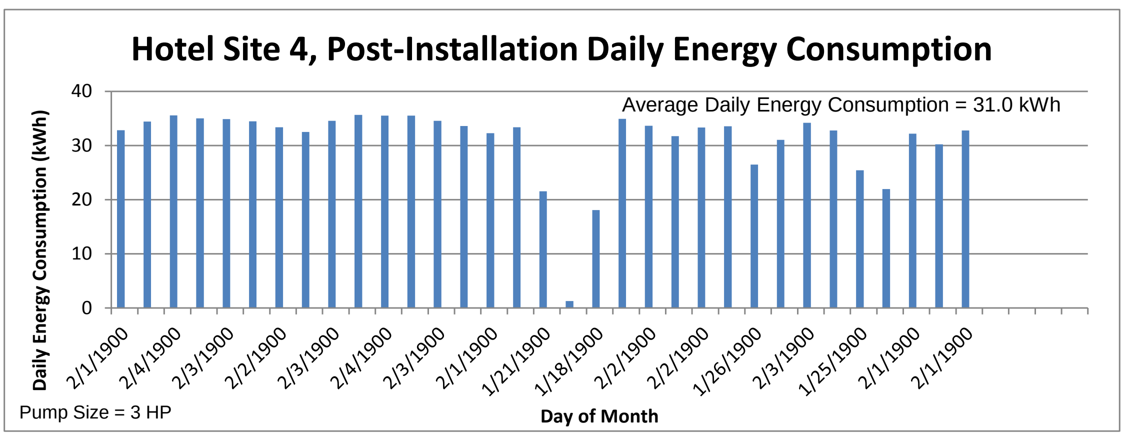


Figure 16. Hotel Post-Installation Daily Energy Consumption – Site 4

The project team recorded an average consumption of 31.0 kWh for the average daily energy consumption. It should be noted that mid-way through the post-installation monitoring period, the customer did begin to use the lower speed settings. There is no clear indication that the customer settled on a final speed or power profile based on the collected data. The daily average energy increase was recorded as 9.4 kWh for this site. Equation 7 calculates the annual energy usage and savings for the VSD pool pump.

Equation 7. Annual Energy Usage and Savings for VSD Pool Pump – Site 4

$$E_{Base}[kWh] = \left(E_{Baseline,Daily}[kWh] * AnnualSchedule\left[\frac{days}{year}\right]\right)$$

Baseline annual energy consumption:

$$7{,}870_{\mathrm{Baseline,Annual}}[\mathrm{kWh}] = \left(21.6_{\mathrm{Baseline,Daily}}[\mathrm{kWh}] * 365\left[\frac{\mathrm{days}}{\mathrm{year}}\right]\right)$$

Post-installation annual energy consumption:

$$11{,}322_{\mathrm{Post,Annual}}[\mathrm{kWh}] = \left(31.0_{\mathrm{Post,Daily}}[\mathrm{kWh}] * 365\left[\frac{\mathrm{days}}{\mathrm{year}}\right]\right)$$

Annual energy savings:

$$-3{,}452_{\mathrm{Savings,Annual}}[\mathrm{kWh}] = \left(7{,}870_{\mathrm{Base,Annual}}[\mathrm{kWh}] - 11{,}322_{\mathrm{Post,Annual}}[\mathrm{kWh}]\right)$$

Figure 17 and Figure 18 show the pre- and post-installation hourly load profiles averaged over the course of their respective periods. The horizontal axis provides the time of day during the monitoring period and the vertical axis provides the average load on the pump, in kW, for each hour of the day during the respective monitoring period.

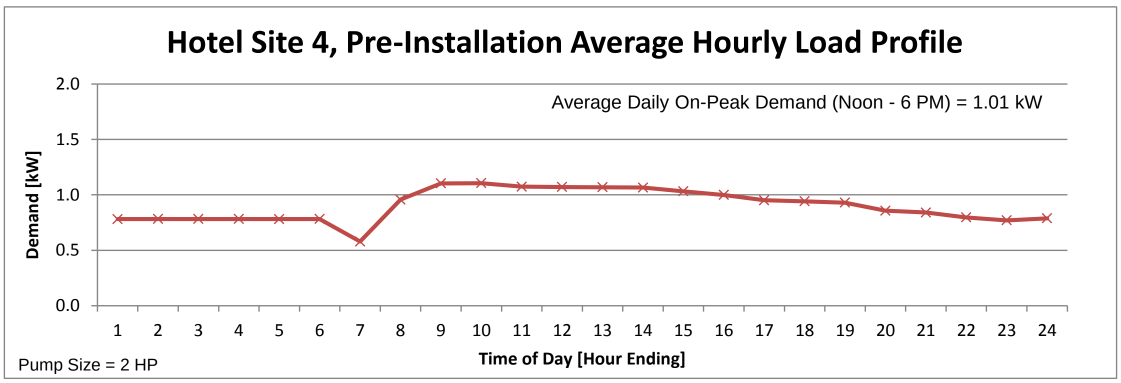


Figure 17. Hotel Site 4, Pre-Installation Hourly Average Load Profile – Site 4

The baseline load profile has a fairly consistent load drop during the morning hours. This is indicative of a regular shut-down cycle during that timeframe. This was not realized during the post-installation monitoring period.

Figure 18 shows the average hourly demand for the post-installation monitoring period. The pump operated in a near continuous manner that was inconsistent with the baseline/pre-installation operating conditions.

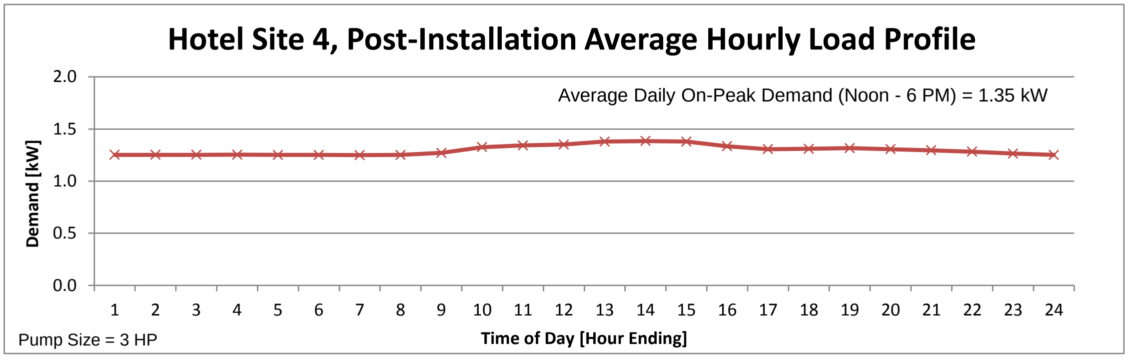


Figure 18. Hotel Post-Installation Hourly Average kW – Site 4

Although the installed pump was larger than the baseline pump, the VSD allows the system to operate at a lower energy consumption rate. The potential energy savings can only be achieved if the site personnel operate the equipment in the most efficient configuration.

Pool Pump Retrofit – Site 5

Site 5 was originally equipped with a 3 hp single-speed pump. However, 10 days after pre-installation monitoring began, the original pump failed and was replaced by the customer's maintenance supervisor with a 2 hp-equivalent pump that was pieced together using old parts. After pre-installation monitoring was complete, the contractor replaced the existing single-speed pump with a 2 hp VSD pump with digital readouts displaying the flow rate in gpm before and after the pool pump. The first four sites were equipped with rpm digital readout displays. The team requested gpm displays for this site to provide better visibility to the customer. The contractor programmed the flow settings to operate at 98 gpm from 8 AM to 8 PM, then at 80 gpm from 8 PM to 11 PM. Between the out-of-service hours of 11 PM and 8 AM, the pump is turned off.

During post-installation monitoring, the pump operated at the contractor's programmed settings for the first four days, and then fluctuated between higher and lower settings for the next several days before settling on lower settings for the final four days of metering. The customer stated they were experimenting with different flow settings to find a flow setting that worked for them.

Figure 19 and Figure 20 show the daily energy consumption recorded at the site during the pre- and post-installation metering periods. The horizontal axis provides the day of the month during the monitoring period, and the vertical axis provides the daily energy pump consumption during the monitoring period. Figure 21 shows the post-installation energy consumption after the customer settled on a finalized speed setting.

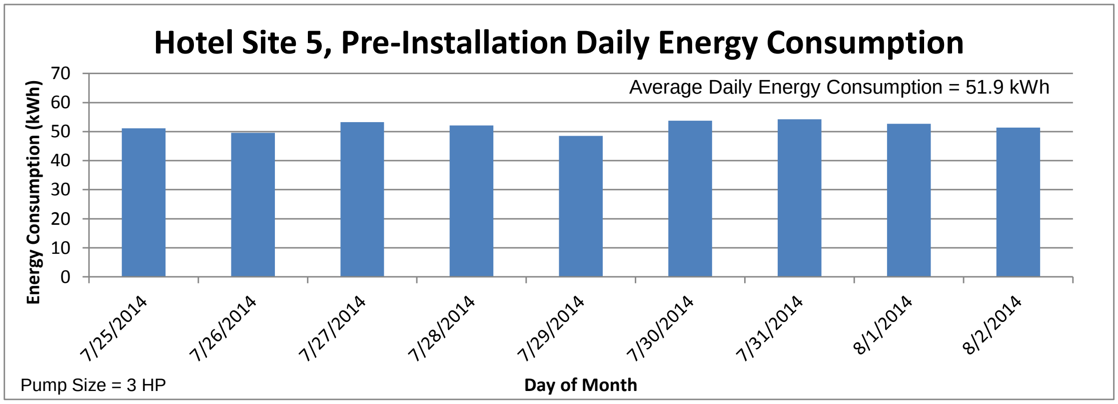


Figure 19. Hotel Pre-Installation Daily Energy Consumption – Site 5

The pre-installation monitoring period was longer than the 9 days presented in Figure 21. The additional data was removed from the analysis due to the existing pump failure. A short time after the logger was installed; the pump failed and had to be replaced. The replacement pump was put together using spare parts from rebuilt pumps associated with other equipment. The motor was from an old spa pump and the pump was from an old pool pump. The parts held together until the replacement pump, with VSD, was installed. The replacement was intended only as a placeholder until the retrofit and as such, does not represent the baseline pump operation. The baseline pump was the 3 hp pump that was monitored for the 9 days before the failure occurred and the temporary pump was placed into service.

The average daily energy consumption was 51.9 kWh during the pre-installation monitoring period.

After the new pump with VSD was installed, the pool maintenance supervisor began to manipulate the settings on the installed VSD. There were a series of tests performed to determine the most favorable operating conditions for the particular configuration (pool and pump). Figure 20 shows the series of settings that were implemented during the testing phase of the pump setup after the initial settings were implemented by the installer.

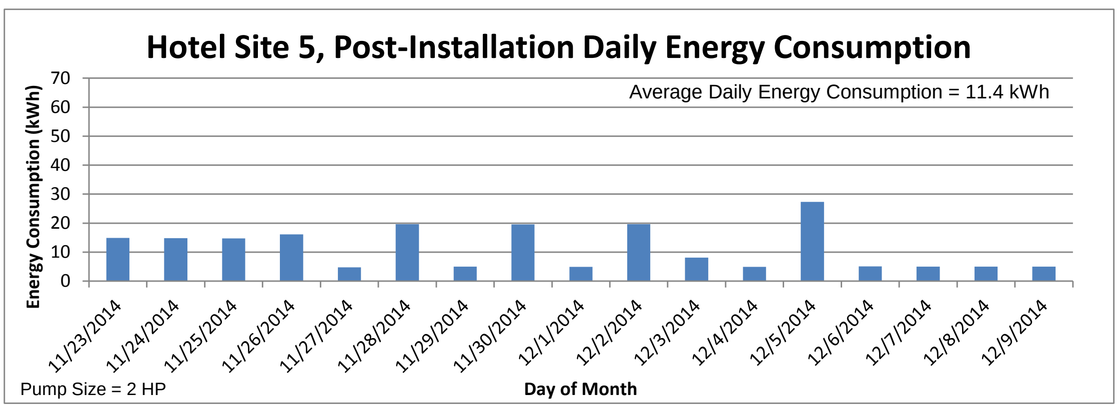


Figure 20. Hotel Post-Installation Daily Energy Consumption – Site 5

The average daily energy consumption was 11.4 kWh during the entire post-installation monitoring period.

Figure 21 shows the final settings for the pump operation as a result of the testing conducted by the pool maintenance supervisor.

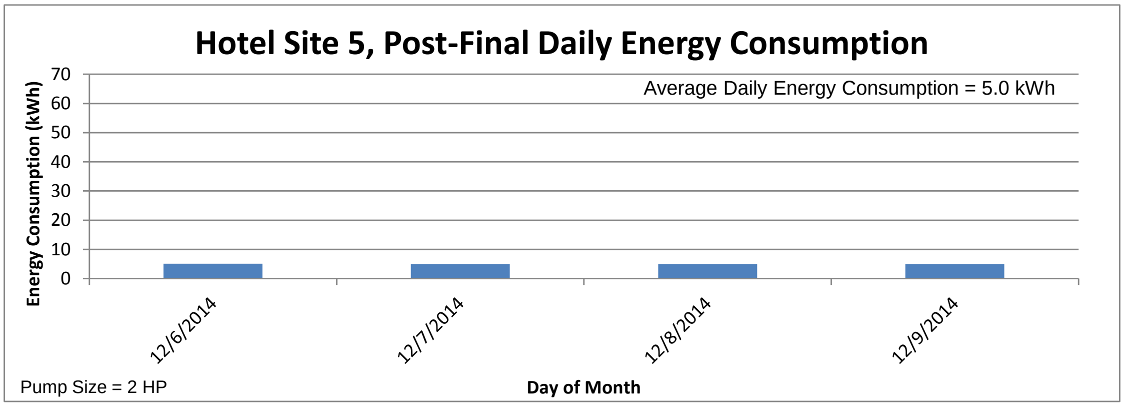


Figure 21. Hotel Post-Final Daily Energy Consumption (Final Speed) – Site 5

After the investigation phase was completed, the pool maintenance supervisor reported that these settings were delivering sufficient water flow to meet their required filtration rates and that these settings were going to be maintained for future operations.

The average daily energy consumption was 5.0 kWh during the post-final monitoring period. The daily average energy savings was recorded as 46.9 kWh for this site. Equation 8 shows the calculation of the annual energy usage and savings for the VSD pool pump for Site 5.

Equation 8. Annual Energy Usage and Savings for VSD Pool Pump – Site 5

$$E_{Base}[kWh] = \left(E_{Baseline,Daily}[kWh] * AnnualSchedule\left[\frac{days}{year}\right]\right)$$

Baseline annual energy consumption:

$$18{,}927_{\mathrm{Baseline,Annual}}[\mathrm{kWh}] = \left(51.9_{\mathrm{Baseline,Daily}}[\mathrm{kWh}] * 365\left[\frac{\mathrm{days}}{\mathrm{year}}\right]\right)$$

Post-installation annual energy consumption:

$$1{,}826_{\mathrm{Post,Annual}}[\mathrm{kWh}] = \left(5.0_{\mathrm{Post,Daily}}[\mathrm{kWh}] * 365\left[\frac{\mathrm{days}}{\mathrm{year}}\right]\right)$$

Annual energy savings:

$$17{,}101_{\mathrm{Savings,Annual}}[\mathrm{kWh}] = \left(18{,}927_{\mathrm{Base,Annual}}[\mathrm{kWh}] - 1{,}826_{\mathrm{Post,Annual}}[\mathrm{kWh}]\right)$$

Figure 22 and Figure 23 show the pre- and post-installation hourly load profiles averaged over the course of their respective periods. The horizontal axis provides the time of day during the monitoring period and the vertical axis provides the average load on the pump, in kW, for each hour of the day during the respective monitoring period.

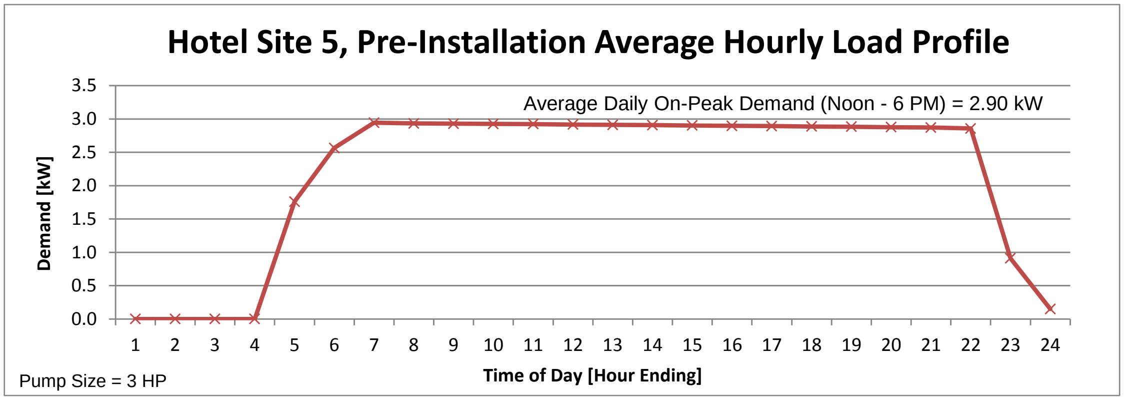


Figure 22. Pre-Installation Hourly Average Load Profile – Site 5

Logging recorded an average demand during the on-peak period (noon to 6 PM) of 2.90 kW in the baseline/pre-installation period.

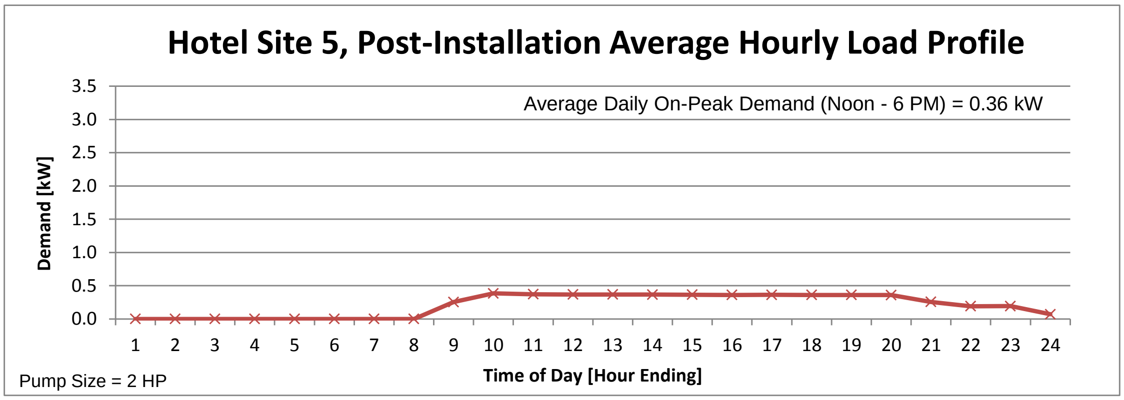


Figure 23. Post-Installation Hourly Average Load Profile – Site 5

Post-installation monitoring recorded an average demand of 0.36 kW during the same noon to 6 PM timeframe of the post-installation period. The difference of 2.54 kW represents the average daily demand reduction during the on-peak period.

COMPARISON OF SURVEY AND FIELD DATA

Table 13 shows the calculated and measured baseline annual energy consumption for the five customer sites. The calculated baseline data is based on information gathered during the on-site surveys and compared with monitored baseline field data.

Table 13. Comparison of Calculated and Measured Energy Consumption

HOTEL NUMBER	CALCULATED ESTIMATE OF BASELINE ANNUAL ENERGY CONSUMPTION (KWH/YEAR)*	FIELD TESTING BASELINE ANNUAL ENERGY CONSUMPTION (KWH/YEAR)
1	14,184	10,804
2	26,595	25,730
3	14,829	16,752
4	16,034	7,870
5	17,252	18,927

Table 14 shows the calculated and measured annual energy savings for the five customer sites. The calculated savings data is based on information gathered during the on-site surveys. These estimates are compared with monitored energy savings data.

Table 14. Comparison of Calculated and Measured Annual Energy Savings

HOTEL NUMBER	CALCULATED ESTIMATE OF ANNUAL ENERGY SAVINGS (KWH/YEAR)*	FIELD TESTING ANNUAL ENERGY SAVINGS (KWH/YEAR)
1	1,482	1,898
2	2,344	4,409
3	4,041	-302
4	5,804	-3,452
5	6,919	17,101

*Annual energy savings were calculated based on equations from SCE13WP008 Commercial Variable Speed Swimming Pool Pump work paper.

In situations where the customer adjusted the VSD settings on the newly installed pool pumps after the installation contractor had completed the initial setup, the conclusions about the retrofit energy usage need to be considered on a case-by-case basis. Specifically, because the pumps at Hotel Sites 3 and 4 were measured as using more energy than the original pumps, the average savings between all five sites is greatly reduced. Conversely, Hotel Site 5 demonstrated that the site manipulated the system settings to reduce the pump energy even further than the initial installation.

This demonstrates the importance of educating the customer on the proper use of the VSD-equipped pool pump in conjunction with retrofitting their original single-speed pump. If the customer continues to use the highest speed setting on the new pump, then the higher energy consumption observed at Hotel Sites 3 and 4 will persist.

It can also be expected that the installation of visible flow indicators, as installed in Hotel Site 5 will very likely have a positive impact on the energy savings of the overall population.

CONCLUSIONS

While three of the five volunteer hotels benefitted from energy savings after installing VSD-equipped pool pumps, it is clear that customer interference with the VSD controls during the metering phase did not allow for a true measurement of the savings potentials of the VSD-equipped pumps. This suggests a need to educate the customer to help them understand how to use the speed settings to achieve energy savings.

In addition, the site with the greatest annual energy savings was Hotel Site 5 which displayed flow readouts to help the customer set a lower speed while still being able to meet their required turnover rates. This seems to suggest that VSD-equipped pool pumps equipped with flow readouts may be a good way to help the customer save energy, and help educate the customer at the same time. This makes it easier to meet the county health codes without having to do their own calculations.

There are often problems getting VSD-equipped pumps with built-in flow controls approved for installation by the county authorities. VSDs with these flow controls are often regarded as too difficult to work with because any change in the flow, such as washing out the system during regular maintenance, can cause the device to lock up or fault. This may be an opportunity to push for better flow controls on VSD-equipped pumps, and to find solutions to these problems so that flow-controls may be more widely accepted.

RECOMMENDATIONS

Based on the results of this metering study, there are several recommendations for future projects similar in nature. The primary issue encountered during this study is that the customer would often change the settings on the VSDs during the test, which would negate the potential savings measured at each site. Even Hotel Site 5, which performed the best of the five sites, showed signs of customer tampering during the test period. This indicates a lack of education on the customer's part.

Moving forward, when conducting this type of study, it would be best to make it clear to the customer that the control settings cannot be changed while metering is taking place. Involving the customer with the calculations made by the contractor may also help the customer understand the purpose of the study.

In addition, VSDs with external flow indicators are an improvement to a standard VSD without any flow indication. While integrated flow VSDs are not widely accepted due to temperamental behavior, the installation of external flow indicators can help site personnel understand whether or not they are meeting their required flow rates.

With these flow controls, the customer is able to set the required gpm needed to achieve their minimum flow-rate directly, rather than having to calculate the speed to achieve the needed flow rate. A VSD will allow the pool pump to maintain the needed flow even as the pool filters become clogged and higher speed is required, which would also benefit customers.

The wide variability in energy savings numbers suggest that this measure is not suitable for deemed savings incentives for the commercial sector at this time.

APPENDIX A ON-SITE QUESTIONNAIRE

Customer Interview:

1. What is the pool operating schedule (along with required and actual turn-over rate) for the year, including any seasonal schedule variations?
    - Yearly Pool Operating Schedule:___________________________________
    - Turn-over Rate: ___________________(req.)_____________________(actual)
2. What are the hours of operation? When is the pool available for daily use?
    - Pool Hours of Operation:____
    - Pump Hours of Operation:____
3. Pump type(s): single, two-speed, or multi-speed (factory preset and non-changeable) or variable speed?
4. Any additional information regarding this pool's operation?
5. Is the customer interested in participating in a VSD pump metering program? This program will involve two weeks of metering the customer's current pump without a VSD, followed by the installation of a VSD-equipped pump with two more weeks of metering on the VSD-equipped pump. The installation costs will be covered by Southern California Edison, at no cost to the customer.

Pump Information & Measurement:

6. What is the pump make and model numbers, if available?
    - Make:____
    - Model Number:______________________________________
7. What is the size of the pool in gallons? (If pool gallons are not known, what are the dimensions of the pool?)
    - Pool size: _________________(gal)
      Or
    - Pool dimensions: ________(length)_________(width)_________(depth)
8. What is the pool pump flow rate (gpm)?
    - Flow rate:________________________(gpm)
9. What is the pool pump nameplate hp, age, efficiency, and motor speed?

- Horsepower: _________(hp)
- Age:_________(years)
- Efficiency: ___________ (%)
- Motor speed:_____________________(rpm)

10. What type of filtration medium is used? (Diatomaceous earth filters, rapid sand filters, high rate sand filters, cartridge filters?) What is the normal pressure drop across the filter(s) when clean, and when dirty?

    - Filtration medium:____
    - Pressure Drop (Clean):__________________
    - Pressure Drop (Dirty):__________________
    - Pressure Drop (Average):__________________

11. Power measurements with either kW (measured by True RMS meter) or amps, volts, and resistance with power factor, single or three phase (for three phase make sure to use a true RMS 3-phase power meter)
    - Power:_______________________(kW)
    - Amps:________________________ (a)
    - Voltage:_______________________(V)
    - Power Factor:___________________

APPENDIX B DETAILED SURVEY RESULTS

HOTEL/MOTEL MARKET SEGMENT

This project focused primarily on the hotel/motel market segment because it is similar to existing multi-family programs at SCE. The 50 sites selected in the hotel/motel market segment included 23 small roadside motels, 18 mid-sized hotels, and 9 larger resorts.

MOTELS

All 23 motels operate on a year-round basis, and while the pool hours of operation vary, the pool pumps are almost always on 24/7. In terms of pool pump operation, 19 of the 23 sites keep their pool pump running 24 hours a day, while the other 7 operate their pumps only during the day while the pool is in use. Figure 24 shows the breakdown in pump hours of operation.

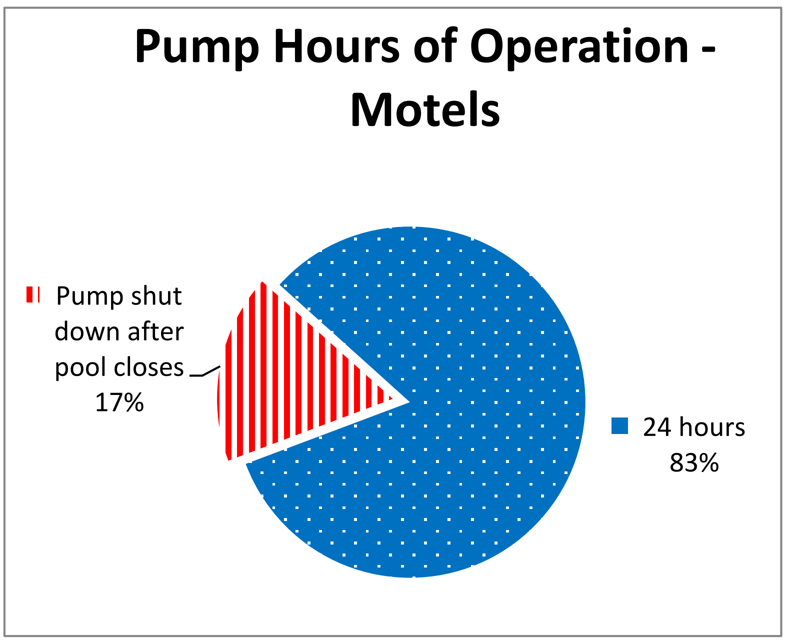


Figure 24. Pump Hours of Operation - Motels

POOL TURNOVER RATE

In addition to hours of operation, survey technicians asked motel operators about the pool turnover rates required by local counties and the actual turnover rate of the pool. While conducting the surveys, survey technicians found that most local regulations required a turnover rate between 4 and 6 hours. When survey technicians asked for the actual turnover rates, they found that most motel operators did not know the current turnover rate for their pools. Of the 23 motels surveyed, only 1 motel knew their actual turnover rate.

PUMP SIZE

All 23 motel pumps surveyed fall within the 0 to 5 hp. Figure 25 shows the pool pump sizes in the motel market segment surveys.

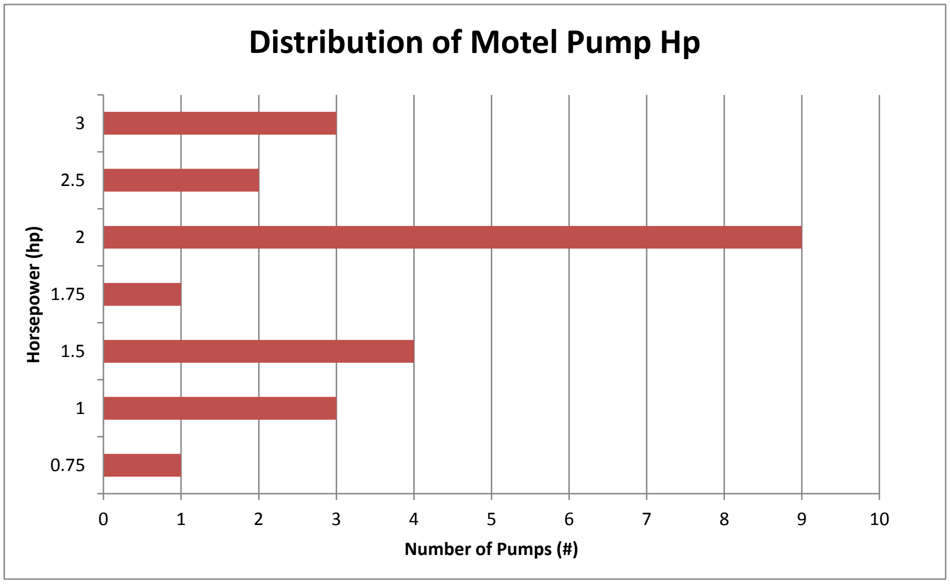


Figure 25. Pool Pump Size Distribution - Motels

POWER USAGE

Figure 26 shows the comparison between pump horsepower and power usage. Similar to the distribution of pump horsepower, the power for the pumps settles between 0.5 kW and 3 kW.

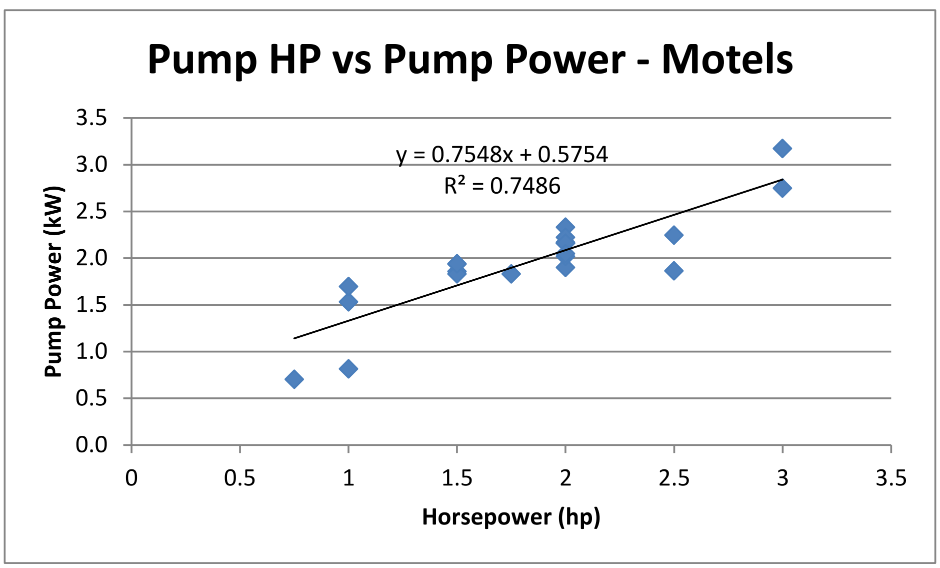


Figure 26. Pump Horsepower Compared to Pump Power - Motels

POOL PUMP SPEED TYPE

According to the Motel segment survey results, all but three pumps are single speed. This lines up with another finding from the surveys; the operators of many surveyed sites keep the pumps running constantly 24/7. This is done to preserve the pools water quality and cleanliness. In Figure 27, Multi Speed refers to pumps with more than two distinct speed settings, and Variable Speed refers to pumps equipped with a VSD.

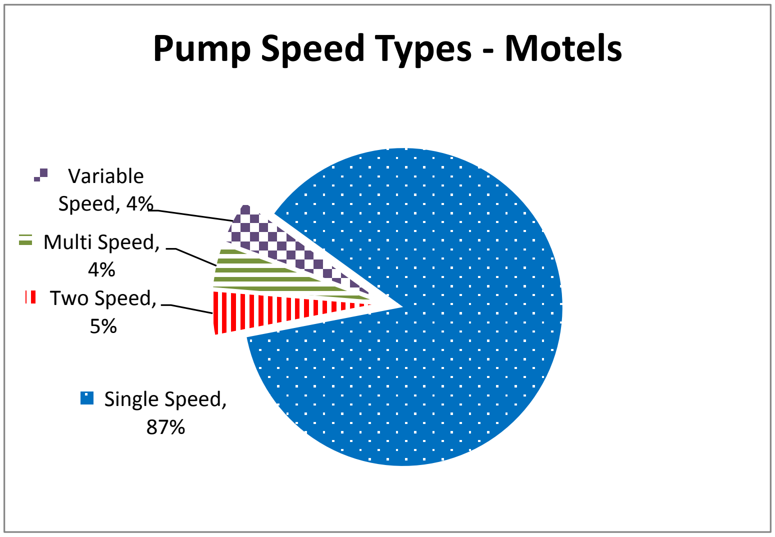


Figure 27. Pump Speed Type - Motels

FILTRATION MEDIUM

During the survey, survey technicians found that motels mainly use diatomaceous earth filters, with High-Rate Sand filters making up the next most popular group. In general, it seems that customers with smaller pumps tend to use diatomaceous earth filters. Figure 28 shows a breakdown of the sites by filtration medium.

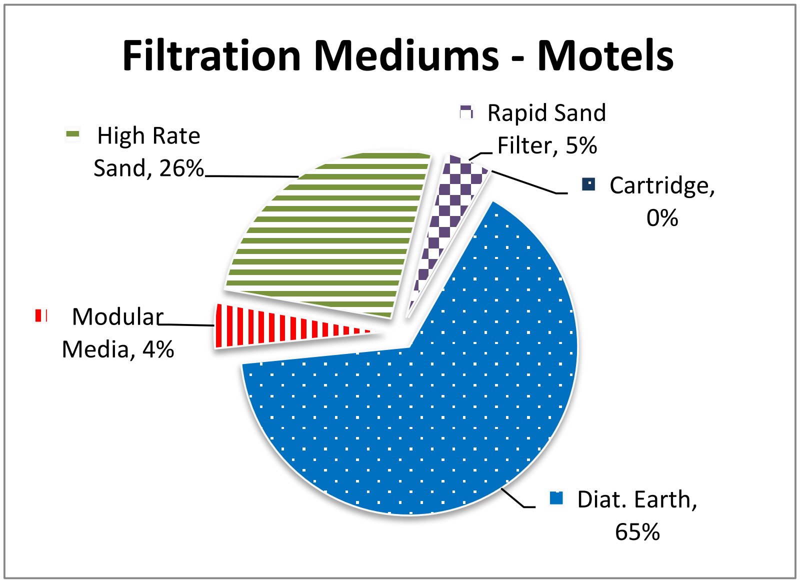


Figure 28. Filtration Mediums - Motels

HOTELS

YEARLY OPERATING SCHEDULE AND HOURS OF OPERATION

All 27 hotel sites surveyed operate on a year-round basis, and while the pool hours of operation vary, the pool pumps are almost always on 24/7, with the exception of one site that only runs during summer months. In terms of pool pump operation, 23 of the 27 sites keep their pool pump running 24 hours a day, while the other 4 operate their pumps during the day while the pool is in use. Figure 29 shows the breakdown in pump hours of operation.

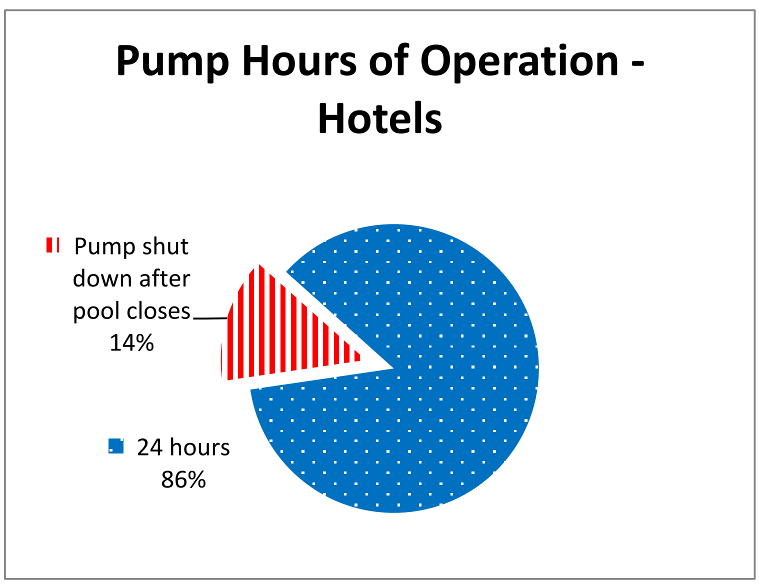


Figure 29. Pump Hours of Operation - Hotels

POOL TURNOVER RATE

In addition to hours of operation, survey technicians asked hotel operators about the pool turnover rates; both those required by local codes and the actual turnover rate of the pool itself. While conducting the surveys, survey technicians found most local regulations required a turnover rate between 4 and 6 hours. When survey technicians asked for the actual turnover rates, they found that most hotel operators did know the current turnover rate for their pools. There is still an opportunity to educate the 30% that did not know this rate. Most that did know fell in between rates of 4 to 6 hours. Figure 30 shows the hotel pool turnover rates.

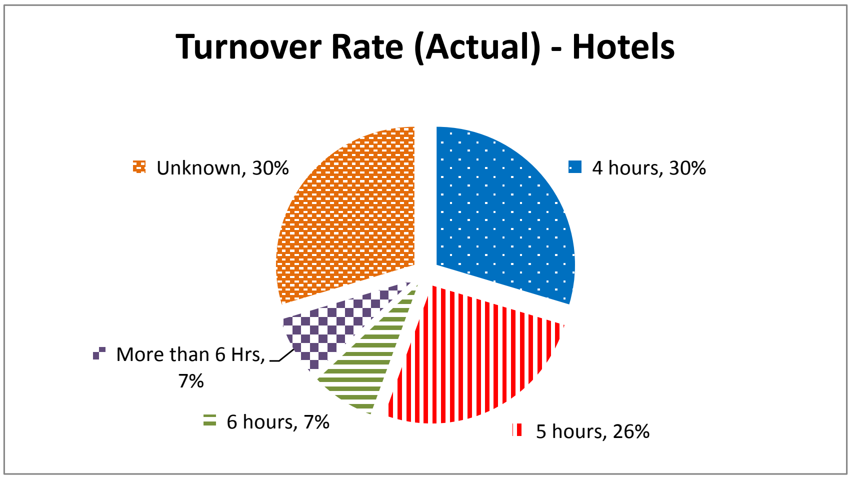


Figure 30. Pool Turnover Rates - Hotels

PUMP HORSEPOWER

Of the hotels surveyed, 21 of the 27 pumps fall under 5 hp. Based on the dimensions of the pools with larger pumps, most tend to be larger lap pools for large resort hotels, rather than the typical hotel pool. Figure 31 shows the pump hours of operation.

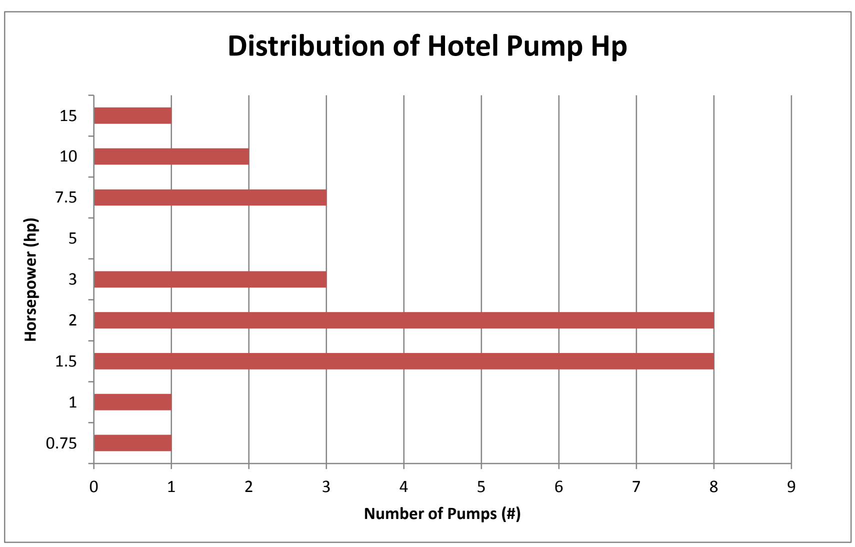


Figure 31. Pump Hours of Operation - Hotels

POOL PUMP POWER USAGE

Figure 32 shows the comparison between pump horsepower and power usage. Similar to the distribution of pump horsepower, the power for the pumps mostly settles between 0.5 kW and 3 kW, with higher values for the handful of larger pumps identified during the surveys.

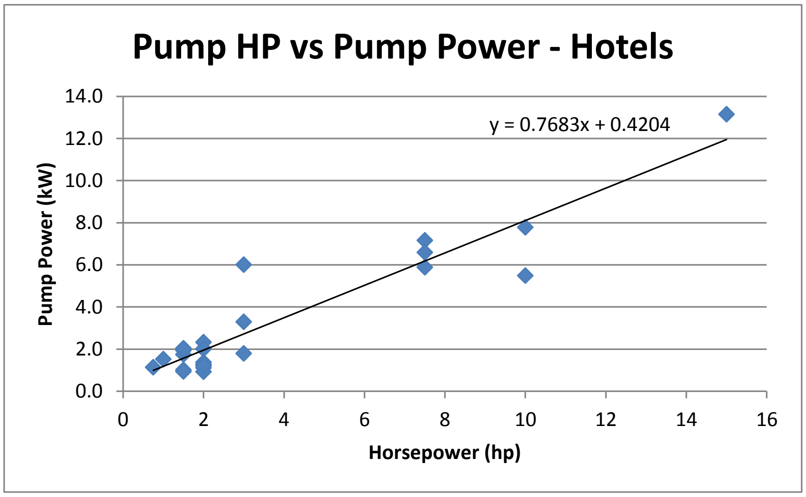


Figure 32. Pump Horsepower vs Pump Power Draw - Hotels

POOL PUMP SPEED TYPE

According to the hotel segment survey results, all but two pumps are single speed. This lines up with another finding from the surveys; the operators of many surveyed sites keep the pumps running constantly 24/7. This is done to preserve the pools water quality and cleanliness. Figure 33 supports this finding.

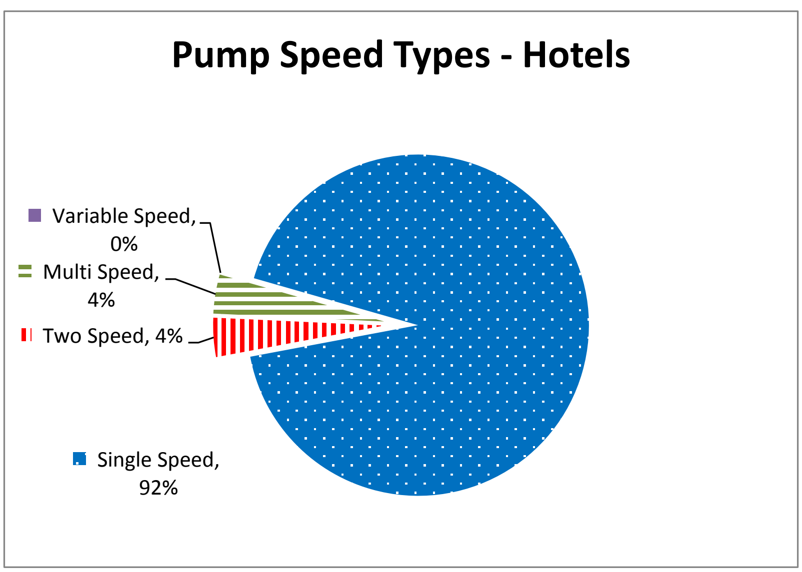


Figure 33. Pump Speed Type - Hotels

FILTRATION MEDIUM

The hotels surveyed mainly use diatomaceous earth filters and high-rate sand filters, with rapid sand filters making up the next most popular group. In general, it seems that customers with smaller pumps tend to use diatomaceous earth filters. Figure 34 shows a breakdown of the sites by filtration medium.

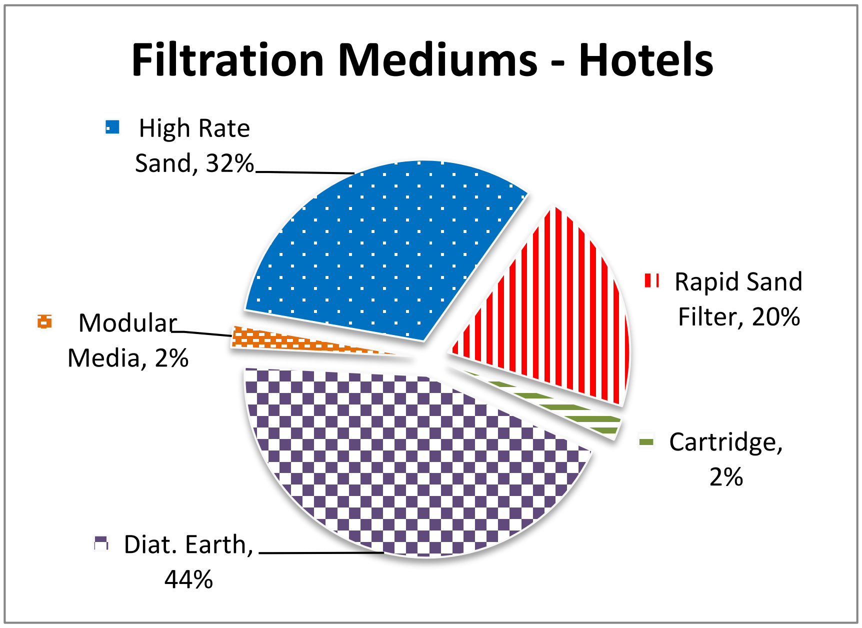


Figure 34. Filtration Mediums - Hotels

EDUCATION MARKET SEGMENT

The 50 selected sites in the education market segment included 36 high schools, 6 colleges, and 8 universities. The education market segment consists of universities, colleges, high schools, and primary schools. Primary schools were not included in this survey because most do not have swimming pools. The findings for the education segment were somewhat different from the other two market segments, because of the size of their pools. Most university pools are competitive lap pools, which are often much larger than pools in both the hotel and assembly market segments.

UNIVERSITIES

YEARLY OPERATING SCHEDULE AND HOURS OF OPERATION

The six surveyed universities operate on a year-round basis, and similarly all eight pool pumps operate 24/7, even when the pools are only open for use during varying hours of the day. This may be because the university maintenance would rather have the pumps running constantly to keep the pool water clean and clear instead of shutting down the pumps to save energy.

POOL TURNOVER RATE

Unlike hotels and motels, many universities seemed to be aware of their actual turnover rate. Again the most common turnover rates were either 4 or 6 hours. Figure 35 shows the breakdown of actual turnover rates for universities.

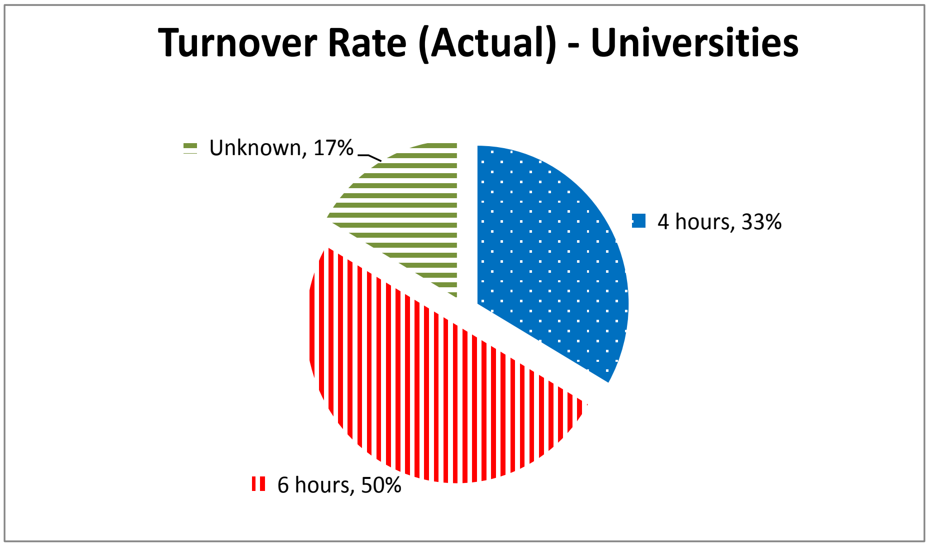


Figure 35. Actual Turnover Rate - Universities

PUMP HORSEPOWER

Nearly all the pools found in the universities were competitive-size lap pools, used in school swimming competitions, water polo, and other aquatic sports. The smaller pools found were usually much shallower wading pools used for swimming lessons and similar activities. Figure 36 shows the distribution of pump horsepower.

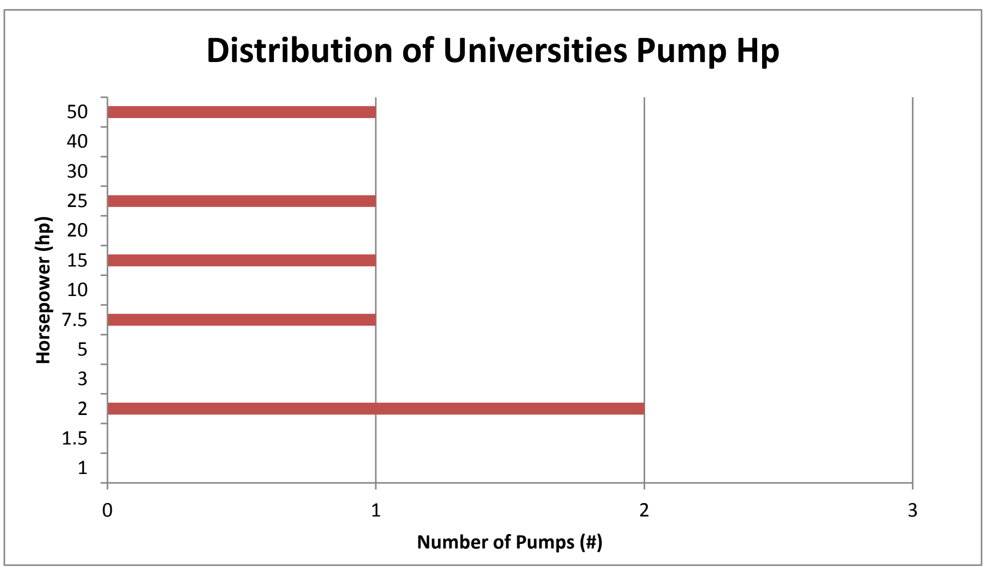


Figure 36. Distribution of Pump Horsepower - Universities

Pool Pump Power Usage

Figure 37 shows the comparison between pump horsepower and power usage. Some of these pumps use three-phase power, which, considering the larger size of the motors, means higher overall power usage for the education segment.

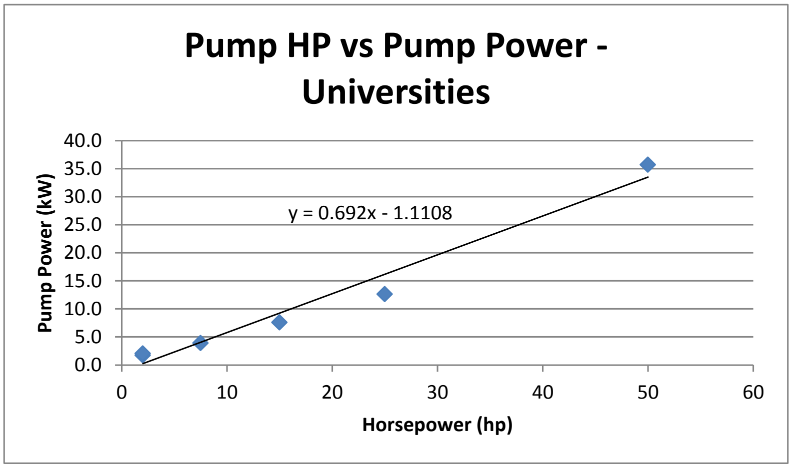


Figure 37. Pump Horsepower vs. Pump Power - Universities

Pool Pump Speed Type

Five out of the six pumps from the universities surveyed are single speed. As many of these pumps are potentially older, large motors, it is not feasible to install a VSD without doing a complete retrofit. The retrofit would involve removing the old large motor and replacing it with several smaller motors. The prevalence of single speed pumps brings up another finding from the surveys; the operators of most surveyed university pools keep the pumps running 24/7 to preserve the water quality and cleanliness in their pools. Figure 38 shows the breakdown of pump speed types in universities.

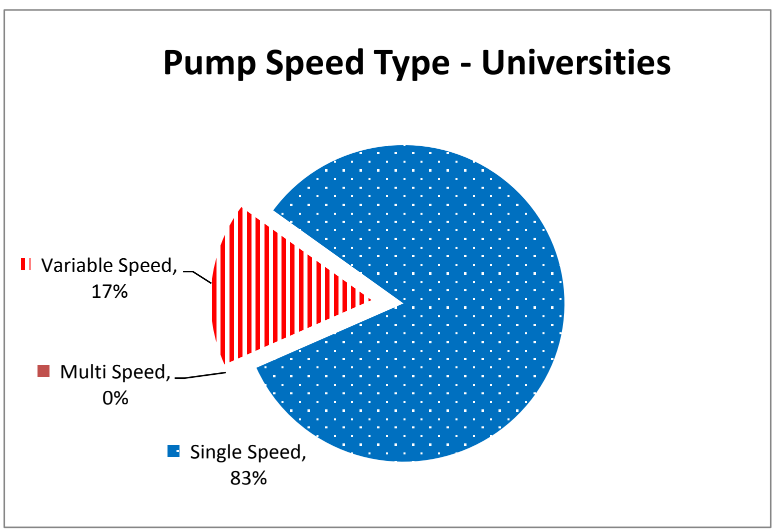


Figure 38. Pool Pump Type - Universities

FILTRATION MEDIUM

The universities that were surveyed mainly use high rate sand filters, with only a few using diatomaceous earth or rapid sand filters. There is an evident correlation between larger size pumps and high rate sand filters. Figure 39 shows a breakdown of the sites by filtration medium.

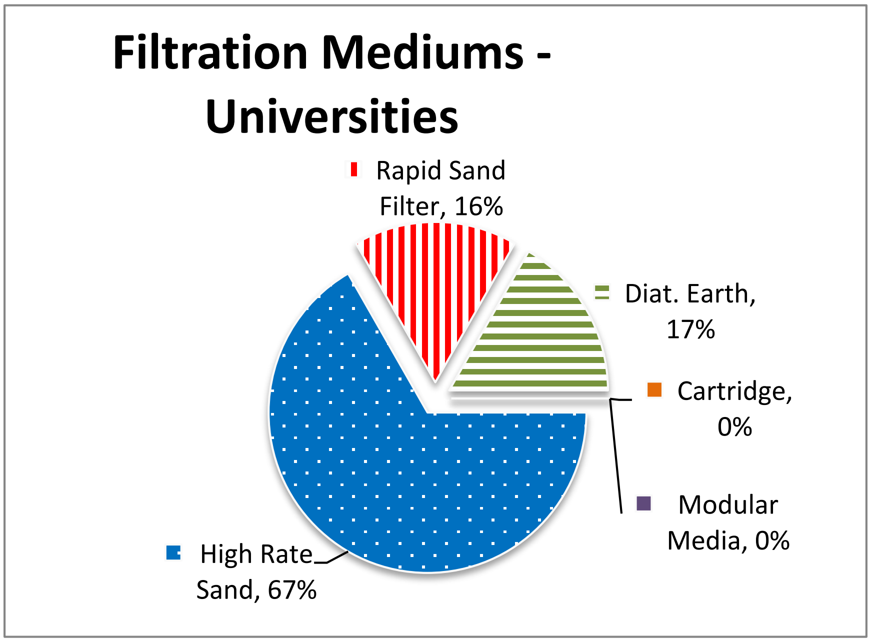


Figure 39. Filtration Medium - Universities

COLLEGES

YEARLY OPERATING SCHEDULE AND HOURS OF OPERATION

Most colleges operate on a year-round basis. The schedules for the pools often depend on school schedules, which vary more than a typical public pool schedule. Like universities, most colleges keep their pool pumps running on a 24/7 schedule. This may be because the operation of the pool pumps is handled primarily by the school district rather than the school itself. Figure 40 shows the breakdown in pump hours of operation for colleges.

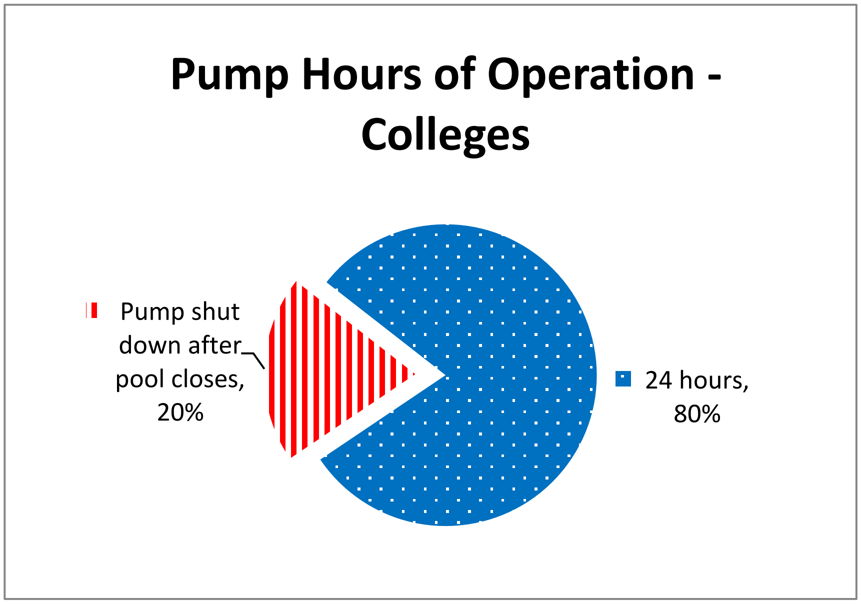


Figure 40. Pump Hours of Operation - Colleges

POOL TURNOVER RATE

In addition, in contrast to the survey of hotels and motels, the majority of colleges seemed to know their actual turnover rate, which may be because the school district handles pool maintenance. Once again, the most common turnover rates were either four or six hours. Figure 41 shows the turnover rate for colleges.

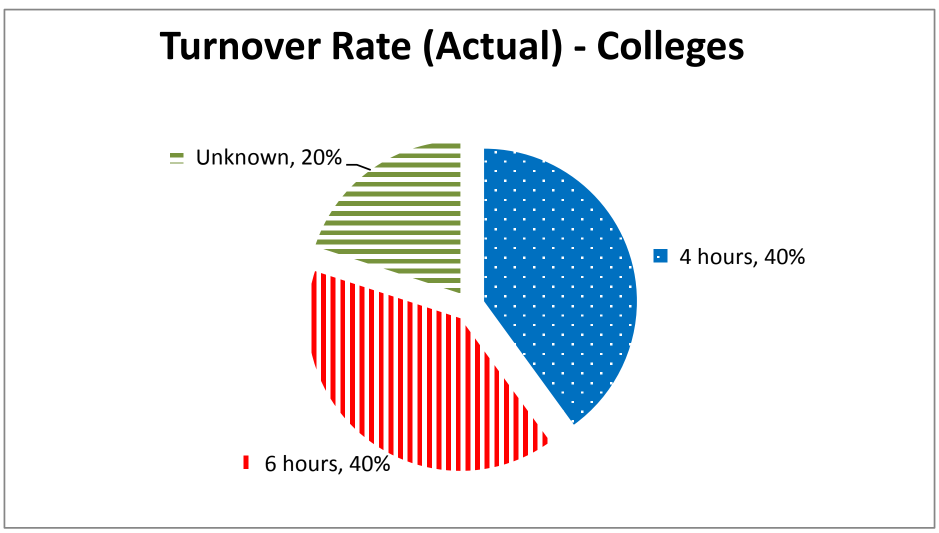


Figure 41. Actual Turnover Rate - Colleges

PUMP HORSEPOWER

Most pumps found at colleges are significantly larger than 5 hp, because of the size of the pools. All pools found in the college surveys were competitive-size lap pools used for school swimming competitions and other aquatic sports. The smaller pools were usually shallow wading pools used for swimming lessons and similar activities. Figure 42 shows the distribution of pump horsepower in colleges.

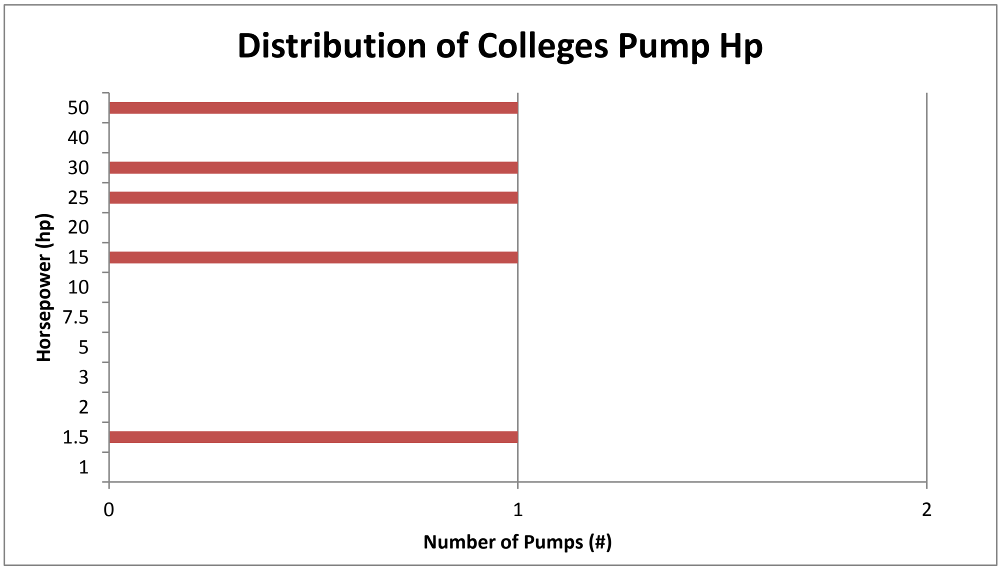
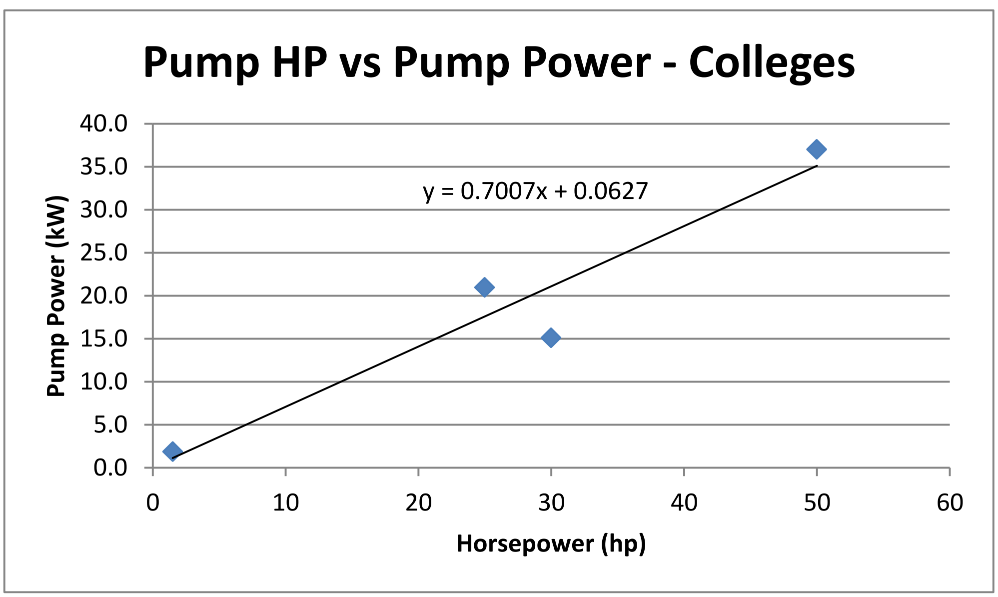


Figure 42. Distribution of Pump Horsepower - Colleges

POOL PUMP POWER USAGE

Figure 43 shows the comparison between pump horsepower and power usage. Because of the large size of the pumps, a significant percentage of these pumps use three-phase power. The larger the motor size means higher overall power usage for the education segment.



*5th data point could not be calculated as there was no current reading at the site.

Figure 43. Pump Horsepower vs. Pump Power – Colleges*

Pool Pump Speed Type

All five pumps surveyed at colleges were single speed. As many of these pumps are potentially older, large motors, it is not feasible to install a VSD without doing a complete retrofit. A complete retrofit involves removing the old large motor and replacing it with several smaller motors. The prevalence of single speed pumps brings up another finding from the surveys; the operators of most surveyed education sites keep the pumps running 24/7. This is done to preserve the pools' water quality and cleanliness.

Filtration Medium

The five colleges surveyed mainly used high rate sand filters or diatomaceous earth filters, with only a few using rapid sand filters. It appears that schools with larger-size pumps use high rate sand filtration more often. Figure 44 shows a breakdown of the sites by filtration medium.

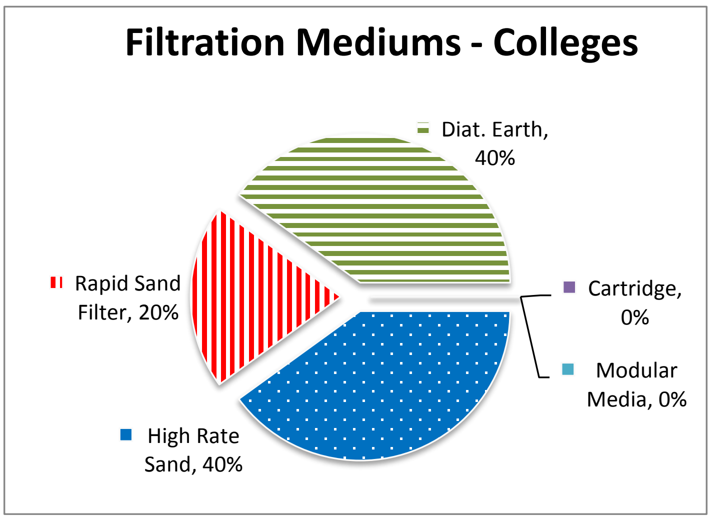


Figure 44. Filtration Mediums - Colleges

High Schools

Yearly Operating Schedule and Hours of Operation

Most high schools surveyed operate on a year-round basis. The schedules for the pools often depend on school schedules, which vary more than a typical public pool schedule. Compared to hotels, a much higher percentage of pools keep their pumps running 24 hours per day. This may be because the operation of the pool pumps is handled primarily by the school district rather than the school itself. Figure 45 shows the breakdown of pump hours of operation for high schools.

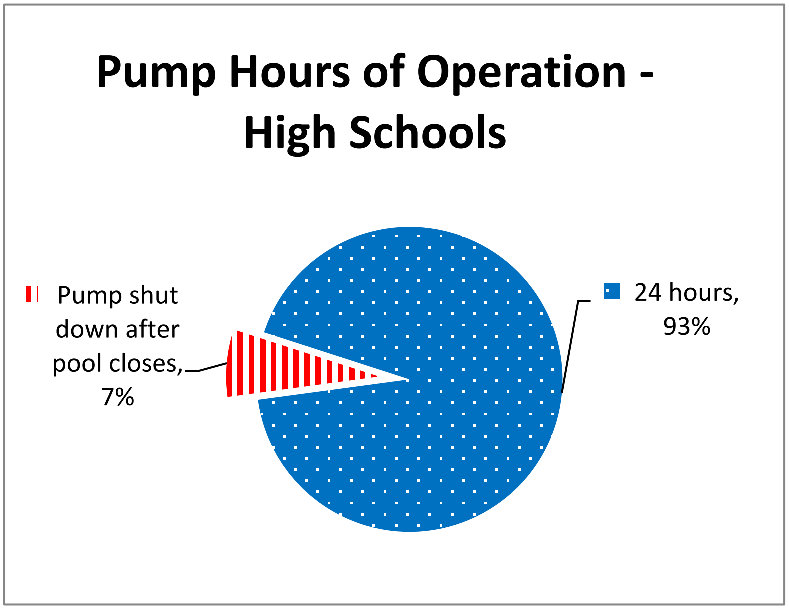


Figure 45. Actual Turnover Rate – High Schools

Pool Turnover Rate

Unlike motels, many more high schools seem to be aware of their actual turnover rate, which again, may be due to the fact that the school district often appears to handle the maintenance of the pools. Again, the most common turnover rates are between four and six hours. Figure 46 shows the actual turnover rate for high schools.

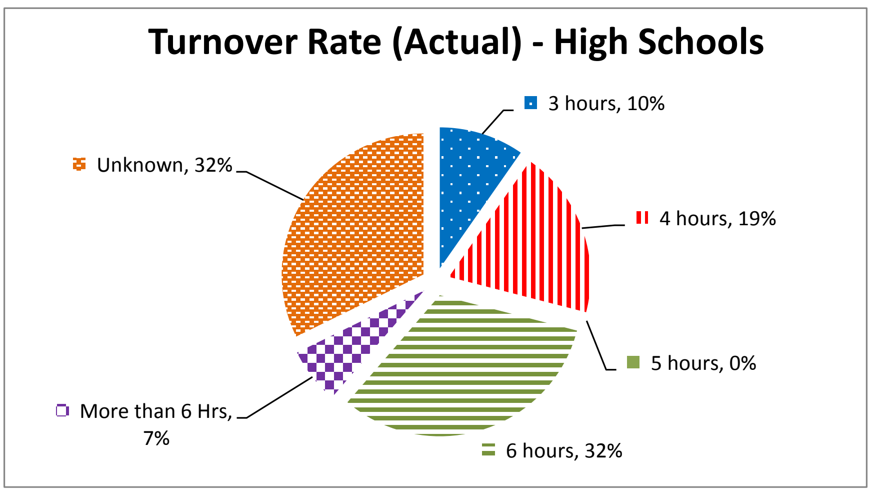


Figure 46. Actual Turnover Rate – High Schools

Most pumps found at high schools are significantly larger than 5 hp, due to the size of pools they serve. Nearly all surveyed high school pools were competitive-size lap pools, used in school swimming competitions and other aquatic sports. The smaller pools found were usually much shallower wading pools used for swimming lessons and similar activities. Figure 47 shows the distribution of pump horsepower in high schools from the survey.

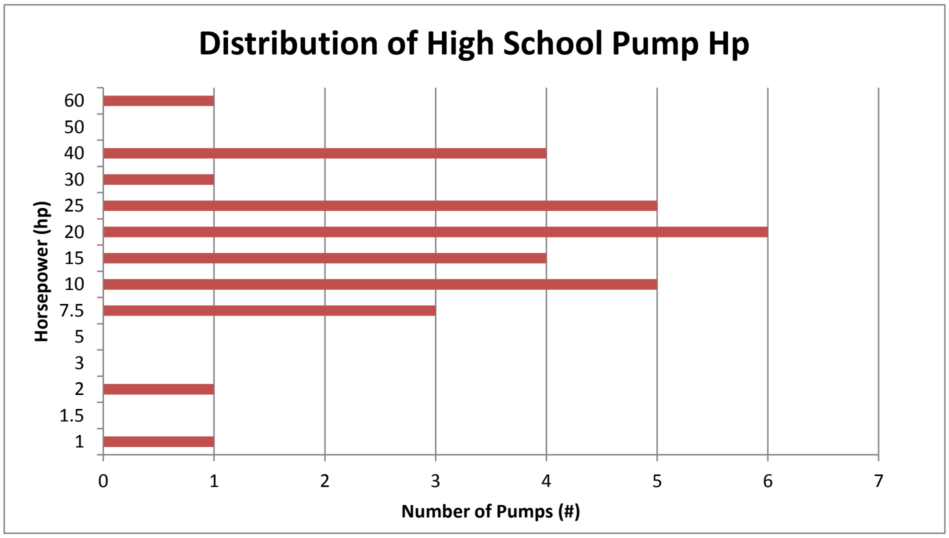


Figure 47. Distribution of Pump Horsepower – High Schools

Pool Pump Power Usage

Figure 48 shows the comparison between pump horsepower and power usage. Due to the large size of the pumps, a significant percentage of these pumps use three-phase power. The larger size of the motors means higher overall power usage for the high school.

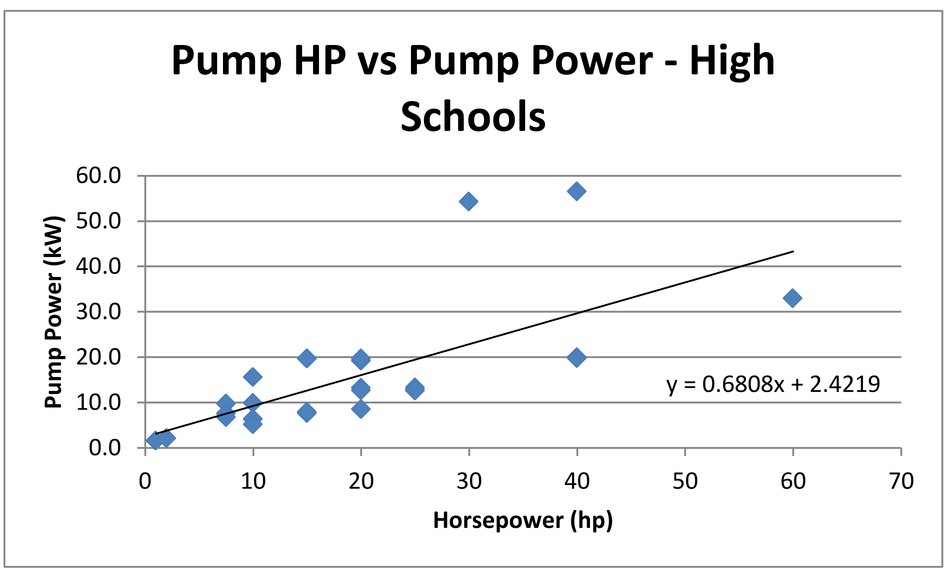


Figure 48. Pump Horsepower vs. Pump Power – High Schools

Pool Pump Speed Type

All but four pumps from the Education market segment are single speed. As many of these pumps are potentially older, large motors, it is not feasible to install a VSD without doing a complete retrofit. A retrofit involves removing the old large motor and replacing it with several smaller motors. The prevalence of single speed pumps brings up another finding from the surveys; the operators of most surveyed education sites keep the pumps running 24/7 in order to preserve the water quality and cleanliness. Figure 49 shows the pump speed types for high schools.

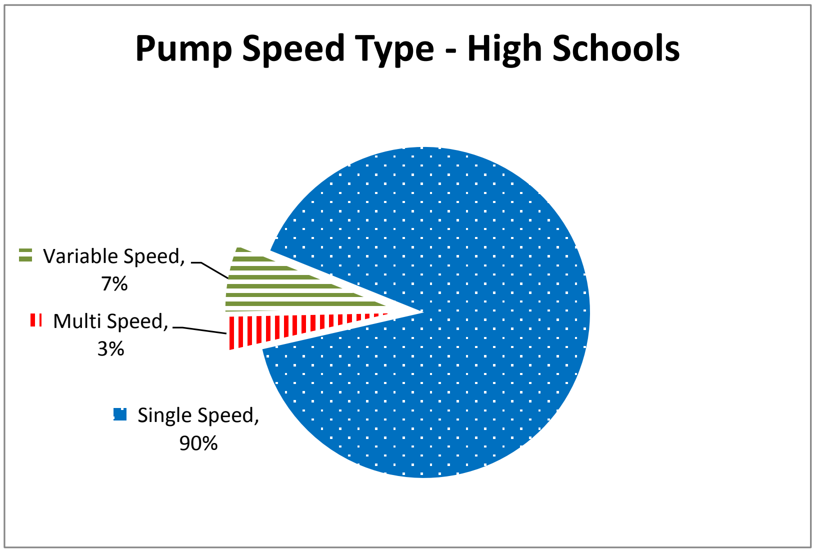


Figure 49. Pool Pump Speed Type – High Schools

FILTRATION MEDIUM

Schools and colleges surveyed use high rate sand filters or rapid sand filters, with only a few using diatomaceous earth filters. It appears that schools with larger size pumps use high rate sand filtration more often. Figure 50 shows a breakdown of the sites by filtration medium.

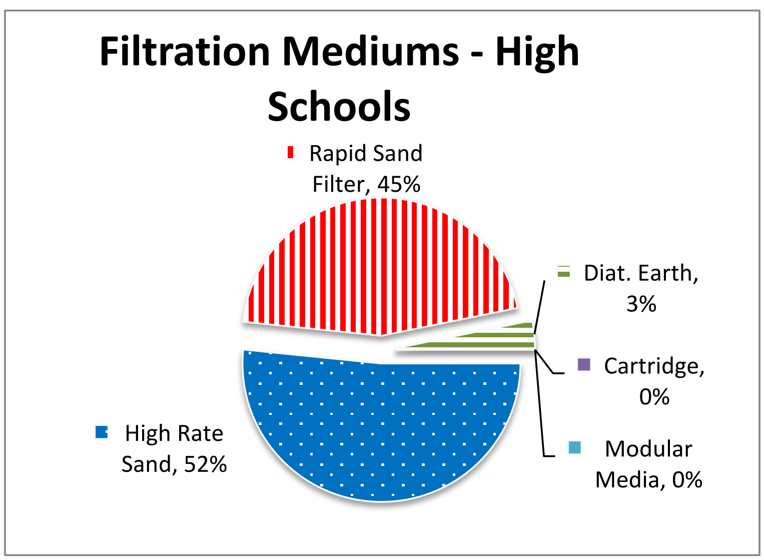


Figure 50. Filtration Mediums – High Schools

Assemblies Market Segment

This market segment covers a wide variety of public sites from fitness centers to amusement parks. This survey includes 8 gyms and fitness centers, 7 recreational parks, 4 amusement parks, 26 sports and recreation clubs, 2 religious retreats, and 3 public pools. Assembly sites showed the most variety among the data collected, mostly because of the wide variety of facility types in this market segment.

Yearly Operating Schedule and Hours of Operation

Assemblies tend to have the same amount of partial schedules during specific months of the year compared to both the hotels/motels and education market segments. Of the three segments, assemblies are also more likely to only run their pumps during hours when the pool is open. Compared to the other market segments, assemblies appear to be most similar to hotels in terms of their operating schedules. The majority of sites still operate 24 hours a day, but there is a larger percentage of the population that shuts down their pumps after the pool closes. Figure 51 shows the breakdown in assemblies pump hours of operation.

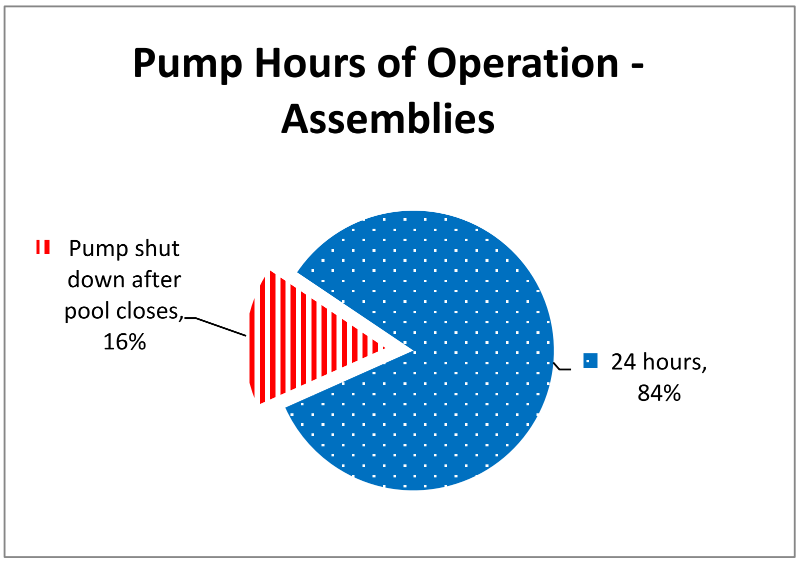


Figure 51. Pump Hours of Operation – Assemblies

Pool Turnover Rate

Also, similar to hotels/motels segments, most pool operators for assemblies do not know their actual turnover rate. A similar opportunity to educate the customer also exists here. Turnover rates between four and six hours appear to be the most common rates for these customers, which lines up with the required rates for these regions. Figure 52 shows the actual turnover rate for assemblies.

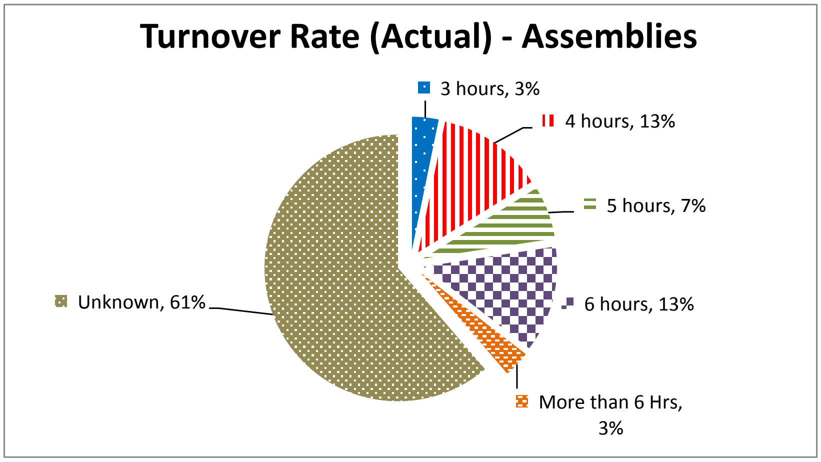


Figure 52. Actual Turnover Rate – Assemblies

PUMP HORSEPOWER

Although most of the pumps encountered at assemblies fall between 1.5 and 3 hp, there is a greater range of pump horsepower compared to the hotel/motel market segments. This may be due to the wider range of pools used in assemblies, which can range from smaller recreational pools, like those typically found at hotels, to larger lap pools found at gyms and other physical fitness centers.

A single 50 hp pump was surveyed at an aquatics center serving an Olympic size lap pool. While most pumps for assemblies fall within smaller motors, it is not uncommon to encounter pools that are closer to those found within the education market segment. Figure 53 shows the distribution of pump horsepower in assemblies.

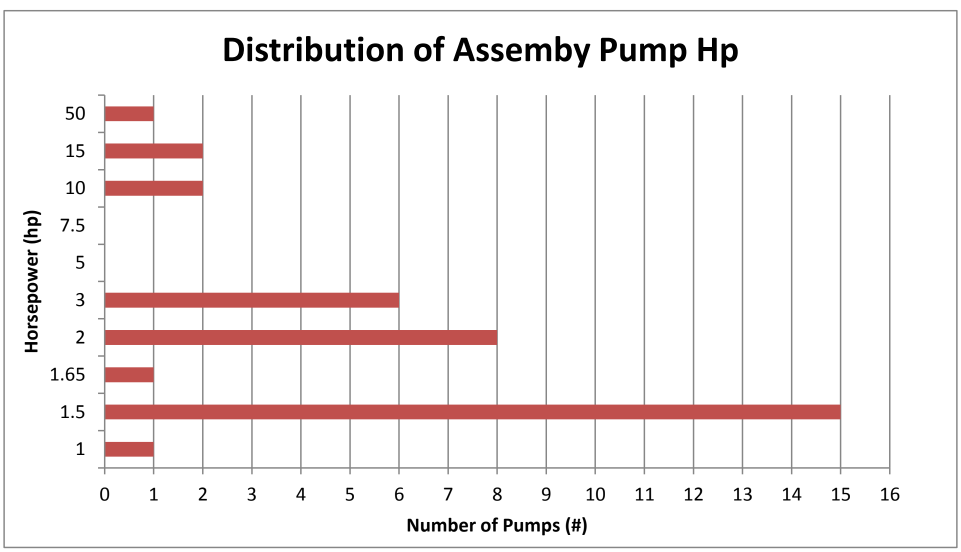


Figure 53. Distribution of Pump Horsepower – Assemblies

Pool Pump Power Usage

Figure 54 shows the comparison between pump horsepower and power usage. The power for the pumps mostly settles between 0.5 kW and 3 kW, with the single 50 hp pump as an outlier compared to the other assembly pumps.

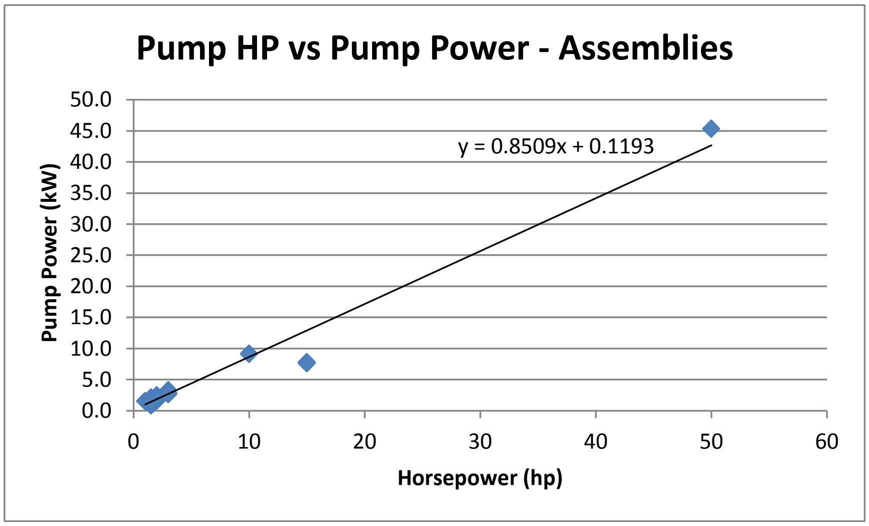


Figure 54. Pump Horsepower vs. Pump Power – Assemblies

Pool Pump Speed Type

Similar to the hotel/motel and education segments survey results, nearly all of the pumps are single speed. Assemblies have the largest percentage of installed VSD pumps, 4 out of the 31 surveyed. The owners of most of the assemblies sites surveyed keep the pumps running 24/7. This is done to preserve the pools' water quality and cleanliness. Figure 55 shows the pool pump types surveyed.

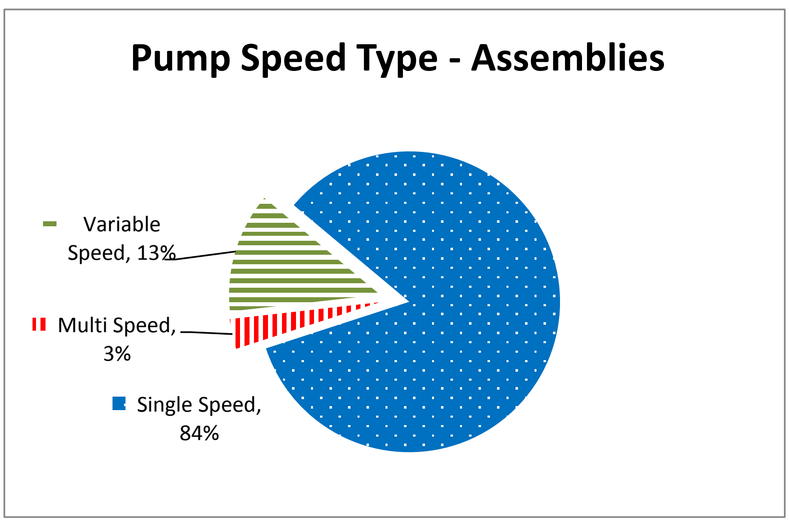


Figure 55. Pump Speed Type – Assemblies

FILTRATION MEDIUM

For assemblies, diatomaceous earth filters are again the most popular type of pool filter, followed by high-rate and rapid sand filters. One site was marked down as "unknown" as access to the filtration system was not possible at the time of the survey. Figure 56shows a breakdown of the sites by filtration medium.

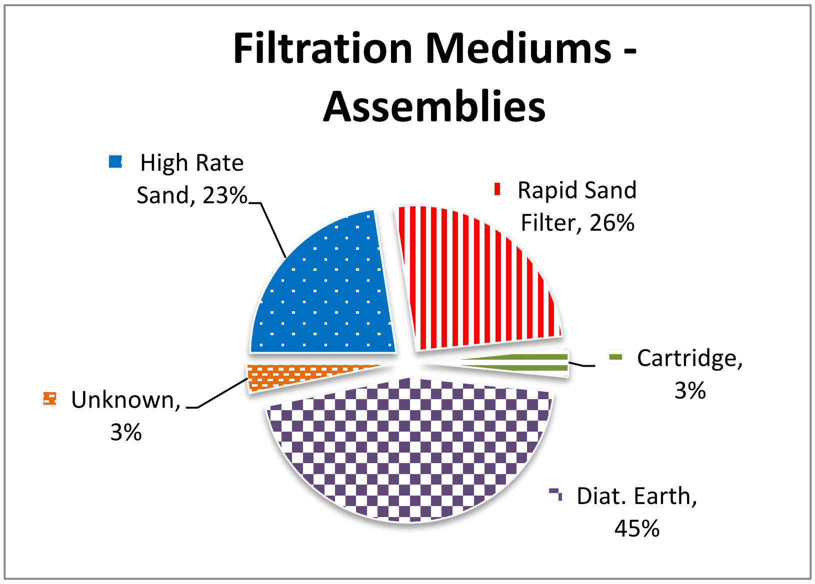


Figure 56. Filtration Medium – Assemblies