Standards Driven Market Transformation; 20 Year Multifaceted Intervention Leads to DOE Pool Pump Standard

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ABSTRACT

In 2016, DOE will adopt the first dedicated purpose pool pump standard in the nation, likely reducing filtration pumping energy use by 75% and demand by 85%, as old pumps are replaced with newly sold variable speed ones. This transformation is clearly and identifiably the result of a 20 year multifaceted efficiency improvement intervention by utilities using voluntary incentives, industry collaboration, trade education, and advocacy for state and federal standards. This paper details methods used, obstacles encountered, results achieved, and costs incurred, with insight into emerging technology, process, interaction of key stakeholders, and remaining opportunities.

Introduction:

A long time ago, in the year 2000, California was beginning to experience an electric supply crisis. It is likely that this was the result of market manipulation more than a real shortage of supply, but either way, it resulted in real curtailments for California customers, the bankruptcy of the Pacific Gas and Electric Company, the recall of then Governor Gray Davis, and cost recovery charges that persist to this day as a burden on California utility customers.

Given the gravity of the situation at the time, the California Public Utilities Commission asked the State's Investor Owned Utilities to propose programs which could be quickly implemented to reduce energy consumption, particularly on-peak. PG&E responded by proposing 3 residential swimming pool pump programs, the actual results from which are addressed later in this paper:

- A pool pump timer switch program which proposed to pay pool owners $25 for moving their pumping time off-peak
- A pump motor efficiency program which proposed to pay incentives for upgrading from pumps with standard cap-start induction run motors to cap-start, cap-run, or permanent split capacitor motors with an expected efficiency gain of 5 to 12%
- A pool pump load management program which proposed to equip pool pumps with radio remote control switches which could turn them off during periods of critically low spinning reserve

The CPUC responded by approving the timer switch and motor efficiency programs, but by rejecting the remote control switch proposal. It was rejected as it was deemed to be load

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management, where the solicitation was directed only toward energy efficiency programs. This was a surprising outcome because the timer switch proposal was just as much load management as the remote control switch one was. Furthermore, it seemed to PG&E that the remote control switch program would result in very substantial demand reduction with very little customer discomfort or inconvenience, making it an ideal choice relative to other options such as central air conditioning demand response. This proposal was never resubmitted as the CPUC never requested an explicit demand reduction solicitation. Residential pool pumps continue to be considered an opportunity where utilities are considering demand response options. Changing appliance standards are making this choice less attractive in the long run as pool pump baseline energy use and electrical demand are reducing consistent with increasing appliance standards requirements.

A question that was asked at the time of the proposal was, "if residential swimming pool pump efficiency improvement is such a good opportunity, why wasn't it previously addressed?" In the early 1990's the Southern California Edison Company and PG&E collaborated to consider such a program. We quickly learned that dedicated purpose pool pumps were not well labeled; little was published about their efficiency, and there was no agreed upon test procedure. Pools were also often considered a luxury item, where a rebate program would raise questions about giving rebates to affluent customers. Of course, this definitely is not true, and the statewide energy crisis dictated that every high potential opportunity be addressed for the benefit of all customers.

This paper qualitatively addresses what will be the 20 year course of this remarkable market transformation, with the hope that policy makers, regulators, evaluators, and program administrators will see how customer information, education, voluntary incentives, and codes & standards collectively contributed to what will likely be a national reduction in individual pool filtration energy consumption from 2600 kWh per year to less than 800, a 70% reduction! If each of these market interventions were viewed individually on a short-term basis, they might have been viewed as non-cost-effective, but collectively, over the long-term they will have transformed the market.

The Beginning and an Overview

After receiving approval in 2000, PG&E quickly went to work on implementing the timer switch program. It was followed immediately by laboratory testing of relative swimming pool pump efficiency, pilot pump program offerings, and a market characterization and evaluation. As experience was gained and obstacles encountered, changes were made to adapt and improve program effectiveness. A strong trade education effort was initiated, rebates were restructured, but most importantly, the California Energy Commission was approached through PG&E's Codes and Standards Program to adopt Appliance Efficiency Regulations for Residential Swimming Pool Pumps and Motors[5]. Phase I of these regulations became effective in 2006, and Phase II went into effect in 2008. Adoption of variable speed pumps and motors has steadily increased as has participation in the rebate program. The CEC is currently revisiting its pool pump motor regulations and the Department of Energy is conducting a Rulemaking for Dedicated Purpose Pool Pumps[6] which is expected to conclude late this year with an effective

[5] www.energy.ca.gov
[6] www.energy.gov

date 4 to 5 years from now. The time between the Rule's adoption and the effective date will give energy efficiency program administrators and implementers an opportunity to "prime-the-pump", by providing information, education, and incentives to encourage early adoption of these measures before they become required.

The remainder of this paper goes into detail discussing each significant aspect of the overall transformation process.

The Timer Switch Program

PG&E offered residential private pool owners a $25 incentive for returning a signed statement affirming that they changed their pool pumping to hours off-peak. Opinion Dynamics was hired to do a pre and post-program survey designed to assess program influence and effect. Pool owners were asked when they started and stopped pumping, if they changed their pumping hours, and if the change was a result of the incentive payment. Program effectiveness was certainly enhanced by the wide spread press coverage about the energy crisis. Given that boost in awareness, the evaluation showed effectiveness to be quite high. Amazingly, one customer who had accepted the incentive actually returned it with a note that she had to go back to on-peak pumping as the pump's noise was bothering the neighbor! By assigning an arbitrary value on 1.0 to each hour of the day randomly selected pool owners reported their pool pumps on, and by dividing by the number of total responses, we were able to develop a load curve showing the percentage of pumps on during each hour of the day. Since the average pump load was found in the ADM Study (referred toon the next page) to be 1.75 kVA, multiplying this by the number of participants and the percentage on during on-peak hours, yielded an estimated 30 MW of demand reduction for the program. The energy use associated with this demand reduction was shifted until later in the day, as can be seen in Figure 1. While this was very successful, we knew this effect would be short lived as the energy crisis eased and timers reverted to more normal on-peak pumping.

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each time of use (TOU) period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure's Total Resource Cost (TRC) benefit. For electricity, Time Dependent Valuation[7] provides avoided costs which vary hourly over an entire year as well as by climate zone. Thus, the net benefits calculation for a measure requires the total annual energy savings (kWh) of the measure, the hourly distribution of that savings over the year, and the geographical distribution of the savings by climate zone, if they are not uniform around the system. Higher economic benefits are associated with on-peak loads in hot climate zones. Swimming pool saturation is highly correlated with hot climate zones, and therefore higher economic value of savings.

Residential swimming private, in-ground pool filtration pumping has a unique load shape, which is driven by pool owner and pool maintenance contractor behavior. Those pools

7 http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/general_cec_documents/Title24_2013_TDV_Methodology_Report_23Feb2011.pdf

being maintained by maintenance contractors tend to have longer operating hours which are more centered on the on-peak period, while those maintained personally by pool owners are likely operate fewer hours more likely to be off-peak.

The swimming pool load shape and responsible owner or contractor behavior is best characterized by three studies which have been conducted. *The Swimming Pool Pump Operating Practices Quantitative Base Line Research,* August 2000, performed by Opinion Dynamics Corporation for PG&E, investigated swimming pool pump operating hours and the factors which influence them. The *Swimming Pool Pump Operating Practices Quantitative Follow-up Research,* December 2000, similarly performed by Opinion Dynamics Corporation for PG&E, investigated the energy savings and demand reduction impacts of PG&E's Pool Pump Timer Switch Program, offered in the fall of 2000. Lastly, the *Evaluation of Year 2001 SI Pool Pump Program Effects Assessment Report (Final Version),* April 2002, performed by ADM Associates for PG&E investigates the impacts of the "Summer Initiative" Timer Switch Program, and the very early stages of the state's utilities pool pump incentive programs. The last of these studies is most commonly used as for the baseline load shape for swimming pool pumping, which is shown in

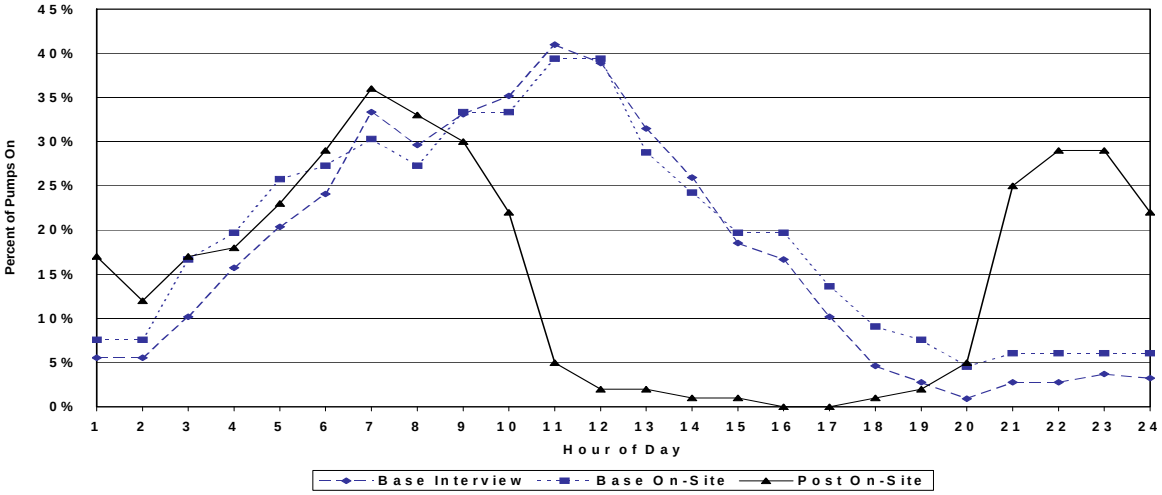
and

Figure 1 below.

Table 1- Percentages of Pumps on during given hour of day for baseline and program periods for PG&E service area.

Hour of Day	***Percentages of Pumps On***			***Hour of Day***	***Percentages of Pumps On***		
	Baseline Interview	***Baseline On-Site***	***Program On-Site***		***Baseline Interview***	***Baseline On-Site***	***Program On-Site***
1	5.6%	7.6%	17.0%	13	31.5%	28.8%	2.0%
2	5.6%	7.6%	12.0%	14	25.9%	24.2%	1.0%
3	10.2%	16.7%	17.0%	15	18.5%	19.7%	1.0%
4	15.7%	19.7%	18.0%	16	16.7%	19.7%	0.0%
5	20.4%	25.8%	23.0%	17	10.2%	13.6%	0.0%
6	24.1%	27.3%	29.0%	18	4.6%	9.1%	1.0%
7	33.3%	30.3%	36.0%	19	2.8%	7.6%	2.0%
8	29.6%	27.3%	33.0%	20	0.9%	4.5%	5.0%
9	33.1%	33.3%	30.0%	21	2.8%	6.1%	25.0%
10	35.2%	33.3%	22.0%	22	2.8%	6.1%	29.0%
11	41.0%	39.4%	5.0%	23	3.7%	6.1%	29.0%
12	38.9%	39.4%	2.0%	24	3.2%	6.1%	22.0%

Figure 1- Load Shape for pool pumps



While the findings from these reports are interesting, and the best data available, they are biased and not representative of actual coincident demand in several subtle and little known ways:

- First, the population of pool owners targeted for participation included 65,000 pool owners who had received PG&E energy audits at one time or other. These customers, having requested audits, were probably more conscious of energy efficiency and peak demand issues than the average population of pool owners.
- Second, all this data was obtained around the time of the California Electrical Crisis, when the State's electrical capacity woes were headline news and at the top of everyone's mind. The Operating Practices Quantitative Baseline Research showed that about 1/3 of pool owners who were aware of the electric supply issues in California had changed their pump operating practices.[i]
- Third, pools known to have solar thermal pool heaters were systematically excluded from this population, as they were expected to have little flexibility in their on-peak pumping and would not be good candidates for the time switch program.**Error! Bookmark not defined.**
- Fourth, pool owners who maintained their own pools were more likely to respond to the program and be surveyed than owners who utilized pool maintenance contractors.**Error! Bookmark not defined.**
- Fifth, the PG&E customer informational and educational communications, systematically and vigorously recommended off-peak pumping. This program related behavioral effect should be included and credited to the program effects rather than be excluded.

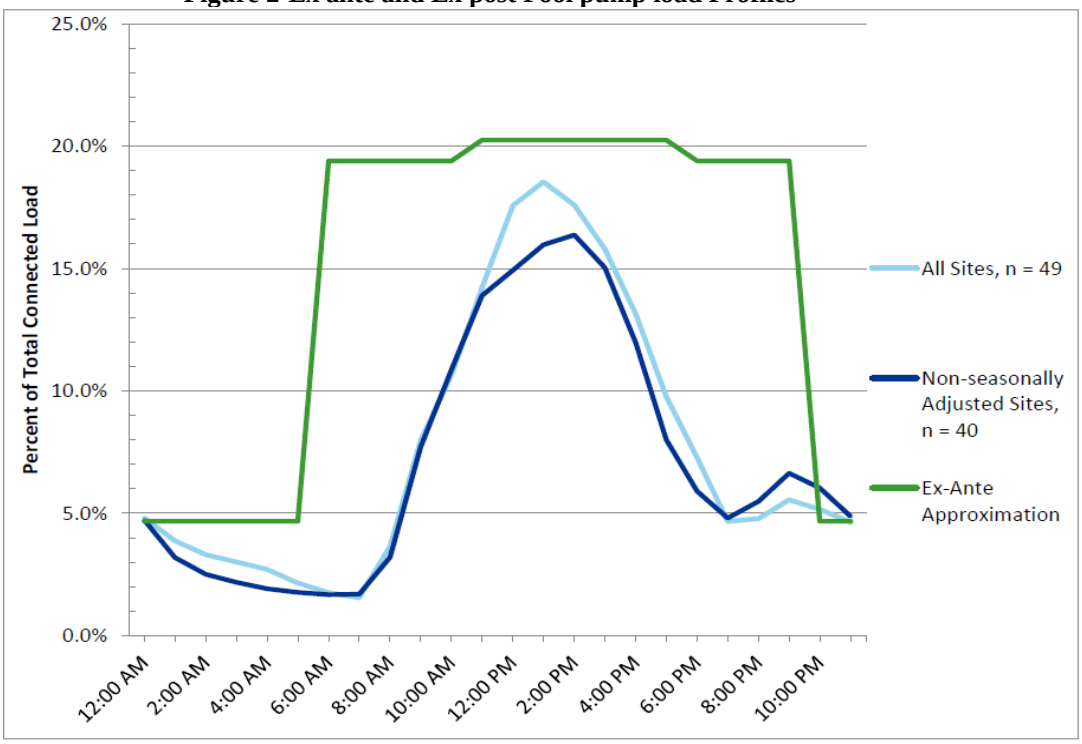
This is to say that demand reduction effect is the sum of the technical demand reduction in going from high to low speed pumping, plus the program related effects of strongly moving from on-peak to off-peak pumping time. It can be seen from the referenced studies that the effect of strongly recommending off peak pumping is significant.

An alternative way to approach this is to simply consider the impact of solar thermal swimming pool heating, which was systematically excluded from the referenced studies. According to the CEC's 2004 Residential Appliance Saturation Survey, approximately 20% of residential pools have active solar thermal heating systems. It is conservative to assume that these pools are

pumping on-peak to maintain the availability and utility of their solar heating systems. While on the hottest days of the summer, water may not actually be circulated through the solar collectors; on-peak pumping is sustained throughout the summer to maintain the capability of supplying solar heat when called for by automatic or manual controls. Further, this pumping is normally run a certain number of hours consistent with gaining the maximum solar heating benefit, which is longer than the time required to only filter the pool's water. Considering all this, it would seem unlikely that swimming pool on-peak coincidence would ever drop below 20% during hot summer on-peak hours.

PG&E believes that at the time, on-peak pumping is actually practiced by 36.2% of the pool owner population, making the on-peak coincidence factor 36.2%. A 2016, CPUC, DNV-GL Evaluation of SDG&E's Pool Pump Program indicates a much broader and more on-peak load curve, as shown in Figure 2 below. This may be because many of the sampled customers were served by pool maintenance contractors who choose to set pumps to pump during the day, despite recommendations from utilities to the contrary.

Figure 2-Ex ante and Ex post Pool pump load Profiles



Laboratory Testing

To evaluate the pool pump motor efficiency opportunity, we asked PG&E's Applied Technology Center in San Ramon to perform a laboratory test of pool pumps[8]. At the time,

[8] PG&E TES, Evaluation of Measures Applied To Residential Swimming Pool Pumps For

StaRite (now owned by Pentair) had the best published technical information, so 14 of their standard and high efficiency single-speed and 2-speed pumps were tested. No standardized or industry accepted test procedure was available at the time for pool pumps. Rather than use the conventional measure of pump efficiency, which is water / shaft horsepower at best efficiency point, or wire to water efficiency at best efficiency point, the lab was asked to evaluate differences in daily energy consumption for 1 full turnover of pool volume for different pool systems as a result of various pump speeds, sizes, and efficiency choices.

There is potentially a great variation in the characteristics of the pool hydraulic systems installed in PG&E's service territory. There are a large number of pumps, filters, heaters and pool cleaners available on the market. And, depending on the age of the system, all of these components could be connected with copper or PVC piping. So, in order to evaluate the impact of this variation, general categories of systems were defined to analyze savings potential for measures applied to these systems. The following pool types broadly describe them:

- Pool 1 (Basic Pool) – filter pump, pool filter, pool heater, manual pool cleaner
- Pool 2 – same as Pool 1 except add automatic pool cleaner
- Pool 3 – same as Pool 2 except add spa
- Pool 4 – same as Pool 2 except add solar pool heating
- Pool 5 – same as Pool 3 except add solar pool heating

Obviously, there are components that are common to all pool types, so variations within each pool type are further described by the following cases:

- Case 1: Small Pool, High Resistance Filter & Backwash Valve
- Case 2: Medium Pool, High Resistance Filter & Backwash Valve
- Case 3: Large Pool, High Resistance Filter & Backwash Valve
- Case 4: Small Pool, Low Resistance Filter, No Backwash Valve
- Case 5: Medium Pool, Low Resistance Filter & No Backwash Valve
- Case 6: Large Pool, Low Resistance Filter & No Backwash Valve

The pool sizes associated with these cases are

- Small Pool: 12 feet x 24 feet; 11,848 gallons
- Medium Pool: 18 feet x 36 feet; 26,659 gallons
- Large Pool: 20 feet x 40 feet; 32, 912 gallons

Electricity Demand and Consumption Savings, Prepared by Technical and Ecological Services, Prepared for Customer Energy Management, November 2001, Report No: 491-01.38

Table 2- The pumps tested

Quantity Tested	Horsepower Rating	Motor Efficiency	Test Speed(s)
3	2	Energy Efficient	3450
2	1.5	Energy Efficient	3450
3	1	Energy Efficient	3450
2	0.75	Energy Efficient	3450
1	2	Standard	3450 & 1725
1	1.5	Standard	3450 & 1725
1	1	Standard	3450
1	0.75	Standard	3450

The following 3 Figures show the demand savings from reducing pump speed, downsizing, and replacing pumps using a standard motors with energy efficient ones. It can be seen that speed reduction results in the most demand reduction, followed by downsizing, and then efficiency improvement. The rebate program was structured to reflect the potential energy savings.

Figure 3- Daily Energy Savings from Reducing Pump Speed, 100% Turnover Operation

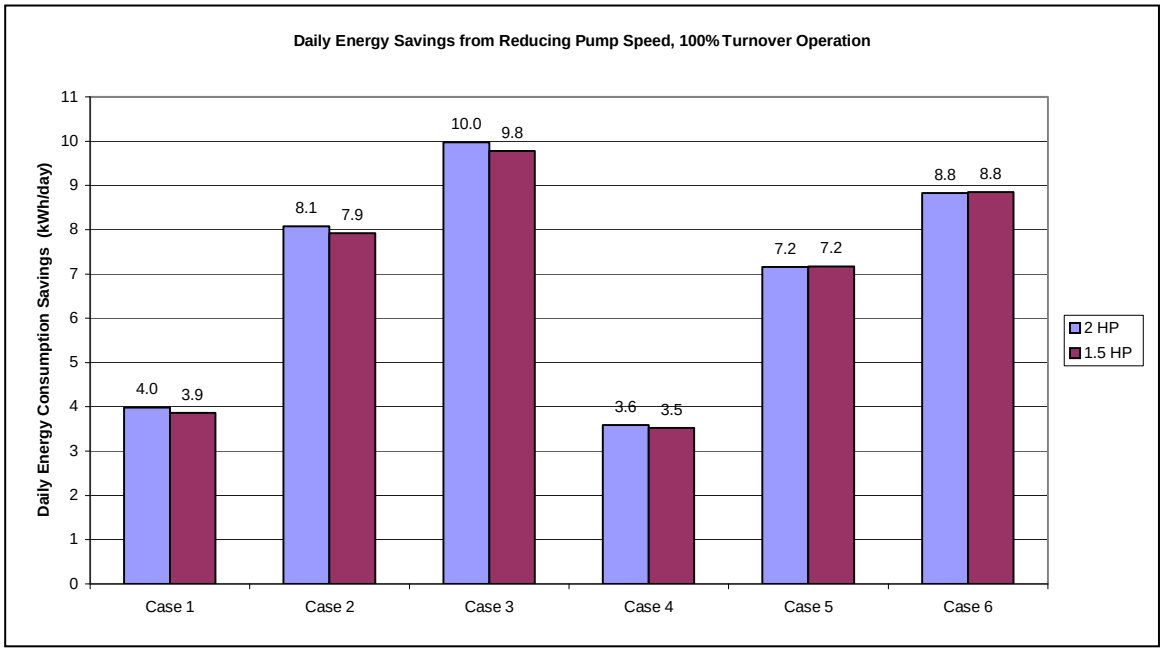


Figure 4- Daily Energy Savings from Downsizing Pump 100% Turnover Operation

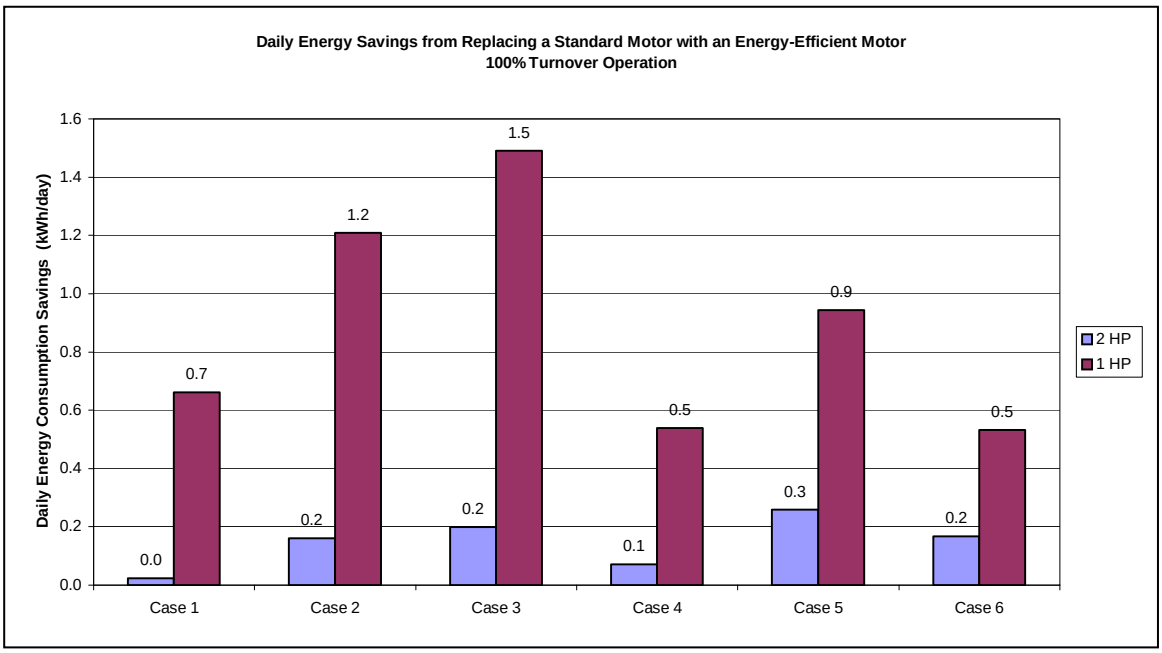
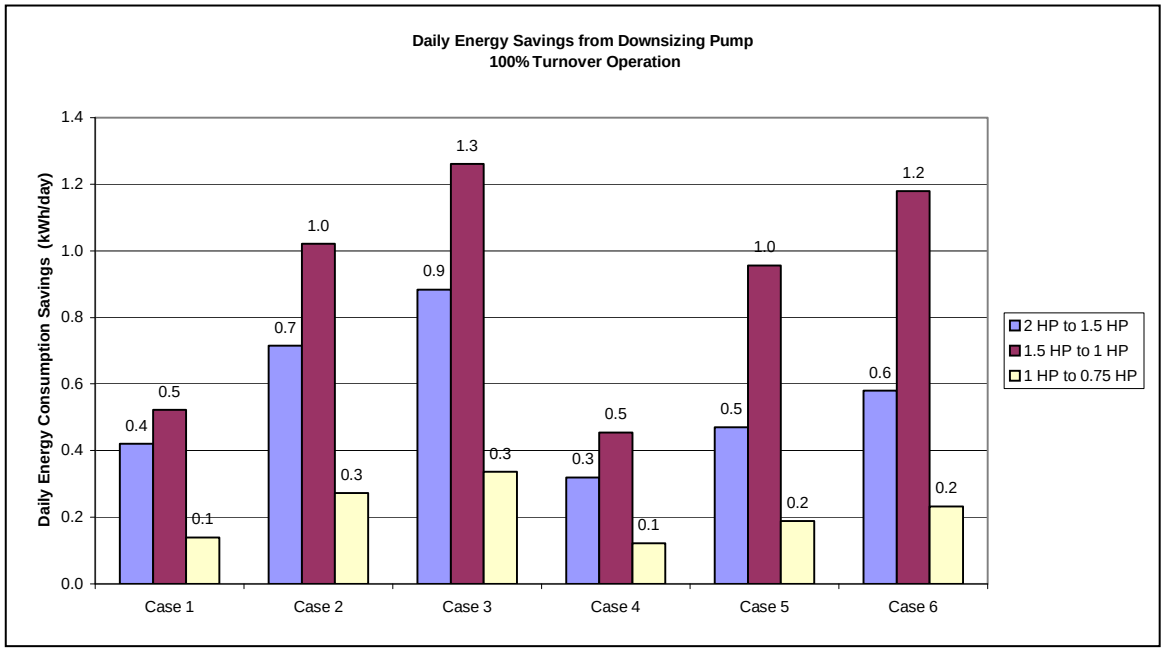


Figure 5- Daily Energy Savings from Downsizing Pump 100% Turnover Operation



The Rebate Program and Customer, Trade, and Industry Education

PG&E's first in the nation residential, in-ground swimming pool filtration pump rebate offered customers $125 for downsizing pumps greater than 1 HP by ½ HP, downsizing 1 HP pumps by ¼ HP, and not downsizing pumps of ¾ HP or less. Additionally, standard pumps needed to be replaced with pumps using high efficiency (Cap-Start, Cap-Run, or PSC) motors. A $300 rebate was offered to customers for 2-speed replacements with 2-speed capable controllers. In 2003, participation in the rebate program was only 357 of 600,000 eligible pools. This initial program was limited to residential pools as the flow rate can be reduced to produce longer than a 6 hour turnover, while for commercial pools, health codes generally prohibit this while pools are open and available for occupancy.

Recognizing that service contractors have the majority of influence in pool owners' choice of replacement equipment, and that for a variety of reasons the pool contractor service community was almost universally opposed to this measure, PG&E's Program Manager Scott Clay made a number of changes to improve program productivity.

In 2004, participation more than doubled to 800 as a result of an increased contractor education effort using a specially built mobile pool pump trailer designed by John Blessent and brilliantly built by Al Beliso of PG&E's Applied Technology Services Department in San Ramon. This trailer traveled all over California and as far as Reno and Las Vegas to demonstrate 2 and variable-speed pump performance and savings to contractors at trade shows and local Independent Pool and Spa Service Association meetings. Today, participation in the rebate program ranges from 5,000 to 6,000 annually. A PG&E-branded energy cost savings slide rule calculator was developed to help contactors estimate savings for customers. Replacement motors were included in the program as savings are completely attributable to the motors, where 40 to 60% of replacements are estimated to be motor only. The rebate was changed to provide $200 to the contractor and $100 directly to customers. It has remained that way through today.

Codes & Standards Advocacy

A couple of years prior to the development of the pool pump rebate program, PG&E proposed and received CPUC approval for a codes & standards advocacy program. By 2004, residential pool pumps and motors were looking like a good opportunity for California Energy Commission Appliance Regulation. PG&E contracted with the Davis Energy Group to prepare a Codes and Standards Enhancement (CASE) Study recommending such regulation. Leo Rainer, then working with DEG, developed the first metric and test procedure for rating pool pump performance. His approach, and Energy Factor metric on CEC System Curves A, B, & C, persist to this day and have been widely accepted in the Industry, by other states, and by Energy Star. A variation of E.F. is being considered by DOE in its current rulemaking.

In 2006, the CEC adopted the proposed Appliance Standards Regulation effectively requiring pool pump motors to be of high efficiency Permanent Split-Capacitor, Cap-Start, Cap-Run, or variable speed designs. Additionally, a Tier II Regulation was to become effective in 2008, requiring that residential, in-ground pool pumps and motors of 1.0 Total Horsepower (nameplate HP x Service Factor) or greater be of 2, multi, or variable speed design. After significant study and consideration, Pentair Pool Products supported this regulation despite a contrary view by their customers, the pool service industry. While eventually conceding, the Independent Pool and Spa Service Association opposed the 1.0 THP "tipping point" in the belief

that 1.0 THP residential filtration pumps should not be required to be 2, multi, or variable speed, even though highly vetted engineering calculations showed this requirement to be highly cost-effective. The pool industry, represented by the Association of Pool and Spa Professionals has generally been collaborative and supportive. It developed its own APSP 15 Efficiency Standard largely reflecting principles contained in rebate programs and related standards.

At the time, and to the present, this 2, multi, or variable speed requirement was limited to residential pool filtration applications as Health Codes require a 6 hour turnover of pool water when pools are open and available for use. Looking forward to new CEC and DOE regulations in progress, it is likely that the high efficiency performance provided by variable speed pumps and motors will be required universally across all markets and applications, as variable speed offers significant savings in all markets and applications while maintaining full compliance with health codes.

The CEC 2-speed pump and motor requirement scheduled to go into effect in 2008, was informally challenged by Leslie Pool Supply, which observed that replacement pool pump motors were not included in the scope of the regulations. As a consequence, the CEC could not enforce the replacement motor speed requirement until revisions were made in 2010.

Current CEC and DOE Rulemakings are changing the regulatory landscape. The CEC is focusing on dedicated purpose pool pump motors being sold with new pumps and for replacement. It is likely that regulations will be adopted which require significantly higher efficiency performance consistent with what variable speed motors offer. This may occur in Phase I and II effective dates, approximately 2 years apart. Dedicated Propose Pool Pump Motors for all applications and market sectors (residential & commercial) will be included, simplifying compliance by eliminating the limitation of scope to residential, in-ground pool filtration pump motors. DOE is addressing integral dedicated purpose pool pumps and will preempt the CEC's pump regulation, limiting the CEC to regulating just pool pump motors. DOE will likely adopt a regulation redefining the Energy Factor metric, refining and improving the test procedure, and including all products for all markets except for integral pump-filters for seasonal above ground pools.

Emerging Technology

In 2001, only single-speed and 2-speed pool pumps were manufactured. Single speed pumps were available with standard efficiency capacitor-start; induction-run, as well as higher efficiency permanent split capacitor, and capacitor-start, capacitor-run motors. While industry experts understood the efficiency differences, the service trade tended to consistently sell the least expensive, least efficient standard efficiency models. Further, there was a generalized belief that "bigger is better", particularly for pools with adjoining in-ground spas where pumps were usually sized for the spa, often making them over-sized for pool filtration.

In 2006, Ike Hornsby, founder and president of Pools by Ike in Bakersfield, California, began offering the Ikerick Dyna-Miser pump, which was a low-head fountain pump coupled to a 1/3 HP motor produced by Sta-Rite Industries. The pump was claimed to circulate 67 gallons per minute at less than 500 Watts of power demand. PG&E considered this to be eligible for the 2-speed pump rebate as it was essentially a dedicated low-speed product.

In 2007, Ike introduced the Dyna-Miser VS, the first variable speed pump, which consisted of a Sta-Rite pump head, 3 phase motor, and Square D variable speed drive. This proved to be quite popular among forward-thinking pool service technicians. Later that year

Pentair, Sta-Rite, and Hayward introduced variable speed pumps. With the introduction by major pump manufacturers, Sta-Rite components for the Ikerick pump became less available to Ike, so he partnered with Hayward to offer a Hayward branded model. Jandy-Zodiac's introduction was delayed by about a year, arriving in late 2008.

There were differences in these early models in that Pentair offered a very high efficiency electronically commutated permanent magnet motor, while the others' early models used 3 phase induction motors. Additionally, the Pentair IntelliFlo VF model included very sophisticated integral controls which were capable of maintaining constant flow within prescribed limits as system head pressure changed with filter loading. This feature offers additional energy saving opportunities that are not fully recognized and valued even today. Controls have also evolved to offer safety vacuum release system functions which will shut down pumps when their suction becomes blocked, offering additional safety by providing some protection against entrapment. This feature has proved to be popular in the small commercial pool market where SVRS systems have become required. The paper authors, with the assistance of pool efficiency contractor Gary Gockel, have recently built a variable speed booster cleaner pump from commercially available pump and motor components. This shows the potential for reducing booster cleaner pump demand from 1300 to 500 Watts, reducing power draw by 800 Watts for the same cleaner performance! At 3.5 hours per day, annual energy savings can be as much as 1,022 kWh/year.

Since then many new, high-efficiency products have been introduced, with wholesale costs dropping from roughly $1800 to $800. Integral controllers are also now offered on most models, further reducing installed costs. Connectivity is the latest emerging technology feature, with many manufacturers offering controls that can connect through the internet to smart phones or similar devices.

Further Recommendations

In the past 15 years, the utility pool pump program and codes and standards efforts have enormously increased customer, contractor, and market acceptance of variable speed pumps and motors. Further trade education and program quality assurance is desperately needed to assure that pools are reconfigured and set up operationally for maximum energy savings. Automatic cleaners or sweeps, filters, backwash valves where used, directional inlets, skimmers, pool heaters, and solar thermal heating systems all offer opportunities for reduction of resistance to the flow of water, or pool system total dynamic head. Additionally, staging of automatic cleaning, skimming, and filtration will allow better performance of each function at lower flow rates and total energy consumption.

Conclusions

From humble beginnings, over a long time, with the concerted effort of many individuals, program implementers, industry collaborators, and regulators, this extremely reticent market will have been transformed to benefit and reduce the nation's pool owner's electric operating cost.