NATURAL RESOURCES DEFENSE COUNCIL

NRDC's Response to CEC's Invitation to Participate in the Development of Appliance Energy Efficiency Measures

2013 Appliance Efficiency Pre-Rulemaking on Appliance Efficiency Regulations: Docket Number 12-AAER-2F - Residential Pool Pumps and Motors

May 9, 2013

Submitted by:
Meg Waltner, Natural Resources Defense Council

On behalf of the Natural Resources Defense Council and our more than 250,000 members and online activists in California, we respectfully submit this response to the Energy Commission's Invitation to Participate in the Development of Appliance Energy Efficiency Measures, posted on March 25, 2013.

According to the 2009 Residential Energy Consumption Survey, 1.2 million homes in CA have swimming pools, representing approximately 15 percent of California's single family homes. Of these pools, approximately 30 percent are heated, with the primary fuel source being natural gas, and 100 percent have filtration systems. Furthermore, pools in California represent approximately 20 percent of all pools in the US.[1]

In 2008, NRDC commissioned Ecos Consulting[2] to write a report on potential energy savings in pools, which is attached as Appendix A. While this report was written prior to the implementation of the current Title 20 standards which require pool pumps and motors to have a minimum of two-speeds, many of its findings are still relevant. The report estimated annual energy costs ranging from $1.1 to 1.6 billion for residential in-ground swimming pools in the US. The report found that the majority of these costs were due to electricity use, which it estimated to be between 9 and 14 billion kWh annually, with 70 to 80% of this electricity use

[1] 2009 EIA Residential Energy Consumption Survey, "Table HC8.11: Water Heating in US Homes in West Region, Divisions, and States, 2009" and "Table HC3.11: Appliances in Homes In West Region, Divisions, and States, 2009"
[2] Now Ecova.

due to pumping. The report estimated natural gas use to be between 36 and 63 million therms annually. This electricity and natural gas usage causes national CO_2 emission approximately equivalent to that of 1.3 million cars and light trucks.

While some of the opportunities for energy savings in pools have been realized through the current Title 20 prescriptive standard and utility programs encouraging the adoption of variable speed pumps and motors, further savings from a performance standard are possible and we encourage CEC to analyze a potential standard and benefits.

1. Basic Information Request:

1.1 Product definitions (there are definitions in existing code)

NRDC supports the implementation of a performance-based standard for single phase pool pump motors under 5 HP.

1.2 Sales information related to pool motors/pumps sold in California.

According to RECS, there were 700,000 swimming pools with filters (indicating the presence of a pump and motor) in California in 2001.[3] This number had grown to1.2 million pools with filter systems in CA in 2009,[4] indicating the addition of an average of 62,500 pool filters per year. These estimates do not include replacements.

1.3 Costs of lower efficiency pool motors/pumps, higher efficiency pool pump/motors, variable speed motors, and two speed motors

No response.

1.4 Products' duty cycle and per unit estimated energy consumption

No response.

1.5 Design life cycle and incremental cost of energy efficiency improvement

No response.

2. Product Information

2.1 Test methods to measure the energy consumption

No response.

2.2 Sources of test data

[3] http://www.eia.gov/consumption/residential/data/2001/pdf/hc/appl/hc5-7a_4popstates2001.pdf
[4] EIA RECS, "Table HC 3.11: Appliances in Homes in West Region, Divisions, and States, 2009"

No response.

2.3 Energy Use Metrics

No response.

2.4 Product Development Trends

As described in further detail in comments submitted by the California IOUs, efficient pool pump options have increased significantly over the last decade. In particular, advanced variable speed pumps and motors have been developed that achieve significant energy savings. Despite these advancements, there has been little progress on improving the efficiency of single-speed and two-speed pump motors, despite the availability of low-cost technology options.

2.5 Market barriers to Energy Efficiency

There are several market barriers preventing the implementation of higher efficiency pool pumps and motors even though they are cost-effective. These barriers include split-incentives (such as the builder or landlord making the purchasing decision) and a focus on first cost, despite long-term energy savings over the life of the product.

2.6 How do consumers identify efficient products on the market?

No response.

2.7 How many small businesses are involved in the manufacture, sale, or installation of these products?

No response.

2.8 Any other data relevant to this proceeding

No response.

3. Residential Pool Pumps & Motors

3.1 Current annual sales 2008-2013 and estimated Compound Annual Growth Rate (in CA and nation).

See response to 1.2.

3.2 What pool pumps models are currently in the market, please provide description/characteristics of the unit i.e. single speed, variable speed, and their efficiency.

No response.

3.3 Do higher efficiency pumps require additional equipment to operate properly in new or existing pools Such as timers or controllers etc?

No response.

3.4 What are the time and installation cost to replace an existing system and how does that vary with different efficiency and technology pool pump motors?

No response.

3.5 What test procedure should be used or modified to measure the efficiency of the pump/motor?

No response.

4. Residential Pool Pumps & Motors

4.1 Are there any new features in pool motors/pumps that offer better efficiency from existing units? Please describe.

There are many available features in pumps on the market today that improve efficiency. These include improved hydraulic design, electronically commutated motors, and variables speed controls and drives.

4.2 How many high efficiency units are in use in California, how much energy do they save?

No response.

4.3 Provide performance data related to pool motors/pumps i.e., total horse power, name plate horse power, service factor, flow rate, and head curves.

No response.

5. Residential Pool Pumps & Motors

5.1 Is there a difference between units sold to residential and commercial sectors?

No response.

5.2 Is there any survey done to gauge consumers' acceptance and performance of the new units? If so, what results?

No response.

5.3 How is pool pump motor energy efficiency marketed to residential and commercial sectors?

No response.

Synergies in Swimming Pool Efficiency:

How Much Can Be Saved?

Prepared for:
Noah Horowitz
NRDC Sr. Scientist

Authors:
Jeremy Rivera, Chris Calwell, Laura Moorefield
Ecos Consulting

Natural Resources Defense Council

March 24, 2008

Executive Summary

Various research reports over the last 25 years have investigated the energy savings achievable from individual swimming pool efficiency measures: more efficient pumps, two-speed pumps, solar or heat pump water heating, etc. This report examines a range of different energy efficiency measures to understand the savings opportunity from *combinations* of energy efficiency measures in new and existing residential in-ground swimming pools.

Uncertainties in total swimming pool energy use remain high, in part because of wide regional variations in usage patterns and a lack of region-specific measured data. We estimate that the total national energy bill for residential in-ground swimming pools is between $1.1 and $1.6 billion per year, with electricity used by pool pumps accounting for the majority of the total. Total annual swimming pool energy use of 9 to 14 billion kWh of electricity and 36 to 63 million therms of natural gas causes national CO_2 emissions of approximately 10 million tons per year – the equivalent of 1.3 million additional cars and light trucks on the road. By themselves, residential in-ground swimming pools consume the annual electrical output of 3 to 4 average-sized coal-fired power plants.

That energy use is spread across roughly 4.5 million pools, averaging $250 to $360 per pool per year. This average masks a wide range of energy use estimates for different climates, utility rates, usage patterns, and pool sizes, with the pools in just five states (California, Florida, Texas, Arizona, and New York) accounting for 58% of the total and more energy use than the pools in all the rest of the states combined. Not surprisingly, the greatest energy savings are possible in pools that consume significantly more energy than average, either because they are used more heavily than typical pools or they are heated. We examined pool energy use in five cities—Los Angeles, Phoenix, San Antonio, Tampa, and New York City — in order to capture a wide range of weather conditions, pool seasons, and energy costs among the nation's most populous and rapidly growing states.

Our research indicates that savings of $400 or more for some pools are possible by addressing inefficiencies in pool pumping. For heated pools, even more savings are possible by addressing thermal losses. Overall, we estimate that at least 2/3 of the energy use can be saved cost effectively in new and existing pools through a series of holistic design approaches:

- Select a properly sized, highly efficient two-speed or variable speed pump. Variable speed pumps can generally achieve greater efficiencies and, if properly programmed, can reduce pool pumping energy by as much as 90%.

- Employ automated controls to ensure the pump runs at low speed for longer periods of filtration and at high speed for short periods of pool vacuuming or water feature operation. Controls can ensure filtering occurs for no longer than necessary and that it occurs during the times of day not coincident with the utility's peak. Automated systems may also provide real-time feedback to owners about heating and pumping energy use, so they can shut down pools for the season as heating costs become prohibitive.

- Use pool cleaners that operate on low pressure or are robotic, self-contained units. These use significantly less energy for cleaning than higher pressure products that require booster pumps.

- For new pools, design the piping system to use 2 inch or greater diameter piping in lengths that are as short and straight as possible, and use sweep elbows instead of 90 degree bends. For sand and diatomaceous earth filters, use larger diameter, lower-pressure backwash valves. Or, use oversize cartridge filters.

- Covers help to reduce heating energy and water losses from evaporation, but the most commonly sold floating bubble covers can be inconvenient and unattractive, making them less likely to be used regularly. Design the pool to utilize an automatic retracting cover if possible. While they cost significantly more, automatic covers can cut heating energy use significantly, minimize the amount of debris that gets into the pool, and cut chemical use for pool sanitation as well. Additionally, they offer aesthetic and safety benefits to the owner.

- Size the heater properly to the remaining load and anticipated swimming season, employing an efficient technology such as a high-efficiency natural gas heater, a solar thermal system, or a heat pump instead of conventional natural gas or electric resistance options[1].

- If possible, install the pool in a location that captures maximum sunshine, shielding it from as much wind as possible, and avoiding debris from trees and loose soil that would require added filtration and cleaning.

Simply replacing a standard single-speed swimming pool pump with a "high-efficiency" pump and motor can save 260 kWh per year, according to research conducted for PG&E (PG&E) by Davis Energy Group. Savings of 1,040 kWh per year can be achieved with a two-speed pump.[2] Efficient variable speed pumps can reduce energy consumption even more. Coupling these savings with additional savings opportunities from more efficient piping and filters and better controls can increase annual pumping electricity savings to about 1,600 kWh per year for each pool. For pools that are heated for at least some portion of year, the additional energy savings achievable from more efficient heating equipment and employing a pool cover are even greater. More than half of the national energy bill for swimming pools could be saved by optimizing their design at the time of installation.

ENERGY STAR®-labeled homes in the states where pools are most commonly installed tend to save about $250 to $700 per year on energy bills, depending on house size, occupant behavior, climate type, and the design strategies employed. We have identified pool pumping energy savings of $250 to $400 per year, and heating energy savings of up to $250 per year from efficient heating and the use of a cover. Giving an ENERGY STAR label to a home without considering the efficiency of its pool, if one is installed, misses a very large opportunity for additional energy savings. *Indeed the pool energy savings opportunity can be larger, more coincident with peak, and more cost effective than the comparable opportunities in the home itself.* However, pools are often constructed subsequent to the home by a different contractor than the original home builder, so the solution is not as simple as adding pool criteria to efficient homes programs.

We make five recommendations to the energy efficiency community:

- Create a standardized software package that allows pool designers and builders to model the energy use high-end, custom pools, and to understand the energy impacts of particular component choices. This software could also be used as a training tool to educate pool builders and consumers about the energy impacts of components of typical pools and how to operate their pools efficiently.

- Once such software is available, it would be possible to assign numeric scores to various efficiency features. This could facilitate a system similar to the Home Energy Rating System (HERS) or various green-built homes programs, whereby builders need to accumulate a certain number of points to achieve particular rating levels.

- ENERGY STAR®, LEED, or other voluntary labeling programs should consider adopting specifications for new pools that promote basic efficiency measures for new construction.

- Utilities should consider deploying energy efficiency incentives and marketing programs keyed to those voluntary ratings, to encourage installation of efficient equipment.

- Utility-funded efforts to document user behavior and verify energy savings in the field are also needed.

---

[1] Proper selection of heating equipment is dependent upon climate and pool usage patterns. High efficiency natural gas heaters are appropriate for occasional rapid heating. Solar thermal systems and heat pumps are ideal for keeping a pool within a set temperature range for a long period of time. Performance of solar thermal systems and heat pumps is affected by climate.

[2] Pacific Gas & Electric Company, *Analysis of Standards Options for Pool Pumps, Motors, and Controls*, prepared by Davis Energy Group, March 11, 2005

Acknowledgements

We would like to thank the following individuals for their contributions to this research and thoughtful review of previous drafts:

- Gary Fernstrom, Pacific Gas & Electric Company
- Leo Rainer, Davis Energy Group
- Antonia Tsobanoudis, Davis Energy Group
- Richard Faesy, VEIC
- Katharine Kaplan, US EPA ENERGY STAR program
- Sam Rashkin, US EPA ENERGY STAR program
- Jeff Farlow, Pentair Water Pool & Spa Division

Jeremy Rivera is a self-employed energy consultant who worked under sub-contract to Ecos to assist with the energy analysis and writing of this report.

This research was funded by a grant from the U.S. Environmental Protection Agency's ENERGY STAR program to the Natural Resources Defense Council. The views and findings expressed herein are solely those of the authors and do not necessarily state or reflect those of the EPA. This draft does, however, reflect revisions in response to comments by EPA. For more information, contact the Project Manager, Noah Horowitz, at nhorowitz@nrdc.org or (415) 875-6100.

Table of Contents

1 INTRODUCTION

As more of the U.S. population has migrated to sun-drenched portions of the southwest and southeast states, residential swimming pools have become increasingly common. Today more than 4.5 million in-ground pools, 3.5 million above-ground pools, and nearly 5.2 million hot tubs are in use residentially nationwide.[3] This report focuses on the energy savings opportunity represented by new, residential, in-ground swimming pools, though much of its analysis could be applied to other pool types as well, significantly increasing the total savings potential. The research was funded by a grant from the U.S. Environmental Protection Agency's ENERGY STAR program to the Natural Resources Defense Council, with the goal of understanding pool energy use and exploring cost-effective ways to reduce it.

Much of the pool efficiency research done to date was performed in the 1970's and 80's, primarily in Florida. That research led to a flurry of early interest in solar and heat pump technologies for pool heating, while also focusing attention on the energy use associated with water pumping. The Florida Solar Energy Center created software to assist with proper solar equipment sizing, and the Department of Energy created Energy Smart Pools software[4] to help consumers understand the energy consequences of various pool design decisions. But in the last decade, much of this research interest has waned, with the DOE no longer distributing its software and utilities focusing their attention largely on pool pump timers and on new efforts to replace oversized single-speed pumps with properly sized two speed pumps. Yet the national energy bill for swimming pools has never been higher, inviting a reexamination of the factors responsible for swimming pool energy use and the technologies and strategies for curbing that energy consumption.

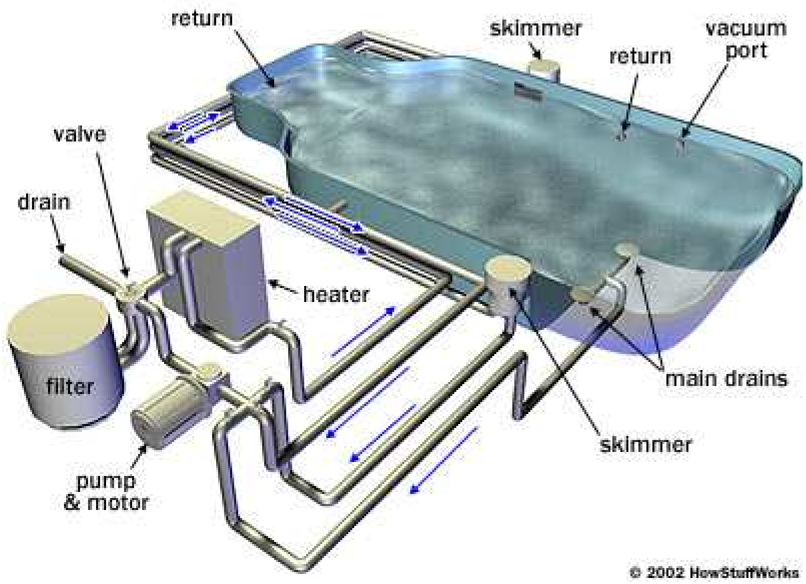
1.1 How Swimming Pools Work

At its most basic, a residential swimming pool is nothing but a lined hole in the ground with plumbing and a large pump to push water through a filter and return it back to the pool. But today's designs employ considerably more components and technology than that. Pool shapes are often elaborate, free-formed designs, integrated with landscaping, lounging, and outdoor dining areas. Water is collected from skimmers on the pool surface and one or more drains at the bottom of the pool to more effectively capture dirt and debris. Chlorine can be dispensed manually into the pool, or chemical balance can be maintained with ozonation, salt water, or bromine systems, often under automatic control. Pool vacuums can be designed to operate automatically off of the pressure side or suction side of the pump. "Robotic" or low voltage electric pool cleaning systems are also available that travel around the pool to collect dirt and debris not automatically filtered by the pool's other systems. Lighting and sound are often integrated into the pool area, again under automatic control. Pools can include "water features" like fountains, waterfalls, and slides, or be integrated with adjacent hot tubs. Heaters are becoming an increasingly common means of lengthening the swimming season. Modern control systems offer users the promise of full pool control from the comfort of their home or even via the Internet. Automatic or manual covers can be fitted to the surface to keep out debris, improve safety, and reduce evaporation.

---

[3] Personal communication, Loren Brown, PK Data, February 10, 2006.
[4] See www.flasolar.com/energy_smart_pools.php

Figure 1. Basic Components of a Swimming Pool



1.2 Market Challenges

The challenges faced by the efficiency community in improving pool efficiency are numerous. Swimming pools tend to be designed and operated based on established industry practices and "rules of thumb". Homeowners and builders often select pool locations with greater attention to aesthetics than practicalities, placing them in locations that are often shaded for part of the day, exposed to prevailing winds (which increase evaporation and heating losses), and near trees that shed leaves and other debris into the pool.

They select pool shapes that are aesthetically appealing but difficult to fit with automatic covers, leaving users a choice between a difficult-to-handle and often unattractive floating cover, an oversized rectangular cover, or no cover at all. Pool designers and installers often employ familiar filter technologies and piping layouts that are undersized. The resulting hydraulic loads are substantial, requiring large pumps that are then often oversized to provide an additional "margin of safety" for the user. Installers may compensate for the high cost of such pumps by selecting inefficient ones to keep the project within budget, further increasing energy use.

Installers then impart rules of thumb to the user about needed hours of pump operation, running filters longer than necessary to maintain water clarity. Even after the pool season ends and the heaters are shut off, owners in mild climates will often continue to operate pumps and filters during the off-season to keep the appearance of the pool attractive and reduce the hassle of preparing it for use the following year. Automatic controls are becoming more popular in new installations, but are far less common in the large number of already installed pools.

Even with natural gas prices having reached extremely high levels in recent years, most pool heaters still employ natural gas. Solar and heat pump technologies are less common, but growing steadily in markets like Florida and California where both function well.

As a result of previous research, several utilities have begun to offer rebates for more energy efficient pumps and motors, particularly two-speed designs. These programs often lead to substantial reductions in energy use and peak power demand, but typically have not addressed other design elements to further reduce the hydraulic load of a pool. Similarly, it has been difficult for utilities to encourage sophisticated control strategies for pool pumping, so many limit their efforts to installing automatic timers that shift pool pump operation away from peak or allow the utility to defer pumping on command during times of peak energy use. Historically, utilities have not been able to employ synergistic approaches to reducing whole-pool energy use in part because the research has not been conducted to suggest what approaches to new construction would make the most sense.

Recently, however, PG&E and San Diego Gas & Electric (SDG&E) funded research in order to propose comprehensive residential swimming pool efficiency standards for the 2008 Title 24 California Building Energy Efficiency Standards[5]. The proposed standards address pump motor selection and controls, pipe design, and filter size selection. These standards are likely to be adopted in early 2008 and will take effect in 2009.[6]

Similarly to the Title 24 report, the research on which this NRDC report is based was conducted to assess the holistic energy savings opportunity represented by swimming pools. It asks what is possible from totally optimizing a new pool design while still maintaining sanitation capabilities and water circulation and rates high enough to maintain acceptable water quality. Five specific technologies and approaches are considered, individually and in combination:

- Installing a cover to greatly reduce evaporative losses and the volume of debris that collects in the pool

- Upgrading from a conventional natural gas heater to a high-efficiency natural gas heater, an electric heat pump, or a solar water heater (depending upon climate and pool usage patterns)

- Reducing friction losses in piping, valves and the filter to minimize hydraulic loads

- Sizing the pump properly to the newly reduced loads, improving its electrical efficiency, and providing two or more operating speeds to allow low-speed pumping during the majority of operating hours

- Improving control strategies to ensure the pool pump is only operating as much as needed to effectively clean and heat the pool and circulate chemicals

Many studies have already been performed on pumping opportunities. Rather than revisiting past analyses of the savings to be gotten from more efficient single or dual-speed pumps, we looked primarily at the additional benefits of variable speed models. We also devoted considerable attention to the savings obtainable from devoting attention to proper hydraulic system design from the outset, compared to existing pools and many standard new ones.

In an effort to gauge the size of the opportunity, a major city in each of the five states with the largest number of pools was selected for analysis. The same set of calculations was performed for an identical pool in each of these cities and the results are presented here. "Energy Smart Pools" software was utilized to generate the heat losses and gains from a pool. The software was developed by the U.S. Department of Energy and uses hourly temperature, humidity, and solar data along with accepted engineering principles to make the calculations.

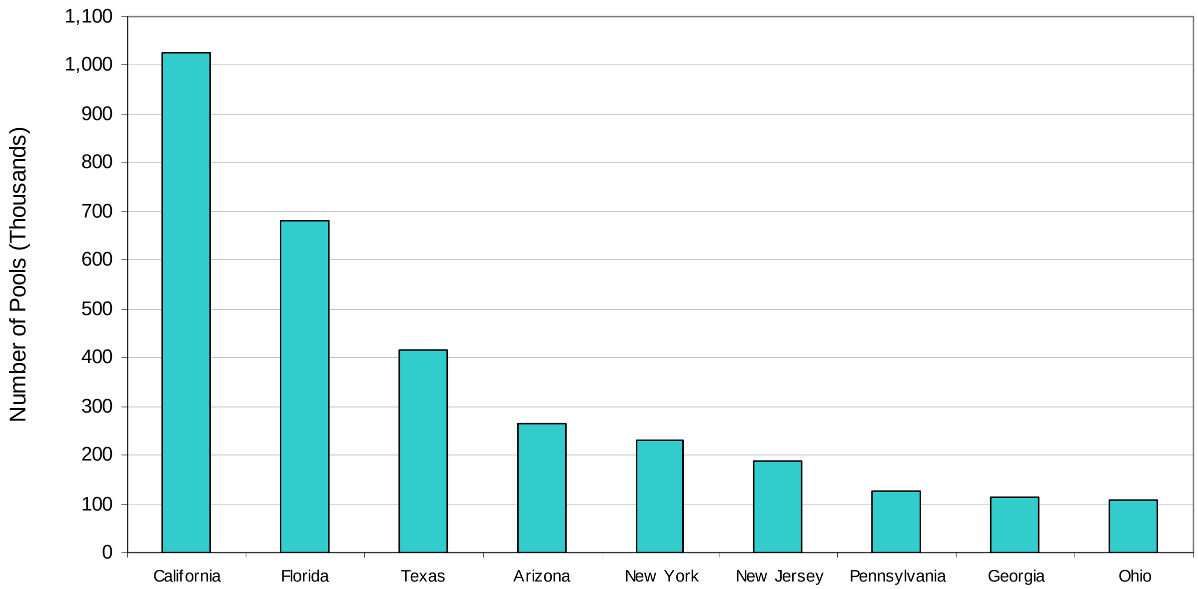
---

[5] See Pacific Gas & Electric Company and San Diego Gas & Electric, March 23, 2007, *Residential Swimming Pools: 2008 California Building Energy Efficiency Standards*, prepared by Davis Energy Group
[6] For current status of proceedings, see the California Energy Commission Title 24 Website, http://www.energy.ca.gov/title24/2008standards/rulemaking/

2 BACKGROUND

Of the 4.5 million in-ground residential swimming pools in the United States, a full 58% are located in just five states—California, Florida, Texas, Arizona, and New York. Only four additional states have more than 100,000 pools each (Figure 2). More than 10% of Florida and Arizona households have an in-ground pool.[7]

Figure 2. Residential In-Ground Pools by State



Sales are rising by 6% per year for new swimming pools, and 11% per year for pool heating systems. While many of these systems are infrequently used, this suggests that pool heaters are a growing source of electric and natural gas demand in the residential sector.[8] Sales are growing the most rapidly in the western and southern states, mirroring the rapid growth in new home sales in those regions. DOE data confirm the growth as well, although at a slower rate, indicating that 3 million households had a pool in 1980, but that 6 million households had one by 2001 (implying an annual growth rate of closer to 3.5%).[9]

Energy use of pool pumps has been the focus of many studies; however, the estimates vary widely. A study by LBNL estimates that national electricity use for pool pumps alone is roughly 1 billion kWh per year in 2005, or just over 200 kWh per year per pool. Recent data suggest that estimate is conservative. The DOE assumes a national average of 1,500 kWh per year based on surveys conducted in 2001.[10] Dividing the DOE estimate by all households, instead of just those households with pools, yields an estimate of 92 kWh per year. A 2004 study commissioned by

[7] Personal communication, Chris Calwell, Ecos Consulting, February 10, 2006, Loren Brown, PK Data.
[8] Personal communication, Catherine Hardy, Ecos Consulting, June 2005, based on internet and telephone market research.
[9] See http://www.eia.doe.gov/emeu/reps/appli/us_table.html.
[10] http://www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html

the California Energy Commission reported annual pool pump energy use of 2580 kWh in California[11]. The 2008 Title 24 analysis funded by PG&E and SDG&E estimated pool pump energy use in California at just over 3,000 kWh per year.[12] A reasonable current estimate for a national average is approximately 2,000 to 2,500 kWh per year, recognizing that the swimming season is longer in California than many other states. That average masks wide variations from region to region, with a handful of states using significantly more and the majority of states using less.

Estimates of pool heater prevalence and energy usage vary widely as well. Pool industry data sources indicate that about 35% or 1.6 million of the 4.5 million in-ground pools are equipped with heaters, though annual hours of heating operation can range from thousands to zero, depending on owners' preferences.[13] DOE's Residential Energy Consumption Survey (RECS) from 2001 indicated that 1.2 million households had pool heaters out of the 6.5 million households estimated to have pools (in-ground and above-ground) with filtration equipment. This implies that about 18% of pools are *able to be heated.* DOE estimates that two-thirds of those heaters rely on natural gas, while the remaining third are electric resistance, electric heat pump, LPG, or other types.[14] Our analysis assumes that about 10% of pools are routinely heated, which is conservative, but consistent with NREL findings below that many people with non-solar heaters use them rarely if at all.

In electrically heated pools, heat pumps are increasingly displacing electric resistance heaters, but it is difficult to find data on the precise split between them. DOE assumes a national average of 2,300 kWh ($207) per year for electric heating of swimming pools, spas, and hot tubs.[15] This is an average for only the 3.3 million households that have such equipment, so the average usage for *all* households is much lower – about 71 kWh per year. Because the RECS data do not distinguish between pool and spa/hot tub heaters, it is difficult to attribute DOE data or estimates specifically to pools. While it takes far more energy to heat a pool than a spa, pools are only operated seasonally, whereas spas can be in use year-round. Apportioning pool heating energy use and type by region is even more challenging. Generally, heat pump heaters are most effective in humid climates like Florida where that can readily transfer latent heat from the air to the water and where the temperature difference between the air and water is small.

Given all of these uncertainties, our analysis predicted that total in-ground residential swimming pool electricity consumption is approximately 9 to 14 billion kWh per year, with about 70 to 80% of that total attributable to pumping. We estimate that pool natural gas consumption is about 36 to 63 million therms per year, entirely attributable to heating. This implies an annual swimming pool energy bill of about $1.1 to $1.6 billion. Likewise, it suggests total annual carbon dioxide emissions from pool energy use of about 10 million tons – the equivalent of 1.3 million additional cars and light trucks on the road.

It is also the case that homes with swimming pools consistently demonstrate higher energy bills that homes without them. Figure 3 illustrates the findings of a recent BC Hydro research project exploring the energy use of large homes in its service territory. Note that the homes with the highest annual natural gas (vertical axis) and electricity (horizontal axis) consumption tend to have pools.

---

[11] California Energy Commission, June 2004, *California Statewide Residential Appliance Saturation Study*, prepared by KEMA-XENERGY, Itron, & RoperASW

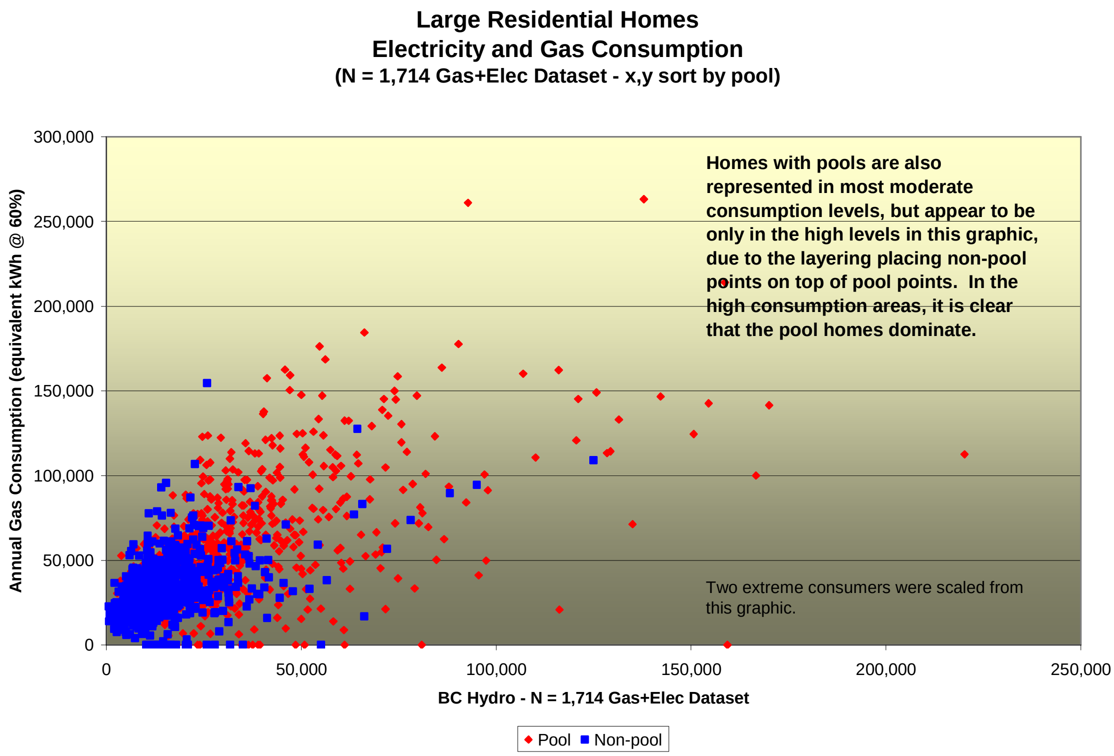
[12] Pacific Gas & Electric Company and San Diego Gas & Electric, March 23, 2007, *Residential Swimming Pools: 2008 California Building Energy Efficiency Standards*, Prepared by Davis Energy Group

[13] Personal communication, Loren Brown, PK Data, February 10, 2006.

[14] U.S. Department of Energy, *2001 Residential Energy Consumption Survey*, Table HC5-1A, "Appliances by Climate Zone," 2003.

[15] http://www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html.

Figure 3. Large Residential Homes Electricity and Gas Consumption



BC Hydro determined that pools tend to add an average of roughly 24,000 kWh/year to the annual electricity consumption of a large home in their service territory. Indoor pools add an additional 6,000 kWh/year beyond that, primarily for the HVAC electricity to dehumidify the rooms adjoining the pool. However, outdoor pools in British Columbia tend to use significantly more natural gas than indoor pools, which is consistent with their exposure to lower average temperatures and more wind. BC Hydro's Dennis Nelson found that the utility's average large home without a swimming pool consumed about 4.6 kWh/square foot of house size/year vs. 7.7 kWh/square foot/year for homes with pools. [16] It is not surprising that these numbers are significantly higher than our national estimates, since BC Hydro was specifically examining the largest homes with the highest energy use in its service territory.

Only a handful of published reports in the public domain address the question of heater and cover use in pools. An NREL study from 1998-1999 of pool owners in California, Arizona, and Florida[17] established a number of key attributes of pool heating technology and usage patterns among the "users" and "non-users" of solar pool heaters (see Figure 4). What is particularly striking about these survey results is the large difference in usage of pool covers between California residents and residents of Arizona and Florida.

They also indicate low usage of pool covers and consistently longer periods of swimming pool use by those with solar pool heaters. Industry data confirm that only about 120,000 pool covers are sold annually. Only 32% of builders sell a cover with the swimming pools they build and, of those, only 24% are automatic covers.[18] Sales and usage of pools covers are likely to increase as state mandates and local ordinances begin to require pool covers for

---

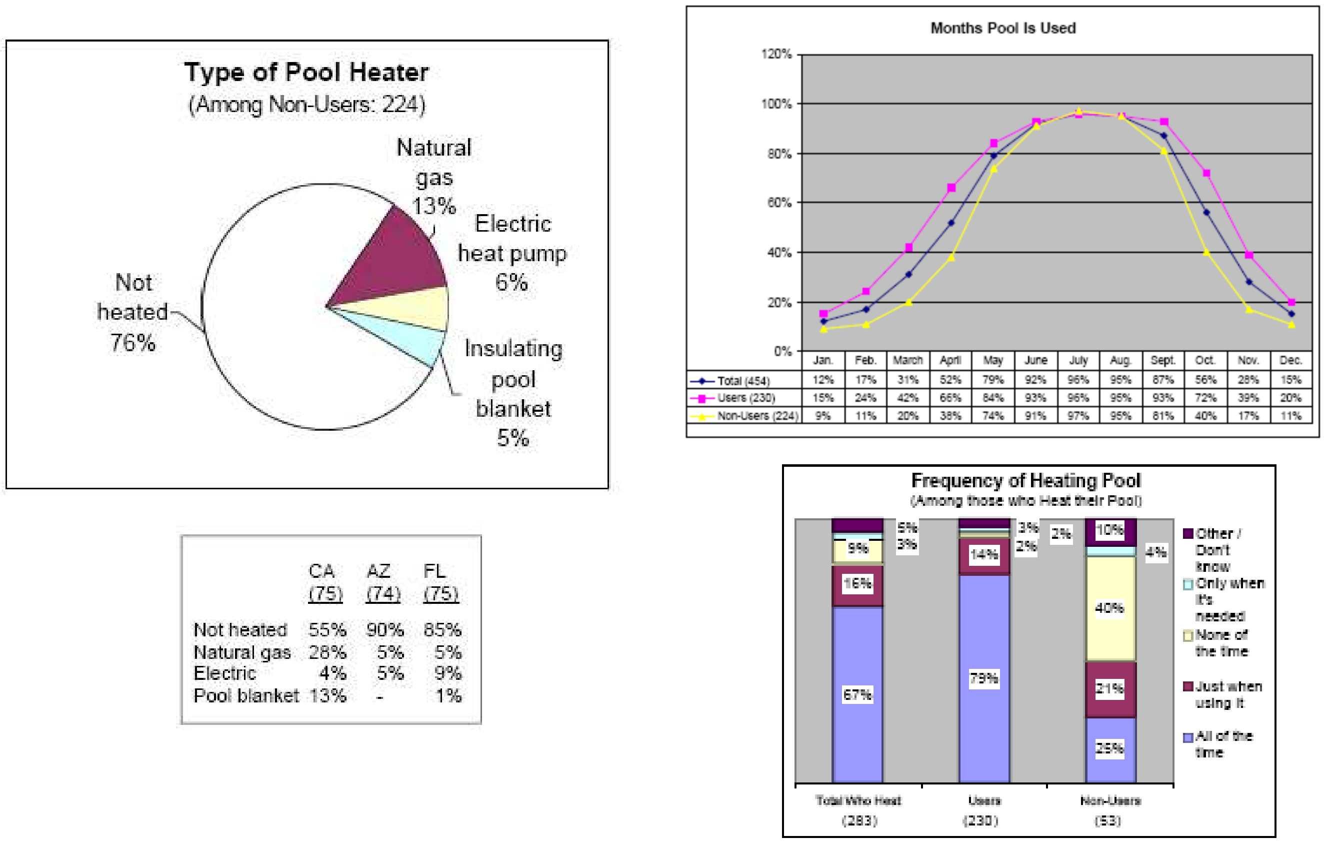
[16] Dennis J. Nelson, BC Hydro, *Electricity Consumption of Large Residential Homes*, poster presentation, ACEEE 2006 Summer Study; and personal communication, Dennis Nelson, August 2006.

[17] Synapse Infusion Group, *Report on Solar Pool Heating Quantitative Survey: August 1998-December 1998*, prepared for the National Renewable Energy Laboratory, NREL/SR-550-26485, April 1999, pp. 9, 20, 22.

[18] "Uncovering the Potential," *Pool & Spa News*, August 2003.

energy and safety considerations. For example, under Title 24, California is likely to require covers for all heated pools and spas[19]. In addition, the 2007 Energy Independence and Security Act recommends that "safety" pool covers be considered for state pool and spa safety requirements[20].

Figure 4. Key NREL Survey Findings about Pool Heating Technology and Use



	CA (75)	AZ (74)	FL (75)
Not heated	55%	90%	85%
Natural gas	28%	5%	5%
Electric	4%	5%	9%
Pool blanket	13%	-	1%

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total (454)	12%	17%	31%	52%	79%	92%	96%	95%	87%	56%	28%	15%
Users (230)	15%	24%	42%	66%	84%	93%	96%	95%	93%	72%	39%	20%
Non-Users (224)	9%	11%	20%	38%	74%	91%	97%	95%	81%	40%	17%	11%

[19] California Energy Commission, *2008 Building Energy Efficiency Standards – 45-Day Language*, SECTION 114 – MANDATORY REQUIREMENTS FOR POOL AND SPA HEATING SYSTEMSAND EQUIPMENT, November 2007. Retrieved from http://www.energy.ca.gov/2007publications/CEC-400-2007-017/CEC-400-2007-017-45DAY.PDF

[20] Energy Independence and Security Act of 2007, H. R. 6 – 307. Retrieved from http://energy.senate.gov/public/_files/getdoc1.pdf

3 POOL TECHNOLOGIES

The major components of all pool pumping systems include the pump, piping system, and a filter. Optional components may include a heater, cover, or some type of pool cleaner. Each of these components falls into one of two larger pool system categories: heating & pumping. All of the above pool components contribute to the overall efficiency of the system in one way or another.

3.1 Pumping System

Swimming pools are often designed by contractors who do not give full consideration to the fluid mechanics of the resulting systems. They focus their designs on what has worked for them in the past, and therefore tend to follow "rules of thumb" for their designs that may perpetuate prior mistakes. The problem is that these mistakes are not visible to the pool owner. For instance, a pool with large pressure drop or an oversized pump is not operating at peak efficiency. This will not typically create any problems other than the fact that it is wasting energy - unbeknownst to the owner.

For energy efficiency, the place to begin is with proper system design. Each component in the piping system (piping, fittings, valves, filters, heaters, etc.) produces a pressure drop (friction loss) that must be overcome by the pump. The total pressure drop in the system is commonly referred to as the total dynamic head. The larger the total dynamic head, the greater the amount of power required to achieve a given flow rate. There are many methods to reduce the total dynamic head. A few of the most common include:

- Increase piping diameter
- Reduce piping length
- Reduce the number of sharp bends and turns in the piping
- Increase the size of the pool return outlets
- Increase the size of the filter
- Increase diameter of backwash (or other) valves when present

Pump Selection

Once the system has been designed with the lowest total dynamic head, the second area for savings is proper pump selection and flow rate. Pump affinity laws indicate that the power demanded by a pump is proportional to the cube of the flow rate. Stated another way, if pump flow rate is doubled, then its power demand is increased by a factor of eight.[21] Therefore, it is important to utilize the smallest pump that can still achieve system turnover in an acceptable amount of time. It must be noted, however, that it is increasingly common for some pools to use the main pump for auxiliary functions such as fountains, water falls, and slides. These additional features require consideration in the pump selection phase. The 2008 California Title 24 45-day language states that "each auxiliary pool load shall be served by either separate pumps or the system shall be served by a multi-speed pump."[22]

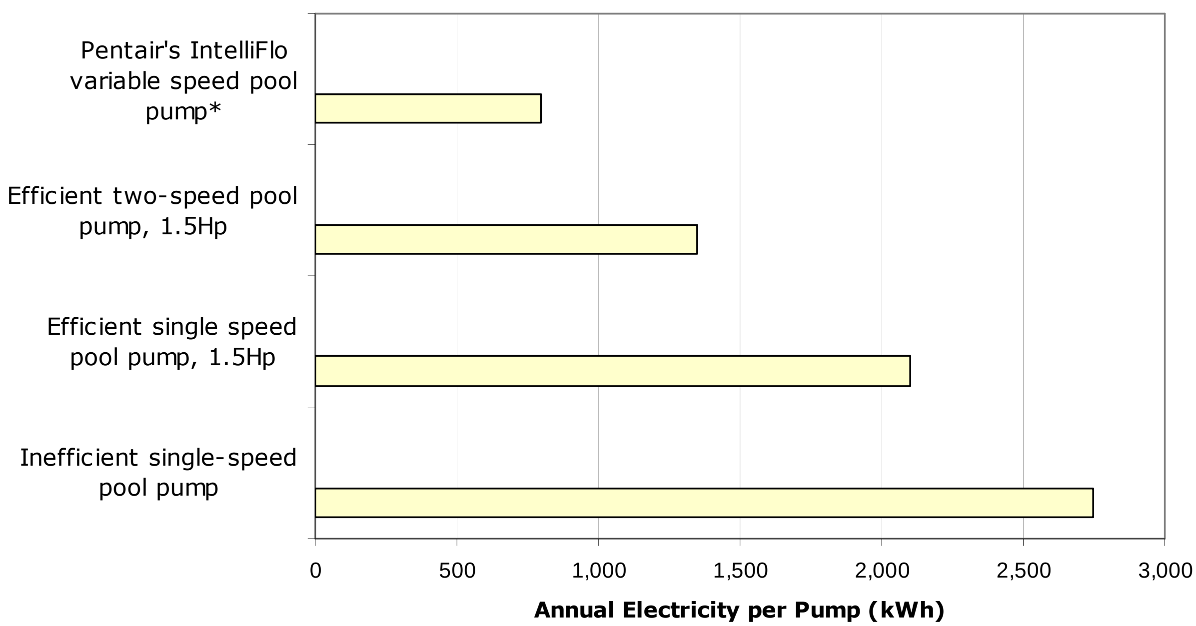
[21] This is the value predicted by theory, but actual performance results are sometimes different. PG&E found that dual speed pumps cut their flow rate in half at the low speed, and should use 75% less energy (1/8 of the original power for twice the time). However, conventional 2-speed induction motors use only about 55% less energy, because of changes in pump and motor efficiency at low speed. High efficiency 2-speed motors perform very close to the theoretical predictions.

[22] California Energy Commission, *2008 Building Energy Efficiency Standards – 45-Day Language*, SECTION 114 – MANDATORY REQUIREMENTS FOR POOL AND SPA HEATING SYSTEMSAND EQUIPMENT, p. 202,

Research funded by PG&E and SDG&E for California's 2008 Title 24 Standards showed that in California two-speed pumps have an incremental retail cost of about $270 over single speed pumps of identical horsepower ratings.[23] While efficient variable speed pumps are more expensive than single and two-speed pumps, preliminary experience from the Nevada Power Pump Rebate Program administered by Ecos Consulting is that their energy savings can lead to a payback of two years or less.[24] Pentair Water Pool & Spa has conducted research that suggests the payback for variable speed pumps in some applications is closer to one year.[25] According to Gary Fernstrom of PG&E, savings from efficient variable speed pumps can approach 90% if these pumps are properly programmed.[26] The cost-effectiveness of variable speed pumps was the subject of a recent proprietary E-Source article: *Pool Pump Offers Energy Savings and Unique Benefits.*[27]

See Figure 5 below for a comparison of the annual electricity consumption from several pool pumps based on data from Pentair and the Database for Energy Efficiency Resources (DEER) program of the California Energy Commission.

Figure 5. Annual Energy Consumption of Pool Pumps



* Estimated by Pentair Water Pool and Spa based on actual field and laboratory meaurements

Source: Database for Energy Efficiency Resources (DEER) report of California standardized baseline power consumption for pool pumps, personal communication with Jeff Farlow, Pentair Water Pool and Spa, October 29, 2007

November 2007. Retrieved from http://www.energy.ca.gov/2007publications/CEC-400-2007-017/CEC-400-2007-017-45DAY.PDF

[23] Pacific Gas & Electric Company and San Diego Gas & Electric, March 23, 2007, *Residential Swimming Pools: 2008 California Building Energy Efficiency Standards*, p. 5, prepared by Davis Energy Group

[24] Personal communication, Robert Roberston, Ecos Consulting, October 26, 2007

[25] Personal communication, Jeff Farlow, Pentair Water Pool & Spa, January 17, 2008

[26] Personal communication, Gary Fernstrom, Pacific Gas & Electric, September 14, 2007

[27] E-Source, *Pool Pump Offers Energy Savings and Unique Benefits*, September-October 2007, Tech News, Volume 8, Issue 9

Pump Motor Efficiency

The California Title 20 standard defines a test method for pool pump efficiency in terms of an "energy factor" expressed in units of gallons per watt hour. Energy factor is an attempt to standardize an efficiency comparison for pumps. This metric is similar to other efficiency metrics (i.e. mpg, cfm/watt, lumens/watt) in that it compares output (gallons pumped) to power demanded or energy consumed. The energy factor can vary widely for different pumps placed in the same pool system, and can even vary for pumps of equivalent horsepower due to differences in motor technology. A pump is generally chosen to meet the system turnover in a given amount of time. Title 20 also prohibits the use of lower efficiency split-phase and capacitor start induction run type motors.

Turnover Time

Turnover time is defined as the amount of time needed to push the entire volume of the pool through the filter system. Another "rule of thumb" for residential pools is that one turnover per day should be achieved for proper filtration. Since a typical residential pool does not have a sensor to monitor total run time or total flow over a period of time, this rule of thumb has become an accepted standard in the industry.

Research by Florida Atlantic University found that this rule of thumb is often not valid, and that pool pumps spend the majority of their time circulating clean water. The problem they observed is that skimming debris from the pool surface required only about 30 minutes of pump operation, and additional pumping time did little to filter dirt from the bottom of the pool unless it was being actively agitated (with pop-up heads or a pool vacuum). In effect, they concluded that dirt tends to naturally collect on the top or bottom of the pool, and so dispersing it and filtering the entire pool volume makes less sense than attempting to filter or vacuum the targeted parts of the pool in which most of the dirt concentrates.

Florida researchers found that daily hours of pump operation could be reduced from an average of 7.74 hours in the summer and 6.65 hours in the winter to an average of 3.35 hours in the summer and 2.48 hours in the winter without diminishing users' perceptions of pool water quality[28]. Mechanical scrubbing of the pool walls and proper pool chemistry proved more important to deterring algae growth and keeping the pool clean than the number of hours the pump operates or its horsepower.[29]

Commercial turnover times are specified by health codes at six hours or less. Much of the savings to be obtained from highly efficient variable speed pumps is in commercial applications, where they can be programmed to achieve turnover times of exactly six hours, even if the filter is dirty. This allows motor speed, power, and energy to be reduced during times when the filters are clean, instead of sizing the pump to assume worst-case operating conditions.

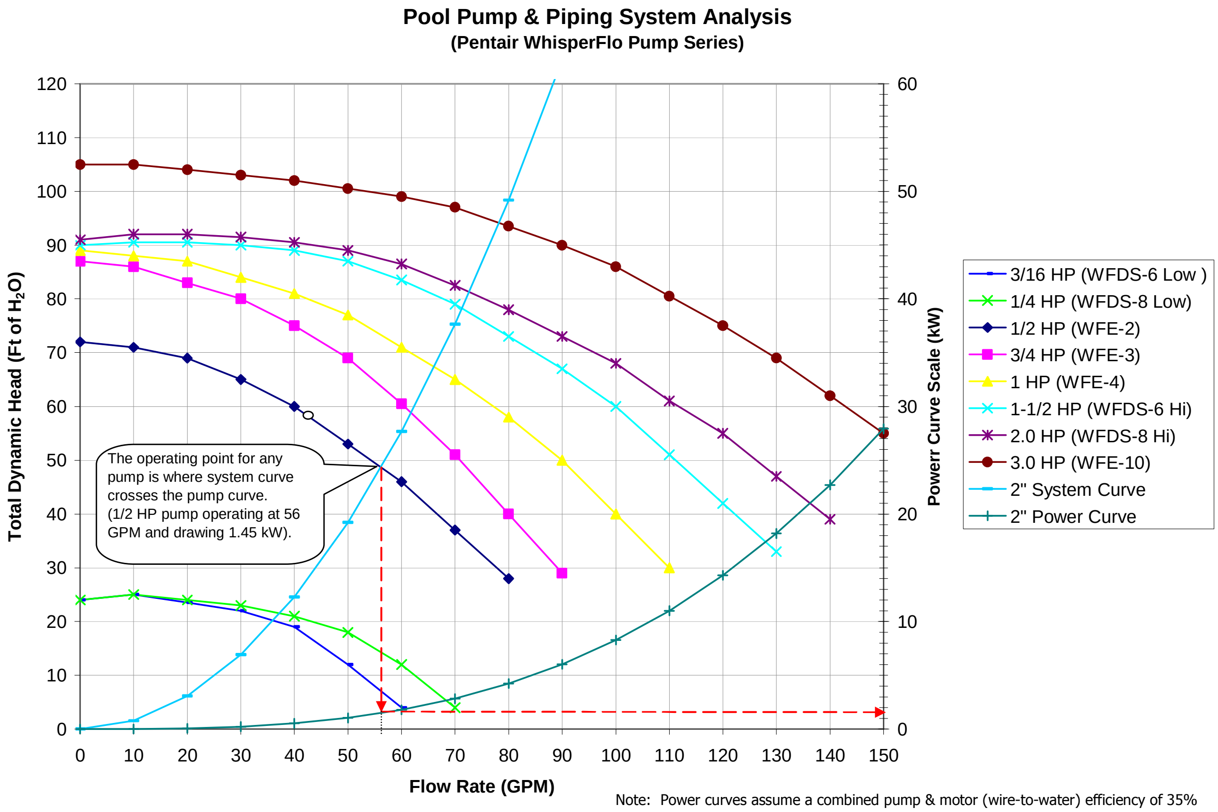
System curves are a measure of the hydraulic loading of a particular pool design. These can be plotted against various pool pump curves to indicate the combination of dynamic head and flow rate that will be achieved when a particular pump is used in a particular pool. Such curves also help to predict how much more power will be required to overcome greater dynamic head, such as when a filter is dirty or a pipe is constricted (see Figure 6).

---

[28] Note that many pool efficiency programs recommend low-speed pumping for an increased number of hours as an energy-reduction measure.

[29] Roger Messenger and Shirley Hayes, *Swimming Pool Circulation System Energy Efficiency Optimization Study*, Final Report submitted to Florida Power & Light Company and National Spa & Pool Institute by Florida Atlantic University, October 25, 1984.

Figure 6. Pump System Curve



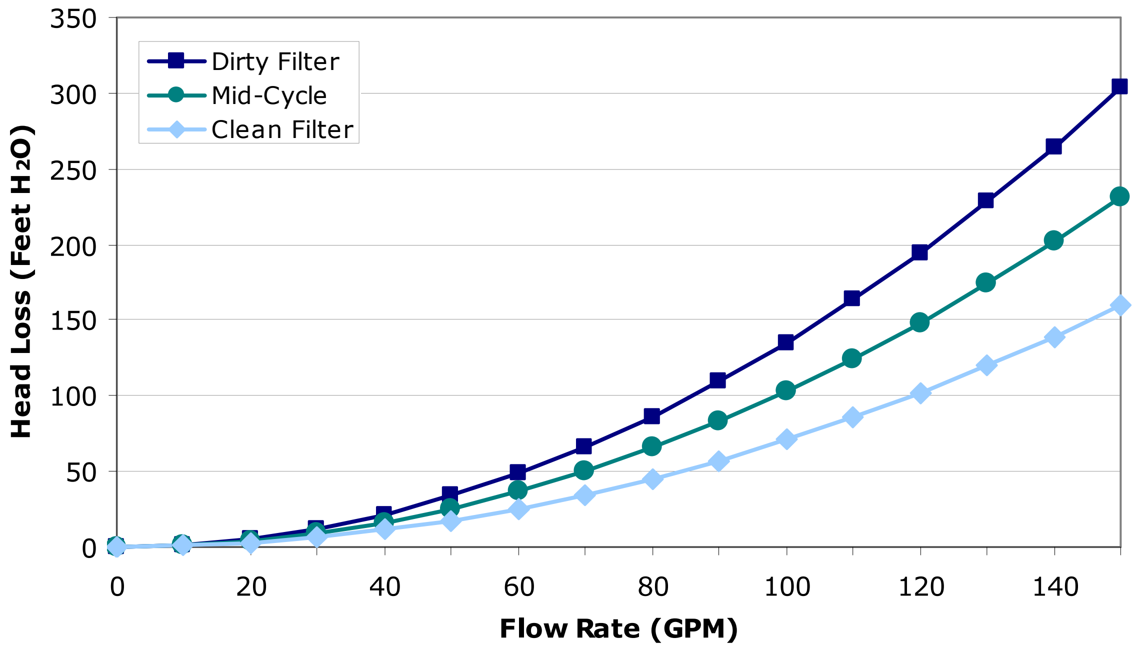
Note: The ½ HP pump (WFE-2) above has a Service Factor of 1.9 making it a 0.95 Total HP motor

Filters

The most common types of pool filters are sand, diatomaceous earth (DE), and cartridge filters. Sand and DE filters function more effectively as they begin to load with dirt. However, a dirty filter creates a significant increase in the workload of the pump. Cartridge filters do not have this problem and can be cleaned more often without affecting filtering performance. Owners' manuals recommend that all three filter types should be cleaned when the pressure increases by 8 – 10 psi (18.5 – 23 ft-H_2O) over the clean filter pressure. This means that the difference between a clean filter and dirty filter can nearly double the overall head loss of the system increasing the work done by the pump (see Figure 7). The energy savings from simply keeping the filter clean can be significant. This also applies to keeping the skimmer basket free of leaves and other debris. It is difficult to provide exact energy savings figures to consumers from keeping filters clean, but this would be one of the easiest, most straightforward strategies for minimizing the energy use of an existing pool.

Cartridge filters lead to additional energy savings vs. sand and DE filters because they do not require backwash valves, which typically add another 12.5 ft of head to the system curves shown in Figure 5. While the type of filter installed is often a personal preference, the energy savings of using an oversized cartridge filter to reduce overall system head loss is well documented.

Figure 7. System Curves with Cartridge Filter



The pump is usually controlled by a timer and set to run daily for a fixed number of hours. As the filter loads up with dirt, the flow rate starts to drop, meaning that less water is being circulated through the system each day. This is true whether a single-speed or dual-speed pump is utilized. A variable speed pump will automatically make adjustments to the operating speed to ensure that the flow rate is maintained regardless of system head loss.

Two-speed and variable speed pumps can be very cost-effective and generate energy savings by operating the majority of hours at low flow rates. High flow rates are often needed to initially prime the pump or fill a solar system with water. High speed is also needed to operate most types of pool sweeps. Multi-speed systems have timers or other controls that will start them on high speed for as long as necessary and then reduce them to low speed for the majority of time needed to circulate water through the filter or solar system. They are very effective at producing energy savings.

Filtration systems operate according to the process of dilution. Each gallon of water that passes through the filter is a little cleaner than the gallon that preceded it. Some systems, such as pop-up cleaning heads are designed to stir the dirt up off the pool floor and get it back into solution and then filtered. Therefore, a pool sweep system is likely to operate fewer hours to remove the same amount of dirt as a pop-up head system.

3.2 Heating System

Conventional Systems

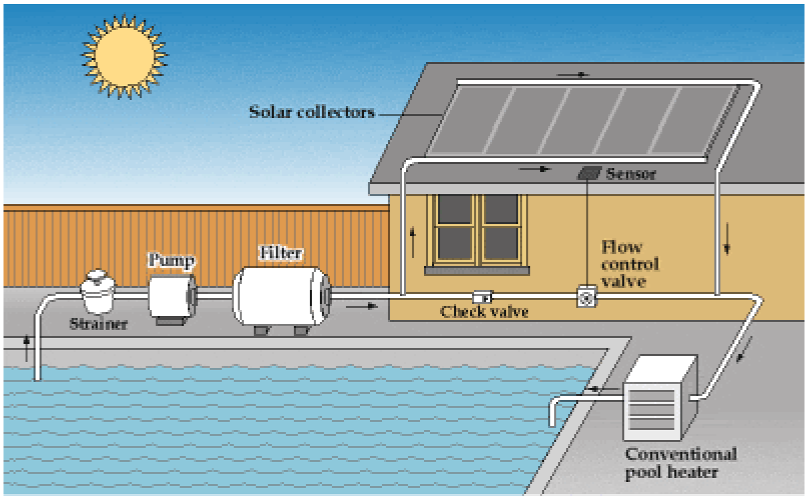
Electric resistance heaters for pools are prohibitively expensive to operate, and are no longer widely installed in new pools. Natural gas heating systems are far more common, and tend to operate at thermal efficiencies of about 78%. Higher efficiency models can be found with thermal efficiencies around 82%, while premium efficiency models operate at thermal efficiencies greater than 90%. Significant energy savings are certainly possible through use of the highest efficiency models. However, in certain climates, dramatic energy savings are also possible from switching to solar thermal or heat pump heating systems.

Solar Thermal

Solar water heating can be very cost-effective because the collectors are often made of unglazed black plastic instead of expensive copper tubing, aluminum housings, insulation, and low-iron tempered glazing. They heat large volumes of water by only a few degrees at a time, taking advantage of existing pumps and plumbing to minimize the additional equipment needed. Payback periods are often only 2 to 3 years in ideal climates like Florida or Arizona, especially at current natural gas prices. Though federal tax credits exist for other types of solar thermal applications, the most recent Energy Policy Act specifically excluded "recreational water heating" applications like pools and spas from consideration.

Solar collectors can require an area equal to at least half of the pool area in order to make a significant contribution to heating, which creates practical and aesthetic challenges in many residential settings. In addition, solar panels are generally installed flat on the roof of a house (at whatever pitch the roof already employs). Often, a southern exposure is not available and roof area limits the size of the array.

Figure 8. Diagram of a Solar Pool Heater[30]



Their greatest drawback is that they generate peak output when the pool itself is often already warm enough, so they need to be designed and oriented carefully to extend the heating season but not attempt to operate under freezing conditions. It takes some skill to size solar water heating systems to the most cost-effective levels, though on-line resources from DOE and software from the Florida Solar Energy Center can help.[31] Systems that are too small need regular natural gas backup; systems that are too big would be expensive and would either overheat the pool or require an additional "heat sink" where excess heat could be dumped. In addition, some solar thermal systems require booster pumps because they can present a high total dynamic head. To minimize any related electrical load, consumers should seek out solar thermal systems that present a low total dynamic head.

Some of the most advanced solar thermal designs integrate domestic hot water, domestic space heating, and pool heating into a single system with fully glazed collectors. While much more complex and expensive than typical solar pool heaters, these systems have a number of advantages. They can be sized to meet 100% of the year-round

---

[30] www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13230

[31] See www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13250, www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13280, and www.fsec.ucf.edu/solar/apps/poolhtg/poolszg.htm.

domestic hot water demand, providing supplemental hot water to domestic space heating during the winter and supplemental hot water to the swimming pool in the summer, thus avoiding the need for a dump load.

Solar systems need to operate during the day and heat pumps are more efficient operating during the day (when the outdoor air temperature is the warmest). This is also the time of the day when electric utilities peak during the summer. While they may be able to generate energy savings, they may actually add to peak electric loads and could cost the owner more to operate if they were on a time-of-use electric rate.

Heat pumps face similar challenges gaining wider acceptance. They can be very efficient in humid climates with modest seasonal temperature swings (such as the Southeast), but are often less efficient in dry climates, particularly when nighttime temperatures drop below 40 degrees. Proponents argue that heat pumps can cut the cost of heating a pool by 80% compared to conventional natural gas, if used in an optimal (warm and humid) climate, though others disagree.[32]

Covers

Bubble covers are also referred to as "solar" covers. They are similar in appearance to a large sheet of bubble packing material and are typically made of blue or clear plastic with UV inhibitors. If the pool is heated any portion of the year, a pool cover is the most cost-effective thing that a user can do to achieve energy savings with a swimming pool. The cover reduces evaporation from the pool, which is the primary component of heat loss. Covers also reduce the convective and radiation losses, but only slightly. On an annual basis, a cover can reduce the evaporative heat loss from more than 60% to less than 20% of the total.

A basic bubble cover will typically range in price from $50 - $100. The water savings alone are enough to justify the minimal cost of a bubble cover even if the pool is unheated. As an added benefit, a cover on an unheated pool in a sunny climate will typically raise the temperature of the pool by 10°F, extending the season during which the pool may be comfortably used. Increasing the temperature of 1 gallon of water in a pool by 1 degree F requires 8.3 BTUs of heat input.[33] But when 1 gallon of already heated water evaporates from a pool, it takes approximately 8,700 BTUs of heat with it, which need to be replaced with subsequent pool heating to maintain a constant temperature. More than 50 gallons of water evaporate from an average pool every day.[34] This suggests that national evaporation losses from in-ground pools are perhaps 200 million gallons of water per day – enough to meet the daily water use of 5 million homes.[35] Covers can reduce the amount of make-up water needed in a swimming pool by 30 to 50% and can cut chemical use by 35-60%.[36]

Automatic retracting covers are a higher-end alternative to bubble covers. They are typically mounted in-ground during the installation of a new pool. An electric motor unfurls the cover by pulling it along tracks mounted on both sides of the pool, making it very convenient to cover the pool whenever it is not in use. These covers last much longer than floating bubble covers and provide safety advantages (they can support the weight of a person who accidentally steps on them), but are also far more expensive. They are also intended to be used with rectangular pools rather than kidney-shaped or free-form designs. These systems can cost $5,000 or more at the time of pool installation, so are difficult to justify on cost-effectiveness grounds alone. However, they offer strong aesthetic, safety, durability, and convenience advantages over bubble covers, and may allow some users to avoid the need for code-required fencing around the pool area.

---

[32] Tom Lane, *Solar Hot Water Systems*, 2004, pp. 162-164.
[33] The energy consumption to accomplish this will be a greater number of BTU's due to efficiency losses in the heater itself.
[34] See www.nspi.org/ProfessionalResources/Government+Relations/ Facts+about+pool+water+usage.htm. Note that this value would vary depending on the temperature of the evaporated water
[35] See http://www.awwa.org/advocacy/pressroom/STUDY.cfm for information regarding average annual water usage by North American homes.
[36] "5 Things You Should Know About Covers," *Pool & Spa News* consumer handout.

4 EXISTING POOL EFFICIENCY REGULATIONS & PROGRAMS

The most important recent developments on the policy landscape have been two mandatory standards by the California Energy Commission: Title 20 and Title 24. The 2006 Title 20 Appliance Efficiency Regulations regulate all pool pump motors and controls sold for new construction or existing retrofits. Title 24, which is likely to be finalized in early 2008, references the Title 20 regulations. The proposed measures address entire pool systems, including pool heating, pumping, system piping, filtration equipment, pool equipment controls, and covers. Title 24 provides broader coverage of efficiency measures than Title 20 does, but it applies only to new construction.

4.1 Covers

The 2005 Title 24 standard requires all new pools that do not have at least 60% of their annual heating energy from site solar energy or recovered energy to have a pool cover. The new Title 24 2008 requirements are expected to make a pool cover mandatory for all heated pools, though no preference is expressed in the requirements for floating bubble covers versus automatic retracting ones. In addition, the recently adopted Energy Independence and Security Act of 2007 addresses the standby power of pool heaters and recommends that states consider safety pool covers as part of pool safety requirements.

4.2 Pumps

Title 20 mandates that "pool pump motors manufactured on or after January 1, 2006 may not be split-phase or capacitor start – induction run type." Additionally, "pool pump motors with a capacity of 1 HP or more which are manufactured on or after January 1, 2008, shall have the capability of operating at two or more speeds with a low speed having a rotation rate that is no more than one-half of the motor's maximum rotation rate." And "Pool pump motor controls manufactured on or after January 1, 2008 shall have the capability of operating the pool pump at least two speeds. The default circulation speed shall be the lowest speed, with a high speed override capability being for a temporary period not to exceed one normal cycle." [37] The Title 24 proposal sets forth additional pool pump regulations that include parameters for minimum turnover time and programmable controls.

4.3 Heating System Efficiency

The Title 24 standard proposal requires heating system efficiency that is in compliance with the existing Title 20 Appliance Efficiency Regulations. Those specify a minimum thermal efficiency for oil and gas fired heaters of 78% and a minimum efficiency for heat pumps that is the average of low temperature and standard temperature ratings with a minimum COP of 3.5. The Title 24 proposal also bans electric resistance heating (with two exceptions) and pilot lights, and requires an on/off switch on the heating unit so that the thermostat does not need to be adjusted in order to turn the unit off.

4.4 System Piping

The Title 24 proposal has design requirements for system piping including water velocity limits, sweep elbows, and pipe lengths between the heater and the filter and before the pump.

4.5 Current Utility Programs

A brief review of current utility programs to promote energy efficient pools indicates that PG&E and several other electric utilities have offered or currently offer rebates to customers who replace conventional single-speed pool pump motors with smaller size, highly efficient single-speed, two-speed, or variable speed motors. Incentive programs for the installation of high-efficiency natural gas or heat pump water heaters for residential pools were not widely evident. However, PG&E and Southern California Gas Company offer rebates for high-efficiency natural gas heaters in commercial pool settings. Recognizing water savings, water utilities sometimes offer rebates on the

[37] California Energy Commission, 2007, *Appliance Efficiency Regulations*, CEC-400-2007-016-REV1, Section 1605.3, p. 119

purchase of a pool cover. In areas where the gas utility is a separate company from the electric utility, competition can lead to concerns about lost revenues when someone switches fuels from a gas-fired heater to an electric heat pump. In any event, we believe there is opportunity for improvement, especially in the warmer regions of the country.

Most programs seem to concentrate on replacement of an existing component with a more energy efficient component which operates at a lower speed to reduce system total dynamic head. While these programs are indeed helping, we feel that there is a largely untapped market in the proper design of new pools. Replacing an oversized pump with a smaller pump will save energy, but the opportunity to reduce these losses even further is lost if not addressed during the pool design and construction. California's Title 24 residential building standards process is considering these broader opportunities for synergy in the pool design process.[38] The approach proposed by PG&E would stipulate mandatory requirements for:

- motor efficiency
- properly sized pumps with pumps 1 hp or larger to be dual or variable-speed
- pump motor control capabilities (must be able to operate the pool pump at a minimum of two speeds, with the default being low-speed)
- limits on fluid velocity that will require larger system piping
- proper filter sizing

The increase in the cost of larger piping and fittings with lower pressure drops is minimal when the pool is constructed. However, with the exception of "above ground" improvements to a pump or filter, a renovation to do the same would not be cost-effective.

We understand and recognize the benefits of a pool cover on a heated pool. However, what is not known is the number of existing pools that are heated and yet do not utilize a cover. This could occur for a number of reasons; the owners did not realize the benefit and/or found it difficult dealing with the cover, or maybe the first one wore out and was never replaced. Whatever the reason, pool covers are inexpensive and their benefits on a heated pool are enormous. If it turns out people are not using the covers because they are inconvenient or unattractive, there may be opportunities to encourage greater utilization through financial incentives, safety requirements, public education, new design efforts, and residential building standards.

In addition to the utility incentive programs that already exist for efficient single speed pumps (where not already required by law such as in California), the following utility programs[39] specifically encourage efficient two-speed and/or multi-speed designs as well:

- Pacific Gas and Electric (PG&E)
- Roseville Electric Pump Rebate Program

---

[38] See California Energy Commission, *2008 Building Energy Efficiency Standards – 45-Day Language,* SECTION 114 – MANDATORY REQUIREMENTS FOR POOL AND SPA HEATING SYSTEMSAND EQUIPMENT, p. 202, November 2007. Retrieved from http://www.energy.ca.gov/2007publications/CEC-400-2007-017/CEC-400-2007-017-45DAY.PDF

[39] The recently adopted 2007 Title 20 regulations require that "Pool pump motors with a capacity of 1 HP or more which are manufactured on or after January 1, 2008, shall have the capability of operating at two or more speeds with a low speed having a rotation rate that is no more than one-half of the motor's maximum rotation rate." (See the 2007 Appliance Efficiency Regulations, CEC-400-2007-016-REV1, Section 1605.3, p. 119.) Therefore, CA utilities are likely to adjust their rebate programs accordingly.

- Sacramento Municipal Utility District (SMUD) Pump Rebate Program
- Palo Alto Pump Rebate Program
- Southern California Edison (SCE) Pool Pump Rebate Programs
- San Diego Gas and Electric (SDG&E) Pump Rebate Program
- City of Burbank Pump Rebate Program
- City of Riverside Public Utilities Pump Rebate Program
- Los Angeles Dept. of Water & Power (LADWP) Pump Rebate Program
- Nevada Power Pump Rebate Program
- Austin Energy (Texas) Pump Rebate Program
- Gainesville Regional Utility (Florida) Pump Rebate Program (launch pending)

5 METHODOLOGY

We used computer modeling to estimate the energy use of pool and the potential savings from design changes and component upgrades. For heating estimates, including the effects of pool covers, we used "Energy Smart Pools" software. For pumping energy estimates, we developed our own Excel-based computer modeling tool. We then modeled a Base Case pool in five cities. The five cities were selected from the states with the five highest numbers of residential in-ground swimming pools.

Characteristics of the Base Case pool were:

1. Rectangular pool that is 18 feet wide by 30 feet long by nearly 6 feet deep
2. Total volume of 24,000 gallons (Average pool sizes in the U.S. tend to be in the low-to-mid 20,000-gallon range.[40])
3. No cover
4. 1 HP single speed pump[41]
5. 1.5" diameter piping system
6. Heated with a 78% efficient natural gas heater for 10% of the time that heat is required during the assumed heating season

Because national research on pool owner behavior is quite limited, we then developed the following assumptions about the way pools are operated based on climate data and anecdotal evidence. We also made assumptions for other variables such as the extent to which a pool might be shaded from sun or screened from wind over the course of the day and the year. It is very difficult to locate data for the average operating period of pools, usage patterns, and their variation with climate. See Table 1 below for the assumptions used in this analysis.

Table 1. Heating and Pumping Season Assumptions by City

City:	New York, NY	San Antonio, TX	Los Angeles, CA	Phoenix, AZ	Tampa, FL
Pumping Season:	Jun-Sep	Apr-Nov	May-Oct	Apr-Nov	Apr-Nov
Heating Season:	Jun-Sep	May-Oct	Jun-Sep	May-Oct	Apr-Nov

"Pumping season" is the time during which we assume a pool owner would operate the pump on a daily basis for one complete turnover per day. For the purposes of this analysis, we assumed no pumping during the rest of the year. This is a very conservative assumption, since many pool owners operate pumps during the off season to maintain water clarity. The "heating seasons" are comprised of the months warm enough for swimming but when the pool water temperature is too low for comfortable swimming. We calculated pool water temperatures during the specified heating seasons, then assumed that pool heaters would be operated sporadically for short periods of time (e.g. for a birthday party) during heating seasons. We estimated this sporadic operation to occur for 10% of the

[40] PK Data, *Waveline Newsletter* No. 7, 2005.

[41] While pumps larger than 1 HP are frequently used, we chose to model a 1 HP pump in order to estimate the minimum potential savings from the Title 20 pump motor requirements which affect "pool pump motors with a capacity of 1 HP or more."

specified heating season.[42] Again, this is a conservative assumption – some pool heaters would clearly be operated much more frequently, but others would be solar, avoiding gas and electricity use.

We then devised three savings scenarios for both new and existing retrofit pools: Toe in the Water, Shallow End, and Deep Dive. (See Table 2) Our recommendations build on the appliance (Title 20) and proposed building code (Title 24) efficiency standards. With each savings scenario, the cost and the scope of measures addressed goes up along with the resulting energy savings. Finally, we modeled the Base Case pool in each city with the design changes outlined below to determine potential savings from different efficiency measures.

Table 2. Pool Energy Efficiency Scenarios

Energy Efficiency Measures	**Retrofit Pools**	**New Pools**
Basic Regulatory Option: **Toe in the Water**	Meet existing CA Title 20 requirements Cover for all pools	Meet existing CA Title 20 requirements Cover for all pools
Voluntary Option: **Shallow End**	Above plus: Variable speed pump with automatic controls Efficient filter	Above plus: Variable speed pump with automatic controls Efficient piping and filter Efficient gas or heat pump heating
Maximum Savings Option: **Deep Dive**	Above plus: Efficient gas, heat pump, or solar heater Robotic cleaner†	Above plus: Automatic cover PV-powered pump Proper solar orientation† Appropriate wind block† Robotic cleaner† Solar heating‡

† These measures not modeled in analysis.

‡ Total dynamic head loss for solar thermal heating system not modeled.

We analyzed energy savings from the following measures which would bring our Base Case pool up to the Toe in the Water efficiency level:

- Replace a 1 HP single-speed pump with a ¾ HP single-speed pump

[42] The heater operational assumptions used are compatible with natural gas heaters.

- Bubble cover (Bubble cover assumed to be in use for 1/3 of the time that the pool is not in use.)
- 2” diameter system piping instead of 1.5” diameter
- 2” diameter backwash valves (for sand and DE filters)

We then evaluated energy savings from the following additional measures which would bring the pool to the Shallow End efficiency level:

- Replace the ¾ HP single speed pump with an efficient variable speed pump with programmable controls
- Replace the 78% efficient natural gas pool heater with an advanced heating (heat pump or 97% efficient natural gas heater). Continue use of bubble cover.[43]

Finally, we analyzed the energy savings from upgrading our Base Case pool all the way to Deep Dive. The additional Deep Dive measure that we analyzed was:

- Replace bubble cover with an automatic cover. (Automatic covers assumed to be in use all of the time that the pool was not in use.)

Other Deep Dive measures, such as solar thermal water heating or a PV-powered pump, would simply eliminate heating or pumping expenses.[44] The solar system provides heat whenever sunshine is available and the pool temperature remains below its desired temperature of 80°F. If the solar system cannot maintain the pool temperature by itself, backup heat is provided by the baseline gas-fired boiler.

We used average natural gas and electricity rates[45] for each city. In some cases, rates varied widely between cities. See Table 3.

Table 3. Average Energy Prices by City

	New York	San Antonio	Los Angeles	Phoenix	Tampa
Cost per kWh ($)	0.16	0.12	0.15	0.08	0.11
Cost per therm ($)	1.42	0.98	1.12	1.51	1.88

[43] Heat pumps generally won’t operate in ambient temperatures below about 40°F – 45° F. Therefore, if utilizing a heat pump in a climate like New York for year round operation, a supplemental gas-fired or electric resistance heater is required.

[44] One of the heating alternatives investigated was the installation of an unglazed solar pool heating system. In speaking with manufacturers and sales professionals, it appears that the typical solar system is sized so that the collector area is approximately half of the pool surface area. Although a larger array might be beneficial, the available area on the roof of the house or elsewhere for solar collectors is usually the limiting factor. For purposes of our analysis, the collector area was assumed to be 270 square feet, which is one-half of the pool surface area. The collector utilized was the Ecosun 16104 manufactured by Aquatherm Industries, Inc – a simple, unglazed design that costs substantially less than the glazed collectors used for solar domestic water heaters.

[45] Rates used are average electricity rates for each city. Pool owners may pay higher than average rates depending on their utility’s pricing structure.

Finally, we scaled our findings for the five pools we modeled up to national pool energy use and savings estimates. It is important to note that our analysis is based on a single, model pool; this pool is in no way an attempt to represent the “average” American pool. Pools vary widely in their energy use based on climate, design, and perhaps most importantly on owner preferences. Little national data are available that detail the many ways owners operate their pools. Therefore, we used our findings for modeled pool in each of the five cities to predict a broad range of annual energy use for residential in-ground pools in the U.S. For the high end of this range, we assumed that the vast majority of pools have annual energy use similar to our Base Case findings. The low end of the range is based on the possibility that half of all pools have annual energy use similar to our Base Case findings and the other half of pools exhibit energy usage more similar to our findings for the Shallow End pools, or that the average pool lies somewhere between our Base Case and Shallow End findings. We then estimated the potential savings from a 1/3 reduction in pumping energy for all pools, and an additional 1/3 reduction in heating energy for heated pools only.

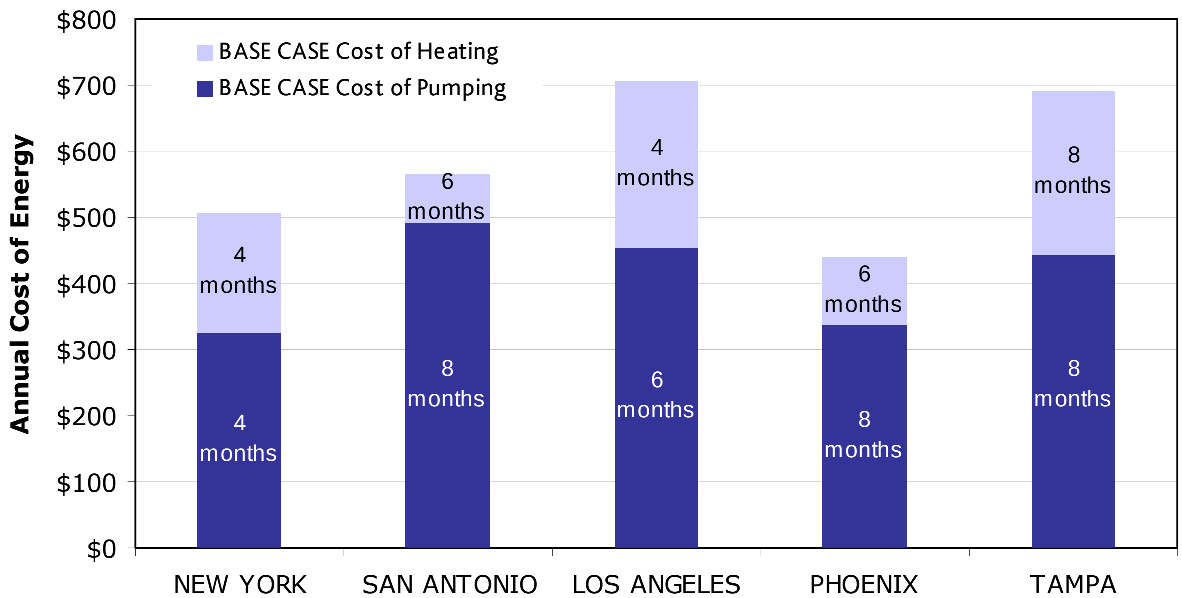
6 FINDINGS

In an effort to gauge the energy and water savings opportunities for in-ground swimming pools, we first modeled the energy use of a Base Case pool in each of five cities, and then analyzed the energy savings from all three levels of savings scenarios in each city.

6.1 Base Case Energy Use

Our energy modeling predicted the annual pool energy expenditures for the Base Case pool in each of the cities below. Assumptions about seasons of use vary by city. See Figure 9. Annual pumping energy ranged from 2,000 kWh per year for climates with the shortest swimming seasons (four months) to just over 4,000 kWh per year for those with the longest swimming seasons (eight months). Annual pumping costs ranged from $326 for four months of pumping in New York City to $490 for eight months of pumping in San Antonio. Note that the cost for eight months of pumping in Phoenix is well below the cost for the same time period of pumping in San Antonio. This is due to the variances in price per kWh between these cities.

Figure 9. Base Case Heating and Pumping Costs



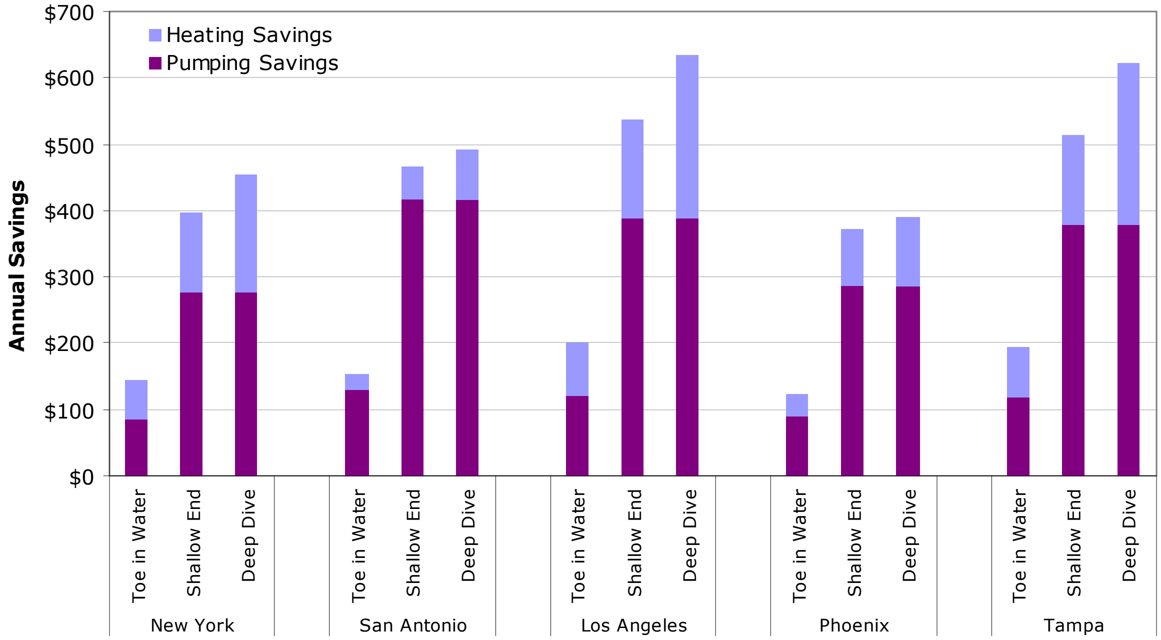
Heating costs ranged from $76 for a six-month heating season in San Antonio to $252 for a four-month heating season in Los Angeles. The reason for this counter-intuitive finding is two-fold: 1) natural gas price vary by city, and 2) more importantly, we designed our model to account for a heating load for only 10% of the time that the pool required heat during the specified heating season. During the four-month (June – September) heating season for Los Angeles, pool heating was required during each of those months. In contrast, during the six month (May – October) heating season in San Antonio, little to no heat was required from June through September.

6.2 Savings from Efficiency Measures

We found significant energy reductions possible through improvements in both heating and pumping measures.

Because the vast majority of pools are not heated, the pumping savings are more likely to represent the savings that most pool owners could experience. It is important to note that variances between the assumptions about the modeled Base Case pool and the way an actual pool is designed and operated would affect the energy use and savings potential.

Figure 10. Sample Savings from Energy Efficiency Measures for New Pools



Toe in the Water

We developed the Toe in the Water measures as an option for a basic regulatory pool efficiency program. From the basic efficiency measures at this level, we found notable energy savings. Our model predicted a 26% savings over our Base Case pool in each city from replacing a 1 HP single speed pump with a ¾ HP single speed pump, increasing pipe diameter from 1.5" to 2", and using a 2" diameter multi-port valve on the filter. Heating savings from simply using a bubble cover were just over 30%.

Shallow End

The Shallow End pumping upgrade of employing a variable speed pump saved nearly 85% over the Base Case, while replacing a 78% efficient natural gas heater with a heat pump[46] resulted in heating savings of approximately 66% over the Base Case heating costs.

Deep Dive

With the Deep Dive measures, which were the most aggressive pool efficiency measures in our analysis, use of an automatic cover resulted in >95% heating energy savings over the Base Case for the months analyzed. Deep Dive pumping savings remained unchanged since no new pumping measures were introduced; however, in some climates, the addition of a PV-powered pool pump could eliminate pumping expenses entirely.

6.3 National Energy Implications

When scaled to a national level, these findings suggest that the total national electric bill for residential in-ground swimming pools is between nine and 14 billion kWh per year. This represents about $1 to $1.4 billion, or about $240 to $360 per pool per year (recognizing that most pools aren't heated).

---

[46] Reported results are findings from our computer modeling. In reality, a high efficiency natural gas heater may be the best choice for a pool heater, depending upon user operation patterns and variances between air and water temperature.

The specific natural gas bill for residential in-ground swimming pools is more difficult to estimate and is heavily influenced by assumptions about the usage of pool covers. In our pool energy model, we used conservative assumptions for pool heating: 10% of all pools use a heater, all of these pools use a 78% efficient natural gas heater, and that these pools operate their heaters for only 10% of the time during their swimming seasons that require heat to bring the pool to swimming temperature. We estimate these systems, depending on the climate and the way owners operate their pools, use between 68 and 224 therms of natural gas per year each (costing between $75 and $250 per year per heated pool). This represents an additional $45 to $80 million annual energy bill.

Overall, our energy modeling indicates the potential to save more than two-thirds of total swimming pool energy use. Comprehensive data on national pool energy use are limited. However, assuming that many pools already employ some efficiency measures, we estimate that if all residential pools were upgraded to reduce pumping energy by only one-third, and all heated pools were also upgraded to reduce heating energy by one-third, total annual savings would be worth more than $360 million. Carbon dioxide emissions would be reduced by at least three million tons — the equivalent of removing all San Antonio's cars from the road for one year.

7 RECOMMENDATIONS

This section briefly discusses areas in which we feel improvements could be made with overall pool efficiency, including recommendations for an ENERGY STAR® Pools Program that would help spur those improvements. Finally, we discuss additional research that could take this investigation to the next level.

7.1 Opportunities for Improvement

Our initial research confirmed that the pool industry had not yet moved to provide standardized energy efficiency information about pool systems and components to designers, installers, and purchasers of pools. Test data regarding the pressure drop of components such as valves, sweep elbows, and filters were often unavailable, or had to be obtained laboriously through special requests to engineering staff at each manufacturer. Software tools for estimating pumping and heating energy use were in many cases out of date, discontinued, or only suited to very specific climatic conditions. Though many past studies of pool pumps have recommended a comprehensive rating system for pump efficiency, standardized Energy Factors (gallons per watt-hour) were still not routinely available for all pumps at the time of purchase. Pool marketing materials and trade shows focused primarily on ways to up-sell additional features and enhancements to customers, many of which increase energy and water consumption.

Yet we have been encouraged in recent months by the number of organizations devoting increasing attention to swimming pool efficiency and proper hydraulic design. Pentair and its competitors have brought highly efficient new variable speed pumps to market and begun collaborating with utilities to encourage their sale. Industry organizations and utilities are offering standardized training courses to installers to make them aware of the benefits of improving efficiency. California and other states are moving to address pool efficiency through appliance and building standards. Indeed, "standard" practice is in the process of changing to give more attention to energy and water efficiency in pools.

With that in mind, our recommendations include:

- Require testing and publishing of standardized hydraulic data for all pool pumping and filtering system components.

- Establish a rating system for pool pumps based on Energy Factor (gallons/Wh). Energy Factor for a pump is dependent upon the overall system pressure, so the rating needs to be stated for several different system curves or graphically. The California Energy Commission has adopted standard system efficiency curves and test procedures that were developed by PG&E for just such a purpose.[47] These could also be used for other states and for voluntary labeling or utility incentive programs. Utility incentive programs should increasing shift to rewarding multi-speed efficient pumps, based on such standardized testing results.

---

[47] The CEC test procedure is stated as follows:
"(A) IEEE 114-2001 shall be used for the measurement of motor efficiency.
(B) ANSI/HI 1.6-2000 shall be used for the measurement of pump and motor combinations efficiency.
(c)Two curves shall be calculated:
Curve A: $H = 0.0167 \times F^2$
Curve B: $H = 0.050 \times F^2$
Where:
H is the total system head in feet of water.
F is the flow rate in gallons per minute (gpm).
(D) For each curve (A&B), the pump head shall be adjusted until the flow and head lie on the curve. The following shall be reported for each curve and pump speed (two-speed pumps shall be tested at both high and low speeds):
1. Head (feet of water)
2. Flow (gallons per minute)
3. Power (watts and volt amps)
4. Energy Factor (gallons per watt hour)
Where the Energy Factor (EF) is calculated as:
EF = Flow (gpm) * 60 / Power (watts)"

- Eliminate pool pump manufacturers' practice of "full-rated" motors with high service factors. This is a confusing practice that can lead to consumers replacing their existing motor with a larger one without realizing it.

- Enact an efficiency standard for small and fractional horsepower motors. Most pool pump motors are currently exempt from federal efficiency standards. California has already required pump manufacturers to test and list their energy factors, has prohibited the sale of less efficient split phase and capacitor run/induction start motors, and has required that pumps and controls manufactured after 2008 have the capability of operating at two speeds. These energy efficiency standards could be considered in other regions.

- Conduct research to verify savings from variable speed pumps. Currently there is a dearth of independently verified energy savings from these pumps.

- Create a standardized software package that allows pool designers and builders to model the energy use high-end, custom pools, and to understand the energy impacts of particular component choices. This software could also be used as a training tool to educate pool builders and consumers about the energy impacts of components of typical pools and how to operate their pools efficiently.

- Once such software is available, it would be possible to assign numeric scores to various efficiency features. This could facilitate a system similar to the Home Energy Rating System (HERS) or various green-built homes programs, whereby builders need to accumulate a certain number of points to achieve particular rating levels.

- ENERGY STAR, LEED, or other voluntary labeling programs should consider adopting specifications for new pools and/or swimming pool equipment (i.e. pumps, motors, valves, cleaners, filters) that promote basic efficiency measures for new construction.

- Utilities should consider deploying energy efficiency incentives and marketing programs keyed to those voluntary ratings, to encourage installation of efficient equipment.

- Utility-funded efforts to document user behavior and verify energy savings in the field are also needed.

Voluntary labeling programs like ENERGY STAR and others established by utilities can also play a role in the development of more efficient pools. In some cases it may be possible to include consideration of pool energy use when labeling a home, but pools are most commonly installed after a new home is built, making it more effective to rate the pool itself for efficiency. Key components of a voluntary rating/labeling program might include:

- Software to help owners estimate annual energy bills with various assumptions about pool size, location, usage pattern, pumping and heating technology, cover options, climate, and energy costs before they choose to build a pool.

- Similar software to assign an efficiency score to pools after they have been constructed for purposes of estimating overall efficiency. Such a scoring system should be divided into two components – one that indicates efficiency relative to other pools of similar size in a similar climate, and the other that estimates annual energy use with typical usage patterns to allow any pool in one location to be compared to any pool in another.

- Criteria for efficient pump, filter, and heating system sizing and component selection.

- Consideration of automated system controls to encourage equipment to operate no longer than needed.

- Consideration of a maximum allowable fluid velocity in the system to encourage larger pipe sizes and lower flow rates, resulting in less pumping energy (the approach proposed in California's pending Title 24 standards).

- Consideration of a maximum allowable total dynamic head to encourage the use of oversized cartridge filters, larger return outlets and sweep elbows

Solar systems and heat pumps offer unique opportunities and also some challenges. Solar systems require the pump to operate during daylight hours, which often represent peak demand periods for utilities and can raise pumping costs if the customer is on a residential time-of-use rate or the heating system extends the swimming season. Similarly, heat pumps will operate more efficiently during the heat of the day than during cooler nighttime temperatures. Additional study would be required before making recommendations on how or if these systems should be incorporated into a voluntary rating program.

Recent research into combination photovoltaic/thermal panels suggests a promising approach to offset pool energy consumption in the future. Since photovoltaic systems operate less efficiently as their surface temperature increases, it can be beneficial to design combination systems that circulate water through the backs of the panels to carry away the excess heat. This has the advantage of imparting “free” heat to the water, as well as generating electricity to offset pool pump energy consumption during the sunniest times of the day.

What is clear is that California’s Title 20 and proposed Title 24 approaches to pool pump motor and new construction pool efficiency requirements could serve as a very useful framework for voluntary pool efficiency programs. A number of efficiency measures like variable speed pumps, robotic cleaners, automatic covers, advanced heating systems, and advanced controls are beyond the scope of California’s proposed policy, but could each be assigned point values that would sum to a total needed to achieve a voluntary label. This would allow California pools to qualify with modest additional improvements beyond those required by mandatory standards, while encouraging pools in other states to meet those standards first as a step toward earning the label.

7.2 Comparison to ENERGY STAR Homes Program Savings

This analysis compares the typical energy savings from upgrading a new home to ENERGY STAR levels to the savings achievable from cost-effective efficiency improvements in a residential in-ground swimming pool. Because the average energy use of both new homes and pools varies widely by location, we have chosen to look at the five states whose populations and climates cause them to that account for 58% of residential swimming pools: California, Florida, Texas, Arizona, and New York. In each case, we have selected a representative city in order to model climate effects and local energy costs: Phoenix, Los Angeles, Orlando (close to Tampa where the heating analysis was done), the New York City metro area (Islip), and San Antonio.

ENERGY STAR aims to save about 30% of the space heating, space cooling, and water heating energy use in a typical new home. Those three end uses in turn represent about 50 to 60% of an average home’s total energy bill, so the ENERGY STAR savings should add up to about 15 to 18% savings from a home’s normal energy bill. Given national average annual utility bills of approximately $1,500 per home, ENERGY STAR’s savings would tend to be about $250 to $300 per home per year, with substantial variations across different home sizes, types, and climates. Actual savings claimed by ENERGY STAR are roughly twice that amount, averaging $500 to $700 for the climate zones we examined. We use these ENERGY STAR numbers for purposes of comparison to estimated swimming pool energy savings.

Table 4 compares the maximum expected swimming pool energy savings from our analysis to the estimated average annual energy savings associated with improving those homes to ENERGY STAR levels. In most cases, these heated swimming pool savings are in the same range. For unheated pools and shorter pool season assumptions, the savings numbers would be lower, but still represent a large enough savings opportunity to merit consideration by ENERGY STAR. For example, the savings from optimized pumping alone represent about $250 to $400 per year, even with swimming seasons that are eight months or less per year. This suggests that more attention to pool efficiency by the market transformation community is absolutely warranted, and the savings that can be achieved are very large indeed.

It would not be uncommon for a heated swimming pool in year-round use to represent the majority of a home’s entire annual energy bill. Even on an average basis (including the large number of unheated pools just used seasonally), the $364/year average annual energy costs for an in-ground pool represent about 25% of average annual home energy bills.[48]

[48] See http://www.eia.doe.gov/emeu/recs/recs2001/ce_pdf/enduse/ce1-1e_climate2001.pdf

Table 4[49]

City	State	Climate Zone	Maximum Annual Savings From Optimized Pool	Annual Energy Bill Savings by Climate Zone from Upgrading a 2,500 sq. ft. Single Story Home to ENERGY STAR Levels				
			Electric & Gas	Electric		Gas		Total
			$	kWh	$	MCF	$	$
Phoenix	AZ	3	$390	3,592	$ 305	13.43	$ 204	**$ 509**
Los Angeles	CA	4	$633	1,885	$ 219	27.63	$ 310	**$ 529**
Orlando (Tampa)	FL	2	$621	4,218	$ 394	13.58	$ 285	**$ 679**
Islip	NY	11	$454	1,995	$ 293	27.26	$ 393	**$ 686**
San Antonio	TX	4	$491	4,075	$ 394	22.27	$ 310	**$ 704**

7.3 Additional Research

As we have seen, heating is by far the largest component in the energy consumption of a heated pool. There could be great opportunities to reduce heating energy consumption, but the scale of the problem is still unknown. A swimming pool season (whether heated or not) is highly dependent upon climate. Proper sizing of the heating system to be cost-effective is challenging. With regard to new installations, we can project energy savings based on a set of assumptions, but we still do not know how the pools are operated once they're built. What months are the pools being utilized? When are they heated? How often is a pool cover in use? All of these questions need answers in order for our savings projections to become more refined. The most effective way to gather this information is likely a market survey. While the information would be valuable for the design of new pools, it would also have huge benefits for existing pools and incentive programs.

As with any energy consuming system, the most effective way to save energy is to turn it off when not needed. When it comes to residential swimming pools, the filtration system has no means of knowing when it has run long enough to achieve proper filtration. Instead, there are "rules of thumb" such as; 1) run it long enough to achieve one turnover of the pool's water volume per day, or 2) run it "X" number of hours per day in the summer and "Y" number of hours in the winter. Pool owners are likely to increase pump run times if water quality is poor, but may not reduce run times if water quality is good.

Items that could help to reduce pump runtimes include various cleaning systems that vacuum dirt from the bottom of the pool once it has settled. Systems that could be counterproductive to this effort might include floor jets that are designed to get the dirt off the floor and back into suspension to be filtered. Additionally, the type and method of chemical dispersion will be important. New systems such as salt chlorine generators and ozone are also gaining acceptance in the marketplace. The only way to determine the effectiveness of the various systems and their effect on pump runtimes would be a field test. Utility-funded field testing is also warranted to assess synergistic effects of combining various efficiency measures and seeing how they are impacted by real-world operating conditions.

---

[49] Estimates provided by Richard Faesy, VEIC, September 15, 2005 based on the dollar value of Builder Option Package savings provided by ENERGY STAR for various home sizes, and modeling of the natural gas/electricity bill split in various climate zones.

Another new idea is turbidity sensors to control pump runtime. Turbidity sensors are currently utilized in many energy efficient dishwashers to monitor water soiling during the rinse cycle and adjust rinse times accordingly. Early research by Southern California Edison conducted by Davis Energy Group found that it is possible but expensive to employ turbidity sensing in residential pools. The technology is somewhat more mature for the larger scale pools found in commercial and public recreational facilities.

Our analysis of heat pump water heaters assumes that the heat pumps are drawing their heat from ambient air and discharging that heat into the swimming pool as is common practice. Other options may also merit consideration, including ground source heat pumps for drier climates or heat pumps located indoors that could cool and dehumidify the home while transferring heat to the pool.

Whether we are talking about existing technology being used in new ways, new technology being developed for the pool industry, or simply proper application of current technology, it is apparent that swimming pools represent a largely untapped market for major energy savings.