PG&E Sempra Energy

CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

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Residential Swimming Pools

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Overview

This project is part of a statewide effort to reduce California's energy consumption cofunded by Pacific Gas and Electric Company (PG&E) and Sempra Energy. The PG&E Codes and Standards Enhancement (CASE) Initiative Project addresses energy efficiency opportunities through Title 24 standards. This report describes the economic, technical, cost-effectiveness and feasibility issues associated with a Title 24 energy code requirement that would mandate various design and operational aspects of new California swimming pools. Pools are currently built to meet numerous safety standards, but energy efficiency is rarely considered and first cost is usually the overriding concern. The proposed measures will establish the minimum acceptable pool design for increased energy efficiency while maintaining safety standards.

Proposed mandates include pump motor selection, pipe design, and filter size selection. Energy savings are obtained by reducing the pool system total dynamic head, or TDH, through recommended pipe design and filter specifications, and by using a correctly sized pump and motor. Special purpose single-phase motors, such as used in residential pool pumps, and two-speed motors are not regulated by federal standards but are included in the 2005 Title 20 appliance standards regulations. The proposed measures herein will enforce the existing appliance standards for new buildings.

With nearly 35,000 new constructed pools annually, total energy savings for the State are estimated as 56.6 GWh per year if all the proposed measures are accepted. Electric demand coincident with utility system peak would be reduced by 31.6 MW. These demand savings are realized without operational measures such as off-peak and demand response.

This project does not aim to regulate optional components such as a pool heaters, sweeps, or cleaners. Pool covers are reviewed to the extent that they were previously specified for heating purposes. They are analyzed as a viable means of reducing cleaning and filter time and hence electricity use. Pool and spa heating energy efficiency are sufficiently covered in the existing Appliance and Building standards. Heat pumps are not a viable option for most of California's climate zones, but are addressed in the Title 20 Appliance Standards. Solar heating systems are efficient and effective during swimming season, and are often used to augment the gas pool heater. Solar collector heating systems are accounted for in off-peak operations, demand response, default low-speed, and pump sizing analyses to certain extents. Only components that pertain to electric pump filtration are explored in this report; no natural gas efficiency measures were investigated.

Description

Pool designs can vary from a basic design that includes just a pump and filter to elaborate designs containing a spa, solar heating collectors, and various features such as waterfalls, shear descents, fountains, vanishing edges, and others. In this report, we consider a simpler design evaluating the bare necessities needed for proper filtration. A description of the major components in a filtration system is presented below with a diagram in Figure 1.

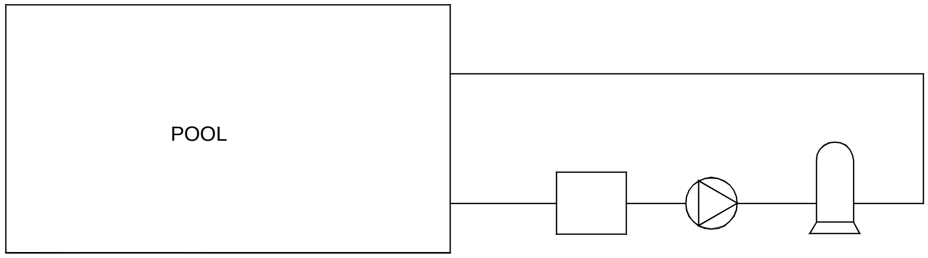

Figure 1. Simplified Piping Diagram for a Pool Filtration System.

Pool Components

Each of the basic components needed for filtration or that aid in filtration are further described below.

Pump motors. Common pump motors types are shown in Table 1, listed in order from least efficient to most efficient. Power typically ranges from ¾ to 3 HP with an average of 1.5 HP (ADM 2003). Most are single-speed, but two-speed, multi-speed, and variable speed options are available.

Table 1. Types of pool pump motors.

Type
Split Phase
Capacitor Start Induction Run (CSIR)
Permanent Split Capacitor (PSC)
Capacitor Start Capacitor Run (CSCR)

Figure 2. Typical pool pump with leaf strainer.

Pipe and fittings. Pools are piped in either PVC or copper. Pipe diameters used range from 1 to 3 inches. There is typically 50 feet of return and suction pipe for an average residential pool. The National Spa and Pool Institute (NSPI) recommends maximum velocities in copper pipes of 8 fps for suction and pressure piping to prevent corrosion (ANSI/NSPI-5 2003) while other piping should not exceed 10 fps for pressure piping and 8 fps for suction piping. Fittings used are generally 90° elbows and tees. Figure 3 below shows a 90° elbow, a proposed short radius sweep elbow, and a lower pressure drop sweep elbow with a long radius.

Figure 3. 90° Elbows: standard, short radius sweep, and long radius 90° sweep ell (from left to right).

Filters. Pool filters consist of three main types: cartridge, sand, and diatomaceous earth (DE). Sand and DE filters are cleaned by backwashing and thus must have a backwash valve consisting of two three-way valves or a single multi-port valve (MPV). Cartridge filters are cleaned by removing the element and washing it. Figure 4 shows the three types of filters and their internal design.

Figure 4. Three filter types (from left to right: sand, DE, and cartridge). Source: www.poolcenter.com

Generally, sand filters should be cleaned when the inlet pressure gauge on the filter increases 10 psi above its initial clean operating level. Residential sand filters require a backwash approximately 1 to 2 times a year. The sand media can last for up to ten years. Conversely, DE filters require new media every time they are backwashed. DE filters manufacturer maximum pressure specifications for backwashing are typically lower than sand. Some city and county jurisdictions require a separation tank for DE filters so that the DE does not enter the sewer and cause problems at the wastewater treatment plant. DE media is nonrenewable and is mined. Cartridge filters need to be rinsed or changed out at least once a season. There are also new types of hybrid filters that combine the benefits of cartridge with the cleaning capabilities of DE. These filters remove particles down to 5 microns while maintaining the cleaning ease of a cartridge filter. Backwashing is still possible, so these units are equipped with a backwash valve, but owners can also rinse the cartridges. Table 2 shows the size, flow rates, and cleaning abilities of the three main filter types according to ranges as reported by filter manufacturers.

Table 2. Filter Characteristics.

Type	Effective Cleaning Flow Rate * (gpm/sq. ft.)	Recommend Maximum Design Filtration Rate** (gpm/sq.ft.)	Clean Filter Head Loss at 60 gpm*** (ft of water)	Smallest Particle Removed (microns)^
Cartridge	0.21 – 1.0	0.375	2	5 – 10
High Rate Sand	15 – 25	20	20	20 – 25
Diatomaceous Earth (DE)	1 – 2	2	17	3 – 5

* Cleaning Flow Rate ranges according to surveyed manufacturer's range.
** Design filtration rate is according to Standard ANSI/NSF 50 for public pools.
*** Head losses for DE and sand filters include losses due to a 2" multi-port valve (MPV)
^ www.pool-filters.com

Covers. Pool covers can be manual or automatic. Automatic pool covers are much easier to operate, but are significantly more expensive. Automatic covers have the added benefit of preventing pool access by children, as do some manual covers in tension. An example of an automatic cover is shown in Figure 5. Higher cost manual covers can be stored on a reel, but the cheaper bubble types are typically folded up when the pool is in use. Manual covers can be made of bubble, vinyl, or insulated vinyl (see Figure 6). When the pool is used, bubble-type covers are usually difficult to store with neither reel system nor folding capabilities.

Figure 5. Picture of an automatic pool cover with permanently mounted tracks underneath the deck. Source: www.coverpools.com

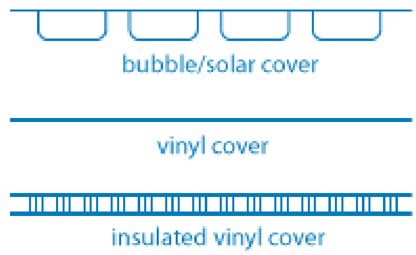

*Figure 6. Types of pool covers. Source: Energy Efficiency and Renewable Energy (*www.eere.energy.gov*)*

Controls. Most filtration systems are regulated with a mechanical or electronic time clock, which operates the pump for a set number of hours per day. Higher end pools with multiple features have a digital control pad that can automate filtration, cleaning, and chemicals, as well as operate the features. Control capability for off-peak operation is currently mandated in the Title 24 Building standards; however, load curves show significant operation during peak hours exceeding those necessary for pools with solar heating. Average filtering time is approximately 4.5 hours and can be as much as eight hours depending on location (ADM 2001).

Cleaners. Various types of cleaners are used in residential pools including those that work off the pressure or suction sides of filter pump systems, ones that use booster pumps exclusively, and more recently, in-floor systems that are also powered by the main filtration system

Definitions

The following definitions are used in this study.

Flow Rate. Flow rate is the volume of water flowing through the filtration system in a given time, usually measured in gallons per minute.

Nameplate Power. The nameplate power is the motor horsepower listed on the nameplate and the horsepower by which a pump is typically sold.

Pumps. Pool pumps usually come with a leaf strainer before the impeller. The pumps contain an impeller to accelerate the water through the housing. The motors for residential us pumps are included in the pump purchase but can be replaced separately. The pumps increase the "head" and "flow" of the water. Head is necessary to move fluid through pipes, drains, and inlets, push water through filters and heaters, and project it through fountains and jets. Flow is the movement of the water used to maintain efficient filtering, heating, and sanitation for the pool.

Return. The return refers to the water in the filtration system returning to the pool. The return lines or return side, relative to the pump, can also be defined as the pressure lines or the pressure side of the pump. Water in the returns is delivered back to the pool at the pool inlets.

Service Factor. The service factor rating indicates the percent above nameplate horsepower at which a pump motor may operate continuously when full rated voltage is applied and ambient temperature does not exceed the motor rating. Full-rated pool motor service factors can be as high as 1.65. A 1.5 hp pump with a 1.65 service factor produces 2.475 hp (total hp) at the maximum service factor point.

Suction. Suction created by the pump is how the pool water gets from the skimmers and drains to the filtration system. The suction side and suction lines refer to the vacuum side of the pump. It is at negative atmospheric pressure relative to the pool surface.

Total Dynamic Head. Total dynamic head, or TDH, refers to the sum of all the friction losses and pressure drops in the filtration system from the pools drains and skimmers to the returns. It is a measure of the system's total pressure drop and is given in units of either psi or feet of water column (sometimes referred to as "feet" or "feet of head").

Total Motor Power. Total motor power, or T-hp, refers to the product of the nameplate power and the service factor of a motor used on a pool pump.

Turnover. A turnover is the act of filtering one volume of the pool.

Turnover Time (also called Turnover Rate). The time required to recirculate the entire volume of water in the pool or spa through the filter. e.g. A turnover time of 6-hours means an entire volume of water equal to that of the pool will be passed through a filter system in six hours.

$$\text{Turnover Time} = \frac{\text{Volume of the pool}}{\text{Flow rate}}$$

Description of Proposed Changes

The proposed changes apply to new construction of swimming pools, specifically aspects controlled under the design of pools. When a permit is requested for a new pool, the inspection process can provide enforcement of the proposed mandatory changes. A synopsis of each proposed topic supporting the pool pumping measure is presented below.

1. MOTOR EFFICIENCY REFERENCE TO TITLE 20 APPLIANCE STANDARDS: This measure references the 2005 Title 20 Appliance standards Section 1605.3 (g)(5)(A) regarding pool pump efficiency and mandates that all pump motors installed in newly constructed pools be found on the CEC listing.

2. LOW SPEED FILTRATION AND MULTI-SPEED PUMPS: This measure limits filtration flow rates to turnover the pool water in no shorter than six hours. This measure also repeats the requirements of the Title 20 standard (1605.3(g)(5)(B)(ii)) by requiring the installation of a two-speed pump for pumps 1 hp

and over, two-speed capable controls, and operating at low speed default filtration. It excludes start up time for priming and any cleaning that might need the pump motor to operate at a higher speed.

3. PIPE DESIGN AND EFFICIENT PIPE FITTINGS: This measure sets maximum filtration system suction and return velocities of 6 and 8 feet per second, respectively. Maximum filtration rates determine the pipe size according to these velocities. It requires a minimum straight length of least four pipe diameters on the suction side of the pump. It requires the use of sweep elbows instead of hard 90° elbows for decreased friction losses through the piping.

4. FILTER SIZING AND SELECTION: This measure specifies that filter selection be sized according to manufacturer's recommendations. In addition, it requires that multi-port valves (MPV) must be appropriately sized.

We examined operational measures that would further enhance the proposed design measures capability for savings. While these operational measures were not presented to the CEC for mandates, their resulting findings are significant and may be used in future research. A synopsis of each operational measure researched is presented below.

5. CONTROLS FOR USE WITH OFF-PEAK OPERATIONS AND DEMAND RESPONSE: Current Title 24 regulations require a time clock for pool pump operation. However, there is no enforcement of when the pool pump should operate. This measure was initially investigated to modify Section 114 (b) 3 so that controls chosen could maintain a schedule through a power failure and that they be set to an off-peak schedule upon final inspection. Due to persistence issues, we are presenting our findings in support of future incentive programs, possible performance measures, future prescriptive measure, or any combination of these. This study also estimates savings of adding demand response (DR) systems to pool controls.

6. POOL & SPA COVERS: This measure initially proposed to require removal of the exception for pool covers in the case of solar heating in the current standards while proposing to require that the pool covers be cut, installed before inspection, or both for heated pools. Pool covers not only prevent heat loss from a pool but also allow for less filtration by keeping out debris, reducing water loss through evaporation, and reducing the amount of chemicals needed. Current regulations require heated pools with less than 60% of the heating provided by solar to have a pool cover. The final consensus for pool covers has been to maintain the current language and ensure proper enforcement. It has been found that in practice, pool covers are not cut to size nor installed before inspection leaving many pools effectively uncovered.

   Despite estimated savings in electricity consumption, since pool covers allow for less filtration time, experts agree that the safe amount of filtration reduction has not been established. Experts do *not* agree on the effects to the chemical properties of the water of leaving pool covers over extending periods. With the new Compliance Form, it is possible to confirm use of pool and spa covers on site.

An aggregate analysis showing the synergistic benefits of all the design measures above presents the potential total energy savings for new pool construction. Operational measures 5 and 6, regarding Controls and Pool Covers, are not modeled in this aggregate analysis.

Energy Benefits

Table 3 shows the annual energy savings on a per pool basis by each of the measures alone. Energy benefits for all the design measures applied average 1624 kWh/year per pool. Statewide energy benefits are 56.6 GWh/year or nearly 50%, based on an original energy consumption increase of 113 GWh per year. Electric demand coincident with utility system peak is reduced by 31.6 MW if proposed measures are accepted. These demand savings are realized without operational measures such as off-peak and demand response.

Table 3. Annual energy benefits per pool per measure.

Measure Title and Proposed Implications	*Energy Savings (kWh/yr)*	*Percent Energy Savings*
1.0 MOTOR EFFICIENCY REFERENCE TO TITLE 20 APPLIANCE STANDARDS		
1.1 Require that pump is listed with CEC	n/a*	n/a*
2.0 LOW SPEED DEFAULT FILTRATION AND PUMP SIZING		
2.1 Reduce pump size to achieve >6 hour turnover (1 speed)	1473	54.0%
2.2 Reduce pump size to achieve >6 hour turnover (2-speed)	1421	52.0%
3.0 PIPE DESIGN AND EFFICIENT PIPE FITTINGS		
3.1 Straight pipe run on suction side before pump at least 4 times the pipe diameter.	104 - 728	4-28%
3.2 Pipe sizing according to 8 and 6 fps in the return and suction lines, respectively.	403	14.7%
3.3 Savings from decreasing 50% unnecessary elbows	85	3.0%
3.4 Efficient pipe fittings sweep elbows	31	1.2%
4.0 FILTER SIZING AND SELECTION		
4.1 Appropriately sized filters	13	0.5%
4.2 Appropriately sized backwash valves	159	5.9%

* Energy savings accounted for in Title20.

Measures 5 and 6 savings are not shown in Table 3 as they were not calculated for the customer benefit. Only from the CEC time dependant values are the savings for these operational measures of controls, demand response, and pool covers shown below under Results.

Non-energy Benefits

The reduced emissions associated with the lower pumping energy needed for efficient pool designs are considerable and are shown in Table 4 under Environmental Impacts. The following other non-energy benefits may be realized from adopting the proposed measures:

1. MOTOR EFFICIENCY REFERENCE TO TITLE 20 APPLIANCE STANDARDS: Pumps operating at lower speeds and properly designed flow rates will have a longer operating life.

2. LOW SPEED FILTRATION AND MULTI-SPEED PUMPS: Default low-speed operation creates less noise than a larger pump or high-speed operation thereby increasing comfort during operation. The same is true for single speed pumps smaller than one hp. Right pump sizing should result in a smaller pump, which reduces initial pump costs.

3. PIPE DESIGN AND EFFICIENT PIPE FITTINGS: Better plumbing practices decrease maintenance problems such as leaking and broken pipes. Pipes will last longer at lower velocities. Efficient pipe fittings and appropriate pipe diameters contribute to decreased head, which allows for a decreased pump size and environmental benefits.

4. FILTER SIZING AND SELECTION: Filters sized appropriately reduce water use and wastewater by allowing a longer filter runtime between backwashes or cartridge cleanings. This also reduces cartridge use and media use by prolonging filter media. DE filters produce waste at every backwash. Some cities regulate DE waste by requiring separation tanks.

5. CONTROLS FOR USE WITH OFF-PEAK OPERATIONS AND DEMAND RESPONSE: Aside from the reduced emissions and reduced environmental impact, using pool pump during off-peak hours and with demand response capabilities could allow pool owners monetary benefits for switching to a time of use rate or savings if customer rates become dynamic.

6. POOL COVERS: Comfort is an added benefit of pool cover use since the pool water will maintain heat longer. Covers reduce water evaporation by between 30 and 50 percent, which results in less chemical use at the pool and less processing of potable water at treatment plants.

Statewide Energy Impacts

For all the proposed design measures put together, the annual energy savings are 1,623 kWh per pool. With nearly 35,000 new constructed pools, total annual energy savings for the State are 56.6 GWh. Electric demand reduction coincident with utility system peak is reduced by 39.5 GW.

This estimate was based upon differences in energy from model simulations of four various base case pools and a desired pool with the design measures applied. Estimates of new pool construction were broken down accordingly: 20% of the market was considered to have desired designs, which included our proposed measures; 60% was the current average design; and, 20% was comprised of bad designs, further broken down by 13% as the bad design scenario and 7% as the worst design scenario. Each pool design was modeled, energy savings were estimated, and weighted accordingly.

Per pool savings were expanded up to the population of one year's new construction which is estimated to be 34,850 based on communication with the pool industry leading market researcher (PK Data, 2006). PK Data estimates could be low due to exclusions of some counties.

Environmental Impact

Some of the design measures may increase pipe, fitting and filter sizes and thus increase the production of PVC and other materials. Conversely, the design measures will reduce pump size, thus reducing the production of steel and copper. Overall, non-energy related environmental impacts and associated costs are considerable and presented in Table 4. The ADM baseline demand profile was used adjusted according to the energy and demand savings found in the aggregate analyses.

Table 4. First year reduction in both emissions and costs from utilizing proposed design measures.

Emission Type	*NO_x*	*PM-10*	*CO_2*
Reduction in Emissions	4,616 lbs	2,759 lbs	20,554 tons
Reduction in Costs	$47,400	$89,012	$265,467

Type of Change

All the measures presented in this CASE Study are mandatory prescriptive measures. Other measures that could be performance based are not considered here. Currently swimming pool models are not included in the ACM or in MICROPAS making it difficult to apply any performance requirements and any tradeoff calculations. A performance-based approach using a pool system design tool, similar to Manual J for HVAC, would provide flexibility to pool contractors in equipment specification and sizing. However, there is not an appropriate tool available at the present time.

The current swimming pool standard checklist is part of the Mandatory Measures Summary (Residential Form MF-1R under Section 114) found in the Residential Compliance Manual for 2005. There is a short section regarding pool standards with respect to heating and heating equipment. We propose to replace the existing section with the new pool-specific form found in Appendix A.

Technology Measures

Many of the pool measures encourage one type of fitting or size of piping over another and specific pumps, pump motors, and pump controls. The following subsections "Measure Availability and Cost" and "Useful Life, Persistence and Maintenance" address the intended and any possible unintended affects of the proposed measures on technology.

Measure Availability and Cost

The prices listed are based on a consistent 30% mark-up from the internet findings. All pipes and fittings are estimated to be Schedule 40 PVC, the current standard in the pool industry. Table 25 summarizes the cost for all the baseline assumptions of the pool model.

1. MOTOR EFFICIENCY REFERENCE TO TITLE 20 APPLIANCE STANDARDS: There are no costs associated with this proposed measure, as it will be enforced under the appliance standards before these 2008 building standards become effective.

2. LOW SPEED FILTRATION AND MULTI-SPEED PUMPS: Single-speed pumps are generally available in a range from ½ to 3 horsepower while 2-speed pumps are generally available in a range from 1 to 3 horsepower. Table 5 compares the retail costs for single and 2-speed pool pumps.

Table 5. Retail Cost of Pool Pumps

Motor Size (Horsepower)	*Motor (Total Horsepower)*	*Single-speed Costs*	*2-speed Costs*
½	0.95	$388	N/A
¾	1.25	$409	N/A
1	1.65	$485	$722
1 ½	2.20	$580	$740
2	2.60	$629	$865
2 ½	2.95	$708	$1,015
3	3.45	$730	$1,062

The cost of single-speed pumps increases linearly with horsepower at ~$110/Hp. Note that for most sizes the incremental cost from a single-speed to two-speed pump is approximately $270. The 2-speed costs for 2 ½ and 3 horsepower are taken from a very small sample of pumps.

3. PIPE DESIGN AND EFFICIENT PIPE FITTINGS: Most modern pools are plumbed exclusively with PVC pipe and fittings that are generally available in sizes ranging from ½" to 3" with 1½" and 2" being the most popular. Table 6 shows the retail cost of various sizes of pipe and fittings. We assumed 50 feet of supply and return piping, eight elbows for return piping, and four elbows for supply piping per pool.

Table 6. Retail costs of PVC pipe and Fittings

Pipe diameter	Pipe ($/foot)	Hard 90º Elbow (each)	Short Sweep Elbow (each)
1"	$0.62	$0.51	$3.28
1 ¼"	$0.88	$0.82	$3.49
1 ½"	$1.03	$0.98	$4.61
2"	$1.32	$1.52	$5.58
2 ½"	$2.16	$5.13	$8.95

Pool contractors do not currently use sweep elbows in significant quantity and so wholesalers do not stock them in all sizes. Many wholesalers do not currently have the molds for short radius sweeps. One manufacturer has stated that short radius sweep elbows are made up to 2" pipe only and then the larger sizes are heat bent into long radius sweeps.

This measure also proposes a requirement for a minimum of straight pipe length leading to the suction side of the pump of at least four pipe diameters. Manufacturers recommend straight leading pipe to the pump on the suction side. Without a leading straight run of pipe, the pump may experience cavitation, extra noise, and impeller wear. Pool builders who do not currently practice designing leading pipe to the pump in hopes of saving room on the equipment pad will either reconfigure the pad or increase the area of the pad. An increase in the equipment pad area would include increased costs in concrete, accordingly. The pipe diameter on the suction side typical of residential pumps could reach upwards of 3", which would translate to at least 1 foot of pipe before the pump.

4. FILTER SIZING AND SELECTION: Pool filters are available in a large range of sizes for all three types of commonly used filters. Costs for all filter types increase linearly with filter area with a cost per additional square foot of $1.45 for cartridge, $106.85 for sand, and $4.66 for DE. Table 7 below summarizes retail costs.

Table 7. Retail Costs of Pool Filters

Cartridge		Sand		DE	
Area (sqft)	Cost	Area (sqft)	Cost	Area (sqft)	Cost
100	$313	0.9	$257	36	$438
200	$485	1.8	$322	48	$502
300	$640	2.3	$351	60	$550
400	$787	3.1	$390		
500	$888	4.9	$689		

5. CONTROLS FOR USE WITH OFF-PEAK OPERATIONS AND DEMAND RESPONSE: Current language in 2005 Title 20 and Title 24 Standards mandate off-peak availability in controls: "The circulation pump shall have a time switch that allows the pump to be set to run in the off-peak electric demand period." Pool controls that can respond to utility curtailment calls are currently not available, but general purpose load control meters are widely used and work well with pool filtration equipment. It is outside the scope of these proposed measures to try to mandate one type of demand response at this time. The savings from demand response program simulations are presented in this report and implementation methods are left to the utilities.

6. POOL COVERS: As the cheapest and easiest to customize, bubble wrap type pool covers will most likely remain the type of cover used for owners not specifying other types. If a pool model is created for use in the ACM, other high-end pool covers may be recommended over the cheaper styles without safety features.

Useful Life, Persistence and Maintenance

Pools have an expected life of 20 to 30 years, which can be extended indefinitely by re-plastering and repair. Pumps and their motors have a lifespan of 10 years (DOE 2001). Pool design and operation can have a significant effect on pool equipment life: undersized piping results in high fluid velocities, high noise levels, and worn pipes. Undersized filters must be cleaned or backwashed more often. Short pipe runs on the inlet to pumps can cause cavitation, noise, and impeller wear. Table 8 summarizes expected lifetimes for pool equipment. Savings due to pipe and fitting selection are effectively locked in for the life of the pool.

Table 8. Pool Equipment Lifetimes

Equipment	*Life (years)*
Pump	10
Filter	15
Pipe and fittings	20
Bubble type cover	3
Automatic cover	Fabric: 5 Mechanism: 15

Performance Verification

With the proposed standards, the underground piping and the equipment on the equipment pad will have to be verified. The proposed compliance form, found in Appendix A, will have to be used at various stages of pool construction. Verification of the controls, size of the filter, pipe diameter, fittings, and pump selection will be done onsite during some of the existing inspections.

Some stakeholders have recommended that outside contractors be used to confirm pool designs and perform inspections and testing, similar to HERS rating for HVAC duct systems. A possible positive consequence of HERS rating verification is shortening the time the pool builders wait for plans examinations. The checklist and accompanying tables found in Appendix A will guide either a HERS rater or plans examiner and inspector through the design and verification processes.

Cost Effectiveness

Net present value of energy savings per pool is estimated at $910 and the incremental life cycle cost for the equipment is $79 resulting in a life cycle cost savings of $831 and a benefit to cost ratio of 11.5 to 1.

The cost effectiveness estimates are based upon the incremental costs of the proposed design measures compared to the average design. Any increased costs due to inspector or outside contractor verifications are not included. The following assumptions were used in calculating the incremental life cycle equipment cost:

- the first year incremental cost of the design measures is estimated to be approximately $173;
- the pool and its pipes, pipe fittings will have to be replaced in 30 years;
- the filter (and any backwash valve) will be replaced in 15 years; and,
- the pump and motor will be replaced every 10 years.

The annual savings of 1624 kWh per pool result in almost $910 of savings using the 2008 lifecycle multiplier for 30 years. These costs account for a purchase of two replacements pumps and one filter. The discount rate is 3 percent.

Analysis Tools

As this measure is proposed as a mandatory measure, Alternative Compliance Method (ACM) swimming pool performance software is not required. However, further savings may be achieved in the future using performance compliance methods. At that point, an ACM pool model will be necessary.

Relationship to Other Measures

No other measures are impacted by the proposed Residential Pool Pumping Measures.

Methodology

The analysis performed to determine savings for the individual measures required the development of a standard pool design for the comparison of existing and proposed practices. A generic "average" pool model was used for comparison purposes. The main goal of this approach is to have a model in which we can hold most of the parameters constant and vary just the ones being studied. The model is as follows in Figure 7:

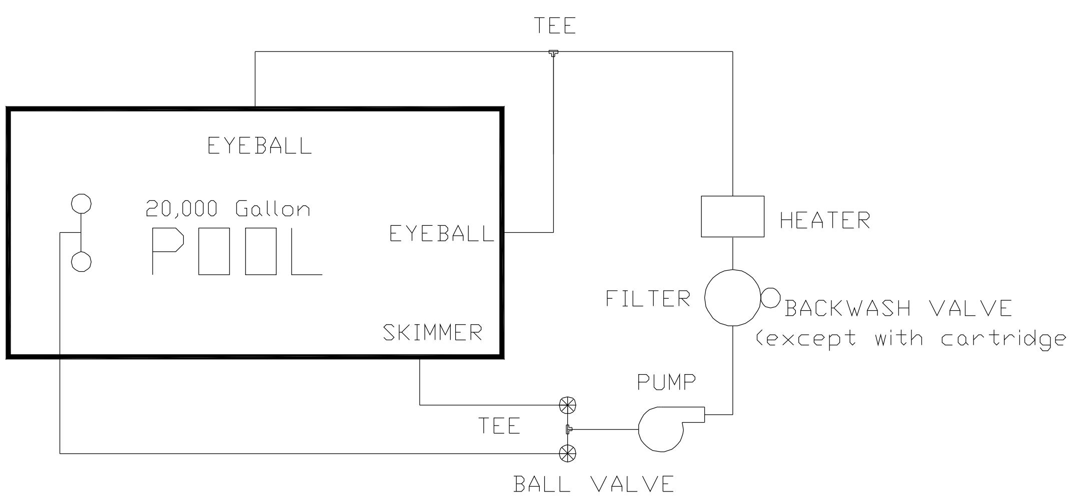

Figure 7: Schematic of model pool.

The model includes a 20,000-gallon pool with a heater, filter, and a backwash (MPV) valve (for sand and DE filters). The suction side consists of 50 feet of 2" pipe, four 90° elbows, one Tee, two ball valves, a main drain, and a skimmer. The return line consist of 50 feet of 1.5" pipe, eight 90° elbows, one tee, and two eyeballs. The pump used for most simulations is a standard 1.5 HP pump with a 1.65 service factor. The exception to this is when different flow rates are being studied, at which time different pumps were chosen to achieve target flow rates.

The following is the sequence of calculations performed for the model simulations:

1. Determine equivalent pipe lengths for fittings
2. Add length of pipe used to the equivalent lengths of the fittings to get the overall equivalent length of the return and suction (in case they are different diameters).
3. Find the head loss due to friction for the equivalent length of pipe for the return and the suction lines at all flow rates (0 to 100gpm in increments of 10), and add them together for each flow rate.

4. Find the head loss due to the heater, filter, and MPV (if applicable) for all flow rates and add them to the pipe head loss for each flow rate.
5. Plot the head losses as a function of flow rate on a graph along with the pump curves of various pumps to see where the operating points lie (see Figure 8).
6. Pick operating point, then find corresponding flow rate and power demand.

The flow rate and power demand that is determined from the simulations is then used to calculate energy savings. Using the volume of the pool and the flow rate, the run time for a single turnover is calculated, which is then multiplied by the power to calculate the energy consumed per day and year. The savings is calculated from the difference between the annual energy consumed by the current practice and the proposed measure.

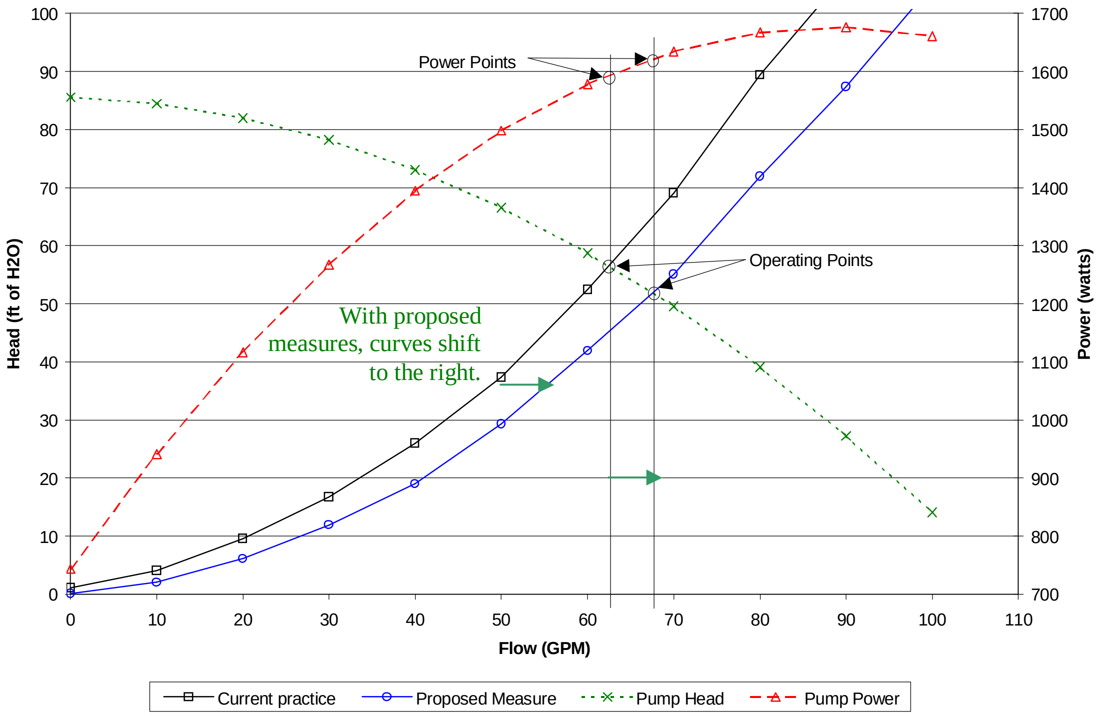

Figure 8. Sample comparison of a proposed measure to the current practice.

For example, Figure 8 above shows the system curves for a current practice and proposed measure that would reduce the TDH of the system. Both system curves are plotted with a pump head curve and the corresponding pump power curve. The power curve is plotted on the secondary Y-axis. The operating points are located at the points where the system curves cross the pump head curve. These points indicate at what head and flow rate each of the systems operate. Directly above the operating point is the corresponding power point. Note that the power demand of the pump increases with the proposed measure, as does the flow rate. The results are summarized in Table 9:

Table 9. Sample measure study results (not actual results).

	Power (Watts)	*Flow (gpm)*	*Turnover Time (hours)*	*Energy Use (kWh/year)*
Current Practice	1,592	62.4	5.3	3,104
Proposed Measures	1,620	67.5	4.9	2,920
Savings				183

Notice that the turnover time for this hypothetical situation is 4.9 hours. Such a quick turnover time (less than 6 hours) indicates a pump that is larger than necessary. If a lower HP pump were installed in this system, the turnover time would increase and the savings would be even greater. This would be due to a decreased "pump head" curve, as it is labeled above in Figure 8, and a decreased corresponding "pump power" curve for the new smaller pump.

The evaluation methods vary by measure, and are described below:

Measure 1 - Energy Efficiency of Pump

The proposed measure requires that the motor used for new construction pools be listed with the CEC. Measure 1 includes a reference to the Title 20 Appliance Energy Efficiency Standards (1605.3(g)(5)(A)) in the Title 24 standards for building energy efficiency. It is included to enable enforcement of the established Title 20 standards. No analysis was performed for this measure. Savings have been researched under the existing appliance standards.

Measure 2 - Low Speed Filtration and Multi-speed Pumps

Measure 2 is a study of maximum flow rate restrictions for default filtration. The purpose of this measure is to encourage pool builders to install the correct size pump for the pool being built by limiting the maximum filtration flow rate.

Measure 2 will limit filtration flow rates to turnover the pool water in no shorter than six hours. The analysis for the first half of this measure involved creating a system curve for a "standard" pool design and plotting it with several pump curves. The energy consumption is then calculated for the system with a 1.5 horsepower pump, the most common pool pump, and with a pump that keeps the flow rate below a 6 hour turnover rate.

The second portion of this measure pertains to multi-speed pumps as an inclusion of Title 20 Appliance Standard 1605.3(g)(5)(B). Measure 2 shall also require that pumps one hp and greater shall be capable of operating at two or more speeds, with a low speed having a rotation rate that is no more than one-half the motors maximum rotation rate. In addition, the proposed adoption of the existing appliance standard requires that the pump motor controls must be capable of operating the pool in at least two speeds and that the default filtration rate be the lower speed. Refer to the Title 20 CASE Initiative for Residential Pool Pumps, Motors, and Controls for analysis methods.

Measure 3 - Pipe Design

Measure three addresses three pipe design issues: pipe velocity (pipe size), straight pipe run before pump, and low head fittings.

Pipe Velocities and Pipe Sizing

Twenty percent of new pools were assumed to have undersized pipes. Undersized pipes increase TDH and increase the work required by a pump for the same flow. Since the flow rate is dictated by pool size and desired turnover rate, maximum return and suction line velocities drive pipe sizing as shown in Equation 1.

Equation 1. Definition of pipe flow (gpm).

$$Q = V \times A$$

Where:
Q = the pipe flow [gpm],
V = the average velocity of the flow [fps], and
A = the cross-sectional area of the pipe [ft^2].

The base pool model was used and the pipe size was varied. Results demonstrate the savings from increases in pipe sizes to facilitate slower velocities. The same pump was used, resulting in higher flow rates. The decrease in the time it takes to move the pool volume through the filtration system was used to calculate energy savings for the year.

Straight Leading Pipe at Pump

Most pump manufacturers recommend that a length of straight pipe equal to 4 to 5 pipe diameters precede the pump. Because the pump operates less efficiently and the flow drops off when the pump is cavitating, a pump would have to operate longer to turn the same volume of water. Pump manufacturers estimate the energy impact is anywhere from 10 to 50%, and that between 50 and 70% of the new pools are installed with insufficient straight pipe.

Efficient Pipe Fittings

The model was used to compare the various choices possible for fittings that are more efficient. The fittings evaluated were hard 90° elbows, short radius sweep 90° elbows, long radius sweep 90° elbows, double 45's used in place of a 90°, and substituting 45's for 90's where diagonal runs are possible. The pool model was used, substituting each of these fitting types. The resulting system curves were plotted on the same pump curve as the previous analysis resulting in new operating points for each system curve. The power and flow rate were determined from the operating points, and the energy use for each run was calculated for a single turnover using the affinity law and existing power data from testing. In addition, the equivalent lengths, or friction losses, of the various fittings were calculated and compared to each other.

Measure 4 - Filter Sizing & Selection

This measure aims to eliminate undersized filters in pool filtration systems and highlight savings possible from various types of filters. Simulations were run with an undersized and an oversized cartridge filter to calculate the savings/year available from requiring the proper sized filters be installed.

The analysis performed for both parts of this measure involved running the pool model with different types of filters and comparing system curves. A few samples of each kind of filter (sized to 60gpm) were compared and the minimum, maximum, and average head loss of each type of filter at 60gpm are reported.

Sand and DE filters usually have higher head losses than Cartridge filters and require a backflow, or multi-port, valve that can have an even higher loss than the filter itself. Backflow valve sizing was analyzed to determine if there was any way to define a standard that would require larger, lower head loss valves for filters.

Measure 5 - Controls for Use with Off-Peak Operations and Demand Response

Shifting pool equipment operation off peak is purely a demand response measure applicable only to residential pools. We estimated the number of pools impacted by this measure at eighty percent. The demand profile for the pool pump was taken from the ADM Study in 2001. We assumed that solar heating collectors are used in nearly 12% of all residential California pools (CEC RASS, 2004[1]) and are operated on the swing seasons during on-peak hours. For the case of our analysis, on peak is established as noon until 6 p.m. for all of California. Table 10 below shows the dates assumed for swing season operation of solar heating collectors.

[1] Communications with P.K. Data indicate that a conservative estimate for Southern California is 8%. A 1994 PG&E Residential Energy Survey states that PG&E territory pools have about 16% of solar pool heating collectors. Pool wholesalers estimated that approximately 10% of their market purchases are for solar heating. The CEC Residential Appliance Saturation Study reports similar percentages for solar heated pools at a total of 11.7% for all reported single-family residential swimming pools and is the source for this analysis.

Table 10. Definition of swimming seasons.

Swing Season (32% of on-peak demand remaining)
April 1 - May 30
September 1 - October 31

Swimming Season (20% of on-peak demand remaining)
June 1 - August 31

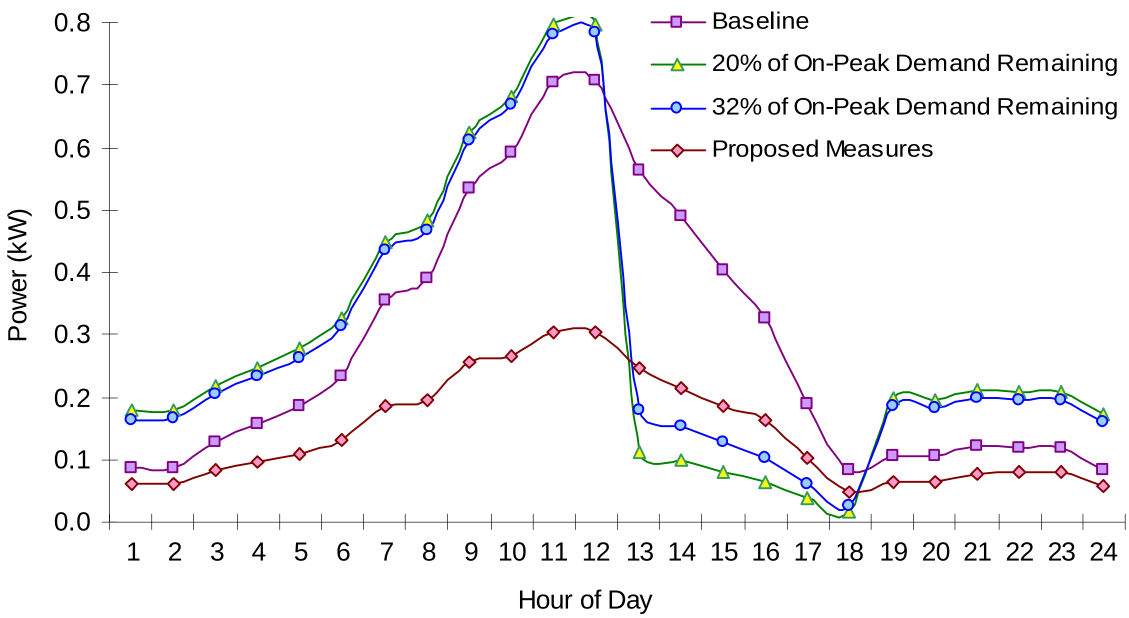

Figure 9. Baseline residential pump demand profile showing adjustments for on-peak operations and proposed design measures.

To calculate the demand response savings, the top 50 hours with the highest TDV values were established for the 16 Climate Zones in California. The loads were not shifted in the analysis but simply eliminated for those highest 50 values, in accordance with studies that show health standards are not compromised if filtration circulation is reduced for up to six hours given proper filtration and circulation of chemicals before and after the interruption (ECOS, 2006). The savings from eliminating the top 50 TDV values were then weighted according to RASS pool saturation data by each climate zone. The pump demand curve for the baseline load was the same as that used for the off-peak operations analysis from the ADM Study in 2001.

Measure 6 - Pool Covers

Pool covers reduce the amount of debris that fall into the pool thereby reducing the need for cleaning and filtration to 50% or less than standard practice (ECOS, 2006). However, pool covers do not alter the need for chemical distribution, another service that filtration provides. They do reduce the need for chemicals by reducing evaporation. The analysis for the impact of pool cover usage involved varying run times for the pool pump in the basic model.

Methodology for the Total Measure Savings

Since the individual measures affect each other, the overall savings is not cumulative. Therefore, to represent the range of existing pool building practice, four pool designs were created to compare the synergistic impact of all the measures. The four designs are shown in Table 11 and range from one design that exceeds the proposed standards though not by much, and a lowest first-cost, below average design. Annual energy use was estimated for each design using the pool model. Market weightings were assigned so that the average weighted energy use matched the averaged pool energy use for California. This does not included savings due to backwash valves and straight run pipes.

Table 11. Representative Pool Designs.

Design Parameter	*Design 1: Above average design*[2]	*Design 2: Average design*	*Design 3: Below average design*	*Design 4: Far below average design*
Return Pipe size:	2"	1.5"	1.25"	1"
Return Pipe length:	50 feet	50 feet	50 feet	50 feet
Fittings in Return:	8 '90s, 1 Tee, 2 eyeballs (in parallel)	8 '90s, 1 Tee, 2 eyeballs (in parallel)	10 '90s, 1 Tee, 2 eyeballs (in parallel)	12 '90s, 1 Tee, 2 eyeballs (in parallel)
Suction Pipe size:	2.5"	2"	1.5"	1.5"
Suction Pipe length:	50 feet	50 feet	50 feet	50 feet
Fittings in Suction line:	4 '90s, 1 Valve, 1 Tee	4 '90s, 1 Valve, 1 Tee	5 '90s, 1 Valve, 1 Tee	6 '90s, 1 Valve, 1 Tee
Filter:	315 sqft Cartridge	150 sqft Cartridge	150 sqft Cartridge	150 sqft Cartridge
Pump size (single-speed):	½ HP[3]	1.5 hp (1.15 SF)	1.5 hp (1.65 SF)	1.5 hp (1.65 SF)
Turnover time:	6.0 hours	4.5 hours	5.2 hours	8.4 hours
Filtration flow rate:	56.1 gpm	73.7 gpm	64.0 gpm	39.9 gpm

The base case models presented below assume a volume of 20,000 gallons and a pool cleaner separate from the filter pump. Heating system energy use was not analyzed in this CASE project, but head losses through a heater were accounted for. The same heater was used for all models. Pool cleaners, controls, and pool covers were not modeled and their use was assumed constant across the pool designs.

Results

The following sections detail the results of the analysis performed both for the individual measures, as well as for the aggregate model that combines the measures.

Some general statistics and assumptions underlie all of the calculations for all of the measures. Approximately 34,387 in ground pools and 9,237 above ground pools were installed in 2005 (PK Data, 2006). Because above ground pools are purchased and installed by a homeowner, it was assumed that none of the above ground pools applies for a permit. All in-ground pools were estimated to go through the permitting process. The amount of pools that apply for permits is not derived from the California Pool Report by P.K. Data but by communications with stakeholders.

[2] The above average design of current practice is the same as an equivalent pool that would employ all the proposed design measures as presented in this CASE Study. This pool design meets the proposed code changes.

[3] The horsepower for the ½ hp pump was unknown. This pump was the best fit for the pool design with available pump curves, including power curves.

Table 12. Quantities of pool types used in the analyses (P.K. Data 2006).

Pool type	Existing	Growth for 2005	Permitted %	Permitted #
In Ground	1,059,637	34,387	100%	34,387
Above Ground	341,661	9,237	0%	0

Because of the lack of a permitting process for equipment repairs and retrofits in most jurisdictions, it is unlikely that Title 24 standards would be enforceable for retrofits. This is unfortunate since, based on a 10-year equipment life approximately 10% of the existing 1,059,637 in-ground and 341,661 above-ground pools will get new equipment each year. The Title 20 Appliance Efficiency measures, which regulate the efficiency and motor control designs, will have much more of an affect than any Title 24 measures until a mandatory permitting process exists, as it does for building retrofits and remodels. Savings from retrofits will be ignored for this study.

Energy and Cost Savings

Measure 1 - Reference T20 Motor Efficiencies

The Title 20 CASE study recommends restricting pump motor types by forbidding Cap-Start/Induction-Run and Split Phase motors. Table 13 shows a comparison of typical efficiencies for different motor types:

Table 13. Motor types and efficiencies typically used in pool pumps.

Type	Efficiency Range (%)
Split Phase	25 – 45
Capacitor Start Induction Run	40 – 55
Permanent Split Capacitor	45 – 60
Capacitor Start Capacitor Run	55 – 75

Source: (Eliot 2007)

The Title 20 study estimated the savings from this measure to be 10% of energy use. With the average energy consumption at approximately 2600 kWh/yr for a pool, this would mean an annual savings of 260 kWh per pool.

Title 24 will reflect the most current Appliance Standard regarding pool pumps and enforce it through this measure.

Measure 2 - Low Speed Default Filtration

Fifty-five percent of the pools surveyed in 2001 had less than one horsepower pumps (ADM 2001). The ADM study did not account for service factors resulting in unknown total horsepower. Using a standard pool design, the savings from using the appropriate sized pump over a standard 1.5 HP pump was approximately 31 GWh.

For a two-speed pump with low speed default filtration, 38% to 65% energy savings and 71% to 73% demand savings were realized in the testing for the Title 20 report. About 45% of the pools investigated in the 2001 Study (4,910 pool owners in sample) fall in the category of 1 HP or above and therefore require a multi-speed pump. Extrapolating these results to the State level, the low-speed default filtration measure has the potential to reduce pool energy use by 17.0 to 29.1 GWh.

Measure 3 - Pipe Design

Pipe Sizing

Specifying pipe diameters that limit return and suction velocity to 8 and 6 fps respectively dramatically reduces system TDH. Table 14 shows the pipes sizes required for each flow rate range in order to maintain pipe velocities below the 8 and 6 fps limits.

Table 14. Minimum Pipe diameters required to meet pipe velocity limits.

Flow rate (high speed if multi-speed pump)	*Pipe Diameter*	
	Return	*Suction*
up to 23 gpm	1	1.25
24 to 33 gpm	1.25	1.5
34 to 59 gpm	1.5	2
60 to 92 gpm	2	2.5
93 to 132 gpm	2.5	3
133 to 235 gpm	3	4
236 to 367 gpm	4	5

Simulations were run for return/suction pipes of both 1.5"/2" (for 34 to 59 gpm range) and 2"/2.5" (for 60 to 92 gpm range) diameters to compare current practice with the proposed pipe-sizing requirement. These two systems were run with the standard 1.5HP pump. Results are presented in Table 15.

Table 15. Energy savings for increase in pipe size.

Pool	*Return Size (in.)*	*Suction Size (in.)*	*Flow (gpm)*	*Power (watts)*	*Turnover Time (hours)*	*Energy Use (kWh/year)*
Current	1.5"	2.0"	74	1646	4.5	2725
Proposed	2.0"	2.5"	88	1674	3.8	2322
Savings						403

The practice of lowering the pipe velocity to 8 and 6 fps yields approximately a 14.8% savings over current practice. These savings, while significant, do not include the added savings possible from pump downsizing. (These savings are more clearly demonstrated in the Total Measure Savings section at the end of the Results).

Straight Pipe Run at Pump

The trend nowadays is towards smaller and smaller equipment pads, which leads to current practices of having elbows or tees too close to the suction side of the pump. This proposed measure could result in energy savings in the range of 4 to 28%, or 104 – 728 kWh per pool annually, according to savings provided by pool professionals.

Efficient Pipe Fittings

Simulations using different fittings on each of the designs show that the energy impact of fitting type increases as pipe size is reduced. The types of fittings studied are shown in Figure 10: A) 90° elbows (standard practice), B) short radius sweep elbows, C) long radius sweep elbows, D) two 45s to form a 90° bend, and E) two 45s to form a jog.

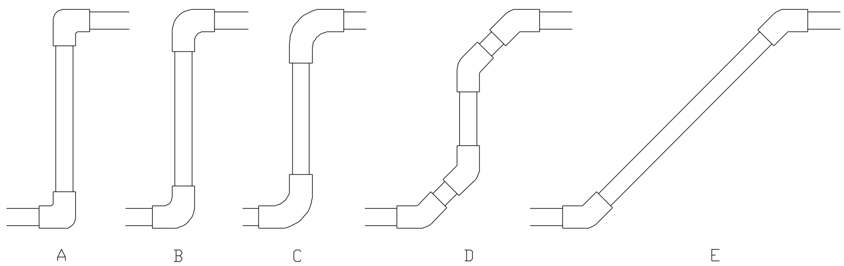

Figure 10. Views of fittings and combinations.

Table 16 compares the fitting head loss and system TDH for each of the various fittings and practices. When compared to the hard 90° elbows, the short and long radius elbows show 14 and 35% reduction in head, respectively. Using two 45s to form a 90° bend yields very little savings (5%) and raises quality issues as it doubles the number of glue joints. The use of a 45° elbow in place of a 90° yields a 53% reduction in head loss, but this practice is rarely possible and thus cannot be used throughout a pool system. The systems accounted for 8 elbows in the return side and 4 in the suction side. The last two columns show the system TDH and percentage reduction in system TDH at 60gpm for each of the designs compared to the hard 90° elbows.

Table 16. Effect of Fitting Type on System Head.

Figure 10 View	*Fitting Type*	*% Reduction in Fitting Head Over Hard 90°*	*System TDH at 60gpm (feet)*	*System Savings*
A	Hard 90	0%	31.2	
B	Short Radius Sweep Elbows	14%	29.8	4.4%
C	Long Radius Sweep Elbows	35%	28.0	10.4%
D	Doubled 45s to turn 90°	5%	30.4	2.8%
E *	Single 45s used in place of 90°	53%	N/A	N/A

* The reduction in head for using a single 45 in place of a 90 is shown here only to compare single fitting reductions. In practice, where a 90° is needed, a 45° elbow will not suffice without proficient planning. It is not applicable (NA) to show system savings for the E scenario.

Using the standard pool design, the percent savings were calculated for using short and long radius sweep elbows in place of typical hard 90° elbows, as well as the practice of using doubled 45° elbows. Table 17 shows the savings realized:

Table 17. Various fittings compared to traditional hard 90° elbows and their savings.

Fitting	*Power (watts)*	*Flow (gpm)*	*Turnover Time (hours)*	*Energy Use (kWh/year)*	*Energy Savings (kWh/year)*	*% Energy Savings*
hard 90's	1646	73.5	4.54	2725		
short radius 90's	1649	74.5	4.47	2693	32	1.2%
long radius 90's	1654	75.8	4.40	2654	71	2.6%
double 45's	1648	74.1	4.50	2706	19	0.7%

As Table 17 shows, the actual energy savings from simply switching out the hard 90s for sweeps or double 45s are rather low. However, like other measures, the reduced TDH from mandating sweep elbows can be combined with other measures for a synergistic effect overall reducing the TDH of the system and enabling the builder to choose a smaller pump.

Measure 4 - Filter Sizing & Selection

Three types of filters were studied for this report, including cartridge, diatomaceous earth (DE), and sand. Most manufacturers offer all three types. DE and Sand filters require backwashing that is most often accomplished using a backwash multi-port valve (MPV). A system of four valves could also serve for backwashing at significantly lower head loss, but it is more complicated for pool owners to operate and is therefore rarely used.

Head losses due to filters vary greatly due to the different types of filters and the need for backwash valves on DE and sand filters. Table 18 shows the vast difference in head loss between the different filter types. Approximately ten different filters were analyzed for each size yielding the resulting range.

Table 18. Head losses for clean and dirty filters at 60 gpm.

*Filter Types**	*Head Loss for Clean Filter (ft of H2O)*		
	Min	Avg	Max
Cartridge	1.5	2.3	3.5
Sand *	15.0	20.4	29.3
DE *	13.6	17.3	21.8

* DE and sand filter values include head loss contributions from a 2" MPV valve.

The practice of installing too small a cartridge filter for the system to reduce first cost is a concern for about 20 percent of new pools. Undersized filters can cause initial head losses as well as increased head losses over time as the filter loads up. Manufacturers recommend between 0.25 and 0.50 gpm per sq ft of cartridge filter area. Table 19 shows the analysis results comparing undersized and right-sized cartridge filters:

Table 19. Comparisonof undersized and oversized cartridge filters.

Area (sqft)	*Power (watts)*	*Flow (gpm)*	*Turnover Time (hours)*	*Energy Use (kWh/year)*	*Energy Savings (kWh/year)*	
150	1646	73.6	4.5	2722		
315	1647	74.0	4.5	2709	13	0.5%

Note that while savings for the larger cartridge filter may be small, the contribution to the system savings is substantial. Moreover, the savings in a larger cartridge filter cannot truly be shown in these analyses evaluating clean filter simulations. Major savings from a larger filter come from slower loading of the cartridges and the resulting greater number of days operated in a clean condition

Next, we present energy savings for right sizing of backwash valves. Table 20 shows the energy savings for various valves. Analyses comparing the performances of two diameters of valves are shown, as well as a high flow and a slide type backwash valve. High flow valve's are designed for better performance while maintaining operational ease. Slide type valve's have the most savings.

Table 20. Comparison of multi-port valves.

Size / Type	*Power (watts)*	*Flow (gpm)*	*Turnover Time (hours)*	*Energy Use (kWh/year)*	*Energy Savings (kWh/year)*	
1.5"	1592	62.4	5.3	3104.1		
2"	1605	64.8	5.1	3013.5	90.6	3.3%
High Flow	1617	66.8	5.0	2944.2	159.8	5.9%
Slide	1620	67.5	4.9	2920.7	183.3	6.7%

While the table shows that the type of filter makes a larger contribution to savings than the size, the easiest way at this time to enforce efficient backwash valves is to restrict them to be no smaller than the filtration piping or a 2"valve diameter, whichever is larger.

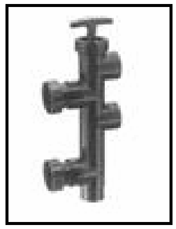

Figure 11. Filter Backwash Valves (a typical Multi-Port Valve on the left and a slide valve on the right).

Measure 5 - Controls for Use with Off-Peak Operations and Demand Response

Pump controls capable of off-peak operation are mandated by existing Title 24 (114(b)(3)), and are included on the MF-1R Residential Compliance form. Off-peak operation has the obvious benefit of reducing peak power demand.

Solar heating is coincident with peak operations during the swing seasons. Peak operations are defined as May through October and noon through 6 pm for most utilities. As such, solar heating systems are included in the analysis of off-peak operations since most are operated through the filter system pump.

Costs are derived from the CEC Time Dependent Valuation (TDV) values on a 2006 dollar per kilo-watt hour value. Potential peak demand reduction is shown in Table 21:

Table 21. Reduced on-peak operations savings per pool for baseline demand curve and demand curve adjusted for off peak operation..

	Baseline	*Proposed*
Without decreased On-Peak Operations	$6,240	$3,068
Decreased on-peak operations	$5,651	$2,792
Savings	$589	$276

The impact per household from demand response is demonstrated in Table 22:

Table 22. Average demand response savings per pool.

	*Base Case**	*Base Case Pool* with Off-Peak Operation*	*Proposed Design Measures*	*Proposed Design Measures with Off Peak Operations*
No Demand Response	$6,240	$5,651	$3,068	$2,792
With Demand Response	$5,935	$5,565	$2,925	$2,752
Savings	$305	$87	$144	$40

*Base Case Pool is Pool Design 2, the demand curve used here is the ADM 2001 baseline demand curve.

Adding the demand response savings together with off-peak operation, could lead to $676 in annual demand savings per pool alone – that is, without any design measures applied. Apply $676 to the existing pools, which are over 1 million as shown in Table 12, and demand savings could be up to $716 million . There are also $305 savings per pool in the existing pools and if demand response measures are applied to each there could be TDV savings of up to

$323 million. In new construction pools with the proposed designs all ready applied, savings from demand response results in $144 per pool or $4.95 million for all of California. As described in the Methodology Section, the demand response savings are derived from eliminating pool filtering during the top 50 TDV hours of the year.

Measure 6 - Pool Covers

The language regarding pool covers will stay the same, but the Compliance Form will ensure that the cover is left for the owner to use by requiring an installed cover. An installed cover ensures use, even if just the initial use, and prevents the same unopened box from being used in another inspection. Studies indicate savings greater than 50 % percent savings (FAU, ECOS) but the standard that exists for pool covers has not been enforced effectively. Potential savings of 50% amount to 56.6 GWh.

Research yielded repeated claims to several non-energy related savings and one energy-related measure in the form of reduced need for filtration and cleaning. An extensive study would need to be undertaken to determine how many pool owners would actually use their pool covers and how often.

Results for Total Measure Savings

Four pool designs were created to represent the different levels of quality of pool designs. Energy savings were calculated for the four models using the same methodology as for the individual measures, by calculating annual energy use for each pool and assuming a single turnover per day.

Figure 12 below shows the system curves for the 4 designs, the pump curves for the 3 pumps specified, and the operating points that were chosen for the evaluation. As the graph shows, the system curves flatten out as the TDH of the pool is reduced.

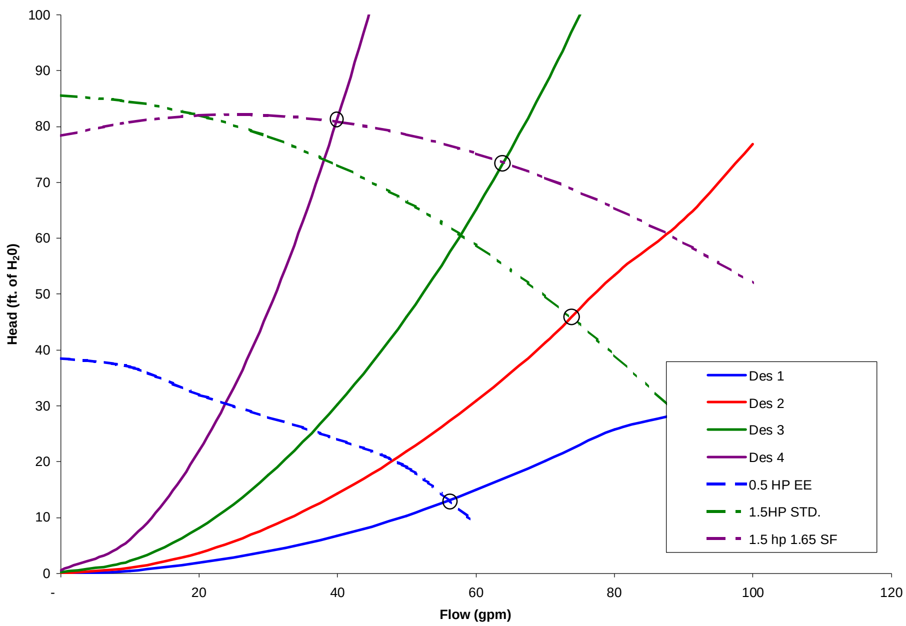

Figure 12. Various pool designs represented by four system curves and the pump curves.

When evaluating two system curves with the same pump, as is the case for Designs 3 and 4, the lower head design results in a higher flow rate, and therefore a higher energy use for the same run time. However, if the run time is adjusted to keep the turnovers the same, the lower TDH curve consumes less energy (a 27% energy reduction from Design 4 to 3). This principle was used to show the savings for the individual measures in the first part of this section. The advantages of lowering filtration flow rates, using larger pipes and choosing smaller pumps are clearly shown with the comparison of Designs 1 and 2 with 3 and 4. As the designs trend towards Design 1 (proposed measures), the savings become apparent. The kWh/year column in Table 23 below shows a 79% savings of Design 1 over Design 4, a 72% savings over Design 3, and a 65% savings over Design 2.

Table 23. Summary of energy savings.

	Flow (gpm)	*Power (W)*	*Turnover Time (hours)*	*Pool Energy Use (kWh)*		*Populat'n Wt.**	*# of pools*	*delta kWh*	*Savings (MWh/year)*
				daily	*annual*				
Des 1	56.1	445	5.9	2.6	965	20%	6,970		
Des 2	73.7	1649	4.5	7.5	2,722	60%	20,909	1,757	36,740
Des 3	64.0	1779	5.2	9.3	3,382	13%	4,530	2,417	10,949
Des 4	39.9	1512	8.4	12.6	4,611	7%	2,439	3,645	8,893
Total Savings									56,583

* This represents the number of pools estimated to perform at this level of design.

Pool industry experts were then consulted as to how the pools being built could be broken down by the different designs. These weighting values (Population Weight column in Table 23) were then used to determine total savings. From these calculations, it was estimated that the proposed measures could produce a reduction of 50% of the annual new pool energy consumption for the state, or 56.6 GWh. This represents an average annual energy savings per pool of 1,623 kWh (based on the current average energy consumption of 2588 kWh). Using the worse case scenario of all pools running in filtration during peak hours, the maximum demand reduction for new pools could reach 57%, or 31.6 MW.

Table 24 shows the pipe sizes and velocities in both the return and suction lines of the four pool designs that we have modeled (pipe sizes were recommended by pool professionals based on what they had seen in the field). Notice that none of the designs have velocities in both pipes that meet the current standards recommendations with the exception of Design 1. Design 1 was created using the pipe flow and sizing recommended by the pool industry.

Table 24. Comparison of designs for pipe velocities.

	Return Diameter (in.)	*Suction Diameter (in.)*	*Flow (gpm)*	*Return Velocity (fps)*	*Suction Velocity (fps)*
Design 1	2	2.5	56.1	5.7	3.7
Design 2	1.5	2	73.7	13.4	7.5
Design 3	1.25	1.5	64.0	16.7	11.6
Design 4	1	1.5	39.9	16.3	7.2

The high velocities raise the head contribution of the pipes and fittings, as can be seen in Figure 13. The total head for Design 1 is 25% of the total head of Design 4. The pipes and fittings contribute 95% of the 80 feet of head for Design 4 mostly due to the pipes, where with Design 1, pipes and fittings contribute only 61% of the 20 feet of head, with the remainder mostly due to the heater. In the below average pool designs, pipe size is responsible for 87 to 95% of the head of the system. Notice that in all systems, the filter contribution to head loss is relatively low due to the selection of cartridge filters over sand or DE filters. With sand or DE filters, a backwash valve would have added substantial head loss to the system.

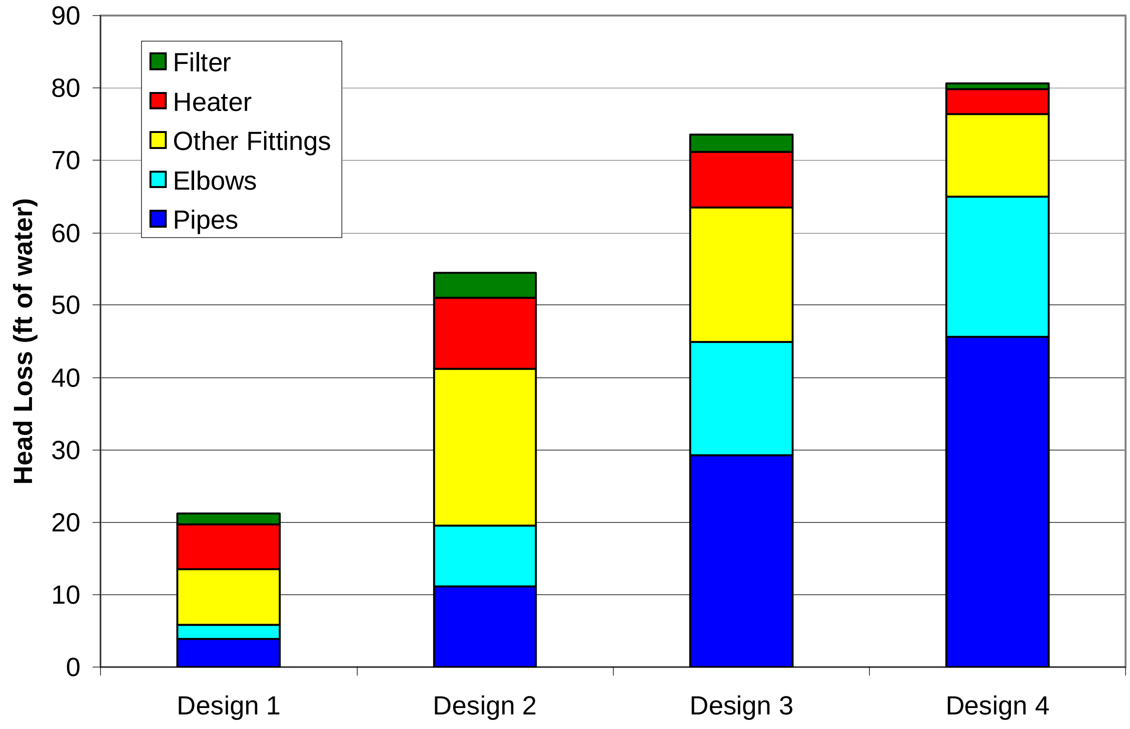

Figure 13. Total system head broken down by system component.

A closer look at the average design (Design 2) and the pool designed to the proposed measures (Design 1) in Figure 14 shows the significant contribution of pipes and fittings to the higher head systems. Even with the below average designs ignored, the upsizing of the pipes to the larger diameter to bring the velocities down to 6 and 8 fps reduces the head of the system at 60gpm by more than 50%.

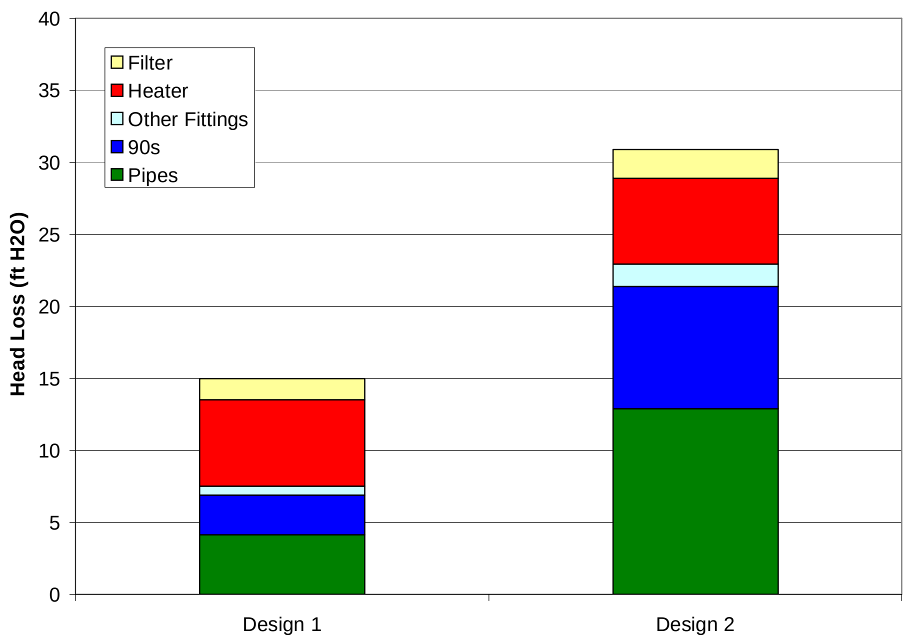

Figure 14. Total system head and breakdown by component between the average design (Design 2) and the proposed measures design (Design 1).

The measures proposed are targeted at bringing current pool construction in line with good pool design practices put forth by the pool industry in their standards. In enforcing the principles of these standards, California has the potential to reduce new pool energy use by approximately 50% and demand by up to 57%.

Cost-effectiveness

Net present value of energy savings per pool is estimated at $910 and the incremental life cycle cost for the equipment is $79 resulting in a life cycle cost savings of $831 and a benefit to cost ratio of 11.5 to 1.

The cost effectiveness estimates are based upon the incremental costs of the proposed design measures compared to the average design. Any increased costs due to inspector or outside contractor verifications are not included. The following assumptions were used in calculating the incremental life cycle equipment cost:

- the first year incremental cost of the design measures is estimated to be approximately $173;
- the pool and its pipes, pipe fittings will have to be replaced in 30 years;
- the filter (and any backwash valve) will be replaced in 15 years; and,
- the pump and motor will be replaced every 10 years.

Table 25. Cost Analysis for Aggregate Design

Design Parameter	*Design 1* *Above average design*	*Design 2* *Average design*	*Incremental Cost**
Turnover time:	6.9 hours	5.29 hours	n/a
Filtration flow rate:	48 gpm	63 gpm	n/a
Time operated:	7 hours	4.2 hours**	n/a
Return Pipe size (inches)	2”	1.5”	
Return Pipe length (feet)	50	50	$14
Fittings in Return	8 '90s, 1 Tee, 2 eyeballs (in parallel)	8 '90s, 1 Tee, 2 eyeballs (in parallel)	$37
Suction Pipe size	2.5"	2"	
Suction Pipe length (feet)	50	50	$42
Fittings in Suction line:	4 '90s, 1 Ball Valve, 1 Tee	4 '90s, 1 Ball Valve, 1 Tee	$30
Filter type:	Cartridge 315 sq ft	Cartridge 150 sq ft	$395
Pump type:	Single Speed	Single Speed	
Pump size:	½ HP or 0.95 T-hp	1.5 hp or 2.2 T-hp	($439)
		TOTAL EXTRA COST:	$79

* Incremental Costs are discounted over the life of the pool. Pipes and fittings are assumed to last for the pool life and the incremental cost for filter and pumps reflects additions over their life. Costs and savings associated with flow rate and filtration run time are not included here as they are included in the calculation of energy savings.

** Average operating time as calculated in the ADM Study. Optimal Technologies survey also found the average time to be 4.3 hours.

The annual savings of 1624 kWh per pool result in almost $910 of savings using the 2008 lifecycle multiplier for 30 years. These costs account for a purchase of two replacements pumps and one filter. The discount rate is 3 percent.

The incremental costs as show in Table 25 are from retail prices. The savings for the final analysis of Design 2, the average pool design, were used and then compared to Design 1, the pool with the proposed design measures applied. Annual savings of 1623 kWh (5538 kBtu) were multiplied by the 2008 Lifecycle Multiplier of $0.1641705 per kBtu to estimate $910 of savings per pool.

Emissions Savings

Emissions savings were calculated using the baseline demand curve from ADM Study (2001). To simulate how the proposed measures might affect the demand curve the peak was reduced nearly 60% and the overall energy consumption of the curve was maintained while reduced 50% from the findings of our proposed design measures. Demand Response savings were not analyzed for emissions as they were out of the scope of this study.

Table 26. First year reduction in emissions without proposed design measures.

	NO_x (lbs)	PM-10 (lbs)	CO_2 (tons)
Proposed Design Measures	4616	2759	20554
Off-peak operations - Baseline Reductions	553	115	1139

Table 27. First year reduction in emissions including design measures and applying off-peak operations.

NO_x (lbs)	PM-10 (lbs)	CO_2 (tons)
262	55	540

Table 28. Reduction in emissions costs (using 30 year prices).

	NO_x	PM-10	CO_2
Off-Peak Operations on Base Case Model	$5,681	$3,724	$14,712
Proposed Measures	$47,400	$89,012	$265,467
Off-Peak Operations with Proposed Measures	$2,691	$1,764	$6,969

Statewide Energy Savings

Savings are calculated using the weighted averages of all the designs, used to represent current building practices, and Design 1, the aggregate of the design measures.

Building Category	*# of new construction*	*Energy Savings per pool*	*Demand Reduction per pool*	*Total Energy Savings*	*Total Demand Reduction*
1st year New Pools	34,849	1,623 kWh	907 W	56.6 GW	31.6 MW

Recommendations

Although it was mentioned earlier that analysis of heating systems and natural gas conservation are not presented in this study, it is noteworthy to state that solar heating panels are a viable and efficient means for heating water while conserving natural gas. The measures and their cost effectiveness presented herein are analyzed so as not to hinder any benefit from solar heating. Off-peak savings include considerations for on-peak operations of solar pool heating collectors. Another consideration of solar heating using collectors is the caveat that multi-speed pumps are allowed to operate at a higher speed, to allow for automatic cleaners and to overcome any static pressure associated with solar collectors, and then switch to low-speed default filtration.

The measures we are proposing encompass nearly all of the mechanical design criteria for the basic pool and allow for expansions of the design to a pool with multiple water features, various heating types, and different cleaning approaches. Appropriate filter sizing and pipe design are particularly important in lowering system TDH. With lower TDH, a smaller size pump may be selected thereby decreasing the pump's power draw. All the appropriate equipment selections are based on establishing flow rates.

Design flow rates are based on the pool volume and turnover time and therefore correct estimation of the pool volume is essential. Pool surface area is readily available as pools are priced according to their area, but volume is more difficult to obtain accurately. A consistent system for estimating the average pool depth should be established to determine the volume accurately.

The recommended measures are broken down into two categories; Design Measures and Operational Measures. Measures 1-4 pertain to design and Measures 5 and 6 address operational measures.

Design Issue Recommendations

The design issue measures refer to and utilize the Title 20 Appliance Standards where they apply to pool mechanical systems. The following is a list of the recommendations based on the results of our research.

Measure 1 – Pump Energy Efficiency 114(b)1(a)

We recommend that any Title 20 Standards regarding motor efficiency apply to Title 24 Building Standards for the construction of new pools. The Title 20 Table V requires that pool pump manufacturers list information on the pump that is also required for the compliance form. Enforcement of energy efficiency requirements will involve confirming that the motor is listed with the CEC and that it is of the correct type.

Measure 2 – Low Speed Default Filtration and Multi-speed Pumps 114(b) 1.

We recommend that the designer and the enforcement official verify that multiple speed pumps (or multiple pumps) are being used for multiple loads. Multiple speed pumps may still be used for single use applications, but pools with spas, waterfalls, fountains, or similar features that create a higher load for filtering must not use a single speed pump or a single pump.

The Title 20 Pool Pump study demonstrated the potential savings that could be achieved with lower speed filtration. The pump affinity laws demonstrate the potential savings for reducing pump flow rate and increasing run time to maintain the same number of turnovers. We recommend limiting the flow rate to that of a 6-hour turnover, whether a fractional horsepower, single speed motor, or a multi-speed motor is used. The method of enforcing this requirement is explained for each of the motor types.

For a single speed pump, the designer would chose a pump with a listed flow below the "Max Pump Flow" found on "Table 1. Pool Inspection Table" in the Compliance Form. With multi-speed pumps, the designer would go to CEC list and choose a pump with a LOW SPEED flow rate that is less than the "Max Pump Flow" found on Table 1. For variable speed pumps the set filter flow rate or programmed flow rate must be less than the "Max Pump Flow" found on Table 1. In all cases, Table 1 states the appropriate “Pump Curve” necessary to get the “Max Pump Flow” based on the size of the pool.

We recommend that any pump installed in a California residential pool be able to operate at 2 or more speeds if it is 1 hp or greater, as stated in the Title 20 Appliance Standards for purchasing in California. This recommendation is included in the enforcement form.

Measure 3: Pipe Design and Efficient Pipe Fittings 114(b)2.

We recommend maintaining the existing requirement of 36” of straight pipe between the filter and the heater for a future solar heating system.

We recommend that a minimum of 4 pipe diameters of straight pipe be required on the suction side of the pump to prevent cavitation. Table 2, labeled “Pipe Leading Straight Lengths,” on the Compliance Form is included on the enforcement document for easy reference.

We recommend that the industry recommendation of maximum velocities in pipes be enforced by using Table 1 on the Compliance Form.

We recommend requiring that 90° fittings be short or long radius sweep ells.

We recommend that the existing Title 24 requirement of directional inlets be maintained in the new code language and enforcement instrument.

Measure 4: Filter Sizing and Selection 114(b)3.

We recommend that filters be sized and selected to industry standards. These standards recommend a maximum flow rate per area of media. The appropriate minimum filter media size is found in Table 1.We recommend that backwash valve diameters be restricted to be no smaller than the return piping or 2”, whichever is larger.

Operational Measures

Measure 5: Controls

Off-peak operations and demand response measures, although analyzed and shown to have considerable potential in saving energy, were not presented as proposed measures after deliberations with stakeholders and issues of enforcement. At this point in time, operational measures to save energy are maintained as the pool industry responsibility to educate customers of the potential. Incentives and educational classes for both customers and pool industry professionals will definitely help in dispelling myths and encouraging proper pool design. The pool industry is on its way to training its professionals with the newly instituted Foundation for Pool and Spa Industry Education (FPSIE). Utilities also have customer awareness programs for swimming pool operations. It is also difficult to differentiate at this time between a pool that is lightly filtering to maintain cleanliness and a pool that is heavily used which could require more filtration, especially vital during peak and partial peak periods which coincide with most heavy swimming loads.

Correct use of pool controls can lower both annual energy use and peak demand. Controls capable of operating multi-speed pumps can provide good cleaning and filtration at lower energy consumption during peak hours. Such controls could also permit solar pool collectors to operate at lower speeds during peak hours potentially adding to the savings found from our off-peak operations analysis. Controls with the simplest demand response capability (power on or off) have shown considerable customer savings potential with no known risk to health standards.

Our current recommendation is to bring the Title 20 requirement that pump controls be capable of multiple speeds and timed operations over to the Title 24 documents.

Measure 6: Pool Covers

We recommend that the current requirement that heated pools have a cover at the time of inspection be maintained for all heated pools. Considering the potential for energy and water savings from even the simplest bubble type cover, and the reduction in chemicals needed, we recommend that the utilities and industry educate pool owners to the advantages of using the covers. If a performance method of evaluating pools is instituted in the future, we recommend that the pool covers (particularly automatic ones) be used as credit against other features.

Future Studies and Recommendations

Further studies on pool cover use are needed, primarily with reference to how covers directly affect filtration. Pool cover studies can prove useful with a performance manual to propose covers as a performance method rather than a mandatory measure, especially for automatic or built in covers. In addition, studies that demonstrate effective filter time and optimum cleaning would answer many questions, may curb common incorrect filtration methods practiced today, and possibly make filtration more efficient. More research in the arena of filtering procedures, operational times, and synergistic filtering and cleaning should also prove useful for energy savings.

Informal studies have been performed to demonstrate that one of the most popular cleaner styles, pressure side cleaners that typically use booster pumps, can benefit from decreased blow-off when used in a pool designed as outlined in this report. It is our recommendation that after pools are built according to these standards presented herein, automatic pool cleaners be investigated through the appliances standards. Data characterizing filter head and flow are also needed. We further recommend better testing and listing for all pool components that contribute to the TDH.

Because a pool has the capacity to double the energy consumption of a property, we recommend a study to explore the possibility of a future performance model for pool designs. In its aim to bring the overall energy consumption of the State down, perhaps the Title 24 standards may trend towards looking at entire property energy consumption, instead of just building energy consumption.

Proposed Residential Standards Language

SECTION 114 – MANDATORY REQUIREMENTS FOR POOL AND SPA ~~HEATING~~ SYSTEMS AND EQUIPMENT

(a) **Certification by Manufacturers**. Any pool or spa heating system or equipment may be installed only if the manufacturer has certified that the system or equipment has all of the following:

1. **Efficiency**. A thermal efficiency that complies with the Appliance Efficiency Regulations; and
2. **On-off switch**. A readily accessible on-off switch, mounted on the outside of the heater that allows shutting off the heater without adjusting the thermostat setting; and
3. **Instructions**. A permanent, easily readable, and weatherproof plate or card that gives instruction for the energy efficient operation of the pool or spa and for the proper care of pool or spa water when a cover is used; and
4. **Electric resistance heating**. No electric resistance heating; and

   EXCEPTION 1 to Section 114 (a) 4: Listed package units with fully insulated enclosures, and with tight-fitting covers that are insulated to at least R-6.

   EXCEPTION 2 to Section 114 (a) 4: Pools or spas deriving at least 60 percent of the annual heating energy from site solar energy or recovered energy.
5. **Pilot light**. No pilot light.

(b) **Installation**. Any pool or spa ~~heating~~ system or equipment shall be installed with all of the following:

1. Pump sizing and flow rate.

   Any pump shall be installed to meet the following:

   i. All pumps shall comply with the Appliance Efficiency Regulations; and

   ii. Each load, such as circulation, water falls and fountains, water slides, solar pool heating system, and filtration systems, shall be served by separate pumps or by a multistage pump capable of varying speed with different loadings; and

   iii. Circulation pumps shall be sized so the filtration flow rate is not greater than the rate needed to turnover the pool water volume in six hours; and

   iv. Pump motors used for circulation with a capacity of one horsepower or more shall have the capability of operating at two or more speeds and with the lowest speed shall be no more than one half of the motor's maximum rotation rate; and

   v. Multi-speed or variable speed pumps shall have controls that are preprogrammed to default to the lowest speed; and

   vi. For multi-speed or variable speed pumps, the controls shall be capable of being programmed to return to the default lowest speed setting within two to twenty four hours and shall have an override capability.

   EXCEPTION to Section 114(b)1: Variable-speed pumps shall be preprogrammed so the filtration flow rate is not greater than the rate needed to turnover the pool water volume in six hours.

2~~1~~. **System piping**.

Any pool piping system shall be installed to meet the following

   i. At least 36 inches of pipe shall be installed between the filter and the heater to allow for the future addition of solar heating equipment; and

   ii. A length of straight pipe that is greater than or equal to at least 4 pipe diameters shall be installed before the pump; and

   iii. Pool piping shall be sized so that the velocity of the water does not exceed eight feet per second in the return line and six feet per second in the suction line; and

   iv. All elbows shall be sweep elbows; and

   v. The pool shall have directional inlets that adequately mix the water.

3. **Filtration equipment:** Pool filters shall be sized based on manufacturer's recommendations; and Multi-port valves size shall be two inches or the size of the return pipe, which ever is greater.

4. **Controls for pools:** The circulation pump shall have a time switch that allows the pump to run during only off-peak electric demand periods, and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

5~~2~~. **Covers**. A cover for heated outdoor pools or outdoor spas.

   ~~EXCEPTION to Section 114 (b) 2: Pools or spas deriving at least 60 percent of the annual heating energy from site solar energy or recovered energy.~~

~~3. Directional inlets and time switches for pools. If the system or equipment is for a pool:~~

   ~~i. The pool shall have directional inlets that adequately mix the pool water; and~~

   ~~ii. The circulation pump shall have a time switch that allows the pump to be set to run in the off-peak electric demand period, and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.~~

   ~~EXCEPTION to Section 114 (b) 3: Where applicable public health standards require on-peak operation.~~

Alternate Calculation Manual

The Alternate Calculation Manual is not affected by these measures. As these measures are proposed as mandatory measures, there is not necessarily a need to model swimming pools in the Alternative Compliance Method (ACM) performance software at this time.

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STA-RITE Commercial Pool/Spa Engineering Design Manual

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Appendix A: Performance Verification Checklists and Tables

Adapted from "Mandatory Measures Summary: Residential, Form MF-1R", page two of two.
Instructions: Check or initial applicable boxes when completed or check NA is not applicable.

DESCRIPTION	NA	Designer	Enforce-ment
§114(a): Pool and Spa Heating Systems and Equipment	ü	ü	ü
1. A thermal efficiency that complies with the Appliance Efficiency Regulations, on-off switch mounted outside of the heater, weatherproof operating instructions, no electric resistance heating and no pilot light.	o	o	o
2. Heater has an external on-off switch	o	o	o
3. There are weatherproof operating instructions with the heater.	o	o	o
4. Heating system is not electric resistance; or Exception 1: A listed package unit is being used that has fully insulated enclosures and tight fitting covers that are insulated to at least R-6. Exception 2: 60 percent of the annual heating energy is from site solar energy or recovered energy.	o	o	o
5. Heating system has no pilot light.	o	o	o
6. A cover is fitted and in place for heated outdoor pools and spas.	o	o	o
§114(b): Pool and Spa Mechanical Systems and Equipment			

Table 1. Pool Inspection Table

Max Pool Volume (gal)	Min Pipe D or greater (in)		Min Filter Area or more (sq.ft.)			Pump Curve	Max Pump Flow* (gpm)
	Return	Suction	Cartridge	Sand	DE		
13,000	1.5	1.5	100	2.4	20	A	36
17,000	1.5	2	130	3.1	25	A	47
21,000	2	2	160	3.9	30	C	58
28,000	2	2.5	210	5.2	40	C	78
42,000	2.5	3	320	7.8	60	C	117
48,000	3	3	360	8.9	70	C	133

*For pumps greater than 1 hp, the Max Pump Flow is the default filtration flow rate

	Designer	Enforce-ment
Calculated Volume of pool______________(gallons)		
Return Pipe Diameter: ____________(inches)	o	o
Suction Pipe Diameter:____________(inches)	o	o
Filter Type __________________(cartridge, sand, DE) Filter Surface Area:_________(sq.ft.)	o	o
Listed Pump Flow:___________ (gpm) on Curve ______(A or C)	o	o

DESCRIPTION	NA	Designer	Enforce-ment
§114(b): Pool and Spa Mechanical Systems and Equipment (continued)			
1. Pump sizing and flow rate specification.			
a. The pump specified is listed in the CEC database of certified pool pumps.		o	o
b. The pool has multiple pumps or a multi-speed pump to operate each multiple feature.	o	o	o
c. The pump is capable of operating at 2 or more speeds (check 'NA' if less than 1 hp).	o	o	o
2. System piping:			
a. At least 36" of pipe between filter and heater for future solar heating (check 'NA' is solar is installed).	o	o	o
b. The suction side pipe is straight for at least 4 pipe diameters before entering the pump. See the following table for required straight run lengths for various pipe sizes. (see Table 2 below)		o	o
c. The design uses low pressure drop fittings (sweep 90s)	o	o	o
d. Pool system has directional inlets	o	o	o
3. Filtration Equipment:			
a. If a backwash valve is used: The diameter of the backwash multi-port valve is 2 inches or as large as the circulation pipe, whichever is greater.	o	o	o
4. Pump controls			
a. The pump controls for filtration circulation has a programmable time switch		o	o
b. The controls are capable of operating a pump at two speeds		o	o
c. The controls are programmed to operate at low speed default filtration (check 'NA' if single speed pump less than 1 HP)	o	o	o

Table 2. Pipe Leading Straight Lengths

Pipe diameter	Pipe length leading into pump
1.5"	6"
2"	8"
2.5"	10"
3"	12"

Appendix B: Title 20 and Title 24 Original Language for Swimming Pools

These are the current Title 20 2005 Appliance Standards and Title 24 2005 Building Standards as they may apply to swimming pools. (This may need to be deleted, but is in the draft for easy reference.)

Title 20: 2005 Appliance Standards

Section 1604

(g) **Pool Heaters, Portable Electric Spas, and Residential Pool Pumps.**

(1) Test Methods for Pool Heaters.

The test methods for pool heaters are shown in Table G.

Table G

Pool Heater Test Methods

Appliance		*Test Method*	
Gas-fired and oil-fired pool heaters		ANSI Z21.56-1998	
Electric resistance pool heaters		ANSI/ASHRAE 146-1998	
Heat pump pool heaters		ANSI/ASHRAE 146-1998, as modified by Addendum Test Procedure published by Pool Heat Pump Manufacturers Association dated April, 1999, Rev 4: Feb. 28, 2000:	
Reading	***Standard Temperature Rating***	***Low-Temperature Rating***	***Spa Conditions Rating***
Air Temperature			
Dry-bulb	27.0°C(80.6°F)	10.0°C(50.0°F)	27.0°C(80.6°F)
Wet-bulb	21.7°C(71.0°F)	6.9°C(44.4°F)	21.7°C(71.0°F)
Relative Humidity	63%	63%	63%
Pool Water Temperature	26.7°C(80.0°F)	26.7°C(80.0°F)	40.0°C(104.0°F)

(2) Test Method for Portable Electric Spas

The test method for portable electric spas is as follows:

(A) Minimum continuous testing time shall be 72 hours.

(B) The water temperature shall remain at or above the test temperature of 102ºF for the duration of the test.

(C) The ambient air temperature shall remain at or below the test temperature of 60ºF for the duration of the test.

(D) The standard cover that comes with the unit shall be used during the test.

(E) The test shall start when the water temperature has been at 102ºF for at least four hours.

(F) Record the total energy use for the period of test, starting at the end of the first heating cycle after the four hour stabilization period, and finishing at the end of the first heating cycle after 72 hours has elapsed.

(G) The unit shall remain covered and in the default operation mode during the test. Energy-conserving circulation functions, if present, must not be enabled if not appropriate for continuous, long-term use.

(H) Data reported shall include: spa identification (make, model, S/N, specifications); volume of the unit in gallons; cover R-value; supply voltage; average relative humidity during test; minimum, maximum, and average water temperatures during test; minimum, maximum, and average ambient air temperatures during test; date of test; length of test (t, in hours); total energy use during the test (P, in Wh); and standby power (P/t, in watts).

(3) Test Method for Residential Pool Pumps

The test method for residential pool pumps is 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)

Section 1605.1

(g) **Pool Heaters, Residential Pool Pumps, and Portable Electric Spas.**

(1) **Energy Efficiency Standard for Gas-Fired Pool Heaters and Oil-Fired Pool Heaters.** The thermal efficiency of gas-fired pool heaters and oil fired pool heaters shall be not less than 78 percent.

(2) **Energy Efficiency Standards for Heat Pump Pool Heaters.** See Section 1605.3(g) for energy efficiency standards for heat pump pool heaters.

(3) **Energy Efficiency Standard for Electric Resistance Pool Heaters.** There is no energy efficiency standard for electric resistance pool heaters.

(4) **Energy Design Standards for Pool Heaters**. See Section 1605.3(g) for energy design standards for pool heaters.

(5) **Energy Efficiency Standards for Portable Electric Spas**. See Section 1605.3(g) for energy efficiency standards for portable electric spas.

(6) **Energy Efficiency Standards and Energy Design Standards for Residential Pool Pumps**. See Section 1605.3(g) for energy efficiency standards and energy design standards for residential pool pumps.

Section 1605.3

(g) **Pool Heaters, Residential Pool Pumps, and Portable Electric Spas.**

(1) **Energy Design Standard for Natural Gas Pool Heaters.** Natural gas pool heaters shall not be equipped with constant burning pilots.

(2) **Energy Design Standard for All Pool Heaters.** All pool heaters shall have a readily accessible on-off switch that is mounted on the outside of the heater and that allows shutting off the heater without adjusting the thermostat setting.

(3) **Energy Efficiency Standard for Heat Pump Pool Heaters.** For heat pump pool heaters manufactured on or after March 1, 2003, the average of the coefficient of performance (COP) at Standard Temperature Rating and the coefficient of performance (COP) at Low Temperature Rating shall be not less than 3.5.

(4) **Energy Efficiency Standards for Gas and Oil Pool Heaters.** See Section 1605.1(g) for energy efficiency standards for gas and oil pool heaters that are federally-regulated consumer products.

(5) **Residential Pool Pumps**.

(A) **Motor Efficiency**. Pool pump motors manufactured on or after January 1, 2006 may not be split-phase or capacitor start – induction run type.

(B) **Two-Speed Capability**.

(i) **Pump Motors.** 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.

(ii) **Pump Controls.** 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.

(6) **Portable Electric Spas**. The standby power of portable electric spas manufactured on or after January 1, 2006, shall be not greater than $5(V^{2/3})$ Watts where V = the total volume, in gallons.

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		Refrigerant Type	Ozone-depleting, non-ozone-depleting
G	Heat Pump Pool Heaters	Heating Capacity at Standard Temperature Rating	
		Readily-Accessible On-Off Switch	Yes, no
		Coefficient of Performance at Standard Temperature Rating	
		Heating Capacity at Low Temperature Rating	
		Coefficient of Performance at Low Temperature Rating	
		Heating Capacity at Spa Conditions Rating	
		Coefficient of Performance at Spa Conditions Rating	
		Refrigerant Type[1]	Ozone-depleting, non-ozone-depleting
	Other Pool Heaters	Energy Source	Natural gas, LPG, oil, electric resistance
		Readily-Accessible On-Off Switch	Yes, no
		Constant Burning Pilot Light (for gas models)	Yes, no
		Input	
		Thermal Efficiency	
	Residential Pool Pumps	Motor Construction	PSC, Cap Start-Cap Run, ECM, Cap Start-Induction run, split-phase
		Motor Design	Single-speed, dual-speed, multiple-speed, variable- speed
		Motor has Capability of Operating at Two or More Speeds with the Low Speed having a Rotation Rate that is No More than One-Half of the Motor's Maximum Rotation Rate	Yes, no
		Pool Pump Motor Service Factor	
		Motor Efficiency (%)	
		Rated Horsepower	
		Flow for Curve 'A' (in gpm)	
		Power for Curve 'A' (in Watts)	
		Energy Factor for Curve 'A' (in gallons per Watt-hour)	
		Flow for Curve 'B' (in gpm)	
		Power for Curve 'B' (in Watts)	
		Energy Factor for Curve 'B' (in gallons per Watt-hour)	
	Portable Electric Spas	*Voltage	
		Volume (gallons)	
		Rated Capacity (number of people)	
		Insulation R-value of Spa Cover Provided with the Spa	
		Standby Power (watts)	
		Spa Enclosure is Fully Insulated	Yes, no
		If Spa is Fully Insulated, R-value of Insulation	

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SECTION 114 – MANDATORY REQUIREMENTS FOR POOL AND SPA HEATING SYSTEMS AND EQUIPMENT

(a) **Certification by Manufacturers**. Any pool or spa heating system or equipment may be installed only if the manufacturer has certified that the system or equipment has all of the following:

1. **Efficiency**. A thermal efficiency that complies with the Appliance Efficiency Regulations; and

2. **On-off switch**. A readily accessible on-off switch, mounted on the outside of the heater that allows shutting off the heater without adjusting the thermostat setting; and

3. **Instructions**. A permanent, easily readable, and weatherproof plate or card that gives instruction for the energy efficient operation of the pool or spa and for the proper care of pool or spa water when a cover is used; and

4. **Electric resistance heating**. No electric resistance heating; and

   EXCEPTION 1 to Section 114 (a) 4: Listed package units with fully insulated enclosures, and with tight-fitting covers that are insulated to at least R-6.

   EXCEPTION 2 to Section 114 (a) 4: Pools or spas deriving at least 60 percent of the annual heating energy from site solar energy or recovered energy.

5. **Pilot light**. No pilot light.

(b) **Installation**. Any pool or spa heating system or equipment shall be installed with all of the following:

1. **Piping**. At least 36 inches of pipe between the filter and the heater to allow for the future addition of solar heating equipment; and

2. **Covers**. A cover for outdoor pools or outdoor spas; and

   EXCEPTION to Section 114 (b) 2: Pools or spas deriving at least 60 percent of the annual heating energy from site solar energy or recovered energy.

3. **Directional inlets and time switches for pools**. If the system or equipment is for a pool:

   The pool shall have directional inlets that adequately mix the pool water; and

   The circulation pump shall have a time switch that allows the pump to be set to run in the off-peak electric demand period, and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

   EXCEPTION to Section 114 (b) 3: Where applicable public health standards require on-peak operation.

SECTION 115 – NATURAL GAS CENTRAL FURNACES, COOKING EQUIPMENT, AND POOL AND SPA HEATERS: PILOT LIGHTS PROHIBITED

Any natural gas system or equipment listed below may be installed only if it does not have a continuously burning pilot

light:

(a) Fan-type central furnaces.

(b) Household cooking appliances.

EXCEPTION to Section 115 (b): Household cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr.

(c) Pool heaters.

(d) Spa heaters.