Measure Information Template
Residential Swimming Pools

2008 California Building Energy Efficiency Standards

Pacific Gas & Electric Company, July 6, 2006

CONTENTS

PURPOSE

The Pacific Gas and Electric Company (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. By reducing the pool system total dynamic head, or TDH, through recommended pipe design and filter specifications, the majority of energy savings are found through using a smaller and more effective 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. With nearly 35,000 new constructed pools, total annual energy savings for the State may be 56.6 GWh. Electric demand reduction coincident with utility system peak may be reduced by 39.5 MW. These demand savings are realized without demand reduction findings from operational measures such as off-peak and demand response.

OVERVIEW

Description	1. MOTOR EFFICIENCY REFERENCE TO TITLE 20 APPLIANCE STANDARDS: This measure will reference the Title 20 Appliance standards Section 1605.3 (5) regarding pool pump efficiency and mandate that all pump motors installed in new pools be found on the CEC list. 2. LOW SPEED FILTRATION AND PUMP SIZING: This measure will repeat the requirements of the Title 20 standard (1605.3(g)(5)(B)(ii)) by requiring the installation of a two-speed pump (for pumps over 1 hp), two-speed capable controls, and operating at low speed default filtration. It will exclude start up time for priming and any cleaning that might need the pump motor to operate at a higher speed. This measure addresses the low-speed filtration issue for both single and multi-speed pumps by mandating a minimum turnover time and therefore a maximum flow rate. This measure shall limit pool pump flow rates to turnover the pool water in no shorter than six hours. 3. PIPE DESIGN AND EFFICIENT PIPE FITTINGS: This measure is three-fold: 1) set maximum suction and return velocities of 6 and 8 feet per second respectively, 2) require a minimum straight length of least four pipe diameters on the suction side of the pump, and 3) require the use of sweep elbows instead of hard 90°elbows. Maximum velocities comply with commercial pool recommendations and recommendations for use with copper pipe, and yield the highest individual energy savings of all proposed design measures. Manufacturers recommend straight leading pipe to the pump on the suction side. Not to have a leading straight run of pipe into the pump causes cavitation, noise, and impeller wear. 4. FILTER SIZING AND SELECTION: This measure will specify that filter selection be sized according to manufacturer's recommendations and appropriately sized multi-port valves (MPV) be used. Many diatomaceous earth (DE) and sand filters have high head losses due to the multi-port valves used for backwashing. Cartridge filters do not require a backwash valve, and over-sizing cartridge filters increases filter effectiveness and reduces energy use. While under-sizing sand and DE filters leads to increased head losses, sand and DE filters should not be oversized since their media need to be packed to work effectively.

Description (continued)	5. POOL & SPA COVERS: Current regulations require heated pools with less than 60% of the heating provided by solar to have a pool cover; this measure proposes to remove any regulations for pool covers while maintaining the standards language for spa covers. 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. In practice however, pool covers are not cut to size nor installed before inspection leaving many pools effectively uncovered. Persistence issues also make it difficult to enforce any measures regarding pool covers.
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. The standards that need to be modified are found in Title 24 Section 114 (b). Modifications for pipe design and fittings, filters, low speed filtration and flow restrictions all aid in decreasing the size of pump necessary to achieve energy savings and may be found below in the Recommendations Section. 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 below in the Material for Compliance Manual Section.
Energy Benefits	Energy benefits for all the design measures applied are average as 1624 kWh/year per pool. Statewide energy benefits are 56.6 GWh/year and nearly 50%, based on an original energy consumption of 113 GW. Electric demand reduction coincident with utility system peak is reduced by 39.5 MW. These demand savings are realized without demand reduction findings from operational measures such as off-peak and demand response. Reference the "Analysis and Results" section below for detailed calculations.

<table>
<tr><td>Energy Benefits (continued)</td><td>

Table 1. Annual energy Benefits by individual measure per pool.

<table>
<tr><th>Measure Title and Proposed Implications</th><th>Energy Savings (kWh/yr)</th><th>Percent Energy Savings</th></tr>
<tr><td>1.0 MOTOR EFFICIENCY REFERENCE TO TITLE 20 APPLIANCE STANDARDS</td><td></td><td></td></tr>
<tr><td>1.1 Require that pump is listed with CEC</td><td>260</td><td>~10%</td></tr>
<tr><td>2.0 LOW SPEED DEFAULT FILTRATION AND PUMP SIZING</td><td></td><td></td></tr>
<tr><td>2.1 Reduce pump size to achieve >6 hour turnover (1 speed)</td><td>1473</td><td>54.0%</td></tr>
<tr><td>2.2 Reduce pump size to achieve >6 hour turnover (2-speed)</td><td>1421</td><td>52.0%</td></tr>
<tr><td>3.0 PIPE DESIGN AND EFFICIENT PIPE FITTINGS</td><td></td><td></td></tr>
<tr><td>3.1 Straight pipe run on suction side before pump at least 4 times the pipe diameter.</td><td>104 - 728</td><td>4-28%</td></tr>
<tr><td>3.2 Pipe sizing according to 8 and 6 fps in the return and suction lines, respectively.</td><td>403</td><td>14.7%</td></tr>
<tr><td>3.3 Efficient pipe fittings sweep elbows</td><td>31</td><td>1.2%</td></tr>
<tr><td>4.0 FILTER SIZING AND SELECTION</td><td></td><td></td></tr>
<tr><td>4.1 Appropriately sized filters</td><td>13</td><td>0.5%</td></tr>
<tr><td>4.2 Appropriately sized MPV valves</td><td>159</td><td>5.9%</td></tr>
</table>

</td></tr>
<tr><td>Non-Energy Benefits</td><td>

The reduced emissions associated with the lower pumping energy needed for efficient pool designs are considerable and are shown in Table 2 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 DEFAULT FILTRATION AND PUMP SIZING: 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 reducing initial pump costs.
3. PIPE DESIGN AND EFFICIENT PIPE FITTINGS: Possibly better plumbing practice could lead to less future maintenance issues including leaking and broken pipes, as 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.

</td></tr>
</table>

<table>
<tr><td>Non-Energy Benefits (continued)</td><td>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. If sand or cartridge filters are used in lieu of DE filters, there is no DE waste produced at every backwash.</td></tr>
<tr><td>Environmental Impact</td><td>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 2.

Table 2. First year reduction in both emissions and costs from utilizing proposed design measures.
<table>
<tr><th>NO_x</th><th>PM-10</th><th>CO_2</th></tr>
<tr><td>4616 lbs</td><td>2759 lbs</td><td>20554 tons</td></tr>
<tr><td>$47,400</td><td>$89,012</td><td>$265,467</td></tr>
</table></td></tr>
<tr><td>Technology Measures</td><td>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 wholesale prices plus a 25% mark-up. All pipes and fittings are estimated to be Schedule 40 PVC, the current standard in the pool industry. Table 20 summarizes the cost for all the pool model baseline assumptions.
1. LOW SPEED DEFAULT FILTRATION AND PUMP SIZING: 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 3 compares the retail costs for single and 2-speed pool pumps. The cost of single-speed pumps increases linearly with horsepower at ~$110/Hp. Note that for most sizes the incremental cost of 2-speed is very small. The 2-speed costs for 2 ½ and 3 horsepower are taken from a very small sample of pumps.</td></tr>
</table>

Technology Measures (continued)

Table 3. Retail Cost of Pool Pumps

Motor Size (Horsepower)	*Motor (Total Horsepower)*	*Single-speed Costs*	*2-speed Costs*
½	0.95	$303	N/A
¾	1.25	$330	N/A
1	1.65	$358	$389
1 ½	2.20	$413	$426
2	2.60	$468	$448
2 ½	2.95	$523	$595
3	3.45	$578	$650

2. PIPE DESIGN AND EFFICIENT PIPE FITTINGS: Most modern pools are plumbed exclusively with PVC pipe and fittings, which are generally available in sizes ranging from ½" to 3" with 1½" and 2" being the most popular. Table 4 shows the retail cost of various sizes of pipe and fittings. Pool contractors do not currently use sweep elbows in significant quantity and so wholesalers do not stock them in all sizes. We assumed 50 feet of supply and return piping, eight elbows for return piping, and four elbows for supply piping per pool.

Table 4. Retail costs of PVC pipe and Fittings

Pipe diameter	*Pipe ($/foot)*	*Hard 90º Elbow (each)*	*Short Sweep Elbow (each)*
1"	$0.49	$0.41	$3.25
1 ¼"	$0.68	$0.53	$0.00
1 ½"	$0.81	$0.76	$3.64
2"	$1.02	$1.18	$4.14
2 ½"	$1.65	$3.73	$4.84

Another aspect of the pipe design proposed measure is the mandate for at least four straight pipe diameters leading into the pump on the suction side. Pool builders who do not currently practice this in hopes of saving room on the equipment pad will either have to reconfigure the pad to accommodate or increase the area of the pad, which would include relatively increased costs in concrete according to the size increased. The suction side pipe diameter typical of residential pumps could reach upwards of 3", which would translate to at least 1 foot of pipe before the pump.

Technology Measures (cont.)

3. FILTER SIZING AND SELECTION: Pool filters are available in a large range of sizes for all three types of commonly used filters. Retail costs are summarized in Table 5. Costs for all filter types increase linearly with filter area with a cost per additional square foot of $1.12 for cartridge, $46 for sand, and $3.58 for DE.

Table 5. Retail Costs of Pool Filters

Cartridge		Sand		DE	
Area (sq.ft.)	Cost	Area (sq.ft.)	Cost	Area (sq.ft.)	Cost
100	$241	0.9	$198	36	$337
200	$373	1.8	$248	48	$386
300	$492	2.3	$270	60	$423
400	$605	3.1	$300		
500	$683	4.9	$530		

4. POOL COVERS: This measure does not encourage one pool cover technology over another.

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. Expected lifetimes for pool equipment are summarized in Table 6. 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 causes cavitation, noise, and impeller wear. Pumps and their motors have a lifespan of 10 years (DOE 2001).

Table 6. Pool Equipment Lifetimes

Equipment	Life (years)
Pump	10
Filter	15
Pipe and fittings	30
Bubble type cover	3
Automatic cover	Fabric: 5 Mechanism: 15

Most of the measures recommended in this report will exhibit very high persistence. Savings due to pipe and fitting selection are effectively locked in for the life of the pool. Although pumps and filters can always be replaced with an incorrect size, pool contractors will have gained experience with correct sizing by having to follow code requirements and will thus be less likely to specify replacement equipment incorrectly.

Performance Verification	With the new proposed standards, a site visit that includes checking the underground piping and the equipment on the equipment pad will have to be performed. The proposed compliance form, designed specifically for new pools and 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 should all be done onsite during some of the preliminary 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. Another alternative is that pool contractors be certified by a third party through a pool design training program. The checklist and accompanying tables found in Appendix A will guide a 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 $278, resulting in a life cycle cost savings of $632 and a benefit to cost ratio of 3.3 to 1. The cost effectiveness estimates are based upon the incremental costs of the proposed design measures. 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 incremental cost of the design measures is estimated as $197; • the pool and its pipes, pipe fittings will have to be replaced in 30 years; • the filter and any MPV will be replaced in 15 years; and, • the pump and motor need replacement every 10 years. The discounted, incremental life cycle equipment cost of the measures is $278 and accounts for any retail mark up. Initial incremental cost in equipment is an increase $197 between the current pool modeled and one with the proposed measured applied. The annual savings of 1624 kWh per pool result in almost $910 of savings using the 2008 lifecycle multiplier for 30 years. The discount rate is 3 percent. For more on cost effectiveness calculations, see the Recommendations Section.
Analysis Tools	These measures are proposed as mandatory and analysis tools are not relevant. Furthermore, pools are not currently modeled in the ACM.
Relationship to Other Measures	There are no other measures that would be impacted by the proposed changes.

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. The model is as follows:

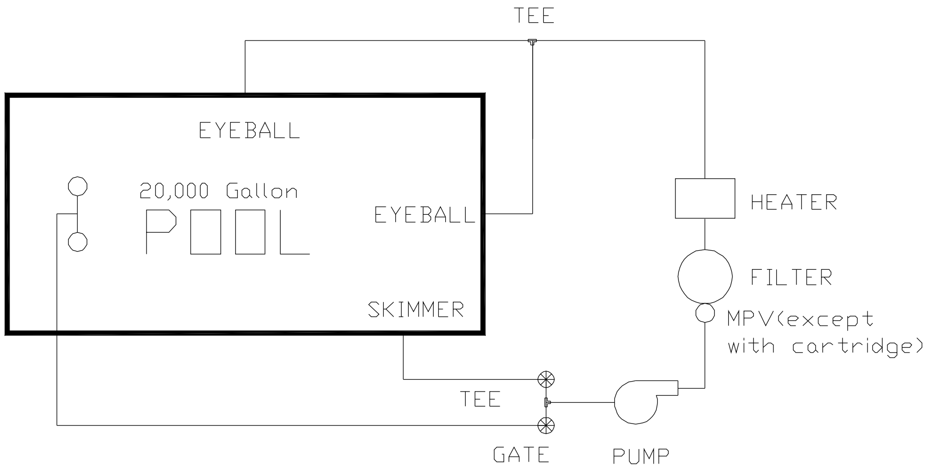

Figure 1: Schematic of model pool.

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 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 joint valves, a 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 motor used for most simulations is a standard 1.5 HP motor 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 an XY-Scatter graph along with the pump curves of various pumps to see where the operating points lie.
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.

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

Measure 1 - Energy Efficiency of Pump

Measure 1 refers to including a reference to the Title 20 Appliance Energy Efficiency Standards (1605.3(g)(5)(A)) in the Title 24 standards for building energy efficiency. This is simply included to enable enforcement of the Title 20 standards that were already researched and established by requiring that the motor used be listed with the CEC. No analysis was performed for this measure.

Measure 2 - Low Speed Filtration and Pump Sizing

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 to a 6-hour turnover rate. Low speed filtration has proven to provide large energy savings (>50%), but there are no standards that prevent pool builders from over sizing the pump. It is widespread practice to put larger pumps on pools and operate them for short periods.

This measure should result in smaller pumps being installed for single-speed systems (if a higher HP pump is needed for any reason, such as suction-side, pressure-side or floor cleaning system or solar heating, then part 2 below will require that greater than 1 horsepower pumps be multi-speed and that default filtration be run on the lower speed.). 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 popular pump sold), and with a pump that keeps the flow rate below that of a 6 hour turnover.

The second portion of this measure that pertains to multi-speed pumps is an inclusion of Title 20 Appliance Standard 1605.3(g)(5)(B). This standard requires that pumps with greater than 1HP 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 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: straight pipe run before pump, design pipe size and low head fittings.

Straight Pipe Run at Pump

The first issue pertains to the recommendation by most pump manufacturers that a length of straight pipe equal to 4 to 5 pipe diameters must precede the pump. This requirement is to reduce turbulence on the suction side of the pump that could lead to cavitation in the pump, increasing energy use and decreasing its effective life. 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.

Pipe Sizing

Twenty percent of new pools are reported to have undersized pipes. There is currently no accepted design standard used by building officials to prevent undersized piping in pool construction. Undersized pipes increase TDH and increase the work required by the pump. ANSI Standard NSPI-5-1995 and pool design guidelines recommend that water velocities not exceed 10 fps in return lines and 8 fps in suction lines. Industry experts believe that lowering these values to 8 fps and 6 fps, as for copper piping is appropriate. 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.

$$Q = V \times A$$

Where: Q = the pipe flow,
V = the average velocity of the flow, and
A = the cross-sectional area of the 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 model was run using each of these fitting types and the resulting system curves were plotted on the same pump curve as the previous analysis. The power and flow rate were determined from the operating points, and the energy use for each run was calculated for a single turnover and compared. In addition, the equivalent lengths of the various fittings were referenced from the Hydraulic Design Manual published by Pentair, 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. Undersized filters restrict water flow, increase the system TDH, and require more frequent cleanings. Like the pipe fitting argument in Measure 3, reducing TDH can increase flow and reduce run-times, or allow a smaller pump to be installed. 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.

Methodology for the Total Measure Savings

Since the individual measures affect each other, the overall savings is not additive. Therefore, to represent the range of existing pool building practice, four pool designs were created to compare the cumulative impact of all the measures. The four designs are shown in Table 7 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 and market weightings were assigned so that the average weighted energy use matched the average California pool energy use.

Table 7. Representative Pool Designs.

Design Parameter	*Design 1: Above average design**	*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 Gate, 1 Tee	4 '90s, 1 Gate, 1 Tee	5 '90s, 1 Gate, 1 Tee	6 '90s, 1 Gate, 1 Tee
Filter:	315 sq.ft. Cartridge	150 sq.ft. Cartridge	150 sq.ft. Cartridge	150 sq.ft. Cartridge
Pump type:	Single Speed	Single Speed	Single Speed	Single Speed
Pump size:	½ HP	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 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.

All 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.

ANALYSIS AND 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 these pools go through a permitting process. All in-ground pools were estimated to go through the permitting process.

Table 8. 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

* The amount of pools that apply for permits is not derived from the California Pool Report by P.K. Data.

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 9 shows a comparison of efficiencies for different motor types:

Table 9. Motor types and efficiencies typically used in pool pumps.

Type	Efficiency Range (%)
Capacitor Start and Split Phase	40 – 50
Permanent Split Capacitor	45 – 55
Capacitor Start Capacitor Run	55 – 70

Source: (Eliot 2004)

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/year for a pool, this would mean an annual savings of 260 kWh per pool.

Measure 2 - Low Speed Default Filtration

Fifty-five percent of the pools surveyed by ADM had less than one horsepower pumps (ADM 2001). Using a standard pool design, the savings from using the appropriate sized pump ($\geq$ 6 hour turnover) over a standard 1.5 HP pump was approximately 31 GWh.

For a two-speed pump, 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 ADM 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

Straight Pipe Run at Pump

The surveys used to estimate average pool energy consumption might not be capturing the impacts of this practice. It is the trend towards smaller and smaller equipment pads, combined with a lack of hydraulics training, which leads to current practices of having elbows or tees too close to the suction side of the pump. This proposed measure could generate energy savings in the range of 4 to 28% statewide, or 104 – 728 kWh per pool annually, according to savings provided by pool professionals.

Pipe Sizing

Specifying pipe diameters that limit return and suction velocity to 8 and 6 fps respectively dramatically reduces system TDH. Table 10 shows the pipes sizes required for each flow rate range in order to maintain pipe velocities below the 8 and 6 fps limits.

Table 10. 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 11.

Table 11. Energy savings for increase in pipe size.

	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).

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 2: 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.

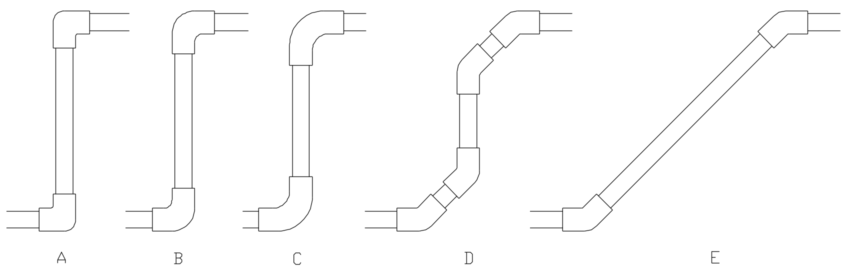

Figure 2. Views of fittings and combinations.

Table 12 compares the fitting head loss and system TDH for each of the various fittings and practices. When compared to the hard 90, the short and long radius elbows show 14 and 35 % reduction in head respectively. Using two 45s to form a 90 yields very little savings (5%) and raises quality issues as it doubles the number of glue joints. This method should be discouraged. The use of a 45 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 last two column show the system TDH and percentage reduction in system TDH at 60gpm for each of the designs compared to hard 90 elbows.

Table 12. Effect of Fitting Type on System Head.

Figure 2 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

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 13 shows the savings realized:

Table 13. 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 13 shows, the actual energy savings from simply switching out the hard 90s for sweeps or double 45s are rather low. However, like other measures, this reduced TDH can be combined with other measures to reduce the overall TDH of the system and enable the designer 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. Cartridge filters dominate the market, but 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 thus 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 14 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 14. Head losses for clean and dirty filters at 60 gpm and appropriately size

Filter Types*	Head Loss for Clean Filter (ft of H2O)			Head Loss for Dirty Filter (ft of H2O)		
	Avg	Max	Min	Avg	Max	Min
Cartridge	2.0	2.5	1.5	4.0	5.0	3.0
DE *	32.5	51.3	22.5	47.4	85.2	27.5
Sand *	36.0	41.0	30.9	54.4	64.5	44.3

* DE and sand filter values include head loss contributions from MPV.

Another concern is the practice of installing too small a cartridge filter for the system to reduce first cost. Undersized filters can cause initial head losses as well as increased head losses over time as the filter loads up. Manufacturers recommend between .25 and .50 gpm per sq ft of cartridge filter area. Table 15 shows the analysis results comparing undersized and right-sized cartridge filters:

Table 15. Comparison of undersized and oversized cartridge filters.

Area (sq.ft.)	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%

Next, we present energy savings for right sizing of multi-port valves (MPV). Table 16 shows the energy savings for various MPV. Analyses comparing the performances of two diameters of MPV are shown, as well as a high flow and a slide type MPV. High flow MPV's are designed for better performance while maintaining operational ease. Slide type MPV's have the most savings.

Table 16. 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%

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

TDV cost savings between current demand profiles and a demand profile adjusted for proposed designs are shown in Table 17:

Table 17. Reduced on-peak operations savings per pool for baseline demand curve and demand curve adjusted for off peak operation..

	Baseline	Proposed
TDV analysis (per pool)	$6,215	$3,056
Savings		$3159

Results for Total Measure Savings

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

The kWh/year column in Table 18 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 18. Summary of energy savings.

	Flow (gpm)	Power (W)	Turnover Time (hours)	Pool Energy Use (kWh)		Est. Wt.*	# of pools	delta kWh	Savings (kWh/year)
				daily	annual				
Des 1	56.1	445	5.9	2644	965	20%	6970		
Des 2	73.7	1649	4.5	7458	2722	60%	20909	1757	36,740,536
Des 3	64.0	1779	5.2	9266	3382	13%	4530	2417	10,949,228
Des 4	39.9	1512	8.4	12632	4611	7%	2439	3645	8,892,743
Total Savings									56,582,507
% Savings									49.9%

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

Pool industry experts were then consulted as to how the pools being build could be broken down by the different designs. These weighting values (Population Weight column in Table 18) were then used to determine total savings. From these calculations, it was estimated that the proposed measures could produce a reduction of 49.9% 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 39.6 MW.

Table 19 shows the pipe sizes and velocities in both the return and suction lines 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 not one of the designs has 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 19. Comparison of designs for pipe velocities.

	Return Diameter (in.)	*Suction Diameter (in.)*	*Flow (gpm)*	*Return Velocity (fps)*	*Suction Velocity (fps)*
Design 1	2.0	2.5	56.1	5.7	3.7
Design 2	1.5	2.0	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 3. The total head for Design 1 is less than 10% of the total head of Design 4. The pipes and fittings contribute 95% of the 178 feet of head for Design 4, or about 170 feet of head, where with Design 1, the contribution is 50% of the 15 feet of head, or 7.5 feet. In the below average pool designs, pipe size is responsible for 88 to 95% of the head of that system.

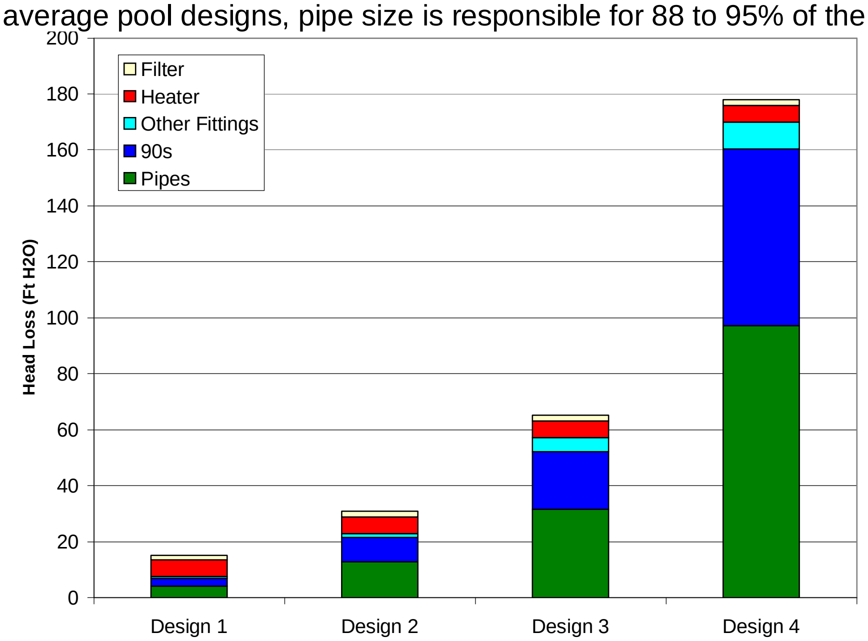

Figure 3. Total system head at 60gpm and breakdown by system component.

A closer look at the average design (Design 2) and the pool designed to the proposed measures (Design 1) in Figure 4 shows the massive 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%.

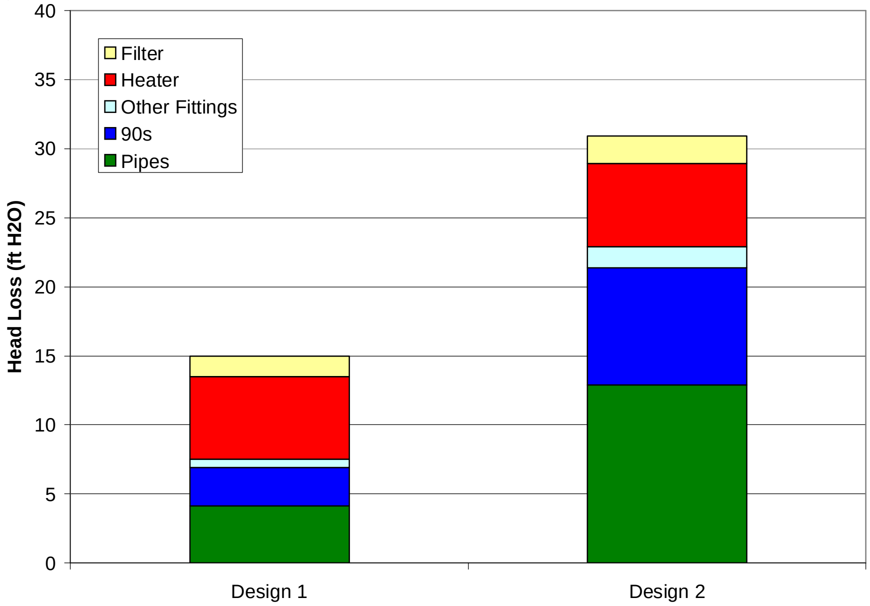

Figure 4. Total system head and breakdown by component between the average design (Design 2) and the proposed measures design (Design 1).

In conclusion, 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 ~50% and demand by 57% or more.

Cost-effectiveness

Net present value of energy savings per pool is estimated at $910 and the incremental life cycle cost for the equipment is $278, resulting in a 30-year life cycle cost savings of $632 and a benefit to cost ratio of 3.3 to 1.

The cost effectiveness estimates are based upon the incremental costs of the proposed design measures. 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 incremental cost of the design measures is estimated to be approximately $246;
- the pool and its pipes, pipe fittings will have to be replaced in 30 years;
- the filter and any MPV will be replaced in 15 years; and,
- the pump and motor need replacement every 10 years.

The discounted, incremental life cycle equipment cost of the measures is $278 and accounts for any retail mark up. Initial incremental cost in equipment is an increase of $246 between the current pool modeled and one with the proposed measured applied.

The annual savings of 1624 kWh per pool result in almost $910 of savings using the 2008 lifecycle multiplier for 30 years. The discount rate is 3 percent.

Table 20. 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	$10
Fittings in Return	8 '90s, 1 Tee, 2 eyeballs (in parallel) at 2 inches	8 '90s, 1 Tee, 2 eyeballs (in parallel)	$27
MPV size:	2"	1.5"	$43
Suction Pipe size	2.5"	2"	
Suction Pipe length (feet)	50	50	$31
Fittings in Suction line:	4 '90s, 1 Ball Valve, 1 Tee	4 '90s, 1 Ball Valve, 1 Tee	$15
Filter type:	Cartridge 315 sq ft	Cartridge 150 sq ft	$232
Pump type:	Single Speed	Single Speed	
Pump size:	½ HP or 0.95 T-hp	1.5 hp or 2.2 T-hp	($112)
		TOTAL EXTRA COST:	$246

* Although there are definite costs and savings associated with flow rate and filtration run time, these costs 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 incremental costs as show in Table 20 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). Demand Response savings were not analyzed for emissions as they were out of the scope of this study.

Table 21. First year reduction in emissions without proposed design measures.

	NO_x (lbs)	PM-10 (lbs)	CO_2 (tons)
Proposed Design Measures	4,616	2,759	20,554

Table 22. 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 23. Reduction in emissions costs (using 30 year prices).

	NO_x	PM-10	CO_2
Proposed Measures	$47,400	$89,012	$265,467

Statewide Energy Savings

Building Category	Number of new construction	Energy Savings per pool*	Demand Reduction per pool	Total Energy Savings	Total Demand Reduction
1st year New pools	34,849	1623	907 W	56.6 GW	39.6 MW

* 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.

RECOMMENDATIONS

SUBCHAPTER 2 ALL OCCUPANCIES

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

(a) **Certification by Manufacturers** for Heaters. 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 Specification. All pumps shall be of the type that comply with the Appliance Efficiency Regulations; and

Pumps shall be sized to dedicated loads, either by dedicating individual pumps to each load or using a multistage pump capable of varying speed with different loadings; and

Pumps shall be sized so that the default pool filtration flow rate is less than a six-hour turnover rate; and

Pool pump motors with a capacity of 1HP or more shall have the 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; and

The default circulation speed shall be the lowest speed (for multi-speed pumps), with a high-speed override capability being for a temporary period not to exceed one normal cycle.

EXCEPTION to Section 114 (b) 1: Variable speed pumps shall be programmed to operate at a flow rate that is less than a six-hour turnover rate.

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

At least 4 pipe diameters of straight pipe before the pump; and

The pool piping shall be sized such that the velocity of the water does not exceed 8 feet per second in the return line and 6 feet per second in the suction line; and

Fittings shall be low friction loss fittings defined as at least short radius sweep 90° elbows; and

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

3. Filtration Equipment. If the system or equipment is for a pool; and

The filter shall be appropriately sized for the pool based on manufacturer's recommendations.

4. ~~3.~~ Controls ~~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 the minimum time necessary to maintain the water in the condition required by applicable public health standards; and

Pool filtration pump controls for all pumps shall have the capability of operating the pool pump at least two speeds.

5. ~~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.~~

MATERIAL FOR COMPLIANCE MANUALS

Adapted from "Mandatory Measures Summary: Residential, Form MF-1R", page two.

Instructions: Check or initial applicable boxes when completed, or check "NA" if not applicable.

DESCRIPTION	NA	Desi gner	Enfo rce- 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
§114(b): Pool and Spa Systems and Equipment			
1. Flow rate and pump selection:			
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 multiple features.	o	o	o
c. The Curve 'A' Flow Rate (CAFR) is less than the Maximum Filtration Flow Rate (MFFR) for the pump specified. (The Curve 'A' flow (in gpm) is listed in the CEC appliances database of certified pool pumps) MFFR = Pool Volume (in gallons) ÷ 360 minutes = _________(gpm) CAFR (<u>LOW SPEED</u> CAFR for multi-speed pumps) = _________(gpm) The CAFR _________(gpm) is less than the MFRR _________(gpm) OR A Programmable Variable Speed pump is specified and the default filtration flow rate is set to a flow rate of _________(gpm); which is less than the MFFR _________(gpm)	o	o	o
d. The Maximum Design Flow Rate (MDFR) is: The Curve 'A' Flow Rate from the CEC appliances database of certified pool pumps for a single speed pump or the <u>HIGH SPEED</u> CAFR of a multi-speed pump _________(gpm) OR The maximum flow rate that will be programmed into a variable speed pump _________(gpm)			
e. 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

<table>
<tr><td>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.
<table><tr><td>Pipe diameter</td><td>Length leading into pump</td></tr><tr><td>1.5”</td><td>6”</td></tr><tr><td>2”</td><td>8”</td></tr><tr><td>2.5”</td><td>10”</td></tr><tr><td>3”</td><td>12”</td></tr><tr><td>4”</td><td>16”</td></tr><tr><td>5”</td><td>20”</td></tr></table></td><td></td><td>o</td><td>o</td></tr>
<tr><td>c. The pipes exceed Minimum Pipe Diameter (as determined from design flow rate and maximum allowable velocities, 8 fps for return and 6 fps for suction). Using the MDFR (from 1.d) for the specified pump, determine Minimum Pipe Diameter from table below:
<table><tr><td>Maximum Design Flow Rate</td><td colspan="2">Minimum Pipe Diameter</td></tr><tr><td>(<u>HI-SPEED </u>for multi-speed pumps greater than 1 hp)</td><td>Return Pipes</td><td>Suction Pipes</td></tr><tr><td>up to 23 gpm</td><td>1"</td><td>1 ¼ “</td></tr><tr><td>24 to 33 gpm</td><td>1 ¼ “</td><td>1 ½ “</td></tr><tr><td>34 to 59 gpm</td><td>1 ½ “</td><td>2”</td></tr><tr><td>60 to 92 gpm</td><td>2”</td><td>2 ½ “</td></tr><tr><td>93 to 132 gpm</td><td>2 ½ “</td><td>3”</td></tr><tr><td>133 to 235 gpm</td><td>3”</td><td>4”</td></tr><tr><td>236 to 367 gpm</td><td>4”</td><td>5”</td></tr></table></td><td></td><td>o</td><td>o</td></tr>
<tr><td>d. The design uses low pressure drop fittings (sweep 90s, etc)</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>e. Pool system has directional inlets</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>3. Filters:</td><td></td><td></td><td></td></tr>
<tr><td>The filter Flow Rate Per Area of media (FRPA) is less than the Maximum Filtration Flow Rate (MFFR from 1.c) per filter surface area as defined by the table below:

FRPA = MFFR/(Area of filter in square feet) = ___________
<table><tr><td>Filter Type</td><td>MFFR Per Area (gpm/sq.ft.)</td></tr><tr><td>Cartridge</td><td>0.375</td></tr><tr><td>Sand</td><td>20</td></tr><tr><td>Diatomaceous Earth (DE)</td><td>2</td></tr></table></td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>If a backwash valve is used: The diameter of the backwash valve is at least as large as the port on the filter (i.e.: reducers shall not be used to port a small backwash valve to a filter designed for a larger one.)</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>4. Controls</td><td colspan="3"></td></tr>
<tr><td>a. The pump controls for filtration circulation has a programmable time switch</td><td></td><td>o</td><td>o</td></tr>
<tr><td>b. The controls are capable of operating a pump at two speeds</td><td></td><td>o</td><td>o</td></tr>
<tr><td>c. The controls are programmed to operate at low speed default filtration</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>5. A cover is in place for outdoor spas.</td><td>o</td><td>o</td><td>o</td></tr>
</table>

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Stakeholders who were involved in meetings, consulted for technical support, or both, include but are not limited to (in alphabetical order by last name): Eric Banvard, Donald Burns, Carvin DiGiovanni, Mike Geremia, Fred Hare, Ike Hornsby, Chuck Kleiber, Charlie Knapper, Michael Orr, Paul Porter, Rick Rubarsky, Dennis Ruis, Chuck Shoch, Jeff Smart, Rob Stiles, Bud Thomas, Al Townsend, Richard Townsend, and Jerry Wallace.