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California Energy Commission

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# Revised Analysis of Efficiency Standards for Pool Pumps and Motors, and Spas

2015 Appliance Efficiency Pre-Rulemaking

Docket Number 15-AAER-02

California Energy Commission

Edmund G. Brown Jr., Governor

June 2016 | CEC-400-2016-002-SD2

# California Energy Commission

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# PREFACE

On March 14, 2012, the California Energy Commission issued an order instituting rulemaking to begin considering standards, test procedures, labeling requirements, and other efficiency measures to amend the *Appliance Efficiency Regulations* (California Code of Regulations, Title 20, Sections 1601 through Section 1609). In this order, the Energy Commission identified appliances with the potential to save energy and/or water. The goal of the rulemaking is to develop proposed appliance efficiency standards and measures to realize these savings opportunities.

On March 25, 2013, the Energy Commission released an "invitation to participate" to provide interested parties the opportunity to inform the Commission about the product, market, and industry characteristics of the appliances identified. The Commission reviewed the information and data received and hosted workshops on May 28 through 31, 2013, to publicly vet this information.

On June 13, 2013, the Energy Commission released an "invitation to submit proposals" to seek proposals for standards, test procedures, labeling requirements, and other measures to improve the efficiency and reduce the energy or water consumption of the identified appliances.

On May 28, 2014, the Energy Commission released a notice to request additional information from interested parties to develop standards for network equipment, commercial clothes dryers, portable electric spas, and pool pumps and motors.

On January 28, 2016, the Energy Commission published its draft staff report, proposing performance standards for pool pump motors and revised performance standards and labeling requirements for portable electric spas. On February 18, 2016, the Commission held a staff workshop to review the draft staff report with interested parties and to take public comment.

The Energy Commission reviewed all the information received. This report contains the proposed regulations for portable electric spas and pool pumps motors, with updates based on comments received at the workshop and in writing in the Commission docket.

# ABSTRACT

This report discusses proposed updates to the pool pumps and motors, and portable electric spas standards in the *Appliance Efficiency Regulations* (California Code of Regulations, Title 20, Sections 1601 to 1609). These proposed updates are part of the 2012 Appliance Efficiency Rulemaking, Phase I (Docket #15-AAER-02). California Energy Commission staff analyzed the cost-effectiveness and technical feasibility of proposed efficiency standards for pool pumps and motors, and portable electric spas. Statewide energy use and savings and related environmental impacts and benefits are also included.

Staff proposes standards for single-speed, dual-speed, multispeed, and variable-speed motors sold in combination with pool pumps or sold separately as replacements. The standards would take effect on January 1, 2019, for all pool pump motors 5 horsepower or less. Staff proposes a timer requirement in lieu of motor efficiency for integral filter pool pump and motor combinations. In addition, staff proposes to amend and add definitions and update test procedures so that the standards can be enforced effectively. The proposed standby power standard and label requirement for portable electric spas would take effect on January 1, 2018. Staff also proposes to maintain the existing scope and portable electric spa definition and add or amend other spa definitions in congruence with the proposed test method.

The proposed updates would save about 226 gigawatt-hours the first year the standard is in effect. By the year that stock turns over in 2026, the proposed standards would have a combined annual savings of about 1,438 gigawatt-hours. This amount equates to roughly $230 million in annual savings to California businesses and individuals. In addition, greenhouse gases would be reduced by 496 thousand tons of carbon dioxide equivalents annually.

Staff analyzed available market data and concluded that the updates to standards for pool pumps and motors and portable electric spas would significantly reduce energy consumption and are technically feasible and cost-effective.

**Keywords:** Appliance Efficiency Regulations, appliance regulations, energy efficiency, pool pumps and motors, replacement pool pump motors, portable electric spas

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# EXECUTIVE SUMMARY

The California Energy Commission intends to take advantage of significant energy efficiency opportunities for pool pump motors and portable electric spas through the Title 20 appliance efficiency standards. The following Appliance Efficiency Program analysis supports the proposed standards. Staff's revised analysis demonstrates that the proposed pool pump motor and portable electric spa standards are technically feasible for the industry and cost-effective for consumers. After full stock turnover, the proposed standards combine for an estimated 1,438 gigawatt-hours of statewide energy savings per year.

Staff proposes to expand the existing scope of pool pump and motor combinations (pump and motor packaged together) and replacement pool pump motors (standalone motors) that are used for filtration and circulation, as water features and waterfalls, and as booster pumps. The proposal includes modifications and additions to the pool pump and motor definitions to match the new scope expansion and ensure that the standards can be enforced effectively. Test procedures are proposed for all pool motors from CSA 747-09 and for all pool pumps from ANSI/HI-40.6-2014.

Standards are proposed for single-speed, dual-speed, multi-speed, and variable-speed motors sold in a combination with pool pumps or sold separately as replacements. The proposed minimum efficiency requirement for single-speed motors at full speed shall be 70 percent for motors 0 to 0.49 total horsepower and 75 percent for motors 0.50 to 0.99 total horsepower (hp). The standard for variable-speed, multispeed, and dual-speed motors at full speed and half speed shall be 80 percent and 65 percent, respectively. The proposed standard would take effect on January 1, 2019, for all pool pump motors that are 5 hp or less. A timer requirement in lieu of the motor efficiency requirement is proposed for integral filter pool pump and motors. The proposed standards would result in an estimated 213 gigawatt-hours (GWh) of first-year energy savings and an estimated 1,277 GWh per year of energy savings after full stock turnover in 2026.

New standards for portable electric spas are also proposed. The existing scope includes all types of portable electric spas, such as exercise spas, combination spas, swim spas, and inflatable/collapsible spas. Staff proposes to maintain this scope and to adopt a uniform standby power performance standard, new test requirements, and new label requirements. The standby power standard will tighten power consumption on larger spas while providing modest relief on smaller spas. The proposed test method elaborates on test setup and measurements. The label requires manufacturers to display the standby power and list the spa cover(s) used during testing to achieve the reported standby power. The label requirement will help consumers make informed choices based on energy, boosting energy savings. The proposed standards would take effect on January 1, 2018. The estimated standby power savings after complete stock turnover is 77 GWh with $12 million in cost savings. The label requirement will yield additional energy savings estimated at 84 GWh with $13 million of cost savings after complete stock turnover.

# CHAPTER 1: Legislative Criteria

Section 25402(c)(1) of the California Public Resources Code mandates that the California Energy Commission reduce the inefficient consumption of energy and water on a statewide basis by prescribing efficiency standards and other cost-effective measures[1] for appliances that require a significant amount of energy and water to operate. Such standards must be technologically feasible and attainable and must not result in any added total cost to the consumer over the designed life of the appliance.

In determining cost-effectiveness, the Energy Commission considers the value of the water or energy saved, the effect on product efficacy for the consumer, and the life-cycle cost of complying with the standard to the consumer. The Commission also considers other relevant factors including, but not limited to, the effect on housing costs, the statewide costs and benefits of the standard over the lifetime of the standard, the economic impact on California businesses, and alternative approaches and the associated costs.

1 These include energy and water consumption labeling, fleet averaging, incentive programs, and consumer education programs.

# CHAPTER 2: Efficiency Policy

The Warren-Alquist Act[2] establishes the California Energy Commission as California's primary energy policy and planning agency. The act mandates that the Commission reduce the wasteful and inefficient consumption of energy and water in the state by prescribing statewide standards for minimum levels of operating efficiency for appliances that consume a significant amount of energy or water.

For nearly four decades, appliance standards have shifted the marketplace toward more efficient products and practices, reaping significant benefits for California's consumers. The state's *Appliance Efficiency Regulations* saved an estimated 22,923 GWh of electricity and 1,626 million therms of natural gas in 2012[3] alone, resulting in about $5.24 billion in savings to California consumers from these regulations.[4] Since the mid-1970s, California has regularly increased the energy efficiency requirements for new appliances sold and new buildings constructed in the state. In the 1990s, the California Public Utilities Commission (CPUC) decoupled the utilities' financial results from their direct energy sales, promoting utility support for efficiency programs. These efforts have reduced peak load needs by more than 12,000 megawatts (MW) and continue to save about 45,519 GWh per year of electricity.[5] The potential for additional savings remains by increasing the energy efficiency and improving the use of appliances.

## Reducing Electrical Energy Consumption to Address Climate Change

Appliance energy efficiency is identified as a key to achieving the GHG emission reduction goals of Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006)[6] (AB 32), as well as the recommendations contained in the ARB's *Climate Change Scoping Plan.*[7] Energy efficiency regulations are also identified as key components in reducing electrical energy consumption in

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2 The Warren-Alquist State Energy Resources Conservation and Development Act, Division 15 of the Public Resources Code, § 25000 et seq., available at http://www.energy.ca.gov/2015publications/CEC-140-2015-002/CEC-140-2015-002.pdf.
3 California Energy Commission. *California Energy Demand 2014-2024 Revised Forecast*, September 2013, available at http://www.energy.ca.gov/2013publications/CEC-200-2013-004/CEC-200-2013-004-V2-CMF.pdf.
4 Using current average electric power and natural gas rates of: residential electric rate of $0.164 per kilowatt-hour, commercial electric rate of $0.147 per kilowatt-hour, residential gas rate of $0.98 per therm, and commercial gas rate of $0.75 per therm. This estimate does not incorporate any costs associated with developing or complying with appliance standards.
5 *California Energy Demand 2014-2024 Final Forecast* available at http://www.energy.ca.gov/2013publications/CEC-200-2013-004/CEC-200-2013-004-V2-CMF.pdf, p. 86.
6 AB 32, California Global Warming Solutions Act of 2006, available at http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.html.
7 *Climate Change Scoping Plan* available at http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.

the Energy Commission's *2013 Integrated Energy Policy Report* (*IEPR*)[8] and the 2011 update to the CPUC's *Energy Efficiency Strategic Plan.*[9] Finally, the Governor and Legislature have identified appliance efficiency standards as a key to doubling the energy efficiency savings necessary to put California on a path to reducing its greenhouse gas emissions to 80 percent below 1990 levels by 2050.[10]

## Loading Order for Meeting the State's Energy Needs

California's loading order places energy efficiency as the top priority for meeting the state's energy needs. *Energy Action Plan II* continues the strong support for the loading order, which describes the priority sequence for actions to address increasing energy needs. The loading order identifies energy efficiency and demand response as the preferred means of meeting the state's growing energy needs.[11]

For the past 30 years, while per capita electricity consumption in the United States has increased by nearly 50 percent, California electricity use per capita has been nearly flat. Continued progress in cost-effective building and appliance standards and ongoing enhancements to efficiency programs implemented by investor-owned utilities (IOUs), publicly owned utilities, and other entities have contributed significantly to this achievement.[12]

## Zero-Net-Energy Goals

The *California Long-Term Energy Efficiency Strategic Plan*,[13] adopted in 2008 by the CPUC and developed with the Energy Commission, the ARB, the state's utilities, and other key stakeholders, is California's roadmap to achieving maximum energy savings in the state between 2009 and 2020, and beyond. It includes four "big, bold strategies" as cornerstones for significant energy savings with widespread benefit for all Californians:[14]

- All new residential construction in California will be zero-net-energy (ZNE) by 2020.
- All new commercial construction in California will be ZNE by 2030.
- Heating, ventilation, and air conditioning (HVAC) will be transformed to ensure that energy performance is best for California's climate.
- All eligible low-income customers will have the opportunity to participate in the low-income energy efficiency program by 2020.

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8 California Energy Commission, *2013 Integrated Energy Policy Report*, January 2014, available at http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.

9 CPUC, *Energy Efficiency Strategic Plan,* updated January 2011, available at http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.

10 Gov. Edmund G. Brown Jr., 2015 Inaugural Address, available at http://gov.ca.gov/news.php?id=18828

11 *Energy Action Plan II,* available at http://www.energy.ca.gov/energy_action_plan/2005-09-21_EAP2_FINAL.PDF , p. 2.

12 *Energy Action Plan II,* available at http://www.energy.ca.gov/energy_action_plan/2005-09-21_EAP2_FINAL.PDF, p. 3.

13 California Energy Commission and CPUC, *Long-Term Energy Efficiency Strategic Plan,* updated January 2011, available at http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.

14 California Energy Commission and CPUC, *Long-Term Energy Efficiency Strategic Plan*, available at http://www.cpuc.ca.gov/NR/rdonlyres/14D34133-4741-4EBC-85EA-8AE8CF69D36F/0/EESP_onepager.pdf , p. 1.

These strategies were selected based on their ability to achieve significant energy efficiency savings and bring energy-efficient technologies and products into the market.

On April 25, 2012, Governor Brown further targeted ZNE consumption for state-owned buildings. Executive Order B-18-12[15] requires ZNE consumption for 50 percent of the square footage of existing state-owned buildings by 2025 and ZNE consumption from all new or renovated state buildings beginning design after 2025.

To achieve these goals, the Energy Commission has committed to adopting and implementing building and appliance regulations that reduce wasteful energy and water consumption. The *Long-Term Energy Efficiency Strategic Plan* directs the Commission to develop a phased and accelerated "top-down" approach to more stringent codes and standards.[16] It also calls for expanding the scope of appliance standards to plug loads, process loads, and water use. The Commission adopted its detailed plan for fulfilling these objectives in the *2013 IEPR*.[17]

# Governor's Clean Energy Jobs Plan

On June 15, 2010, as a part of his election campaign, Governor Brown proposed the *Clean Energy Jobs Plan*,[18] which directed the Energy Commission to strengthen appliance efficiency standards for lighting, consumer electronics, and other products. The Governor noted that energy efficiency is the cheapest, fastest, and most reliable way to create jobs, save consumers money, and cut pollution from the power sector. He stated that California's efficiency standards and programs have triggered innovation and creativity in the market. Today's appliances are not only more efficient, but they are cheaper and more versatile than ever, due, in part, to California's leadership in the area.

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15 Office of Edmund G. Brown Jr., Executive Order B-18-12, April 25, 2012, available at http://www.gov.ca.gov/news.php?id=17506http://gov.ca.gov/news.php?id=17506; Senate Bill 350, Clean Energy and Pollution Reduction Act of 2015, De Leon, Ch. 547 (2015-2016 Reg. Session).
16 California Energy Commission and CPUC, *Long-Term Energy Efficiency Strategic Plan*, p. 64.
17 California Energy Commission, *2013 IEPR*, pp. 21-26.
18 Office of Edmund G. Brown Jr., *Clean Energy Jobs Plan,* available at http://gov.ca.gov/docs/Clean_Energy_Plan.pdf.

# PART A: POOL PUMPS AND MOTORS

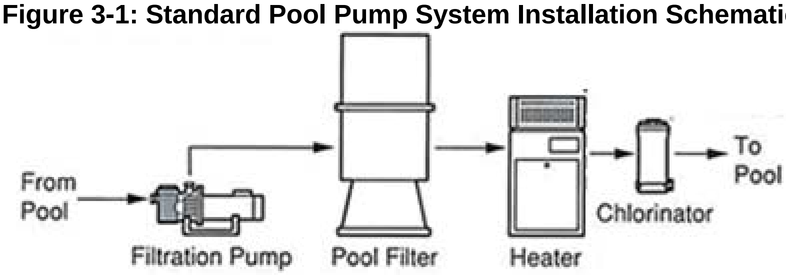
# CHAPTER 3: Product Description

## Overview of Pool Water Circulation System

The pool water circulation system incorporates technological advances in filtering and chlorination introduced to reduce frequent outbreaks in waterborne illness in the drinking supply system. Pool users demand that pool water be clean and clear, and that the water be free of disease-causing pathogens such as typhoid, dysentery, polio, and cholera. Although the first recorded use of chlorine in pools was in 1903,[19] health codes in the 1960s began to require chlorine as a pool disinfectant in response to polio outbreaks. The pool circulation system provides the essential functions to meet both aesthetic and safety requirements.[20]

A pool pump and motor combination circulates pool water through a filter and ensures adequate chlorination to maintain clarity and sanitation. The filter removes dirt, leaves, hair, insects, and other debris. The heater maintains the water temperature, and the chlorinator adds sanitizing disinfectants, oxidizers, and algaecides. A search of online pool pump and motor vendors shows many recommend that residential pool systems be designed to circulate the entire pool water volume in 8 to 12 hours.[21,22,23] Commercial pool systems are designed to complete circulation or turnover in 6 hours due to higher level of use.[24] A common pool system configuration including these components is seen in **Figure 3-1.**

**Figure 3-1: Standard Pool Pump System Installation Schematic**




Source: epoolshop.com

19 Olsen, Kevin, Clear Waters and a Green Gas: A History of Chlorine as a Swimming Pool Sanitizer in the United States, Bulletin for the History of Chemistry, Volume 32, Number 2, pp. 129-140, 2007.
20 *The History of Drinking Water Treatment*, U.S. EPA Feb, 2000, available at http://www.epa.gov/safewater/consumer/pdf/hist.pdf.
21 *Hayward Hydraulics and Pump Sizing for Existing Pools*, Hayward Industries, 2011, p. 7, available at http://www.nuccibros.com/sec_0934drRb_dl/data_sheets/Hydraulics%20%20and%20Pump%20Sizing%20for%20Existing%20Pools%20Guide.pdf.
22 *How to Size a Pool Pump for Your In-Ground Pool*, INYO Pools, 2015, available at http://www.inyopools.com/HowToPage/how_to_size_a_pool_pump_for_your_in_ground_pool_.aspx.
23 *Pool Pump Sizing*, poolplaza.com, 2015, available at https://www.poolplaza.com/pool-pump-sizing.
24 California Health and Safety Code Sections 116064.2 (b) (2) (E).

Pool maintenance programs are typically broken up into filtering, heating, and cleaning applications. An in-ground spa will require an additional application to provide high-speed jets for spa massage. These maintenance applications, as well as the pool equipment types, pool plumbing design, and pool volume, influence the pool pump and motor sizing.

Filtering is the primary maintenance task for pools. A filtering time should be selected that will ensure adequate water turnover (that is, the entire pool water volume will be filtered once per day). Significant energy and cost savings can be achieved if the pump is set to the lowest possible speed that will result in complete water filtration. In addition, at lower speeds, the filtration system will more completely clean the water as less water will bypass the filter at lower flow rates.

Heating requires a minimum flow rate to ensure efficient heat transfer within the heating system and to protect against overheating. A moderate to high flow rate should be selected according to the heater guidelines.

The cleaning and in-ground spa tasks require the highest flow. Cleaning provides a high flow rate into the pool to stir up settled debris so that it is captured by the filter. Running the jets in an in-ground spa applications also requires a high flow to provide the user with a therapeutic massage. The cleaning and jet tasks are typically shorter than the pool filtering task.

**Figure 3-2: Pool Plumbing System Complete With Filter, Heater, Skimmer, and Pump and Motor Combination**

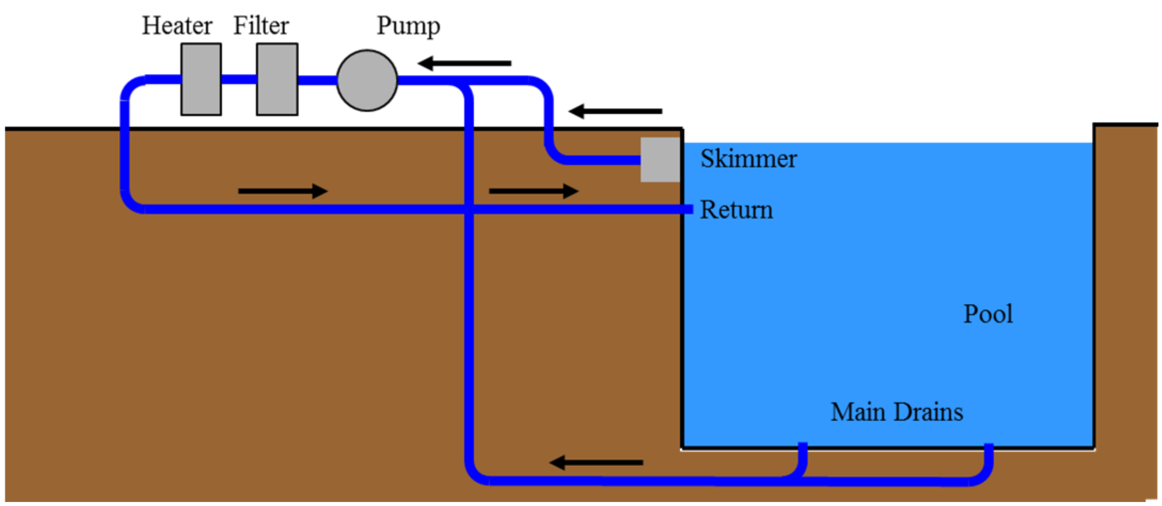



Illustration Credit: Staff illustration

The pool pump-motor combination may also be called upon to provide water flow to the pool sweeper and vacuum and to run water features such as a waterfall or fountain. Motors used in these applications are run at full speed for longer durations, resulting in substantial energy consumption.[25] Some pool systems may employ a second pool pump motor combination, commonly referred to as a *pool booster pump*, to provide high pressure to drive the pool sweeper and vacuum. An additional pool pump motor combination, known as a *waterfall pump*, may be added to the system to supply water to a decorative waterfall.

A pool owner can achieve significant energy savings by running the pool pump and motor combination at the lowest available motor speed that meets the minimum water flow requirements of the task.[26] Different motor technologies exist to allow the consumer to select the speed adequate to the pool maintenance task to achieve energy savings. Variable-speed pool pump and motor combinations provide the most flexibility and provide the greatest savings. Dual-speed motors provide a low-speed choice to enable savings for the pool filtering task. Single-speed pool pump and motors require all pool maintenance tasks to be run at full speed and do not provide a choice in motor speeds.

## Pump and Motor Equipment Description

A pool pump relies on an end suction centrifugal rotor design to move the water through the system. The pump draws water through the center of the impeller, or rotor, of the pump and generates a pressure force sufficient to overcome flow resistance in the plumbing system of the pool. The pressure head forces the water through the pool plumbing, filtering equipment, and heater. Pool pumps use end-suction centrifugal pump designs exclusively due to the low initial cost, low complexity, and moderate energy efficiency when compared to double suction centrifugal pumps or positive displacement pumps.[27]

An electric motor powers the pump by converting electrical energy to rotational energy. The electric motor is typically sized between 0.1 and 5.0 nameplate hp. The motor may provide single-speed, dual-speed, multiple-speed, or variable-speed operation, depending upon the electric motor design.

Pool pump and motor combinations are typically sold when a consumer installs a pool or upgrades an existing pool pump and motor combination from a single-speed to a dual-speed or variable-speed system. Pool pump and motor combinations are also sold with above-ground storable pools. As a low-cost alternative, electric motor manufacturers sell replacement pool pump motors since the motor typically fails before the pump. Electric motors used in pool pump applications have a lifetime expectancy depending upon pool pump and motor combination type. A recent survey of pool pump and motor combination manufacturers by the

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25 U.S. DOE, *Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings*, pp. 2-3, available at http://www.nrel.gov/docs/fy12osti/54242.pdf.
26 *Variable Speed Pumping, A Guide to Successful Applications*, Executive Summary, pp. 4-5 available at http://www.energy.gov/sites/prod/files/2014/05/f16/variable_speed_pumping.pdf.
27 *Improving Pumping System Performance, A Sourcebook for Industry*, U.S. DOE Second Edition, pp. 13-14, available at http://energy.gov/sites/prod/files/2014/05/f16/pump.pdf.

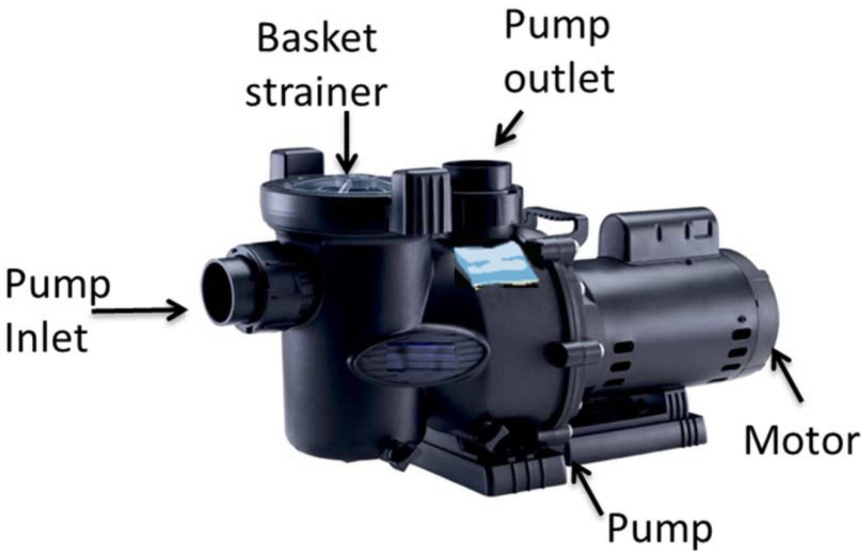
U.S. DOE found life expectancies vary, as shown in **Table 3-1.**[28] Replacement pool pump motors are included within the scope of this report. **Figure 3-3** shows a typical pool pump and motor combination. **Figure 3-4** shows a typical replacement pool pump motor.

**Table 3-1: Average Product Lifetime**

| | **Average Lifetime (years)** | | |
|---|---|---|---|
| **Pump Type** | **Single-Speed** | **Dual-Speed** | **Variable-Speed** |
| Self-priming filter pumps | 7 | 7 | 7 |
| Non-self-priming filter pumps | 5 | 5 | 5 |
| Waterfall pumps | 7 | Not Available | Not Available |
| Pressure cleaner booster pumps | 5 | Not Available | Not Available |
| Integral cartridge/sand filter pumps | 4 | Not Available | Not Available |

Source: U.S. Department of Energy, Building Technologies Office

**Figure 3-3: Pool Pump and Motor Combination**




Source: Hayward Pools

28 April 18-19, 2016, Meeting slides for the Dedicated Purpose Pool Pumps (DPPP) Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Working Group, U.S. Department of Energy Building Technologies Office, Slide 45. Docket ID EERE-2015-BT-STD-0008, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0067.

**Figure 3-4: Replacement Pool Pump Motor**

Source: Century A.O. Smith

## Pool Circulation System Energy Consumption

The pool circulation energy consumption consists of the energy dissipated by the circulation process since the pool water begins and ends in the same location. The pool water is drawn from the pool, pushed through the plumbing system, and returned to the pool. The energy is dissipated by energy losses in the electrical motor and frictional losses within the plumbing system.

The total energy consumption of a pool circulation system depends on the motor efficiency, the pump efficiency, pool plumbing configuration, and the options available to the user to select pump motor speed and run time.

In-ground public swimming pool and plumbing configurations are regulated by California Health and Safety Code (Sections 116025 through 116068) and California Building Code, California Code of Regulations, Title 24, Part 2 (Sections 3101B through 3162). Residential in-ground and above-ground swimming pools and spas are regulated by California Building Code, California Code of Regulations, Title 24, Part 6 (Sections 110.4 and 150.0 [p]). The requirements control the design of new pools and the significant retrofit of existing in-ground public swimming pools and residential in-ground and above-ground swimming pools and spas to ensure safe and energy-efficient pools and pool maintenance. The regulations control the placement of pool inlets and outlets, skimmers and drains, pipe sizing, and the use of pipe elbows. The pool system configuration requirements are outside the scope of the Title 20 *Appliance Efficiency Standards*, but understanding them is relevant to determining the representative energy performance of the pool pump and motor.

The California Health and Safety Code and the California Building Code do not regulate portable, inflatable, and storable swimming pool plumbing configurations.

The energy dissipated in the plumbing system is proportional to the speed or flow rate that the water is pushed through plumbing system.[29] The energy loss phenomenon is similar to the energy losses encountered by a car from wind resistance. Just as a car will achieve better fuel economy at lower speeds by reducing the wind resistance, a pool system will achieve greater efficiency by reducing the resistance in the plumbing system at lower flow rates. The phenomenon is described by the three pump affinity laws shown below that are applicable to a wide field of systems using pumps and fans, and including pool circulation systems. The laws describe how varying the pump rotational speed affects the flow rate, pressure, and power performance of a pump system.

**Pump Affinity Law 1 Flow Rate (gallon per minute)**

$q_1/q_2 = (n_1/n_2)$

where q = volume flow rate (gpm) and n = Motor Speed - revolution per minute (rpm)

**Pump Affinity Law 2 Head or Pressure (psi)**

$h_1/h_2 = (n_1/n_2)^2$

where h = head or pressure (psi)

**Pump Affinity Law 3 Power (kW or hp)**

$P_1/P_2 = (n_1/n_2)^3$

where P = power (kW, hp)

**Energy Consumption (kWh)**

Energy = Power × time

According to the pump affinity laws, there is a cubic relationship between the power requirement of the motor and the rotational speed of the attached pump. Therefore, if a pump rotor speed were reduced to one-half of the maximum, the electrical power demanded by the motor would be reduced to one eighth of its maximum. The pump affinity laws also state that the volumetric flow rate is directly proportional to the speed of the motor. For example, the volumetric flow rate through a pump would be reduced by half if the rotational speed of the attached pump is reduced by half.[30] To achieve the same volume of flow, the pump must be run twice as long at half-speed. The total energy consumed then, as defined by power multiplied by time, is 25 percent of the energy to move the same quantity of water at the full speed of the pump. Substantial energy savings can be realized by running the motor at the lowest speed adequate to meet the needs of the pool maintenance application.

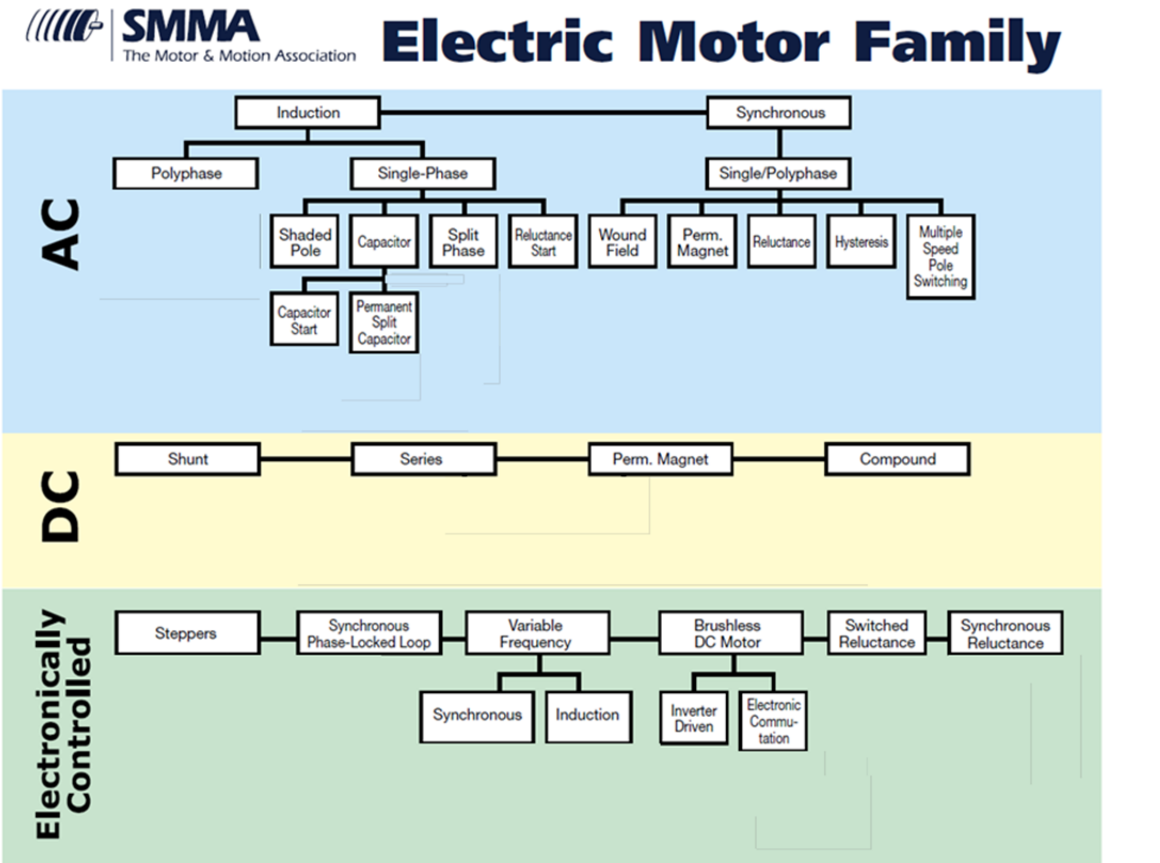
29 U.S. DOE, *Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings*, pp. 3-4, available at http://www.nrel.gov/docs/fy12osti/54242.pdf.
30 *Pump Affinity Laws*, The Engineering Toolbox, available at http://www.engineeringtoolbox.com/affinity-laws-d_408.html.

## Motor Energy Consumption and Efficiency

The type, design, and size of the electric motor determine the efficiency of the motor. Motor types for pool circulation applications include single-phase alternating current (AC) induction, three-phase AC induction, permanent magnet synchronous, variable-frequency-driven AC induction, and electrically commutated brushless motors (ECM). Smaller portable or storable pools use permanent magnet synchronous and AC induction pool pump motors. Single-phase AC induction motors can achieve full-speed efficiencies between 64 and 83 percent, and three-phase induction AC and electronically commutated motors can achieve full speed efficiencies between 77 and 92 percent.[31] Three-phase AC induction motors are more energy-efficient than single-phase induction motors although the application is limited to sites that have three-phase electrical service. Different motor types are summarized by power type and motor technologies, as seen in **Figure 3-5**. The ranges of efficiency and differences between motor types are discussed in Chapter 8.

31 Average motor efficiency of models in the Appliance Efficiency Database of Title 20-compliant pool pump motors.

**Figure 3-5: Electric Motor Types by Power Source and Motor Technology**




Source: Small Motors and Motion Association

## Pool Pump and Motor Categories

### Single-Speed Pumps

Single-speed pool pumps are powered by single-phase or three-phase AC induction motors and permanent magnet synchronous motors. ECM motors could also power single-speed pool pumps, although none are certified in the appliance database as of March 2016. The motor design requires full-speed operation at the highest flow and pressure capacity for the pump. Single-speed pumps cost significantly less and are simpler to install and control than dual-, multiple-, or variable-speed pumps. Due to the simplicity of installation and low cost, most pool pump motors in California are single-speed motors.[32]

Single-speed pumps are the least energy-efficient pool pump type because the pump and motor must be run at full speed for all pool operations. Single-speed pump and motors dominate the

32 Eaton, Eileen, *CEE High Efficiency Residential Swimming Pool Initiative*, December 2012, pp. 18-19.

pool pump market even as more energy-efficient designs are mandated by regulation.[33] Single-speed pump and motors persist in the market due to a lack of awareness among consumers and contractors regarding the regulation and energy savings of more efficient pump designs. An additional barrier is a need to educate pool contractors on how to select, install, and configure non-single-speed pump systems to achieve energy savings while maintaining pool cleanliness.[34]

**Dual-/Multiple-Speed Pumps**

Dual-speed pump motors are powered by single-phase AC induction motors. The motor design allows for dual-speed operation at full and half speeds for the pump and motor. At full speed, equivalent to a single-speed pump operation, the pump generates the highest flow and pressure, but this is the least energy-efficient operational speed due to higher frictional losses within the pool plumbing system. The cleaning and vacuuming tasks of the pool require full-speed pump and motor operation to agitate and remove debris as effectively as possible. The circulation for filtration tasks of the pool requires less flow and pressure, making the half-speed operation suitable for these tasks.[35] The lower operating speed results in more energy-efficient operation because losses within the pool plumbing system are minimized. While the pump will need to operate twice as long to move the same quantity of water, the power consumption during this time will be 1/8, resulting in roughly 75 percent energy savings over full-speed operation. Multiple-speed pump motors are similar in construction to dual-speed pump motors but allow the user to select from three or more set speeds, rather than just half speed and full speed. The multiple-speed pump may allow a user to select a more suitable and lower power pump speed for the task and, thereby, provide more savings.

**Variable-Speed Pumps**

Variable-speed pump motors are powered by ECM motors that allow a user to select a speed most appropriate for the pool maintenance task. Electronics on board the motor modify the incoming AC current and commutate the current to a three-phase wave form to set the motor speed and minimize electrical losses within the motor. A variable-speed motor may provide speeds between a minimum of 1/8 of full speed to full speed.[36]

A variable-speed pool pump motor accrues energy savings exceeding dual- and multiple-speed motors in two ways. First, the user may select a speed slower than half speed or the lowest set

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33 CASE Report, *Analysis of Standards Proposal for Residential Swimming Pool & Portable Spa Equipment*, pp. 20-22, available at http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2F_Residential_Pool_Pumps_and_Replacement_Motors/California_IOUs_Response_to_the_Invitation_to_Submit_Proposals_for_Pool_and_Spas_2013-07-29_TN-71756.pdf.
34 Eaton, Eileen, *CEE High Efficiency Residential Swimming Pool Initiative*, Consortium for Energy Efficiency, Inc., Dec. 2012, pp. 18-20.
35 Davis Energy Group, *Analysis of Standards Options for Residential Pool Pumps, Motors, and Controls*, pp. 11-12, available at http://consensus.fsu.edu/FBC/Pool-Efficiency/CASE_Pool_Pump.pdf.
36 CASE Report, *Analysis of Standards Proposal for Residential Swimming Pool & Portable Spa Equipment*, pp. 5-6, available at http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2F_Residential_Pool_Pumps_and_Replacement_Motors/California_IOUs_Response_to_the_Invitation_to_Submit_Proposals_for_Pool_and_Spas_2013-07-29_TN-71756.pdf.

speed on a multiple-speed motor to accomplish the circulation and filtering tasks, resulting in energy savings. In addition, the slower speeds achieved by variable-speed motors offer quieter operation and longer service life than can be achieved at half speed with a dual-speed motor.

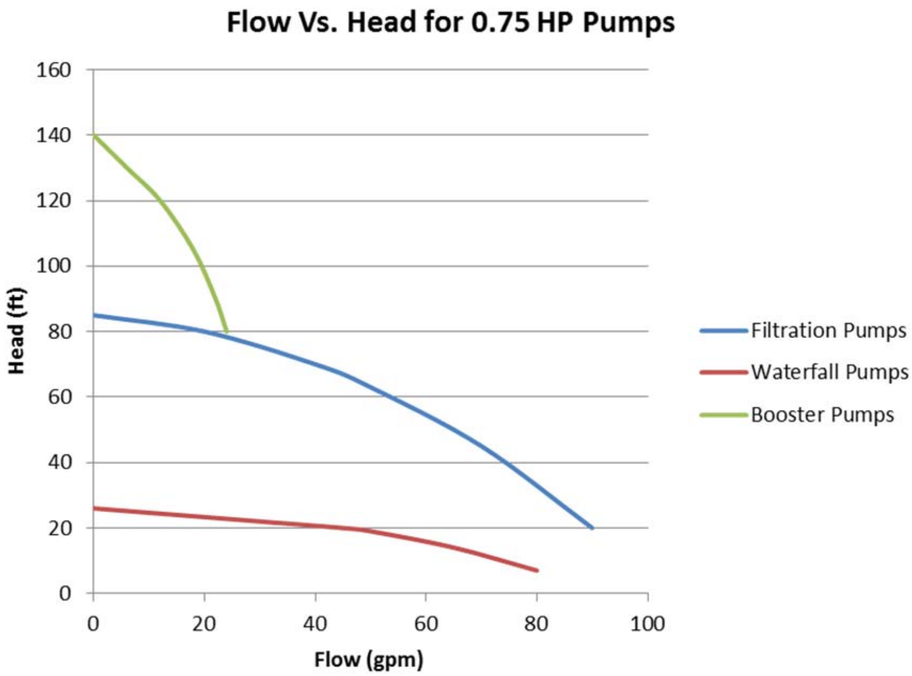
Second, variable-speed motors use a permanent magnet rotor design that replaces the electromagnetic rotor design in AC induction motors. The variable-speed motor achieves greater efficiency than the AC induction motor while running at the same speed because no current is required to power the rotor magnet, as is required by the AC induction motor.[37]

**Pump and Motor Combinations for Various Intended Uses**

Manufacturers have developed varieties of pool pump and motor combinations and optimized the pool pump and motor design for the intended use. In-ground, above-ground, and portable pool filtration pumps, as well as specialty pressure cleaner booster pumps and waterfall pumps, are adapted to meet the unique pressure and flow requirements of the intended use. The pumps are not interchangeable and would not offer satisfactory operation if not used for the intended purpose. **Figure 3-6** shows a comparison of 0.75 hp (nameplate) pool pump performance curves. **Figure 3-7** shows a comparison of pool constructions. Pool pump and motor combinations intended for all pool types are within the scope of the proposed rulemaking.

37 *Machine Design, The Difference Between AC Induction, Permanent Magnet, and Servomotor Technologies*, available at http://machinedesign.com/motorsdrives/difference-between-ac-induction-permanent-magnet-and-servomotor-technologies.

**Figure 3-6: Pump Performance Curve Comparison**




Source: Staff illustration

**Figure 3-7: Representative In-Ground, Above-Ground and Portable/Storable Pools**

Source: Staff illustration with photos from vinyl in-ground pools, Aquamagazine.com, and Arthurpools.com

### In-Ground Filtering Pool Pump and Motor Combinations

In-ground pool filtering pumps and motors are supplied with pump heads capable of moderate pressure and moderate-to-high flow rates to meet the primary objective of filtering the pool water. They are self-priming by the use of a diffuser that draws water into the impeller to help the pump achieve prime since the pumps are installed above the pool water level. In-ground filtering pumps are available with single-speed, dual-speed, and variable-speed motors. In-ground pump and motor combinations are sold with or require a basket strainer before the impeller to prevent debris from clogging the pump. Some in-ground filtering pumps and motor combinations and replacement motors incorporate a freeze protection feature. The freeze protection automatically turns on the pump to move water to prevent the pump and piping from freezing during cold weather. An in-ground filtering pump is shown in **Figure 3-3**.

### Above-Ground Filtering Pool Pump and Motor Combinations

Above-ground filtering pumps are similar in design to in-ground filtering pumps with the exception that they are non-self-priming since they are installed below the pool water level. Above-ground filtering pool pumps are available with single-, dual-, and variable-speed motors. Above-ground pool pumps also require a basket strainer to remove debris from the pool water. **Figure 3-8** shows a typical above-ground pool pump and motor combination.

**Figure 3-8: Above-Ground Filtering Pool Pump and Motor Combination**


Source: Pentair

### Portable and Storable Filtering Pool Pump and Motor Combinations

Portable and storable pools are seasonal pools intended to be set up and taken down each year to serve the swimming season typically estimated between 100 to 150 days.[38] The portable and storable pool pumps use AC induction and permanent magnet synchronous motors and are typically only single-speed. The pumps do not require a basket strainer and instead are sold with an integrated cartridge or sand filter. **Figure 3-9** shows an integrated cartridge filter pump and sand filter pump.

**Figure 3-9 Portable and Storable Pool Pump Motor Combinations**


Source: Intex

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38 Matthew Vartola, Comment to the Docket 15-AAER-02, TN 210550, February 29, 2016, http://docketpublic.energy.ca.gov/PublicDocuments/15-AAER-02/TN210550_20160229T035915_Matthew_Vartola_Comments_Pool_Pump_Staff_Workshop.pdf.

**Pressure Cleaner Booster Pump and Motor Combinations**

Pressure cleaner booster pumps and motor combinations provide a high-pressure, low-flow water supply to provide hydraulic power to drive a robotic cleaner. Booster pumps are non-self-priming and rely on the filtration pump to be run at the same time to provide prime to the booster pump. Booster pumps typically use single-speed AC induction motors and rely on the use of flow restrictors and pressure regulating valves to reduce excess flow to the cleaner.

**Figure 3-10: Pressure Cleaner Booster Pump and Motor Combination**

Source: Polaris

**Waterfall Pump and Motor Combinations**

Waterfall pumps share many of the characteristics of the in-ground filtering pumps, including the basket strainer and AC induction motor. Waterfall pumps are intended for applications with a high flow and low head. Waterfall pumps typically are run at a single speed of 1,725 revolutions per minute (RPM), or equivalent to half speed.

**Figure 3-11: Waterfall Pump and Motor Combination**

Source: Jandy

**Residential and Commercial Pool Pumps and Motor Combinations**

A survey of manufacturer marketing materials shows manufacturers designate the same in-ground filtering pool pumps for both residential and commercial applications for pump 5 hp total capacity or less.[39]

39 Pentair product catalog, Section 8 Pumps, pg 168, 2016, https://www.pentairpartners.com/productcatalog/pdf/US2016/sec08_Pumps.pdf.

### Three-Phase Pool Pump and Motor Combinations

Some manufacturers offer three-phase AC induction and ECM motors for use at homes and commercial facilities where three-phase AC induction power is available. Pump and motor combinations with three-phase power inputs share the characteristics of in-ground pool pump and motors, such as self-priming and basket strainers. Three-phase pool pump and motor combinations that are 5 hp total capacity and less are considered in the scope of the rulemaking.

### Freeze Protection Functionality

The freeze protection function provides automatic water flow through the pool plumbing system to prevent damage when the air temperatures are near the freezing temperature of water. Freeze protection is initiated when the pool pump and motor combination senses an air temperature below a set point, typically 40 degrees Fahrenheit (F), and begins the flow of water. The pumping will continue for a period determined by the freeze protection settings. The heat from the pool water prevents damage from freezing. The freeze protection feature is now found on pool pump and motor combinations and replacement pool pump motors with integrated controls. The default settings for starting temperature, pump duration, and motor speed vary by manufacturer.[40]

40 California Investor Owned Utilities (CA IOUs), 2015-12-04 Working Group Material: Stakeholder Preliminary Freeze Protection Research Spreadsheet, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0047.

# CHAPTER 4: Regulatory Approaches

## Historical Approach

The Energy Commission did not regulate pool pumps and motors before 2004. Most pool pump and motor systems used single-speed motors, with some systems using inefficient electric motor types. In 2004, the Commission adopted standards for residential pool pumps and motors, which included a prohibition on inefficient split-phase or capacitor-start induction-run electric motors and a requirement that all pumps and motors that have a total horsepower of 1 hp or greater provide at least two-speed operation and controllers. The 2004 standards prohibited split-phase or capacitor-start induction motors effective in January 2006, and the two-speed requirements for pool pump motors with a total horsepower of 1 hp or greater took effect in January 2008.

In 2008, the Commission revised the 2004 standards to include a requirement that motors with a total horsepower of 1 hp or greater, manufactured after January 2010, shall be capable of at least two speeds or be of variable-speed design. The scope of the regulation was expanded to include replacement residential pool pump motors.[41]

California's regulation has required that manufacturers test and certify all pool pump and motor combinations and replacement pool pump motors sold or offered for sale in California. The testing includes motor efficiency and pump performance along three hydraulic system curves, A, B, and C, intended to simulate the types of pools found in California.

## Federal Regulations

There are no federal standards for pool pumps and motors.

The U.S. Department of Energy (U.S. DOE) is undertaking a rulemaking to consider new energy conservation standards and test procedures for dedicated purpose pool pumps.[42] The standards are under negotiation through a working group formed by the Appliance Standards and Rulemaking federal Advisory Committee. The Energy Commission is a member of this working group.

41 Chrisman, Betty, Harinder Singh, Gary Flamm, and William Staak, *Proposed Amendments to the Appliance Efficiency Regulations*, Dec. 2008, p. 2, available at http://energy.ca.gov/2008publications/CEC-400-2008-021/CEC-400-2008-021-15DAY.pdf.

42 U.S. DOE, Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards for Dedicated-Purpose Pool Pumps, Docket Number EERE-2015-BT-STD-0008, available at https://www.regulations.gov/#!docketDetail;D=EERE-2015-BT-STD-0008.

## California Regulations

The 2013 California Building Code set standards to regulate the construction and operation of public swimming pools. Both regulations require that the pool circulation system must achieve a six-hour turnover time and that the circulation volume during in-use periods not fall below 65 percent of the six-hour turnover time.[43]

The Energy Standards (California Code of Regulations, Title 24, Part 6) incorporate the Title 20 requirements for pool pumps and motor combinations and provide further requirements for sizing the pumping equipment based upon pool size. Pool pump and motor combinations over 1 hp are required to be multiple-speed. The Energy Standards place requirements on system piping, filters, and valves to ensure energy-efficient operation.[44]

## Regulations in Other States

Arizona enacted Title 44, Section 1375.02 (B) (2), Pool and Spa Energy Requirements, that require all pool pumps and pool pump motors to be certified in the Association of Pool and Spa Professionals' database or the Energy Commission database. The regulation carries the same prohibition as California on motor types as well as the requirement for two speeds for motors above 1 total hp. The law became effective January 1, 2012.

Florida enacted Florida Building Code, Section 403.9.4, that carries the same prohibition as California on motor types, as well as the requirement for two speeds for motors above 1 total hp. The law provides an exception for the default low-speed operation during periods of high solar heat gain. The law also requires compliance with national energy standards ANSI/APSP 15 for residential pools and in-ground spas for new construction. The law became effective December 31, 2011.

Washington enacted Washington Building Code, Section 403.9.4, that carries the same prohibition as California on motor types as well as the requirement for a minimum of two speeds for motors above 1 total hp. The law became effective January 1, 2010.

Connecticut and New York have adopted residential pool pump standards similar to the California Title 20 regulations.[45]

Texas, Nevada, Michigan, Oregon, and New Jersey have considered legislative bills to adopt standards similar to the California Title 20 regulations for pools and spas.[46]

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43 California Building Code. Title 24, Chapter 31B, Sections 3101B – 3162, available at http://www.ecodes.biz/ecodes_support/free_resources/2013California/13Building/PDFs/Chapter%2031B%20-%20Public%20Swimming%20Pools.pdf.
44 Energy Commission Building Standard Section 150.0 (N) Pool Systems and Equipment Installation, available at http://www.energy.ca.gov/2012publications/CEC-400-2012-004/CEC-400-2012-004-CMF-REV2.pdf.
45 http://library.cee1.org/sites/default/files/library/9986/cee_res_swimmingpoolinitiative_07dec2012_pdf_10557.pdf.
46 http://www.poolspanews.com/legislation/states-introduce-out-of-date-energy-laws.aspx.

## ENERGY STAR®

ENERGY STAR, a partnership program of the U.S. Environmental Protection Agency (U.S. EPA), collaborates with stakeholders to establish voluntary specifications for efficient appliances; among them are pool pumps and motors.

ENERGY STAR rates pool pump and motor combinations on an energy factor basis. The U.S. EPA defines energy factor as the volume of water pumped in gallons per watt hour of electric energy used. The U.S. EPA uses test procedures and hydraulic system curves to measure the pump and motor combination's performance identical to the California Title 20 regulation. Testing is required along system Curves A, B, and C. Manufacturers must meet the energy factor criteria for performance measured on system Curve A. Single-speed pump and motor combinations are tested at full speed while multispeed, dual-speed, and variable-speed pump and motor combinations are measured at the most efficient speed.[47] Products must achieve an energy factor of at least 3.8 at low speed to meet the ENERGY STAR product specification. An energy factor of 3.8 was chosen to encourage the sale of dual-speed or variable-speed pool pump and motor combinations.[48]

## The CASE Report

In July 2013, the California IOUs submitted a Codes and Standards Enhancement (CASE) report to the Energy Commission in response to the Commission's invitation to submit proposals.[49] In September 2014, the IOUs submitted a revised proposal for pool pump standards.[50] In general, the proposal recommends that the current prescriptive standards be replaced with performance standards for all pool pump and motor combinations and replacement motors that are less than a total horsepower of 5 hp by adding minimum efficiency requirements, measured at full speed and half speed. The proposal recommends the use of the Canadian Standards Association (CSA) test procedure C747-09 to verify compliance for motor efficiency.

The CASE team estimates the proposed standard would result in 63 GWh of energy savings in the first year and 630 GWh of energy savings each year after full stock turnover.[51]

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47 https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Pool%20Pumps%20-%20Program%20Requirements%20Version%201.1.pdf.
48 ENERGY STAR-Certified Pool Pumps, available at https://www.energystar.gov/products/certified-products/detail/pool-pumps.
49 CASE Report, *Pools & Spas* (July 29, 2013), available at http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2F_Residential_Pool_Pumps_and_Replacement_Motors/California_IOUs_Response_to_the_Invitation_to_Submit_Proposals_for_Pool_and_Spas_2013-07-29_TN-71756.pdf.
50 CASE Report, *Analysis of Standards Proposal for Residential Swimming Pool & Portable Spa Equipment*, available at http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2F_Residential_Pool_Pumps_and_Replacement_Motors/California_IOUs_Response_to_the_Invitation_to_Submit_Proposals_for_Pool_and_Spas_2013-07-29_TN-71756.pdf.
51 Stock turnover occurs when all pumps in California meet proposed standards.

# CHAPTER 5: Alternatives Consideration

Staff analyzed the proposal in the CASE report to determine whether it meets the legislative criteria for the Energy Commission's prescription of appliance efficiency standards. Staff also reviewed and analyzed state standards for (1) maintaining current Title 20 standards, (2) incorporating the CASE report suggestions, and (3) incorporating the CASE team proposal with uniform full-speed efficiency for all motor types. Staff also considered comments from interested parties made during the February 18, 2016, staff workshop and in written comments to Commission Docket 15-AAER-02.

## Alternative 1: Maintain Current Title 20 Appliance Standards

Under this alternative, staff would not amend the appliance efficiency standards for pool pump and motor combinations and pool pump motors. This would not achieve any additional energy savings. The Title 20 standards need to be updated to adequately reflect the current market. The standards rely on prescriptive definitions for pool pump and motor combinations and replacement pool pump motors that result in low compliance rates. Based on the increased market penetration of higher efficiency products, it is reasonable to raise the minimum efficiency requirements to better reflect the cost-effective savings these products offer.

## Alternative 2: Incorporate CASE Team Proposal

The CASE team proposal would establish minimum motor efficiency requirements (full- and half-speed) for all pump and motor combinations and replacement motors for residential and commercial pools that are less than 5 hp. The recommended efficiency standards for single-speed, dual-speed, and variable-/multiple-speed pump and motor combinations and replacement pump motors are shown in **Table 5-1**, and would go into effect one year from adoption. Most dual-speed motors in the Appliance Efficiency Database of certified pool pump motors qualify with the proposed full-speed motor efficiencies while only some pass the half-speed efficiency requirement. **Figure 5-1** plots pump and motor combinations certified in the database for both full- and half-speed motor efficiency.

The proposal recommends a half-speed requirement based on the half-speed horsepower of the motor. Dual-speed motors running at half-speed minimum efficiencies would vary between 48 percent at a total horsepower of 1 hp and 57 percent at a total horsepower of 5 hp. Variable-speed motors running at half-speed minimum efficiencies would vary between 63 percent at 1 total hp and 72 percent at a total horsepower of 5 hp. The proposal recommends a new CSA test method C747-09 to verify motor efficiency. This proposal would result in roughly 630 GWh of electricity savings once stock turnover is achieved in 2026.[52]

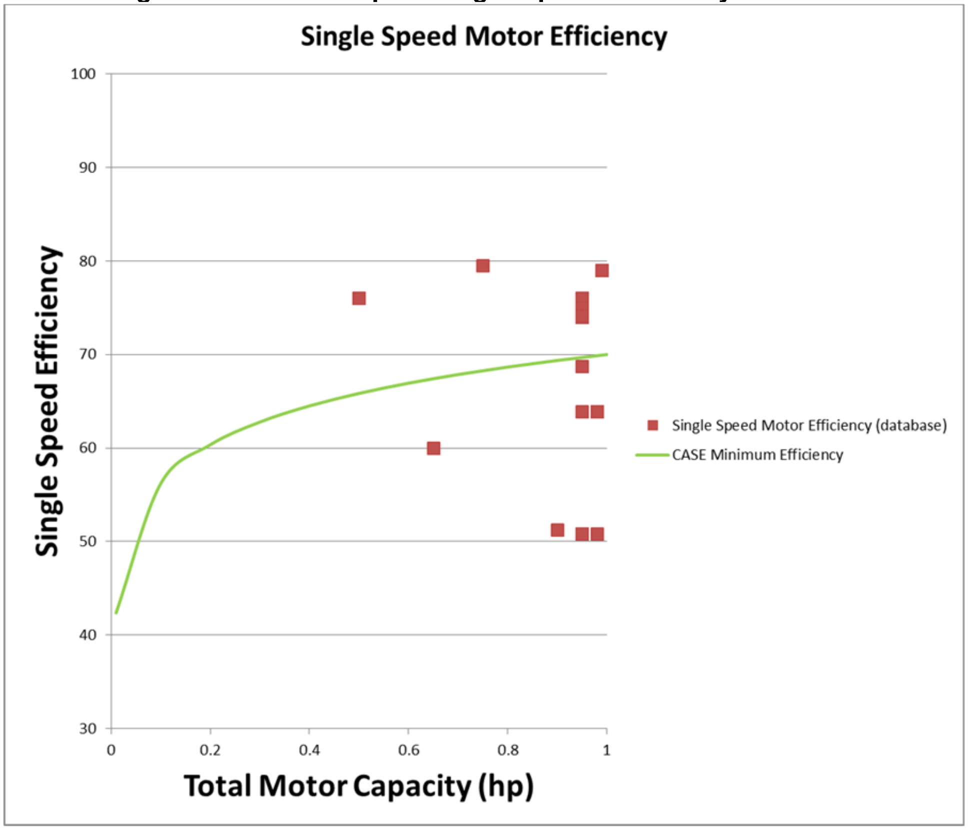
While the CASE team proposal offers significant energy savings, a more stringent standard can achieve additional savings.

**Table 5-1: IOU Proposed Standards for Pool Pump Motors – Effective July 1, 2017**

| Proposed Minimum Efficiency according to modified CSA C747-09 Test Procedure | | |
|---|---|---|
| **Motor Design** | **Full Speed (3450 RPM)** | **Half Speed (1725 RPM)** |
| Single Speed (upto 1 HP) | $(0.06 * \ln(HP_{3450}) + 0.7) * 100\%$ | N/A |
| Dual Speed | 70% | $(0.06 * \ln(HP_{1725}) + 0.6) * 100\%$ |
| Variable Speed/Multi-Speed | 80% | $(0.06 * \ln(HP_{1725}) + 0.75) * 100\%$ |

Source: CASE Team Data Revised Request Response, 9/30/2014

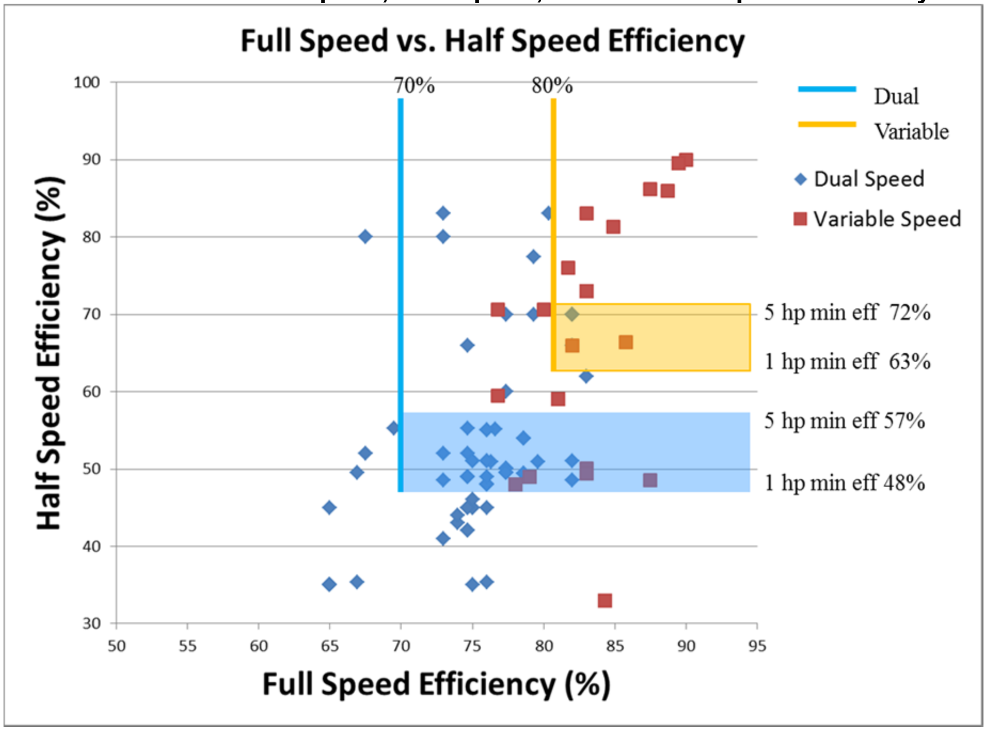
**Figure 5-1: CASE Report Single-Speed Efficiency Standard**




Source: Staff illustration with Appliance Efficiency Database data 6/30/2015

52 Worth, Chad, Gary Fernstrom, *Revised Data Request Response for Pool Pumps and Motors*, pp. 4-5, September 30, 2014. http://docketpublic.energy.ca.gov/PublicDocuments/Migration-12-22-2015/Non-Regulatory/12-AAER-2F/2014/TN%2073792%2010-03-14%20REVISED%20Data%20Request%20Response%20for%20POOL%20PUMPS%20AND%20MOTORS.pdf.

**Figure 5-2: CASE Team Dual-Speed, Multispeed, and Variable-Speed Efficiency Standard**




Source: Staff illustration with Appliance Efficiency Database data 6/30/2015

## Alternative 3: Incorporate CASE Team Proposal With Uniform Full-Speed Efficiency for All Motor Types

Staff proposed establishing a two-tiered motor efficiency approach (see **Tables 5-2** and **5-3**) in the January 2016 draft staff report. The Tier 1 and Tier 2 single-speed motor efficiency would be set equal to the dual-speed, multispeed, and variable-speed motor efficiency at full speed. The Tier 1 and Tier 2 effective dates would be one and four years from the adoption of the standard. Tier 1 will achieve 617 GWh/yr of electricity savings, while Tier 2 will achieve an additional 580 GWh/yr of electricity savings for a combined 1,197 GWh of savings per year after stock turnover. The savings presented in the previous staff report represented savings from considering filtering and nonfiltering pool pump and motor combinations.

**Table 5-2: Previous Staff Proposed Alternative 3, Tier I – Effective January 1, 2018**

| Proposed Minimum Efficiency According to Modified CSA C747-09 Test Procedure | | |
|---|---|---|
| **Motor Design** | **Full-Speed (3450 RPM)** | **Half-Speed (1725 RPM)** |
| Single-Speed (up to 1 total hp) | 70% | N/A |
| Variable-/Multiple-/Dual-Speed (1 to 5 total hp) | 70% | 50% |

Source: Energy Commission Staff

**Table 5-3: Previous Staff Proposed Alternative 3 Tier II Effective January 1, 2021.**

| Proposed Minimum Efficiency According to Modified CSA C747-09 Test Procedure | | |
|---|---|---|
| **Motor Design** | **Full Speed (3450 RPM)** | **Half Speed (1725 RPM)** |
| Single-Speed (up to 1 total hp) | 80% | N/A |
| Variable-/Multiple-/Dual-Speed (1-5 total hp) | 80% | 65% |

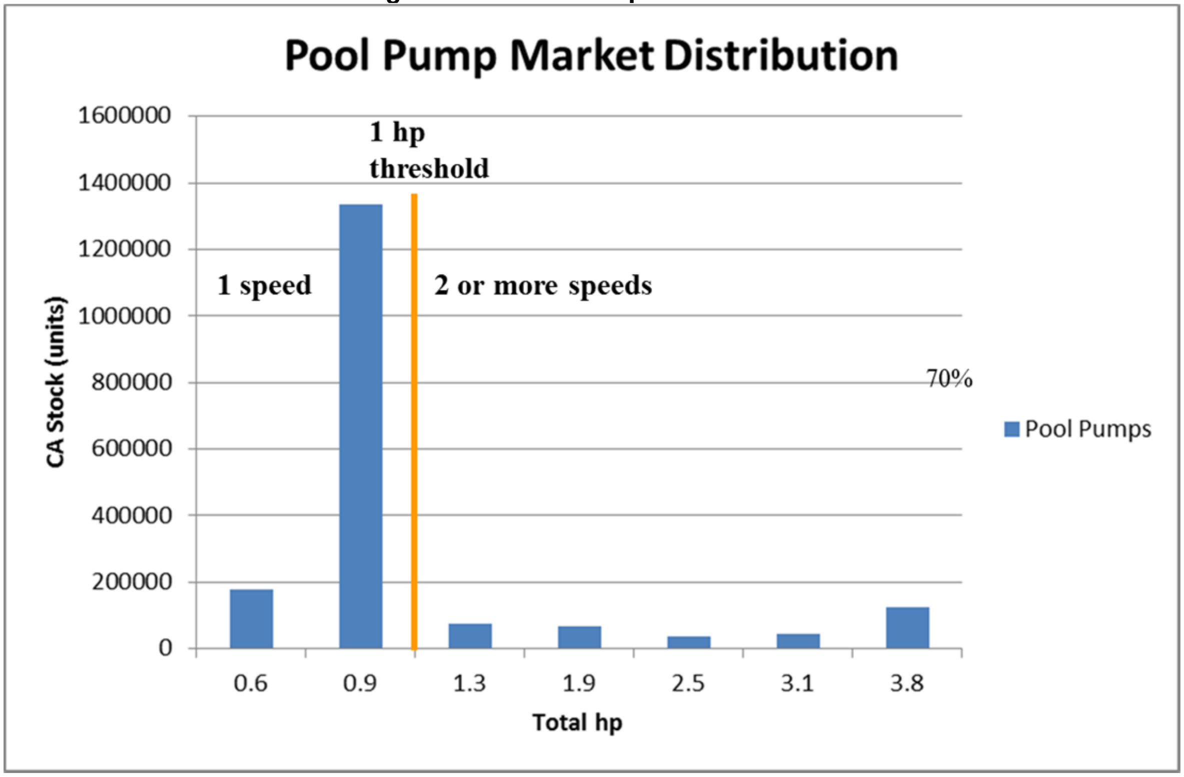
Source: Energy Commission Staff

In response to comments received during the February 18, 2016, workshop and in the Commission Docket as well as information made available by the U.S. DOE Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Dedicated Purpose Pool Pump (DPPP) Working Group. Staff proposes a single-tiered standard as shown in Table 5-4. The effective date would be two years from the adoption of the standard. Staff proposes the change based upon large quantity of available compliant models shown in the Energy Commission Appliance Database showing that the motor efficiency standard levels are technically feasible. The additional consumer price data presented at the US DOE ASRAC DPPP WG affirm the proposed standards cost effectiveness.

Staff considered changing the two or more speed requirement threshold from 1 total horsepower to 0.5 or 0.75 total horsepower to extend the savings from half-speed motor operation to a greater portion of the pool pump motor market. Figure **5-3** illustrates the distribution of pool pump motors within California as a function of total horsepower.[53] Lowering the two or more speed threshold could provide significant additional savings than are presented in the staff proposal. Staff seeks comments from the public regarding the 2 or more speed hp threshold.

53 Worth, Chad, Fernstrom, Gary, CASE Report, *Pools & Spas* (July 29, 2013), Table 5.1 pg. 20, available at http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2F_Residential_Pool_Pumps_and_Replacement_Motors/California_IOUs_Response_to_the_Invitation_to_Submit_Proposals_for_Pool_and_Spas_2013-07-29_TN-71756.pdf.

**Figure 5-3: Pool Pump Market Distribution**




Source: Staff illustration from 2013 CASE Report market data

In response to comments received during the February 18, 2016, workshop and in the Commission docket, staff proposes a prescriptive motor timer requirement in place of the minimum motor efficiency requirement for pool pump and motor combinations with integral cartridge filters and integral sand filters. The timer would automatically turn on and off the motor and provide a user-selectable pump operation not to exceed 12 hours of pumping time per 24-hour cycle. Staff estimates the timer requirement will save an additional 196 GWh/yr after stock turnover. The timer requirement will be effective January 1, 2019. Total savings for both the motor efficiency and timer requirements will be 1,277 GWh/yr after stock turnover. The current savings are updated to consider savings for filtering, pressure cleaner booster, and waterfall pool pump and motor combinations.

Staff proposes no minimum motor efficiency requirement for waterfall pool pumps. Waterfall pool pumps must be tested and certified by the Energy Commission. Testing would apply only to the maximum motor speed that by definition is roughly equivalent to half-speed for other motor types (1,725 rpm). Staff found insufficient cost-effective energy savings to propose a motor efficiency performance standard due to the low energy consumption and duty cycle. The test and list requirement would be effective January 1, 2019. The test conditions will be the flow at 17 feet of head set to be consistent with the proposed U.S. DOE test conditions.  The two-speed or more requirement would apply to waterfall pumps where the input power when tested at the maximum pump motor speed exceeds 750 watts.

Staff proposes a minimum motor efficiency requirement for pressure cleaner booster pump and motor combinations and replacement pressure cleaner booster pump motors. The motor efficiency standard would be identical to the standard presented. The test conditions will be the flow at 90 feet of head. Staff chose the pressure and flow conditions to be consistent with the proposed U.S. DOE test conditions.

Staff proposes prescriptive requirements for pool pump and motor combinations and replacement pool pump motors with the freeze protection function. The requirements would control default settings for minimum air temperature to initiate freeze protection, pumping duration before temperature recheck and motor speed during freeze protection.

As discussed in the following section, Alternative 3 is cost-effective and technically feasible and provides significant electrical energy savings.

**Table 5-4: Staff Proposed Alternative 3 – Effective January 1, 2019**

| Proposed Minimum Efficiency According to Modified CSA C747-09 Test Procedure | | |
|---|---|---|
| **Motor Design** | **Full-Speed (3450 RPM)** | **Half-Speed (1725 RPM)** |
| Single-Speed (0 total hp up to 0.49 total hp) | 70% | N/A |
| Single-Speed (0.50 total hp up to 0.99 total hp) | 75% | N/A |
| Variable-/Multiple-/Dual-Speed (1 to 5 total hp) | 80% | 65% |

Source: Energy Commission Staff

# CHAPTER 6:
# Staff Proposed Standards for Pool Pump and Motor Combinations and Replacement Pool Pump Motors

Staff analyzed the cost-effectiveness and technical feasibility of standards proposed in the CASE report, considered public comments, and surveyed the pool pump and motor combination and replacement motor market. Based on the information available, the savings resulting from reduced energy consumption under the proposed standards are significant and cost-effective to consumers. In addition, the proposed standards are attainable through products already available in the market.

## Scope and Definitions

Expanding the existing scope of pool pump and motor combinations and replacement pool pump motors will ensure that the standards can be enforced effectively. Pool pump and motor combinations (pump and motor sold together) and replacement pool pump motors (motors sold alone) that are used for filtration and circulation, to run water features and waterfalls, and as booster pumps will be covered under this proposal. The proposed scope will no longer distinguish between pool pumps used in residential pools and small commercial pools. The regulation will continue to apply to pumps and motors for both in-ground and above-ground pools.

The pool pump and motor definitions were amended to expand the scope by creating a new pool pump and motor combination definition that includes all pool pump and motor combinations, including the existing residential filtration pool pump and motor definition. The residential filtration pool pump and motor standard will be retained for those residential pool pump and motor combinations manufactured before the effective date of the proposed standard. Similar changes are proposed for the residential pool pump, residential pool pump motor, and replacement residential pool pump motor definitions.

Proposed definitions for pool filter pumps, pressure cleaner booster pumps, integral filter pumps, and waterfall pumps identify classes of pool pump and motor combinations and replacement pool pump motors. The classes proposed identify performance based on differences among different types of pumps and to propose standards and test conditions to account for the differences. Staff has modeled the definitions from the U.S. DOE ASRAC Dedicated Purpose Pool Pump (DPPP) Working Group effort in hopes of harmonizing the definitions between the state and federal rulemakings. The definitions provide a means to examine a product for physically verifiable characteristics to determine the classification of the products.

Staff proposes a new pool filter pump definition to include filtering pumps intended for in-ground and above-ground pools and that commonly rely on either self-priming or non-self-priming pumps. Staff considered comments made at the February 18, 2016, workshop, the Energy Commission docket, and the U.S. DOE ASRAC WG meetings, as well as performed independent reviews of manufacturers' technical and marketing materials. Staff concluded based upon this evidence that there was not sufficient difference in utility between self-priming pumps marketed for in-ground pools and non-self-priming pumps marketed for above-ground to justify separate definitions or standards. Staff found some pumps marketed as suitable for both above-ground and in-ground applications in the 48 motor frame, a motor size typically marketed for above-ground pools.[54] Staff proposes one definition and a unified performance standard for this equipment.

Since the U.S. DOE ASRAC DPPP Working Group has not proposed a pressure cleaner booster pool pump definition, staff proposes to define pressure cleaner booster pumps and motor combinations through the absence of a basket strainer and the high pressure to flow pump performance curve. Measuring five pump performance curve points, as is required by the ANSI/HI 40.6 test method and calculating the average pressure head-to-flow ratio, is also proposed. Pressure cleaner booster pool pumps would be identified as those above a calculated value of 2 feet of head per 1 gallon per minute of flow. **Figure 6-1** illustrates the differences between a typical pool filter pump and a pressure cleaner booster pump. **Tables 6-1** and **6-2** illustrate the definitions and the associated test method and standards.

**Table 6-1: Pool Pump and Motor Combination Definitions, Tests, and Standards**

| Pool Pump and Motor Combination | Pump Test per ANSI/HI 40.6-2014 Conditions | Motor Test Per CSA 747-09 | Test and List in Energy Commission Database | Minimum Motor Efficiency | Timer Requirement |
|---|---|---|---|---|---|
| Pool Filter Pump and Motor Combination | Curves A, B and C | yes | Yes | Yes | N/A |
| Integral Filter Pool Pump and Motor Combination | Curves A, B and C | yes | Yes | No | Timer |
| Pressure Cleaner Booster Pool Pump and Motor Combination | Flow at 90 ft of head | yes | Yes | Yes | N/A |
| Waterfall Pool Pump and Motor Combination | Flow at 17 ft of head | yes | Yes | N/A | N/A |

Source: California Energy Commission

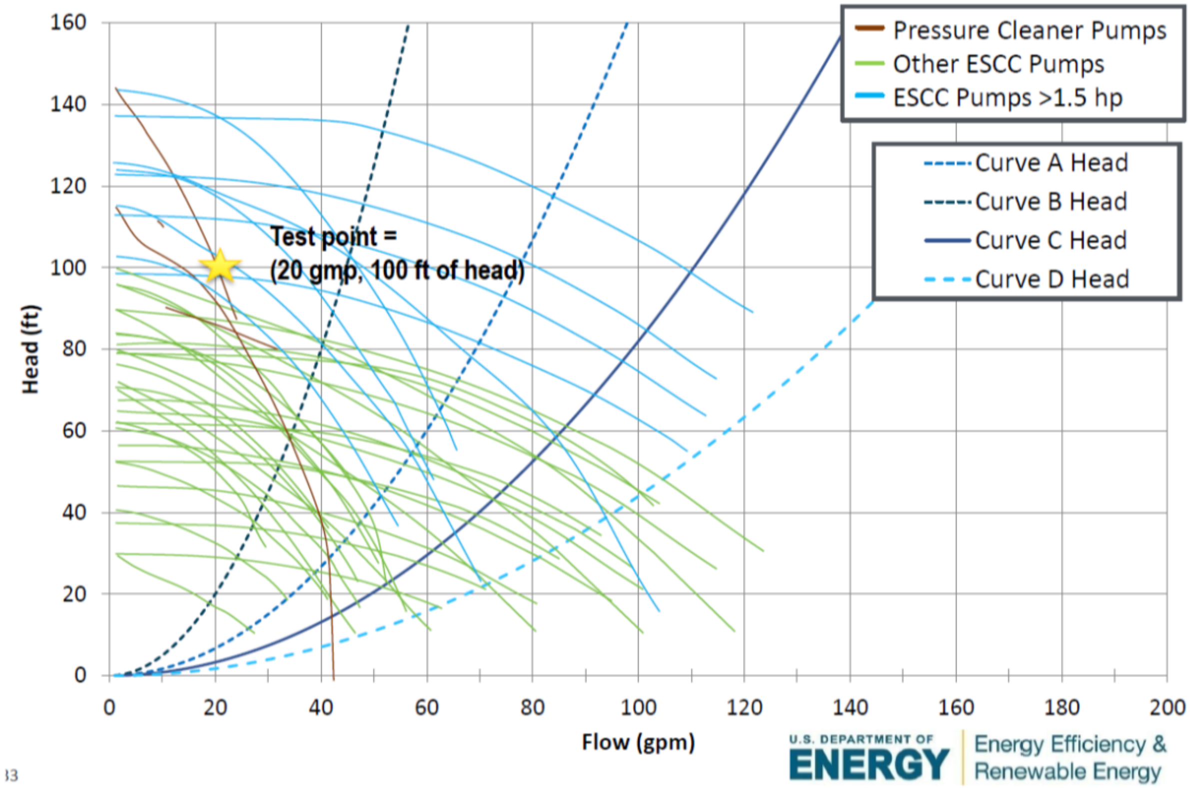
**Table 6-2: Replacement Pool Pump Definitions, Tests, and Standards**

| Replacement Pool Pump Motor | Pump Test per ANSI/HI 40.6-2014 Conditions | Motor Test Per CSA 747-09 | Test and List in Energy Commission Database | Minimum Motor Efficiency | Timer Requirement |
|---|---|---|---|---|---|
| Replacement Pool Filter Pump Motor | Not Applicable | yes | Yes | Yes | N/A |
| Replacement Pressure Cleaner Booster Pool Pump Motor | Not Applicable | yes | Yes | Yes | N/A |
| Replacement Waterfall Pool Pump Motor | Not Applicable | yes | Yes | N/A | N/A |

54 Hayward Pool Products, Super Pump VS 115V Brochure, pg. 2, http://www.hayward-pool.com/pdf/literature/super-pump-vs-115v-LITSUPVS11515.pdf.

Source: California Energy Commission

**Figure 6-1: Pool Filter Pump to Pressure Cleaner Booster Pump Performance Curve Comparison**




Source: U.S. Department of Energy, Building Technologies Office

# Motor Efficiency

Staff proposes standards for single-, dual-, multi-, and variable- speed motors sold in combination with pool pumps or sold separately as replacements. These proposed standards will take effect two years from adoption by the Energy Commission.  Motors sold in combinations or sold as replacements for integral filter pool pumps will need to meet a timer requirement rather than the motor efficiency requirement. No minimum motor efficiency standard is proposed for waterfall pool pump and motor combinations or replacement waterfall pool pump motors.

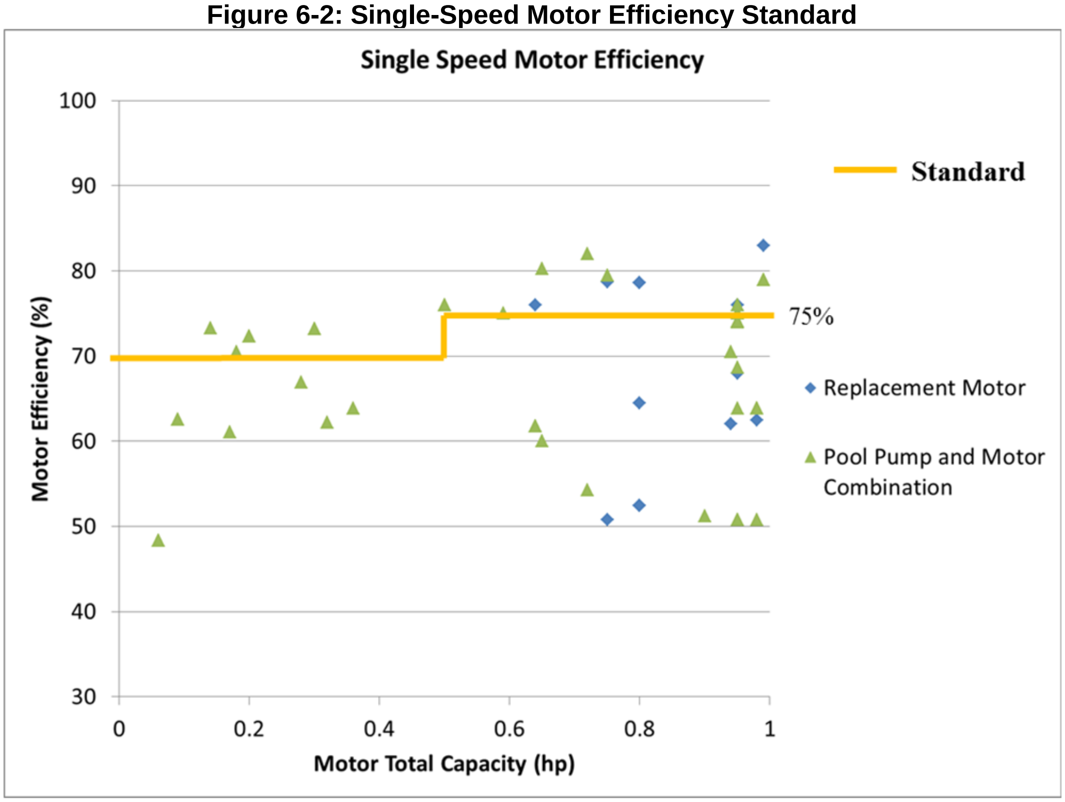
All pool pump motors, except those for integral filter pool pumps and waterfall pumps, which are a total horsepower of 5 or less, manufactured on or after January 1, 2019, shall meet the efficiency standards outlined in **Table 6-3**.

**Table 6-3: Proposed Standards for Pool Pump Motors**

| Proposed Minimum Efficiency According to Modified CSA C747-09 Test Procedure | | |
|---|---|---|
| **Motor Design** | **Full-Speed (3450 RPM)** | **Half-Speed (1725 RPM)** |
| Single-Speed (0 total hp up to 0.49 total hp) | 70% | N/A |
| Single-Speed (0.50 total hp up to 0.99 total hp) | 75% | N/A |
| Variable-/Multiple-/Dual-Speed (1 to 5 total hp) | 80% | 65% |

Source: California Energy Commission

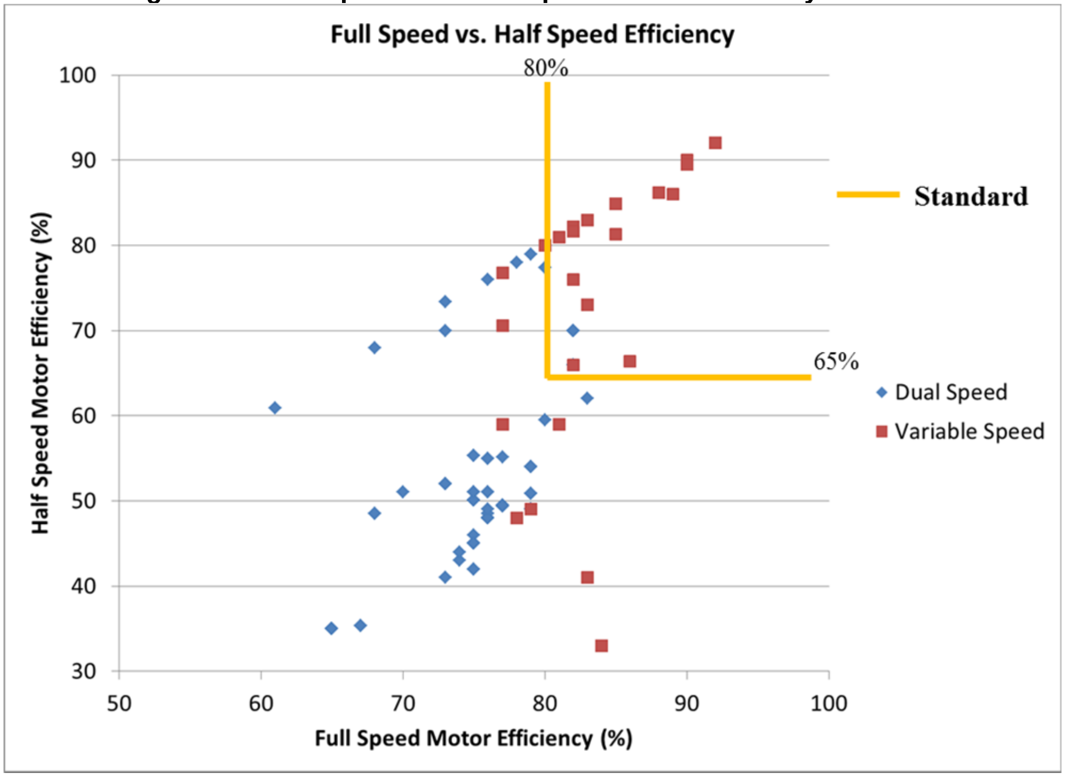
**Figure 6-2: Single-Speed Motor Efficiency Standard**




Source: California Energy Commission

A simultaneous full-speed and half-speed minimum pool pump motor efficiency is proposed for motors between 1 and 5 hp to impose minimum performance standards on the two primary duty cycles for these motors. The minimum efficiencies are proposed to achieve significant energy savings without imposing a significant burden on the pool pump motor industry, as many products are available in the market that meet the standards.

**Figure 6-3: Full-Speed and Half-Speed Motor Efficiency Standard**




Source: California Energy Commission

### Remove Prohibition on Split-Phase and Capacitor-Start Induction Run Motors

The prescriptive prohibition for split-phase and capacitor-start induction run motor types as the performance standard proposed in this staff report will exceed the energy savings from the prescriptive requirements. The prohibited motor types have full-speed efficiency in the range of 40 to 50 percent, which is considerably lower than the proposed full-speed efficiency standard.[55] The previously banned motor types could be sold in California under the proposed standard as long as they meet the minimum motor efficiency standard.

## Integral Filter Timer Requirement

A prescriptive motor timer requirement would replace the minimum motor efficiency requirement for pool pump and motor combinations and replacement pool pump motors with integral cartridge filters and integral sand filters. The timer would automatically turn on and off the motor and provide a user-selectable duration not to exceed 12 hours of pumping time

55 Davis Energy Group, Gary B. Fernstrom, *Analysis of Standards Options for Residential Pool Pumps, Motors and Controls*, 2004, p. 6.

per 24-hour cycle. Pool pump motor combinations would be required to perform pump and motor testing and report values for certification.

Based on staff's independent analysis of the available data, including those from the CASE report and manufacturers' information, the proposed regulations are both cost-effective and technically feasible. Staff assumptions and calculation methods are provided in **Appendix A**.

## New Proposed Pool Pump Motor Types

Pool pump motor types are in use that do not conform to the list of allowable answers found in Title 20, Section 1606, Table X, and that are not prohibited motor types under the existing regulations. Staff proposes to add motor types to allow certification of all pool motor types identifiable at this time that are not prohibited. This would take effect as soon as the proposed regulations are published by the California Secretary of State.

## New Proposed Freeze Protection Requirements

Pool pump motor combinations and replacement pool pump motors with freeze protection will be required to meet a prescriptive requirement for air temperature set point to start freeze protection, a maximum duration of pumping before rechecking the air temperature, and a limit on the maximum speed of the motor while performing in freeze protection mode.

## Motor Efficiency Test Procedure

The current motor test procedure will be amended to require all pool motors to test to the CSA 747-09 energy efficiency test method for small motors.

The CSA 747-09 test method provides a better test method than the IEEE-114-2001. The CSA test method is intended for all types of small motors, while the IEEE method includes only single-phase AC induction motors. The CSA test procedure allows for testing at multiple motor speeds, while the IEEE test procedure allows for only full-speed motor testing. The CSA 747-09 test procedure is superior because it has more expansive test conditions and motor types.

The proposed standard will require manufacturers to report performance data at up to four speeds depending upon the speed capability of the pool pump motor. Single-speed motors will report performance at full speed, while dual-speed motors will report performance at full and half speed. Variable-speed and multispeed motors will report performance at ¼, ½, ¾, and full speed. The new reporting requirement will improve the consistency in reported performance data by making the performance reported at uniform speeds. The reporting will allow consumers, regulators, and industry to make more meaningful side-by-side comparisons of motors at uniform speeds.

# Pump Efficiency Test Procedure

The *Appliance Efficiency Standards* require the pool pump for pool pump and motor combinations to be tested to the Hydraulic Institute (HI) ANSI/HI 1.6-2001, Centrifugal Pump Tests. Since the 2001 version, HI has updated and consolidated the test procedure for pumps to ANSI/HI 14.6-2011, the Rotodynamic Pumps for Hydraulic Performance Acceptance Tests. The ANSI/HI-14.6-2011 incorporates the requirements for ANSI/HI 1.6. Since the January 2016 draft staff report, the U.S. DOE has issued a rule for commercial and industrial pumps to test to ANSI/HI-40.6-2014. Staff seeks to update to the ANSI/HI-40.6-2014 test procedure to harmonize what is used by the industry with the anticipated U.S. DOE test procedure for dedicated purpose pool pumps. The test procedure is intended for factory testing of pump types used by the pool pump industry.

# CHAPTER 7: Savings and Cost Analysis

The proposed standards would significantly reduce energy consumption. To determine incremental cost of a pool pump motor that meets the proposal, the CASE team gathered retail price data from pool pump and motor vendor websites. Staff performed an independent market search and confirmed the retail price data in the CASE report. The data were analyzed to estimate the cost difference to the consumer as motor efficiency increases. The CASE team determined the cost increase estimate for motor size and motor type. Staff used the CASE team analysis to estimate the incremental cost between noncompliant models and models that meet but do not exceed the proposed standard for the January 2016 draft of the report. Since the January 2016 draft report, the U.S. DOE has provided incremental cost data based upon manufacturer interviews. Staff has updated the cost analysis using the U.S. DOE data.[56] See **Appendix A** for a detailed calculation.

Comments were received at the staff workshop and in the docket to determine the cost-effectiveness of standards for pressure cleaner booster pumps, waterfall pumps, above-ground pumps, and integral filter pumps. Nonfiltering pumps would be subject to the standard for the first time, and the duty cycle, design life, and consumer cost varies among the various pump styles.

Comments were also received on design life for pool pump motors. Comments stated the 10-year design life relied upon an outdated study that no longer reflects manufacturing practice for pool pump motors and consumer experience. Staff updated the design life based upon the results from recent U.S. DOE interviews with manufacturers in support of the federal dedicated purpose pool pump rulemaking.[57]

Data provided by the U.S. DOE ASRAC DPPP Working Group were used to estimate the cost to improve motors for pressure cleaner booster pumps, waterfall pumps, and motors found in non-self-priming pumps intended for above-ground pool applications. The U.S. DOE information also provided an estimated cost to add a timer to the integral filter pumps.[58]

Comments were received regarding the savings possible if commercial pools turned down the motor speed of variable speed pool pump motors as permitted by the U.S. Centers for Disease

56 April 18-19, 2016 Meeting Slides for the Dedicated Purpose Pool Pumps (DPPP) Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Working Group, Department of Energy Building Technologies Office. Docket ID EERE-2015-BT-STD-0008, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0067.
57 April 18-19, 2016 Meeting Slides for the Dedicated Purpose Pool Pumps (DPPP) Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Working Group, Department of Energy Building Technologies Office, Slide 45. Docket ID EERE-2015-BT-STD-0008, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0067.
58 April 18-19, 2016 Meeting Slides for the Dedicated Purpose Pool Pumps (DPPP) Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Working Group, Department of Energy Building Technologies Office, Slide 42. Docket ID EERE-2015-BT-STD-0008, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0067.

Control and Prevention's (CDC) Model Aquatic Code. Staff reviewed California County Health Department guidelines for commercial pools and found a 25 percent turndown of motor speed is permitted when the pool is not occupied.[59] The health departments for Los Angeles, Orange, Riverside, and Contra Costa Counties permit and provide guidance as to when turndown is allowed. Staff performed a simple calculation, assuming a 25 percent turndown for a pool that is unoccupied for 12 hours per day, and found a savings opportunity of 230 GWh/yr. This savings opportunity is presented in **Table 7-1** for commercial pools, in parenthesis to indicate the additional $661 per unit per year life-cycle benefit that a compliant motor with a variable-speed capability could provide.

**Table 7-1: Annual Energy and Monetary Savings per Unit**

| Product | Design Life (years) | Electricity Savings (kWh/yr) | Incremental Cost | Average Annual Savings | Life-Cycle Savings | Life-Cycle Benefit |
|---|---|---|---|---|---|---|
| Variable-Speed | 7 | 51 | $18 | $8 | $57 | $39 |
| Dual-Speed | 7 | 424 | $276 | $68 | $475 | $199 |
| Single-Speed Residential Filtration Tier 1 | 7 | 400 | $59 | $64 | $448 | $389 |
| Pressure Cleaner Booster Pumps | 5 | 338 | $126 | $54 | $270 | $144 |
| Waterfall Pool Pumps | 0 | 0 | $0 | $0 | $0 | $0 |
| Single-Speed Commercial | 7 | 3,144 | $395 | $503 (661) | $3,522 ($4627) | $3,127 (7,754) |
| Integral Filter Pool Pumps | 4 | 888 | $10 | $142 | $568 | $558 |

Source: CASE report and U.S. DOE ASRAC Working Group, as modified by Energy Commission staff

The values in **Table 7-1** list the design life, incremental cost, and monetary savings in 2016 dollars for each product. Thus, the average annual savings are the savings that consumers will receive once the product is installed. The estimation of cost and benefits is conservative as it does not consider utility rebates or contractor discounted prices for installation (that is, contractors purchase the pumps and install them at a discounted price).

59 *Centers for Disease Control and Prevention Model Aquatic Code,* 1st Edition, August 2014, Section 4.7.1.10.6, p. 130. http://www.cdc.gov/healthywater/pdf/swimming/pools/mahc/Complete-First-Edition-MAHC-Code.pdf.

The annual savings of each unit (benefits) is calculated by multiplying the annual energy savings by $0.16 per kilowatt-hour (kWh).[60] The life-cycle benefit represents the savings the consumer will receive over the life of the appliance and is the product of the average annual savings multiplied by the average design life of the unit. The net life-cycle benefits are the differences between the savings and the incremental cost of each appropriate unit.

Staff considered a request to determine the cost difference between dual-speed and variable-speed pool pump and motor combinations of similar total motor capacity.[61] The comment stated the likely impact of the regulation would be a shift of the market from dual-speed to variable-speed motors to meet the motor efficiency requirements. Market prices of pool pump and motor combinations were provided by the stakeholder. **Table 7-2** compares the market prices based upon the data provided. The average variable-speed motor cost was found to be less in the 2 to 2.5 total hp range than the average dual-speed motor. The data provided did not allow for other direct comparisons of dual-speed and variable-speed motors. At 3.5 to 4 total hp, the single-speed motor is modestly more expensive than a variable-speed motor. The consumer price difference is less than the life-cycle benefit for a consumer choosing a compliant motor over a noncompliant motor.

**Table 7-2: Average Consumer Price Comparison**

| Total HP | Single-Speed | Dual-Speed | Variable-Speed |
|---|---|---|---|
| <1 | $ 504 | Not provided | Not provided |
| 1-1.5 | $ 517 | Not provided | Not provided |
| 1.5-2 | $ 543 | $ 660 | Not provided |
| 2-2.5 | $ 585 | $ 797 | $ 772 |
| 2.5-3 | $ 702 | $ 845 | Not provided |
| 3.5-4 | $ 858 | Not provided | $ 1,015 |

Source: Staff calculation from data provided by APSP comment to Docket 15-AAER-02, TN 210561, February 29, 2016

The survey results from the California IOUs, and as reported in the CASE report, were used for the total stock of pool pump motors by types. Roughly 2.6 million residential and commercial

60 Energy Information Administration – electricity prices for 2013 through December 2013 http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_b.
61 APSP Pump & Motor Comments on Docket No. 15-AAER-02, February 29, 2016, TN 21056, Table 2A and 2B http://docketpublic.energy.ca.gov/PublicDocuments/15-AAER-02/TN210561_20160229T170049_Jennifer_Hatfield_Comments_APSP_Pump__Motor_Comments_on_Docket.pdf.

pools are in use in California; most use single-speed motors.[62] Staff assumed a 1 percent growth rate for new pool installation based upon the Commission's energy demand forecast and information from the CASE team.[63] Assuming a 14-20 percent replacement rate based on a five- to seven-year design life, yearly shipments of 452,000 units are estimated. Staff compared this estimate to the U.S. DOE estimate of 2.4 million pool pump shipments per year nationwide.[64] The California and nationwide estimates seem consistent and proportional.[65]

Staff received comments at the February 18, 2016, workshop and in the docket indicating that nearly 52,000 pumps intended for portable pools were sold in California.[66] Based upon the four-year design life shown in the U.S. DOE study, it is estimated that about 206,000 integral filter pool pumps are in use in California. Staff reviewed shipment data for integral filter pumps provided by the U.S. DOE ASRAC DPPP, and based on these data, California would account for only 5 percent of the national integral filter market. This percentage seems low; therefore staff seeks clarification from stakeholders as to total shipments of integral filter pumps for California.

The U.S. DOE ASRAC DPPP effort presented results for waterfall pool pumps and pressure cleaner booster pump annual shipments. Staff reviewed the shipment data to estimate 13 percent of nonfiltration pumps in the CASE report were waterfall pumps, while 87 percent were pressure cleaner booster pumps.[67]

Above-ground pool pump and motor energy savings are included in the savings estimates with in-ground pumps and motors for variable-, dual-, and single-speed motors due to the similarities in design. In 2003, the National Spa and Pool Institute estimated above-ground pools to be roughly one-fourth of all permanently installed pools in California.[68]

The savings estimates compare the baseline energy consumption for each product with their respective energy consumption under the proposed standards. For statewide estimates, these savings are multiplied by sales for first-year figures and by total California stock. These

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62 CASE Report, *Analysis of Standards Proposal for Residential Swimming Pool & Portable Spa Equipment*, pp. 20-22, available at http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2F_Residential_Pool_Pumps_and_Replacement_Motors/California_IOUs_Response_to_the_Invitation_to_Submit_Proposals_for_Pool_and_Spas_2013-07-29_TN-71756.pdf.

63 Kavalec, Chris, Nicholas Fugate, Bryan Alcorn, Mark Ciminelli, Asish Gautam, Kate Sullivan, and Malachi Weng-Gutierrez, 2013. *California Energy Demand 2014-2024 Preliminary Forecast, Volume 1,* California Energy Commission, Publication Number CEC-200-2013-004-SD-V1, p. 30.

64 April 18-19, 2016, meeting slides for the Dedicated Purpose Pool Pumps (DPPP) Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Working Group, Department of Energy Building Technologies Office, Slide 65. Docket ID EERE-2015-BT-STD-0008, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0067.

65 Eaton, Eileen, *CEE High Efficiency Residential Swimming Pool Initiative*, December 2012, Table 2-2, p. 6, https://library.cee1.org/sites/default/files/library/9986/cee_res_swimmingpoolinitiative_07dec2012_pdf_10557.pdf.

66 Association of Pool and Spa Professionals, APSP Storable Pool Pumps Workshop Slides, 15-AAER-02, TN 210391, February 28, 2016.

67 April 18-19, 2016, meeting slides for the Dedicated Purpose Pool Pumps (DPPP) Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Working Group, Department of Energy Building Technologies Office, Slide 65. Docket ID EERE-2015-BT-STD-0008.

68 Wagner, Steven K., "A Pool That's Above but Not Beyond," *Los Angeles Times*, July 17, 2003, http://articles.latimes.com/2003/jul/17/home/hm-swimmingpool17.

calculations are available in **Appendix A**. In **Tables 7-3**, **7-4,** and **7-5**, the potential energy savings of the proposed standards are provided. Energy savings are further separated into first-year savings and stock savings. *First-year savings* is the annual reduction of energy consumed associated with annual sales, one year after the standards take effect. *Annual stock savings* is the annual energy savings achieved after all existing stock in use complies with the proposed standards.

Staff calculations and assumptions used to estimate first-year savings and stock change savings are provided in **Appendix A**. As provided in **Table 7-3**, if all pool pumps and motors complied with the proposed standards (annual stock savings), California would save 1,081 GWh of energy per year. Using a residential electricity rate of $0.16 per kWh, full implementation of the proposed standards for pool pumps and motors would achieve roughly $173 million a year in reduced utility costs. An additional 196 GWh of energy and $31.3 million savings per year would be realized due to the integral filter timer requirement, assuming a reduction in duty cycle from 24 hours to 12 hours during a 150-day-per-year swim season. Total savings would be 1277 GWh and $204 million per year for all proposals.

The peak power reduction was calculated to be 1,277 GWh divided by 8,760 hours, which is roughly 146 MW. This calculation is based on the simplified assumption that the load profile for pool pumps and motors is completely flat and energy would be evenly generated over the entire year to provide electricity to consumers.

**Table 7-3: Statewide Annual Savings**

| | First-Year Savings | | Annual Existing and Incremental Stock Savings | |
|---|---|---|---|---|
| **Product** | **Electricity Savings (GWh/yr)** | **Savings ($M)** | **Electricity Savings (GWh/yr)** | **Savings ($M)** |
| Variable-Speed | 1.4 | $0.2 | 10 | $1.6 |
| Dual-Speed | 12.3 | $2.0 | 86 | $13.8 |
| Single-Speed Residential Filtration | 92.9 | $14.9 | 650 | $104.0 |
| Pressure Cleaner Booster Pump | 33.3 | $5.3 | 167 | $26.7 |
| Waterfall Pool Pumps | 0.0 | $0.0 | 0 | $0.0 |
| Single-Speed Commercial | 24.0 | $3.8 | 168 | $26.9 |
| **Total Savings** | **164.0** | **$26.2** | **1,081** | **$173.0** |

Source: Staff calculation

**Table 7-4: Statewide Integral Filter Timer Annual Savings**

| | First-Year Savings | | Annual Existing and Incremental Stock Savings | |
|---|---|---|---|---|
| **Product** | **Electricity Savings (GWh/yr)** | **Savings ($M)** | **Electricity Savings (GWh/yr)** | **Savings ($M)** |
| Integral Filter Pool Pumps | 49.0 | $7.8 | 196 | $31.3 |

Source: Staff calculation

**Table 7-5: Motor Efficiency and Integral Filter Timer Statewide Annual Savings**

| Product | First-Year Savings | | Annual Existing and Incremental Stock Savings | |
|---|---|---|---|---|
| | **Electricity Savings (GWh/yr)** | **Savings ($M)** | **Electricity Savings (GWh/yr)** | **Savings ($M)** |
| Motor Efficiency Total Savings | 164.0 | $26.2 | 1081 | $173 |
| Integral Filter Timer Savings | **49.0** | **$7.8** | **196** | **$31.3** |
| Total Savings | **213.0** | **$34.1** | **1277** | **$204.3** |

Source: Staff calculation

Freeze protection energy use depends primarily on the three elements of the prescriptive standard. The *freeze protection standard* is a set of requirements that will prevent the pump from freezing through an adequate duration of water flow and at times when it is needed. The CASE team provided illustrative calculations to show significant savings between freeze protection settings optimized for energy savings and freeze protection settings that use energy when freeze protection is not required. The calculations were based upon a survey of pool pump and motor combinations that employ freeze protection with weather conditions found in Bakersfield, California. The CASE team found a range of settings with durations between 30 minutes and 8 hours, and motor speeds between 1,000 and 2,600 RPM. Using the settings as inputs, the CASE team found energy consumption varied from 14 to 432 kWh, yielding a cost saving opportunity of about $67 per year with a $0.16 per kWh electricity cost.[69]

The CASE team estimated the cost of software changes to be less than $1 per unit in mass production for other appliance types.[70] Since the settings are typically determined by the user through software, implementing a set of uniform efficient freeze protection default settings will deliver significant energy savings to consumers with modest, if any, cost to manufacturers.

In conclusion, the proposed standards are clearly cost-effective, as consumers will receive a net savings from the installation of compliant pump and motor combinations and replacement pool pump motors over the life of the pump.

69 California Investor-Owned Utilities (CA IOUs), 2015-12-04 Working Group Material: Stakeholder Preliminary Freeze Protection Research Spreadsheet, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0047.
70 2013 CASE study: *Electronic Displays Technical Report – Engineering and Cost Analysis*, p, 37, http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2A_Consumer_Electronics/California_IOUs_Supplemental_Technical_Report_Electronic_Displays_2014-01-08_TN-72475.pdf.

# CHAPTER 8: Pool Pumps and Motors Standard Technical Feasibility

## Motor Efficiency

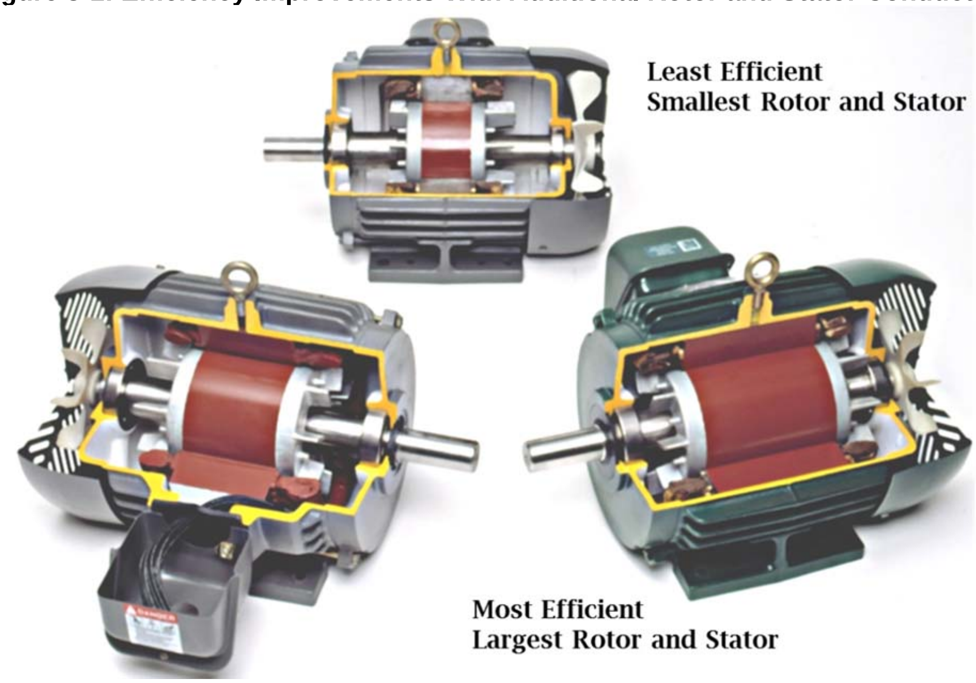
*Motor efficiency* is the ratio of rotational power at the motor shaft to the electrical power input into the motor. The motor efficiency will always be less than 100 percent due to losses within the motor. Energy losses within electric motors are classified as conduction losses and speed losses. Manufacturers have used a variety of approaches to achieve more efficient motor performance.

### Conduction Losses

*Conduction losses* are due to the resistance the electric current encounters when it flows through a conductor – in this case, the winding wire inside the motor. The power is dissipated as heat rather than converted into rotational energy. The power dissipated by electrical resistance is proportional to the square of the applied current. Manufacturers have lowered the resistance within the motor by modifying the stator and rotor geometry to add more area for the wire conductors.[71] Electrical losses predominate at low speed. Other sources of motor losses at low speed, such as friction, are small compared to the conduction losses.

71 "The Difference Between AC Induction, Permanent Magnet, and Servomotor Technologies," *Machine Design*, available at http://machinedesign.com/motorsdrives/difference-between-ac-induction-permanent-magnet-and-servomotor-technologies.

**Figure 8-1: Efficiency Improvements With Additional Rotor and Stator Conductors**




Source: National Electrical Manufacturers Association

## Speed Losses

Speed losses include hysteresis and eddy currents within the stator and rotor, frictional losses within bearings, and motor windage (the loss the motor rotor encounters as a drag force as it rotates through air).[72] Hysteresis and eddy currents are due to the interaction between alternating electrical currents and magnetic materials within both AC induction and ECM motor stators and rotors. Losses can be reduced by minimizing stator and rotor steel laminations to reduce eddy currents and using ferromagnetic materials with properties that present less hysteresis. Bearing friction can be reduced by appropriate selection of bearings for the motor load and speed. Motor windage can be reduced by streamlining airflow within the motor and removing obstacles such as sharp edges or drastic changes in cross section.[73]

*Stray losses* are miscellaneous losses from leakage flux, nonuniform current distribution, and mechanical imperfection in the air gaps between the rotor and windings stator. Careful design and improved manufacturing processes can minimize stray losses and improve overall motor efficiency.

72 Vrancik, James E., *Prediction of Windage Power Loss in Alternators*, NASA Technical Note D-4849, 1968, p. 4.
73 Tong, Wei, *Mechanical Design of Electric Motors*, CRC Press, 2014, p. 402.

## Motor Efficiency Market Survey

**Tables 8-1**, **8-2,** and **8-3** show existing pool pump motors compliant with the motor efficiency standard in the Energy Commission database as of March 2016. Staff notes that at the February 18, 2016, workshop, manufacturers stated a need to update the half-speed motor efficiencies that they had provided to the Energy Commission. However, these have not yet been updated. The number of models that already comply shows that the proposed efficiency standards are technically feasible for the pool pump motor industry.

**Table 8-1: Single-Speed Pool Pump Motor Performance of Motors in Energy Commission Database – March 2016**

| Motor Size (Total hp) | Total Models | Compliant |
|---|---|---|
| <0.25 | 9 | 4 |
| 0.25-0.49 | 5 | 2 |
| 0.50-0.74. | 10 | 6 |
| 0.75-0.90 | 9 | 4 |
| 0.91-0.99 | 25 | 14 |

Source: Energy Commission Appliance Database, March 2016

**Table 8-2: Dual-Speed Pool Pump Motor Performance in Energy Commission Database - March 2016**

| Motor Size (Total hp) | Total Models | Compliant |
|---|---|---|
| <1 | 0 | 0 |
| 1 | 19 | 0 |
| 1.5 | 19 | 0 |
| 2 | 26 | 1 |
| 2.5 | 20 | 4 |
| 3 | 3 | 2 |
| 4 | 0 | 0 |

Source: Energy Commission Appliance Database, March 2016

**Table 8-3: Variable-Speed Pool Pump Motor Performance of Motors in Energy Commission Database – March 2016**

| Motor Size (Total hp) | Total Models | Compliant |
|---|---|---|
| <1 | 2 | 0 |
| 1 | 7 | 4 |
| 1.5 | 21 | 10 |
| 2 | 11 | 11 |
| 2.5 | 19 | 15 |
| 3 | 6 | 2 |
| 4 | 26 | 22 |

Source: Energy Commission Appliance Database, March 2016

A significant market for dual-speed or variable-speed motors less than 1 hp or greater than 3 hp total horsepower was not found. However, should such motors be needed, there do not appear to be any technical barriers to prevent them from being compliant.

The Association of Pool & Spa Professionals (APSP) pool database[74] shows two single-speed pump models less than 1 hp total horsepower that achieve 80 percent efficiency and four pump models above 79 percent efficiency. The single-speed efficiency requirement is obtainable with currently available models.

In-ground, above-ground, and pressure cleaner booster, pumps rely upon similar motor total capacities, types, and construction. Manufacturers may choose to adapt the pump housing, shaft seal, and impellor to meet the existing compliant motor interfaces, if needed. The adaptations to the interfaces can be made so that compliant above-ground and pressure cleaner pumps and motor combinations could be made available to consumers by the proposed effective dates. The California IOUs demonstrated the adaptation of a compliant variable-speed replacement motor to a pressure cleaner booster pump.[75] The motor was installed without adaptation to either the replacement motor or booster pump interface. While manufacturers have raised concerns that such combinations of replacement motors and pumps are not tested and certified, the combination could be tested and certified before the proposed effective date.

74 The Association of Pool and Spa Professionals (APSP) Energy Efficient Pool Pumps Database, http://apsp.org/resources/energy-efficient-pool-pumps.aspx.

75 Chad Worth, Fernstrom, Gary, CA IOU Booster Pump Presentation 3-21-2016, Comment to US DOE Docket EERE-2015-BT-STD-0008-0061, March 24, 2016, Slide 4,, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0061.

## Integral Filter Timer Requirement

Integral filter pool pump and motor combinations can be equipped with separable timers that install at the plug interface or are built into the unit. A staff survey of pool pump manufacturer websites found integral pool pumps with timers. Consumers are instructed to use a filtration table to determine the number of hours per day to run the pump based upon pump flow rate and pool volume and then adjust the timer setting to provide the required duty cycle.[76] Staff found examples where the timer could be set to between 2 and 12 hours per day in two-hour increments.

76 Intex 1,500 gallon pool pump instructional video, minutes 8-9 http://www.intexcorp.com/support/28635eg.html#videos.

## Two or More Speed Pump Requirement

All new pumps and motors between 1 and 5 hp must be capable of operating at two or more speeds. New pump and motor combinations, and replacement pool pumps between 1 and 5 hp, shall be dual-speed, multiple-speed, or variable-speed type. The requirement will extend to all pool pumps and motors beyond the current requirement for residential filtration pumps, including motors for commercial pool pumps, booster pumps, and waterfall pumps. Pumps and motors under 1 hp total capacity may be single-speed in addition to dual-, multiple-, or variable-speed.

The large quantity of pool pumps and motors available for sale (**Table 8-4** and **8-5)** show two or more speed products between 1 and 5 hp, demonstrating that this requirement is technically feasible.

The requirement will extend – for the first time – to nonfiltration pumps and commercial pumps. Staff received comments that pressure cleaner booster pumps are designed with a total motor capacity slightly above 1 hp. Stakeholders commented that a possible response to the regulations would be to redesign the pressure cleaner booster pump to use a less than 1 hp total capacity motor; however, this reduction would lead to longer cleaning times, less consumer satisfaction, and greater energy consumption. Staff reviewed the pressure cleaner booster pump and determined that it is common practice to bleed off excess hydraulic power using a flow-restrictor disk and bypass valve, indicating that many applications of the pumps do not require the full pump output to perform the cleaning function.[77] Alternatively, pressure cleaner booster pump designs could be adapted to mate to existing compliant pool pump motors to meet the two or more speed requirement.

Staff surveyed pool pump vendor catalogs and found many above-ground pool pump and motor combinations that meet the two or more speed requirement.

The two or more speed requirement would apply to waterfall pumps where the input power when tested at the maximum pump motor speed exceeds 750 watts. Staff is not aware of any waterfall pump motors that operate at a power level above 750 watts, but a product could be developed that is capable of operating at two or more speeds.

An integral filter pool pump greater than 1 hp total capacity would be required to the meet two or more speed requirement. Staff is not aware of any integral filter pool pumps greater than 1 hp total capacity.

Commercial pool pumps that meet the two or more speed motor requirement are available. The requirement can be met with single-phase AC induction motors, ECM motors, or three-phase AC induction motors.

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77 Worth, Chad, Gary Fernstrom, CA IOU Booster Pump Presentation 3-21-2016, Comment to US DOE Docket EERE-2015-BT-STD-0008, March 24, 2016, Slide 1,, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0061.

## Freeze Protection Control Requirement

All pool pump motor combinations and replacement pool pump motors with freeze protection will be required to meet a prescriptive requirement for the air temperature set point to start the freeze protection, a maximum duration of pumping before rechecking the air temperature, and a limit on the maximum speed of the motor while performing the freeze protection task. The CASE team performed a market survey and presented results at the U.S. DOE ASRAC DPPP working group showing several pool pump and motor combinations and replacement pool pump motors that meet the requirements. Staff is not aware of any pool pump and motor combinations under 1 hp that have freeze protection. The half-speed requirement would not apply to single-speed motors under 1 hp total motor capacity because by definition the half-speed motor setting is not available. The half-speed requirement would apply to dual-speed and variable-speed motors under 1 hp total capacity.[78]

78 California Investor-Owned Utilities (CA IOUs), 2015-12-04 Working Group Material: Stakeholder Preliminary Freeze Protection Research Spreadsheet, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0047.

# CHAPTER 9: Environmental Impacts

## Impacts

Pool owners replace pool pumps and motors at the end of the useful lives. The proposed standards would not change that, so the replacement of these pumps and motors would present no additional impact to the environment beyond the natural cycle.

## Benefits

Improving the efficiency of pool pumps and motors through mandatory appliance standards will reduce overall energy consumption statewide, providing important air quality and climate benefits. Staff estimated the reduction of criteria air pollutants[79] and greenhouse gas (GHG) emissions resulting from the proposed standards. The reductions are tabulated in **Table 9-1**.

Staff calculated GHG emission reductions using the estimated avoided energy savings; it was assumed that there are 690 lbs. of avoided $CO_2e$ per MWh of electricity saved.[80] For criteria air pollutants, the California Air Resources Board (ARB) suggested emission factors were used to estimate the cost-effectiveness of emission reductions:[81]

- Oxides of nitrogen ($NO_x$) = 0.07 lb. per MWh
- Sulfur dioxide ($SO_x$) = 0.01 lb per MWh
- Carbon monoxide (CO) = 0.1 lb. per MWh
- Particulate matters ($PM_{2.5}$) = 0.03 lb. per MWh

79 Criteria air pollutants are those for which a state or federal standard has been established. They include nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), carbon monoxide (CO), ozone ($O_3$) and its precursors, oxides of nitrogen (NOx) and volatile organic compounds (VOC), particulate matter less than 2.5 microns ($PM_{2.5}$) and less than 10 microns in diameter ($PM_{10}$), and lead (Pb).
80 *Energy Aware Planning Guide Feb 2011*, available at http://www.energy.ca.gov/2009publications/CEC-600-2009-013/CEC-600-2009-013.pdf.
81 *ARB Economic Analysis Assumptions*, available at http://www.arb.ca.gov/regact/2010/res2010/res10d.pdf.

**Table 9-1: Criteria and Greenhouse Gas Emissions Reductions**

| Annual Reductions (tons) | Avoided Emissions (tons) | | | | |
|---|---|---|---|---|---|
| | Oxides of Nitrogen ($NO_x$) | Sulfur Dioxide ($SO_x$) | Carbon Monoxide (CO) | Particulate Matter ($PM_{2.5}$) | Greenhouse Gas ($eCO_2$) |
| Dual- and Variable-Speed | 3.36 | 0.48 | 4.80 | 1.44 | 33,125 |
| Single-Speed | 34.48 | 4.93 | 49.26 | 14.78 | 339,864 |
| Integral Filter | 6.86 | 0.98 | 9.80 | 2.94 | 67,596 |
| **Total Avoided Emissions** | 44.70 | 6.39 | 63.85 | 19.16 | 440,585 |

Source: Staff calculation

As seen in **Table 9-1**, about 134 tons of criteria air contaminants and 440 thousand tons of GHG equivalents will be avoided annually due to the savings from the proposed standards.

# CHAPTER 10: Regulatory Language

The following are the proposed changes to specific Sections of Title 20 applicable to pool pumps and motors. Underline means new added text and ~~strike out~~ means deleted text.

**Section 1601 Scope.**

…

(g) Gas pool heaters, oil pool heaters, electric resistance pool heaters, heat pump pool heaters, ~~residential~~ pool pump and motor combinations, replacement ~~residential~~ pool pump motors, and portable electric spas.

…

**Section 1602 Definitions.**

…

**(g) Pool Heaters, Portable Electric Spas, ~~Residential~~ Pool Pumps, and Motor Combinations, and Replacement ~~Residential~~ Pool Pump Motors.**

"Basket strainer" means a perforated or otherwise porous receptacle that prevents solid debris from entering a pump, when mounted within housing on the suction side of a pump. The basket strainer receptacle is capable of passing spherical solids of 1 mm in diameter and can be removed by hand or using only simple tools. Simple tools include, but are not limited to, a screwdriver, pliers, and an open-ended wrench.

…

"Integral" means a part of the device that cannot be removed without compromising the function of the device or destroying the physical integrity of the unit.

"Integral filter pool pump and motor combination" means a pool pump and motor combination distributed in commerce with a sand filter or removable cartridge filter where the filter cannot be bypassed for testing.

…

"Permanent magnet synchronous" means a motor that has a permanent magnet rotor and windings on the stator controlled by single-phase sinusoidal alternating current.

…

"Polyphase induction" means an alternating current motor having polyphase (as three-phase) windings.

…

“Pool filter pump and motor combination” means a pool pump motor coupled to a pool pump that either:

(1) includes an integrated basket strainer, or

(2) does not include an integrated basket strainer but requires a basket strainer for operation as stated in manufacturer literature provided with the pump; and may be distributed in commerce connected to, or packaged with, a sand filter, removable cartridge filter, or other filtration accessory, so long as the bare pump and filtration accessory are connected with consumer removable connections that allow the pump to be plumbed to bypass the filtration accessory for testing.

“Pool pump” means a mechanical device using suction or pressure to raise or move non-potable water.

“Pool pump and motor combination” means a pool pump motor coupled to a pool pump.

“Pool pump motor” means a motor that is used as a replacement pool pump motor or as part of pool pump and motor combination.

“Pressure cleaner booster pump and motor combination” means a pool pump motor coupled to a pool pump that,

(1) does not include an integrated basket strainer, and

(2) achieves an average head to flow ratio, defined over the entire pump curve as greater than 2 (feet) to 1 (gallon per minute) when tested per ANSI/HI 40.6-2014.

…

“Removable cartridge filter” means a filter component with fixed dimensions that captures and removes suspended particles from water flowing through the unit. The filter component is not capable of passing spherical solids of 1 mm in diameter, and can be removed from the filter housing by hand or using only simple tools. Simple tools include but are not limited to a screwdriver, pliers, and an open-ended wrench.

“Replacement pool pump motor” means a replacement motor intended to be coupled to an existing pool pump.

…

“Replacement pressure cleaner booster pump motor” means a replacement motor intended to be coupled to an existing pressure cleaner booster pump

“Replacement waterfall pool pump motor” means a replacement motor intended to be coupled to an existing waterfall pool pump with a maximum 1800 rpm nominal speed.

…

"Sand filter" means a device designed to filter water through sand or an alternate sand type media.

…

"Timer" means a device used to control the pool pump motor on and off operation through use of a clock and user selectable duration of pump operation during a 24 hour cycle.

"Total horsepower ~~(of an AC motor~~)(of a pool pump motor)" means a value equal to the product of the motor's service factor and the motor's nameplate (rated) horsepower.

…

"Waterfall pool pump and motor combination" means a maximum 1800 rpm nominal speed, motor-driven pool pump and motor combination with maximum head less than or equal to 30 feet.

…

**Section 1604 Test Methods for Specific Appliances.**

…

**(g) Pool Heaters, Portable Electric Spas, ~~Residential~~ Pool Pump and Motor Combinations, and Replacement ~~Residential~~ Pool Pump Motors.**

…

(3) Test Method for Residential Pool Pumps
The test method for residential pool pumps manufactured on or after January 1, 2006, is as follows:

…

(4) Pump Test Method for Pool Pumps and Motor Combinations
The pump test method for pool pump and motor combinations manufactured on or after January 1, 2019, is as follows:

(A) Reported motor efficiency shall be verifiable by test method described in Section 1604 (g)(5).

(B) ANSI/HI 40.6-2014 shall be used for the measurement of pump efficiency.

(C) Three system curves shall be calculated.

Curve A: $H = 0.0167 \times F^2$

Curve B: $H = 0.050 \times F^2$

Curve C: $H = 0.0082 \times F^2$

Where:
H is the total system head in feet of water.

F is the flow rate in gallons per minute (gpm).

(D) For all pool pump and motor combinations except pressure cleaner booster pump and motor combinations and waterfall pump and motor combinations:
For each curve (A, B, or C), the pump head shall be adjusted until the flow and head lie on the curve. The following shall be tested and reported for the intersect point of the pump performance curve with each system curve:

1. Motor nominal speed
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
5. Motor Efficiency (percent %)

(i) For single-speed, two-speed, or multi-speed pumps with fixed, non-adjustable speeds, test and report performance at the intersect point of the pump performance curve with each system curve (curves A, B, and C). Intersect data shall be reported for each speed and system curve.

(ii) For two-, multi-, or variable-speed pumps with adjustable speeds, test and report performance at the intersect point of the pump performance curve with each system curve (curves A, B, and C). Intersect data shall be reported for the speeds shown in Table G-3.

(E) For pressure cleaner booster pump and motor combinations:
The pump head shall be adjusted until the head measures 90 ft. The following shall be tested and reported:

1. Motor nominal speed
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
5. Motor Efficiency (percent %)

(i) For single-speed, two-speed, or multi-speed pumps with fixed, non-adjustable speeds, test and report performance at the intersect point of the pump performance curve with 90 ft of pump head for all motor speeds that achieve 90 ft of pump head. Intersect data shall be reported for each speed that achieves 90 ft of pump head.

(ii) For two-, multi-, or variable-speed pumps with adjustable speeds, test and report performance at the intersect point of the pump performance curve with 90 ft of pump head for all motor speeds that achieve 90 ft of pump head. Intersect data shall be reported for the speeds shown in Table G-3.

6. The average head to flow ratio shall be calculated per pump performance curve points obtained through testing to ANSI/HI 40.6-2014. Five evenly spaced pump performance curve points covering the entire operating range of the pump shall be used to calculate the average head to flow ratio.

Average Head to Flow Ratio (ft/gpm)= $(H_1+H_2+H_3+H_4+H_5)/(F_1+F_2+F_3+F_4+F_5)]$

F) For waterfall pump and motor combinations:

The pump head shall be adjusted until the head measures 17 ft. The following shall be tested and reported:

1. Motor nominal speed
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
5. Motor Efficiency (percent %)

(i) Test and report performance at the intersect point of the pump performance curve at 17 ft of pump head. Intersect data shall be reported.

(5) Motor Test Method for Pool Pump and Motor Combinations and Replacement Pool Pump Motors

The test method for pool pump and motor combinations and replacement pool pump motors is as follows:

(A) Each pool pump and motor combination and replacement pool pump motor shall be tested in accordance with CSA-C747-09 with modified torque settings at different speeds as is shown in Table G-3 and G-4.

(1) Single-speed, two-speed, multi-speed, variable-speed, and waterfall pool pump and motor combinations and replacement pool pump motors shall be tested at the speeds shown below in Table G-3.

**Table G-3 - Testing Criteria for Pool Pump Motors**

| Motor Design | Full Speed (3450[1] RPM) | 3/4 Speed (2590[1] RPM) | 1/2 Speed (1725[1] RPM) | 1/4 Speed (860[1] RPM) |
|---|---|---|---|---|
| Single-Speed | X | N/A | N/A | N/A |
| Dual-Speed | X | N/A | X | N/A |
| Variable-Speed | X | X | X | X |
| Multiple-Speed[2] | X | X | X | X |
| Waterfall | N/A | N/A | X | N/A |
| [1]Tolerance of +/-50 RPM.<br>[2]If no preset speeds exist within tolerance, then test to nearest preset speed. | | | | |

(2) Torque settings and horsepower ratings for single-speed, two-speed, multi-speed, variable-speed, and waterfall pool pump and motor combinations and replacement pool pump motors shall be calculated as shown in Table G-4.

**Table G-4 - Torque Settings for Pool Pump Motors**

| Speed (RPMs) | | Torque Setting (N-m) | Total Horsepower (THP) |
|---|---|---|---|
| $RPM_{full}$ | Full Speed (RPM) | $T_f$ (per section 6.5 of CSA C747-09) | $THP_{full}$ |
| $RPM_{3/4}$ | Three Quarter Speed (if applicable) (RPM) | $T_{3/4} = (RPM_{3/4} / RPM_{full})^2 \times T_f$ | $THP_{3/4} = (RPM_{3/4} / RPM_{full})^3 \times THP_{full}$ |
| $RPM_{1/2}$ | Half Speed (if applicable) (RPM) | $T_{1/2} = (RPM_{1/2} / RPM_{full})^2 \times T_f$ | $THP_{1/2} = (RPM_{1/2} / RPM_{full})^3 \times THP_{full}$ |
| $RPM_{1/4}$ | One Quarter Speed (if applicable) (RPM) | $T_{1/4} = (RPM_{1/4} / RPM_{full})^2 \times T_f$ | $THP_{1/4} = (RPM_{1/4} / RPM_{full})^3 \times THP_{full}$ |
| $RPM_x$ | Other Preset Speed (if applicable) (RPM) | $T_x = (RPM_x / RPM_{full})^2 \times T_f$ | $THP_x = (RPM_x / RPM_{full})^3 \times THP_{full}$ |

The torque $T_1$ shall be set in accordance to CSA-C747-09.

(3) Power factor for pool pump and motor combinations and replacement pool pump motors shall be reported for the maximum motor speed per CSA C747-09.

...

The following documents are incorporated by reference in Section 1604.

…

CSA Group (CSA)

| | |
|---|---|
| CSA C747-09 | Energy efficiency test methods for small motors |
| Copies available from: | CSA Group<br>178 Rexdale Blvd<br>Toronto, ON<br>Canada M9W 1R3<br>http://shop.csa.ca/<br>Phone (416) 747 4044<br>FAX (416) 747 2510 |

…

HYDRAULIC INSTITUTE (HI))

…

| | |
|---|---|
| ANSI/HI 1.6 - 2000 | Centrifugal Pump Tests |
| HI 40.6-2014 | Standard for Methods for Rotodynamic Pump Efficiency Testing |
| Copies available from: | Hydraulic Institute<br>9 Sylvan Way<br>6 Campus Drive<br>Parsippany, NJ 07054<br>http://www.pumps.org/<br>www.hydraulicinstitute.com<br>Phone: (973) 267-9700<br>FAX: (973) 267-9055 |

…

**1605.1 Federal and State Standards for Federally-Regulated Appliances.**

…

**(g) Pool Heaters, Portable Electric Spas, Residential Pool Pump and Motor Combinations, and Replacement Residential Pool Pump Motors.**

…

(6) Energy Efficiency Standards and Energy Design Standards for ~~Residential~~ Pool Pump and Motor Combinations and Replacement ~~Residential~~ Pool Pump Motors. See Section 1605.3(g) for energy efficiency standards and energy design standards for ~~residential~~ pool pump and motor combinations and replacement ~~residential~~ pool pump motors.

…

**1605.2 State Standards for Federally-Regulated Appliances.**

…

**(g) Pool Heaters, Portable Electric Spas, ~~Residential~~ Pool Pump and Motor Combinations, and Replacement ~~Residential~~ Pool Pump Motors.**

…

(2) See Section 1605.3(g) for energy efficiency standards and energy design standards for portable electric spas and ~~residential~~ pool pump and motor combinations and replacement ~~residential~~ pool pump motors.

…

**Section 1605.3 State Standards for Non-Federally-Regulated Appliances.**

…

**(g) Pool Heaters, Portable Electric Spas~~, Residential~~ Pool Pump and Motor Combinations, and Replacement ~~Residential~~ Pool Pump Motors.**

**…**

(5) ~~Residential~~ Pool Pump and Motor Combinations, and Replacement ~~Residential~~ Pool Pump Motors**.**

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

1. <u>Residential pool pump motors manufactured on or after January 1, 2006, may not be split-phase or capacitor start–induction run type.</u>

…

<u>2.</u> <u>All pool pump and motor combinations and replacement pool pump motors that have a total horsepower of 5 hp or less, manufactured on or after January 1, 2019, shall meet the efficiency standards in Table G-5, except integral filter pool pump and</u>

motor combinations, waterfall pool pump and motor combinations, and replacement waterfall pool pump motors.

**Table G-5**

**Standards for Pool Pump Motors Manufactured on or After January 1, 2019**

| **Motor Design** | **Full Speed (3450 RPM) Minimum Efficiency** | **Half Speed (1725 RPM) Minimum Efficiency** |
|---|---|---|
| Single-Speed (0 total hp up to 0.49 total hp) | 70% | N/A |
| Single Speed (0.49 total hp up to 1 total hp | 75% | N/A |
| Dual-Speed and Variable-Speed/Multiple-Speed | 80% | 65% |

(B) **Two-, Multi-, or Variable-Speed Capability.**

1. **Residential-Pool Pump Motors.** Residential pool pump motors with a pool pump motor capacity total horsepower of 1 hp or greater which are manufactured on or after July 1, 2010 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. The pool pump motor must be operated with a pump control that shall have the capability of operating the pump at least at two speeds.

2. **Pool Pump Motors.** Pool pump and motor combinations and replacement pool pump motors with a pool pump motor total horsepower of 1 hp or greater which are manufactured on or after January 1, 2019, 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. The pool pump and motor combination or replacement pool pump motor must be operated with a pump control that shall have the capability of operating the pump at least at two speeds. Waterfall pool pump and motor combinations and replacement waterfall pool pump motors with an input power less than 750 watts when tested at maximum speed are exempt from the two or more speed requirement..

3. **2Pump Controls.** Pool pump motor controls manufactured on or after January 1, 2008 that are sold for use with a two- or more speed pump shall have the capability of operating the pool pump at least at two speeds. The control's default circulation speed setting shall be no more than one-half of the motor's maximum rotation rate. Any high speed override capability shall be for a

temporary period not to exceed one 24-hour cycle without resetting to default settings.

**(C) Freeze Protection**.

Pool pump motor and motor combinations and replacement pool pump motors with freeze protection manufactured on or after January 1, 2019, shall have the following default settings.

i. The default dry-bulb air temperature setting shall not be greater than 40˚ Fahrenheit (F).

ii. The default run time setting shall be no greater than 60 minutes before the temperature is rechecked.

iii. The default motor speed shall not be more than half of the motor's maximum speed except for single speed motors under 1 total horsepower.

(D) **Timer Control**

Integral filter pool pumps and motor combinations shall be sold with a timer capable of a user-defined pump duration input to set pump operation to no more than 12 hours during a 24 hour cycle.

…

**Section 1606. Filing by Manufacturers; Listing of Appliances in Database.**

**(a) Filing of Statements.**

{skipping (a)(1)-(3) and sections A-F of Table X} …

Table X –Data Submittal Requirements

…

| | Appliance | Required Information | Permissible Answers |
|---|---|---|---|
| G | ~~Residential~~ Pool Pump and Motor Combinations and Replacement ~~Residential~~ Pool Pump Motors | Pool Pump Motor Construction) | PSC, Capacitor Start-Capacitor Run, ECM, Capacitor Start-Induction Run, Split-Phase, Permanent Magnet Synchronous, Polyphase Induction, Other |
| | | Pool Pump Motor Design | Single-speed, dual-speed, multi-speed, variable-speed |
| | | Frame | |
| | | Maximum Speed (in RPM) | |
| | | 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 |
| | | Unit Type | Residential Pool Pump and Motor Combination, Replacement Residential Pool Pump Motor, Pool Filter Pump and Motor Combination, Replacement Pool Filter Pump Motor, Integral Filter Pool Pump and Motor Combination, Waterfall Pool Pump and Motor Combination, Replacement Waterfall Pool Pump Motor, Pressure Cleaner Booster Pool Pump and Motor Combination, Replacement Pressure Cleaner Booster Pool Pump Motor |
| | | Pool Pump Motor Total Horsepower ~~Capacity~~ | |
| | | Motor Service Factor | |
| | | Motor Efficiency at full speed (3450 RPM) (%)(except water fall pump motors) | |

| | Appliance | Required Information | Permissible Answers |
|---|---|---|---|
| | | Motor Efficiency at ¾ speed (2590 RPM) (%) (multi-speed and variable-speed only) | |
| | | Motor Efficiency at ½ speed (1725 RPM) (%) (dual-speed, multi-speed, variable-speed, and waterfall pool pump motors only) | |
| | | Motor Efficiency at ¼ speed (860 RPM) (%) (multi-speed and variable-speed only) | |
| | | Nameplate Horsepower | |
| | | Power Factor | |
| | | Unit has freeze protection feature | Yes, no |
| | | Freeze Protection (compliance with Section 1605.3(g)(5)(B)(3.) | Yes, no |
| | | Unit includes timer (Integral filter pool pump and motor combinations only) | Yes, no |
| | | Timer default operation duration setting (hrs) | |
| | | Pump Control Speed (compliance with Section 1605.3(g)(5)(B)(3.) | Yes, no |

| | Appliance | Required Information | | Permissible Answers |
|---|---|---|---|---|
| | | This information must be reported for each tested speed, as applicable (For pool pump and motor combinations except pressure cleaner booster pool pump and motor combinations, waterfall pool pump and motor combinations) | Motor Speed (RPM) | |
| | | | 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) | |
| | | | Flow for Curve 'C' (in gpm) | |
| | | | Power for Curve 'C' (in watts) | |
| | | | Energy Factor for Curve 'C' (in gallons per watt-hour) | |

| | Appliance | Required Information | | Permissible Answers |
|---|---|---|---|---|
| | | This information must be reported for each tested speed, as applicable (For pressure cleaner booster pool pump and motor combinations). | Motor Speed (RPM) | |
| | | | Flow at 90 ft head (in gpm) | |
| | | | Power (in watts) | |
| | | | Energy Factor (in gallons per watt-hour) | |
| | | | Average Head to Flow Ratio (ft/gpm) | Greater than or equal to 2.0 |
| | | This information must be reported for each tested speed, as applicable (For waterfall pool pump and motor combinations). | Motor Speed (RPM) | |
| | | | Flow at 17 ft head (in gpm) | |
| | | | Power (in watts) | |
| | | | Energy Factor (in gallons per watt-hour) | |

. .[skipping remainder of  Table X]

…

…

(4) Declaration.

(A) Each statement shall include a declaration, executed under penalty of perjury of the laws of California, that

…

(5) all units of the appliance are marked as required by Section 1607, and, for the following appliances, are marked as follows:

…

g. for two-, multi-, or variable-speed residential pool pumps, each pool pump is marked permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than 1/4", with the nameplate HP of the pump and, if manufactured on or after January 1, 2010, with the statement, "This pump must be installed with a two-, multi-, or variable-speed pump motor controller";

h. for residential pool pump motors, each pool pump motor is marked permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than 1/4", with the pool pump motor capacity of the motor.,

i. for two-, multi-, or variable-speed pool pumps manufactured on or after January 1, 2019, each pool pump is marked permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than 1/4", with the nameplate HP of the pump and, , with the statement, "This pump must be installed with a two-, multi-, or variable-speed pump motor controller";

j. for pool pump motors manufactured on or after January 1, 2019, each pool pump motor is marked permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than 1/4", with the pool pump motor capacity of the motor.

…

**Section 1607 Marking of Appliances.**

…

(d) Energy Performance Information.

…

(9) ~~Residential~~ Pool Pumps.

(A) Each residential pool pump, and pool pump manufactured on or after January 1, 2019, shall be marked, permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than 1/4”, the nameplate HP of the pump.

(B) Each residential pool pump motor, and pool pump motor manufactured on or after January 1, 2019, shall be marked, permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than 1/4”, the pool pump motor capacity of the motor.

(C) Two-, multi-, or variable-speed residential pool pumps manufactured on or ~~certified to Section 1606 of this Article on or~~ after January 1, 2010, and two-, multi-, or variable-speed pool pump and motor combinations and replacement pool pump motors manufactured on or after January 1, 2019, shall be marked, permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than 1/4” “This pump must be installed with a two-, multi-, or variable-speed pump motor controller,”

# PART B: PORTABLE ELECTRIC SPAS

# CHAPTER 11: Product Description

Portable electric spas are factory-built, free-standing electric spas or hot tub units that can be rigid, flexible, or inflatable. They are defined as above-ground units that are electrically heated and not permanently installed in the ground or attached to a pool. They are supplied with pumps, heaters, and jets for heating, circulation, filtration, and maintenance, all of which result in significant energy consumption statewide.

According to a 2013 APSP market report, more than 1 million spas are being used in California, and more than 100,000 new units were sold each year in 2011 and 2012.[82] The APSP also estimated that, in 2015, 15,000 inflatable spas were sold.[83] Uses vary from recreational to health and fitness. There are various comfort features and configurations of the heating system, the pumping system, and the filtering system for portable electric spas, making them one of the highest residential electrical loads.[84] The typical components in portable electric spas include a heating element, a pump and motor combination, a filter, insulation, a shell or tub wall, an exterior cabinet, jets, and, a spa cover. (See **Figure 11-1**.[85]) These components provide opportunities for energy efficiency improvements. The average lifetime of a portable electric spa is 10 years, while a spa cover has an average lifetime of 5 years.[86] Inflatable spas have an estimated average lifetime of 3 years.[87]

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82 The Association of Pool & Spa Professionals, P.K. Data Research Industry Statistics. Retrieved from http://apsp.org/portals/0/images/APSP%20statistics%202013.jpg.

83 APSP's presentation at staff workshop on February 18, 2016. Docket 15-AAER-02, TN 210390, February 17, 2016.

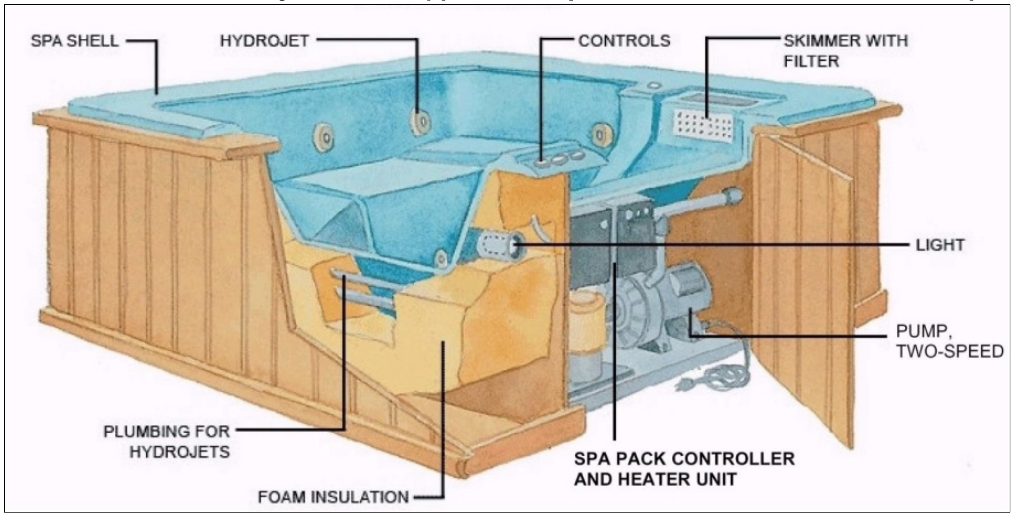
84 Davis Energy Group, Energy Solutions, (2004), *Analysis of Standards Options for Portable Electric Spas.* California: PG&E.

85 Hamill, A. I. (2012). *Measurement and Analysis of the Standby Power of Twenty-Seven Portable Electric Spas.* California Polytechnic State University, San Luis Obispo, Mechanical Engineering . San Luis Obispo: Andrew Ian Hamill.

86 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas.* Energy Solutions, PG & E. California Statewide Utility Codes and Standards Program. Retrieved July 2015.

87 APSP's presentation at staff workshop on February 18, 2016. Docket 15-AAER-02, TN 210390, February 17, 2016.

**Figure 11-1: Typical Components in a Portable Electric Spa**




Source: The Spa Guys, "How Hot Tubs Work"

As of May 2016, the California Energy Commission's modernized appliance efficiency database system (MAEDBS) lists 1,321 certified portable electric spas. Spas are distinguished as hot tubs/portable spas and exercise spas/swim spas. For this report, two types of spas were analyzed: portable spas and exercise spas. Using the certified portable electric spa manufacturers in the MAEDBS as sources, the key differences between the two types of spas are the volume capacity (or water surface area), the type of features, and the intended use.

## Portable Spas

Portable spas are intended for mostly recreational use and provide the user with a comforting warm-water massage by electrically heating and aerating the water.[88] Portable spas may include hydrotherapy or therapeutic features that use a jet system that projects streams of water at different pressure outputs in multiple locations. The volume capacity for portable spas can range from 120 gallons to more than 800 gallons.[89] Portable spas can be rigid bodied or nonrigid, containing inflatable or separable structural components for easier storage and relocation. (See **Figure 11-2**.) Although the smaller-volume, inflatable, and self-assembly spa units are intended to be used seasonally, both rigid and nonrigid easily-stored spas typically have a temperature range between 60˚F and 104˚F[90] like conventional free-standing spas.[91]

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88 Jacuzzi. (2011, November 30). "Jacuzzi Hot Tubs Lists the Most-Wanted Hot Tub Feature." Retrieved from Jacuzzi: http://www.jacuzzi.com/hot-tubs/about/press-releases/jacuzzi-hot-tubs-lists-most-wanted-hot-tub-feature/.

89 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas.* Energy Solutions, PG&E. California Statewide Utility Codes and Standards Program. Retrieved July 2015.

90 Energy Commission- certified portable electric spa manufacturers: Catalina Spas, Masters Spas Inc., Sundance , Dimension One Spas.

91 "Best Inflatable Hot Tub Reviews: Easier Way to Compare." *Inflatable Hot Tub Report.* (2016). http://www.inflatablehottubreport.com/.

Sorting by volume range, there are 1,321 portable spas ranging from 110 to 850 gallons certified to MAEDBS.

**Figure 11-2: Portable Electric Spa**


Sources: Jacuzzi Spas, Jacuzzi.com, Comfort Line Products, Coleman, Amazon.com

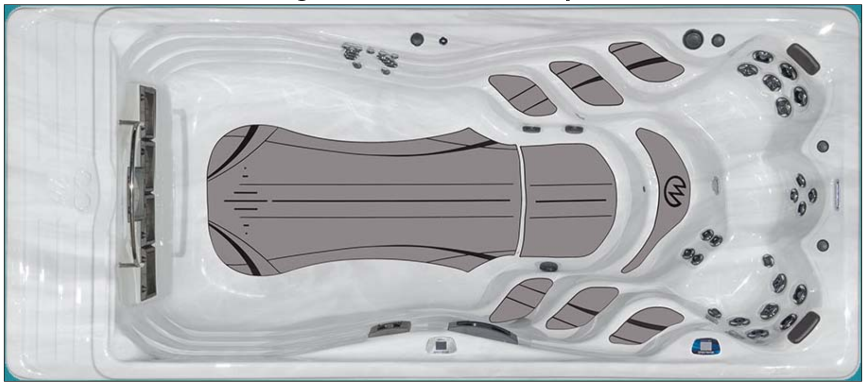
## Exercise Spas

Exercise spas are intended for health, fitness, and recreational use. (See **Figure 11-3**). Health and fitness uses include swimming, aquatic fitness or exercising, and hydrotherapy. The swimming mode uses a propulsion system to create a current of rushing water the user can swim against. The therapeutic mode offers hydrotherapy configurations for exercising or for physical therapy, thus requiring a larger volume or water surface area.[92] Exercise spas that are designed to have two separate bodies of water at different temperatures are called *combination spas*, one body of water for swimming and the other for hydrotherapy.[93] (See **Figure 11-4.**) USA Swimming and the Aquatic Exercise Association recommend a water temperature range of 78˚F to 82˚F for competitive swimming, 83˚F to 88˚F for aquatic exercise, and 90˚F to 95˚F for aquatic

92 Hartey, M. (2013). "Swim Spa Basics." Retrieved from Pool & Spa Outdoor: http://www.poolspaoutdoor.com/hot-tubs-swim-spas/swim-spas/articles/swim-spa-basics.aspx.
93 Poolandspa.com. (2015, August 21). "What Is a Swim Spa?" Retrieved from poolandspa.com: http://www.poolandspa.com/page6210.htm.

therapy. Most exercise spas have a built-in temperature range of 60˚F to 104˚F[94] and are capable of meeting those recommendations. Users can still select the temperature of their choice. Exercise spas have capacities that range from 900 gallons to 2,500 gallons.[95]

**Figure 11-3: Exercise Spa**



Source: Michael Phelps Swim Spas

**Figure 11-4: Combination Spa**

Source: Grand Cayman Dual Zone Swim Spa

By filtering spa data in MAEDBS using the volume ranges stated above for exercise spas, there are 65 certified exercise spas ranging from 924 gallons to 2,400 gallons.

94 Energy Commission certified portable electric spa manufacturers: Catalina Spas, Masters Spas Inc., Sundance , Dimension One Spas

95 Various exercise spa manufacturers: Artic Spas, Dimension One Spas, and Master Spas Inc.

## Heating System

Portable electric spas heat water electrically. The heating system accounts for the majority of the energy consumption. Most heating systems use electric resistance heaters and, in some cases, waste heat from the pump system to heat and maintain the water at a set temperature.[96]

According to a 2012 Cal Poly study, the heater is used during startup, standby, and active use. During startup mode, recently filled water is heated to a set temperature or temperature range with the spa cover on. The startup mode can take from 5 to more than 24 hours to reach a water temperature of 102˚F. Duration of the startup is affected by multiple factors including, but not limited to, the insulation (or lack thereof) and ambient air temperature if used in colder climates. After the water has reached the set temperature, the unit is put into standby mode to maintain the set temperature and to circulate and filter the water. When it is time for use, the spa cover is removed, and the spa is occupied. The heater is used to maintain the set temperature.[97] Most spas are kept in standby mode year round when not in use, since startup mode requires a lot of time and energy.[98] Over the lifetime of the unit, the standby mode represents typically 75 percent of the energy consumed by a portable electric spa.[99] More than half of the energy consumed during standby mode is due to maintaining heat.[100]

For smaller-volume, easy-storage units such as inflatable spas, some are designed with a heating mode that includes an automatic shutoff switch after the spa has operated for 72 hours.[101] Moreover, some units will shut off if the designated heating/standby temperature was never reached during the first 72 hours of operation.[102]

The heating system functions the same through each mode. There are many configurations of the heating system, but generally the pump draws water from the footwell through a suction fitting and/or from the surface through a skimmer/filter to the heater. **Figure 11-5** shows a general configuration. The warm water is returned to the spa through the jets or a main return. The water can be filtered before or after reaching the heater.

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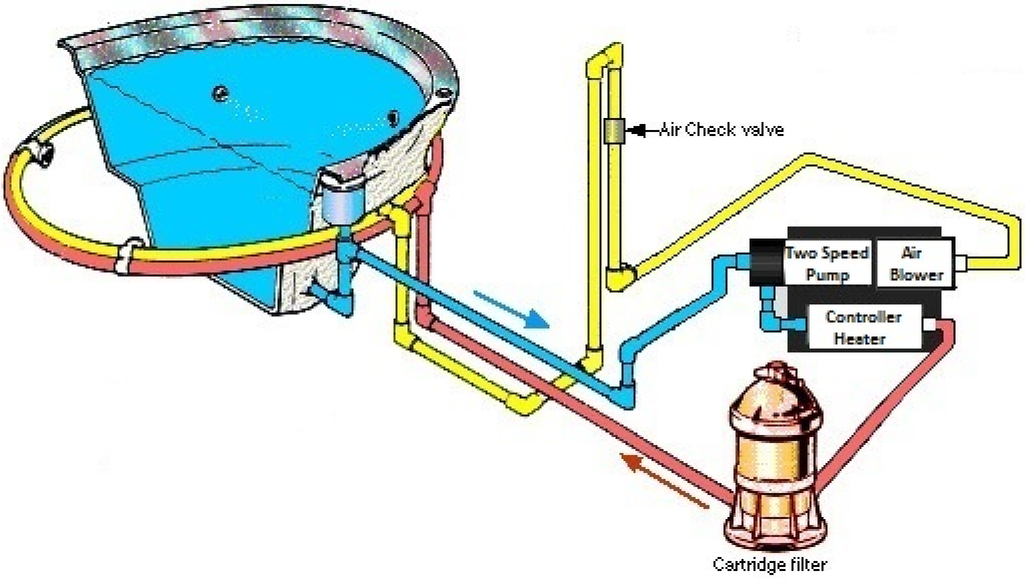
96 Davis Energy Group, Energy Solutions. (2004). *Analysis of Standards Options for Portable Electric Spas.* California: PG&E.
97 Hamill, A. I. (2012). *Measurement and Analysis of the Standby Power of Twenty-Seven Portable Electric Spas.* California Polytechnic State University, San Luis Obispo, Mechanical Engineering. San Luis Obispo: Andrew Ian Hamill.
98 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas.* Energy Solutions, PG&E. California Statewide Utility Codes and Standards Program. Retrieved July 2015.
99 Appliance Standards Awareness Project. (2015). "Portable Electric Spas." Retrieved from ASAP - Appliance Standards Awareness Project: http://www.appliance-standards.org/product/portable-electric-spas.
100 Davis Energy Group, Energy Solutions. (2004). *Analysis of Standards Options for Portable Electric Spas.* California: PG&E.
101 Intex Recreation Corp (2015). *PureSpa 77" Quick Start Guide.* http://www.intexcorp.com/support/28403e.html.
102 Intex Recreation Corp (2015). *PureSpa 77" Manual.* http://www.intexcorp.com/support/28403e.html.

**Figure 11-5: General Configuration of Heating and Pumping System**




Source: Spa Plumbing Diagrams, PoolSpasHelp.com

Electric resistance heaters are theoretically 100 percent energy-efficient because all the electricity is converted to heat.[103] In practice, resistance heaters in portable electric spas can have efficiencies of 98 percent or more.[104] Thus, the energy efficiency is already high for heaters in a portable electric spa.

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103 U.S. DOE. (2015). "Electric Resistance Heating." Retrieved from Energy.gov: http://energy.gov/energysaver/articles/electric-resistance-heating.

104 Davis Energy Group, Energy Solutions. (2004). *Analysis of Standards Options for Portable Electric Spas.* California: PG&E.

## Pumping System

After the heating system, the pumping system is the most energy-intensive integrated part of a portable electric spa and can account for 25 to 50 percent of the total energy consumed by the unit, depending on how often different features are used. Energy consumption can vary due to possible configurations for the pumping system. Most portable electric spas have at least one pump with multiple speed options for filtering, circulating, aerating, and jet action. For example, some spas have a two-speed pump motor where the low-speed option is used during standby mode and the high-speed option is used for operating the jets. These pumps are not very efficient in any mode, especially during standby, because the motor is lightly loaded and running at low efficiency.[105] Some models include a separate pump for specific features or maintenance, which can save a significant amount of energy over the low-speed option on a larger pump.[106] Larger spas, like exercise spas, typically have multiple pumps. For example, exercise spas sold in California can have up to four pumps.[107]

Depending on how the unit is setup internally, the pumping system functions nearly the same for heating and filtering. Water is pumped into the heating element or the filter, then returned to the unit through the jets or a main return. For other maintenance duties and features, such as aeration, circulation, and hydrotherapy, the pumping system supplies water and air to the jets at varying pressures.[108] The type of jets within a system can vary as well. Some supply air and water separately, but most are a combination of air and water. (See **Figure 11-6**.) Portable electric spas that are marketed as hydrotherapy spas have multiple jets of different types. Increasing the number of jets increases the power demand of the pumping system. Thus, some units include a separate pump for jets and circulation.[109] The secondary pump can be used to optimize the primary pump and generate savings in standby mode.

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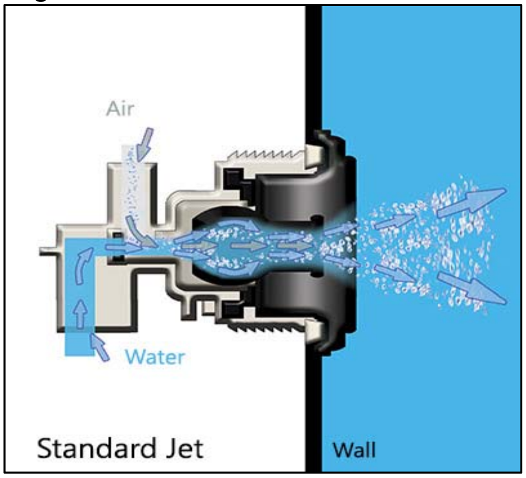
105 Western Area Power Administration. (2009). "What Goes Into an Energy-Efficient Spa or Hot Tub?" Lakewood: Western Area Power Administration.
106 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas.* Energy Solutions, PG&E. California Statewide Utility Codes and Standards Program. Retrieved July 2015.
107 Masters Inc. (2014). "Models - H2X Swim Spas." Retrieved July 2015, from H2X Water To The Extreme, available at http://www.h2xswimspa.com/h2x-swimspa-models.html.
108 Hamill, A. I. (2012). *Measurement and Analysis of the Standby Power of Twenty-Seven Portable Electric Spas.* California Polytechnic State University, San Luis Obispo, Mechanical Engineering . San Luis Obispo: Andrew Ian Hamill.
109 Western Area Power Administration. (2009). "What Goes Into an Energy-Efficient Spa or Hot Tub?" Lakewood: Western Area Power Administration.

**Figure 11-6: Standard Jet Cross-Section**




Source: H2X Swim Spas, Master Inc.

# Water Treatment

The water treatment system is inclusive of the pumping system since water treatment requires circulation and suctioning of water through the filtration unit. Filtration cycles can vary from programmed settings to continuous settings. Portable electric spas typically have one central pump that performs all operations including the filtration cycle, although some spas use a separate pump specifically for filtration and circulation.[110] Again, the filtration system can have various configurations and can include different types of water treatment mechanisms to improve water quality, such as cartridge filters with or without media, skimmers, an ozonator, ultraviolet (UV) system, and the addition of minerals and sanitizing chemicals.[111] A single cartridge filter is the most common filtration system for smaller spas. Larger spas typically have a cartridge filter and an ozone treatment system paired together. (See **Figure 11-7**.)

Untreated water is suctioned through the cartridge filter, where large particles and contaminants are removed.[112] For units that include an ozonator (an ozone system), the filtered water is injected and mixed with ozone ($O_3$), an oxidizing-agent that effectively treats organic and inorganic contaminants. The treated water is then returned to the water through the jets or a main return.[113]

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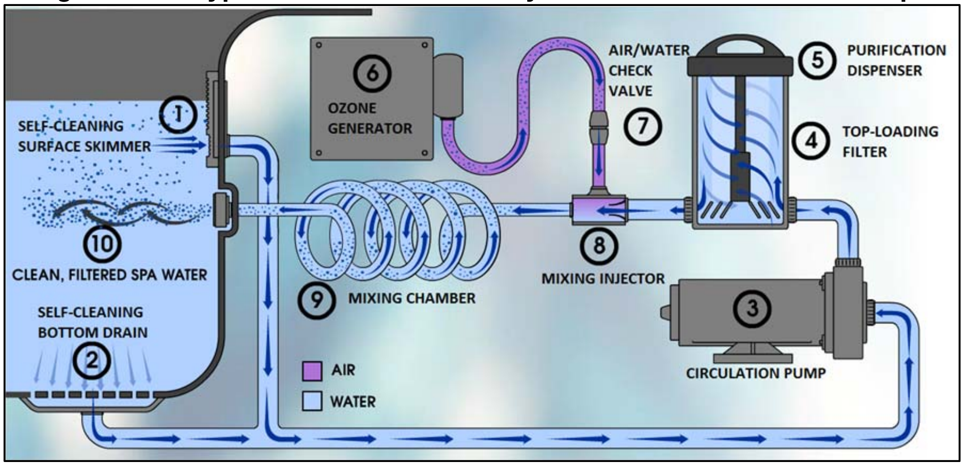
110 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas.* Energy Solutions, PG&E. California Statewide Utility Codes and Standards Program. Retrieved July 2015.
111 The Spa Depot. (2015). "Hot Tub Maintenance." Retrieved from SpaDepot.com: http://www.spadepot.com/spacyclopedia/hot-tub-maintenance.htm.
112 National Academy of Sciences. (2007). "Filtration Systems - Technologies." Retrieved from Safe Drinking Water is Essential: http://www.koshland-science-museum.org/water/html/en/Treatment/Filtration-Systems-technologies.html#tech4.
113 National Academy of Sciences . (2007). "Chemical Disinfection/Oxidants - Technologies." Retrieved from Safe Drinking Water is Essential: http://www.koshland-science-museum.org/water/html/en/Treatment/Chemical-Disinfection-Oxidants-technologies.html#tech3.

**Figure 11-7: Typical Water Treatment System in a Portable Electric Spa**




Source: Baja Spas

# Insulation and Spa Covers

Since portable electric spas circulate and heat water, reducing the energy consumption of the heating system presents an opportunity to save energy. To this end, manufacturers use good insulation and spa covers to combat heat and water loss. Insulation minimizes heat loss during operating and idle periods, while a spa cover minimizes heat loss and water loss through evaporation. Ensuring that a spa cover is being used and improving the cover and insulation reduce the work of the heater and the pump motor needed to maintain a set temperature during idle periods.

The spa unit insulation and spa cover offer the greatest opportunity to save energy, since they help retain the heat in the water by the design and construction materials. Insulation is used within the walls of the spa unit and within the spa cover. The insulation used within the walls or the cavity between the tub wall and the cabinet enclosure is usually either foam or fiberglass. According to the Energy Commission database, more than 99 percent of spas listed are fully insulated.[114]

For spa covers, according to the 2009 Residential Appliance Saturation Survey, 43 percent of California spa owners did not own a spa cover.[115] Consumers need to be made aware that a spa cover is a key component to their system. Using a spa cover is critical to saving energy and water (lost through evaporation.) The evaporation rate due to not using a spa cover while heating the water from 60˚F to 102˚F was calculated by using the average volume capacity in each volumetric zone to determine a typical water surface area for that volume. (See **Table 11-1**). Larger units typically have a greater water surface area, which results in more water and

114 California Energy Commission. (2015). MAEDBS. Retrieved from Appliance Search http://maedbs/Pages/ApplianceSearch.aspx.
115 KEMA. (2010). *California Statewide Residential Appliance Saturation Study*. Retrieved from https://websafe.kemainc.com/RASS2009/Default.aspx.

heat loss than standard units. For example, a 450-gallon unit can lose more than one gallon of water per hour, whereas a 2,250-gallon unit can lose almost three gallons of water per hour. Looking at the evaporation rate as a relationship between the exposed surface area of water relative to the volume of the unit will separate the spas into different groups or "zones" that better represent the water losses that occur.

**Table 11-1: Evaporation Rate Without a Spa Cover**

| Zone | Unit Volume Capacity (gallons) | Water Surface Area ($m^2$) | Evaporation Rate, $w_p$ (gallons/hr) |
|---|---|---|---|
| Zone 1A | 140 | 3.3 | 0.70 |
| Zone 1B | 240 | 3.9 | 0.83 |
| Zone 2 | 450 | 5.7 | 1.21 |
| Zone 3 | 750 | 5.8 | 1.23 |
| Zone 4 | 1,050 | 8.0 | 1.69 |
| Zone 5 | 1,350 | 8.7 | 1.85 |
| Zone 6 | 1,650 | 10.9 | 2.31 |
| Zone 7 | 1,950 | 13.0 | 2.76 |
| Zone 8 | 2,250 | 14.0 | 2.96 |

Source: Design Considerations for Pools and Spas (Natatoriums) by John W. Lund; see Appendix B for calculations.

Assuming evaporation rates of 0.5 gallons to 2.96 gallons during standby operating hours (8,760 hours per year), as shown in **Table 11-1**, a determination can be made about the amount of energy required in a worst case scenario to heat the spa, the evaporation rate, the water wasted, and the costs associated with not using a spa cover. The energy costs range from $1,800 to $10,500 per unit per year. The amount of water that evaporates due to not using a spa cover is significant as well. For an evaporation rate of one gallon of water per hour, the amount of water that could be wasted is about 8,700 gallons per year per unit. (See **Table 11-2**.) Using a cover can reduce evaporation by 90 to 95 percent.[116]

116 Azusa Light & Water. (July 27, 2015). *Rebates*. Retrieved from Azusa Light & Water: http://www.ci.azusa.ca.us/index.aspx?nid=368.

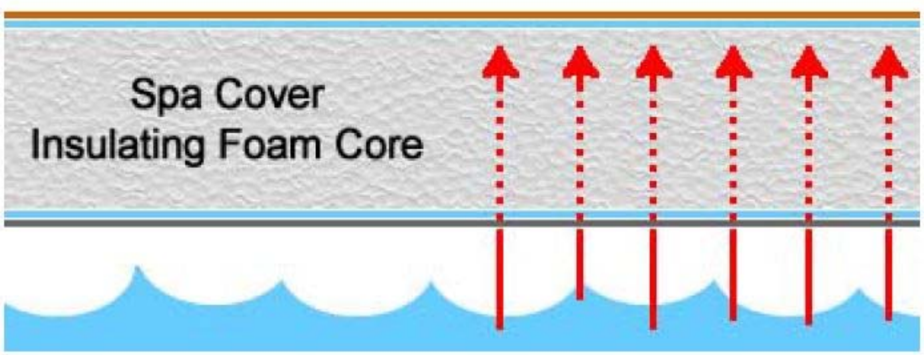
**Table 11-2: Annual Energy and Water Waste Without a Spa Cover**

| Evaporation Rate, w (gallons/hr) | Energy Consumption (kWh/year) | Water Lost to Evaporation (gallons/year) | Energy Costs for Heating Water ($) |
|---|---|---|---|
| 0.5 | 10,844 | 4,380 | $1,756 |
| 1 | 21,688 | 8,760 | $3,511 |
| 2 | 43,376 | 17,520 | $7,023 |
| 3 | 65,064 | 26,280 | $10,534 |

Source: Building Technology: Mechanical and Electrical Systems by B. Stein. See Appendix B for calculations.

Spa covers conserve heat by reducing heat flow due to conduction, convection, radiation, and evaporation. The foam core within the spa cover acts as a thermal insulator, reducing heat transfer from the warm water to the colder air outside. (See **Figure 11-7**.) The thermal resistance of the insulating material, in this case the foam core, is measured or rated by the R-value, which depends on the insulation type, thickness, and density. A high R-value indicates greater resistance to heat flow.[117] The arrows in **Figure 11-7** indicate heat loss dissipating through the foam core.

**Figure 11-7: Cross-Section of a Spa Cover**




Source: Duratherm, The Spa Depot

The foam core is typically made of polystyrene.[118] Polystyrene is a colorless, transparent thermoplastic.[119] Two types of rigid polystyrene are used as foam cores for spa covers: expanded polystyrene (EPS) and extruded polystyrene (XPS). EPS is composed of small plastic beads that are fused together by heat and pressure, leaving open voids between the beads, whereas XPS begins as a molten material that is extruded into a closed cell matrix (no spaces

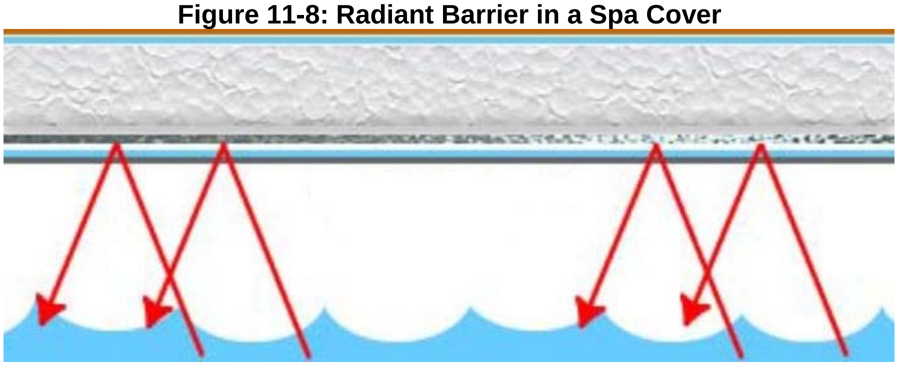
117 U.S. DOE. (2015, April 27). *Insulation.* Retrieved from Energy.Gov: http://energy.gov/energysaver/articles/insulation.
118 Hamill, A. I. (2012). *Measurement and Analysis of the Standby Power of Twenty-Seven Portable Electric Spas.* California Polytechnic State University, San Luis Obispo, Mechanical Engineering . San Luis Obispo: Andrew Ian Hamill.
119 U.S. Department of Energy. (April 27, 2015). "Insulation Materials." Available at Energy.Gov http://energy.gov/energysaver/articles/insulation-materials.

between cells). Both have different performance properties due to the manufacturing process for each.

XPS is less water-absorbent than EPS. The voids in EPS allow for significant water to be absorbed. When the foam absorbs water, the insulation loses thermal resistance. Water can also freeze and thaw, compromising the structural integrity of the foam. XPS also has a higher R-value than EPS when dry or wet. Dry EPS R-value ranges from 3.1 to 4.3 per inch, depending on the density. The R-value varies for EPS because the smaller the voids, the higher the density, resulting in a slightly higher R-value. The R-value for XPS is a uniform 5 per inch regardless of density, since the cell structure has no voids.[120] Most spa covers are made of EPS foam as they are able to provide enough insulation and keep a rigid structure while being resistant to mold, mildew, or bacteria growth.[121] They are also lightweight and require only one person to apply or remove. Thus, there is an opportunity to improve the insulation of the spa cover with highly efficient polystyrene that already exists in the market.

The R-value of a spa cover can also be increased by enclosing the foam core with a waterproof barrier, such as vinyl.[122] Other measures are available to prevent waterlogging and to reduce the conductive heat flow.[123] These options are to enclose the foam core within a polyethylene (common plastic wrap) wrap or a radiant barrier. The plastic wrap prevents water absorption and exposure to water treatment chemicals. A radiant barrier uses a highly reflective material that re-emits heat rather than absorbing it (**Figure 11-8**[124]).

**Figure 11-8: Radiant Barrier in a Spa Cover**



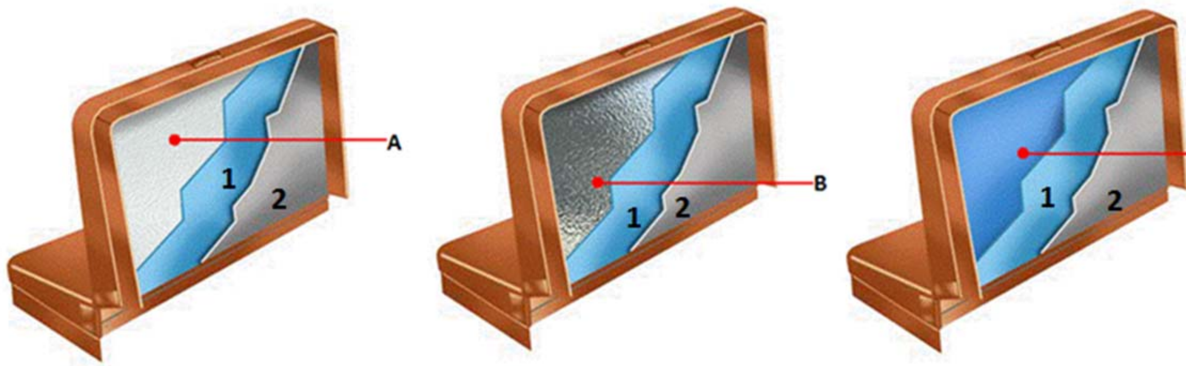
**Heat flow being reflected from the radiant barrier.**

Source: Duratherm, The Spa Depot

120 Owens Corning Foam Insulation, LLC. (2013). “Technical Bulletin: For Foam Plastic Insulation, Extrusion Matters Performance Equals Resisting Water XPS Performs Better Than EPS.” Toledo: Owens Corning.
121 The Foam Factory. (January 18, 2012). *Insulate and Protect Your Hot Tub With a Custom Polystyrene Cover.* Retrieved from The Foam Factory at https://www.thefoamfactory.com/blog/index.php/insulate-and-protect-your-hot-tub-with-a-custom-polystyrene-cover.
122 Hamill, A. I. (2012). *Measurement and Analysis of the Standby Power of Twenty-Seven Portable Electric Spas.* California Polytechnic State University, San Luis Obispo, Mechanical Engineering . San Luis Obispo: Andrew Ian Hamill.
123 Hot Tub Covers Canada.Ca. (2015). R-Values and Insulation. Retrieved from Hot Tub Covers Canda.Ca: http://www.hottubcoverscanada.ca/our-spa-covers/hottub-cover-r-values.html.
124 U.S. DOE. (2015, April 27). *Insulation Materials.* Retrieved from Energy.Gov: http://energy.gov/energysaver/articles/insulation-materials.

Examples of the type of enclosures and combination of barriers are shown in **Figure 11-9**. Each of these use a vinyl wrap, a moisture barrier (1), and a heavy-duty liner (2). From left to right, the first option shows the foam core (A) being enclosed by barriers (1) and (2); the second encloses the foam core with a reflective barrier (B) and barriers (1) and (2); and the third option encloses the foam with a another moisture barrier (C) and barriers (1) and (2).

**Figure 11-9: Types of Spa Cover Enclosures**




Source: Duratherm, The Spa Depot

The design and construction of spa covers vary depending on size and shape, but most covers have a hinge down the middle that allows the cover to fold in half. The hinge is typically not insulated, is about two inches wide, and runs the entire length of the cover, making it easy to fold but also allowing for significant heat loss. This type is known as a *dual-hinge* or *double-hinge*. This heat loss can be avoided by using a single-hinge design or an insulated hinge design. **Figure 11-10** shows a dual-hinge on the left compared to a single-hinge on the right.[125]

125 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas*. Energy Solutions, PG&E. California Statewide Utility Code s and Standards Program. Retrieved July 2015.

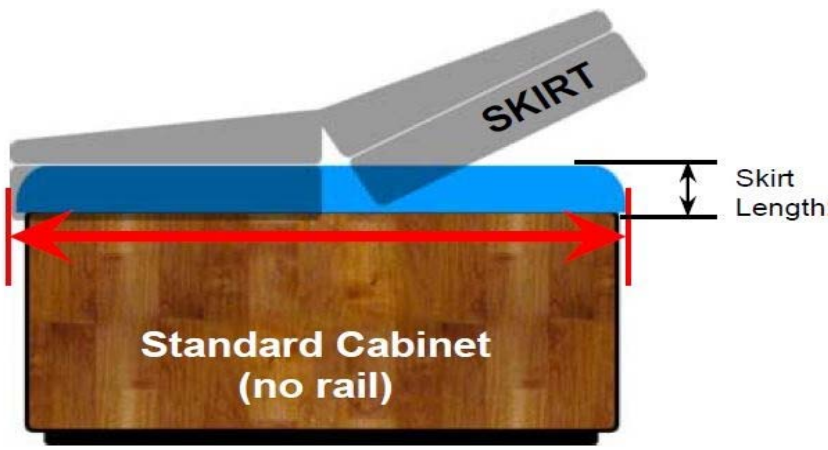
**Figure 11-10: Dual-Hinge and Single-Hinge Spa Covers**

**A single-hinge avoids heat loss by elminating the gap at the hinge compared to a dual-hinge.**

Source: Portable Electric Spas CASE Report 2014

Another design factor creates a seal between the spa cover and the surface of the unit exterior. Most spa covers have a vinyl skirt around the perimeter that overlaps the exterior of the unit to reduce water and heat losses, as shown in **Figure 11-11.**[126]

**Figure 11-11: Spa Cover Skirt**




Source: Duratherm, The Spa Depot

Another source of reducing energy and water consumption is the use of a floating blanket as shown in **Figure 11-12.** The floating blanket reduces moisture and chemical contact with the underside of the spa cover. It also acts as another barrier to prevent heat loss and evaporation.[127]

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126 Hamill, A. I. (2012). *Measurement and Analysis of the Standby Power of Twenty-Seven Portable Electric Spas.* California Polytechnic State University, San Luis Obispo, Mechanical Engineering. San Luis Obispo: Andrew Ian Hamill.
127 Lara, D. (April 10, 2014). "Increasing the Energy Efficiency of Your Hot Tub or Spa." Retrieved from Hot Tub Works: http://www.hottubworks.com/blog/increasing-the-energy-efficiency-of-your-hot-tub-or-spa/.

**Figure 11-12: Spa Floating Blanket**

Source: Duratherm, The Spa Depot

## Energy Use

The total energy use of portable electric spas, according to the current Title 20 test method, is the total energy consumed during the default operation mode over a 72-hour period with the spa cover that comes with the unit in use.[128] Andrew Ian Hamill of California Polytechnic State University was able to determine which modes and cycles contribute most to the total standby power from his analysis of 27 portable electric spas using the Title 20 test method. The modes, or cycles, were categorized in four groups: heater cycle, filtration cycle, pulses cycle, and constant filtration cycle.

The heater cycle uses the heater along with the pumps to maintain the water at a set temperature range. The filtration cycle uses the pumps to draw the water into the filter and circulate the water to keep the water clean for a set period. The pulses cycle uses the pumps to circulate the water for a short period. The constant filtration cycle uses the pumps to continuously circulate water, providing filtration and preventing bacterial growth. Hamill's results, shown in **Table 11-3**, confirm that more than half of the energy consumed is due to the heating during standby mode. The percentage contribution to the standby power using the heater cycle ranged from 8 to 100 percent of total power. The power demand for the heater cycle ranged from 706 to 4,331 watts, with a median demand of 3,141 watts. The testing was of spas with capacities ranging from 142 to 470 gallons,[129] typical of a portable spa.

128 California Energy Commission, *2015 Appliance Efficiency Regulations.* Title 20, Section 1604(g)(2). May 2014.
129 Hamill, A. I. (2012). *Measurement and Analysis of the Standby Power of Twenty-Seven Portable Electric Spas.* California Polytechnic State University, San Luis Obispo, Mechanical Engineering . San Luis Obispo: Andrew Ian Hamill.

**Table 11-3: Percent Contributions to the Total Standby Power by Cycle Type**

| | Heater Cycle | Filter Cycle | Constant Filtration | Pulses |
|---|---|---|---|---|
| Average Percent Contribution to Standby Power | 72 | 24 | 40 | 4 |

**The percentages in Table 11-3 are not to be summed to equal 100 percent. Each percentage describes the overall average percent contribution to each cycle type for the 27 portable electric spas that were tested during standby mode.**

Source: *Measurement and Analysis of the Standby Power of Twenty-Seven Portable Electric Spas*, Andrew Ian Hamill

It is important to note the volume capacity range of the units tested because there are more than 190 portable electric spas with a volume greater than 470 gallons and up to 2,400 gallons that would have a greater power demand during the heating cycle. Some of these are portable spas (up to roughly 900 gallons), while others are exercise or combination spas.

# CHAPTER 12: Regulatory Approaches

## Current Title 20 Standards

In 2004, the Energy Commission adopted standards and testing procedures for portable electric spas that took effect in 2006.[130] These standards require that the standby power of a spa must not exceed a sliding scale of wattage as a function of the volume of a spa: [5 x Volume$^{2/3}$].

## Federal Approaches

There is no federal standard and no ENERGY STAR specification for portable electric spas.

## Other State Approaches

In 2010, Florida adopted the ANSI/APSP/ICC-14 2011 standard for portable electric spa energy efficiency, which took effect March 15, 2012. This test procedure is based on the test procedure in the Title 20 Appliance Efficiency Regulations and elaborates more on how testing and measurements are to be performed.[131]

Effective January 1, 2012, portable electric spas sold in Arizona cannot exceed a normalized standby power consumption of the fill volume of the spa raised to the two-thirds power based on ANSI/APSP/ICC-14 2011.[132]

## Industry Standards

The spa industry, represented by the APSP, has accepted ANSI/APSP/ICC-14 2014, which was approved by the American National Standard Institute (ANSI) on September 12, 2014, a revision of ANSI/APSP/ICC-14 2011.[133] In general, the ANSI/APSP/ICC-14 2014 standard is similar to the Energy Commission's Title 20 standard with a few exceptions: ANSI/APSP/ICC-14 requires a more stringent standby power limit, requires labels on all spas, applies specific testing requirements to exercise spas, and modifies the test chamber certification testing. The ANSI/APSP/ICC-14 standards represent best industry practice but are not mandatory or enforced.

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130 California Energy Commission, *2015 Appliance Efficiency Regulations.* Title 20. May 2014.
131 APSP. "APSP Standard Becomes Federal Law Through the Virginia Graeme Baker Pool and Spa Safety Act," August 8, 2011. APSP. September 21, 2015. <http://apsp.org/portals/0/PDfs/714.pdf>.
132 Arizona State Legislature. Title 44, Chapter 9, Article 19, 1375.02. Retrieved from http://www.azleg.gov/FormatDocument.asp?inDoc=/ars/44/01375-02.htm&Title=44&DocType=ARS.
133 APSP, American National Standards Institute. (2014). American National Standard for Portable Electric Spa Energy Efficiency. Alexandria: APSP.

## The CASE Report

In July 2013, the IOUs and the Natural Resources Defense Council submitted a CASE report in response to the Energy Commission's invitation to submit proposals.[134] In May 2014, they submitted a revised proposal for portable electric spa standards.[135] The proposal recommends adopting the ANSI/APSP/ICC-14 2014 standard, with the exception of regulating exercise spas. More specifically, they recommend adopting the test procedures, test room requirements, and the lower standby power limit [3.75 x Volume$^{2/3}$ + 40 watts] stated in the ANSI/APSP/ICC-14 2014 standard. In addition, the CASE report recommends adding requirements for original equipment and third-party spa covers and requiring labels on spa units that will inform consumers of the tested standby power consumption, maximum allowable standby power consumption, and the spa cover make and model used during testing to achieve the displayed standby performance.

The CASE team estimates that implementing the proposal would result in a reduction of about 6 GWh the first year the standards are in effect and a savings of about 64 GWh after full-stock turnover in 10 years.

134 CASE Report, *Pools & Spas* (July 29, 2013). Retrieved from http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2F_Residential_Pool_Pumps_and_Replacement_Motors/California_IOUs_Response_to_the_Invitation_to_Submit_Proposals_for_Pool_and_Spas_2013-07-29_TN-71756.pdf.

135 CASE Report, *Portable Electric Spas.* (May 15, 2014). Retrieved from http://www.energy.ca.gov/appliances/2013rulemaking/documents/comments/12-AAER-2G_Portable_Electric_Spa_Labeling/12-AAER-2G_Portable_Electric_Spas_Final_CASE_Report_2014-05-15_TN-73027.pdf.

# CHAPTER 13: Alternative Considerations

Staff analyzed the proposal in the CASE report to determine whether it meets the legislative criteria for the Energy Commission's prescription of appliance efficiency standards. State standards for three scenarios were considered: (1) maintaining current Title 20 standards, (2) incorporating the CASE report's proposal, (3) modifying the scenario proposed by the CASE team, and (4) providing an alternate requirement to be met in the previous, modified CASE team scenario. Comments from interested parties made during the February 18, 2016, staff workshop and to the Commission docket were also reviewed.

## Alternative 1: Maintaining Current Title 20

Title 20 requires portable electric spas to meet a standby requirement and report results to the Commission, but it does not require labeling of spas to help consumers choose between products based on efficiency levels. Visits to residential spa show rooms at the California State Fair in 2013 revealed spas that were offered for sale carried labels that described the products as "efficient" without any explanation of why or how they were rated. This type of labeling leaves consumers without any means to make an educated purchase related to the efficiency of the unit.

Dealers' purchases of original equipment covers are not verified, and customers have no direct means to ensure they are receiving original equipment covers. This raises the concern that the performance integrity of the spa (as tested and certified) may be compromised. This could undermine the effectiveness of the current portable electric spa standard and the requirements found in Section 1608(a)(3) of the California Code of Regulations.

Moreover, spas have improved techniques for insulation and covers that will lead to lower standby energy consumption, presenting an opportunity to improve spa efficiency in the marketplace. For these reasons, staff believes the Title 20 performance standards must be updated.

## Alternative 2: Incorporate CASE Team Proposal

The CASE team proposal would establish a more stringent energy consumption standard for portable electric spas (not including exercise spas or inflatable spas), add requirements for specific effective spa covers, add a labeling requirement to provide consumers with tools for informative purchases, and update test procedures. Specifically, the proposal recommends:

- Establishing more efficient spas by lowering standby power consumption limit. The current standard of [$5xV^{2/3}$] should be changed to [($3.75xV^{2/3}$) + 40], consistent with the most recent version of ANSI/APSP/ICC-14 2014. The new proposed standard allows reduction of heat losses from the spa surface area while supporting the minimum baseline energy consumption needed to operate other equipment, such as the pump and controller.

- Incorporating ANSI/APSP/ICC-14 2014 as the new test method and labeling template for compliance verification.
- Adding a clarifying requirement that would require new spas to be sold with a cover.
- Reporting and listing approved spa covers used during certification testing.

This proposal presents a significant opportunity for energy savings that are cost-effective and technically feasible. However, staff is considering the potential energy savings opportunities in the exercise spa market that could further benefit California's efforts in energy efficiency and greenhouse gas reductions. Furthermore, staff believes inflatable and self-assembly spas provide the same function and heating temperatures within scope of the existing, technology-neutral standard.

## Alternative 3: Updated Standby Standards, Spa Cover Reporting, and Spa Unit Labeling

The CASE team's proposal was evaluated and the data of certified portable electric spas and exercise spas in the Appliance Efficiency Database were analyzed to see if the proposed standby energy consumption standard could be achieved as 47 percent of the certified exercise spas sold in California could meet the new standard. The remaining 53 percent of exercise spas that would not meet the standard will have a compliance pathway with the standby test temperature for exercise spas being lowered by 15 degrees in the proposed test procedure. Alternative 3 includes recommendations similar to the CASE team's proposal but clarifies the testing and labeling requirements, which accommodates the other spa types (exercise and combination spas) that fall within the existing Title 20 scope and definition.

- Portable electric spas would maintain the existing broad definition that includes traditional, storable, exercise, and combination spas.
- ANSI/APSP/ICC-14 2014 would be incorporated as the new test method.
- The current standard of [$5xV^{2/3}$] would be changed to [($3.75xV^{2/3}$) + 40] for all types of portable electric spas.
- ANSI/APSP/ICC-14 2014 would be incorporated as the basic labeling template, with the following modifications. The label shall display the manufacturer and model number of the spa cover(s) used during certification testing and allowed for sale with the unit in accordance with Section 1608(a)(3) of the California Code of Regulations. The normalized standby watts displayed on the label shall represent the spa unit-cover combination that yields the maximum energy consumption.
- The model number of the spa cover used during testing shall be reported to MAEDBS.

This alternative achieves a similar amount of energy savings to the CASE report and would allow consumers to purchase a spa cover of their choice since each unit-and-cover test combination would have been reported and certified in MAEDBS. Prior to purchase, the consumer would be informed of what cover should be bought with the unit to achieve the standby performance that was labeled and reported for certification and sale in California. This alternative is both cost-effective and technically feasible, and achieves a significant amount of energy savings.

## Alternative 4: Standby Mode Design Requirement, Alternate Design Requirement for Non-Standby-Compliant Models, Updated Standby Standards, Required Spa Cover Reporting, and Spa Unit Labeling

Staff considered a fourth alternative that would provide relief for models that are not compatible with the testing requirements of ANSI/APSP/ICC-14 2014, as this was a concern about some inflatable, easy-storage units. This proposal is similar to Alternative 3, except that for spa units that do not have the capability to operate in standby mode for the full duration of the proposed test procedure, the unit must include a timer that automatically shuts off the unit's heating function after 72 hours of operation.

The prescriptive timer requirement would address any smaller-volume, easy-storage units, such as inflatable spas, that may not be capable of being tested for the duration of the ANSI/APSP/ICC-14 2014 test procedure (at least 76 hours to measure the standby performance).[136]

However, creating a design requirement could be an opportunity for a manufacturer of any spa type (conventional, exercise, inflatable, or self-assembly) to shift production toward simply satisfying this required design feature rather than meeting a performance standard. Since no performance data would be tested and reported during certification of any products choosing to take this design route, the Energy Commission's ability to pursue any future, potential energy savings opportunities would be inhibited. Furthermore, the proposed labeling requirement and beneficial consumer education would apply only to units that could be tested for the minimum duration of performance testing in the new test method.

Moreover, this alternative would result in a significant loss of energy savings. If inflatable spas cannot meet the existing performance standard up through the effective date of the proposed standards, the baseline stock for 2017 and total energy consumption would be roughly zero and zero GWh. The short lives of these products (estimated to be no more than three years) would result in most currently used units needing repair or complete replacement.[137] If any

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136 APSP, American National Standards Institute. (2014). *American National Standard for Portable Electric Spa Energy Efficiency*. Alexandria: APSP.

137 APSP's presentation at staff workshop on February 18, 2016. Docket 15-AAER-02, TN 210390, February 17, 2016.

have survived, these products have been noncompliant to a standard that was effective since 2006 and should have been certified before the release-date sales in California.

The Energy Commission does not have any evidence to show that inflatable spas can meet the existing standby requirements for portable electric spas. Staff therefore assumes that none are being lawfully sold or offered for sale in the state, as they do not comply with the applicable Title 20 requirements.

Using mostly conservative assumptions for inflatable spa annual energy consumption and a baseline statewide energy use in 2017 of zero GWh, reintroducing these products without any design or performance requirements would offset by more than 35 GWh the targeted first-year savings of about 11.34 GWh achieved through the other portable electric spas (detailed in **Appendix B**.) Adding a design requirement would still introduce 20.8 GWh of energy usage in the first year, which results in an approximate statewide net addition of 9 GWh in the first year.

After a few assumptions, for example, a $310[138] inflatable spa that operates continuously at 1,400W, at a cost of $0.1619 per kWh, is estimated to have a monthly cost of $65 during seasonal use. The operating cost per season (three months of the year) would be at least half of the price of purchase. Inflatable spa owners could use the spa beyond seasonal usage, which could push the total operating cost per year beyond the purchase price of the spa. This would be very concerning for low-income consumers who want to enjoy the spa experience for a low purchase price but who are forced to either pay a high operating cost or run their units less than desired.

Because this alternative would increase energy consumption statewide, staff believes that it is not a viable proposal for efficiency standards.

138 Amazon.com. http://www.amazon.com/Bestway-Lay-Z-Spa-Miami-Inflatable-Hot/dp/B00HRT863U/ref=sr_1_4?ie=UTF8&qid=1464374838&sr=8-4&keywords=inflatable+spa.

# CHAPTER 14: Staff-Proposed Standards for Portable Electric Spas and Exercise Spas

Staff analyzed the cost-effectiveness and technical feasibility of the third alternative approach. Based on this information, as well as analysis on all known spa types, staff proposes the ANSI/APSP/ICC-14 2014 test procedure, an updated standby performance standard, and some modifications for labeling and testing spa covers. The proposed standard is for all portable electric spas (including inflatable, exercise spas, and combination spas) manufactured on or after January 1, 2018, or one year from the adoption date, whichever is later.

Based on independent analysis of the best available data and few assumptions, including those from the CASE report, staff concluded that the proposed regulations are both cost-effective and technically feasible and will save a significant amount of energy statewide. Staff assumptions and calculation methods are provided in **Appendix B**.

## Scope

Staff recommends keeping the current portable electric spa definition in Section 1602(g) of the California Code of Regulations. This definition covers traditional, storable, exercise, and combination above-ground spas.

## Test Procedure

All portable electric spas shall be tested in accordance with ANSI/APSP/ICC-14 2014, with the exception of the swim spa standby consumption limit in Section 6.3.1 of the test procedure. A uniform standby consumption limit will be applied to all portable electric spa types.

The proposal to use the test procedure ANSI/APSP/ICC-14 2014 is based on a collaborative effort dating back to 2005. This effort included the APSP, leading portable spa manufacturers, the Energy Commission, Davis Energy Group, and the IOUs. The test procedures in this standard are based on that effort and the test method for portable spas described in Section 1604 of Title 20, California Code of Regulations, as amended December 3, 2008. To further support the claims in this standard, the portable electric spa manufacturers, working through APSP, researched and tested the energy efficiency of portable spas. The standard was prepared in accordance with ANSI.[139]

139 APSP, American National Standards Institute. *American National Standard for Portable Electric Spa Energy Efficiency*. Alexandria: APSP, 2014.

## Standby Power Consumption

All portable electric spas shall not exceed the normalized standby power consumption of $[(3.75xV^{2/3}) + 40]$.

Changing the standby power limit from $[5xV^{2/3}]$ to [(3.75xV2/3) + 40] will save a size-weighted average of 8 percent of energy consumption, according to the CASE team. The CASE team selected this standard level after working with spa manufacturers and the APSP-14 Committee. As a result of conversations with spa manufacturers, the CASE team and Energy Commission staff believe the proposed standard "addresses industry's concerns of smaller spas being disproportionally impacted by a potential updated standard, while significantly tightening the standard on larger spas."[140]

## Labeling Requirements

The label shall meet the design and specification listed in Section 7 of the ANSI/APSP/ICC-14 2014 with wording modifications. (See Chapter 18). The spa shall be marked by the manufacturer where readily visible on the shell or front skirt panel during the point of sale. The marking shall be on a removable adhesive backed label and shall only be removed by the consumer.[141]

Staff proposes using a categorical or continuous label for portable electric spas. A *categorical label* uses a ranking system that allows consumers to tell how energy efficient a model is by using multiple classes that progress from least efficient to most efficient or most energy consuming to least energy consuming. A *continuous label* uses a bar graph or line scale that allows consumers to see where the unit fits into the range of similar models. The CASE team collaborated with APSP-14 committee and designed a spa energy label similar those shown in **Figures 14-1** and **14-2**, which are staff's modified versions.[142] For more details on the information present on the label, refer to **Appendix B.**

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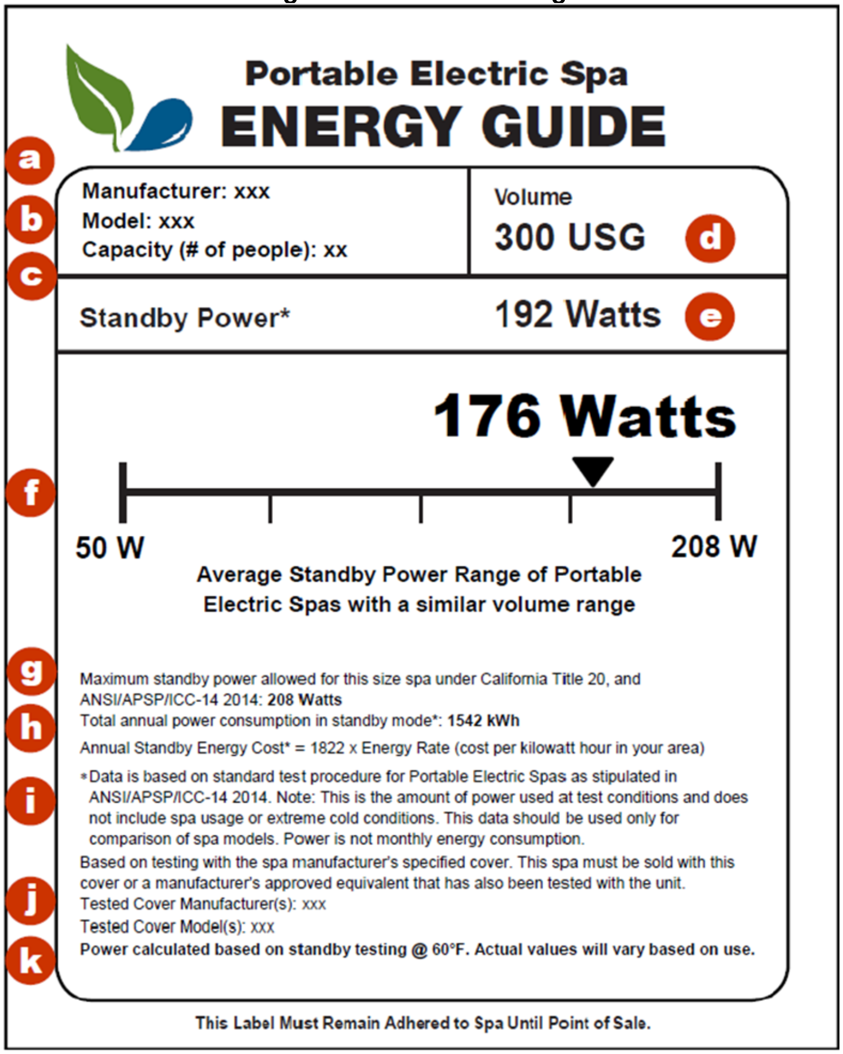
140 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas*. Energy Solutions, Pacific Gas and Electric Company. California Statewide Utility Codes and Standards Program. Retrieved July 2015.
141 APSP, American National Standards Institute. (2014). *American National Standard for Portable Electric Spa Energy Efficiency*. Alexandria: APSP.
142 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas*. Energy Solutions, Pacific Gas and Electric Company. California Statewide Utility Codes and Standards Program. Retrieved July 2015.

**Figure 14-1: Label Design**

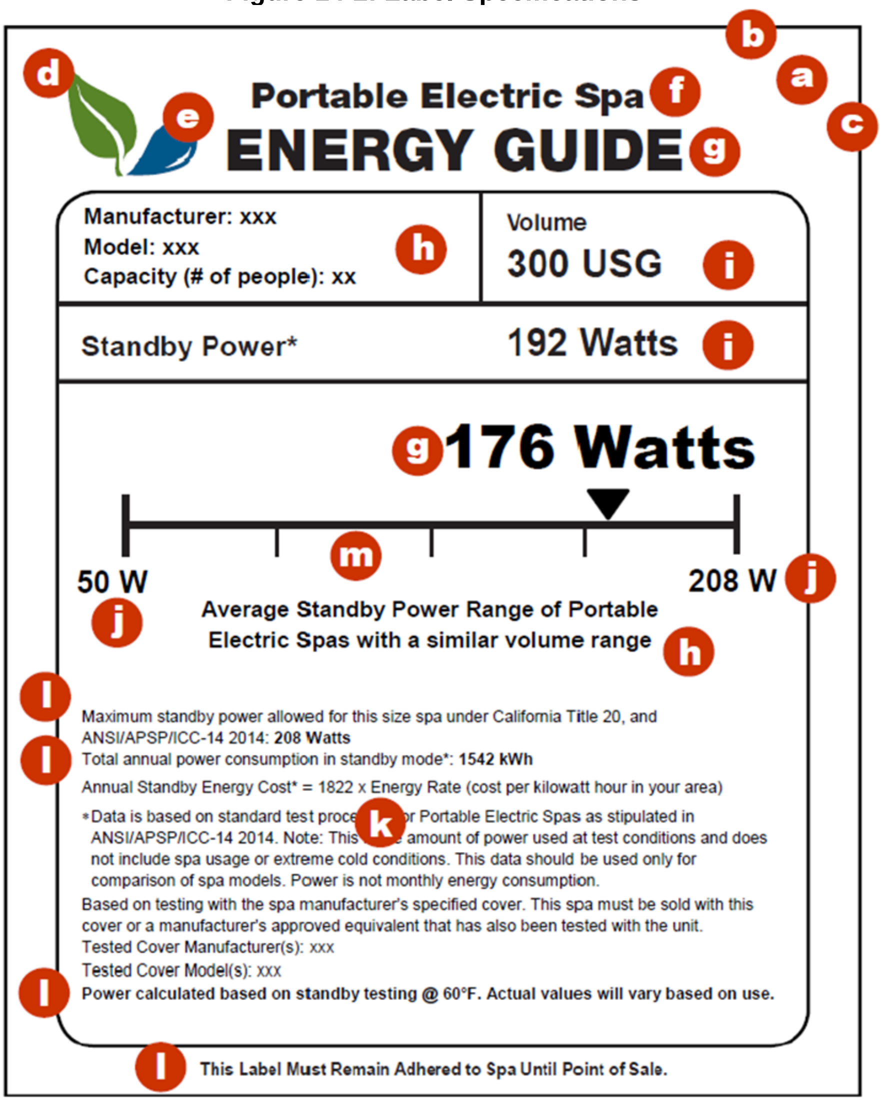



Source: Modified from Figure 7.2 in ANSI/APSP/ICC-14 2014

Codes:

a. Spa manufacturer
b. Spa model
c. Spa capacity (# of people)
d. Spa volume
e. Standby power
f. Standby power chart arrow location and standby power value
g. Maximum standby power allowed
h. Total annual power consumption in standby mode
i. Annual standby energy cost
j. Specified cover manufacturer
k. Specified cover model

**Figure 14-2: Label Specifications**




Source: Modified from Figure 7.3 in ANSI/APSP/ICC-14 2014

**Figure 14-2** shows the design specifications for the label format.

- Label shall be printed on a removable adhesive-backed white polymer label or the equivalent.
- Text color shall be black; leaf color shall be equivalent to Pantone 363 green (also permitted to be black); water color shall be equivalent to Pantone 7691 blue (also permitted to be black).
- Label codes:
  a. Shall be printed on a white label with black text
  b. Minimum label width: 5 inches
  c. Minimum label height: 6.25 inches
  d. Leaf color: equivalent to Pantone 363 green (also permitted to be black)

e. Water color: equivalent to Pantone 7691 blue (also permitted to be black)
f. Font: Helvetica Neue Black; character height shall not be less than 15 pt type
g. Font: Helvetica Neue Black; character height shall not be less than 24 pt type
h. Font: Arial Bold; character height shall not be less than 9.5 pt type
i. Font: Arial Bold; character height shall not be less than 16 pt type
j. Font: Arial Bold; character height shall not be less than 12 pt type
k. Font: Arial. Character height shall not be less than 8 pt type, and may be horizontally scaled to no less than 85 percent
l. Font: Arial Bold; character height shall not be less than 8 point type, and may be horizontally scaled to no less than 85 percent
m. The standby power chart arrow shall be scaled at the appropriate location between the minimum and maximum power range using the standby power value for the spa which is being installed. The minimum standby power shall be 50 watts, and the maximum standby power shall be [(3.75x$V^{2/3}$) + 40], where the result is in watts and V is the volume of the spa in U.S. gallons.

## Spa Cover Labeling and Reporting Requirements

The same model number of the tested spa cover displayed on the label is required to be reported during data submittal and certification for the Appliance Efficiency Database. Where there are multiple compatible covers that were tested with the unit, the standby watts on the comparison spectrum on the label shall represent the spa unit-cover combination that yielded the maximum energy consumption.

With the current Title 20 test method, portable electric spas are tested with the “standard cover that comes with the unit.” The standard cover of the spa unit is typically sold with the purchase of a new spa as required under Section 1608(a)(3) of the California Code of Regulations. The cover that is sold with the unit is sometimes made by a third party. However, it must be the same model cover used during the test. Where there are multiple covers tested for the spa unit certification, all covers that allowed the unit to pass the standby test must be included in separate listings of the unit within MAEDBS and have a unique set of tested performance data.

Any cover (the manufacturer’s or a third party’s) that is tested with the unit and yields a failed standby test or any cover that was not used in the standby test cannot be sold with the unit at the point of sale. Covers differing in color or other non-energy-impacting features are the exception and can be sold as long as they have the same basic model number as the test cover and were made by the same manufacturer. If a lower-quality, less energy-efficient spa cover is sold to a consumer during the sale of a spa certified with a higher-performing standard cover, the certified energy consumption can be compromised.[143] However, any cover (manufacturer’s,

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143 Worth, C., and  Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas*. Energy Solutions, PG&E. California Statewide Utility Code s and Standards Program. Retrieved July 2015.

third party, or replacement) sold as a stand-alone purchase is acceptable because it is not within the scope of Section 1601 of the California Code of Regulations, which concerns only the sale of the appliance (the spa unit).

In the cases where multiple covers passed a standby test, customers will likely base their purchasing choice on the lowest retail price of the possible spa unit-cover combinations, which can have an unrealized, negative effect on energy consumption and operating costs.[144] Thus, labeling the unit with the highest consuming cover result, as well as the other compatible cover model numbers in accordance with the listings in MAEDBS, allows dealers to better inform customers what the opportunities are while presenting the worst-case scenario. Consumers will be educated by the energy consumption and yearly cost formula on the label, which can lead to more energy-efficient purchasing decisions.[145]

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144 Western Area Power Administration. (2009). "What Goes Into an Energy-Efficient Spa or Hot Tub?" Lakewood: Western Area Power Administration.
145 Ibid.

# CHAPTER 15: Savings and Cost Analysis

The proposed updated standards for portable electric spas would significantly reduce energy consumption and are both cost-effective and technically feasible. **Table 15-4** summarizes the potential energy savings of the proposed standards. Energy savings are further separated into first-year savings and stock savings for portable spas and exercise spas. *First-year savings* mean the annual energy reduction associated with annual sales, one year after the standards take effect. *Annual stock turnover savings* mean the annual energy reduction achieved after all existing stock in use complies with the proposed standards. Staff's calculations and assumptions used to estimate the first-year savings and the stock change savings are provided in **Appendix B**.

## Incremental Costs

The CASE team reported no incremental cost increase in implementing the proposed standard. However, the label could lead to improved spa covers or more efficient spa covers to go with a manufacturer's unit. Thus, staff believes there would be incremental costs from improving the spa cover and implementing the standby energy consumption requirement. When the current standby power limit standard was being proposed in 2004, various sources estimated incremental costs for portable electric spas, shown in **Table 15-1**. Staff believes that over time these costs have decreased significantly. The most recent estimated incremental costs of $100 by Nadel, deLaski, Eldridge, and Kleisch in 2006 will be used. Since exercise spas are typically three times as expensive as conventional portable electric spas, an assumed incremental cost of $375 will be used for these units.[146]

146 Poolandspa.com. (2015). "What Is a Swim Spa?" http://www.poolandspa.com/page6210.htm.

**Table 15-1: Estimated Incremental Costs for Current Standard**

<table>
<tr><th>Source</th><th colspan="2">Incremental Cost</th></tr>
<tr><td>Pope, Rainer, Fernstrom, & Eilert, 2002</td><td colspan="2">$750</td></tr>
<tr><td rowspan="6">Davis Energy Group, Energy Solutions, 2004</td><td>Measure</td><td>Incremental Cost</td></tr>
<tr><td>Improved Cover</td><td>$100</td></tr>
<tr><td>Improved Spa Insulation</td><td>$200</td></tr>
<tr><td>Improved Motor Configurations and Efficiency</td><td>$300</td></tr>
<tr><td>Improved Controls</td><td>$50</td></tr>
<tr><td>Total</td><td>$650</td></tr>
<tr><td>Douglas Mahone & Heschong Mahone Group Inc., 2005</td><td colspan="2">$300</td></tr>
<tr><td>Nadel, deLaski, Eldridge, & Kleisch, 2006</td><td colspan="2">$100 for portable electric spas</td></tr>
<tr><td>Staff assumption based on price difference between product types in 2016</td><td colspan="2">$375 for exercise and combination spas</td></tr>
</table>

Source: Modified from CASE report table[147]

The CASE report states the cost of labeling portable electric spas with a removable sticker is estimated to be minimal. Using the sources and assumption in the CASE report for determining labeling costs, and adding an assumption for combination spas within the exercise spa market, staff has estimated the per label cost to be $0.39 per label.[148] Details of this estimate are shown in **Table 15-2**.

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147 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas*. Energy Solutions, PG&E. California Statewide Utility Code s and Standards Program. Retrieved July 2015.

148 Western Area Power Administration. (2009). "What Goes Into an Energy-Efficient Spa or Hot Tub?" Lakewood: Western Area Power Administration.

**Table 15-2: Label Costs for Portable Electric Spas**

| One Time Set-Up Costs | | Units |
|---|---|---|
| Engineer/Designer Time | 40 | Hours |
| Engineer/Designer Hourly Wage | $ 44.36 | Dollars/Hour |
| Setup Cost to Each Manufacturer | $ 1,774 | Dollars |
| *Number of Spa, Exercise, and Combo Spa Manufacturers | 47 | Manufacturers |
| **Total Set-Up Cost Statewide** | **$ 85,171** | Dollars |
| **Material Cost** | | **Units** |
| Printing Costs | 0.22 | Dollars/Label |
| 2017 Stock** | 596,776 | Portable Electric Spa Units |
| **Total Printing Costs to Label Stock** | **$ 131,291** | Dollars |
| **Labor Costs to Apply Label** | | **Units** |
| Time to Adhere Each Label | 8 | Seconds |
| Total Time to Adhere Labels to Entire Stock | 1,326 | Hours |
| Packaging and Filling Machine Operators Hourly Wage | $ 13.44 | Dollars/Hour |
| **Total Labor Costs** | **$ 17,824** | Dollars |
| **Total** | | **Units** |
| **Total Cost to Label Stock** | **$ 225,414** | Dollars |
| Label Cost per Unit | $ 0.39 | Dollars/Label |

Source: Staff calculation using information from Portable Electric Spas CASE Report 2014
*Number of spa manufacturers includes an assumption of 4 combination spa manufacturers statewide in 2017.
**Stock is based on the year 2017 when the assumption for the effective date was July 1, 2017.

Life-cycle costs and benefits of the proposed standard for portable electric spas and exercise spas are shown in **Table 15-3.** Life-cycle costs are based on the estimated incremental costs for improving the standby efficiency of the unit and labeling costs. The life-cycle benefit represents the savings the consumer should receive over the life of the appliance. Staff based life-cycle benefits by comparing the weighted-average standby power consumption under the current standard with respect to the proposed standard.

**Table 15-3: Weighted Unit Energy Savings and Life-Cycle Benefits**

| | Design Life (years) | Electricity Savings (kWh/year) | Lifecycle Costs ($/unit) | Life-Cycle Benefit ($/unit) | Life-Cycle Benefit/Cost Ratio |
|---|---|---|---|---|---|
| Portable Electric Spas | 10 | 317 | $ 100.39 | $ 512 | 5 |
| Exercise Spas | 10 | 1,451 | $ 375.39 | $ 2,349 | 6 |

Source: Staff calculations; see Appendix B

In conclusion, the proposed standard is cost-effective as the compliant product has a high benefit-to-cost ratio.

## Standby Power Efficiency Savings

As summarized in **Table 15-4**, if all portable electric spas complied with the proposed standards (annual stock turnover savings), California would save 72.6 GWh of energy per year. Using a residential rate of $0.16 per kWh of electricity, implementation of the proposed standards for portable electric spas would achieve an estimated $12.6 million a year in reduced utility costs after full implementation. Exercise spas contribute 24.1 GWh of energy savings per year and $3.9 million per year in reduced utility costs after full implementation. Due to a lack of market inventory and a potential lack of operational data for exercise spas, these estimates could be underrepresenting the actual energy savings, as the only data used were from the 65 exercise spas certified in MAEDBS.

**Table 15-4: Standby Power Standard Statewide First-Year and Stock Turnover Savings**

| | First-Year Savings | | Complete Turnover Savings | |
|---|---|---|---|---|
| | Energy Consumption (GWh/yr) | Savings ($M) | Energy Consumption (GWh/yr) | Savings ($M) |
| Portable Electric Spas (Zones 1-3) | 4.2 | 0.7 | 53.5 | 8.7 |
| Exercise Spas (Zones 4-8) | 1.9 | 0.3 | 24.1 | 3.9 |
| **Total** | **6.1** | **1.0** | **77.6** | **12.6** |

Source: Staff calculation; see Appendix B

## Spa Cover Savings

Savings from using a spa cover versus not using a spa cover are presented separately because the performance standard relies on a spa cover to meet the performance standard. Staff calculated evaporation rates using industry standard methods. **Table 15-5** presents the evaporation rate, energy lost, and energy cost for a typical five-person spa left uncovered year round. Again, this would be in a worst case scenario if spas were not sold with covers. Based on the existing requirement in Section 1608(a)(3) of the California Code of Regulations, staff assumes this is not the case in the market as the standard cover of a spa is a key, performance-altering testing component of a spa, thus requiring inclusion at the point of sale.[149]

149 California Energy Commission, *2015 Appliance Efficiency Regulations.* Title 20, Section 1608(a)(3). May 2014.

**Table 15-5: Energy Cost for Uncovered Spa**

| Evaporation Rate, $w_p$ (gallons/hr) | Energy Consumption (kWh/year) | Water Wasted (gallons/year) | Energy Costs | Estimated Spa Cover Price | Design Life of Spa Cover (years) | Unit Savings With Spa Cover ($/yr) |
|---|---|---|---|---|---|---|
| 1 | 21,688 | 8,760 | $3,511 | $500 | 5 | $3,411 |

Source: Staff calculations; see Appendix B

## Spa Labeling Savings

The MAEDBS shows that units with the same volume capacity have very different standby energy consumption values. The range can go up to 150 watts for units with the same volume capacity.[150] This wide range of standby power consumption is affected by factors such as the spa cover, construction materials, and design of the unit. Consumers may be unaware that a wide range exists and must rely on the information given by the seller and manufacturer. Thus, consumers can benefit from having a label affixed to the unit to inform them of the energy consumption and energy savings. Labeling programs such as ENERGY STAR and "EnergyGuide" have proven to succeed in providing consumers with energy-saving information, which can lead to purchasing decisions that increase energy efficiency. In addition to a spa model number being listed in the MAEDBS, a label will inform the consumer at the point of sale that the unit meets California's appliance efficiency standards and is certified to be sold in California.[151]

Labeling portable electric spa units will lead to energy savings by educating consumers to choose a more efficient unit. However, determining how many consumers will choose a more efficient unit, how much more efficient a unit they choose, and how the label affects that decision is more of an art than a science. Staff estimates that the potential savings are equivalent to about 5 percent of the total energy consumption.[152] This estimate is based on half of the 10 percent improvement in sales-weighted average efficiency for refrigerators using the categorical European Union (EU) Label scheme.[153] **Table 15-6** presents the savings when applying the potential 5 percent savings by affixing a label to portable electric spas.[154]

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150 California Energy Commission. (2015). "Modernized Appliance Efficiency Database System." Retrieved from Appliance Search: http://maedbs/Pages/ApplianceSearch.aspx.
151 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas.* Energy Solutions, PG&E. California Statewide Utility Code s and Standards Program. Retrieved July 2015.
152 Ibid.
153 Bertoldi, Paolo. *Energy Efficient Equipment Within SAVE: Activities, Strategies, Success and Barriers.* Brussels: European Commission, 2000.
154 "European Union Efforts to Promote More Efficient Use of Electricity: the PACE Programme." *1996 Summer Study on Energy Efficiency in Buildings.* Washington, D.C.: American Council for an Energy-Efficient Economy, 1996.

**Table 15-6: Statewide Annual Stock Savings Adjusting for Label Effect**

| | First-Year Savings | | Complete Turnover Savings | |
|---|---|---|---|---|
| | **Energy Consumption (GWh/yr)** | **Savings ($M)** | **Energy Consumption (GWh/yr)** | **Savings ($M)** |
| Portable Electric Spas | 4.8 | 0.8 | 57.8 | 9.4 |
| Exercise Spas | 2.1 | 0.3 | 26.0 | 4.2 |
| **Total** | **6.9** | **1.1** | **83.8** | **13.6** |

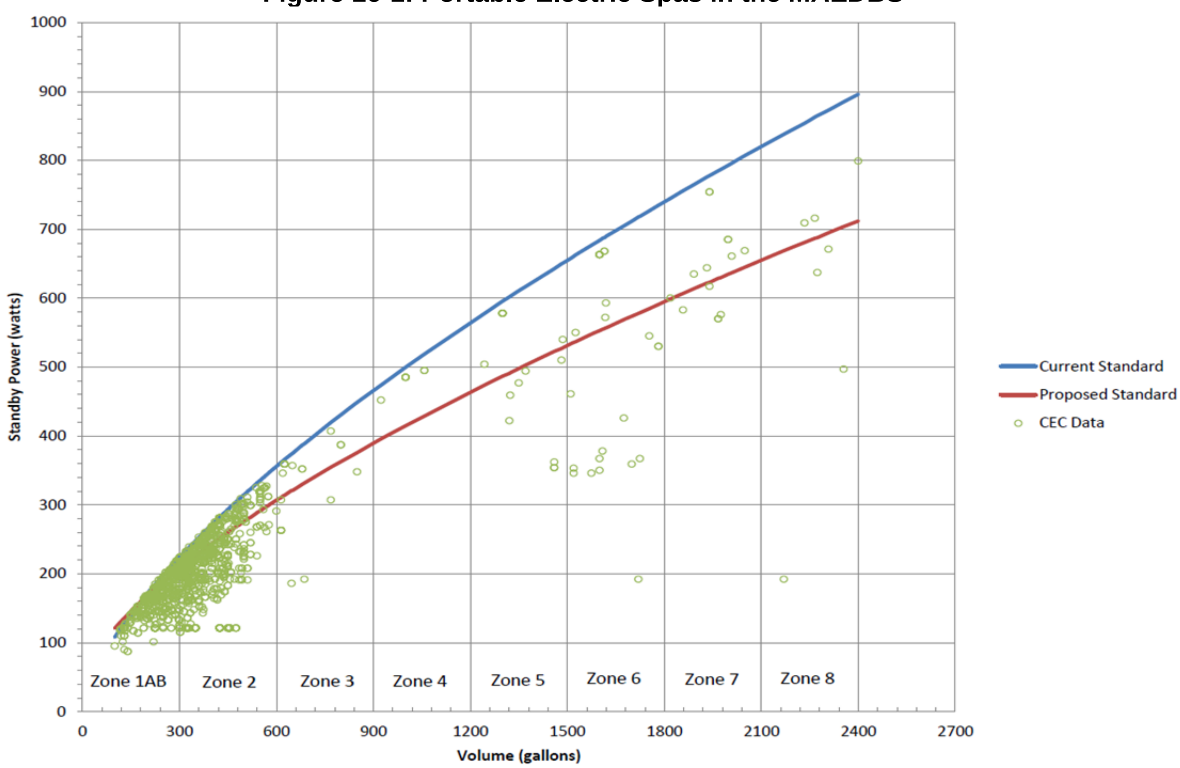
Source: Staff calculation; see Appendix B

# CHAPTER 16: Technical Feasibility of Proposed Standards for Portable Electric Spas

As of May 2016, the Energy Commission database lists 1,321 portable electric spas, more than 70 percent of which would meet the proposed standards. **Table 16-1** shows a breakdown of the compliance rate for the portable electric spas in the MAEDBS. The quantity and variety of compliant spas available for sale indicate that compliant products are technically feasible and readily available in California.

As **Figure 16-1** demonstrates, a significant number of existing spas would meet the proposed standard, demonstrating that it is technically feasible.

**Figure 16-1: Portable Electric Spas in the MAEDBS**




Source: MAEDBS, California Energy Commission

**Table 16-1** details the compliance rate illustrated in **Figure 16-1**. The CASE report stated 29 percent of the portable electric spas in the MAEDBS would not meet the proposed standard limit, which is similar to the results found in July 2015. **Table 16-1** shows the total number of certified spas in MAEDBS, which has increased since then. Sixty percent of combination spas are estimated to comply with the proposed standards. These are rolled into the calculation for exercise spas in **Table 16-1.**

**Table 16-1: Compliance Rate of Portable Electric Spas**

| | Zones | Compliant (%) | Non-Compliant (%) |
|---|---|---|---|
| Portable Spas | 1AB to 3 | 72.5 | 27.5 |
| Exercise Spas | 4 to 8 | 47.7 | 52.3 |
| All Certified Units | 1AB to 8 | 71.3 | 28.7 |

Source: MAEDBS, California Energy Commission

The energy consumption of portable electric spas can be enhanced by employing better insulation, better-designed covers, and the use of a more efficient pump for circulation and filtration. Using the same test temperature under the existing Title 20 test method, 52 percent of exercise spas would be noncompliant with the proposed normalized standby power standard. However, ANSI/APSP/ICC-14 2014 decreases the standby power test temperature for exercise spas by 15 degrees. The difference between the current test spa temperature and the ambient temperature is 37 degrees. Staff presumes that a 15 degree reduction for the test spa temperature could reduce the energy consumption for exercise spas by at least 25% providing a path for compliance.

## Insulation

Most manufacturers already insulate the shell and base of spas using high R-value insulation materials. According to the Energy Commission database, more than 99 percent of spas listed are fully insulated.

Staff found that units with the same volume capacity have very different standby energy consumption values, up to 150 watts. The cause of this difference is in the method and materials of insulation. For example, hit and miss spots at the shell and base of spas can largely reduce the effectiveness of insulation. Therefore, improvements on the method of applying uniform insulation would improve efficiency. Implementing this improvement would decrease energy use by up to 30 percent for an average-to-low efficiency spa. This is the easiest method to implement, requiring little additional engineering and design work.[155]

The CASE report also identified that manufacturers use a combination of closed cell foam and radiant barriers, instead of fiberglass, which can help reduce the heat loss.[156]

## Spa Covers

Improvements to spa covers, such as using high R-value and less water-absorbent insulation, adding radiant barriers, and better sealing covers, can reduce heat and water loss from the spa and already exist in the industry. Improving the construction and design

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155 Davis Energy Group, Energy Solutions. (2004). *Analysis of Standards Options for Portable Electric Spas.* California: PG&E.
156 Worth, C., and Fernstrom, G. (2014). *Codes and Standards Enhancement (CASE) Initiative for PY 2012: Title 20 Standards Development- Analysis of Standards Proposal for Portable Electric Spas.* Energy Solutions, PG&E. California Statewide Utility Codes and Standards Program. Retrieved July 2015.

work of the spa cover, such as using single-hinged or insulated hinge covers instead of double-hinged, can yield additional efficiency savings.[157]

## Pump and Motor

Manufacturers have used waste heat from circulation pumps to replace separate heating or to supplement heating of water, which can greatly improve spa efficiency.[158] Most spa manufacturers of large portable electric spas add a separate low-wattage circulation pump to run specific cycles. This addition can save nearly 15 percent of the energy consumption and up to half of the pumping energy used for circulation and filtering. Other options include improved pump efficiency with advanced multispeed motor designs and using variable-speed motors and controls. Options like these would require manufacturers to invest in product development and design, which would most likely begin after insulation improvement.[159]

157 Ibid.
158 Ibid.
159 Davis Energy Group, Energy Solutions. (2004). *Analysis of Standards Options for Portable Electric Spas.* California: PG&E.

# CHAPTER 17: Environmental Impacts

## Environmental Impacts

Spas are generally replaced at the end of the useful lives; replacement would not present an additional impact to the environment beyond the natural cycle.

## Benefits

The proposed standards are estimated to result in reductions of 16 tons of criteria air pollutants and 55,000 tons of GHG emissions due to the avoided energy used. **Table 17-1** shows the criteria for air pollutant and GHG emissions reductions in using the annual statewide stock savings energy consumption after complete turnover values listed in **Table 15-4** and **15-6**.

**Table 17-1: Greenhouse Gas Emissions Reductions**

| | Annual Avoided Emissions (tons) | | | | | |
|---|---|---|---|---|---|---|
| | **Oxides of Nitrogen ($NO_x$)** | **Sulfur Dioxide ($SO_x$)** | **Carbon Monoxide (CO)** | **Particulate Matter ($PM_{2.5}$)** | **Total Air Pollutants** | **Greenhouse Gas ($eCO_2$)** |
| Portable Electric Spas | 3.9 | 0.56 | 5.57 | 1.67 | 11.7 | 38,399 |
| Exercise Spas | 1.75 | 0.25 | 2.51 | 0.75 | 5.26 | 17,285 |
| **Total** | **5.5** | **0.77** | **7.93** | **2.38** | **16.96** | **55,684** |

Source: Emission factors from the ARB

# Chapter 18: Regulatory Language

The following shows staff's proposed changes to the portable electric spa standard. Underlines mean new added text and ~~strike outs~~ mean deleted text.

**Section 1602(g) Definitions**

"Combination spa" (also known as a "combo spa") means an exercise spa with multiple reservoirs of water capable of heating each body of water.

"Exercise spa" (also known as a "swim spa") means a portable electric spa designed to produce a water flow intended for water therapy or recreational physical activity, including, but not limited to, swimming in place.

"Spa volume" means the actual fill volume of the spa, under normal use, in gallons, as defined in the test method in ~~Section 1604(g)(2)(B)~~ANSI/APSP/ICC-14 2014.

"Standby mode" means that only the default settings as shipped by the manufacturer are enabled, except water temperature, which may be adjusted to meet the test conditions. No manual operations are enabled (as defined in ANSI/APSP/ICC-14 2014).

The following documents are incorporated by reference in Section 1602.

| *Number* | *Title* |
|---|---|
| **THE ASSOCIATION OF POOL AND SPA PROFESSIONALS (APSP)** | |
| ANSI/APSP/ICC-14 2014 | American National Standard for Portable Electric Spa Energy Efficiency |
| Copies available from: | The Association of Pool and Spa Professionals<br>2111 Eisenhower Avenue<br>Alexandria, VA 22314-4695<br>www.apsp.org<br>Phone: (703) 838-0083 |

**Section 1604(g)(2) Test Method for Portable Electric Spas.**

(A) The test method for portable electric spas manufactured on or after January 1, 2006, is as follows:

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

(ii) ~~(B)~~ The spa shall be filled with water to the halfway point between the bottom of the skimmer basket opening and the top of the spa. If there is no skimmer basket, the spa shall be filled with water to six inches below the top of the spa.

(iii) ~~(C)~~ The water temperature shall be 102˚F, ± 2˚F for the duration of the test.

(iv) ~~(D)~~ The ambient air temperature shall be 60˚F, ± 3˚F for the duration of the test.

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

(vi) ~~(F)~~ The test shall start when the water temperature has been at 102˚F, ± 2˚F for at least four hours.

(vii) ~~(G)~~ Record the total energy use for the period of test, starting at the end of the first heating cycle after the stabilization period specified in Section 1604(g)(2)(A~~F~~)(vi), and finishing at the end of the first heating cycle after 72 hours has elapsed.

(viii) ~~(H)~~ 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. Ancillary equipment including, but not limited to lights, audio systems, and water treatment devices, shall remain connected to the mains but may be turned off during the test if their controls are user accessible.

(ix) ~~(I)~~ The measured standby power shall be normalized to a temperature difference of 37˚F using the equation,

$$\text{Pnorm} = \text{Pmeas}\,\frac{\Delta\,\text{T ideal}}{\Delta\,\text{T meas}}$$

Where:

Pmeas = measured standby power during test (E/t)

$\Delta$ Tideal = 37˚F

$\Delta$ Tmeas = Twater avg – Tair avg

Twater avg = Average water temperature during test

Tair avg = Average air temperature during test

(x) ~~(J)~~ Data reported shall include: spa identification (make, model, S/N, specifications); volume of the unit in gallons; supply voltage; 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 (E, in Wh); and normalized standby power (Pnorm, in watts).

(B) Portable electric spas manufactured on or after January 1, 2018, shall be tested in accordance with ANSI/APSP/ICC-14 2014, with the exception of Section 6.3.1.

The following documents are incorporated by reference in Section 1604.

| ***Number*** | ***Title*** |
|---|---|
| **THE ASSOCIATION OF POOL AND SPA PROFESSIONALS (APSP)** | |
| ANSI/APSP/ICC-14 2014 | American National Standard for Portable Electric Spa Energy Efficiency |
| Copies available from: | The Association of Pool and Spa Professionals<br>2111 Eisenhower Avenue<br>Alexandria, VA 22314-4695<br>www.apsp.org<br>Phone: (703) 838-0083 |

**Section 1605.3(g)**

**(6) Portable Electric Spas**

(A) The normalized standby power, as defined in Section 1604(g)(2)(A~~I~~)(ix), of portable electric spas manufactured on or after January 1, 2006, shall be not greater than $5(V^{2/3})$ watts, where V = the fill volume, in gallons.

(B) The normalized standby power, as defined in Sections 6.2 and 6.3 of ANSI/APSP/ICC-14 2014, of portable electric spas manufactured on or after January 1, 2018, shall be not greater than $[3.75(V^{2/3}) + 40]$ watts where V = the fill volume, in gallons.

The following documents are incorporated by reference in Section 1605.3.

| ***Number*** | ***Title*** |
|---|---|
| **THE ASSOCIATION OF POOL AND SPA PROFESSIONALS (APSP)** | |
| ANSI/APSP/ICC-14 2014 | American National Standard for Portable Electric Spa Energy Efficiency |
| Copies available from: | The Association of Pool and Spa Professionals<br>2111 Eisenhower Avenue<br>Alexandria, VA 22314-4695<br>www.apsp.org<br>Phone: (703) 838-0083 |

**Section 1606(a)(3)(c)**

**Table X – Data Submittal Requirements**

| | Appliance | Required Information | Permissible Answers |
|---|---|---|---|
| G | Portable Electric Spas | **Tested Spa Cover Model Number | |
| | | *Spa Type | Portable Electric Spa, Exercise Spa, Combination Spa |
| | | *Voltage | |
| | | Spa Volume (gallons) (for spas and combination spas only) | |
| | | Exercise Spa Volume (gallons) (for exercise and combination spas only) | |
| | | Rated Capacity (number of people) | |
| | | Normalized Standby Power Spa Portion (watts) (for spas and combination spas only) | |
| | | Normalized Standby Power Exercise Spa Portion (watts) (for exercise and combination spas only) | |
| | | Spa Enclosure is Fully Insulated | Yes, No |

*"Identifier" information as described in Section 1602(a).

**Required for portable electric spas manufactured on or after January 1, 2018

The following documents are incorporated by reference in Section 1606.

***Number*** ***Title***

**THE ASSOCIATION OF POOL AND SPA PROFESSIONALS (APSP)**

ANSI/APSP/ICC-14 2014 — American National Standard for Portable Electric Spa Energy Efficiency

Copies available from:

The Association of Pool and Spa Professionals
2111 Eisenhower Avenue
Alexandria, VA 22314-4695
www.apsp.org
Phone: (703) 838-0083

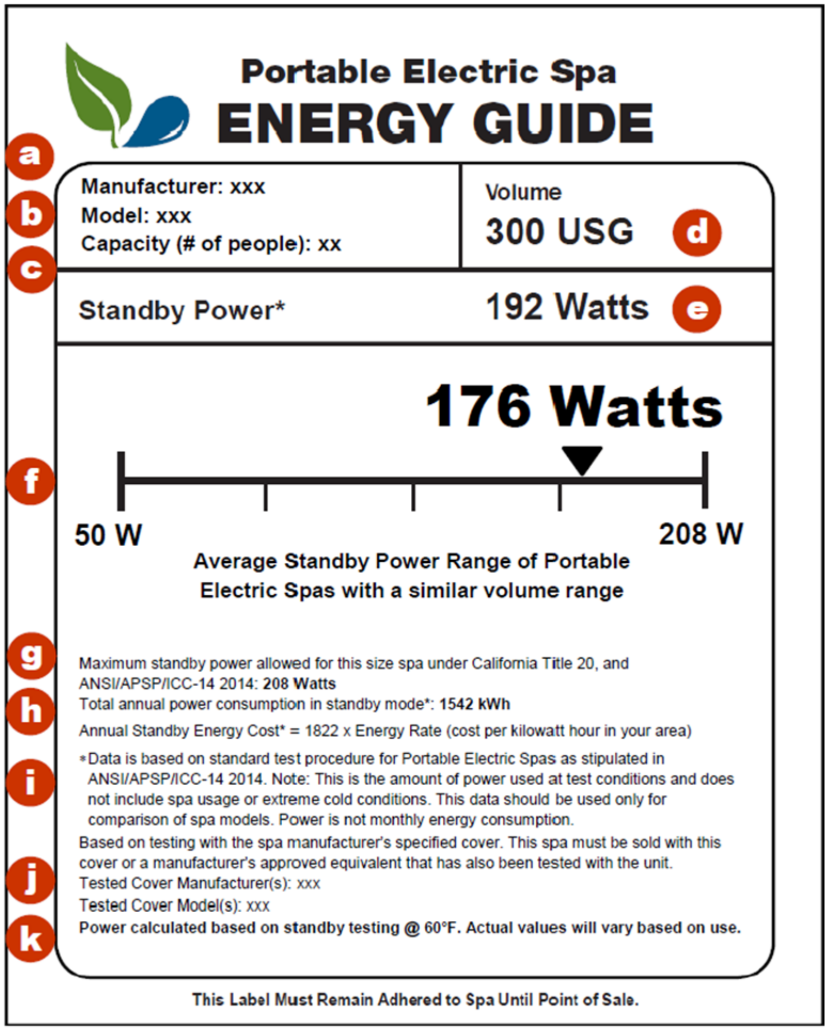
**Section 1607(d) Energy Performance Information.**

**(12) Portable Electric Spas**

(A) Portable electric spas manufactured on or after January 1, 2018, shall be marked by the manufacturer in a readily visible location on the shell or front skirt panel. The marking shall be on a removable adhesive-backed label and shall be removed only by the consumer.

(B) The label shall conform to the design specifications listed below and shall include the information specified (modified from ANSI/APSP/ICC-14 2014). If the spa has been tested with multiple spa covers, the label shall display the maximum normalized standby power test result obtained in accordance with Section 1605.3(g)(6)(B).

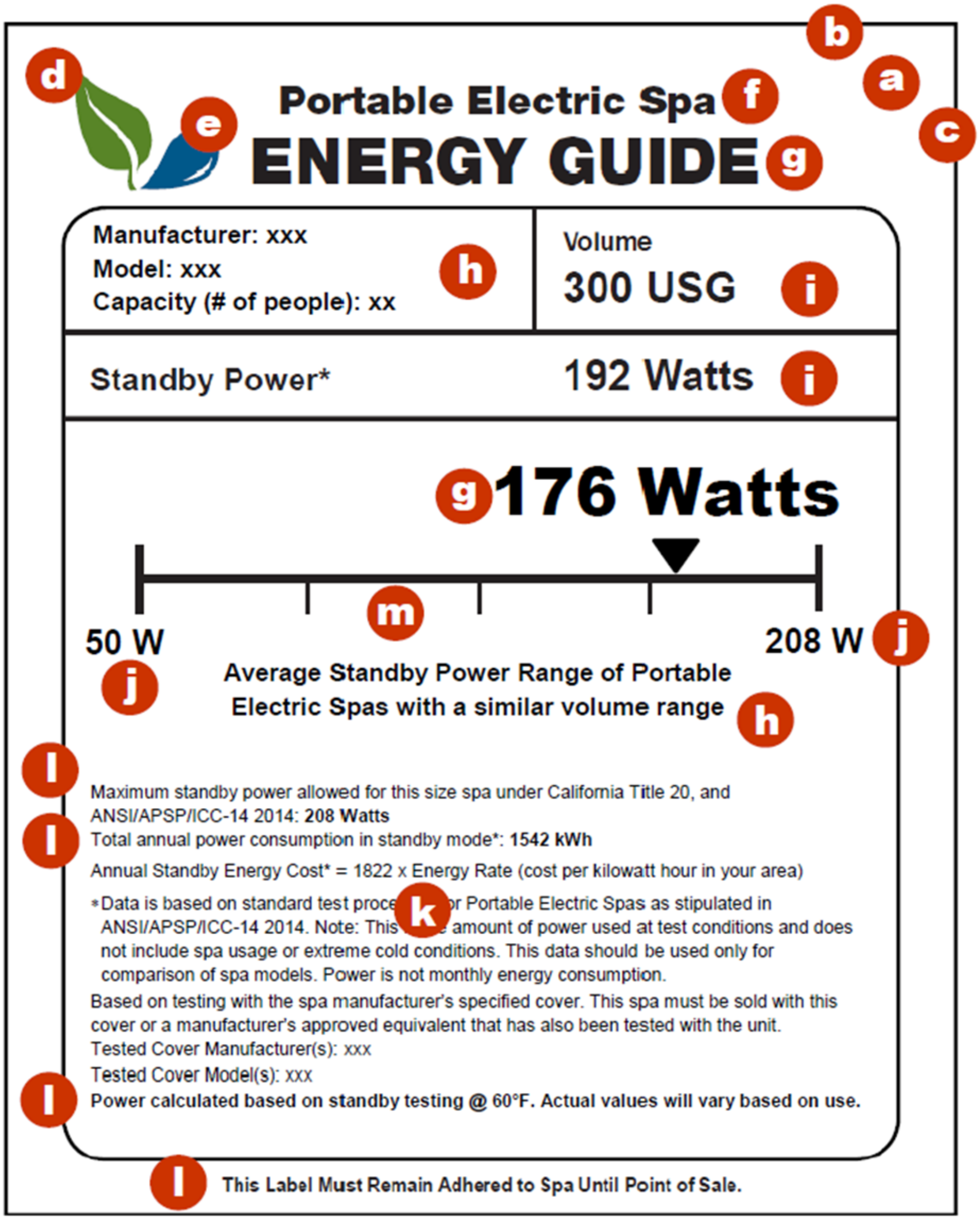
## Label Design




(Source: Modified from Figure 7.2 in ANSI/APSP/ICC-14 2014 )

(i) Label design codes:
- a. Spa manufacturer
- b. Spa model
- c. Spa capacity (# of people)
- d. Spa volume
- e. Standby power
- f. Standby power chart arrow location and standby power value
- g. Maximum standby power allowed
- h. Total annual power consumption in standby mode
- i. Annual standby energy cost
- j. Specified cover manufacturer
- k. Specified cover model

**Label Specifications**




(Source: Modified from Figure 7.3 in ANSI/APSP/ICC-14 2014 )

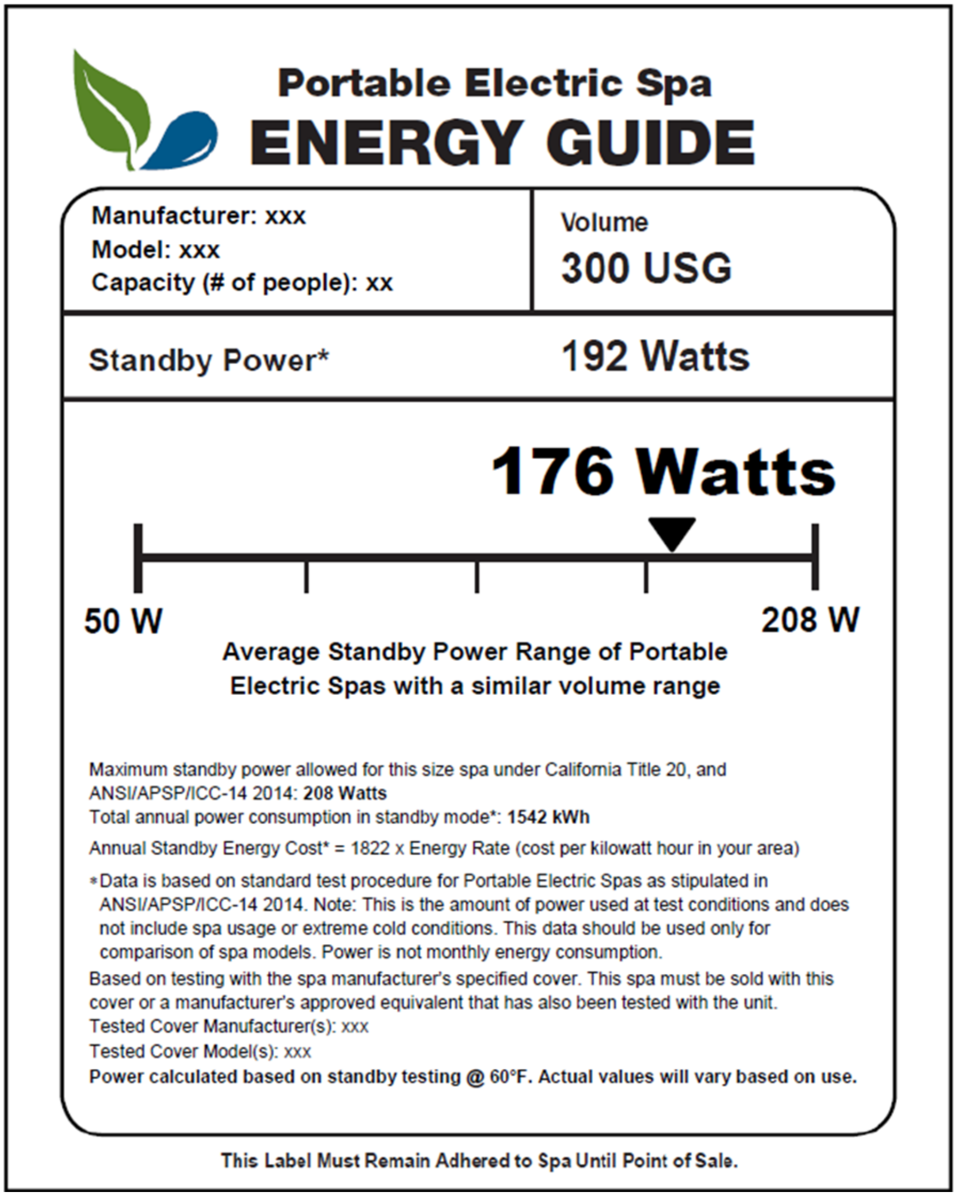
(ii) The label shall be printed on a removable adhesive-backed white polymer label or the equivalent.

(iii) The text color shall be black and the leaf color shall be equivalent to Pantone 363 green (also permitted to be black.) The water color shall be equivalent to Pantone 7691 blue (also permitted to be black.)

(iv) Label specification codes:

a. Shall be printed on a white label with black text
b. Minimum label width: 5 inches
c. Minimum label height: 6.25 inches
d. Leaf color: equivalent to Pantone 363 green (also permitted to be black)
e. Water color: equivalent to Pantone 7691 blue (also permitted to be black)
f. Font: Helvetica Neue Black; character height shall not be less than 15 pt type
g. Font: Helvetica Neue Black; character height shall not be less than 24 pt type
h. Font: Arial Bold; character height shall not be less than 9.5 pt type
i. Font: Arial Bold; character height shall not be less than 16 pt type
j. Font: Arial Bold; character height shall not be less than 12 pt type
k. Font: Arial; character height shall not be less than 8 pt type, and may be horizontally scaled to no less than 85 percent
l. Font: Arial Bold; character height shall not be less than 8 point type, and may be horizontally scaled to no less than 85 percent
m. Standby power chart arrow shall be scaled at the appropriate location between the minimum and maximum power range using the standby power value for the spa which is being installed. The minimum standby power shall be 50 watts and the maximum standby power shall be $[(3.75xV^{2/3}) + 40]$, where the result is in watts and V is the volume of the spa in U.S. gallons.

**Labeling Template for Portable Electric Spas**




(Source: Modified from Figure 7.1(a) in ANSI/APSP/ICC-14 2014 )

## Labeling Template for Exercise Spas

**Portable Electric Exercise Spa**

# ENERGY GUIDE

| | |
|---|---|
| **Manufacturer: xxx**<br>**Model: xxx**<br>**Capacity (# of people): xx** | Volume<br>**1675 USG** |
| **Standby Power*** | **426 Watts** |

**426 Watts**

**50 W** — **569 W**

**Average Standby Power Range of Exercise Spas with a similar volume range**

Maximum standby power allowed for this size spa under California Title 20, and ANSI/APSP/ICC-14 2014: **569 Watts**
Total annual power consumption in standby mode*: **3732 kWh**

Annual Standby Energy Cost* = 3732 x Energy Rate (cost per kilowatt hour in your area)

*Data is based on standard test procedure for Portable Electric Spas as stipulated in ANSI/APSP/ICC-14 2014. Note: This is the amount of power used at test conditions and does not include spa usage or extreme cold conditions. This data should be used only for comparison of spa models. Power is not monthly energy consumption.

Based on testing with the spa manufacturer's specified cover. This spa must be sold with this cover or a manufacturer's approved equivalent that has also been tested with the unit.
Tested Cover Manufacturer(s): xxx
Tested Cover Model(s): xxx

**Power calculated based on standby testing @ 60°F. Actual values will vary based on use.**

**This Label Must Remain Adhered to Spa Until Point of Sale.**

(Source: Modified from Figure 7.1(b) in ANSI/APSP/ICC-14 2014 )

## Labeling Template for Combination Spas

**Portable Electric Combo Spa**

# ENERGY GUIDE

| Manufacturer: xxx<br>Model: xxx<br>Capacity (# of people): xx | Exercise Spa Portion | Spa Portion |
|---|---|---|
| Volume | 1450 USG | 280 USG |
| Standby Power* | 481 Watts | 176 Watts |

**657 Watts**

**50 W** — **Average Standby Power Range of Combo Spas with a similar volume range** — **720 W**

Maximum standby power allowed for this size spa under California Title 20, and ANSI/APSP/ICC-14 2014: **520 Watts (exercise spa portion) + 200 Watts (spa portion) = 720 Watts**

Total annual power consumption in standby mode*: **5755 kWh**

Annual Standby Energy Cost* = 5755 x Energy Rate (cost per kilowatt hour in your area)

*Data is based on standard test procedure for Portable Electric Spas as stipulated in ANSI/APSP/ICC-14 2014. Note: This is the amount of power used at test conditions and does not include spa usage or extreme cold conditions. This data should be used only for comparison of spa models. Power is not monthly energy consumption.

Based on testing with the spa manufacturer's specified cover. This spa must be sold with this cover or a manufacturer's approved equivalent that has also been tested with the unit.

Tested Cover Manufacturer(s): xxx

Tested Cover Model(s): xxx

**Power calculated based on standby testing @ 60°F. Actual values will vary based on use.**

**This Label Must Remain Adhered to Spa Until Point of Sale.**

(Source: Modified from Figure 7.1(b) in ANSI/APSP/ICC-14 2014 )

The following documents are incorporated by reference in Section 1607.

| ***Number*** | ***Title*** |
| --- | --- |
| **THE ASSOCIATION OF POOL AND SPA PROFESSIONALS (APSP)** | |
| ANSI/APSP/ICC-14 2014 | American National Standard for Portable Electric Spa Energy Efficiency |
| Copies available from: | The Association of Pool and Spa Professionals<br>2111 Eisenhower Avenue<br>Alexandria, VA 22314-4695<br>www.apsp.org<br>Phone: (703) 838-0083 |

# APPENDIX A:
# Staff Assumptions and Calculation Methods

Appendix A contains the information and calculations used to characterize pool pump and motor combinations and replacement pool pump motors in California, current energy use, and potential savings. The source of much of the information for these tables is the CASE report submitted to the Energy Commission by the IOUs. All calculations were based on the assumption of an effective date of January 1, 2019.

## Stock and Sales

**Table A-1** lists the annual sales of each appliance, the total stock of appliances for each category, their duty cycle (annual hours of operation), and expected lifetime as surveyed by PG&E, SCE, and SDG&E, and reported in the CASE report.

**Table A-1: Stock and Sales**

| Product | Total Stock 2012 (Thousand) | Stock Growth per Year (Thousand) | First - Year Stock 2019 (Thousand) | Total Stock 2019 (Thousand) | Life-time (Years) |
|---|---|---|---|---|---|
| Variable-Speed | 180 | 2 | 28 | 193 | 7 |
| Dual-Speed | 190 | 2 | 29 | 203 | 7 |
| Single-Speed Residential Filtration | 1,520 | 15 | 232 | 1,626 | 7 |
| Pressure Cleaner Booster Pumps | 461 | 5 | 99 | 493 | 5 |
| Waterfall Pool Pumps | 69 | 1 | 11 | 74 | 7 |
| Integral Filter Pool Pumps | 206 | 2 | 55 | 221 | 4 |
| Single-Speed Commercial | 50 | 1 | 8 | 54 | 7 |

Source: CASE report, p. 20 and staff calculation

Sales for 2019 are estimated by dividing the total stock by the appliance lifetime in years. Staff projected the 2019 stock numbers by assuming a noncompounded growth rate of 1 percent per year to the 2012 stock numbers presented in the CASE report. The 1 percent growth rate is based upon the California population forecast increase of about 1 percent.[160]

Residential and commercial pool pumps and motors are separated for energy consumption calculations due to different duty cycles.

Example: Variable-speed pumps total stock and sales calculation:

**Total Stock 2019**

$N_{2019} = N_{2012} \times 1.07\%$
193,000 = 180,000 × 1.07%

**Sales 2019**

$S_{2019} = N_{2019} \div L$
27,571= 193,000 ÷ 7
where:
$S_{2019}$ = Sales for year 2019
$N_{2019}$ = Total stock for year 2019
$N_{2012}$ = Total stock for year 2012
L = Product lifetime in years

## Compliance Rates

Staff used the CASE report estimates for compliance to the proposed motor efficiency standards. The single-speed, dual-speed, and variable-speed compliance rates were estimated based upon data in the Energy Commission's Appliance Efficiency Database, the CASE report and the US DOE DPPP analysis.[161] **Table A-2** lists current compliance rates for the proposed standards. Staff adjusted compliance rates to maintain consistent baseline unit energy consumption with the January 2016 draft staff report.

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160 Kavalec, Chris, Nicholas Fugate, Bryan Alcorn, Mark Ciminelli, Asish Gautam, Kate Sullivan, and Malachi Weng-Gutierrez, 2013. *California Energy Demand 2014-2024 Preliminary Forecast, Volume 1*, California Energy Commission, Publication Number CEC-200-2013-004-SD-V1, p. 30.
161 April 18-19, 2016 meeting slides for the Dedicated Purpose Pool Pumps (DPPP) Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Working Group, Department of Energy Building Technologies Office, Slide 48. Docket ID EERE-2015-BT-STD-0008

**Table A-2: Compliance Rates**

| Product | Non-Compliant (%) | Compliance (%) |
|---|---|---|
| Variable-Speed | 10 | 90 |
| Dual-Speed | 97 | 3 |
| Single-Speed Residential Filtration | 84 | 16 |
| Pressure Cleaner Booster Pumps | 95 | 5 |
| Waterfall Pool Pumps | 0 | 100 |
| Integral Filter Pool Pumps | 80 | 20 |
| Single-Speed Commercial | 95 | 5 |

Source: CASE report, p. 22, and Energy Commission Appliance database

## Duty Cycle

The duty cycle is an estimate of consumer behavior for pool pump motor combinations and replacement pool pump motors. Duty cycle describes how often and for how long the product is used. The duty cycles represent current average annual usage to make meaningful estimates of product energy consumption and savings. These figures rely on metering and behavior studies where possible and use reasonable estimates where this type of information is unavailable.

Integral filter pool pumps are most often used with portable and storable pools that consumers use for only part of the year. When not in use the portable and storable pools are stored and do not require filtering. The integral filter pool pump duty cycle is based upon industry estimates of 150 days per year of use. A non-compliant unit is assumed to run 24 hours per day while a compliant unit with timer control would run a maximum of 12 hours per day. The duty cycle of the compliant unit is conservative as consumers may select a shorter duty cycle to meet their filtering needs.

**Table A-3a: Duty Cycle**

| Product | Full Speed (Hrs/Yr) | Half Speed (Hrs/Yr) |
|---|---|---|
| Variable-Speed | 700 | 1800 |
| Dual-Speed | 700 | 1800 |
| Single-Speed Residential Filtration | 1700 | N/A |
| Pressure Cleaner Booster Pump | 900 | N/A |
| Waterfall Pool Pumps | N/A | 900 |
| Single-Speed Commercial | 8760 | N/A |

Source: CASE report

**Table A-3b: Duty Cycle Integral Filter Pool Pump**

| Product | Full Speed (Hrs/Yr) |
|---|---|
| Compliant Integral Filter Pool Pumps | 1800 |
| Non-Compliant Integral Filter Pool Pumps | 3600 |

Source: Comment to Docket TN 210550 Matthew Vartola Comments: Pool Pump Staff Workshop, Date 2/29/2016

## Baseline Energy Use

The power consumption assumptions for pool pump and motor combinations and replacement pool pump motors are derived from the CASE report, which relies on market data gathered by utilities and pool owner surveys to determine full-speed and half-speed usage. The baseline usage was calculated for single-speed, dual-speed, and variable-speed at various motor sizes. Baseline motor efficiency was estimated by calculating the average efficiency of noncompliant models in the Energy Commission's Appliance Efficiency Database. Estimated annual energy consumption per pool pump type and size is calculated using a combination of the power of the various modes and the duty cycles of those modes. For example, the annual energy consumption of full speed is calculated by multiplying full-speed mode power by full-speed mode duty cycle. For each motor type, the average energy consumption was calculated and is shown in **Table A-4** and **A-5**. The average was weighted based upon sales data per motor size.

The energy consumption calculation is performed for both the full-speed and half-speed mode of operation with values for name plate power, motor service factor, and efficiency for full and half speed gathered from the CASE report and the Appliance Efficiency

Database. Compliance rates are assumed to be same for both full and half speed since the motor must meet both standards.

Integral filter pool pump and motor combination energy consumption calculations were performed in a similar manner to the other pool pump and motor combinations except different assumption are made for the duty cycles and motor efficiencies of compliant and noncompliant motors. Staff considered a 1/15 and 1/2 hp motor size in performing the energy consumption calculations. The motor efficiencies for the compliant and noncompliant pool pump motors were assumed equal since it is likely the same motor will be used regardless of whether a timer is present. The duty cycle was varied between the noncompliant and compliant pool pump and motor combinations to account for the timer operation.

**Total motor power output capacity**

$P_o = P_{np} \times SF$
where
$P_o$ = Total motor power output capacity
$P_{np}$ = Nameplate motor output
SF = Service Factor

For example total motor capacity of a 1 hp motor with 1.25 service factor is:
$P_o$ = 1 hp x 1.25 = 1.25 hp

The half speed total motor capacity is found by observing the pump affinity laws.
$P_{half\ speed} = P_{full\ speed} \times (1/2)^3$
where
½ represents the ratio of half speed to full speed
Convert hp to kilowatts (kW) using conversion factor.
kW= .746 (kW/hp) × hp

**Full speed baseline power consumption:**

$P_i = (P_o \div \eta_{non\ compliant}) \times (1\text{-}C) + (P_o \div \eta_{compliant}) \times (C)$
where:
$P_i$ = Motor power input at full speed
$P_o$ = Motor power output at full speed
C = Compliance rate
$\eta_{non\ compliant}$ =Average motor efficiency at full speed for noncompliant units
$\eta_{compliant}$ =Average motor efficiency at full speed for compliant units

**Half speed baseline power consumption:**

$P_i = (P_o \div \eta_{non\ compliant}) \times (1\text{-}C) + (P_o \div \eta_{compliant}) \times (C)$
where:
$P_i$ = Motor power input at half speed
$P_o$ = Motor power output at half speed

C = Compliance rate

$\eta_{non\ compliant}$ =Average motor efficiency at half speed for noncompliant units

$\eta_{compliant}$ =Average motor efficiency at half speed for compliant units

**Average full speed power**

$P_{annual\ average} = (P_{1.0\ hp} \times \%_{1.0\ hp}) + (P_{1.5\ hp} \times \%_{1.5\ hp}) + (P_{2.0\ hp} \times \%_{2.0\ hp}) + (P_{2.5\ hp} \times \%_{2.5\ hp}) + (P_{3\ hp} \times \%_{3\ hp})$

where:

$P_{annual\ average}$ = Average full speed power per appliance type

$P_{1.0\ hp}$ = Full speed input power as calculated above for 1.0 hp motor

$P_{1.5\ hp}$ = Full speed input power as calculated above for 1.5 hp motor

$P_{2.0\ hp}$ = Full speed input power as calculated above for 2.0 hp motor

$P_{2.5\ hp}$ = Full speed input power as calculated above for 2.5 hp motor

$P_{3.0\ hp}$ = Full speed input power as calculated above for 3.0 hp motor

$\%_{1.0\ hp}$ = percent sales at 1.0 hp

$\%_{1.5\ hp}$ = percent sales at 1.5 hp

$\%_{2.0\ hp}$ = percent sales at 2.0 hp

$\%_{2.5\ hp}$ = percent sales at 2.5 hp

$\%_{3.0\ hp}$ = percent sales at 3.0 hp

Average half-speed power per appliance is calculated in a similar manner.

**Average Energy consumption per appliance per motor size**:

$E_{annual} = (P_{avg\ full\ speed} \times D_{full\ speed}) + (P_{avg\ half\ speed} \times D_{half\ speed})$

where:

$E_{annual}$ = Annual energy consumption per appliance

$P_{avg\ full\ speed}$ = Power input calculated above for full-speed motor operation

$P_{avg\ half\ speed}$ = Power input calculated above for half-speed motor operation

$D_{full\ speed}$ = Duty cycle for full speed

$D_{half\ speed}$ = Duty cycle for half speed

**Total stock energy consumption per motor type**:

$E_{total\ baseline\ stock} = E_{annual\ baseline} \times N_{2017}$

where:

$E_{total\ stock}$ = Total baseline stock energy consumption per motor type

$E_{annual\ average}$ = Average annual energy consumption per appliance type

$N_{2017}$ = Total stock for year 2017

**Average duty cycle for integral filter pool pumps**

$D_i = D_{non\ compliant} \times (1\text{-}C) + D_{compliant} \times (C)$

Where:

$D_{non\ compliant}$ = Duty Cycle of noncompliant integral filter pool pumps

$D_{compliant}$ = Duty Cycle of compliant integral filter pool pumps

C = compliance rate

**Table A-4** presents baseline energy consumption prior to the motor efficiency standard. **Table A-5** presents baseline energy consumption prior to the integral filter pool pump timer requirement.

**Table A-4: Baseline Energy Consumption**

| Product | Full Speed (kW) | Half Speed (kW) | Annual Energy Consumption (kWh per Appliance /yr) | Total Annual Stock Energy Use (GWh/yr) |
|---|---|---|---|---|
| Variable-Speed | 2.81 | 0.44 | 2,753 | 530 |
| Dual-Speed | 2.33 | 0.43 | 2,403 | 488 |
| Single-Speed Residential Filtration | 1.09 | N/A | 1,858 | 3,022 |
| Pressure Cleaner Booster Pumps | 1.42 | N/A | 1,282 | 633 |
| Waterfall Pool Pumps | N/A | 0.16 | 145 | 11 |
| Single-Speed Commercial | 2.32 | N/A | 20,350 | 1,089 |

Source: Staff Calculation

**Table A-5: Baseline Energy Use Integral Filter Pool Pump**

| Product | Full Speed (kW) | Average Duty Cycle (hrs/yr) | Annual Energy Consumption (kWh per Appliance) | Total Annual Stock Energy Use (GWh/yr) |
|---|---|---|---|---|
| Integral Filter Pool Pumps | 0.62 | 3,240 | 1,998 | 441 |

Source: Staff calculation

**Table A-6: Sales Weight Data**

| Product Class | Nameplate Motor Power (hp) | Sales Weight by hp (%) |
|---|---|---|
| Variable-Speed | 1 | 13 |
| | 1.5 | 10 |
| | 2 | 16 |
| | 2.7 | 19 |
| | 3 | 42 |
| Dual-Speed | 0.75 | 9 |
| | 1 | 29 |
| | 1.5 | 28 |
| | 2 | 4 |
| | 2.5 | 4 |
| | 3 | 26 |
| Single-Speed Filtration | 0.5 | 12 |
| | 0.75 | 84 |
| Pressure Cleaner Booster Pump | 0.75 | 100 |
| Waterfall Pumps | 0.75 | 100 |
| Single-Speed Commercial | 1 | 30 |
| | 1.5 | 32 |
| | 2 | 20 |
| | 2.5 | 7 |
| | 3 | 11 |
| Integral Filter Pool Pump | 0.07 | 20 |
| | 0.5 | 80 |

Source: CASE report (shown in spreadsheet but not in text of CASE report)

Table A-7: Efficiency and Compliance Data

| Product Class | Nameplate Motor Power (hp) | Full-Speed Motor Efficiency (non-compliant units) | Half-Speed Motor Efficiency (non-compliant units) | Full-Speed Motor Efficiency (compliant units) | Half-Speed Motor Efficiency (compliant units) |
|---|---|---|---|---|---|
| Variable-Speed | 1 | 0.70 | 0.50 | 0.80 | 0.65 |
| | 1.5 | 0.70 | 0.50 | 0.80 | 0.65 |
| | 2 | 0.70 | 0.50 | 0.80 | 0.65 |
| | 2.7 | 0.70 | 0.50 | 0.80 | 0.65 |
| | 3 | 0.70 | 0.50 | 0.80 | 0.65 |
| Dual-Speed | 0.75 | 0.68 | 0.38 | 0.80 | 0.65 |
| | 1 | 0.66 | 0.41 | 0.80 | 0.65 |
| | 1.5 | 0.7 | 0.47 | 0.80 | 0.65 |
| | 2 | 0.7 | 0.49 | 0.80 | 0.65 |
| | 2.5 | 0.7 | 0.50 | 0.80 | 0.65 |
| | 3 | 0.7 | 0.50 | 0.80 | 0.65 |
| Single-Speed Filtration | 0.5 | 0.61 | N/A | 0.75 | N/A |
| | 0.75 | 0.56 | N/A | 0.75 | N/A |
| Pressure Cleaner Booster Pump | 0.75 | 0.58 | N/A | 0.80 | N/A |
| Waterfall Pool Pump | 0.75 | N/A | 0.65 | N/A | 0.65 |
| Single-Speed Commercial | 1 | 0.66 | N/A | 0.70 | N/A |
| | 1.5 | 0.65 | N/A | 0.80 | N/A |
| | 2 | 0.67 | N/A | 0.80 | N/A |
| | 2.5 | 0.70 | N/A | 0.80 | N/A |
| | 3 | 0.70 | N/A | 0.80 | N/A |
| Integral Filter Pool Pump | 0.07 | 0.50 | N/A | 0.50 | N/A |
| | 0.5 | 0.50 | N/A | 0.50 | N/A |

Source: CASE report

## Compliant Energy Use

The power consumption of compliant products is estimated based on minimum requirements to meet the proposed regulations. For example, the proposed full-speed motor efficiency is 80 percent, so products were assumed to consume exactly the bare minimum power to accomplish this standard. It is noted those cases where the baseline power for a given mode was already more efficient than the standard that the report does not assume that power will increase, but rather that it will remain the same. The annual energy consumption is calculated using the same method as baseline energy use. **Tables A-8 and A-9** show predicted energy consumption of compliant units and stock.

**Table A-8: Compliant Energy Consumption**

| Product | Full Speed (kW) | Half Speed (kW) | Annual Energy Consumption (kWh per Appliance /yr) | Total Annual Stock Energy Use (GWh/yr) |
|---|---|---|---|---|
| Variable-Speed | 2.77 | 0.43 | 2,702 | 520 |
| Dual-Speed | 2.03 | 0.31 | 1,979 | 402 |
| Single-Speed Residential Filtration | 0.86 | N/A | 1,458 | 2,372 |
| Pressure Cleaner Booster Pumps | 1.05 | N/A | 944 | 466 |
| Waterfall Pool Pumps | N/A | 0.16 | 145 | 11 |
| Single-Speed Commercial | 1.96 | N/A | 17,205 | 920 |

Source: Staff Calculation

**Table A-9 Compliant Energy Use Integral Filter Pool Pump**

| Product | Full Speed (kW) | Average Duty Cycle (hrs/yr) | Annual Energy Consumptio n (kWh per Appliance) | Total Annual Stock Energy Use (GWh/yr) |
|---|---|---|---|---|
| Integral Filter Pool Pumps | 0.62 | 1800 | 1,110 | 245 |

Source: Staff calculation

## Cost and Energy Savings

The annual existing and incremental stock energy savings are calculated by subtracting the compliant energy use from the baseline energy use.

### Stock Energy Savings

$E_{\text{stock savings}} = E_{\text{baseline stock}} - E_{\text{compliant stock}}$

where:

$E_{\text{stock savings}}$ = Annual stock energy savings at full stock turnover

$E_{\text{baseline stock}}$ = Annual stock baseline energy consumption

$E_{\text{compliant stock}}$ = Annual stock compliant energy consumption

### First-Year Energy Savings

$E_{\text{1 year savings}} = E_{\text{stock savings}} \div L$

where:

$E_{\text{1 year savings}}$ = Energy savings from first years sales of compliant units.

$E_{\text{stock savings}}$ = Annual stock energy savings at full stock turnover

L = Product lifetime in years

**Table A-10: Statewide Cost and Energy Savings**

| | First-Year Savings | | Annual Existing and Incremental Stock Savings | |
|---|---|---|---|---|
| **Product** | **Electricity Savings (GWh/yr)** | **Savings ($M)** | **Electricity Savings (GWh/yr)** | **Savings ($M)** |
| Variable-Speed | 1.4 | $0.2 | 10 | $1.6 |
| Dual-Speed | 12.3 | $2.0 | 86 | $13.8 |
| Single-Speed Residential Filtration | 92.9 | $14.9 | 650 | $104.0 |
| Pressure Cleaner Booster Pumps | 33.3 | $5.3 | 167 | $26.7 |
| Waterfall Pool Pumps | 0.0 | $0.0 | 0.0 | $0.0 |
| Single-Speed Commercial | 24.0 | $3.8 | 168 | $26.9 |
| **Total Savings** | **164.0** | **$26.2** | **1081** | **$173.0** |

Source: Staff calculation

**Table A-11: Statewide Cost and Energy Savings Integral Filter Pool Pumps**

| | First-Year Savings | | Annual Existing and Incremental Stock Savings | |
|---|---|---|---|---|
| **Product** | **Electricity Savings (GWh/yr)** | **Savings ($M)** | **Electricity Savings (GWh/yr)** | **Savings ($M)** |
| Integral Filter Pool Pumps | 49.0 | $7.8 | 196 | $31.3 |

Source: Staff calculation

**Table A-12: Motor Efficiency and Timer Statewide Cost and Energy Savings**

| | First Year Savings | | Annual Existing and Incremental Stock Savings | |
|---|---|---|---|---|
| | **Electricity Savings (GWh/yr)** | **Savings ($M)** | **Electricity Savings (GWh/yr)** | **Savings ($M)** |
| Motor Efficiency Total Savings | 164.0 | $26.2 | 1081 | $173.0 |
| Integral Filter Timer Savings | 49.0 | $7.8 | 196 | $31.3 |
| Motor Efficiency and Timer Total Savings | **213.0** | **$34.0** | **1277** | **$204.3** |

Source: Staff Calculation

Unit cost savings (benefits) are calculated by multiplying the annual energy savings by $0.16 per kWh and by the design life.

**Annual unit energy savings**

$E_{\text{annual savings}} = E_{\text{annual baseline}} - E_{\text{annual Compliant}}$

where:

$E_{\text{annual savings}}$ = Annual unit energy savings
$E_{\text{annual baseline}}$ = Annual unit baseline energy consumption
$E_{\text{annual compliant}}$ = Annual unit compliant energy consumption

**Lifetime unit energy savings**

$B_{\text{energy savings}} = E_{\text{annual savings}} \times L$

where:

$B_{\text{energy savings}}$ = Lifetime unit energy savings
$E_{\text{annual savings}}$ = Annual unit energy savings
L = Product lifetime in years

Net unit savings are calculated by subtracting costs from benefits.

**Net energy savings:**

$B_{\text{net}} = B_{\text{energy savings}} - C_{\text{incremental}}$

where:

$B_{\text{net}}$ = Net energy savings
$B_{\text{energy savings}}$ = Lifetime unit energy savings
$C_{\text{incremental}}$ = Incremental cost

**Table A-13: Annual Energy and Monetary Savings**

| Product | Design Life (years) | Electricity Savings (kWh/yr) | Incremental Cost | Average Annual Savings | Life-Cycle Savings | Life-Cycle Benefit |
|---|---|---|---|---|---|---|
| Variable-Speed | 7 | 51 | $18 | $8 | $57 | $39 |
| Dual-Speed | 7 | 424 | $276 | $68 | $475 | $199 |
| Single-Speed Residential Filtration | 7 | 400 | $59 | $64 | $448 | $389 |
| Pressure Cleaner Booster Pumps | 5 | 338 | $126 | $54 | $270 | $144 |
| Waterfall Pool Pumps | 0 | 0 | $0 | $0 | $0 | $0 |
| Single-Speed Commercial | 7 | 3,144 | $395 | $503 | $3,522 | $3,127 |
| Integral Filter Pool Pumps | 4 | 888 | $10 | $142 | $568 | $558 |

Source: Staff Calculation

# APPENDIX B:
# Staff Assumptions and Calculation Methods

Appendix B discusses the information and calculations used to characterize portable electric spas in California, the current energy use, and the potential savings. The source of much of this information is the CASE report submitted to the Energy Commission. All calculations were based on the assumption of an effective date of January 1, 2017, although the effective date is proposed to be January 1, 2018. The difference in effective dates does not significantly alter the calculations. After careful review, staff has altered some of the figures from the CASE report as appropriate to fit staff's approach to energy consumption and savings.

For the inflatable spa and combination spa energy use assumptions, sample calculations revolve around an effective date of January 1, 2018.

**Table B-1: Summary of Values and Assumptions**

| Value | Description | Source |
|---|---|---|
| 5.0 % | Average Percent of New Units in California | APSP, 2012-2013 (see Table B-2) |
| 44.0% | Average percentage of California Spa Owners that own an outdoor, above-ground spa | KEMA, 2010 (see Table B-3) |
| 0% | Inflatable spas' rate of compliance for current and future standard | Energy Commission MAEDBS |
| 0 GWh | Inflatable spas' statewide energy consumption for 2017 (baseline consumption) | Assumption made by staff due to 0% compliance rate |
| 90 days/yr. | Inflatable Spa Seasonal Duty Cycle | Assumption made by staff for calendar days in a season |
| 3000 | Combination Spa California Stock for 2017 | Assumption made by staff based on special use and high cost |
| 300 | Combination Spa California Sales for 2017 | Assumption made by staff based on special use and high cost |
| 4 | Number of combo spa manufacturers | Assumption made by staff based on few online manufacturers |
| 5 | Number of combo spa product lines | Assumption made by staff based on few online products found |
| 60% | Compliance rate of combo spas with proposed performance standard | Assumption made by staff in parallel with current MAEDBS compliance |
| 8,760 hrs./yr. | Standby mode operating hours | Worth & Fernstrom, 2014 |
| 102°F ± 2°F | Surface water temperature required for Title 20 test method | Title 20, Section 1604 (g)(2) |
| 60°F ± 3°F | Air temperature required for Title 20 test method | Title 20, Section 1604 (g)(2) |
| 6.95 kPa | $P_w$, saturation vapor pressure taken at a surface water temperature of 38.89°C or 102°F | Brice & Hall, 2014 |
| 1.768 kPa | $P_a$, saturation vapor pressure at room temperature of 15.56°C or 60°F | Brice & Hall, 2014 |
| 0.10 m/s | Recommended air velocity over water surface | Lund, 2000 |
| 1.0 | Activity factor for whirlpools and spas | Lund, 2000 |
| 43 | Number of Manufacturers who have certified portable electric spas in the MAEDBS | MAEDBS July 2015 |
| 0.1619 $/kWh | Average Residential Retail Price in California for Electricity | U.S. Energy Information Administration, 2013 |
| 5.0% | Label Impact Rate Savings | Assumption by CASE Team, Portable Electric Spas CASE Report 2014 |
| 0.07 lb/MW | Oxides of nitrogen emission factor | California Air Resources Board, 2010 |
| 0.01 lb/MW | Sulfur Dioxide emission factor | California Air Resources Board, 2010 |

| | | |
|---|---|---|
| 0.10 lb/MW | Carbon Monoxide emission factor | California Air Resources Board, 2010 |
| 0.03 lb/MW | Particulate matters emission factor | California Air Resources Board, 2010 |
| 690.00 lb/MW | Carbon Dioxide emission factor | Energy Aware Planning Guide as cited in Staff Analysis of Water Efficiency Standards for Showerheads 2015 Report |

Source: Assumptions and values used for staff calculations

## Stock and Sales

**Table B-2** lists annual stock and annual sales for portable electric spas in California during 2011 and 2012. These include commercial, in-ground, and above-ground spa units.

**Table B-2: Number of Portable Electric Spa Units in California**

| Year | Stock in California | New Units Sold/Installed in California | Percent of New Units in California |
|---|---|---|---|
| 2011 | 1,488,016 | 71,525 | 4.8% |
| 2012 | 1,142,352 | 58,922 | 5.2% |
| | | Average | 5.0% |

Source: APSP - U.S. Swimming Pool and Hot Tub 2012 and 2013 Market Reports

**Table B-3** lists the number of outdoor, above-ground spas in California from the 2003 and 2009 Residential Appliance Saturation Study (RASS).

**Table B-3: Outdoor and Above-Ground Spas in California**

| Building Type | 2003 | 2009 |
|---|---|---|
| Single Family | 356,265 | 443,731 |
| Townhouse, Duplex, Row House | 8,368 | 5,725 |
| Apt Condo 2-4 Units | 2,002 | 5,498 |
| Apt Condo 5+ Units | 531 | 3,877 |
| Mobile Home | 6,181 | 8,162 |
| Other | 1,366 | 227 |
| Total Outdoor and Above-ground spas | 374,713 | 467,220 |
| Total of California Residents that own a spa | 804,660 | 1,102,560 |
| Percent of California Spa Owners that own an outdoor, above-ground spas | 47% | 42% |
| Average | | 44% |

Source: California Statewide Residential Appliance Saturation Study

Using information from the Residential Energy Consumption Survey (RECS) database by the U.S. Energy Information Administration from 1993 to 2009, APSP U.S. Swimming Pool and Hot Tub Market Reports, and the 2009 RASS, staff estimated the annual stock and sales in California, as shown in **Table B-4**.

**Table B-4: Estimated Annual Stock and Sales**

| Year | Stock of Spas in California[1] | Stock of Portable Electric Spas in California[2] | Sales[3] |
|---|---|---|---|
| 2012 | 1,142,352 | 508,026 | 25,312 |
| 2013 | 1,182,265 | 525,776 | 26,196 |
| 2014 | 1,222,178 | 543,526 | 27,080 |
| 2015 | 1,262,091 | 561,276 | 27,965 |
| 2016 | 1,302,004 | 579,026 | 28,849 |
| 2017 | 1,341,917 | 596,776 | 29,733 |
| 2018 | 1,381,830 | 614,526 | 30,618 |
| 2019 | 1,421,743 | 632,276 | 31,502 |
| 2020 | 1,461,656 | 650,026 | 32,387 |
| 2021 | 1,501,569 | 667,776 | 33,271 |
| 2022 | 1,541,482 | 685,526 | 34,155 |
| 2023 | 1,581,395 | 703,276 | 35,040 |
| 2024 | 1,621,308 | 721,026 | 35,924 |
| 2025 | 1,661,221 | 738,776 | 36,808 |
| 2026 | 1,701,134 | 756,527 | 37,693 |
| 2027 | 1,741,047 | 774,277 | 38,577 |
| 2028 | 1,780,960 | 792,027 | 39,462 |
| 2029 | 1,820,873 | 809,777 | 40,346 |
| 2030 | 1,860,786 | 827,527 | 41,230 |

**[1]Stock includes commercial, in-ground, and above-ground units**
**[2]Stock of units outdoor and above-ground using RASS esimates.**
**[3]Using APSP report estimates.**

Source: See **Table B-2** and **Table B-3**, RECS database

## Design Life

The design life is an estimate of the length of the typical operation usefulness of a product. The design life figures were taken from the CASE report and are shown in **Table B-5**.

**Table B-5: Estimated Design Life of Noninflatable, Portable Electric Spas**

| Component | Design Life (years) |
|---|---|
| Spa Cover | 5 |
| Portable Electric Spa | 10 |

Source: Portable Electric Spa CASE Report 2014

## Compliance Rates

Compliance rate is the percentage of compliant units over the total stock units. **Table B-6** lists the estimated or reported compliance rates. A compliance rate percentage indicates the ratio of compliant appliances to the total market or stock. Thus, a compliance rate of 40 percent means that 40 percent of that particular appliance already meets the proposed standard.

**Table B-6: Compliance Rate for Portable Electric Spas**

| | Zones | Compliant (%) | Non-Compliant (%) |
|---|---|---|---|
| Portable Spas | 1AB to 3 | 72.5 | 27.5 |
| Exercise Spas* | 4 to 8 | 47.7 | 52.3 |
| All Certified Units | 1AB to 8 | 71.3 | 28.7 |

Source: MAEDBS, California Energy Commission

*The Exercise Spas category includes an estimated 60 percent compliance rate for combination spas.

**Table B-7** lists the estimated compliances rates for each zone.

**Table B-7: Unit Population and Compliance Rate for Each Zone**

| Zones | Compliant Units | Non-Compliant Units | Total Units | Units per Zone (%) | Compliant (%) | Non-Compliant (%) |
|---|---|---|---|---|---|---|
| 1A | 67 | 0 | 67 | 5.07 | 100 | 0 |
| 1B | 312 | 53 | 365 | 27.63 | 85.5 | 14.5 |
| 2 | 523 | 281 | 804 | 60.86 | 65 | 35 |
| 3 | 9 | 11 | 20 | 1.51 | 45 | 55 |
| 4 | 0 | 7 | 7 | 0.53 | 0 | 100 |
| 5 | 8 | 6 | 14 | 1.06 | 57.1 | 42.9 |
| 6 | 14 | 9 | 23 | 1.74 | 60.9 | 39.1 |
| 7 | 5 | 9 | 14 | 1.06 | 35.7 | 64.3 |
| 8 | 7* | 5* | 12 | 0.91 | 58.3 | 41.7 |

Source: MAEDBS, California Energy Commission, and staff assumptions

*Exercise Spas including combination spas

## Duty Cycle

The duty cycle of an appliance is an estimate of consumer behavior for that particular appliance. It is directly tied to how often the appliance is used and for how long. In the context of this report, the duty cycle is the usage of the regulated standby mode or cycle of the unit. The duty cycle used in this report (see **Table B-8**) is taken directly from the CASE report and applied to both portable electric spas and exercise spas.

**Table B-8: Duty Cycle**

| Unit | Operating Hours |
|---|---|
| Portable Electric Spas | 8,760 hrs/yr |
| Exercise Spas | 8,760 hrs/yr |
| *Inflatable/Easy-Storage Spas | 2,160 hrs/yr |

Source: Portable Electric Spas CASE Report 2014

*Staff assumption of 90 days/yr. for seasonal-use and easy-storage units.

## Baseline Energy Use

After applying the proposed standby power limit to the certified units in the MAEDBS displayed in **Figure 16-1**, the graph shows a high saturation of data on the lower left which could cause some discrepancies in calculating energy consumption. Also, the CASE report does not include portable electric spas with a volume of more than 800 gallons. The units currently in the MAEDBS are certified under the current Title 20 standard and will fall below the current standard curve. There are cases where units do not pass the current standard and are not represented in the graph. There could also be instances where current units will be upgraded or discontinued, therefore being removed from MAEBDS. These cases will modify the data. Thus, using an average of the standby power consumption of the units in the database as the base for calculations would inaccurately represent the energy consumption. Instead of using a weighted-average of the standby power consumption, a weighted-average of the maximum allowable standby power from the current and proposed standard equations will be used.

The current standby power limit equation is as follows:

$$P = 5 \times V^{2/3}$$

where
P = maximum allowable standby power (watts)
V = volume (gallons).

The proposed standby power limit equation is as follows:

$$P = \left(3.75 \times V^{2/3}\right) + 40$$

where

P = maximum allowable standby power (watts)

V = volume (gallons).

**Table B-9** lists the volume used in the equations above and is the average volume of the volume range in each zone.

**Table B-9: Average Volume used for Calculations**

| Zone | Volume Range (gallons) | Average Volume (gallons) |
|---|---|---|
| 1A | 100-180 | 140 |
| 1B | 181-300 | 240 |
| 2 | 301-600 | 450 |
| 3 | 601-900 | 750 |
| 4 | 901-1,200 | 1,050 |
| 5 | 1,201-1,500 | 1,350 |
| 6 | 1,501-1,800 | 1,650 |
| 7 | 1,801-2,100 | 1,950 |
| 8 | 2,101-2,400 | 2,250 |

Source: Staff calculation

**Figure B-1** displays the results of inputting the average volume of each zone into the standby power limit equation for the current and proposed standard. The graph also displays the standby power limit for the proposed standard when applying the 5 percent potential savings as a result of adding a label to portable electric spas.

Sample Calculation (Zone 2, V = 450 gallons):

Current Standard:

$$P = 5 \times V^{2/3}$$

$$P = 5 \times (450\ gallons)^{2/3} = 293.62\ watts \approx 294\ watts$$

Proposed Standard:

$$P = \left(3.75 \times V^{2/3}\right) + 40$$

$$P = \left(3.75 \times (450\ gallons)^{2/3}\right) + 40 = 260.21\ watts \approx 260\ watts$$

Proposed Standard + Label:

$$P = \left(3.75 \times V^{2/3}\right) + 40$$

$$Unit_{Label\ Savings} = P \times 5\%\ Potential\ Savings$$

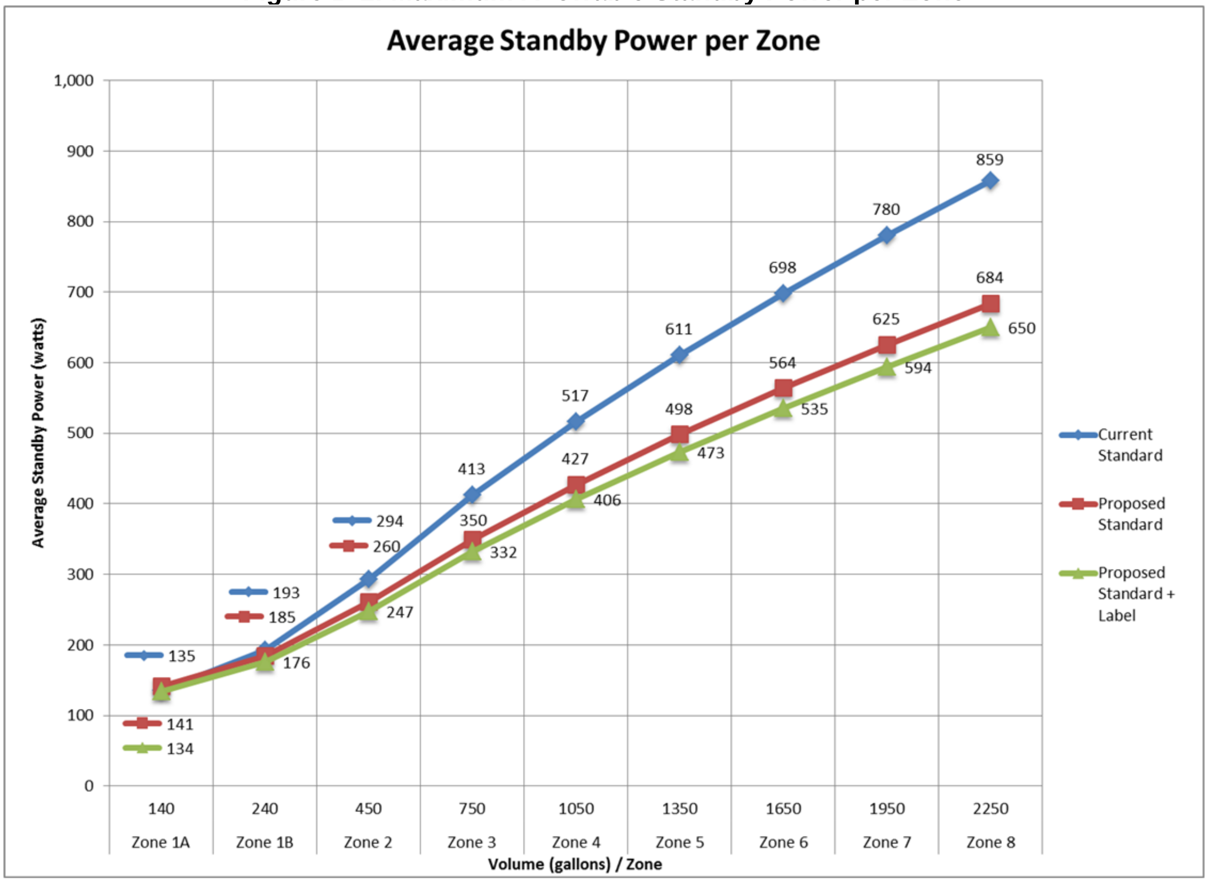
$$P_{Label} = P - Unit_{Label\ Savings}$$

$$P = \left(3.75 \times (450\ gallons)^{2/3}\right) + 40 = 260.21\ watts$$

$$Unit_{Label\ Savings} = 260.21\ watts \times 5\%\ Potential\ Savings = 13.01\ watts$$

$$P_{Label} = 260.21 - 13.01 = 247.2\ watts$$

**Figure B-1: Maximum Allowable Standby Power per Zone**




Source: California Energy Commission

The baseline average energy consumption of the appliance is the estimate of energy consumed by the market representative ratio of compliant and noncompliant units. For example, the annual energy consumption of a portable electric spa is calculated by multiplying the average maximum allowable standby power by the duty cycle and by the compliancy rate for each zone. **Table B-10** lists the baseline energy consumption without the labeling impact for the purpose of explaining the calculations in this study.

**Table B-10: Baseline Energy Consumption Without Label Savings**

| Zones | Compliant Energy Use (Wh/yr) | Non-Compliant Energy Use (Wh/yr) | Total Energy Use (Wh/yr) | Sales Weighted Average Energy Consumption (Wh/yr) |
|---|---|---|---|---|
| 1A* | 1,235,160 | 0 | 1,235,160 | 70,404 |
| 1B | 1,385,613 | 245,149 | 1,630,762 | 450,580 |
| 2 | 1,480,440 | 901,404 | 2,381,844 | 1,449,590 |
| 3 | 1,379,700 | 1,989,834 | 3,369,534 | 50,880 |
| 4* | 0 | 4,528,920 | 4,528,920 | 24,003 |
| 5 | 2,490,976 | 2,296,162 | 4,787,138 | 50,744 |
| 6 | 3,008,850 | 2,390,762 | 5,399,612 | 93,953 |
| 7 | 1,954,575 | 4,393,490 | 6,348,065 | 67,289 |
| 8 | 3,493,242 | 3,137,858 | 6,631,100 | 60,343 |

Source: California Energy Commission

Zone 2 in **Table B-10** will be used as the basis of explaining the calculations in this report.

Sample Calculations (Zone 2):

Proposed Standard:

$$E_{Annual} = (Average\ Standby\ Power\ Consumption\ Limit) \times (Duty\ Cycle) \times\ (Compliant\ Rate\ \%)$$

$$E_{Annual} = (260\ watts) \times \left(8{,}760\frac{hr}{yr}\right) \times\ (0.65) = 1{,}480{,}440\ Wh/yr$$

Current Standard:

$$E_{Annual} = (Average\ Standby\ Power\ Consumption\ Limit) \times (Duty\ Cycle) \times\ (Non\ Compliant\ Rate\ \%)$$

$$E_{Annual} = (294\ watts) \times \left(8{,}760\frac{hr}{yr}\right) \times\ (0.349) = 901{,}404\ Wh/yr$$

Total Energy Consumption for Zone 2:

$$E_{Annual}Zone\ 2 = (E_{Annual}Proposed + E_{Annual}Current)$$

$$E_{Annual}Zone\ 2 = (1{,}480{,}440 + 901{,}404) = 2{,}381{,}844\ Wh/yr$$

The baseline average energy consumption for portable electric spas was calculated by multiplying the energy consumption by the percent of units in each zone.

$$Average\ Energy\ Consumption_{Zone} = (E_{Annual}Zone\#) \times (Unit\ Population\ \%_{Zone})$$

Sample Calculations (Zone 2):

$$Average\ Energy\ Consumption_{Zone2} = (2{,}381{,}844\ Wh/yr) \times (0.6086) = 1{,}449{,}590\ Wh/yr$$

The annual stock energy consumption for portable electric spas is the product of average energy consumption and the annual stock in 2017.

$$Annual\ Stock\ Energy\ Consumption_{Zone} = (Ave.\, Energy\ Consumption_{Zone}) \times (2017\ Stock) \times 10^{-9}$$

Sample Calculations (Zone 2):

$$Annual\ Stock\ Energy\ Consumption_{Zone2} = \left(1{,}449{,}590\,\frac{Wh}{yr}\right) \times (596{,}776\ units) \times 10^{-9} = 865\,\frac{GWh}{yr}$$

The total annual stock energy consumption is the addition of the annual stock energy consumption for each zone. **Table B-11** lists the baseline total annual stock energy consumption for 2017 and 2026. Calculations for 2026, when full implementation is complete, are similar.

**Table B-11: Baseline Energy Use**

| Year | Stock | Total Annual Energy Consumption (GWh/yr) |
|---|---|---|
| 2017 | 596,776 | 1,383.2 |
| 2026 | 756,527 | 1,753.5 |

Source: Staff calculation

### Baseline Energy Use of Inflatable Spas

To estimate the baseline use of inflatable spas, staff began with the current rate of compliance of zero to the current performance standard. Assuming that none of the inflatable units will comply with the current standard up through the January 1, 2018, effective date, the compliance rate and stock for 2017 would also be zero. Unless noncompliant models are still being sold, this equals no additional state energy usage for 2017, as well as in 2018 after the updated performance standard takes effect.

## Compliant Energy Use

The power consumption of compliant products is estimated based on minimum requirements to meet the proposed regulations. The annual energy consumption is calculated using the same methodology as baseline energy use. **Table B-12** lists the compliant total annual stock energy consumption for 2017 and 2026.

**Table B-12: Compliant Energy Use**

| Year | Stock | Total Annual Energy Consumption (GWh/yr) |
|---|---|---|
| 2017 | 596,776 | 1,377.1 |
| 2026 | 756,527 | 1,675.9 |

Source: Staff calculation

## Cost and Savings

**Table B-13** lists the energy savings for portable electric spas once the proposed standard becomes effective in 2017 and when complete implementation has occurred in 2026.

**Table B-13: Standby Power Standard Statewide Annual Stock Savings**

| | First-Year Savings | | Complete Turnover Savings | |
|---|---|---|---|---|
| | Energy Consumption (GWh/yr) | Savings ($M) | Energy Consumption (GWh/yr) | Savings ($M) |
| Portable Electric Spas (Zones 1-3) | 4.2 (69%) | 0.7 | 53.5 (69%) | 8.7 |
| Exercise Spas (Zones 4-8) | 1.9 (31%) | 0.3 | 24.1 (31%) | 3.9 |
| Total | 6.1 (100%) | 1.0 | 77.6 (100%) | 12.6 |

Source: Staff calculation

The energy savings are calculated by subtracting the compliant energy use from the baseline energy use.

$$E_{Annual\ Savings} = E_{Annual\ Baseline} - E_{Annual\ Compliant}$$

Sample Calculation:

$$E_{Annual\ Savings} = (1{,}383.2 - 1{,}377.1)\frac{GWh}{yr} = 6.1\frac{GWh}{yr}$$

The cost savings (benefits) are calculated by multiplying the annual energy savings by $0.1619 per kWh.

$$B_{Savings} = \frac{\$0.1619}{kWh} \times E_{Annual\ Savings}$$

Sample Calculation:

$$B_{Savings} = \frac{\$0.1619}{kWh} \times 6.1\frac{GWh}{yr} \times \frac{10^6 kWh}{1GWh} = \$987{,}590\ or\ \$0.99\ Million$$

The cumulative energy and costs savings when the proposed standard has reached complete implementation is the summation of savings from each year beginning in 2017 and ending in 2026.

**Table B-14** lists the energy savings and cost savings for labeled portable electric spas once the proposed standard becomes effective in 2017 and when complete implementation has occurred in 2026. The savings in the table below assumes the standard is completely implemented for the first year and after complete turnover.

**Table B-14: Statewide Annual Stock Savings Adjusting for Label Impact**

| | First-Year Savings | | Complete Turnover Savings | |
|---|---|---|---|---|
| | Energy Consumption (GWh/yr) | Savings ($M) | Energy Consumption (GWh/yr) | Savings ($M) |
| Portable Electric Spas | 4.8 (69%) | 0.8 | 57.8 (69%) | 9.4 |
| Exercise Spas | 2.1 (31%) | 0.3 | 26.0 (31%) | 4.2 |
| Total | 6.9 (100%) | 1.1 | 83.8 (100%) | 13.6 |

Source: Staff calculation

The total energy savings are calculated by applying the 5 percent potential label savings to the total compliant annual energy consumption for 2017 and 2026 (refer to **Table B-11** and **Table B-12**).

$$First - Year\ Energy\ Consumption\ Savings = Compliant\ AEC \times 100\%\ Standard\ Implementation \times 5\%\ Label\ Savings \times 10\%\ Design\ Life\ Rate$$

$$Complete\ Turnover\ Energy\ Consumption\ Savings = Compliant\ AEC \times 100\%\ Standard\ Implementation \times 5\%\ Label\ Savings$$

Sample Calculation:

$$First - Year\ Energy\ Consumption\ Savings = 1377.1 \frac{GWh}{yr} \times \frac{100\%}{100} \times \frac{5\%}{100} \times \frac{10\%}{100} \approx 6.9\ GWh/yr$$

$$Complete\ Turnover\ Energy\ Consumption\ Savings = 1675.9 \frac{GWh}{yr} \times \frac{100\%}{100} \times \frac{5\%}{100} \approx 83.8 \frac{GWh}{yr}$$

Staff calculated the energy consumption savings for each type of portable electric spa (that is, portable electric spas and exercise spas) by using the ratio of the energy consumption savings of each type to the total energy consumption savings based on the standby power standard only (see **Table B-13**) and then applying it to the total energy consumption savings from the label savings (**Table B-14**). **Table B-15** summarizes the ratio for each type of portable electric spa.

**Table B-15: Percentage of Energy Consumption After Applying the Standby Power Standard**

| Type | Percentage |
|---|---|
| Portable Electric Spas | 69% |
| Exercise Spas | 31% |

Source: Staff calculation

$$Portable\ Electric\ Spa\ Energy\ Consumption\ Savings = Total\ Energy\ Consumption\ \times 69\%$$

$$Exercise\ Spa\ Energy\ Consumption\ Savings = Total\ Energy\ Consumption\ \times 31\%$$

Sample Calculation:

$$Exercise\ Spa\ Energy\ Consumption\ Savings_{CompleteTurnover} = 83.8\frac{GWh}{yr} \times \frac{31\%}{100} = 26.0\frac{GWh}{yr}$$

The cost savings are calculated by multiplying the energy consumption savings by the California retail price of electricity.

$$Cost\ Savings = Energy\ Consumption\ Savings\ \times \frac{\$0.1619}{kWh} \times Unit\ Converter$$

Sample Calculation:

$$Cost\ Savings_{TotalAfterCompleteTurnover} = 81\frac{GWh}{hr} \times \frac{\$0.1619}{kWh} \times \approx \$13.6\ Million$$

**Table B-16** lists the weighted unit energy savings, life-cycle costs, and life-cycle benefits.

**Table B-16: Weighted Unit Energy Savings and Life-Cycle Benefits/Costs**

| | Design Life (years) | Energy Savings (kWh/year) | Life-Cycle Costs ($/unit) | Life-Cycle Benefit ($/unit) | Life-Cycle Benefit/Cost Ratio |
|---|---|---|---|---|---|
| Portable Electric Spas | 10 | 316 | $ 100.39 | $ 512 | 5 |
| Exercise Spas | 10 | 1,446 | $ 375.39 | $ 2,342 | 6 |

Source: California Energy Commission

The calculation for energy savings per unit is the difference between the baseline and compliant consumption per unit, which is similar to the calculations in the previous steps. The life-cycle benefit is the product of the energy savings per unit, the life of unit, and the average retail price of electricity.

The total setup cost is calculated by multiplying the set-up cost for each manufacturer by the number of manufacturers in the MAEDBS.

$$Total\ Set - Up\ Cost\ Statewide = (Engineer\ Time) \times (Engineer\ Hourly\ Wage) \times (No.of\ Manufacturers)$$

The total printing costs to label stock are calculated by multiplying the printing cost per label by the stock in 2017.

$$Total\ Printing\ Costs\ to\ Label\ Stock = (\$0.22\ per\ label) \times (2017\ stock)$$

The total labor costs are calculated by multiplying the total time to adhere labels to the entire stock by the packaging and filling machine operators' hourly wage.

$$Total\ Labor\ Costs = (2017\ Stock) \times (Time\ to\ adhere\ label) \times (Operator\ Hourly\ Wage)$$

The total cost to label stock is the addition of total set-up cost, total printing costs, and otal labor costs.

$$Total\ Cost = (Total\ SetUp\ Cost) + (Total\ Printing\ Costs) + (Total\ Labor\ Costs)$$

The label cost for each portable electric spa is calculated by dividing the total cost to label stock by the 2017 stock.

$$Label\ Cost\ per\ Unit = \frac{Total\ Cost\ to\ Label\ Stock}{2017\ Stock}$$

The method above does not specifically display the labeling cost and life-cycle benefit for combination spas, as no annual stock numbers were available for staff's calculation.

## Sample Calculations for Reintroducing Inflatable Spas on January 1, 2018, Through Compliance With a Timer Design Requirement

Staff considered an alternate design requirement approach that would allow inflatables and other easy-storage or assemble-it-yourself spas to comply if they were designed with an automatic shutoff switch after a specific duration.

The reintroduced statewide energy consumption following an inflatable spa exemption on the January 1, 2018, effective date is determined by assuming how many hours per season (each year) and how many heating watts are required for the standby mode.

$$First - Year\ Energy\ Consumption = (Heating\ \&\ Filtering\ Watts) \times (Estimated\ Duty\ Cycle) \times (Estimated\ Annual\ Stock)$$

Where,
Heating & Filtering Watts ≈ 1500 (watts/unit)
Estimated Duty Cycle ≈ 90 (days/year)
Estimated Annual Stock (used from 2015) ≈ 15,000 (units)[162]

$$First\ Year\ Energy\ Consumption = 1500\ \frac{watts}{unit} \times \frac{24\ hours}{1\ day} \times \frac{90\ days}{1\ year} \times \frac{1GWh}{10^9 Wh} \times 15{,}000\ units \approx 48.6\ GWh/yr$$

Staff considered a design requirement option for an automatic shutoff switch that would terminate all heating and filtering after 72 hours of operation. Staff researched multiple inflatable spas and made assumptions on the weighted average of watts needed for heating and filtering, and how the duty cycle would change with a shutoff switch. One manufacturer that was discovered already featured an automatic shutoff switch which activates hibernation after 72 hours of operation. Since research was not found on how often an inflatable spa requires a filtering cycle, it was not factored into the following assumptions.

$$Reduced\ First - Year\ Energy\ Consumption = (Heating\ \&\ Filtering\ Watts) \times (Impacted\ Duty\ Cycle) \times (Annual\ Stock)$$

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162 Ibid.

Where,
Heating & Filtering Watts ≈ 1500 (watts/unit)
Reduced Duty Cycle ≈ one 72-hour cycle per week during season (hours/week)
Annual Stock ≈ 15,000 (units) estimated by The Association of Pool and Spa Professionals

With 90 days being assumed for the maximum duty cycle of a seasonal-use product, staff further assumed that an automatic shutoff switch would reduce the amount of weekly operation hours from the full, 168 hours per week to one 72-hour cycle each week during the season.

$$Reduced\ First - Year\ Energy\ Consumption$$
$$= 1500\ \frac{watts}{unit} \times \frac{90\ days}{1\ year} \times \frac{12.86\ weeks}{90\ days} \times \frac{72\ hours}{1\ week} \times \frac{1GWh}{10^9 Wh} \times 15{,}000\ units$$
$$\approx 20.8\ GWh/yr$$

Creating a provision for a design requirement still results in about 20.8 GWh of additional statewide energy use during the first year.

## Sample Calculations for Water Evaporation and Related Energy Cost

**Table B-17** lists approximate water surface area based on the average volume of each zone and the evaporation rate based on the approximate water surface area.

**Table B-17: Evaporation Rate Without a Spa Cover**

| Zone | Unit Volume Capacity (gallons) | Water Surface Area ($m^2$) | Evaporation Rate[163], $w_p$ (gallons/hr) |
|---|---|---|---|
| Zone 1A | 140 | 3.3 | 0.70 |
| Zone 1B | 240 | 3.9 | 0.83 |
| Zone 2 | 450 | 5.7 | 1.21 |
| Zone 3 | 750 | 5.8 | 1.23 |
| Zone 4 | 1,050 | 8.0 | 1.69 |
| Zone 5 | 1,350 | 8.7 | 1.85 |
| Zone 6 | 1,650 | 10.9 | 2.31 |
| Zone 7 | 1,950 | 13.0 | 2.76 |
| Zone 8 | 2,250 | 14.0 | 2.96 |

Source: Staff calculations; Lund, *Design Considerations for Pools and Spas (Natatoriums)*

The evaporation rate is determined from using an equation found in the *Design Considerations for Pools and Spas (Natatoriums)* by John W. Lund.

$$w_p = \frac{A(p_w - p_a)(0.089 + 0.0782V)F_a}{\mathrm{Y}}$$

where,

$w_p$=evaporation rate (kg/s)

A=area of pool surface ($m^2$)

$p_w$=saturation vapor pressure taken at surface water temperature (kPa), 6.95 kPa

$p_a$=saturation pressure at room air dew point (kPa), 1.768 kPa

V=air velocity over water surface (m/s), 0.1 m/s

$F_a$=activity factor, 1

Y=latent heat required to change water to vapor, 2257 kJ/kg

Staff Sample Calculations for Zone 2 (Average Volume =450 gallons):

$$w_p = \frac{5.7 \times (6.95 - 1.768)kPa \times \left(0.089 + 0.0782 \times 0.1\frac{m}{s}\right) \times 1}{2257\frac{kJ}{kg}} = 0.001267\frac{kg}{s}$$

Convert kilogram per second to gallons per hour

$$w_p = 0.001267\frac{kg}{s} \times \frac{0.26417\ gallons}{1\ kg} \times \frac{60\ sec}{1\ min} \times \frac{60\ min}{1\ hr} = 1.21\ \frac{gallons}{hr}$$

163 Lund, John W., *Design Considerations for Pools and Spas (Natatoriums).* Klamath Falls: Geo-Heat Center Oregon Institute of Technology, 2000.

**Table B-18** lists the total energy and the total power required to heat a certain amount of water. In this case, this amount of water is an assumption of how much water would evaporate due to not having a spa cover.

**Table B-18: Total Energy and Power Required to Heat Evaporated Water**

| Evaporation Rate, $w_p$ (gallons) | Energy Required to Heat Water to 104°F (kJ) | Energy Required to Vaporize Water (kJ) | Total Energy[164] (kJ) | Total Power Required (kW) |
|---|---|---|---|---|
| 0.5 | 185 | 4,272 | 4,456 | 1 |
| 1 | 369 | 8,544 | 8,913 | 2 |
| 2 | 738 | 17,088 | 17,826 | 5 |
| 3 | 1,107 | 25,632 | 26,739 | 7 |
| 4 | 1,476 | 34,176 | 35,652 | 10 |
| 5 | 1,845 | 42,719 | 44,565 | 12 |

Source: Staff calculation

The energy required to heat water to 102˚F is calculated by using the specific heat relationship.

$$Q_{HW} = c \cdot m \cdot \Delta T$$

where,

$$Q_{HW} = energy\ required\ to\ raise\ temperature\ of\ water\ (kJ)$$
$$c = specific\ heat,\ 4.186\frac{kJ}{kg - ℃}$$
$$m = evaporation\ loss\ (kg)$$
$$\Delta T = T_2 - T_1\ (℃)$$
$$T_1 = 15.6℃\ (60°F)$$
$$T_2 = 38.89℃\ (102°F)$$

The energy required to vaporize water is based on the latent heat.

$$Q_{VP} = m \cdot L$$

where,
$Q_{VP} = energy\ required\ to\ vaporize\ water\ (kJ)$
$m = evaporation\ loss\ (kg)$
$L = latent\ heat\ of\ vaporization\ of\ water,\ 2257\ \frac{kJ}{kg}$

164 Stein, Benjamin. *Building Technology: Mechanical and Electrical Systems*. New York: John Wiley and Sons, Inc., 1997.

The total energy is calculated by adding the energy to heat water to 102˚F and the energy to vaporize water.

$$Total\ Energy\ (kJ) = Q_{HW} + Q_{VP}$$

The total power required is the total energy over an hour.

$$Total\ Power\ (kW) = \frac{Total\ Energy\ (kJ)}{3600s}$$

**Table B-19** lists the annual energy consumption and annual water consumption based on the total power required to heat the evaporated water listed.

**Table B-19: Annual Energy and Water Consumption**

| Evaporation Rate, w (gallons/hr) | Energy Consumption (kWh/year) | Water Wasted (gallons/year) | Water Costs ($/1000 gallons) | Energy Costs ($) |
|---|---|---|---|---|
| 0.5 | 10,844 | 4,380 | 33 | 1,756 |
| 1 | 21,688 | 8,760 | 66 | 3,511 |
| 2 | 43,376 | 17,520 | 131 | 7,023 |
| 3 | 65,064 | 26,280 | 197 | 10,534 |

Source: *Building Technology: Mechanical and Electrical Systems* by B. Stein.

The energy consumption is calculated by multiplying the total power by the duty cycle.

$$Energy\ Consumption = Total\ Power\ (kW) \times 8{,}760\ standby\ mode\ operating\ hours\ per\ year$$

The water wasted or water loss is calculated by multiplying the evaporation rate by the duty cycle.

$$Water\ Loss = Evaporation\ Loss\ \times 8{,}760\ standby\ mode\ operating\ hours\ per\ year$$

The energy costs are calculated by multiplying the energy consumption by the average retail price of electricity.

$$Energy\ Costs = Energy\ Consumption \left(\frac{kWh}{year}\right) \times \$0.1619\ per\ kWh$$

The water costs are calculated by multiplying the water loss by the delivery charge and treatment charge of water.

$$Water\ Costs = Water\ Loss\ \left(\frac{gallons}{year}\right) \times \left(\frac{\$2.82}{1000\ gallons} + \frac{\$4.66}{1000\ gallons}\right)$$

# APPENDIX C: Acronyms

| Acronym | Description |
|---|---|
| AB | Assembly Bill |
| AC | Alternating Current |
| ANSI | American National Standards Institute |
| APSP | The Association of Pool & Spa Professionals |
| ARB | Air Resources Board |
| ASRAC | Appliance Standards and Rulemaking Federal Advisory Committee |
| CASE Team | Codes and Standards Enhancement Team |
| CDC | Centers for Disease Control and Prevention |
| CO | Carbon Monoxide |
| CPUC | California Public Utilities Commission |
| CSA | CSA |
| DOE | Department of Energy |
| DPPP | Dedicated Purpose Pool Pump |
| ECM | Electrically Commutated Motor |
| EF | Energy Factor |
| EPA | Environmental Protection Agency |
| EPS | Expanded Polystyrene |
| GHG | Greenhouse Gas |
| GWh | Gigawatt-hour |
| HI | Hydraulics Institute |
| HP | Horsepower |
| HVAC | Heating, Ventilation, and Air Conditioning |
| ICC | International Code Council |

| | |
|---|---|
| IEEE | Institute of Electrical and Electronics Engineers |
| IEPR | Integrated Energy Policy Report |
| IOU | Investor Owned Utility |
| MAEDBS | Modernized Appliance Efficiency Database System |
| MW | Megawatt |
| MWh | Megawatt-hour |
| NOx | Oxides of nitrogen |
| PG&E | Pacific Gas and Electric |
| PM | Particulate Matter |
| RASS | Residential Appliance Saturation Study |
| RECS | Residential Energy Consumption Survey |
| RPM | Rotations per Minute |
| SCE | Southern California Edison |
| SDG&E | San Diego Gas and Electric |
| SF | Service Factor |
| SOx | Oxides of sulfur |
| UV | Ultraviolet |
| XPS | Extruded Polystyrene |
| ZNE | Zero Net Energy |