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California Energy Commission

**DRAFT STAFF REPORT**

# Second 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**

**July 2017 | CEC-400-2016-002-SD3**

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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 products, markets, and industry characteristics of the appliances identified. The Commission reviewed the information and data received and hosted workshops May 28 through 31, 2013, to publicly vet this information.

On June 13, 2013, the 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 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 Commission published a 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, a staff workshop was held to review the report with interested parties and to gather public comment.

On June 16, 2016, the Commission revised the report based on comments received at the workshop and in writing in the Commission docket. On July 13, 2016, the Commission held a staff workshop to review the revised report with interested parties and to gather public comment.

The 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, and based on federal standards for dedicated-purpose pool pumps.

# 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 replacement pool pump 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 pool pump motors sold separately from the pumps as replacements. The standards would take effect on January 1, 2019, for all replacement pool pump motors 5 horsepower or less. 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, 2019. 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 103 gigawatt-hours the first year the standard is in effect. By the year that stock turns over in 2029, the proposed standards would have a combined annual savings of about 801 gigawatt-hours. This equates to roughly $148 million in annual savings to California businesses and individuals.

Staff analyzed available market data and concluded that the updates to standards for replacement pool pump 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, replacement pool pump motors, portable electric spas

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# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# EXECUTIVE SUMMARY

The California Energy Commission intends to take advantage of significant energy efficiency opportunities for replacement pool pump motors and portable electric spas through the Title 20 appliance efficiency standards. Energy Commission staff estimates yearly sales of 90,000 replacement pool pump motors in California. The following Appliance Efficiency Program analysis supports the proposed standards. Staff's revised analysis demonstrates that the proposed replacement 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 801 gigawatt-hours (GWh) of statewide energy savings per year.

Staff proposes to expand the existing scope of replacement pool pump motors (stand-alone motors) that are used for filtration and circulation to run water features and waterfalls, and for booster pumping to align with the scope for the federal dedicated-purpose pool pumps. The proposal includes modifications and additions to the replacement 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 replacement pool pump motors using Energy Efficiency Test Methods for Small Motors, CSA 747-2009.

Standards are proposed for pool pump motors sold separately as replacements. The proposed minimum performance standards are aligned to the recently adopted federal Dedicated-Purpose Pool Pump standard. The standard would set an energy factor score, a measure of useful work performed versus, energy consumed, to compare the motor power output versus the motor power input. The proposed standard would take effect January 1, 2019, for all replacement pool pump motors that are 5 horse power or less. The proposed standards would result in an estimated 91 GWh of first-year energy savings and an estimated 657 GWh per year of energy savings after full stock turnover in 2026, resulting in $121.8 million in annual cost savings.

Updated 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 January 1, 2019. The estimated standby power savings after complete stock turnover is 62.8 GWh with $11.6 million in cost savings. The label requirement will yield additional energy savings estimated at 81.9 GWh with $15.2 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, California has regularly increased the energy efficiency requirements for new appliances sold and new buildings constructed in the state. Through the Appliance Efficiency Program, appliance standards have shifted the marketplace toward more efficient products and practices, reaping significant benefits for California's consumers. The state's Title 20 Appliance Efficiency Regulations, along with federal appliance standards encompassing a variety of appliance types, saved an estimated 30,065 GWh[3] of electricity in 2015 alone, resulting in about $4.84 billion in savings[4] to California consumers. 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 8,645 MW and continue to save about 32,594 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] and Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016)[7], as well as the recommendations contained in the California Air Resources Board's *Climate Change Scoping Plan.*[8] Energy efficiency regulations are also identified as key components in reducing electrical energy consumption in the *2015 Integrated Energy Policy Report* (*IEPR*)[9] and the

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/2017publications/CEC-140-2017-001/CEC-140-2017-001.pdf.
3 California Energy Commission, *California Energy Demand 2016-2026 Revised Electricity Forecast*, January 2016, available at http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN207439_20160115T152221_California_Energy_Demand_20162026_Revised_Electricity_Forecast.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. This estimate does not incorporate any costs associated with developing or complying with appliance standards.
5 California Energy Commission, *California Energy Demand 2016-2026 Revised Electricity Forecast,* January 2016, available at http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN207439_20160115T152221_California_Energy_Demand_20162026_Revised_Electricity_Forecast.pdf.
6 AB 32, California Global Warming Solutions Act of 2006, available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.
7 SB 32, California Global Warming Solutions Act of 2006, available at
https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB32.
8 *Climate Change Scoping Plan* available at http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.
9 California Energy Commission, *2015 Integrated Energy Policy Report*, 2015, available at http://energy.ca.gov/2015_energypolicy/.

2011 update to the CPUC's *Energy Efficiency Strategic Plan*.[10] Finally, Governor Edmund G. Brown Jr. and the 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 GHG emissions to 80 percent below 1990 levels by 2050,[11] a commitment made to the Subnational Global Climate Leadership Memorandum of Understanding (Under 2 MOU) agreement along with 167 jurisdictions representing 33 countries.[12]

On October 7, 2015, the Governor signed the Clean Energy and Pollution Reduction Act of 2015 or Senate Bill 350 (De León, Chapter 547, Statutes of 2015), requiring the Energy Commission to establish annual targets for statewide energy efficiency savings and demand reduction that will achieve a doubling of energy savings from buildings and retail end uses by 2030.[13] Appliance efficiency standards will be critical in meeting this goal. In addition, the Energy Commission adopted the *Existing Buildings Energy Efficiency Action Plan* in September 2015 and updated it in December 2016 to transform existing residential, commercial, and public buildings into energy-efficient buildings. [14] Appliance efficiency standards are essential to the plan approach to reducing the energy consumption in existing buildings from plug-in loads.

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

California's loading order places energy efficiency as the top priority for meeting energy needs. The *Energy Action Plan II* strongly supports the loading order, which describes the priority sequence for actions to address increasing energy needs. Energy efficiency and demand response are the preferred means of meeting the state's growing energy needs.[15]

For the past 30 years, while per capita electricity consumption in the United States has increased by nearly 50 percent, California's per capita electricity use 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.[16]

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10 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.

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

12 Subnational Global Climate Leadership Memorandum of Understanding, available at http://under2mou.org/background/.

13 *2016 Integrated Energy Policy Report Update*, available at http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-01/TN216281_20170228T131538_Final_2016_Integrated_Energy_Policy_Report_Update_Complete_Repo.pdf

14 *California's Existing Buildings Energy Efficiency Action Plan – 2016 Update*, available at http://docketpublic.energy.ca.gov/PublicDocuments/16-EBP-01/TN214801_20161214T155117_Existing_Building_Energy_Efficency_Plan_Update_Deceber_2016_Thi.pdf.

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

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

## Zero-Net-Energy Goals

The *California Long-Term Energy Efficiency Strategic Plan*,[17] adopted in 2008 by the CPUC and developed with the Energy Commission, the CARB, the state's utilities, and other key stakeholders, is California's roadmap to achieving maximum energy savings between 2009 and 2020, and beyond. It includes four "big, bold strategies" as cornerstones for significant energy savings with widespread benefit for all Californians:[18]

- 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 matches California's climate.
- All eligible low-income customers will have the opportunity to participate in the low-income energy efficiency program by 2020.

These strategies were selected based on the 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[19] 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.[20] 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*.[21]

17 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.
18 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.
19 Office of Edmund G. Brown Jr., Executive Order B-18-12, April 25, 2012, available at https://www.gov.ca.gov/news.php?id=17508.
20 California Energy Commission and CPUC, *Long-Term Energy Efficiency Strategic Plan*, p. 64.
21 California Energy Commission, *2013 IEPR*, pp. 21-26.

## Governor’s Clean Energy Jobs Plan

On June 15, 2010, as a part of his campaign, Governor Brown proposed the *Clean Energy Jobs Plan*,[22] 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 also 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 less expensive and more versatile than ever due, in part, to California’s leadership in the area.

22 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

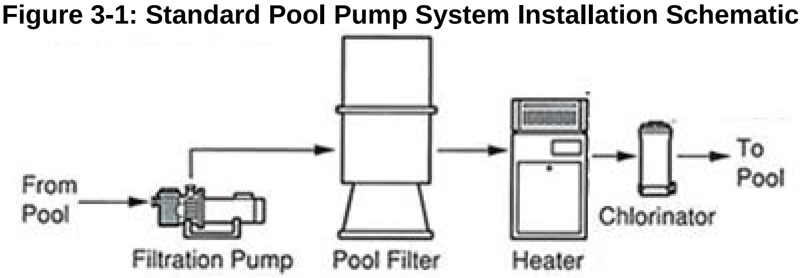
# CHAPTER 3:
# Product Description

## 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,[23] health codes began to require chlorine as a pool disinfectant in response to polio outbreaks in the 1960s. The pool circulation system functions to meet both aesthetic and safety requirements.[24]

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.[25,26,27] Commercial pool systems are designed to complete circulation or turnover in six hours due to higher level of use.[28] 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

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. These maintenance applications, as well as the pool equipment types, pool plumbing design, and pool volume, influence the pool pump and motor sizing.

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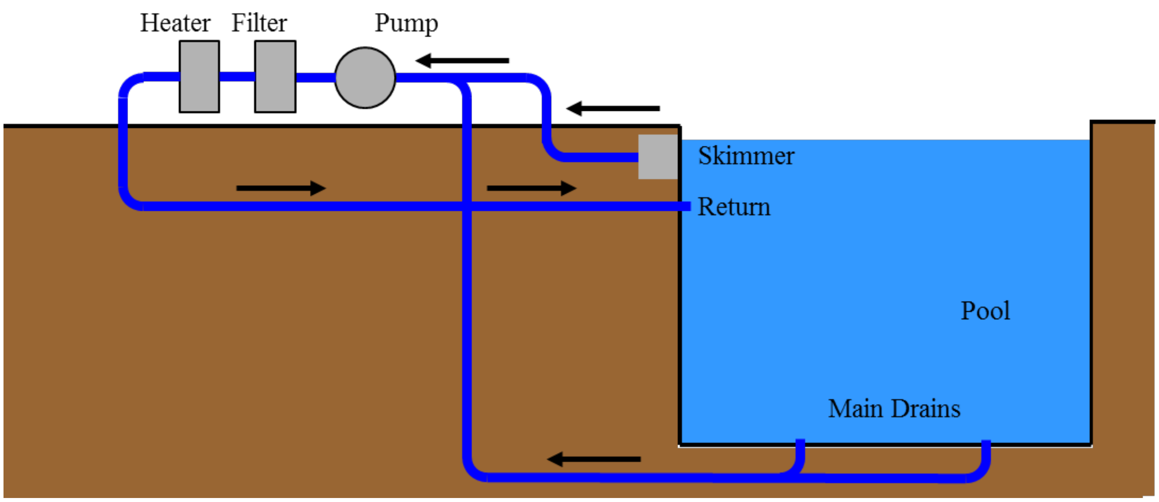
23 Olsen, Kevin, "Clear Waters and a Green Gas: A History of Chlorine as a Swimming Pool Sanitizer in the United States," *Bulletin for the History of Chemistry*, Volume 32, Number 2, pp. 129-140, 2007.
24 *The History of Drinking Water Treatment*, U.S. EPA Feb, 2000, available at http://www.epa.gov/safewater/consumer/pdf/hist.pdf..
25 *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.
26 *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.
27 *Pool Pump Sizing*, poolplaza.com, 2015, available at https://www.poolplaza.com/pool-pump-sizing.
28 California Health and Safety Code Sections 116064.2 (b) (2) (E).

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. At lower speeds, the filtration system will clean the water more completely 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 application 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**




Source: California Energy Commission

The pool pump-motor combination may also provide water flow to the pool sweeper and vacuum and 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.[29] 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 waterfall.

29 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.

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.[30] 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 the greatest savings. Dual-speed motors provide a low-speed choice to enable some savings compared with running the pool filtering task at full speed. 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 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.[31]

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 to replacing the full pump and motor combination, electric motor manufacturers sell replacement pool pump motors since the motor typically fails before the pump. However, for this report, electric motors used in pool pump applications are assumed to have a lifetime expectancy equivalent to that of the pool pump and motor combination. A recent survey of pool pump and motor combination manufacturers by the U.S. Department of Energy (U.S. DOE) found life expectancies vary among pump types, as shown in **Table 3-1**.[32] **Figure 3-3** shows a typical pool pump and motor combination. **Figure 3-4** shows a typical replacement pool pump motor.

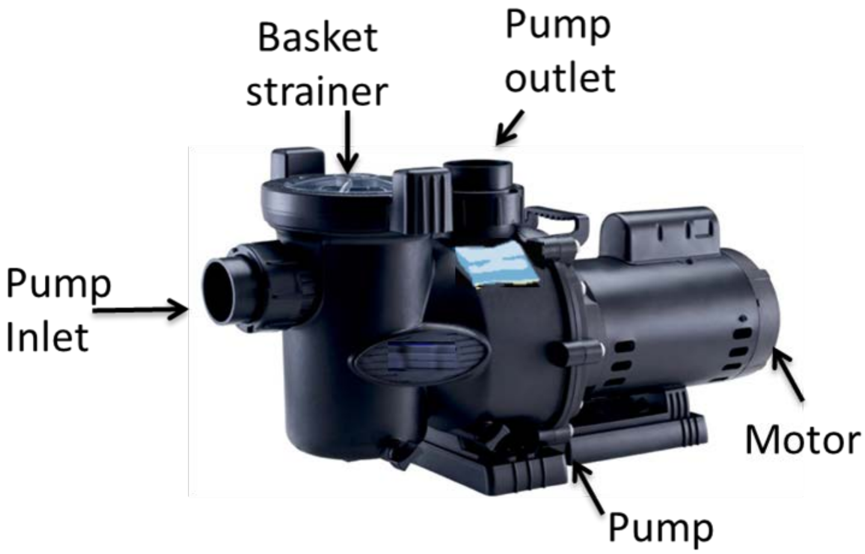
30 *Variable Speed Pumping, A Guide to Successful Applications*, Executive Summary, pp. 4-5 available at http://www.energy.gov/sites/prod/files/2014/05/f16/variable_speed_pumping.pdf.
31 *Improving Pumping System Performance, A Sourcebook for Industry*, U.S. DOE Second Edition, pp. 13-14, available at http://energy.gov/sites/prod/files/2014/05/f16/pump.pdf.
32 Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps, December 2016, Table 8.2.46, page 8-31, EERE-2015-BT-STD-0008-0105.

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

| | Average Lifetime (years) | | |
|---|---|---|---|
| **Pump Type** | **Single-Speed** | **Dual-Speed** | **Variable-Speed** |
| Self-priming filter pumps | 7.3 | 7.3 | 7.3 |
| Non-self-priming filter pumps | 5.3 | 5.3 | 5.3 |
| Waterfall pumps | 7.3 | Not Available | Not Available |
| Pressure cleaner booster pumps | 5.3 | Not Available | 5.3 |
| Integral cartridge/sand filter pumps | 4.2 | Not Available | Not Available |

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

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




Source: Hayward Pools

**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.[33] 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 apply 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 (pounds per square inch [psi])**

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

where h = head or pressure (psi)

**Pump Affinity Law 3 Power (kilowatt [kW] or hp)**

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

where P = power (kW, hp)

**Energy Consumption (kilowatt-hour [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 the 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.[34] 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.

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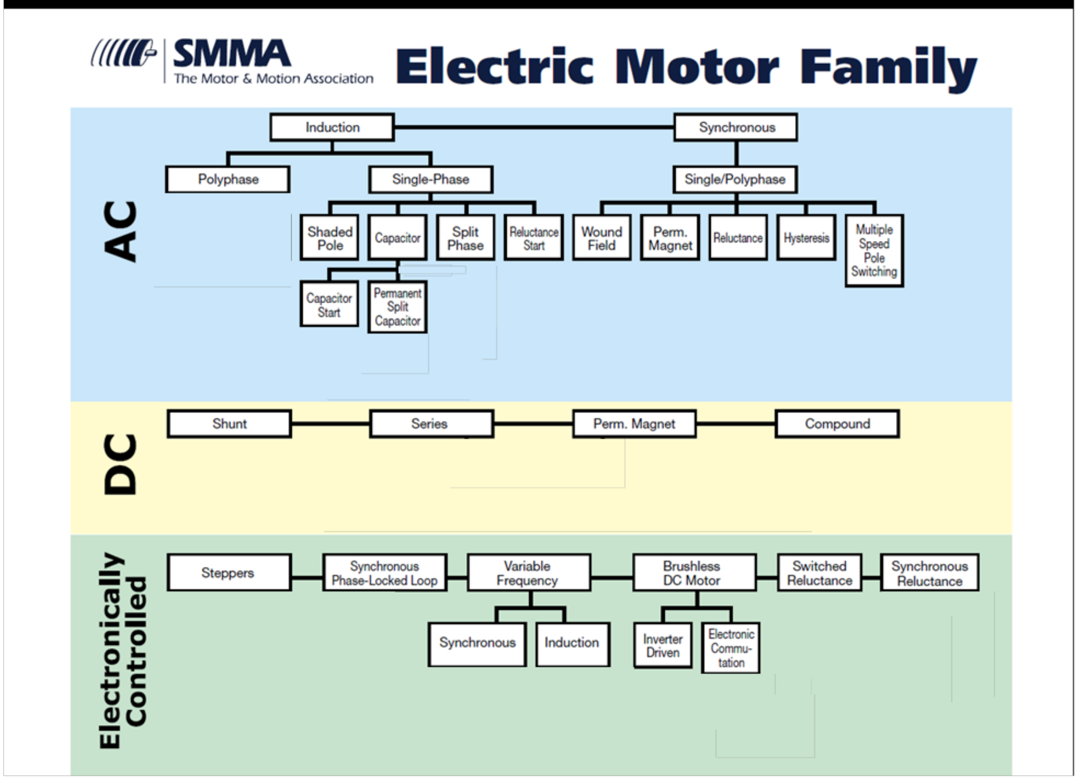
33 U.S. DOE, *Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings*, pp. 3-4, available at http://www.nrel.gov/docs/fy12osti/54242.pdf.
34 *Pump Affinity Laws*, The Engineering Toolbox, available at http://www.engineeringtoolbox.com/affinity-laws-d_408.html.

## 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.[35] 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, (**Figure 3-5)**. The ranges of efficiency and differences between motor types are discussed in Chapter 8.

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




Source: Small Motors and Motion Association

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

## 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 were certified in the appliance database as of April 2017. 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. Therefore, most pool pump motors in California are single-speed motors.[36]

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 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. Another 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.[37]

### 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. Cleaning and vacuuming require full-speed pump and motor operation to agitate and remove debris effectively. Circulation for filtration tasks of the pool requires less flow and pressure, making the half-speed operation suitable for these tasks.[38] 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 the user to select a lower power pump speed for tasks, thereby, increasing savings.

### Variable-Speed Pumps

Variable-speed pump motors are powered by ECM motors that allow the user to select a speed most appropriate for the pool maintenance task. Electronics onboard the motor modify the incoming AC current and commutate the current to a three-phase wave form to set the motor speed and minimize

36 Eaton, Eileen, *CEE High Efficiency Residential Swimming Pool Initiative*, December 2012, pp. 18-19.
37 Eaton, Eileen, *CEE High Efficiency Residential Swimming Pool Initiative,* Consortium for Energy Efficiency, Inc., Dec. 2012, pp. 18-20.
38 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.

electrical losses within the motor. A variable-speed motor may provide speeds between a minimum of 1/8 of full speed to full speed.[39]

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 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.[40]

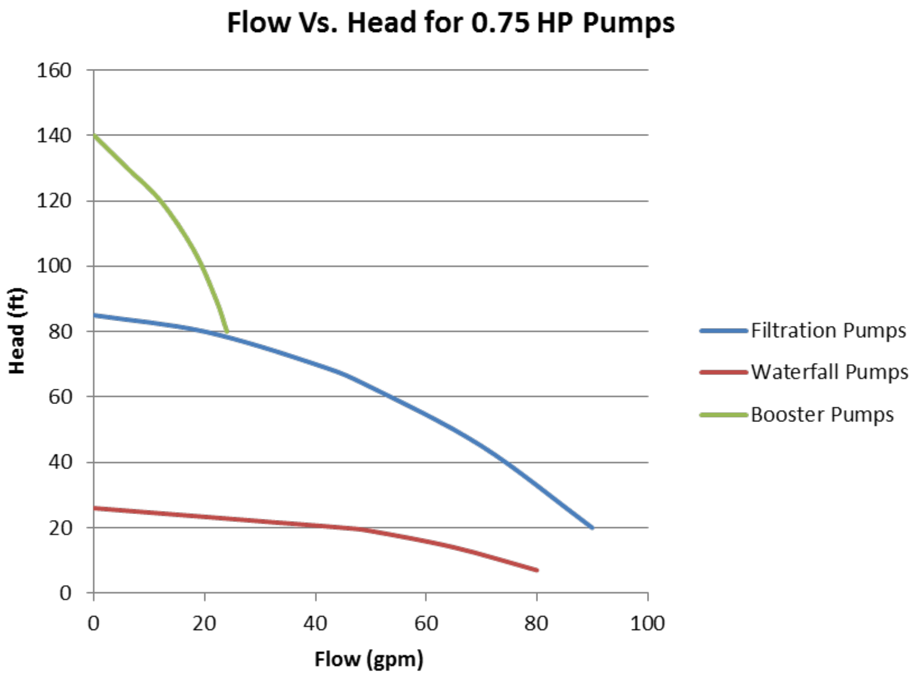
### Pump and Motor Combinations for Various Intended Uses

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. Replacement pool pump motors intended for all pool types are within the scope of the proposed rulemaking.

39 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.

40 *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: California Energy Commission

**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 except 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 to serve the swimming season, estimated between 100 to 150 days.[41] 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 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

### 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. Recently, variable-speed pressure cleaner booster pump and motor combinations have entered the market.[42] Multistage pumps have also been introduced to improve the hydraulic efficiency of the pressure cleaner booster pumps.[43]

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41 Matthew Vartola, comment to 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.
42 Power Defender Booster Pump, Waterway Plastics, Available at: http://waterwayplastics.com/products/pool-products/pumps/booster-pumps-2/power-defender-booster-pump/.
43 Polaris PB4SQ, Zodiac Pool Systems, Available at: http://www.polarispool.com/en/products/booster-pumps/polaris-pb4sq.

**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 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 marketing materials shows manufacturers designate the same in-ground filtering pool pumps for both residential and commercial applications for pumps 5 hp total capacity or less.[44]

### Three-Phase Replacement Pool Pump Motor

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. Replacement three-phase pool pump motors that are 5 hp total capacity and less are considered in the scope of the rulemaking. Staff requests comments from stakeholders to identify and remove products preempted by federal appliance standards for electric motors and small electric motor rules.

### Freeze Protection Functionality

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

The freeze protection function provides automatic water flow through the pool plumbing system to prevent damage when 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 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.[45]

45 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.[46]

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 for pool pump and motor combinations 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. Replacement pool pump motors are tested only for motor efficiency.

## Federal Regulations

There are no federal standards or test procedures for replacement pool pump motors at the writing of this report.

The U.S. Department of Energy (U.S. DOE) has issued a direct final rule establishing new energy conservation standards for dedicated-purpose pool pumps (DPPP).[47] In addition, the U.S. DOE has issued a prepublication final rule establishing test procedures for these products. The standards and test procedures were negotiated through a working group formed by the Appliance Standards and Rulemaking federal Advisory Committee. The Energy Commission was a member of this working group. The group included representatives from California investor-owned utilities, pool pump manufacturers, replacement

46 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.

47 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.

pool pump motor manufacturers, and environmental advocates. The group reached unanimous consensus on all terms for the DPPP test procedure and standards.

The prepublished test procedure direct final rule (DFR) establishes definitions, test procedures, certification requirements, enforcement testing procedures, and labeling provisions for DPPPs. The test procedure DFR identifies equipment classes for self-priming and non-self-priming pool filter pumps, waterfall pumps, pressure cleaner booster pumps, integral cartridge-filter pool pumps, integral sand-filter pool pumps, storable electric spa pumps, or rigid electric spa pumps and whether a test procedure applies to measure pump performance.[48]

The U.S. DOE established a new metric to define the efficiency of the pump and motor by measuring the quantity of water pumped and the quantity of electrical energy used. Depending upon equipment class, the pump will be tested at different load points, and the performance will be weighted according to the rules of the test procedure. The metric is the weighted energy factor (WEF).[49]

The U.S. DOE established both minimum performance standards and prescriptive requirements depending upon equipment class. Self-priming and non-self-priming pool filter pumps and pressure cleaner booster pumps must meet minimum WEF performance scores that scale as a function of the output hydraulic horsepower of the pump. Waterfall pumps must measure WEF but do not need to meet a minimum WEF score. Integral cartridge-filter pool pumps and integral sand-filter pool pumps must meet a prescriptive timer requirement. Any DPPP provided with freeze protection controls must meet a set of criteria as to when and for how long the freeze protection controls will run the DPPP.[50]

The U.S. DOE offered an optional test method for replacement pool pump motors in the prepublished final rule for the DPPP test procedure. The U.S. DOE proposes that a replacement motor would be paired with an appropriate DPPP bare pump and subject to the DPPP test procedure. The test method could provide consumers with standardized performance information on replacement motors.[51]

The federal standards take effect for products manufactured on or after July 19, 2021.

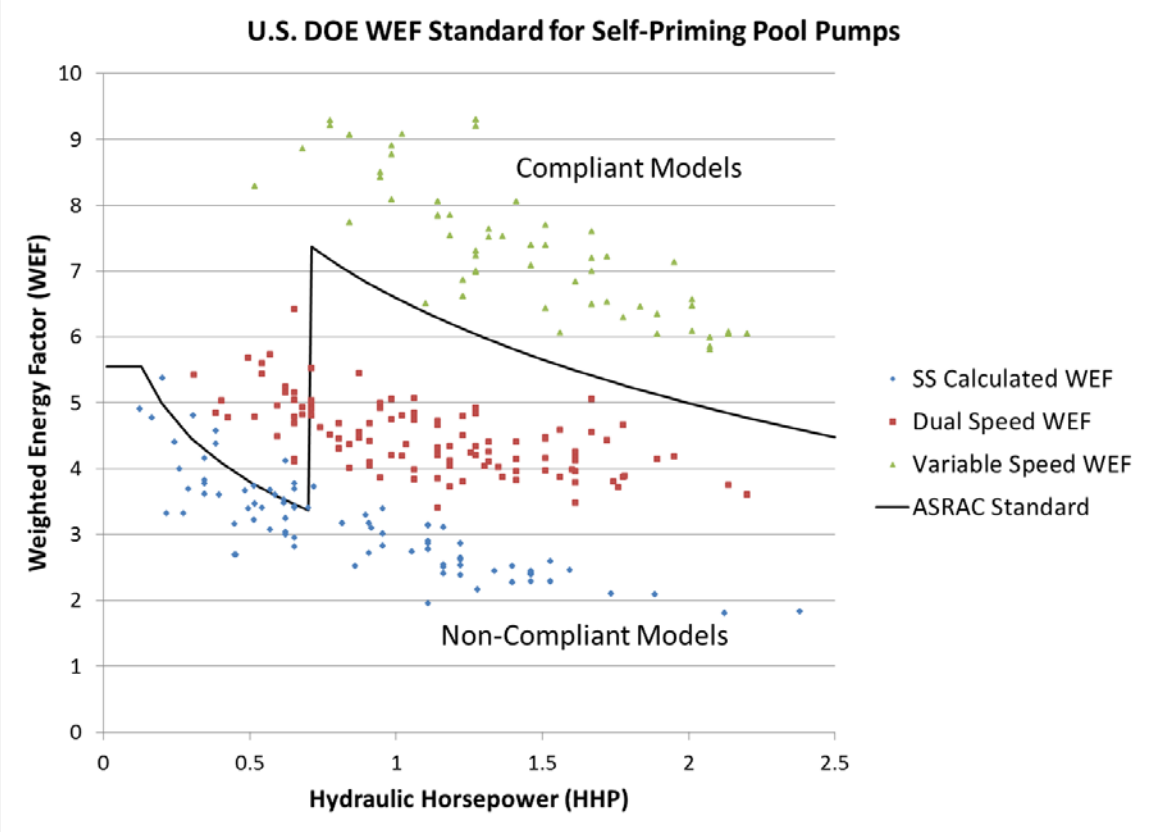
48 U.S. Department of Energy, Energy Conservation Program: Test Procedure for Dedicated-Purpose Pool Pump, Direct Final Rule, Docket No. EERE-2016-BT-TP-0002, RIN 1904-AD66, pg. 14. https://energy.gov/sites/prod/files/2016/12/f34/DPPP_TP_Final_Rule.pdf

49 U.S. Department of Energy, Energy Conservation Program: Test Procedure for Dedicated-Purpose Pool Pump, Direct Final Rule, Docket No. EERE-2016-BT-TP-0002, RIN 1904-AD66, pg. 14. https://energy.gov/sites/prod/files/2016/12/f34/DPPP_TP_Final_Rule.pdf

50 U.S. Department of Energy, Energy Conservation Program: Energy Conservation Standards for Dedicated Purpose Pool Pumps, Direct Final Rule, pg. 10-11, https://energy.gov/sites/prod/files/2016/12/f34/DPPP_ECS_Direct_Final_Rule.pdf.

51 U.S. Department of Energy, Energy Conservation Program: Test Procedure for Dedicated-Purpose Pool Pump, Direct Final Rule, Docket No. EERE-2016-BT-TP-0002, RIN 1904-AD66, pg. 179-184. https://energy.gov/sites/prod/files/2016/12/f34/DPPP_TP_Final_Rule.pdf.

**Figure 4-1: Proposed U.S. DOE DPPP Standard for Self Priming Pool Pumps**




Source: Energy Commission staff plot of U.S. DOE provided data

# 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.[52]

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.[53]

52 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.

53 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.

## 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 contains an exception that the rule applies only if the cost of replacing a pool pump for an existing pool exceeds 30 percent of the assessed value of the home. The exception effectively eliminates the requirement to use two or more speed pool pumps when replacing a pump for an existing pool.[54] The law became effective March 15, 2012.

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.[55]

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.[56]

## 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 performance of the pump and motor combination 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.[57]

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54 Crayton III, Gary, Understanding the Loophole in the New Florida Energy Law, July 3, 2012, available at http://www.bayareapoolservice.com/blog/understanding-the-loophole-in-the-florida-energy-law.aspx.
55 http://library.cee1.org/sites/default/files/library/9986/cee_res_swimmingpoolinitiative_07dec2012_pdf_10557.pdf.
56 http://www.poolspanews.com/legislation/states-introduce-out-of-date-energy-laws.aspx.

57 https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Pool%20Pumps%20-%20Program%20Requirements%20Version%201.1.pdf.

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.[58]

## 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.[59] In September 2014, the IOUs submitted a revised proposal for pool pump standards.[60] 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.

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58 ENERGY STAR-Certified Pool Pumps, available at https://www.energystar.gov/products/certified-products/detail/pool-pumps.
59 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.
60 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.

# CHAPTER 5:
# Alternatives Consideration

Staff reviewed and analyzed state standards for (1) maintaining current Title 20 standards, (2) incorporating the CASE report suggestions, (3) incorporating the CASE team proposal with uniform full-speed efficiency for all motor types, and (4) aligning the replacement pool pump motor standards with the U.S. DOE DPPP test procedure, metric, and standards. Staff also considered comments from interested parties made during the February 18, 2016, staff workshop; the July 13, 2016, staff workshop; and in written comments to Commission Docket 15-AAER-02. Because the U.S. DOE has covered dedicated-purpose pool pumps, staff considered only proposals or portions of proposals that affected replacement pool pump motors.

## 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 replacement 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.

Commission staff reviewed comments from manufacturers during the U.S. DOE DPPP rulemaking. Manufacturers expressed concerns that the lack of a replacement pool pump motor standard at the federal level may cause consumers to prefer replacing their motors when they fail rather than replacing the entire pool pump and motor combination. Another concern was that the lack of a standard would drive consumers to low-cost, less efficient motors[61] [62] [63] [64] [65]. Since the U.S. DOE adopted performance-based regulations for the pump and motor combinations, staff believes amending the replacement pool pump motor regulations to align with the U.S. DOE standard will address this concern while leading to greater cost-effective energy savings.

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61 Association of Pool & Spa Professionals, Final APSP 5.8.17 submission to EERE-2015-BT-STD-000, May 9, 2017, available at https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0127.

62 Hayward Pool Products, Comment on Final Rule for Dedicated Purpose Pool Products, May 9, 2017, available at https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0125.

63 Regal Beloit America, Inc., 20170508_DPPP Regal Comment, May 8, 2017, available at https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0122.

64 Zodiac Pool Systems, Inc., Zodiac DPPP 5.8.17 comments on EERE-2015-BT-STD-000, May 9, 2017, available at https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0134.

65 Pentair Aquatic Systems, Pentair DPPP Final rule comments, May 9, 2017, available at https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0132.

## Alternative 2: Incorporate CASE Team Proposal

The CASE team proposal would establish minimum motor efficiency requirements (full- and half-speed) 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 replacement pool pump motors are shown in **Table 5-1** and would take 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.

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.[66]

While the CASE team proposal offers significant energy savings, the standard would not align with the U.S. DOE rule for dedicated purpose pool pumps, making it difficult to select a replacement motor that would match the performance expected from the pump and motor combination.

**Table 5-1: IOU 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 (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

66 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.

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

Under this alternative, staff would set minimum uniform full-speed motor efficiency level for single-speed and two-or-more-speed replacement pool pump motors.

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. Staff learned through the U.S. DOE rulemaking effort that the market segment below 1-hp has considerably less market share than assumed.[67] Lowering the two-or-more-speed threshold would not provide significant additional savings, and staff has chosen to keep the 1-hp threshold to maintain consistency with the approach proposed by the US DOE DPPP standard.

Staff had proposed no minimum motor efficiency requirement for waterfall pool pumps. Waterfall pool pumps must be tested and certified by the Energy Commission.

Staff previously proposed prescriptive requirements for 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.

While Alternative 3 is cost-effective and technically feasible and provides significant electrical energy savings, staff now proposes Alternative 4 to harmonize the replacement pool pump motor standard with the proposed U.S. DOE DPPP test procedure and standard.

**Table 5-2: Staff Proposed Alternative 3 – Effective January 1, 2019**

| 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 staff

67 Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps, December 2016, Table 3.5.4, pp. 3-24, EERE-2015-BT-STD-0008-0105.

## Alternative 4: Harmonize Replacement Pool Pump Motor Testing and Standard With U.S. DOE DPPP Test Procedure and Standard

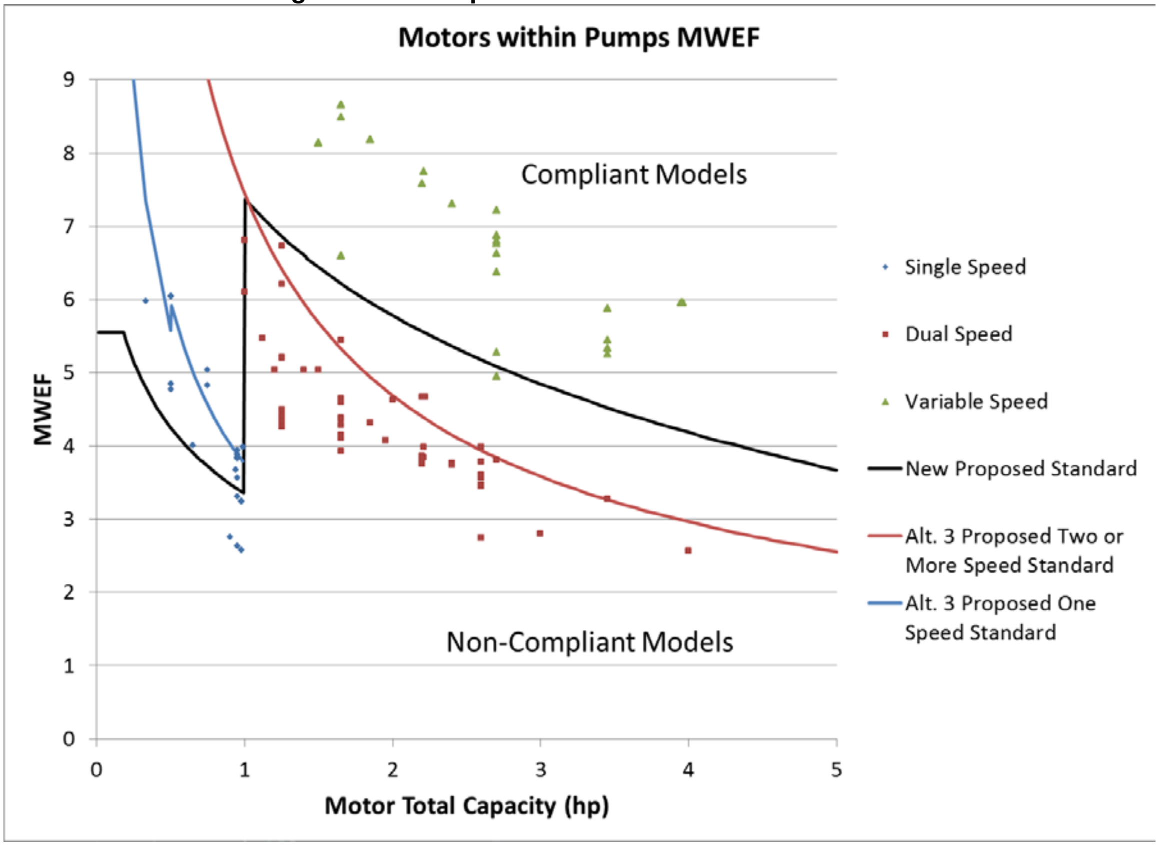
Under Alternative 4, staff would harmonize test procedures and standards for replacement pool pump motors with the proposed U.S. DOE test procedure and standard for DPPP. This would ensure that a replacement motor performs as efficiently as the original motor it would replace under the U.S. DOE DPPP standard. The test procedure would be an alternative to the optional U.S. DOE replacement DPPP motor method. The method differs from the U.S. DOE method by measuring the motor output power on a dynamometer rather than pairing the replacement motor with a bare pump and measuring the output water flow. Staff believes the proposed test method will generate more reproducible results since the CSA motor test conditions will be more tightly controlled.

Alternative 4 would apply a weighted energy factor standard similar to the U.S. DOE DPPP standard. The U.S. DOE standard measures DPPP performance through an energy factor of pool water flow rate (kilogallons per hour) per pump input power (kilowatt). Through the pump affinity laws, the pump power is equivalent to the cube of the pump flow. Alternative 4 would measure the mechanical output power of the motor and compare the output to the motor input power. The motor standard will be weighted similar to the pump weighted energy factor to combine motor performance between the high- and low-speed operation. A minimum motor WEF score would apply to the replacement motors using logarithmic functions similar to the U.S. DOE WEF score logarithmic functions.

Staff compared Alternative 4 to Alternative 3 and found that Alternative 4 is more stringent for motors 1 hp or larger and less stringent for motors less than 1 hp. However, Alternative 4 will lead to larger statewide savings since the larger motors use more energy. Less than 1 hp motors are less than 10 percent of the market.[68] Staff provides a plot of pool motors certified to the Energy Commission, used to plot a motor WEF score. Staff compared the proposed standard (black line) against motors that would have minimally met the previously proposed two-or-more-speed standard (red line) and the previously proposed single-speed standard (blue line).

68 ASRAC 2016-06-23 Working Group Meeting Transcript: Dedicated Purpose Pool Pumps Meeting, page 233, available at https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0092.

**Figure 5-3: Comparison of Alternative 3 and Alternative 4**




Source: Staff illustration created with Appliance Efficiency Database data, April 4, 2017

# CHAPTER 6: Staff-Proposed Standards for Replacement Pool Pump Motors

Given the savings from Alternative 4 and the benefit of having aligned standards for U.S. DOE DPPP and California replacement pool pump motors, Alternative 4 is proposed for potential regulations. As the next chapters will show, these standards are cost-effective to consumers, are technically feasible to achieve, and will result in significant energy savings.

## Scope and Definitions

Staff proposes to align the scope and definitions for replacement motors with the scope and definitions for federally regulated dedicated purpose pool pumps. The definitions state that a replacement motor, designed and marketed for a variety of DPPP, is a replacement DPPP motor of that variety. The proposal incorporates many of the DPPP pump definitions and supporting definitions found within the U.S. DOE TP NOPR to reinforce the consistency between the Commission and U.S. DOE proposals.

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

Staff could not find physical features on the replacement pool pump motors that would distinguish the motors from motors intended for other water pumps such as irrigation or well pumping. The replacement motor definitions will rely upon the “designed and marketed” definition that will identify replacement pool pump motors that can be shown to be intended for use with a pool pump by the markings on the motor packaging, or through descriptions in catalogs or other publicly available documents. A vendor replacement motor matching guide that lists the replacement motor model number as a suitable replacement to the motor in a DPPP would be an example of a publicly available document showing the motor to be designed and marketed for use in a DPPP. A replacement motor designed and marketed for multiple pump types would need to be certified for each motor type and meet the standard for each motor type.

The replacement residential pool pump motor standard will be retained for replacement residential pool pump motors manufactured before the effective date of the proposed standard.

No changes are proposed to the existing pool pump and motor combination definitions, as these standards and definitions will remain in effect until the federal dedicated-purpose pool pump standards take effect in 2021.

## Motor-Weighted Energy Factor

Staff proposes a motor-weighted energy factor (MWEF) to harmonize the replacement pool pump motor standards with the proposed U.S. DOE DPPP-weighted energy factor (WEF). The California replacement pool pump motor standard can be harmonized with the U.S. DOE DPPP standard since the U.S. DOE standard efficiency levels (EL) relied upon incremental improvements to the motors found within the DPPP. **Table 6-1** is adapted from the U.S. DOE DPPP Technical Support Document and shows the ELs and the associated expected improvement to the motor technology found within the pump to meet the EL. Staff intends to require the same efficiency level of motor performance for the replacement motors. If a variable-speed motor is required for the Standard-Size Self-Priming Pool Filter Pump DPPP, then the replacement motor should also be required to be variable-speed to provide an equal level of performance to the consumer. Therefore, the proposed motor standards shown in **Table 6-2** correspond to the Trial Standard Level 3 (TSL3) that the U.S. DOE selected for the DPPP.

**Table 6-1: U.S DOE Trial Standard Level 3 Efficiency Levels**

| Equipment Class | Definition | EL |
|---|---|---|
| Standard-Size Self-Priming Pool Filter Pump | Variable-speed motor, Low hydraulic efficiency | 6 |
| Small-Size Self-Priming Pool Filter Pump | 1-speed motor, High-efficiency motor, Low hydraulic efficiency | 2 |
| Standard-Size Non-Self-Priming Pool Filter Pump | 1-speed motor, Medium-efficiency motor, Low hydraulic efficiency | 1 |
| Waterfall Pump | 1-speed motor, Low-efficiency motor, Low hydraulic efficiency | 0 |
| Pressure Cleaner Booster Pump | 1-speed motor, Medium-efficiency motor, Low hydraulic efficiency | 1 |

Source: Adapted from Tables 5.6.1 and 10.2.1 of U.S. DOE DPPP Direct Final Rule Technical Support Document

The U.S. DOE set a minimum allowable WEF score as a function of the hydraulic output power of the DPPP. The WEF is a measure of the pump output measured in thousands of gallons per hour, versus power input measured in kilowatts. The WEF measures performance at either high-speed, or high-and-low-speed, depending upon the equipment class and size of the DPPP. The high speed represents when the pump is run to operate the pool cleaner, while the low speed represents when the pump filters the pool water.

The WEF calculation has been adapted to provide an analogous measure of power out and power in by comparing the motor output power to the motor input power. **Figure 6-1** diagrams the torques found within a pool pump and motor. The motor converts electrical power into shaft torque and rotation that are used to spin an impeller that moves the water through the pool pump. The torque on the impellor will equal the torque on the motor shaft. Therefore, a replacement motor can be tested without a pump present by measuring the motor torque and making an assumption for the hydraulic efficiency of the pump. **Figure 6-2** diagrams the torques found when the pump motor is measured by a dynamometer. Staff follows the assumption by the U.S. DOE and assumes a low efficiency for the pump. By following the guidelines in the U.S. DOE DPPP test procedure, MWEF scores can be calculated for replacement motors and compared to the WEF score for similar-sized DPPP equipment.

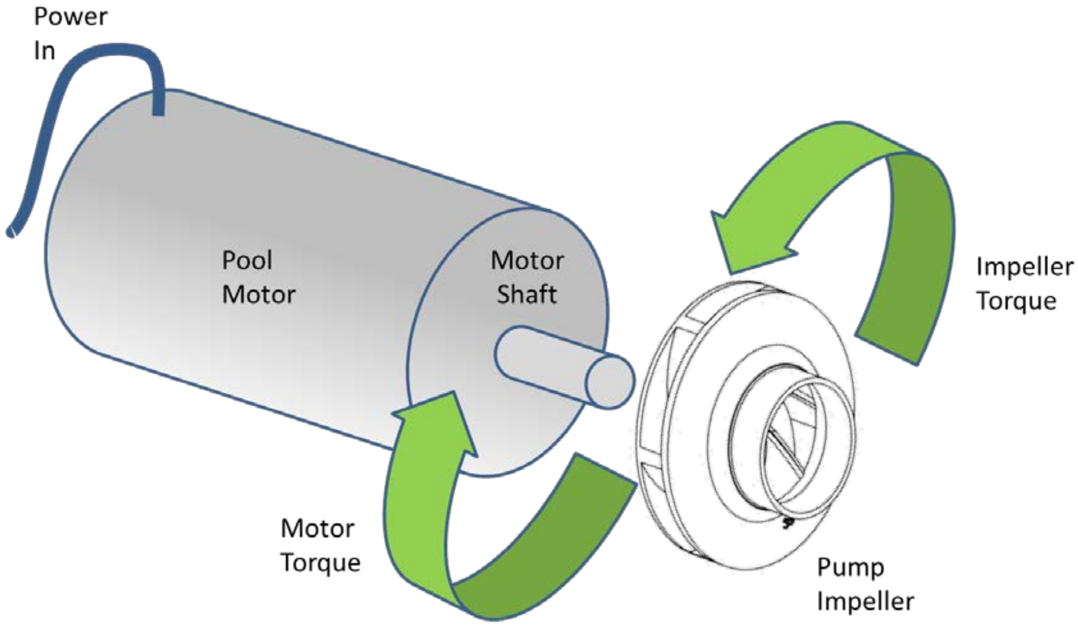
**Table 6-2: Comparison of Proposed U.S. DOE DPPP WEF vs. Proposed MWEF**

| Energy Factor | Measured Output | Measured Input | Equation |
|---|---|---|---|
| US DOE DPPP WEF | Flow (Q) | Electrical Power | $WEF = \dfrac{\sum_i W_i * \dfrac{Q_i}{1,000} * 60}{\sum_i W_i * \dfrac{P_i}{1,000}}$ |
| RDPPPM MWEF | Motor Hp (T*N) | Electrical Power | $MotorWEF = \dfrac{\sum_i W_i * \sqrt[3]{T_i * N_i * n_{pump} * 91.8} * \dfrac{60}{1,000}}{\sum_i W_i * \dfrac{P_i}{1,000}}$ |

Source: California Energy Commission

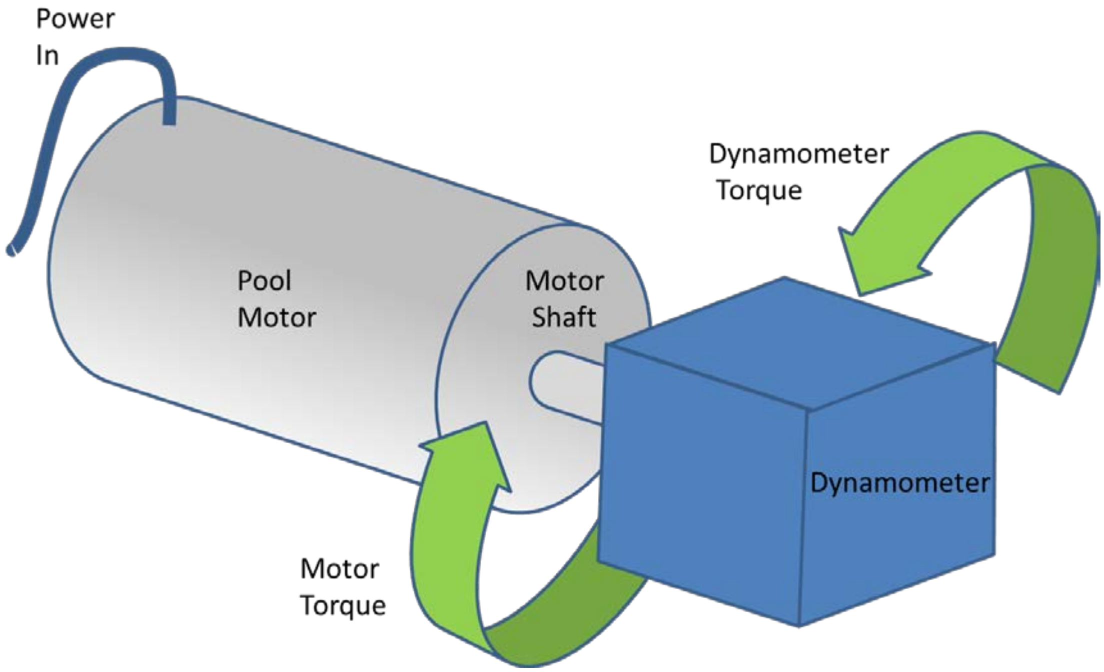
The derivation and details of the conversion from DPPP WEF to the MWEF for replacement pool pump motors are presented in Appendix A.

**Figure 6-1: Impeller and Motor Shaft Torque**




Source: California Energy Commission staff

**Figure 6-2: Dynamometer and Motor Shaft Torque**




Source: California Energy Commission staff

All replacement pool pump motors that are a total horsepower of 5 hp or less, manufactured on or after January 1, 2019, shall meet the efficiency standards outlined in **Table 6-3**.

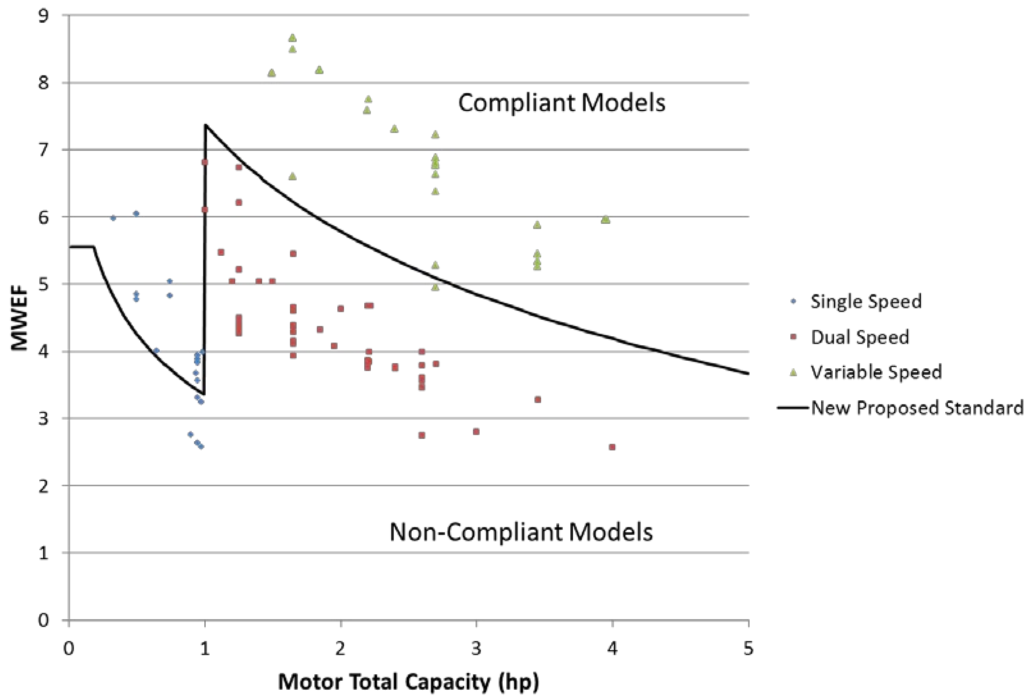
**Table 6-3: Proposed Standards for Replacement DPPP Motors**

| | Proposed Minimum Motor Weighted Energy Factor According to Modified CSA C747-09 Test Procedure | | |
|---|---|---|---|
| **Replacement Pool Pump Motor Unit Type** | **Total Motor Capacity (Horsepower)** | **Motor Phase** | **Minimum Allowable MWEF Score** |
| Replacement Standard-Size Self-Priming Pool Filter Pump Motors | =>1.0 hp and <5.0 hp | Single | MWEF = -2.30*ln (hp/1.4)+6.59 |
| Replacement Small-Size Self-Priming Pool Filter Pump Motors | < 1 hp | Single | MWEF = 5.55 for hp <=0.26 hp, -1.30*ln (hp/1.4) +2.90 for hp >.26 hp |
| Replacement Non-Self-Priming Pool Filter Pump Motors | < 5.0 hp | Any | MWEF = 4.6 for hp <=0.26 hp, -0.85*ln (hp/1.4) +2.87 for hp >.26 hp |
| Replacement Waterfall Pump Motors | Any | Any | None |
| Replacement Pressure Cleaner Booster Pump Motors | Any | Any | MWEF = .42 |

Source: California Energy Commission

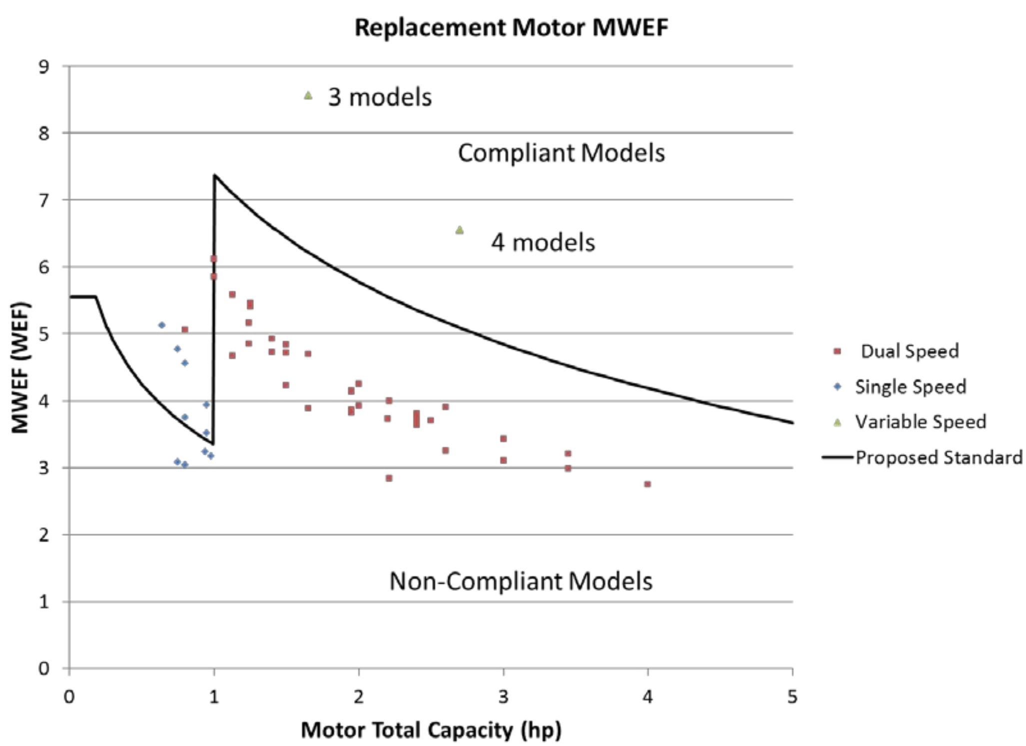
The minimum efficiencies are proposed to achieve significant energy savings without imposing a significant burden on the replacement pool pump motor industry, as many products are available in the market that meet the standards. **Figure 6-2** and **Figure 6-3** show the MWEF scores for models certified to the Commission's Appliance Database.

**Figure 6-3: MWEF Scores for Motors Within Pool Pump and Motor Combinations**




Source: California Energy Commission

**Figure 6-4: MWEF Scores for Replacement Residential Pool Pump Motors**




Source: California Energy Commission

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

Staff proposes to remove the prescriptive prohibition for split-phase and capacitor-start induction run motor types as the performance standard proposed in this 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 required by the MWEF standard.[69] The previously banned motor types could be sold in California under the proposed standard as long as they meet the minimum motor MWEF standard.

### New Proposed Freeze Protection Requirements

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 replacement DPPP motors to test to the CSA 747-2009 (RA2014) Energy Efficiency Test Method for Small Motors.

The CSA 747-2009 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 747-2009 allows multiple motor speeds, while the IEEE allows for only full-speed motor testing. The CSA 747-2009 is superior due to more expansive test conditions and motor types.

The proposed standard will require manufacturers to report performance data at up to two 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 high- and low-speed. Variable-speed and multispeed motors will report performance at high- and low-speed with an option to turn down motor speeds if chosen by the manufacturer. 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.

The CSA 747-2009 allows for motor testing at various loads. Staff has reviewed literature to determine the speed-torque curve behavior of centrifugal pumps under restricted and unrestricted flow conditions. At restricted flow, the torque on the shaft is at a minimum, while at unrestricted flow, the torque rises to a maximum.[70] To be consistent with the U.S. DOE's selection of the pool system Curve C where flow is less

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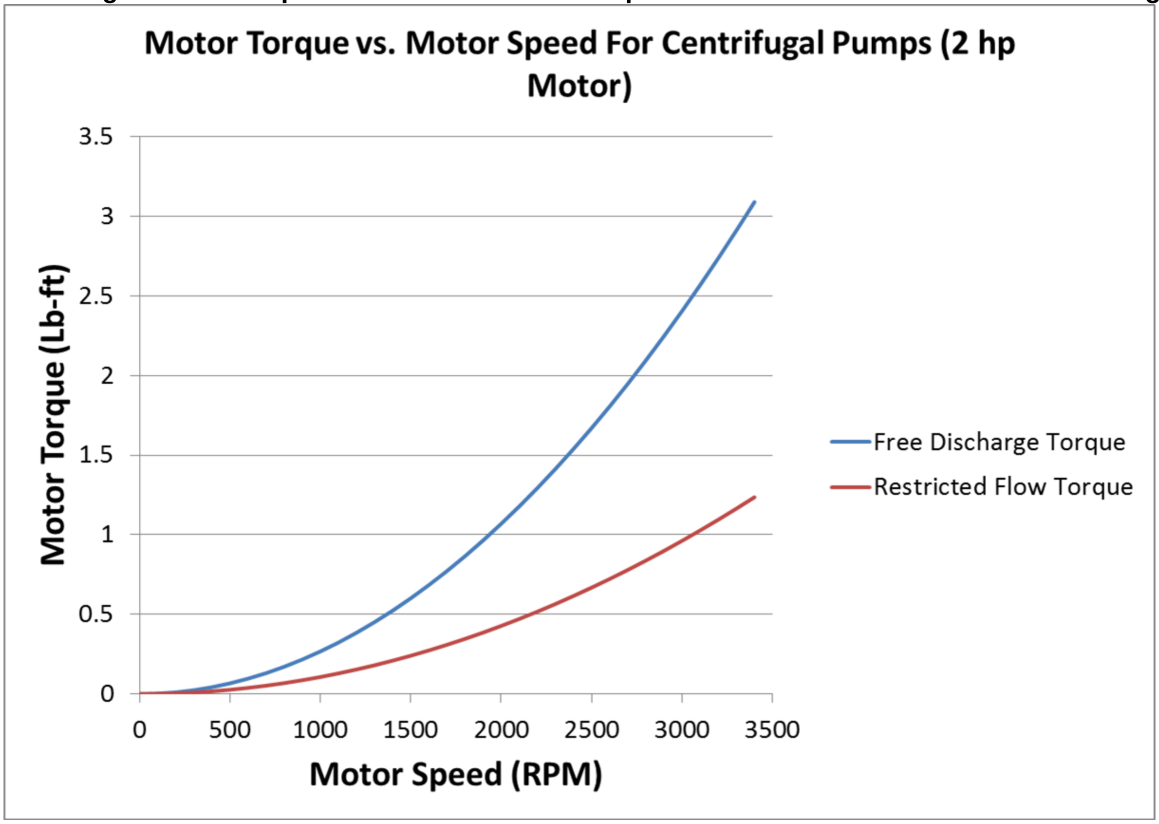
69 Davis Energy Group, Gary B. Fernstrom, *Analysis of Standards Options for Residential Pool Pumps, Motors and Controls*, 2004, p. 6.
70 Girdhar, Paresh and Octo Moniz, *Practical Centrifugal Pumps*, 2011, pg 108-110.

restricted, staff tested the pump motors at full load per CSA 747-2009. Therefore, all test points will require the motor to perform at full load as calculated by the CSA 747-2009 test procedure.

**Figure 6-5: Comparison of Motor Shaft Torque Under Closed Valve and Free Discharge**




Source: California Energy Commission

## MWEF Test Points for Replacement Pool Pump Filter Motors

Test points for replacement pool pump motors were chosen to maintain consistency with the U.S. DOE DPPP test procedure. Speed capability and motor size determine whether to test at one or two points and to determine the minimum speed and load. For the low-speed test point, the U.S. DOE allows selection of the lowest speed capable of delivering a minimum flow on Curve C. The minimum flow represents the minimum hydraulic output a pump must perform to filter. The minimum mechanical power output of the motor to perform the filtering task was calculated by assuming the pump hydraulic efficiency to be 55 percent.[71] Staff then calculated the minimum motor mechanical power output. Using the minimum mechanical output, the minimum speed and torque at full load may be calculated using the requirements of CSA 747-2009.

Single-speed replacement self-priming and non-self-priming pool filter pump motors will be tested at the maximum speed and full load of the motors as determined by CSA 747-2009.

71 *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps*, December 2016, Table 5.6.4, pp. 5-28, EERE-2015-BT-STD-0008-0105.

Two-speed replacement self-priming and non-self-priming pool filter pump motors will be tested at the maximum speed and at the lowest speed capable of delivering the mechanical power output as shown in Table 6-4.

Variable-speed replacement self-priming and non-self-priming pool filter pump motors will be tested similar to two-speed motors, except that the high speed may be reduced to 80 percent of the maximum speed to account for the ability of the variable-speed pump motor to be "right-sized" to meet the need of the filtering task.

In each test case, the torque and motor rotation speed, input power, and power factor will be measured and reported for certification.

### MWEF Test Points for Replacement Waterfall Pump Motors

Staff chose the test point for replacement waterfall pump motors to be consistent with the test point for DPPP waterfall pumps. The replacement waterfall pump motor test point is proposed to be at maximum speed and full load as determined by the requirements of CSA 747-09. Staff seeks comment as to whether a full load or a higher load would better represent the conditions a similar motor would see during a DPPP waterfall pump test.

### MWEF Test Points for Replacement Pressure Cleaner Booster Pump Motors

Staff chose the test point for replacement pressure cleaner booster pump motors to be similar to the test conditions for the motor within a DPPP pressure cleaner booster pump. Similar to the pool filtering pump motor testing, staff calculated the minimum hydraulic output based upon the U.S. DOE's 10 gallon per minute and 60 feet of head.[72] Staff then converted the value to a minimum motor mechanical output assuming a hydraulic efficiency of 25 percent.[73] Using the minimum mechanical output, the minimum speed and torque at full load may be calculated using the requirements of CSA 747-2009.

### Motor-Weighted Energy Factor Calculation

The U.S. DOE selected a weighted energy factor approach to characterize the DPPP performance over the possible low- and high-speed performance. Staff chose a similar approach to score the replacement pool pump motor performance. The MWEF calculation weights the high- and low-speed operation as a ratio of the hours of operation. The U.S. DOE estimates that 20 percent of the operation time of a DPPP is at high-speed while 80 percent of the time is at low-speed. Staff chose the same weighting factors for the replacement motor performance calculation to harmonize the test method.

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72 U.S. Department of Energy, Energy Conservation Program: Test Procedure for Dedicated-Purpose Pool Pump, Direct Final Rule, Docket No. EERE-2016-BT-TP-0002, RIN 1904-AD66, p. 104.
https://energy.gov/sites/prod/files/2016/12/f34/DPPP_TP_Final_Rule.pdf.

73 *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps*, December 2016, Table 5.6.4, pp. 5-28, EERE-2015-BT-STD-0008-0105.

## Table 6-4 Test Points and Weights for Energy Factor Calculation

| Replacement Motor Design | Speed Configuration(s) | Number of Load Points (n) | Load Point (i) | Test Points: Motor Horsepower Output | Test Points: Torque (ft-lb) | Test Points: Speed |
|---|---|---|---|---|---|---|
| Replacement self-priming pool filter pump motors and replacement non-self-priming pool filter pump motors | Single-speed replacement dedicated-purpose pool pump motor and all replacement self-priming and non-self-priming pool filter pump motors not meeting the definition of two-, multi-, or variable speed replacement dedicated purpose pool pump motor | 1 | High | Motor Total Capacity | $T_{max} = \frac{Motor\ Total\ Capacity \times 5252}{RPM}$ | Maximum Speed |
| | Two speed replacement dedicated purpose pool pump motors | 2 | Low | HP associated with the specified torque and speed: $HP_{low} \geq .124$ if $motor\ total\ capacity > 1.5$ or $HP_{low} \geq .062$ if $motor\ total\ capacity \leq 1.5$ | $T_{low} = T_{max} \times \left(\frac{HP_{low}}{HP_{max}}\right)^2$ | Lowest speed capable of meeting the specified horsepower and torque values, if any. |
| | | | High | Motor Total Capacity | $T_{max} = \frac{(HP_{out} \times 5252)}{RPM}$ | Maximum Speed |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Multi-speed and variable speed replacement dedicated-purpose pool pump motors | 2 | Low | HP associated with the specified torque and speed: $HP_{low} \geq .124$ if $motor\ total\ capacity > 1.5$ or $HP_{low} \geq .062$ if $motor\ total\ capacity \leq 1.5$ | $T_{low} = T_{max} \times \left(\frac{HP_{low}}{HP_{max}}\right)^2$ | Lowest speed capable of meeting the specified HP and torque values. |
| | | | High | $HP_{out} \geq Motor\ total\ capacity \times \left(\frac{8}{10}\right)^3$ | $T_{max} = \frac{(HP_{out} \times 5252)}{RPM}$ | Lowest speed capable of meeting the specified HP and torque values. |
| Replacement Waterfall Pump Motors | Single-speed replacement dedicated-purpose pool pump motor | 1 | High | Motor Total Capacity | $T_{max} = \frac{Motor\ total\ capacity \times 5252}{RPM}$ | Maximum Speed |
| Pressure Cleaner Booster Pumps | Any | 1 | High | $HP_{low} \geq .61$ | $T_{low} = T_{max} \times \left(\frac{HP_{low}}{HP_{max}}\right)^2$ | Lowest speed capable of meeting the specified HP and torque values. |

Source: California Energy Commission

## Standby-Mode and Off-Mode Test Procedure

Staff proposes a standby-mode and off-mode test procedure to measure the energy consumption of the replacement DPPP motors. The active-mode, standby-mode, and off-mode definitions align with the U.S. DOE definitions.[74] The standby and off-mode test procedure is similar to the procedure adopted by the U.S. DOE Residential Furnaces and Boilers Final Rule.[75] The test procedure uses IEC 62301 (Second Edition). The power for standby and off mode will be measured and provided as part of the appliance certification. Staff does not propose a standard for standby-mode or off-mode power consumption.

74 10 CFR 430.2 Definitions.

75 United States Department of Energy, 2016-01-15 Energy Conservation Program for Consumer Products: Test Procedures for Residential Furnaces and Boilers; Final Rule, Section 8.11, available at https://www.regulations.gov/document?D=EERE-2012-BT-TP-0024-0038.

# CHAPTER 7: Savings and Cost Analysis

The proposed standards would significantly reduce energy consumption. Since the January 2016 draft report, the U.S. DOE has provided incremental cost data based upon manufacturer interviews. The cost analysis has been updated using the U.S. DOE data.[76] 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 replacement motors for pressure cleaner booster pumps and above-ground pumps. Replacement motors for nonfiltering pumps would be subject to the standard for the first time, and the duty cycle, design life, and consumer cost vary 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.[77]

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 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.[78] 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 71 GWh/yr. This savings opportunity is presented in **Table 7-1** for commercial pools, in parenthesis to indicate the additional savings per unit per year life-cycle benefit that a compliant motor with a variable-speed capability could provide.

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76 U.S. Department of Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps,* December 2016, Table 8.2.13-8.2,19 page 8-15 to 8-17, EERE-2015-BT-STD-0008-0105, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0105.
77 U.S. Department of Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps,* December 2016, Table 8.2.46 page 8-31, EERE-2015-BT-STD-0008-0105, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0105.
78 *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.

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

| Product | Application | Design Life (years) | Electricity Savings (kWh/yr) | Incremental Cost | Average Annual Savings | Life-Cycle Savings | Life-Cycle Benefit |
|---|---|---|---|---|---|---|---|
| Replacement SP Pool Filter Pump Motor, standard-size (1.90 hp) | Residential | 7.3 | 1,027 | $284 | $191 | $1,391 | $1,107 |
| Replacement SP Pool Filter Pump Motor, standard-size (3.76 hp) | Residential | 7.3 | 1,306 | $173 | $242 | $1,769 | $1,595 |
| Replacement SP Pool Filter Pump Motor, small-size | Residential | 7.3 | 349 | $66 | $65 | $473 | $407 |
| Replacement NSP Pool Filter Pump Motor | Residential | 5.3 | 151 | $9 | $28 | $148 | $139 |
| Replacement Waterfall Pump Motor (0.80 hp) | Residential | 7.3 | 0 | $0 | $0 | $0 | $0 |
| Replacement Pressure Cleaner Booster Pump Motor (1.24 hp) | Residential | 5.3 | 47 | $20 | $9 | $46 | $26 |
| Replacement SP Pool Filter Pump Motor, standard-size (1.90 hp) | Commercial | 7.3 | 1,908 | $284 | $354 | $2,584 | $2,300 ($3,121) |
| Replacement SP Pool Filter Pump Motor, standard-size (3.76 hp) | Commercial | 7.3 | 2,743 | $173 | $509 | $3,714 | $3,541 ($5,292) |
| Replacement SP Pool Filter Pump Motor, small-size | Commercial | 7.3 | 1,579 | $66 | $293 | $2,139 | $2,073 ($3,302) |

Source: U.S. DOE Technical Support Document, as modified by Energy Commission staff

The values in **Table 7-1** list the design life, incremental cost, and monetary savings in 2017 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, the contractor purchases the replacement motor and installs it at a discounted price).

The annual savings of each unit (benefits) is calculated by multiplying the annual energy savings by $0.1855 per kWh.[79] 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.

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 2.5 million residential and commercial pools are in use in California.[80] 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.[81] Assuming a 14-20 percent replacement rate based on a five- to seven-year design life, staff estimates 374,000 pool pump and motor combinations and replacement pool pump motors are shipped to California yearly. Staff compared this estimate to the U.S. DOE estimate of 2.4 million pool pump shipments per year nationwide.[82] The California and nationwide estimates seem consistent and proportional.[83]

Staff applied the U.S. DOE estimate that 95 percent of DPPP are used for residential applications and 5 percent are used for commercial applications. The assumption leads to an estimate of 9,000 pool pump shipments per year. That is somewhat higher than the previous CASE team estimate of 5,000 pool pump shipments per year.[84] [85] The difference can be explained by the shorter design life assumed when compared to the CASE team report. Increased sales are necessary to maintain the installed base due to the shorter design life.

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79 Energy Information Administration – Residential electricity prices for 2017 through February 2017, retrieved May 4, 2017. http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_b.

80 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.

81 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.

82 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.

83 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.

84 U.S. Department of Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps*, December 2016, Page 6-2, EERE-2015-BT-STD-0008-0105, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0105.

85 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.

Based on comments to the Commission docket and the results of a staff survey of California pool pump and motor retailers, consumers will choose to replace the motor of an existing pool pump and motor combination, rather than replace the entire system, between 25 percent and 60 percent of the time.[86] [87] Staff presented statewide savings in this report assuming a 25 percent replacement rate to provide a conservative assessment of statewide savings. An assessment of statewide savings assuming 60 percent may be found by multiplying staff's statewide savings by 2.4 (60%/25%=2.4).

The U.S. DOE Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) DPPP effort presented results for waterfall pool pumps and pressure cleaner booster pump annual shipments. Staff reviewed the U.S. DOE shipment data to estimate the quantity of pressure cleaner booster pumps and waterfall shipments to California.[88]

Above-ground replacement pool pump 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.[89]

The savings estimates compare the baseline energy consumption for each product with the 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 calculations are available in **Appendix A**. In **Table 7-2**, 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* are the annual reduction of energy consumed associated with annual sales, one year after the standards take effect. *Annual stock savings* are 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 7-2**, if all replacement pool pump motors complied with the proposed standards (annual stock savings), California would save 657 GWh of energy per year. Using a residential electricity rate of $0.1855 per kWh, full implementation of the proposed standards for pool pumps and motors would achieve roughly $122 million a year in reduced utility costs.

The peak power reduction was calculated to be 657 GWh divided by 8,760 hours, which is roughly 75 MW. This calculation is based on the simplified assumptions that the load profile for pool pumps and motors is

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86 Nidec Motor Corporation, Donald Lanser, Nidec Motor Corp. Comments on CEC Proposed Changes to Pool Pumps and Spa Labeling Docket Number: Docket # 15-AAER-02, available at http://docketpublic.energy.ca.gov/PublicDocuments/15-AAER-02/TN212507_20160729T133835_Donald_Lanser_Comments_Nidec_Motor_Corp_Comments_on_CEC_Propose.pdf.
87 Energy Commission Staff assumption of 25 percent market share based upon Commission phone survey of California pool pump and motor retailers conducted June 2016
88 U.S. Department of Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps,* December 2016, Table 3.5.4, pp. 3-24, EERE-2015-BT-STD-0008-0105.
89 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.

completely flat and energy would be evenly generated over the entire year to provide electricity to consumers.

**Table 7-2: Statewide Annual Savings**

| | | First-Year Savings | | Annual Existing and Incremental Stock Savings | |
|---|---|---|---|---|---|
| **Product** | **Application** | **Electricity Savings (GWh/yr)** | **Savings ($M)** | **Electricity Savings (GWh/yr)** | **Savings ($M)** |
| Replacement Self-Priming Pool Filter Pump Motor, standard-size (1.90 hp) | Residential | 27.6 | $5.1 | 201 | $37.4 |
| Replacement Self-Priming Pool Filter Pump Motor, standard-size (3.76 hp) | Residential | 35.1 | $6.5 | 256 | $47.5 |
| Replacement Self-Priming Pool Filter Pump Motor, small-size (0.88 hp) | Residential | 2.4 | $0.5 | 18 | $3.3 |
| Replacement Non-Self Priming Pool Filter Pump Motor (1.04 hp) | Residential and Commercial | 2.5 | $0.5 | 13 | $2.5 |
| Replacement Waterfall Pump Motor (0.80 hp) | Residential and Commercial | 0.0 | $0.0 | 0 | $0.0 |
| Replacement Pressure Cleaner Booster Pump Motor (1.24 hp) | Residential and Commercial | 0.6 | $0.1 | 3 | $0.5 |
| Replacement Self-Priming Pool Filter Pump Motor, standard-size (1.90 hp) | Commercial | 8.6 | $1.6 | 63 | $11.7 |
| Replacement Self-Priming Pool Filter Pump Motor, standard-size (3.76 hp) | Commercial | 13.4 | $2.5 | 98 | $18.2 |
| Replacement Self-Priming Pool Filter Pump Motor, small-size (0.88 hp) | Commercial | 0.6 | $0.1 | 4 | $0.8 |
| Total Savings | | 90.8 | $16.9 | 657 | $121.8 |

Source: Energy Commission 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 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 (Kern County). 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 $78 per year with a $0.1855 per kWh electricity cost.[90]

The CASE team estimated the cost of software changes to be less than $1 per unit in mass production for other appliance types.[91] 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.

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90 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.
91 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:
# 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.

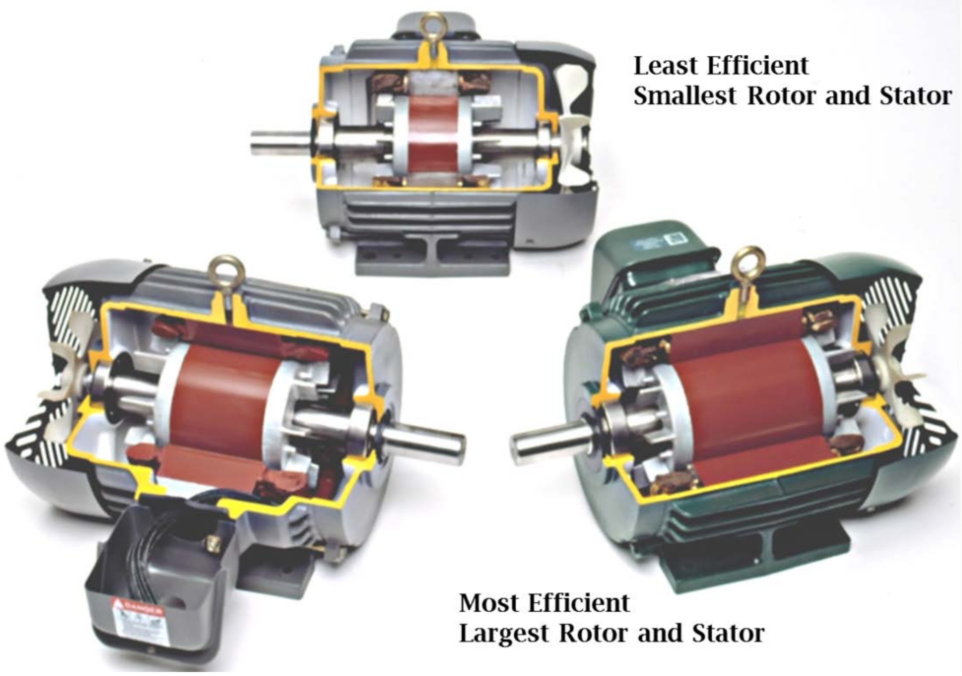
The motor MWEF is a measure of motor efficiency that allows an overall appraisal of the motor performance at multiple test points that is weighted to reflect the expected differences in length of time of the motor duty cycles. As motor efficiency improves at the selected test points, the MWEF will also improve.

### 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.[92] Electrical losses predominate at low speed. Other sources of motor losses at low speed, such as friction, are small compared to the conduction losses.

92 "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).[93] 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 the cross-section.[94]

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.

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

## Motor Efficiency and MWEF Market Survey

Staff reviewed data from the Commission's Modernized Appliance Efficiency Database for residential pool pump and motor combinations, and replacement residential pool pump motors. The certifications provide motor performance data showing motor power output and motor efficiency. The information can be used to calculate MWEF for the replacement motors. Staff considered both replacement motors as well as motors sold within pool pump and motor combinations in determining how many models would comply with the proposed standard.

**Table 8-1** shows existing standard-sized and small-sized self-priming filtering pool pump motors compliant with the MWEF standard in the Energy Commission database as of April 2017. *Standard-sized self-priming filtering pool pump motors* are defined as those motors with a total capacity of 1.0 hp or greater. Total capacity is the nameplate horsepower multiplied by the motor service factor. The U.S. DOE set the standard with evidence that DPPP with variable-speed motors would comply with the standard. The small number of compliant replacement residential pool pump motors indicates the stringency of the standard as well as recent market consolidation of manufacturing. Replacement residential pool pump motors are also marketed in that they can be "right-sized" or the motor capacity of these motors can be adjusted through a speed adjustment to meet the need of the pool system. This has allowed industry to market only several variable-speed models to cover a variety of size applications where many more dual- or single-speed models would be required.[95] 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 MWEF standards are technically feasible for the pool pump motor industry.

**Table 8-1: Self-Priming Pool Filter Pump Motor Performance in Energy Commission Database – May 2017**

| Motor Size (Total hp) | Residential Pool Pump and Motor Combinations Total Models | Residential Pool Pump and Motor Combinations Compliant | Replacement Residential Pool Pump Motors Total Models | Replacement Residential Pool Pump Motors Compliant |
|---|---|---|---|---|
| Small-Size (<1hp) | 30 | 22 | 14 | 9 |
| Standard-Size (>= 1hp) | 162 | 72 | 49 | 7 |

Source: Energy Commission Appliance Database, April 4, 2017

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

95 Century Electric Motor, VGreen 165 Product Brochure, VGreen165_Bulletin_2751CS.pdf available at https://www.centuryelectricmotor.com/MotorCategory.aspx?LangType=1033&id=6442450977.

to meet the existing compliant motor interfaces, if needed. The adaptations to the interfaces can be made so that compliant motors for above-ground and pressure cleaner pumps 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.[96] 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.

## Freeze Protection Control Requirement

All 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.[97]

96 Worth, Chad and 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.
97 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 pump motors at the end of the useful lives. The proposed standards would not change that, so the replacement of these motors would present no additional impact to the environment beyond the natural cycle.

# 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 dedicated-purpose pool pump motors with total motor capacity up to 5 horsepower, replacement residential pool pump motors, and portable electric spas.

...

**Section 1602 Definitions.**

...

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

"Active mode" of a replacement dedicated purpose pool pump motor means the condition in which the motor, or motor and onboard controller —

(1) Is connected to a main power source;

(2) Has been activated; and

(3) Provides one or more main functions.

...

"Basket strainer" means a perforated or otherwise porous receptacle, mounted within a housing on the suction side of a pump, that prevents solid debris from entering 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 such as a screwdriver, pliers, or an open-ended wrench.

...

"Dedicated-purpose pool pump" comprises self-priming pool filter pumps, non-self-priming pool filter pumps, waterfall pumps, pressure cleaner booster pumps, integral sand-filter pool pumps, integral-cartridge filter pool pumps, storable electric spa pumps, and rigid electric spa pumps.

...

"Designed and marketed" means that the equipment is designed to fulfill the indicated application and, when distributed in commerce, is designated and marketed for that application, with the designation on the packaging or any publicly available documents such as product literature, catalogs, and packaging labels.

…

“Freeze protection control” means a pool pump motor control that, at a certain ambient temperature, turns on the replacement dedicated-purpose pool pump motor to circulate water for a period of time to prevent the pool and water in plumbing from freezing.

…

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

“Integral cartridge-filter pool pump” means a pump that requires a removable cartridge filter, installed on the suction side of the pump, for operation and the cartridge filter cannot be bypassed.

“Integral sand-filter pool pump” means a pump distributed in commerce with a sand filter that cannot be bypassed.

…

“Multi-speed motor” means a motor for a residential pool pump and motor combination or replacement residential pool pump motor whose speed may be selected from several different pre-set ranges.

“Multi-speed replacement dedicated-purpose pool pump motor” means a replacement dedicated-purpose pool pump motor that is capable of operating at more than two discrete, pre-determined operating speeds separated by speed increments greater than 100 rpm, where the lowest speed is less than or equal to half of the maximum operating speed and greater than zero, and must be distributed in commerce with an on-board pool pump control (i.e., variable speed drive and user interface or programmable switch) that changes the speed in response to pre-programmed user preferences and allows the user to select the duration of each speed or the operational times or both.

…

“Non-self-priming pool filter pump” means a pool filter pump that is not certified under NSF/ANSI 50–2015 to be self-priming and is not capable of re-priming to a vertical lift of at least 5.0 feet with a true priming time less than or equal to 10.0 minutes, when tested in accordance under Section 1604(g), and is not a waterfall pump.

“Off mode” of a replacement dedicated purpose pool pump motor means the condition in which the motor, or motor and onboard controller —

(1) Is connected to a main power source; and

(2) Is not providing any stand-by or active mode function.

…

“Pool filter pump” means an end suction pump that:

(1) Either:

(i) Includes an integrated basket strainer; or

(ii) Does not include an integrated basket strainer, but requires a basket strainer for operation, as stated in manufacturer literature provided with the pump; and

(2) May be distributed in commerce connected to, or packaged with, a sand filter, removable cartridge filter, or other filtration accessory, provided that the filtration accessory is connected with consumer-removable connections that allow the filtration accessory to be bypassed.

"Pressure cleaner booster pump" means an end suction, dry rotor pump designed and marketed for pressure-side pool cleaner applications, and which may be UL listed under ANSI/UL 1081–2016, "Standard for Swimming Pool Pumps, Filters, and Chlorinators".

...

"Removable cartridge filter" means a filter component with fixed dimensions that captures and removes suspended particles from water flowing through the unit. The removable cartridge filter is not capable of passing spherical solids of 1 mm in diameter or greater, and can be removed from the filter housing by hand or using only simple tools such as screwdrivers, pliers, open-ended wrench.

...

"Replacement dedicated purpose pool pump motor" means a motor designed and marketed for use as a replacement motor for a dedicated purpose pool pump that is less than 5 hp.

"Replacement non-self-priming pool filter pump motor" means a motor designed and marketed for use as a replacement motor for a non-self-priming pool filter pump.

"Replacement pressure cleaner booster pump motor" means a motor designed and marketed for use as a replacement motor for a pressure cleaner booster pump.

"Replacement residential pool pump motor" means a replacement motor manufactured before January 1, 2019 and intended to be coupled to an existing residential pool pump that is used to circulate and filter pool water in order to maintain clarity and sanitation.

"Replacement self-priming pool filter pump motor" means a motor designed and marketed for use as a replacement motor for a self-priming pool filter pump.

"Replacement waterfall pump motor" means a motor designed and marketed for use as a replacement motor for a waterfall pump.

...

"Rigid electric spa pump" means an end suction pump that does not contain an integrated basket strainer or require a basket strainer for operation as stated in manufacturer literature provided with the pump and that meets the following three criteria:

(1) Is assembled with four through bolts that hold the motor rear endplate, rear bearing, rotor, front bearing, front endplate, and the bare pump together as an integral unit;

(2) Is constructed with buttress threads at the inlet and discharge of the bare pump; and

(3) Uses a casing or volute and connections constructed of a non-metallic material.

…

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

"Self-priming pool filter pump" means a pool filter pump that is certified under NSF/ANSI 50–2015 to be self-priming or is capable of re-priming to a vertical lift of at least 5.0 feet with a true priming time less than or equal to 10.0 minutes, under tested with section 1604(g), and is not a waterfall pump.

"Self-priming pump" means a pump that either is a self-priming pool filter pump or a pump that:

(1) Is designed to lift liquid that originates below the centerline of the pump inlet;

(2) Contains at least one internal recirculation passage; and

(3) Requires a manual filling of the pump casing prior to initial start-up, but is able to reprime after the initial start-up without the use of external vacuum sources, manual filling, or a foot valve.

…

"Single-speed replacement dedicated-purpose pool pump motor" means a replacement dedicated-purpose pool pump motor that is capable of operating at only one speed.

…

"Standby mode" of a replacement dedicated purpose pool pump motor means the condition in which the motor, or motor and onboard controller —

(1) Is connected to a main power source; and

(2) Offers one or more of the following functions:

(i) Facilitate The activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer; or

(ii) Continuous functions, including information or status displays (including clocks) or sensor-based functions

"Storable electric spa pump" means a pump that is distributed in commerce with the following:

(1) An integral heater; and

(2) An integral air pump.

"Submersible pump" means a pump that is designed to be operated with the motor and bare pump fully submerged in the pumped liquid.

…

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

"Two-speed motor" means a motor <u>for a residential pool pump and motor combination or replacement residential pool pump motor</u> designed or intended to be operated at one of two preset speeds.

<u>"Two-speed replacement dedicated-purpose pool pump motor" means a replacement dedicated-purpose pool pump motor that is capable of operating at only two different pre-determined operating speeds, where the low operating speed is less than or equal to half of the maximum operating speed and greater than zero, and must be distributed in commerce either:</u>

<u>(1) With a motor control such as a variable speed drive and a user interface or switch that is capable of changing the speed in response to user preferences; or</u>
<u>(2) Without a motor control that has the capability to change speed in response to user preferences, but is unable to operate without the presence of such a motor control.</u>

<u>"Variable speed drive" means equipment capable of varying the speed of the motor.</u>

"Variable speed motor" means a motor <u>for a residential pool pump and motor combination or replacement residential pool pump motor</u> whose speed can vary continuously over a specified range.

<u>"Variable-speed replacement dedicated-purpose pool pump motor" means a replacement dedicated-purpose pool pump motor that is capable of operating at a variety of user-determined speeds, where all the speeds are separated by at most 100 rpm increments over the operating range and the lowest operating speed is less than or equal to one-third of the maximum operating speed and greater than zero. Such a motor must include a variable speed drive and be distributed in commerce either:</u>

<u>(1) With a user interface that changes the speed in response to pre-programmed user preferences and allows the user to select the duration of each speed, the operational times, or both; or</u>

<u>(2) Without a user interface that changes the speed in response to pre-programmed user preferences and allows the user to select the duration of each speed, the operational times, or both, but is unable to operate without the presence of a user interface.</u>

<u>"Waterfall pump" means a pool filter pump with a certified maximum head less than or equal to 30.0 feet, and a maximum speed less than or equal to 1,800 rpm.</u>

...

...[skipping remaining text of 1602(g)]

...[skipping rest of 1602]

**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.**

...

(4) Motor Test Method for Replacement Dedicated Purpose Pool Pump Motors

The test method for replacement dedicated purpose pool pump motors is as follows:

(A) A replacement dedicated purpose pool pump motor manufactured on or after July 1, 2018 shall be tested in accordance with CSA-C747-2009 (Reaffirmed 2014), (CSA C747-2009 (RA2014)), "Energy Efficiency Test Methods for Small Motors" with modified torque settings at different speeds as is shown in Table G-3.

(1) Single-speed, two-speed, multi-speed, and variable-speed, replacement dedicated purpose pool pump motors shall be tested at the speeds, power output and motor torques shown below in Table G-3. Motor torque shall be recorded in lb-ft, motor speed in rotations per minute, and input power in watts.

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

| RDPPPM Motor Design | Speed Configuration(s) | Number of Load Points (n) | Load Point (i) | Test Points: Motor Horsepower Output | Test Points: Torque (ft-lb) | Test Points: Speed | Weight |
|---|---|---|---|---|---|---|---|
| Replacement self-priming pool filter pump motors and replacement non-self-priming pool filter pump motors | Single-speed replacement dedicated-purpose pool pump motor and all replacement self-priming and non-self-priming pool filter pump motors not meeting the definition of two-, multi-, or variable speed replacement dedicated purpose pool pump motor | 1 | High | Motor Total Capacity | $T_{max} = \frac{Motor\ total\ capacity \times 5252}{RPM}$ | Maximum Speed | 1.0 |
| | Two speed replacement dedicated purpose pool pump motors | 2 | Low | HP associated with the specified torque and speed: $HP_{low} \geq .124$ if $Motor\ total\ capacity > 1.5$ or $HP_{low} \geq .062$ if $Motor\ total\ capacity < 1.5$ | $T_{low} = T_{max} \times \left(\frac{HP_{low}}{HP_{max}}\right)^2$ | Lowest speed capable of meeting the specified HP and torque values, if any. | 0.8 |
| | | | High | Motor Total Capacity | $T_{max} = \frac{(HP_{out} \times 5252)}{RPM}$ | Maximum Speed | 0.2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Multi-speed and variable speed replacement dedicated-purpose pool pump motors | 2 | Low | HP associated with the specified torque and speed: $HP_{low} \geq .124$ if $Motor\ total\ capacity > 1.5$ or $HP_{low} \geq .062$ if $Motor\ total\ capacity \leq 1.5$ | $T_{low} = T_{max} \times \left(\frac{HP_{low}}{HP_{max}}\right)^2$ | Lowest speed capable of meeting the specified HP and torque values. | 0.8 |
| | | | High | $HP_{out} \geq Motor\ total\ capacity \times \left(\frac{8}{10}\right)^3$ | $T_{max} = \frac{(HP_{out} \times 5252)}{RPM}$ | Lowest speed capable of meeting the specified HP and torque values. | 0.2 |
| Replacement Waterfall Pump Motors | Single-speed replacement dedicated-purpose pool pump motor | 1 | High | Motor Total Capacity | $T_{max} = \frac{Motor\ total\ capacity \times 5252}{RPM}$ | Maximum Speed | 1.0 |
| Pressure Cleaner Booster Pumps | Any | 1 | High | $HP_{low} \geq .61$ | $T_{low} = T_{max} \times \left(\frac{HP_{low}}{HP_{max}}\right)^2$ | Lowest speed capable of meeting the specified HP and torque values. | 1.0 |

(2) Power factor for replacement dedicated -purpose pool pump motors shall be reported for each test point per CSA C747-2009 and Table G-3.

(3) Motor-Weighted Energy Factor (MWEF)

Determination of Motor-Weighted Energy Factor. MWEF shall be determined as a ratio of the measured motor output power and driver power input to the replacement dedicated-purpose pool pump motor in accordance with the following equation:

$$MotorWEF = \frac{\sum_i W_i * \sqrt[3]{T_i * N_i * n_{pump} * 91.8} * \frac{60}{1,000}}{\sum_i W_i * \frac{P_i}{1,000}}$$

MotorWEF = Weighted Energy Factor in Hp/kW;

$W_i$ = weighting factor at each load point i, as specified in Table G-4;

$T_i$ = flow at each load point i, in lb-ft;

$N_i$ = motor speed at each load point i, in rotations per minute, RPM,

$N_{pump}$ = pump efficiency, 55 percent for replacement pool filtering and waterfall motors, 25 percent for pressure cleaner booster pumps

Pi = driver power input to the motor (or controls, if present) at each load point i, in watts;

i = load point(s), defined uniquely for each RDPPPM variety and speed configuration as specified in Table G-3; and

n = number of load point(s), defined uniquely for each RDPPPM variety and speed configuration as specified in Table G-3.

**Table G-4: Load Point Weights ($w_i$)**

| RDPPPM Motor Design | Speed Configuration(s) | Load Point(s) i | |
|---|---|---|---|
| | | Low Speed | High Speed |
| Replacement self-priming pool filter pump motors and replacement non-self-priming pool filter pump motors | Single-speed replacement dedicated-purpose pool pump motor and all replacement self-priming and non-self-priming pool filter pump motors not meeting the definition of two-, multi-, or variable-speed replacement dedicated-purpose pool pump motor | - | 1.0 |
| | Two-speed replacement dedicated-purpose pool pump motors | 0.80 | 0.20 |
| | Multi-speed and variable-speed replacement dedicated-purpose pool pump motors | 0.80 | 0.20 |
| Replacement Waterfall Pump Motors | Single-speed replacement dedicated-purpose pool pump motor | - | 1.0 |
| Pressure Cleaner Booster Pumps | Any | - | 1.0 |

(6) The test method for replacement dedicated-purpose pool pump motor freeze protection control shall be Part 429.134 (i)(2)(iv)(A) of *Issuance: 2016-12-22 Energy Conservation Program: Test Procedure for Dedicated-Purpose Pool Pumps; Final Rule.*

(7) Replacement Dedicated-Purpose Pool Pump Motor Standby-Mode and Off-Mode Test Method

(A) Standby power measurement. With all electrical auxiliaries of the replacement dedicated-purpose pool pump motor not activated, measure the standby power (P W,SB) in accordance with the procedures in IEC 62301(2011) (E). Measure the wattage so that all possible standby-mode wattage for the entire appliance is recorded, not just the standby-mode wattage of a single auxiliary. Round the recorded standby power (P W,SB) to the second decimal place, except for loads greater than or equal to 10W, which must be recorded to at least three significant figures.

(B) Off-mode power measurement. If the unit is equipped with an off switch or there is an expected difference between off-mode power and standby-mode power, measure off-mode power (P W, OFF) in accordance with the standby power procedures in IEC 62301(2011) (E). Measure the wattage so that all possible off-mode wattage for the entire appliance is recorded, not just the off-mode wattage of a single auxiliary. If there is no expected difference in off-mode power and standby-mode power, let P W,OFF = P W,SB, in which case no separate measurement of off-mode power is necessary. Round the recorded off-mode power (P W,OFF) to the second decimal place, except for loads greater than or equal to 10W, in which case round the recorded value to at least three significant figures.

(8) The test method for dedicated-purpose pool pumps for self-priming capability shall be Subsection F, Determination of Self-Priming Capability, of Section I. of Appendix B1 and Appendix B2 to Subpart Y of Part 431 of *Issuance: 2016-12-22 Energy Conservation Program: Test Procedure for Dedicated Purpose Pool Pumps; Final Rule.*

...

The following documents are incorporated by reference in Section 1604.

...

FEDERAL TEST METHODS

...

C.F.R., Title 10, sections 431.443, 431.444, and 431.445

PROPOSED FEDERAL TEST METHODS

Issuance: 2016-12-22 Energy Conservation Program: Test Procedure for Dedicated-Purpose Pool Pumps; Final Rule

| | |
|---|---|
| Copies available from: | Superintendent of Documents<br>U.S. Government Printing Office<br>Washington, DC 20402<br>http://ecfr.gpoaccess.gov/ |

...

CSA Group (CSA)

| | |
|---|---|
| CSA C747-2009(RA2014) | 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 |

…

…[skipping rest of 1604]

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

**…**

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

…

(6) Energy Efficiency Standards and Energy Design Standards for Residential Pool Pump and Motor Combinations, Replacement Dedicated-Purpose Pool Pump Motors, 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, replacement dedicated-purpose pool pump motors, and replacement residential pool pump motors.

…

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

…

**(g) Pool Heaters, Portable Electric Spas, Residential Pool Pumps and Motor Combinations, Replacement Dedicated-Purpose Pool Pump Motors, 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, replacement dedicated-purpose pool pump motors, and replacement residential pool pump motors.

…

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

…

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

...

(5) **Residential Pool Pumps and Motor Combinations, Replacement Dedicated-Purpose Pool Pump Motors, and Replacement Residential Pool Pump Motors.**

(A) **Motor Efficiency.**

(1) Residential pPool pump motors manufactured on or after January 1, 2006 and before January 1, 2019, may not be split-phase or capacitor start - induction run type.

(2) All replacement dedicated purpose 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,

**Table G-5**

**Standards for Replacement Dedicated-Purpose Pool Pump Motors Manufactured on or After January 1, 2019**

| Proposed Minimum Motor Weighted Energy Factor According to Modified CSA C747-09 Test Procedure | | |
|---|---|---|
| **Replacement Pool Pump Motor Unit Type** | **Total Motor Capacity (Horsepower)** | **Minimum Allowable MWEF Score** |
| Replacement Standard-Size Self-Priming Pool Filter Pump Motors | =>1.0 hp and <5.0 hp | MWEF = -2.30*ln (hp/1.4)+6.59 |
| Replacement Small-Size Self-Priming Pool Filter Pump Motors | < 1 hp | MWEF = 5.55 for hp <=0.26 hp, -1.30*ln (hp/1.4) +2.90 for hp >.26 hp |
| Replacement Non- Self-Priming Pool Filter Pump Motors | < 5.0 hp | MWEF = 4.6 for hp <=0.26 hp, -0.85*ln (hp/1.4) +2.87 for hp >.26 hp |
| Replacement Waterfall Pump Motors | Any | None |
| Replacement Pressure Cleaner Booster Pump Motors | Any | MWEF = .42 |

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

**(1) Residential Pool Pump Motors.** Residential pool pump motors with a pool pump motor capacity 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. This section shall remain in effect for pool pump and motor combinations until July 19, 2021, and for replacement pool pump motors until January 1, 2019.

**(2) Pump 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. This section shall remain in effect for controls sold with pool pump and motor combinations until July 19, 2021, and for controls sold with replacement pool pump motors until January 1, 2019.

...

**(C) Freeze Protection**. Replacement dedicated-purpose pool pump motors with freeze protection manufactured on or after January 1, 2019, shall have the following default settings.

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

(2). The default run time setting shall be no greater than 1 hour before the temperature is rechecked.

(3). 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.

...

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

{[skipping (a) through Table X, Section G "Other Pool Heaters"} ...

Table X
Data Submittal Requirements

...

| | Appliance | Required Information | Permissible Answers |
|---|---|---|---|
| G | Residential Pool Pump and Motor Combinations manufactured before July 19, 2021, and Replacement Residential Pool Pump Motors manufactured before January 1, 2019 | Motor Construction | PSC, Capacitor Start-Capacitor Run, ECM, Capacitor Start-induction run, split-phase, Permanent Magnet Synchronous |
| | | Motor Design | Single-speed, dual-speed, multi-speed, variable-speed |
| | | Frame | |
| | | 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 Pump Motor Capacity | |
| | | Motor Service Factor | |
| | | Motor Efficiency (%) | |
| | | Nameplate Horsepower | |
| | | Pump Control Speed (compliance with Section 1605.3(g)(5)(B)2.) | Yes, no |
| | | Flow for Curve 'A' (in gpm) | |
| | | Power for Curve 'A' (in watts) | |

| | Appliance | Required Information | Permissible Answers |
|---|---|---|---|
| | | 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) | |
| G | Replacement Dedicated Purpose Pool Pump Motors | Replacement Dedicated-Purpose Pool Pump Motor Type | Replacement non-self-priming pool filter pump motor, Replacement pressure cleaner booster pump motor, Replacement self-priming pool filter pump motor, Replacement waterfall pump motor |
| | | Replacement Dedicated-Purpose Pool Pump Motor Design | Single-speed, two-speed, multi-speed, variable-speed |
| | | Motor Phase | Single-phase, polyphase |
| | | Frame | |
| | | Maximum Speed (in RPM) | |
| | | Pool Pump Motor Total Capacity | |
| | | Motor Service Factor | |
| | | Motor Efficiency at high speed | |
| | | Motor Speed (high speed) | |
| | | Motor Torque (high speed) (lb-ft) | |
| | | Motor Output Horsepower (high speed) | |
| | | Motor Output (high speed) (watts) | |
| | | Motor Efficiency at low speed (if applicable) | |
| | | Motor Speed (low speed) (if applicable) | |

| | Appliance | Required Information | Permissible Answers |
|---|---|---|---|
| | | Motor Torque (low speed) (lb-ft) (if applicable) | |
| | | Motor Output Horsepower (low speed) (if applicable) | |
| | | Motor Power Input (low speed) (watts) (if applicable) | |
| | | Motor Weighted Energy Factor | |
| | | Nameplate Horsepower | |
| | | Power Factor (high speed) | |
| | | Power Factor (low speed) (if applicable) | |
| | | Unit has freeze protection feature | Yes, no |
| | | Freeze Protection (compliance with Section 1605.3[g][5][C]) | Yes, no |
| | | Freeze Protection default dry bulb air temperature setting (F) | |
| | | Freeze Protection Default Time Setting (minutes) | |
| | | Freeze Protection Default Motor Speed (rpm) | |
| | | Pump Control Speed (compliance with Section 1605.3(g)(5)(B)(3) | Yes, no, N/A |
| | | Standby-Mode Power | |
| | | Off-Mode Power | |

. .[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:

…

i. For replacement dedicated-purpose pool pump motors manufactured on or after January 1, 2019, each replacement dedicated purpose pool pump motor is marked permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than ¼”, with the pool pump motor capacity of the motor.

…

**Section 1607 Marking of Appliances.**

…

(d) Energy Performance Information.

…

(9) ~~Residential~~ Pool Pumps.

….

(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 shall be marked, permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than ¼”, “This pump must be installed with a two-, multi-, or variable-speed pump motor controller,”

(D) Replacement dedicated 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” with the motor-weighted energy factor value as certified to the Energy Commission.

# PART B: PORTABLE ELECTRIC SPAS

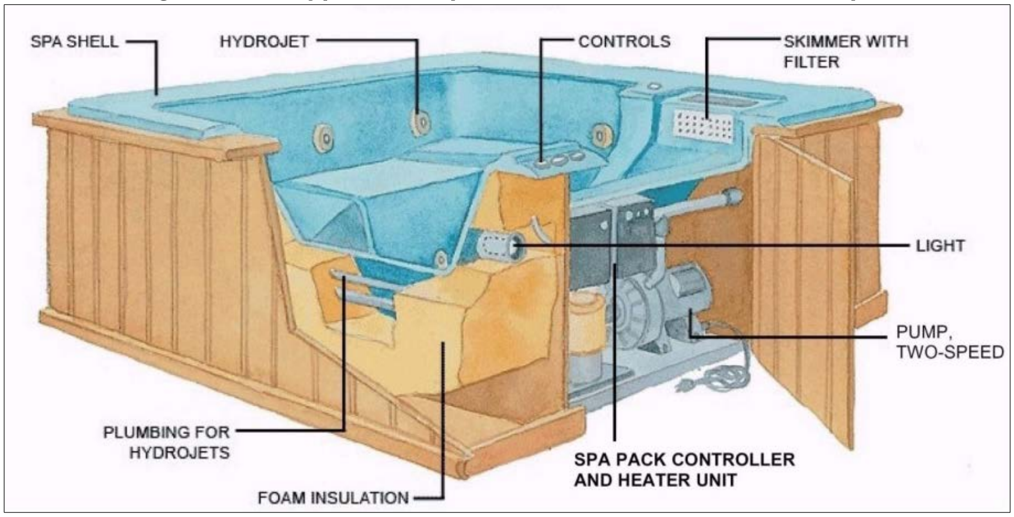
# CHAPTER 11: Product Description

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 the 2015 Association of Pool and Spa Professionals (APSP) market report, more than 1 million were installed in California, and more than 75,000 new units were sold in 2011.[98] The APSP also estimated that, in 2015, 15,000 inflatable spas were sold.[99] 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.[100] 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**.[101]) 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 five years.[102] Inflatable spas have an estimated average lifetime of three years.[103]

98 The Association of Pool & Spa Professionals, P.K. Data Research Industry Statistics. Retrieved from http://www.apsp.org/Portals/0/2016%20Website%20Changes/2015%20Industry%20Stats/2015%20Industry%20Stats.pdf.
99 APSP's presentation at staff workshop on February 18, 2016. Docket 15-AAER-02, TN 210390, February 17, 2016.
100 Davis Energy Group, Energy Solutions, (2004), *Analysis of Standards Options for Portable Electric Spas*. California: PG&E.
101 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.
102 Worth, C., and G. Fernstrom. (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.
103 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 March 2017, the California Energy Commission's modernized appliance efficiency database system (MAEDBS) lists 1,334 certified portable electric spa entries. Spas are distinguished as hot tubs/portable spas and exercise spas/swim spas. For this report, three types of spas were analyzed: portable, exercise, and combination spas. As a fourth type, inflatable or storable spas were analyzed as a type of portable spa. Using the certified portable electric spa manufacturers in the MAEDBS as sources, the key differences among the three types of spas are the volume capacity (or water surface area), the features, and the intended use.

## Portable Spas

Portable spas are intended mostly for recreational use and provide the user with a comforting warm-water massage by electrically heating and aerating the water.[104] 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. Portable spas can be rigid bodied or non-rigid, containing inflatable or separable structural components for easier storage and relocation, and range from requiring assembly to requiring no assembly. Examples of portable electric spas are shown in **Figure 11-2**. Example (1) shows a spa where the interior shell is acrylic, the exterior shell is a synthetic wood cabinet, and it is fully insulated with foam;[105] (2) shows a spa where the entire shell is made of a polyethylene (plastic) mold and is fully insulated with foam;[106] (3) shows a spa where the entire shell is made of textured vinyl and is fully

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104 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/.

105 Jacuzzi Inc. (2017). Our Brand - Quality. Retrieved May 2017, from Jacuzzi: https://www.jacuzzi.com/en-us/hot-tubs/our-brand/quality.

106 The Home Depot. (2017). Lifesmart - Key Largo HD. Retrieved May 2017, from HomeDepot.com: http://www.homedepot.com/p/Lifesmart-Key-Largo-DLX-4-Person-Hot-Tub-Spa-with-Upgraded-20-Jet-Package-Includes-Free-Energy-Savings-Value-Package-and-Delivery-Key-Largo-HD/205326535.

insulated with a patented foam blend;[107] (4) shows a spa where the entire shell is made of three-layered polyvinyl chloride (PVC) vinyl and is filled with air to produce the structure of the spa;[108] and (5) shows a spa where the exterior shell is made of wooden panels and is lined with three-layered PVC vinyl.[109]

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


Sources: (1)Jacuzzi Spas, Jacuzzi.com, (2) Lifesmart, HomeDepot.com, (3) Softub, Inc., Softubplus.com, (4) Coleman SaluSpa, Bestwaycorp.us, (5) Comfort Line Products, Amazon.com

The volume capacity for portable spas can range from 120 gallons to more than 800 gallons.[110] The volume capacity for inflatable spas can range from 130[111] gallons to more than 260 gallons.[112] Although

107 Softub. (2016). Softub 140. Retrieved May 2017, from Softub: https://www.softub.com/models-features/softub-140/.
108 The Home Depot. (2017). Bestway - SaluSpa Miami. Retrieved May 2017, from HomeDepot.com: http://www.homedepot.com/p/Bestway-SaluSpa-Miami-4-Person-Inflatable-Hot-Tub-with-Heater-54124E/207052767.
109 Stellar Goods. (2017). Portable Spas: Spa-N-A-Box Deluxe Edition. Retrieved May 2017, from Stellar Goods: http://www.stellargoods.com/spa-n-a-box-deluxe-edition-with-real-wood-panels-hardcover/.
110 Worth, C., and G. Fernstrom. (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.

the smaller-volume, inflatable, and self-assembly spa units are intended to be used seasonally (6-7 months),[113] both rigid and nonrigid, easily-stored spas typically have a temperature range between 60°F and 104°F[114] like traditional free-standing spas.[115] Sorting by volume range, there are 906 portable spas ranging from 110 to 850 gallons certified to MAEDBS.

## Exercise Spas

Exercise spas are intended for health, fitness, and recreation. (See **Figure 11-3**.) Health and fitness uses include swimming, aquatic fitness or exercise, 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.[116] 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 therapy. Most exercise spas have a built-in temperature range of 60°F to 104°F[117] and are capable of meeting those recommendations. Users can still select the temperature of their choice. Exercise spas range in capacity from 900 gallons to 2,500 gallons.[118]

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111 Amazon.com. SaluSpa Siena AirJet Inflatable Hot Tub. Retrieved March 16, 2017, from Amazon.com: https://www.amazon.com/SaluSpa-Siena-AirJet-Inflatable-Hot/dp/B01KQ2XAKS/ref=sr_1_8?ie=UTF8&qid=1491507649&sr=8-8&keywords=inflatable+spa .

112 The Home Depot. (n.d.). Canadian Spa Company Swift Current 5-Person Portable Spa. Retrieved March 16, 2017, from The Home Depot: http://www.homedepot.com/p/Canadian-Spa-Company-Swift-Current-5-Person-Portable-Spa-KP-10002/205523856.

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

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

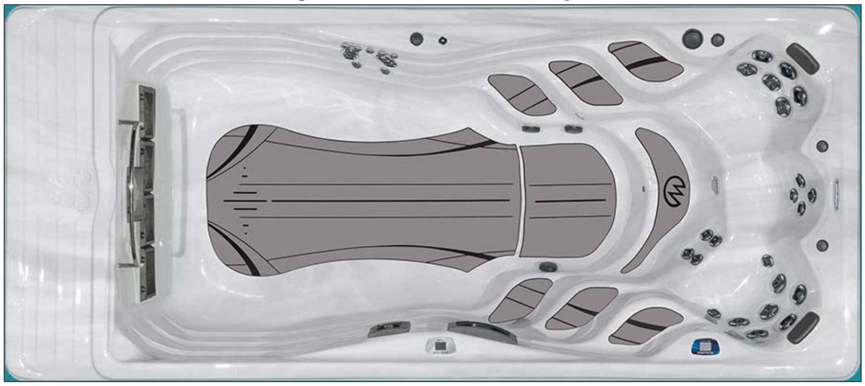
115 "Best Inflatable Hot Tub Reviews: Easier Way to Compare." *Inflatable Hot Tub Report.* (2016). http://www.inflatablehottubreport.com/.

116 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.

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

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

**Figure 11-3: Exercise Spa**



Source: Michael Phelps Swim Spas

By filtering spa data in MAEDBS using the volume ranges stated above for exercise spas, there are 48 certified exercise spas ranging from 924 gallons to 2,400 gallons.

### Combination Spas

Exercise spas that are designed to have two separate bodies of water at different temperatures are *combination spas*, with one body of water for swimming (swim portion) and the other for hydrotherapy (spa portion).[119] (See **Figure 11-4.**) Because of the two different temperatures and uses, it is important to separately characterize the energy consumption characteristics of each portion of a combination spa.

**Figure 11-4: Combination Spa**

Source: Grand Cayman Dual Zone Swim Spa

Although the Energy Commission does not collect data to distinguish exercise spas from combination spas, staff researched the certified entries in MAEDBS and determined there were seven certified combination spa models ranging from 1,620 gallons to 2,325 gallons.

## 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.[120] Electric resistance heaters are theoretically 100 percent energy-efficient because all the electricity is converted to heat.[121] In practice, resistance heaters in portable electric spas can have efficiencies of 98 percent or more.[122] Thus, the

119 Poolandspa.com. (2015, August 21). "What Is a Swim Spa?" Retrieved from poolandspa.com: http://www.poolandspa.com/page6210.htm.
120 Davis Energy Group, Energy Solutions. (2004). *Analysis of Standards Options for Portable Electric Spas*. California: PG&E.
121 U.S. DOE. (2015). "Electric Resistance Heating." Retrieved from Energy.gov: http://energy.gov/energysaver/articles/electric-resistance-heating.
122 Davis Energy Group, Energy Solutions. (2004). *Analysis of Standards Options for Portable Electric Spas*. California: PG&E.

energy efficiency is already high for heaters in a portable electric spa. While the electric heating element is efficient, a large amount of energy is required for initial startup heating and standby maintenance due to heat loss through the shell and cover.

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 for traditional portable electric spas.[123] According to the owner's manual for the Bestway's Saluspa inflatable spa, the startup mode can take from 9 to 32 hours, depending on the starting water temperature and ambient temperature or 2-3°F per hour with an ambient temperature of 77°F to reach a water temperature of 104°F.[124] 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.[125] Most spas are kept in standby mode year-round when not in use, since startup mode requires a lot of time and energy.[126] Inflatable spas are intended for seasonal use (6-7 months)[127] due to possible damage to the inflatable spa material when outdoor temperatures are below 40°F.[128] However, the California average minimum temperature is above 40°F, allowing these units to operate beyond the seasonal use in some regions.[129] More than half of the energy consumed during standby mode is due to maintaining heat.[130] Over the lifetime of a traditional unit, the standby mode represents typically 75 percent of the energy consumed by a portable electric spa compared to other modes and is thus considered representative of the efficiency of the spa.[131]

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.[132] Moreover, some units

123 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.

124 Bestway. (2017). SaluSpa Owner's Manual. Retrieved April 2017, from Bestway http://www.bestwaycorp.us/Product/ProductForm?productId=606#manuallink.

125 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.

126 Worth, C., and G. Fernstrom. (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.

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

128 Bestway. (2017). SaluSpa Owner's Manual. Retrieved April 2017, from Bestway http://www.bestwaycorp.us/Product/ProductForm?productId=606#manuallink.

129 Western Regional Climate Center. (April 2017). Climate Anomaly Maps and Tables - Western U.S. Retrieved April 2017, from Western Region and State ACIS Maps: http://www.wrcc.dri.edu/anom/, See Appendix B for Monitoring Map.

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

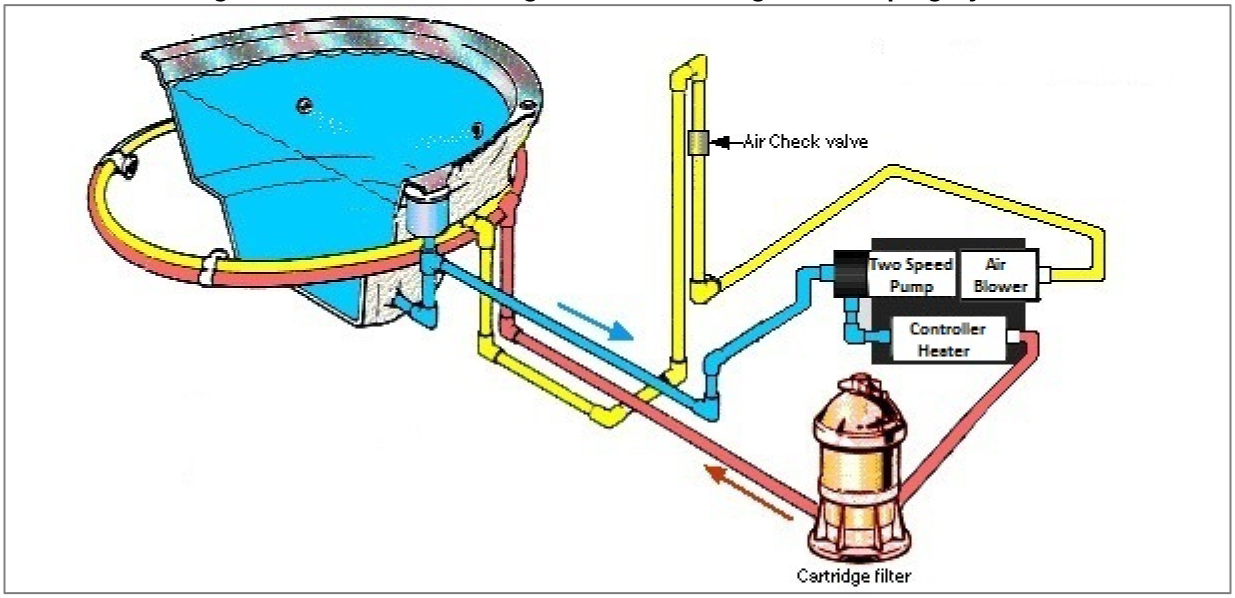
131 Davis Energy Group, Energy Solutions. (2004). *Analysis of Standards Options for Portable Electric Spas*. California: PG&E.

132 Intex Recreation Corp (2015). *PureSpa 77" Quick Start Guide*. http://www.intexcorp.com/support/28403e.html.

will shut off if the designated heating/standby temperature was never reached during the first 72 hours of operation.[133]

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.

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




Source: Spa Plumbing Diagrams, PoolSpasHelp.com

# Pumping System

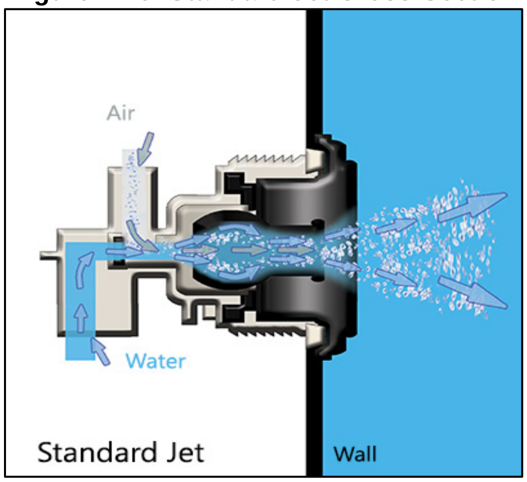
After the heating system, the pumping system is the most energy-intensive integrated part of a portable electric spa and can account for 25 to 50 percent of the total energy consumed by the unit, depending on how often different features are used. Energy consumption can vary due to possible configurations 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 two-speed pumps are not very efficient in any mode, especially during standby, because the motor is lightly loaded and running at low efficiency.[134] 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

133 Intex Recreation Corp (2015). *PureSpa 77" Manual*. http://www.intexcorp.com/support/28403e.html.
134 Western Area Power Administration. (2009). "What Goes Into an Energy-Efficient Spa or Hot Tub?" Lakewood: Western Area Power Administration, available at https://www.wapa.gov/EnergyServices/Documents/HotTubs.pdf.

larger pump.[135] Larger spas, like exercise spas, typically have multiple pumps. For example, exercise spas sold in California can have up to four pumps.[136]

Although the layout of the pumping system may differ, the heating and filtering process is similar. Water is pumped into the heating element or the filter, and 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.[137] 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.[138] The secondary pump can be used to optimize the primary pump and generate savings in standby mode.

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




Source: H2X Swim Spas, Master Inc.

## Water Treatment

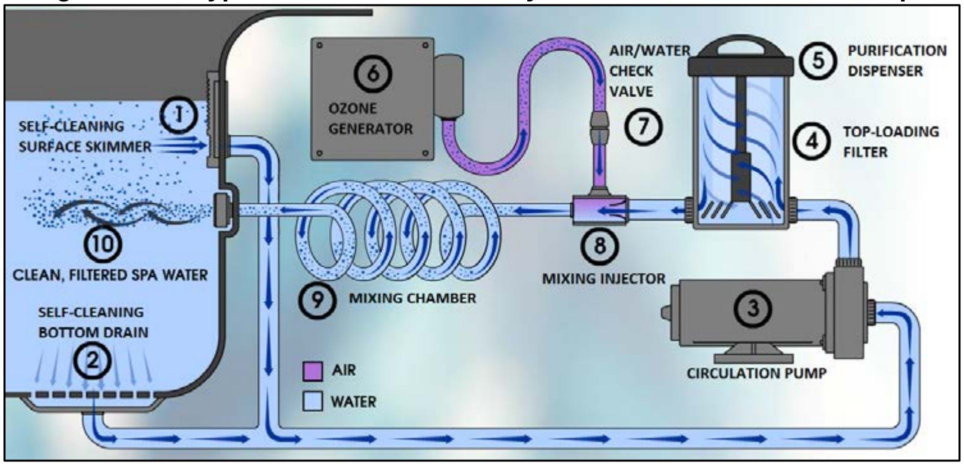
The water treatment system includes the pumping system since water treatment requires circulation and suctioning of water through the filtration unit. Filtration cycles can vary from programmed settings to continuous settings. Portable electric spas typically have one central pump that performs all operations including the filtration cycle, although some spas use a separate pump specifically for filtration and

135 Worth, C., and G. Fernstrom. (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.
136 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.
137 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.
138 Western Area Power Administration. (2009). “What Goes Into an Energy-Efficient Spa or Hot Tub?” Lakewood: Western Area Power Administration.

circulation.[139] Again, the filtration system can have various configurations and can include different types of water treatment mechanisms to improve water quality, such as pleated cartridge filters, media filters, skimmers, an ozonator, ultraviolet (UV) system, and the addition of minerals and sanitizing chemicals.[140] A 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.[141] For units that include an ozone treatment 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.[142]

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




Source: Baja Spas

139 Worth, C., and G. Fernstrom. (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.
140 The Spa Depot. (2015). "Hot Tub Maintenance." Retrieved from SpaDepot.com: http://www.spadepot.com/spacyclopedia/hot-tub-maintenance.htm.
141 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.
142 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.

Depending on the type of filtration system the spa is designed with and how often bathers are using the spa, the time to drain the spa water and replace it with fresh, clean potable water varies. Manufacturers recommend that inflatable spas should have the water changed every 3[143] to 90 days,[144] and traditional portable electric spas should have the water changed every two[145] to six months.[146]

## 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.[147]

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 (**Figure 11-8**). 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.[148] The arrows in **Figure 11-8** indicate heat loss dissipating through the foam core.

143 Bestway. (2017). SaluSpa Owner's Manual. Retrieved April 2017, from Bestway: http://www.bestwaycorp.us/Product/ProductForm?productId=606#manuallink.

144 Intex. (2017). PureSpa™ SSP-H-10-2 Owner's Manual. Retrieved April 2017, from Intex: http://www.intexcorp.com/support/28403e.html.

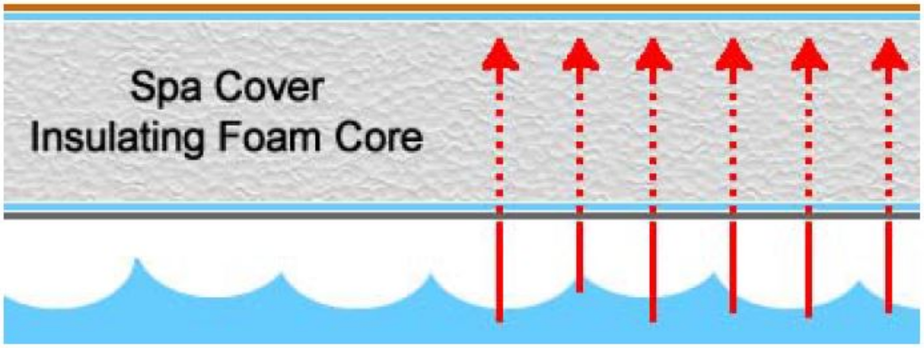
145 Catalina Spas. (2013). Catalina Spas Owner's Manual. Retrieved April 2017, from Catalina Spas - State of the Art Construction: http://www.catalinaspas.com/Docs/CatalinaOwnersManual2013.pdf.

146 Master Spas. (2017). H2X Fitness Swim Spas. Retrieved April 2017, from Master Spas: http://www.masterspas.com/documents/_manuals/2017/2017-h2x-owners-manual.pdf .

147 California Energy Commission. (2015). MAEDBS. Retrieved from Appliance Search http://maedbs/Pages/ApplianceSearch.aspx.

148 U.S. DOE. (2015, April 27). *Insulation*. Retrieved from Energy.Gov: http://energy.gov/energysaver/articles/insulation.

**Figure 11-8: Cross-Section of a Spa Cover**




Source: Duratherm, The Spa Depot

The foam core is typically made of polystyrene.[149] Polystyrene is a colorless, transparent thermoplastic.[150] 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 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 a significant amount of 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.[151] 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.[152] They are also lightweight and require only one person to apply or remove. There is a significant opportunity to improve the insulation of the spa cover with efficient XPS insulation already in the market.

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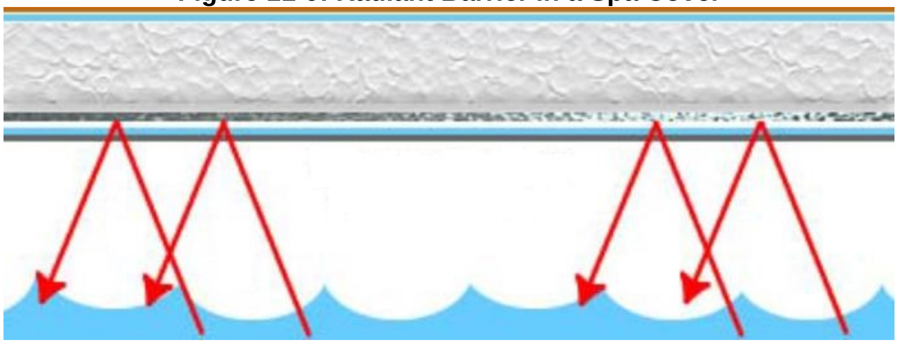
149 Hamill, A. I. (2012). *Measurement and Analysis of the Standby Power of Twenty-Seven Portable Electric Spas*. California Polytechnic State University, San Luis Obispo, Mechanical Engineering . San Luis Obispo: Andrew Ian Hamill.
150 U.S. Department of Energy. (April 27, 2015). "Insulation Materials." Available at Energy.Gov. http://energy.gov/energysaver/articles/insulation-materials.
151 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.
152 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.

The foam core is typically wrapped with vinyl. To further increase the effectiveness of spa covers, a waterproof barrier (polyethylene plastic wrap) and a radiant barrier may be added to enclose the foam insulation.[153] The plastic wrap prevents water absorption (waterlogging) and exposure to water treatment chemicals. A radiant barrier uses a highly reflective material that re-emits heat rather than absorbing it (**Figure 11-9**).[154]

**Figure 11-9: Radiant Barrier in a Spa Cover**

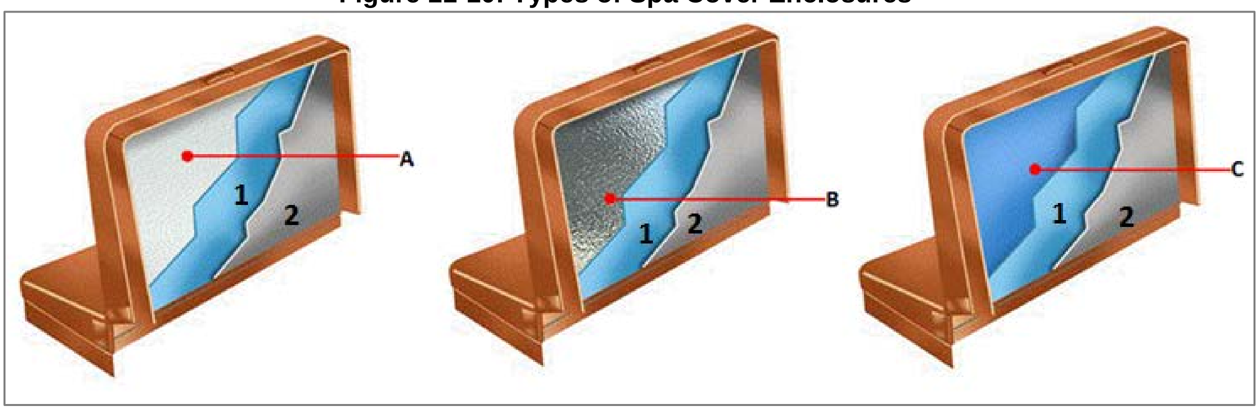


**Heat flow being reflected from the radiant barrier.**

Source: Duratherm, The Spa Depot

Examples of the type of enclosures and combination of barriers are shown in **Figure 11-10**. 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 11-10: Types of Spa Cover Enclosures**




Source: Duratherm, The Spa Depot

153 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.
154 U.S. DOE. (2015, April 27). *Insulation Materials*. Retrieved from Energy.Gov: http://energy.gov/energysaver/articles/insulation-materials.

The design and construction of spa covers vary depending on size and shape, but most covers are designed with a double-hinge or dual-hinge down the middle that allows the cover to fold in half. This hinge is typically not insulated, about two inches wide, and runs the entire length of the cover, making it easy to fold but allowing for significant heat loss.[155] Using a single-hinge design can greatly reduce the heat loss of spas. A single-hinge design eliminates the gap or insulates the gap preventing heat loss, as shown in **Figure 11-11**.[156]

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

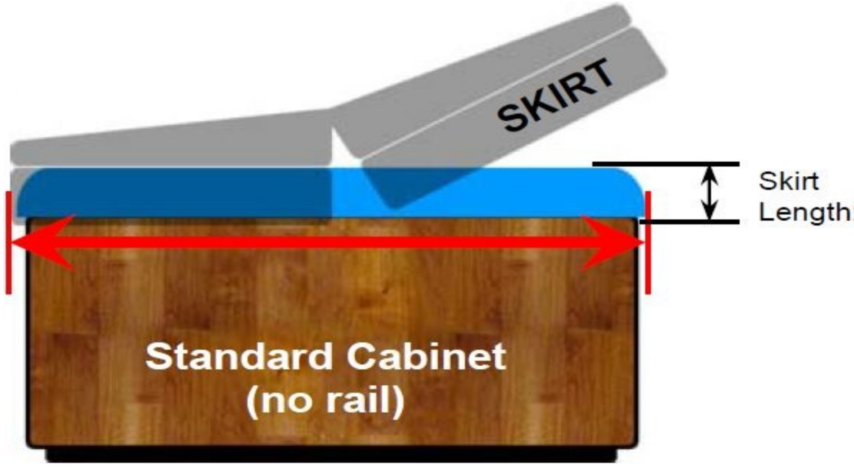
**A single-hinge avoids heat loss by elminating the gap at the hinge compared to a dual-hinge.**

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 11-12.**[157]

155 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.
156 Worth, C., and G. Fernstrom. (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.
157 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.

**Figure 11-12: 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 11-13**. 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.[158]

**Figure 11-13: Spa Floating Blanket**

Source: Duratherm, The Spa Depot

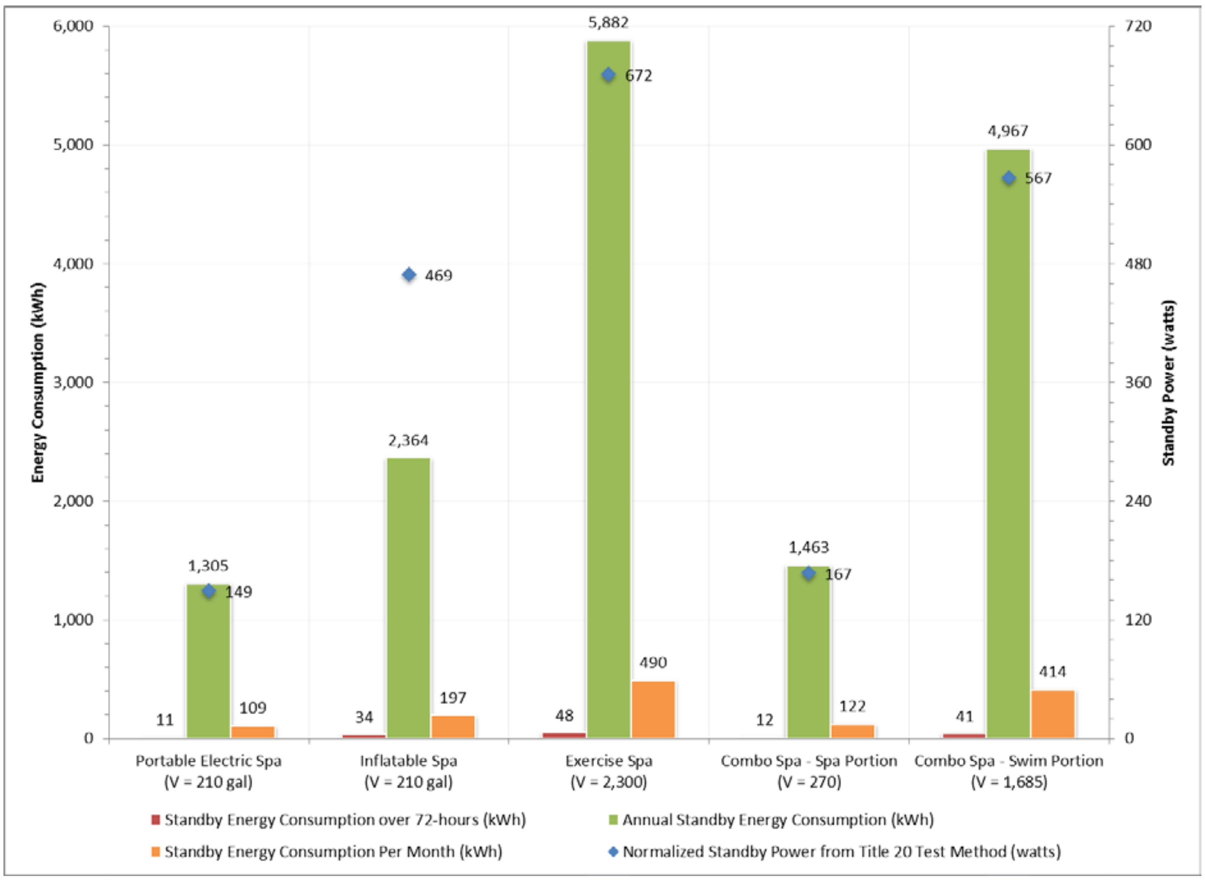
According to the 2003 and 2009 Residential Appliance Saturation Survey, an average of 38 percent of California spa owners did not own a spa cover.[159] Although most California spa owners have a spa cover, consumers need to be made aware that a spa cover is a key component to their system.

158 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/.
159 KEMA. (2010). *California Statewide Residential Appliance Saturation Study*. Retrieved from https://websafe.kemainc.com/RASS2009/Default.aspx. Includes outdoor in-ground and above-ground spas, indoor spas, spa owners, and spas in common areas.

## 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.[160] **Figure 11-14** compares the energy consumption over a 72-hour period, over a month, and over a year, based on the normalized standby power determined in the test procedure for four types of spas. (See **Appendix B** for calculations.) Again, the startup mode can take anywhere from 5 to 36 hours (See the Heating System section on page 76) and uses more power than during standby mode to reach the designated temperature. Thus, consumers are more likely to run the spa on standby mode rather than turning the spa off and on to save time, water, and energy. Therefore, the measured power (defined as the total energy use during the test divided by the length of the test) is the best representation of spa usage since most spas are operated in standby mode longer than startup mode.

**Figure 11-14: Energy Consumption Comparison across Different Portable Electric Spas**




**Note: The annual energy consumption for inflatable spas is based on a seasonal use of seven months per year. The annual energy consumption is averaged over 12 months resulting in the per month energy consumption. (See Appendix B for calculations.)**

Source: MAEDBS, Staff Assumptions, and Intex's Docketed Test Report (15-AAER-02 TN 212386)

160 California Energy Commission, *2015 Appliance Efficiency Regulations*. Title 20, Section 1604(g)(2). May 2014.

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 to get an accurate reading of the water temperature, to prevent possible freezing in the pipes, or to prevent bacterial growth in the pipes if left stagnant. The constant filtration cycle uses the pumps to continuously circulate water, providing filtration and preventing bacterial growth.[161] Hamill's results, shown in **Table 11-1**, 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,[162] typical of a portable spa.

**Table 11-1: Percentage 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 11-1 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 185 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.

161 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.
162 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.

# 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.[163] 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.

## 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.[164] 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 2014 requires a more stringent standby power limit of [3.75 x $Volume^{2/3}$ +40] for spas and a standby power limit of [5 x $Volume^{2/3}$] for exercise spas. The standard provides specific testing requirements for exercise spas and combination spas. In addition, the standard requires labels on all spas to include information on spa volume, standby power, the maximum standby power allowed, total annual consumption in standby mode, annual standby energy cost, specified cover manufacturer, specified cover model number, spa manufacturer, and spa model number. The label will be printed on a removable adhesive-backed label and must remain adhered to the spa until point of sale to the consumer. Lastly, the standard requires all testing laboratories to be qualified by an accredited certification body to ensure the testing facility, testing equipment, and personnel are able to perform the tests in the standard.[165] The ANSI/APSP/ICC-14 standards represent best industry practice but are not mandatory or enforced.

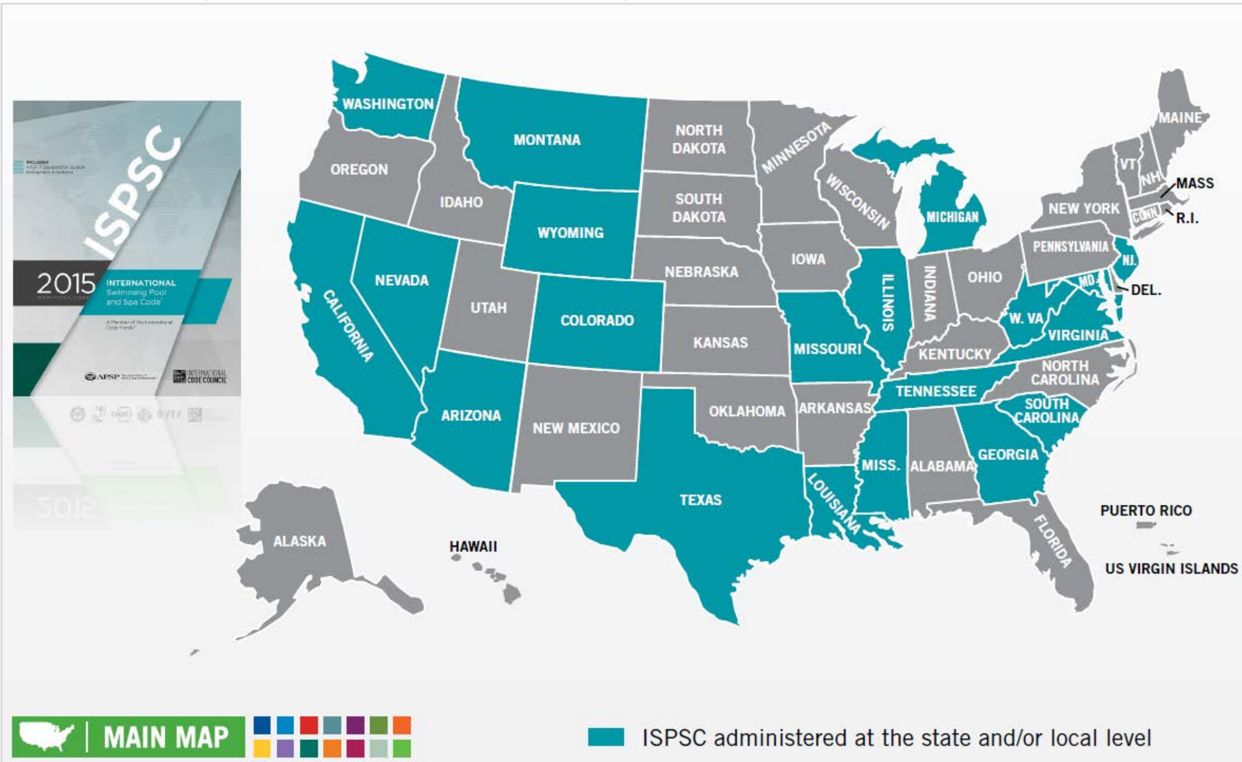
The 2015 International Swimming Pool and Spa Code (ISPSC) and the 2015 International Energy Conservation Code (IECC) developed by the International Code Council (ICC) adopted the energy

163 California Energy Commission, *2015 Appliance Efficiency Regulations*. Title 20. May 2014.
164 APSP, American National Standards Institute. (2014). American National Standard for Portable Electric Spa Energy Efficiency. Alexandria: APSP.
165 APSP, American National Standards Institute. (2014). American National Standard for Portable Electric Spa Energy Efficiency. Alexandria: APSP.

consumption requirements of ANSI/APSP/ICC-14 2011.[166] The 2018 version of ISPSC will be updated to match the language of ANSI/APSP/ICC-14 2014.[167]

As of May 2017, the International Swimming Pool and Spa Code is in use or adopted in local governments and/or statewide in 21 states and the District of Columbia (**Figure 12-1**), and the International Energy Conservation Code is in use or adopted in all states (except California and Indiana), the District of Columbia, Puerto Rico, and the U.S Virgin Islands.[168]

**Figure 12-1: International Swimming Pool and Spa Code Adoption Map**




Source: International Code Council

166 2012 and 2015 International Swimming Pool and Spa Code, available at http://codes.iccsafe.org/app/book/content/PDF/2012%20International%20Codes/ISPSC/Chapter%2011-Referenced%20Standards.pdf and http://codes.iccsafe.org/app/book/content/2015-I-Codes/2015%20ISPSC%20HTML/Chapter_3.html.

167 Scott Younker, *Spa Efficiency Standard Calls for Labeling* ( May 5,2015) available at http://www.poolspanews.com/how-to/codes/spa-efficiency-standard-calls-for-labeling_o.

168 International Codes- Adoption by State list, available at http://www.iccsafe.org/international-code-adoptions/ .

## Other State Approaches

Oregon, Connecticut, Washington, and Arizona require portable electric spas to meet the same requirements as California's current efficiency standards in Title 20, Section 1605.3.[169,170,171, 172]

## 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.[173] In May 2014, they submitted a revised proposal for portable electric spa standards.[174] 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.

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169 Appliance Standards Awareness Project, Portable Electric Spas (2017), Retrieved from https://appliance-standards.org/product/portable-electric-spas.

170 Connecticut General Assembly. Chapter 298, Title 16, Section 16a-48. Retrieved from http://search.cga.state.ct.us/dtsearch_pub_statutes.html.

171 Washington State Legislature. Title 19, Chapter 19.260, Section 19.260.040. Retrieved from http://app.leg.wa.gov/RCW/default.aspx?cite=19.260.040.

172 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.

173 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.

174 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

State standards for four 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 both the February 18, 2016, and the July 13, 2016, staff workshops 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.

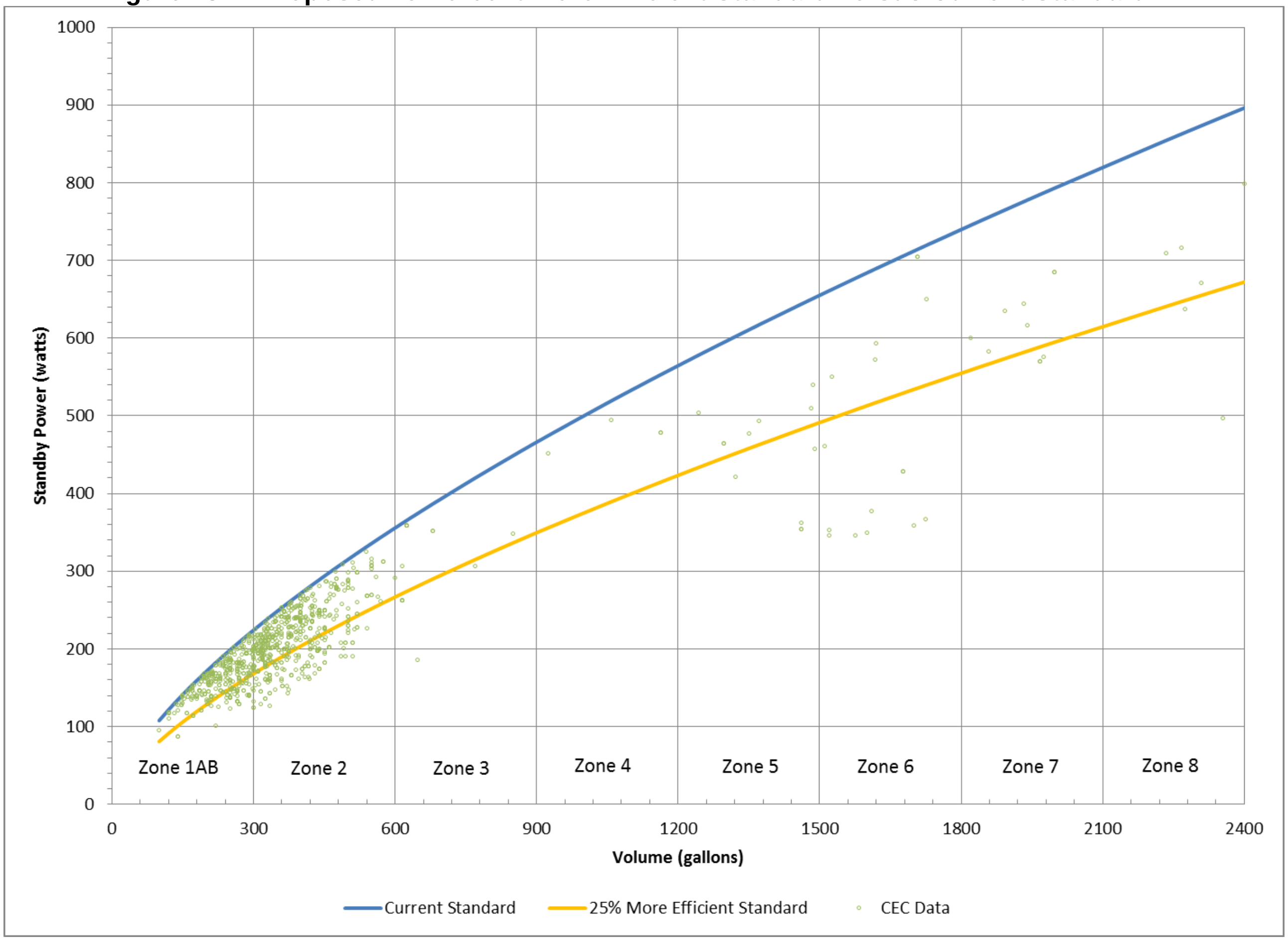
## Alternative 2: 25 Percent More Efficient Standby Standard, Modified Test Procedure, Spa Cover Reporting, and Spa Unit Labeling

Alternative 2 would establish a more stringent energy consumption standard for portable electric spas (including exercise spas, combination spas, and inflatable spas), modify the current Title 20 test procedure, add requirements for specific effective spa covers, and add a labeling requirement to provide consumers with tools for informative purchases. Specifically, the proposal recommends the following:

- Portable electric spas would maintain the existing broad definition that includes traditional, storable/inflatable, exercise, and combination spas.
- Spas would be made more efficient by lowering the standby power consumption limit by 25 percent. The current standard of [$5xV^{2/3}$] would be changed to [($3.75xV^{2/3}$)] for all types of portable electric spas.
- The current Title 20 test method would be modified by adding testing requirements for exercising spas and combination spas. The water temperature for exercise spas and the swim portion of combination spas shall be at least the maximum water temperature available on the unit but no greater than 102°F (±2°F) and no less than 87°F (±2°F) for the duration of the test. For combination spas, each reservoir will be powered on simultaneously and heated to the appropriate temperature for the entire duration of the test.
- 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. For combination spas, clarify that each reservoir or spa side shall be labeled appropriately.
- The model number of the spa cover used during testing shall be reported to MAEDBS.

This proposal presents a significant opportunity for energy savings. However, more than 75 percent of portable electric spas currently in the database would not meet this proposed standard (**Figure 13-1**). The proposed standard treats all spas equally, providing no relief to smaller spas. That is, both a spa with a volume of 200 gallons and a spa with a volume of 1,600 gallons will need to be 25 percent more efficient. Larger spas have more energy-saving opportunities than smaller spas through the design, controls, and insulation. Achieving 25 percent efficiency would dramatically increase incremental costs. Staff believes this proposal is not cost-effective and not technically feasible.

**Figure 13-1: Proposed 25 Percent More Efficient Standard versus Current Standard**




Source: MAEDBS, California Energy Commission

## Alternative 3: Moderate Standby Standard, Industry Accepted Test Procedure, Spa Cover Reporting, and Spa Unit Labeling

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/inflatable, exercise, and combination spas.
- Definitions would be added for standby mode, exercise spa, combination spa, rated capacity, and rated volume to elaborate the scope and to provide clarity.
- 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 new test method, with the following clarifications. For combination spas, each reservoir will be powered on simultaneously and heated to the appropriate temperature, according to the test procedure, for the entire duration of the test.
- 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 volume on the label shall represent the rated volume. For combination spas, clarify that each reservoir or spa side shall be labeled appropriately.
- New data submittal requirements in Section 1606(a)(3)(c) Table X , or data reported to MAEDBS, will include most of the label descriptors and data needed to validate the efficiency of the portable electric spas. These new requirements include the spa cover manufacturer, spa cover model, rated volume, fill volume, and normalized standby power for each type of portable electric spa. Other informative data submittal requirements will include voltage, rated capacity, and whether both the spa cover and the spa enclosure are insulated.

This alternative 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 proposal also provides 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 the scope of the existing, technology-neutral standard. 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, plus Alternative 3

Staff considered another 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 heating function of the unit 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).[175]

However, creating a design requirement could be an opportunity for a manufacturer of any spa type (traditional, 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 2019 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.[176] If any have survived, these products have been noncompliant to a standard that was effective since 2006 and should have been certified before selling 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 2019 of zero GWh, reintroducing these products without any design or performance requirements would offset the targeted first-year savings of 11.7 GWh through the other portable electric spas by more than 35 GWh (as detailed in **Appendix B**). Adding a design requirement would still introduce 17 GWh of energy usage in the first year, which results in an approximate statewide net addition of more than 5 GWh in the first year.

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

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

As an example, a $374[177] inflatable spa that operates continuously at 506 W[178] during standby mode with the design requirement, at a cost of $0.1619 per kWh, is estimated to have a monthly cost of $59 during seasonal use, or $34 a month when averaged over a year (detailed in **Appendix B**). The operating cost per season (seven months of the year) would be more than the full price of the 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 alternative would reintroduce an inefficient appliance to the market and in doing so increase energy consumption statewide; staff believes that it is not a viable proposal for efficiency standards.

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177 Amazon.com. https://www.amazon.com/s/ref=nb_sb_noss?url=search-alias%3Daps&field-keywords=Intex+77+Pure+Spa April 6, 2017.

178 Intex Inflatable Portable Electric Spa Test Report, submitted by IAPMO EGS, Docket 15-AAER-02 TN 212386, July 16, 2016.

# 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 with some clarifications, 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, 2019, or one year from the adoption date, whichever is later.

Based on independent analysis of the best available data, staff concludes 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/inflatable, 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 8.2 of the test procedure. A uniform standby consumption limit will be applied to all portable electric spa types. Combination spas and exercise spas are addressed separately in the test procedure to ensure that the lowered temperature is reflected in the test results.

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.[179]

179 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 [(3.75x$V^{2/3}$) + 40].

Changing the standby power limit from [5x$V^{2/3}$] 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 will tighten the standard on larger spas while providing some relief to smaller spas, a concern that the industry had with the existing standard.[180]

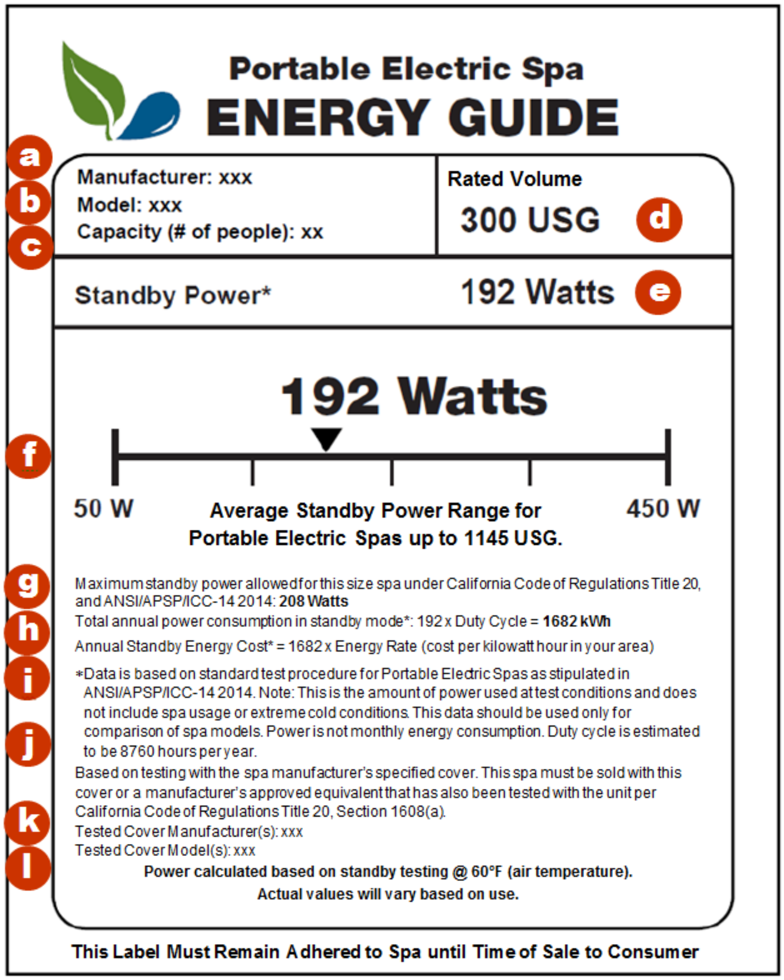
## Labeling Requirements

The label shall meet the design and specifications 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 be removed only by the consumer.[181]

Staff proposes using a continuous label rather than a categorical 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 or categories that progress from least efficient to most efficient or most energy-consuming to least energy-consuming. A continuous label uses a performance bar or line scale that allows consumers to see where the unit fits into the range of similar models. The CASE team collaborated with the APSP-14 committee and designed a spa energy label similar to the example shown in **Figures 14-1** and **14-2**, which are staff's modified versions.[182] The standby power scale for portable electric spas will have a range from 50 watts to 450 watts, whereas, the standby power scale for exercise spas will have a range from 100 watts to 750 watts. Combination spas would bear two labels, one for each portion of the spa (exercise and portable). See **Chapter 18** for label specifics.

180 Worth, C., and G. Fernstrom. (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.
181 APSP, American National Standards Institute. (2014). *American National Standard for Portable Electric Spa Energy Efficiency*. Alexandria: APSP.
182 Worth, C., and G. Fernstrom. (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**

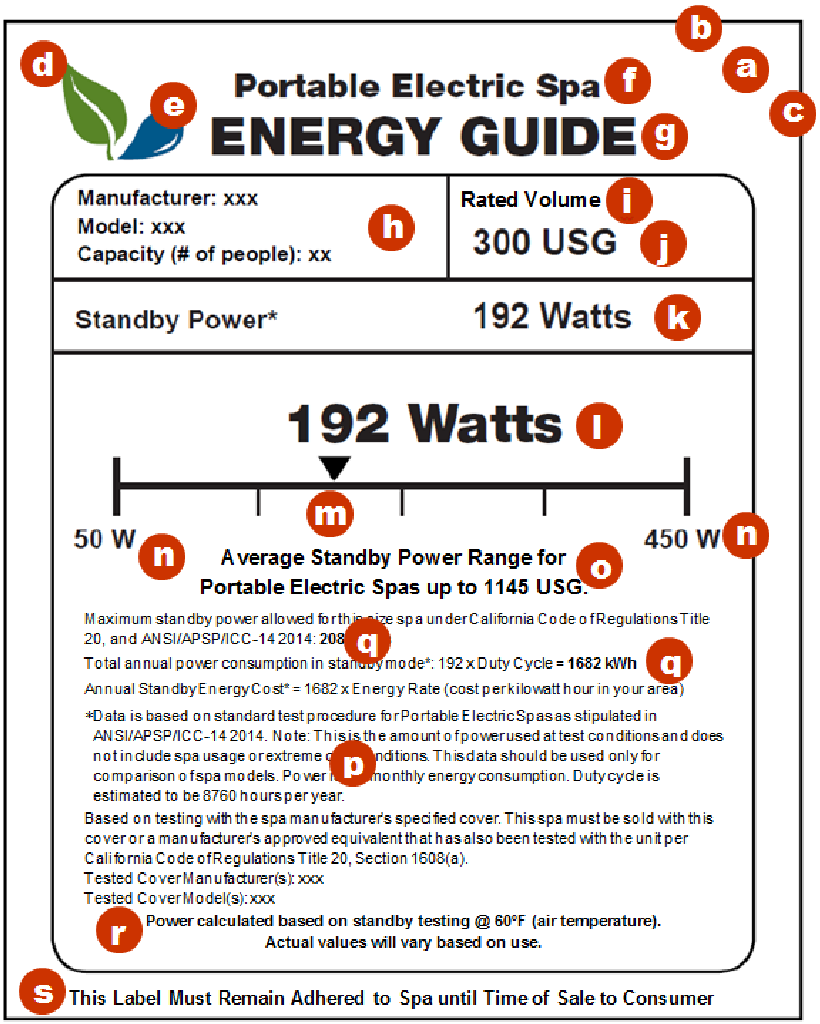



Source: Modified from Figure 7.2 in ANSI/APSP/ICC-14 2014

Codes:

a. Spa manufacturer
b. Spa model number
c. Spa capacity (number of people)
d. Spa rated volume
e. Tested standby power
f. Standby power scale, chart arrow location, and tested standby power value
g. Maximum standby power allowed
h. Total annual power consumption in standby mode
i. Total annual power consumption in standby mode for the annual standby energy cost formula
j. Duty cycle
k. Specified cover manufacturer
l. 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; text shall state: Portable Electric Spa or Portable Electric Exercise Spa

g. Font: Helvetica Neue Black; character height shall not be less than 24 pt type; text shall state the following: ENERGY GUIDE
h. Font: Arial Bold; character height shall not be less than 9.5 pt type; text shall state the following and be modified accordingly to Section 1607(d)(15)(B)(1):

    Manufacturer: [name of manufacturer]
    Model: [model number]
    Capacity (# of people): [number of people]

i. Font: Arial Bold; character height shall not be less than 9.5 pt type; text shall state the following: Rated Volume
j. Font: Arial Bold; character height shall not be less than 16 pt type; text shall state the following and be modified accordingly to Section 1607(d)(15)(B)(1): [rated volume value] USG
k. Font: Arial Bold; character height shall not be less than 16 pt type; text shall state the following and be modified accordingly to Section 1607(d)(15)(B)(1): Standby Power* [tested standby power value]
l. Font: Helvetica Neue Black; character height shall not be less than 24 pt type; text shall state the following and be modified accordingly to Section 1607(d)(15)(B)(1): [tested standby power value] Watts
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 450 watts for portable electric spas. The minimum standby power shall be 100 watts and the maximum standby power shall be 750 watts for exercise spas.
n. Font: Arial Bold; Character height shall not be less than 12 pt type.
o. Font: Arial Bold; character height shall not be less than 9.5 pt type; for portable electric spa labels, the text shall state "Average standby Power Range for Portable Electric Spas up to 1145 USG."; for exercise spas, the information shall state "Average standby Power Range for Exercise Spas up to 2605 USG."
p. Font: Arial. Character height shall not be less than 8 pt type, and may be horizontally scaled to no less than 85 percent; text shall state the following and be modified accordingly to Section 1607(d)(15)(B)(1):

    Maximum standby power allowed for this size spa under California Code of Regulations Title 20, and ANSI/APSP/ICC-14 2014: [maximum standby power value] Watts
    Total annual power consumption in standby mode*: [tested standby power value] x Duty Cycle = [total annual power consumption value] kWh
    Annual Standby Energy Cost* = [total annual power consumption value] x Energy Rate (cost per kilowatt hour in your area)
    *Data 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. Th data should be used only for comparison of spa models. Power is not monthly energy consumption. Duty cycle is estimated to be [duty cycle value] hours per year.

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 per California Code of Regulations Title 20, Section 1608(a).
Tested Cover Manufacturer(s): [name of manufacturer]
Tested Cover Model(s): [cover model number]

q. The format for the maximum standby power value and total annual power consumption is the following: Font: Arial Bold; Character height shall not be less than 8 point type, and may be horizontally scaled to no less than 85 percent.
r. Font: Arial Bold; character height shall not be less than 8 point type, and may be horizontally scaled to no less than 85 percent. The text shall state the following: "Power calculated based on standby testing @ 60°F (air temperature). Actual values will vary based on use."
s. Font: Arial Bold; Character height shall not be less than 8 pt type, and may be horizontally scaled to no less than 85 percent. The text shall state the following: This Label Must Remain Adhered to Spa until Time of Sale to Consumer.

## Spa Cover Labeling and Reporting Requirements

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.

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, reinforcing Section 1608(a)(3). 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 most recent spa unit-cover combination that yielded the maximum energy consumption, and 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 to the consumer. 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.[183] However, any cover (manufacturer's, 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).

183 Worth, C., and G. Fernstrom. (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.

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.[184] 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.[185]

184 Western Area Power Administration. (2009). "What Goes Into an Energy-Efficient Spa or Hot Tub?" Lakewood: Western Area Power Administration.
185 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, exercise spas, and combo 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 the structure of the unit, 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 roughly two times[186] more expensive than traditional portable electric spas,[187] an assumed incremental cost of $230 will be used for these units.[188]

186 Purch. (2017). The Best Swim Spas of 2017. Retrieved May 8, 2017, from Top Ten Reviews : http://www.toptenreviews.com/home/outdoor/best-swim-spas/.

187 Bullfrog Spas. (2014). How much does a hot tub cost? Retrieved May 8, 2017, from Bullfrog Spas: http://www.bullfrogspas.com/blog/how-much-do-hot-tubs-cost/.

188 Median cost of exercise spa is $15,000 and median cost for mid-tier spas is $6,500, resulting in a ratio of 2.3.

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

| Source | Incremental Cost | |
|---|---|---|
| Pope, Rainer, Fernstrom, & Eilert, 2002 | $750 | |
| Davis Energy Group, Energy Solutions, 2004 | **Measure** | **Incremental Cost** |
| | Improved Cover | $100 |
| | Improved Spa Insulation | $200 |
| | Improved Motor Configurations and Efficiency | $300 |
| | Improved Controls | $50 |
| | Total | $650 |
| Douglas Mahone & Heschong Mahone Group Inc., 2005 | $300 | |
| Nadel, deLaski, Eldridge, & Kleisch, 2006 | $100 for portable electric spas | |
| Staff assumption based on price difference between product types in 2016 | $230 for exercise and combination spas | |

Source: Modified from CASE report table[189]

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, staff has estimated the per label cost to be $0.38 per label for single reservoir portable electric spas and $2.50 for combination spas.[190] Details of this estimate are shown in **Table 15-2**.

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189 Worth, C., and G. Fernstrom. (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.

190 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 and Exercise Spa Manufacturers | 46 | Manufacturers |
| Number of Combo Spa Manufacturers | 5 | Manufacturers |
| **Total Set-up Cost Statewide for Spas & Exercise Spas** | **$ 81,622** | Dollars |
| **Total Set-Up Cost Statewide for Combo Spas** | **$ 8, 872** | Dollars |
| **Material Cost** | | **Units** |
| 2019 Stock | 609,479 | Units |
| 2019 Spa & Exercise Spa Stock | 605,039 | Units |
| 2019 Combo Spa Stock | 4,439 | Units |
| Printing Costs for Spas & Exercise Spas | $ 0.22 | Dollars/Label |
| Printing Costs for Combo Spas | $ 0.44 | Dollars/Label |
| **Total Printing Costs to Label Spa & Exercise Spa Stock** | **$ 133,109** | Dollars |
| **Total Printing Costs to Label Combo Spa Stock** | **$ 1,953** | Dollars |
| **Labor Costs to Apply Label** | | **Units** |
| Time to Adhere Each Label | 8 | Seconds |
| Time to Adhere Each Label to a Combo Spa | 16 | Seconds |
| Total Time to Adhere Label to Spa & Exercise Spa Stock | 1,345 | Hours |
| Total Time to Adhere Label to Combo Spa Stock | 19.7 | Hours |
| Packaging and Filling Machine Operators Hourly Wage | $ 13.44 | Dollars/Hour |
| **Total Labor Costs for Spa & Exercise Spa Stock** | **$ 18,071** | Dollars |
| **Total Labor Costs for Combo Spa Stock** | **$ 265** | Dollars |
| **Total** | | **Units** |
| **Total Cost to Label Spa & Exercise Spa Stock** | **$ 232,802** | Dollars |
| **Total Cost to Label Combo Spa Stock** | **$ 11,091** | Dollars |
| Label Cost per Spa/Exercise Spa Unit | $ 0.38 | Dollars/Label |
| Label Cost per Combo Spa Unit | $ 2.50 | |

Source: Staff calculation using information from Portable Electric Spas CASE Report 2014

## Standby Power Efficiency Savings

As summarized in **Table 15-3**, if all portable electric spas complied with the proposed standards (annual stock turnover savings), California would save about 63 GWh of energy per year. Using a residential rate of $0.1855 per kWh of electricity,[191] implementation of the proposed standards for portable electric spas would achieve an estimated $10 million a year in reduced utility costs after full implementation. Exercise spas contribute 18.3 GWh of energy savings per year and $3.4 million per year in reduced utility costs after full implementation. Combo spas contribute 4.2 GWh of energy savings per year and $0.8 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 underrepresent the actual energy savings, as the only data used were from the 74 exercise spas certified in MAEDBS.

**Table 15-3: 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 | 3.3 | 0.61 | 40.3 | 7.4 |
| Exercise Spas | 1.5 | 0.28 | 18.3 | 3.4 |
| Combo Spas | 0.3 | 0.06 | 4.2 | 0.8 |
| **Total** | **5.1** | **0.95** | **62.8** | **11.6** |

Source: Staff calculation; see Appendix B

191 Energy Information Administration – Residential electricity prices for 2017 through February 2017, retrieved May 4, 2017. http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_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.[192] 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.[193]

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. 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.[194] **Tables 15-4 and 15-5** present the savings when applying the 5 percent savings assumed by affixing a label to portable electric spas.[195]

Life-cycle costs and benefits of the proposed standard for portable electric spas, exercise spas, and combo spas are shown in **Table 15-4**. 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.

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192 California Energy Commission. (2015). "Modernized Appliance Efficiency Database System." Retrieved from Appliance Search: http://maedbs/Pages/ApplianceSearch.aspx.
193 Worth, C., and G. Fernstrom. (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.
194 Bertoldi, Paolo. *Energy Efficient Equipment Within SAVE: Activities, Strategies, Success and Barriers*. Brussels: European Commission, 2000.
195 "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 15-4: 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 | 307 | $ 100.38 | $ 569 | 6 |
| Exercise Spas | 10 | 1,426 | $ 230.38 | $ 2,645 | 11 |
| Combo Spas | 10 | 1,612 | $ 232.50 | $ 2,991 | 13 |

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.

**Table 15-5: 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 | 4.4 | 0.82 | 52.5 | 9.7 |
| Exercise Spas | 2.0 | 0.37 | 23.9 | 4.4 |
| Combo Spas | 0.5 | 0.09 | 5.5 | 1.0 |
| **Total** | **6.9** | **1.28** | **81.9** | **15.1** |

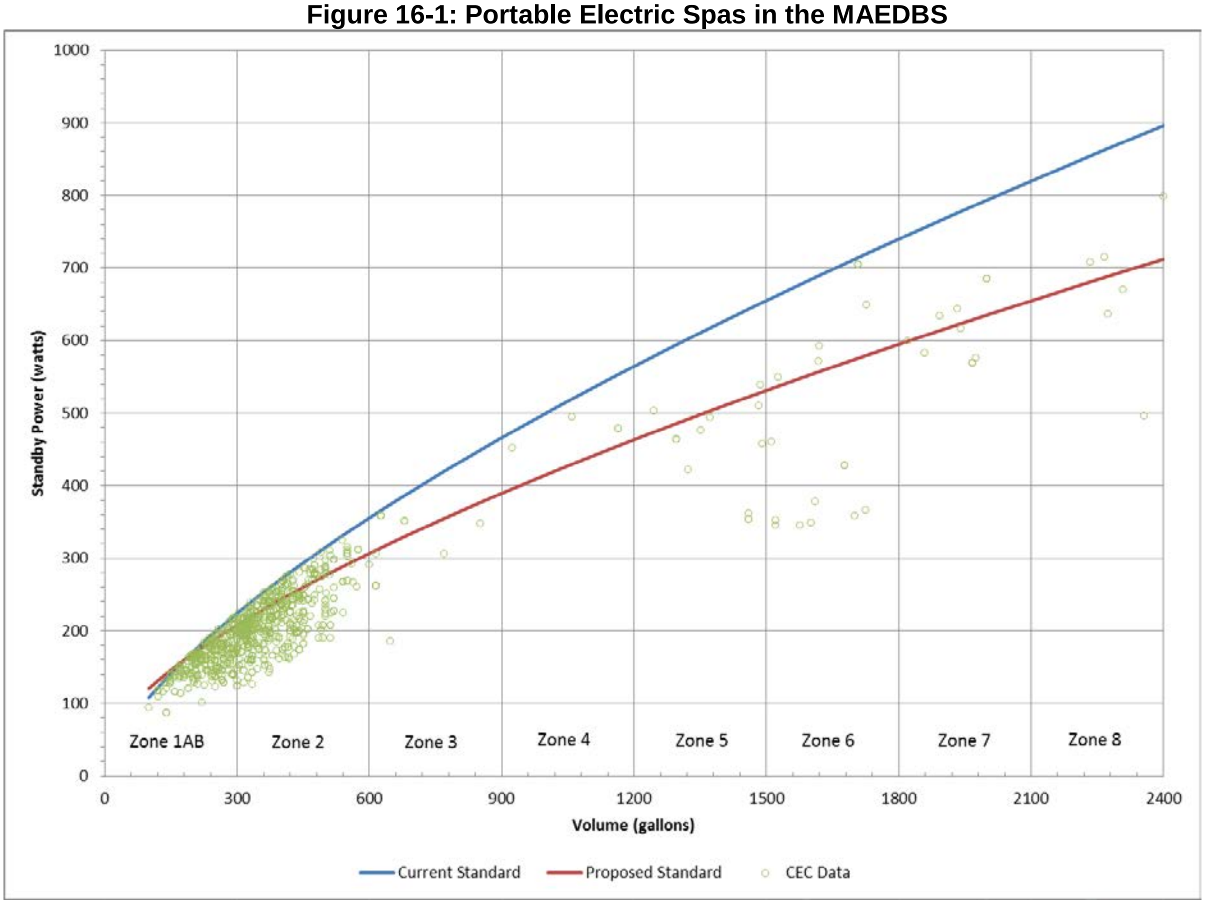
Source: Staff calculation; see Appendix B

# CHAPTER 16: Technical Feasibility

As of March 2017, the Energy Commission database lists 1,334 portable electric spas, more than 75 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 to make 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. The data points below the red curve are portable electric spas that would comply with the proposed standard.

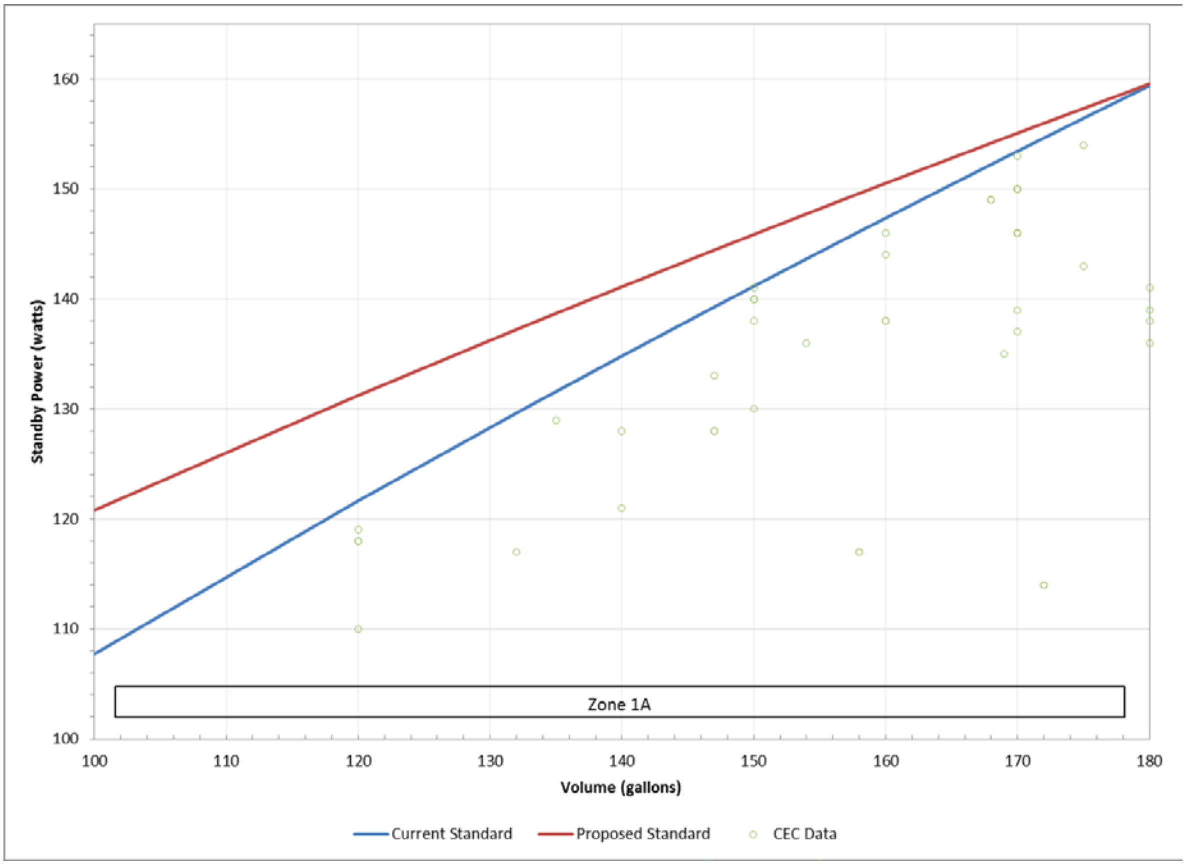
**Figure 16-1: Portable Electric Spas in the MAEDBS**




Source: MAEDBS, California Energy Commission

In addition, as **Figure 16-2** demonstrates, the proposed standard will provide a modest relief to smaller spas ranging from 100 gallons to 180 gallons. This is the point to the left where the proposed standard curve and the current standard curve intersect, providing slightly greater standby allowance for small spas.

**Figure 16-2: Portable Electric Spas in Zone 1A**




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.

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

| | Zones | Compliant (%) | Noncompliant (%) |
|---|---|---|---|
| Portable Spas | 1AB to 3 | 79 | 21 |
| Exercise Spas | 4 to 8 | 58 | 42 |
| Combo Spas | - | 43 | 57 |
| All Certified Units | | 77 | 23 |

Source: MAEDBS, California Energy Commission

Using the same test temperature under the existing Title 20 test method, 42 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 percent, providing a path for compliance.

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.

## 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.[196]

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.[197]

## Spa Covers

Improvements to spa covers, such as using high R-value and less water-absorbent insulation, adding radiant barriers, and using better sealing covers, can reduce heat and water loss from the spa and already exist in the industry. Improving the construction and design work of the spa cover, such as using single-hinged or insulated hinge covers instead of double-hinged, can yield additional efficiency savings.[198]

## 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.[199] 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.[200]

196 Davis Energy Group, Energy Solutions. (2004). *Analysis of Standards Options for Portable Electric Spas*. California: PG&E.
197 Worth, C., and G. Fernstrom. (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.
198 Ibid.
199 Ibid.
200 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.

# 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.

"Rated capacity" means the number of people capable of fitting in a portable electric spa as specified by the manufacturer.

"Rated volume" means the water capacity of the portable electric spa, in gallons, as specified by the manufacturer on the spa, on the spa packaging, or the spa marketing materials.

"~~Spa~~ Fill volume" means the ~~actual fill volume~~ water capacity of the portable electric spa, in gallons, at the halfway point between the bottom of the skimmer opening and the top of the spa~~, under normal use, in gallons, as defined in the test method in Section 1604(g)(2)(B)~~. In the absence of a skimmer, the water capacity is six inches below the top of the spa.

"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) The test method for portable electric spas manufactured on or after January 1, 2019, is ANSI/APSP/ICC-14 2014, with the exception of Section 8.2.

(i) For combination spas, each reservoir shall be powered on, and the water temperature of the spa portion shall be a minimum of 100°F (38°C) and the water temperature of the exercise spa portion shall be a minimum of 85°F (29°C), for the duration of the test.

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)(AI)(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, 2019, 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 |

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

**Table X – Data Submittal Requirements**

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

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

**Section 1606(a)(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:

(j) for all portable electric spas manufactured on or after January 1, 2019, each portable electric spa is marked by the manufacturer with the tested spa cover model number, the tested spa cover manufacturer, with the statement "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 per California Code of Regulations Title 20, Section 1608(a)," and complies with the labeling requirements of Section 1607(d)(15). If the portable electric spa has been tested with multiple spa covers, the label shall display the most recent spa unit-cover combination that yielded the maximum normalized standby power test result obtained in accordance with Section 1605.3(g)(6)(B). The label shall be removed only by the consumer.

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 |

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Alexandria, VA 22314-4695
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**Section 1607(d) Energy Performance Information.**

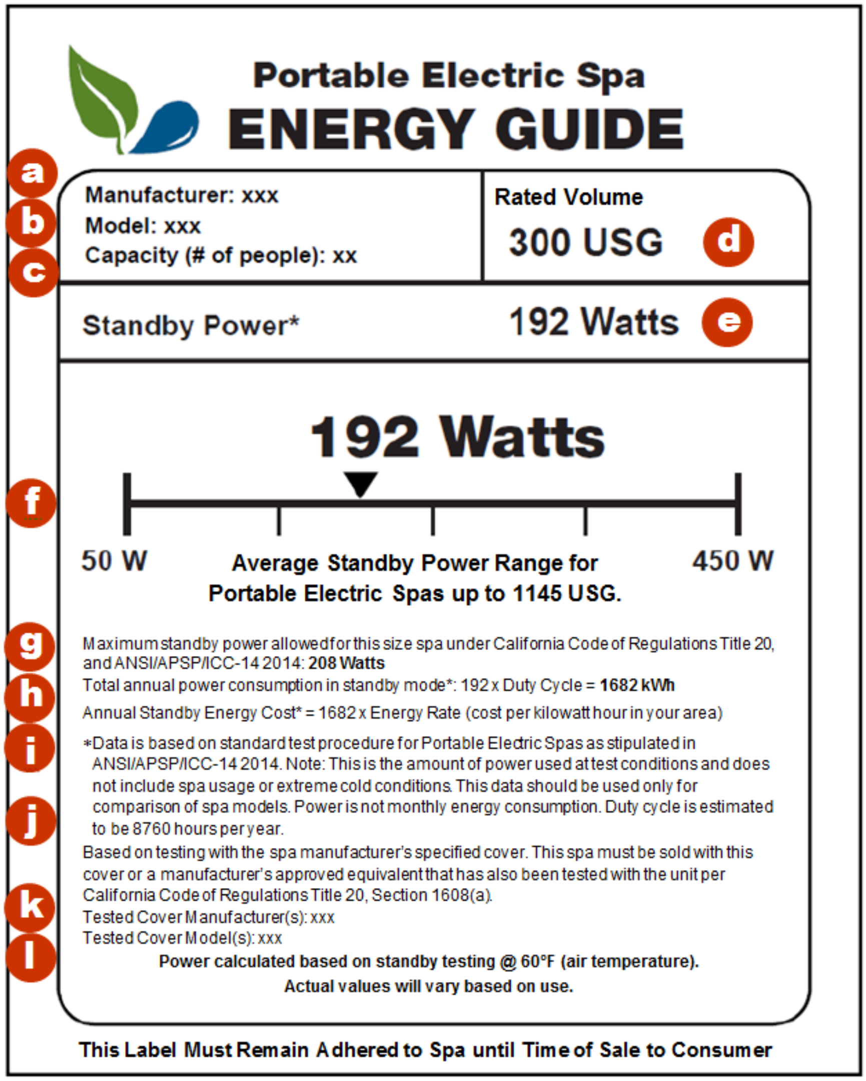
**(15) Portable Electric Spas**

(A) Portable electric spas manufactured on or after January 1, 2019, shall be marked by the manufacturer in a readily visible location on the shell or front skirt panel. The marking shall be removed only by the consumer.

(B) The label shall conform to the design specifications listed in Section 1607(d)(15)(B)(1) through Section 1607(d)(15)(B)(6). 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).

1. **Label Design.** The label shall contain the following model specific information as shown in Figure 1 and as described in Section 1607(d)(15)(B)(2).

Figure 1

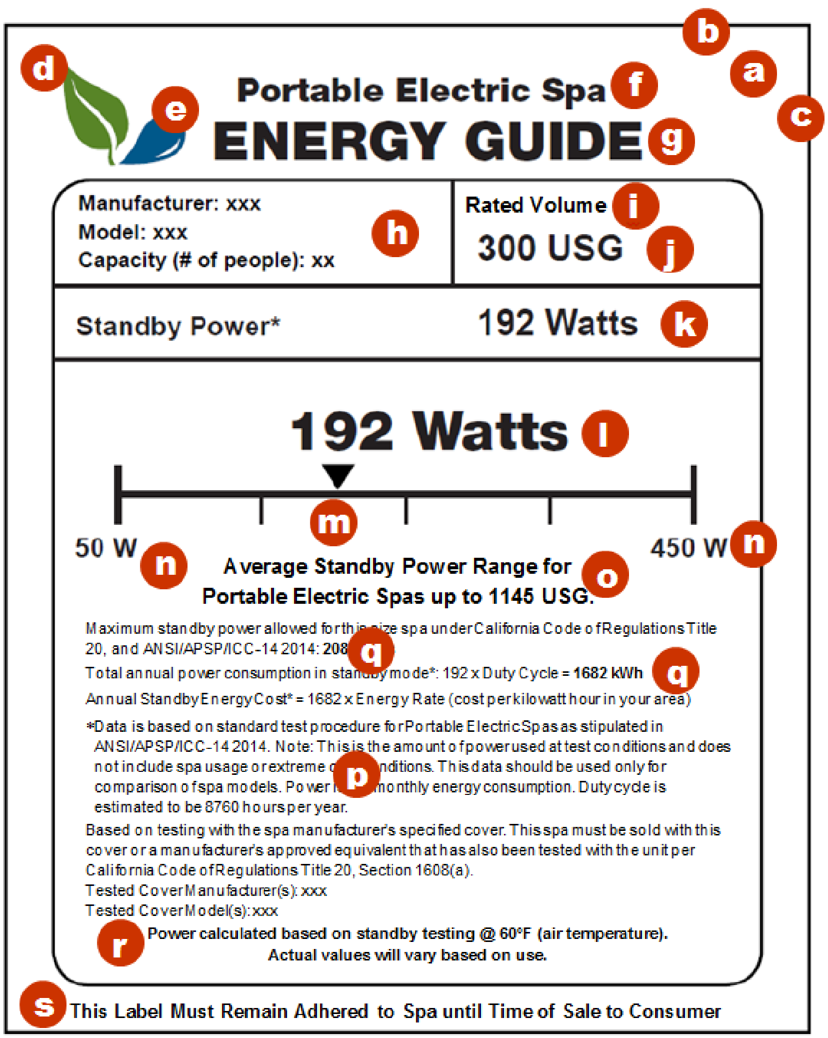



2. Letter codes for Figure 1 in Section 1607(d)(15)(B)(1):
   a. Spa manufacturer
   b. Spa model number
   c. Spa capacity (number of people)
   d. Spa rated volume
   e. Tested Standby power
   f. Standby power scale, chart arrow location, and tested standby power value
   g. Maximum standby power allowed
   h. Total annual power consumption in standby mode

i. Total annual power consumption in standby mode for the annual standby energy cost formula
j. Duty cycle
k. Specified cover manufacturer
l. Specified cover model

3. **Label Specifications.** The label shall be formatted as shown in Figure 2 and as directed in Section 1607(d)(15)(B)(4).

Figure 2




4. Letter codes for Figure 2 in Section 1607(d)(15)(B)(3):

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. Text shall state the following: Portable Electric Spa or Portable Electric Exercise Spa.

g. Font: Helvetica Neue Black; character height shall not be less than 24 pt type. Text shall state the following: ENERGY GUIDE.

h. Font: Arial Bold; character height shall not be less than 9.5 pt type. Text shall state the following and be modified accordingly to Section 1607(d)(15)(B)(1):
Manufacturer: [name of manufacturer]
Model: [model number]
Capacity (# of people): [number of people]

i. Font: Arial Bold; character height shall not be less than 9.5 pt type. Text shall state the following: Rated Volume

j. Font: Arial Bold; character height shall not be less than 16 pt type. The text shall state the value of the rated volume in U.S. gallons and shall state the units of the rated volume.

k. Font: Arial Bold; Character height shall not be less than 16 pt type. The text shall state the following and be modified accordingly to Section 1607(d)(15)(B)(1): Standby Power* [tested standby power value]

l. Font: Helvetica Neue Black; character height shall not be less than 24 pt type. The text shall state the following and be modified accordingly to Section 1607(d)(15)(B)(1): [standby power value] Watts

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 450 watts for portable electric spas. The minimum standby power shall be 100 watts and the maximum standby power shall be 750 watts for exercise spas.

n. Font: Arial Bold; Character height shall not be less than 12 pt type.

o. Font: Arial Bold; Character height shall not be less than 9.5 pt type. For portable electric spa labels, the text shall state "Average standby Power Range for Portable Electric Spas up to 1145 USG." For exercise spas, the information shall state "Average standby Power Range for Exercise Spas up to 2605 USG."

p. Font: Arial; Character height shall not be less than 8 pt type, and may be horizontally scaled to no less than 85 percent. The text shall state the following and be modified accordingly to Section 1607(d)(15)(B)(1):
Maximum standby power allowed for this size spa under California Code of Regulations Title 20, and ANSI/APSP/ICC-14 2014: [maximum standby power value] Watts
Total annual power consumption in standby mode*: [tested standby power value] x Duty Cycle = [value] kWh
Annual Standby Energy Cost* = [total annual power consumption value] 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. Duty cycle is estimated to be [duty cycle value] hours per year.

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 per California Code of Regulations Title 20, Section 1608(a).
Tested Cover Manufacturer(s): [name of manufacturer]
Tested Cover Model(s): [cover model number]

q. The format for the maximum standby power value and total annual power consumption is the following: Font: Arial Bold. Character height shall not be less than 8 point type and may be horizontally scaled to no less than 85 percent.

r. Font: Arial Bold; Character height shall not be less than 8 point type, and may be horizontally scaled to no less than 85 percent. The text shall state the following: "Power calculated based on standby testing @ 60°F (air temperature). Actual values will vary based on use."

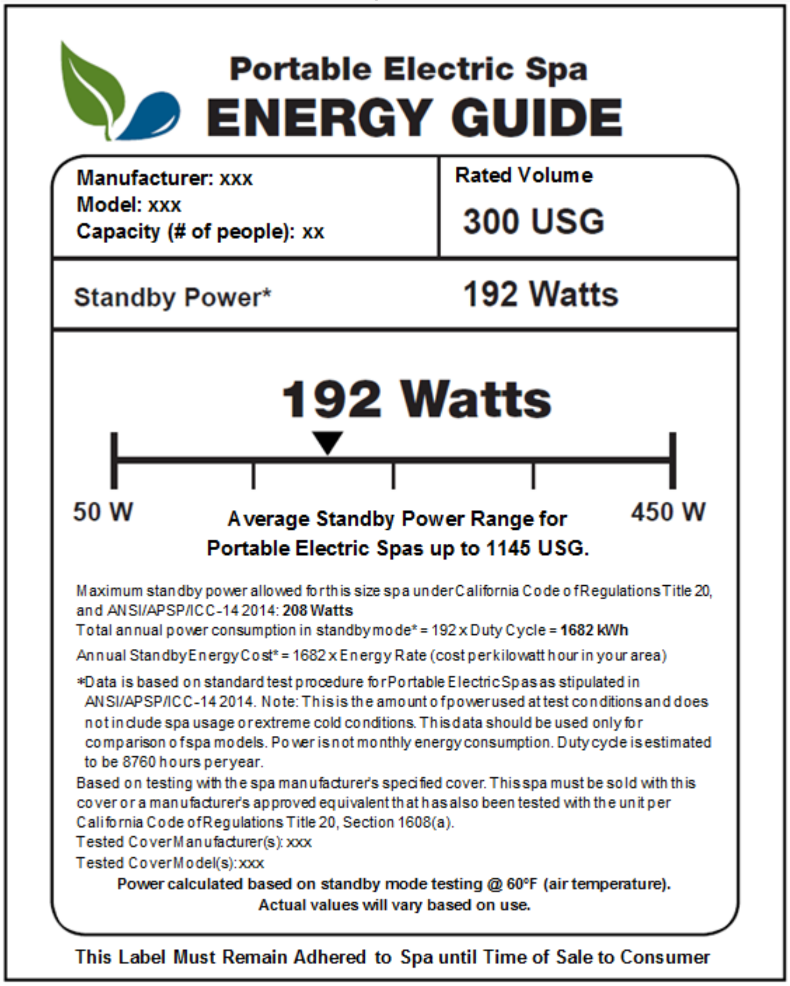
s. Font: Arial Bold; Character height shall not be less than 8 pt type, and may be horizontally scaled to no less than 85 percent. The text shall state the following: This Label Must Remain Adhered to Spa until Time of Sale to Consumer.

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

6. All adhesive labels should be applied so they can be easily removed without the use of tools or liquids, other than water, but should be applied with an adhesive with an adhesion capacity sufficient to prevent dislodgment during normal handling throughout the chain of distribution to the consumer.

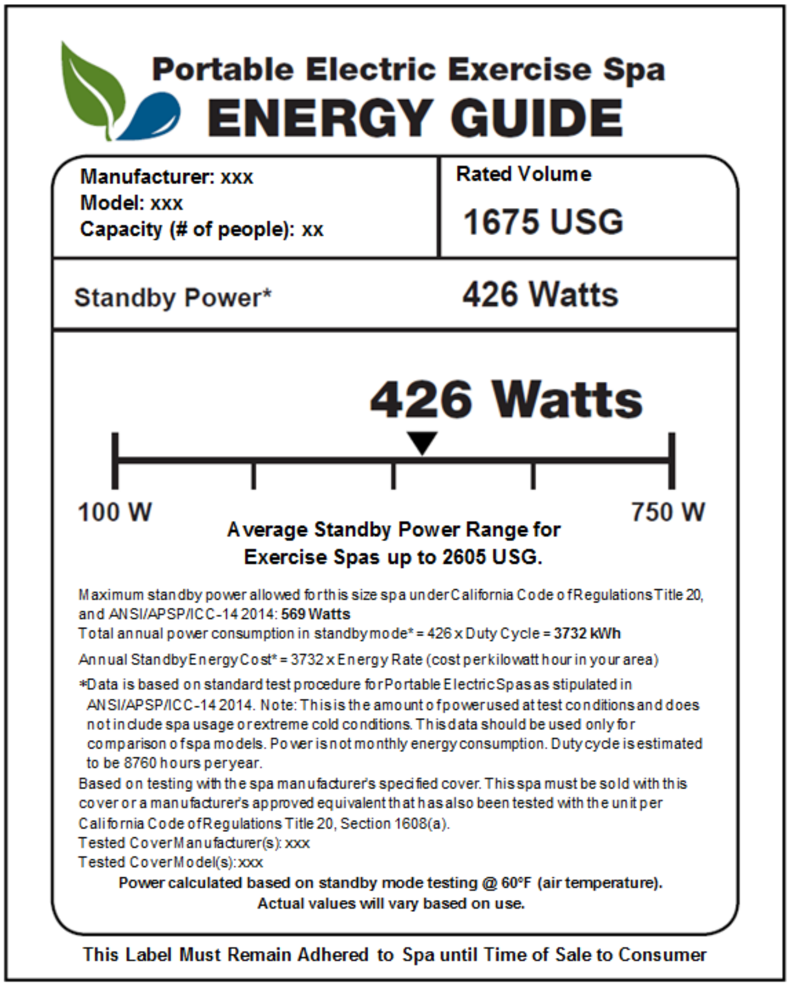
(C) **Labeling Template for Portable Electric Spas.** Labels must contain the statements as shown in Figure 3 and modified as directed in Section 1607(d)(15)(B)(1) through 1607(d)(15)(B)(4), shall be formatted as shown in Figure 3, and applied as directed in Section 1607(d)(15)(B)(5) through Section 1607(d)(15)(B)(6) for portable electric spas and for the portable electric spa portion of combination spas.

Figure 3




(D) **Labeling Template for Exercise Spas.** Labels must contain the statements as shown in Figure 4 and modified as directed in Section 1607(d)(15)(B)(1) through 1607(d)(15)(B)(4), shall be formatted as shown in Figure 4, and applied as directed in Section 1607(d)(15)(B)(5) through Section 1607(d)(15)(B)(6) for exercise spas and for the exercise spa portion of combination spas.

Figure 4



Portable Electric Exercise Spa
ENERGY GUIDE
Manufacturer: xxx
Model: xxx
Capacity (# of people): xx
Rated Volume
1675 USG
Standby Power*
426 Watts
426 Watts
100 W
750 W
Average Standby Power Range for Exercise Spas up to 2605 USG.
Maximum standby power allowed for this size spa under California Code of Regulations Title 20, and ANSI/APSP/ICC-14 2014: 569 Watts
Total annual power consumption in standby mode* = 426 x Duty Cycle = 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. Duty cycle is estimated to be 8760 hours per year.
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 per California Code of Regulations Title 20, Section 1608(a).
Tested Cover Manufacturer(s): xxx
Tested Cover Model(s): xxx
Power calculated based on standby mode testing @ 60°F (air temperature).
Actual values will vary based on use.
This Label Must Remain Adhered to Spa until Time of Sale to Consumer

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 |

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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, the respective 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: Residential Stock and Sales**

| Product | National Pump Shipments 2015 (Thou) | Percentage Pump Shipments to CA | CA Pump Shipments 2015 (Thou) | Pump Shipment Growth per Year (Thou) | CA Pump Shipments 2019 (Thou) | CA Repl. Motor Shipments (Thou) | CA Pump and Motors Total Stock 2019 (Thou) | CA Repl. Motor Total Stock 2019 (Thou) | Design Lifetime (years) |
|---|---|---|---|---|---|---|---|---|---|
| SP Pool Filter Pump, standard-size (1.90 hp) | 294 | 26.4% | 78 | 0.78 | 81 | 27 | 785 | 196 | 7.3 |
| SP Pool Filter Pump, standard-size (3.76 hp) | 294 | 26.4% | 78 | 0.78 | 81 | 27 | 785 | 196 | 7.3 |
| SP Pool Filter Pump, small-size (0.88 hp) | 76 | 26.4% | 20 | 0.20 | 21 | 7 | 203 | 51 | 7.3 |
| NSP Pool Filter Pump (1.04 hp) | 373 | 13.0% | 48 | 0.48 | 50 | 17 | 356 | 89 | 5.3 |
| Waterfall Pump (0.80 hp) | 10 | 26.4% | 2.6 | 0.03 | 2.7 | 0.92 | 26.7 | 6.7 | 7.3 |
| Pressure Cleaner Booster Pump (1.24 hp) | 129 | 26.4% | 34 | 0.34 | 35 | 12 | 250 | 62 | 5.3 |
| Total Pool Pump and Motors | 1,175 | | 260.6 | | 271 | 90 | 2,405 | 601 | |

Source: U.S. DPPP TSD data (Tables 3.5.4, 7.2.2 and 8.2.46) and staff calculation

**Table A-2 Commercial Stock and Sales**

| **Product** | **National Pump Shipments 2015 (Thou)** | **Percentage Pump Shipments to CA** | **CA Pump Shipments 2015 (Thou)** | **Pump Shipment Growth per Year (Thou)** | **CA Pump Shipments 2019 (Thou)** | **CA Repl. Motor Shipments (Thou)** | **CA Pump and Motors Total Stock 2019 (Thou)** | **CA Repl. Motor Total Stock 2019 (Thou)** | **Design Lifetime (years)** |
|---|---|---|---|---|---|---|---|---|---|
| SP Pool Filter Pump, standard-size (1.90 hp) | 15.45 | 26.4% | 4.08 | 0.04 | 4.24 | 1.41 | 41.30 | 10.32 | 7.3 |
| SP Pool Filter Pump, standard-size (3.76 hp) | 15.45 | 26.4% | 4.08 | 0.04 | 4.24 | 1.41 | 41.30 | 10.32 | 7.3 |
| SP Pool Filter Pump, small-size (0.88 hp) | 4.00 | 26.4% | 1.06 | 0.01 | 1.10 | 0.37 | 10.69 | 2.67 | 7.3 |
| Total Pool Pump and Motors | 35 | | 9 | | 10 | 3 | 93 | 23 | |

Source: U.S. DPPP TSD data (Tables 3.5.4, 7.2.2 and 8.2.46) and staff calculation

Staff relied upon data collected from DPPP manufacturers by the U.S. DOE and presented in the DPPP TSD. The U.S. DOE presents national shipments. Staff found shipments in California by multiplying the percentage of sales by the national sales. Staff projected the 2019 stock numbers by assuming a noncompounded growth rate of 1 percent per year to the 2015 stock numbers presented in the U.S. DOE TSD. The 1 percent growth rate is based upon the California population forecast increase of about 1 percent.[201]

Residential and commercial pool pumps and motors are separated for energy consumption calculations due to different duty cycles. The U.S. DOE assumed residential sales represented 95 percent of shipments, while commercial sales represented 5 percent of shipments. The values in the tables may show differences due to rounding. Staff maintained the unrounded values throughout the calculations.

Example: Self-priming pool filter pump total stock and sales calculation:

**Residential California Pump Shipments 2019**

$$P_{2015} = NP_{2015} \times 26.4\%$$

$$77{,}510 = 293{,}600 \times 0.264$$

Where:

$P_{2015}$ = California Pump Shipments in 2015

$NP_{2015}$ = National Pump Shipments in 2015

26.4% = The Percentage of Pumps Shipments to California

**Shipment Growth per Year**

$$G = 1\% \times P_{2015}$$

$$775 = 0.01 \times 77{,}510$$

Where:

G = Growth in Pump Shipments per Year

---

201 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.

1% = The Estimated Growth in Pump Shipments

$P_{2015}$ = California Pump Shipments in 2015

**California Pump Shipments 2019**

$$P_{2019} = P_{2015} + (G \times 4)$$

$$80{,}610 = 77{,}510 + (775 \times 4)$$

Where:

$P_{2015}$ = California Pump Shipments in 2015

$P_{2019}$ = California Pump Shipments in 2019

G = Growth in Pump Shipments per Year

**California Replacement Motor Shipments**

Staff chose to assume replacement motor shipments represent 25 percent of the total market. Therefore the U.S. DOE pump shipments represents 75 percent of the market (75%+25%=100%). 25 percent divided by 75 percent is equal to 1 divided by 3. Replacement motor shipments are found by dividing pump shipments by 3.

$$RM = P_{2019}/3$$

$$26{,}870 = 80{,}610/3$$

Where:

RM = Replacement Motor

$P_{2019}$ = California Pump Shipments in 2019

**California Pump and Motors Total Stock**

$$Stock_{Total} = (P_{2019} + RM) * DL$$

$$784{,}604 = (\ 80{,}610 + 26{,}870) * 7.3$$

Where:

$Stock_{Total}$ = Total Stock 2019

$P_{2019}$ = California Pump Shipments 2019

$RM$ = California Replacement Motor Shipments

$DL$ = Design Lifetime

**California Replacement Motor Total Stock 2019**

$$RM_{ts} = RM * DL$$

$$196{,}151 = 26{,}870 * 7.3$$

Where:

$RM_{ts}$ = California Replacement Motor Total Stock 2019

$RM$ = Replacement Motor Shipments

$DL$ = Design Lifetime

## Compliance Rates

Staff used the U.S. DOE TSD estimates for compliance to the proposed motor efficiency standards. The compliance rates were estimated based on the U.S. DOE DPPP TSD assuming an efficiency level as required to meet the minimum DPPP WEF score. Staff assumed 100 percent compliance with existing California Appliance Efficiency Standards. Therefore the compliance rate for standard size self-priming pool filter pumps was calculated as the total of EL0 through EL 2.[202] **Table A-4** lists current compliance rates for the proposed standards.

202 U.S. Department of Energy, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps, December 2016, Table 9.3.3, pp. 9-6, EERE-2015-BT-STD-0008-0105.

**Table A-3: Market Share of Pool Pumps by Efficiency Level (EL) in 2015**

| | EL0 | EL1 | EL2 | EL3 | EL4 | EL5 | EL6 | EL7 |
|---|---|---|---|---|---|---|---|---|
| SP Pool Filter Pump, standard-size (1.90 hp) | 45% | 15% | 10% | 2% | 2% | 2% | 8% | 16% |
| SP Pool Filter Pump, standard-size (3.76 hp) | 45% | 15% | 10% | 2% | 2% | 2% | 8% | 16% |
| SP Pool Filter Pump, small-size (0.88 hp) | 45% | 15% | 10% | 2% | 2% | 2% | 8% | 16% |
| NSP Pool Filter Pump (1.04 hp) | 32% | 32% | 32% | 2% | 1% | 1% | 0% | 0% |
| Waterfall Pump (0.80 hp) | 70% | 20% | 10% | 0% | N/a | N/a | N/a | N/a |
| Pressure Cleaner Booster Pump (1.24 hp) | 17% | 74% | 10% | 0% | 0% | N/a | N/a | N/a |

Source: U.S. DOE TSD Table 9.6.3

**Table A-4: Compliance Rates**

| Product | Non-Compliant (%) | Compliance (%) | Non-Compliant EL | Compliant EL |
|---|---|---|---|---|
| SP Pool Filter Pump, standard-size (1.90 hp) | 76% | 24% | (EL0-EL5) | (EL6-EL7) |
| SP Pool Filter Pump, standard-size (3.76 hp) | 76% | 24% | (EL0-EL5) | (EL6-EL7) |
| SP Pool Filter Pump, small-size (0.88 hp) | 60% | 40% | (EL0-EL1) | (EL2-EL7) |
| NSP Pool Filter Pump (1.04 hp) | 32% | 68% | (EL0) | (EL1-EL7) |
| Waterfall Pump (0.80 hp) | 0% | 100% | N/A | (EL0-EL3) |
| Pressure Cleaner Booster Pump (1.24 hp) | 17% | 84% | (EL0) | (EL1-EL4) |

Source: California Energy Commission with data from U.S. DOE TSD

**Non-Compliant %**

$$\sum Pool\ Pumps\ Efficiency\ Level\ (EL\ 0 - EL\ 5)$$

$$76\% = 45\% + 15\% + 10\% + 2\% + 2\% + 2\%$$

**Compliance %**

$$\sum Pool\ Pumps\ Efficiency\ Level\ (EL\ 6 - EL\ 7)$$

$$24\% = 8\% + 16\%$$

## 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 estimates provided by the U.S. DOE ASRAC working group. Duty cycles are calculated using the methods as documented in the U.S. DOE TSD. Full-speed operation is assumed to be a minimum of 2 hours per day. Pumps that have two or more speeds are assumed to have a low-speed operation in addition to the high-speed operation to filter the pool. Pool water volume and pump flow rate at low speed are used to calculate the daily low speed operating time. Staff presents data found in the U.S. DOE TSD that was used to calculate operating time and energy consumption. Single-speed pumps duty cycles were calculated as the minimum time to perform the required turnover of pool water.

**Table A-5: Performance of Representative 0.44 hhp Self-Priming Pool Filter Pump by Efficiency Level**

| | High-Speed Load Point | | | | | Low Speed Load Point | | | | | WEF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **EL** | **Motor Eff. (%)** | **WtW Eff%** | **Flow (gpm)** | **Head (feet H20)** | **Input Power (W)** | **Motor Eff. (%)** | **WtW Eff%** | **Flow (gpm)** | **Head (feet H20)** | **Input Power (W)** | |
| EL 0 | 55 | 25 | 60 | 30 | 1331 | n/a | n/a | n/a | n/a | n/a | 2.69 |
| EL 1 | 69 | 31 | 60 | 30 | 1061 | n/a | n/a | n/a | n/a | n/a | 3.37 |
| EL 2 | 76 | 34 | 60 | 30 | 963 | n/a | n/a | n/a | n/a | n/a | 3.72 |
| EL 3 | 64 | 29 | 60 | 30 | 1143 | 38 | 14 | 30 | 7 | 288 | 4.68 |
| EL 4 | 70 | 31 | 60 | 30 | 1045 | 46 | 17 | 30 | 7 | 238 | 5.38 |
| EL 5 | 73 | 33 | 60 | 30 | 1002 | 51 | 19 | 30 | 7 | 215 | 5.77 |
| EL 6 | 81 | 30 | 48 | 19 | 565 | 57 | 21 | 25 | 5 | 109 | 8.78 |
| EL 7 | 81 | 40 | 48 | 19 | 424 | 57 | 29 | 25 | 5 | 82 | 11.71 |

Source: U.S. DOE TSD Table 5.6.5

**Table A-6: Performance of Representative 0.95 hhp Self-Priming Pool Filter Pump by Efficiency Level**

| EL | High-Speed Load Point | | | | | Low Speed Load Point | | | | | WEF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Motor Eff. (%) | WtW Eff% | Flow (gpm) | Head (feet H20) | Input Power (W) | Motor Eff. (%) | WtW Eff% | Flow (gpm) | Head (feet H20) | Input Power (W) | |
| EL 0 | 55 | 33 | 77 | 49 | 2172 | n/a | n/a | n/a | n/a | n/a | 2.13 |
| EL 1 | 69 | 41 | 77 | 49 | 1731 | n/a | n/a | n/a | n/a | n/a | 2.67 |
| EL 2 | 77 | 46 | 77 | 49 | 1551 | n/a | n/a | n/a | n/a | n/a | 2.98 |
| EL 3 | 64 | 38 | 77 | 49 | 1866 | 38 | 22 | 39 | 12 | 404 | 3.98 |
| EL 4 | 71 | 42 | 77 | 49 | 1682 | 46 | 27 | 39 | 12 | 334 | 4.6 |
| EL 5 | 73 | 43 | 77 | 49 | 1636 | 51 | 29 | 39 | 12 | 301 | 4.88 |
| EL 6 | 81 | 39 | 62 | 32 | 940 | 57 | 27 | 31 | 8 | 170 | 6.89 |
| EL 7 | 81 | 48 | 62 | 32 | 754 | 57 | 34 | 31 | 8 | 136 | 8.59 |

Source: U.S. DOE TSD Table 5.6.6

**Table A-7: Performance of Representative 1.88 hhp Self-Priming Pool Filter Pump by Efficiency Level**

| EL | High-Speed Load Point | | | | | Low Speed Load Point | | | | | WEF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Motor Eff. (%) | WtW Eff% | Flow (gpm) | Head (feet H20) | Input Power (W) | Motor Eff. (%) | WtW Eff% | Flow (gpm) | Head (feet H20) | Input Power (W) | |
| EL 0 | 75 | 42 | 97 | 77 | 3344 | n/a | n/a | n/a | n/a | n/a | 2.13 |
| EL 1 | 79 | 49 | 97 | 77 | 2860 | n/a | n/a | n/a | n/a | n/a | 2.67 |
| EL 2 | 84 | 52 | 97 | 77 | 2690 | n/a | n/a | n/a | n/a | n/a | 2.98 |
| EL 3 | 74 | 46 | 97 | 77 | 3053 | 49 | 35 | 48 | 19 | 501 | 3.98 |
| EL 4 | 76 | 47 | 97 | 77 | 2973 | 55 | 39 | 48 | 19 | 446 | 4.6 |
| EL 5 | 83 | 57 | 97 | 77 | 2461 | 62 | 41 | 48 | 19 | 428 | 4.88 |
| EL 6 | 83 | 51 | 77 | 49 | 1608 | 57 | 26 | 31 | 8 | 178 | 6.89 |
| EL 7 | 83 | 59 | 77 | 49 | 1203 | 57 | 35 | 31 | 8 | 133 | 8.59 |

Source: U.S. DOE TSD Table 5.6.7

Table A-8: Performance of Representative 0.52 hhp Non-Self-Priming Pool Filter Pump by Efficiency Level

| EL | High-Speed Load Point | | | | | Low Speed Load Point | | | | | WEF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Motor Eff. (%) | WtW Eff% | Flow (gpm) | Head (feet H20) | Input Power (W) | Motor Eff. (%) | WtW Eff% | Flow (gpm) | Head (feet H20) | Input Power (W) | |
| EL 0 | 55 | 28 | 63 | 33 | 1368 | n/a | n/a | n/a | n/a | n/a | 2.77 |
| EL 1 | 69 | 36 | 63 | 33 | 1091 | n/a | n/a | n/a | n/a | n/a | 3.47 |
| EL 2 | 72 | 37 | 63 | 33 | 1045 | n/a | n/a | n/a | n/a | n/a | 3.62 |
| EL 3 | 61 | 31 | 63 | 33 | 1234 | 38 | 16 | 32 | 8 | 306 | 4.62 |
| EL 4 | 68 | 35 | 63 | 33 | 1107 | 48 | 20 | 32 | 8 | 242 | 5.47 |
| EL 5 | 72 | 37 | 63 | 33 | 1045 | 51 | 21 | 32 | 8 | 228 | 5.8 |
| EL 6 | 81 | 42 | 50 | 21 | 589 | 57 | 15 | 25 | 5 | 154 | 7.42 |
| EL 7 | 81 | 54 | 50 | 21 | 366 | 57 | 24 | 25 | 5 | 96 | 11.96 |

Source: U.S. DOE TSD Table 5.6.9

**Table A-9: Performance of Representative 0.31 hhp Pressure Cleaner Booster Pump by Efficiency Level**

| EL | High-Speed Load Point | | | | | WEF |
|---|---|---|---|---|---|---|
| | Motor Eff. (%) | WtW Eff% | Flow (gpm) | Head (feet H20) | Input Power (W) | |
| EL 0 | 55 | 13 | 10 | 112 | 1741 | 0.34 |
| EL 1 | 67 | 16 | 10 | 112 | 1429 | 0.42 |
| EL 2 | 72 | 17 | 10 | 112 | 1330 | 0.45 |
| EL 3 | 81 | 20 | 10 | 112 | 1182 | 0.51 |
| EL 4 | 81 | 22 | 10 | 112 | 1075 | 0.56 |

Source: U.S. DOE TSD Table 5.6.10

**Table A-10: Performance of Representative 0.40 hhp Waterfall Pump by Efficiency Level**

| EL | High-Speed Load Point | | | | | WEF |
|---|---|---|---|---|---|---|
| | Motor Eff. (%) | WtW Eff. (%) | Flow (gpm) | Head (feet $H_2O$) | Input Power (W) | |
| EL 0 | 65 | 40 | 93 | 17 | 745 | 7.46 |
| EL 1 | 70 | 43 | 93 | 17 | 698 | 7.95 |
| EL 2 | 78 | 48 | 93 | 17 | 621 | 8.95 |
| EL 3 | 78 | 53 | 93 | 17 | 564 | 9.85 |

Source: U.S. DOE TSD Table 5.6.10

**Table A-11 Residential Duty Cycle**

| Product | Mean Pool Size (gallons) | Number of Daily Turnovers | Daily High Speed (hr/day) | Daily High Speed (Single Speed) (hr/day) | Daily Low Speed (Half) (hr/day) | Daily Low Speed (Min) (hr/day) | High Speed (hrs/yr) | Daily High Speed (Single Speed (hr/day) | Low Speed (Half) (hrs/yr) | Low Speed (Min) (hrs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 20,000 | 1.47 | 2.0 | N/A | 10.6 | 13.8 | 730 | N/A | 3856 | 5039 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 22,000 | 1.47 | 2.0 | N/A | 9.2 | 15.4 | 730 | N/A | 3369 | 5616 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 13,000 | 1.47 | 2.0 | 5.3 | 8.6 | 10.7 | 730 | 1938 | 3145 | 3920 |
| Non-Self Priming Pool Filter Pump (0.52 hhp) | 12,000 | 1.47 | 2.0 | 4.7 | 7.2 | 9.8 | 730 | 1703 | 2623 | 3562 |
| Waterfall Pump (0.40 hhp) | N/A | N/A | N/A | N/A | 2 | N/A | N/A | N/A | 730 | N/A |
| Pressure Cleaner Booster Pump (0.31 hhp) | N/A | N/A | N/A | 2.5 | N/A | N/A | N/A | 912.5 | N/A | N/A |

Source: California Energy Commission with data from U.S. DOE TSD

**Table A-12: Commercial Duty Cycle**

| Product | Mean Pool Size (gallons) | Number of Daily Turnovers | Daily High Speed (hr/day) | Daily High Speed (Single Speed (hr/day) | Daily Low Speed (Half) (hr/day) | Daily Low Speed (Min) (hr/day) | High Speed (hrs/yr) | Daily High Speed (Single Speed (hr/day) | Low Speed (Half) (hrs/yr) | Low Speed (Min) (hrs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 20,000 | N/A | 24.0 | N/A | 0.0 | 0.0 | 8760 | N/A | 0 | 0 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 22,000 | N/A | 24.0 | N/A | 0.0 | 0.0 | 8760 | N/A | 0 | 0 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 13,000 | N/A | 24.0 | 24 | 0.0 | 0.0 | 8760 | N/A | 0 | 0 |

Source: California Energy Commission with data from U.S. DOE TSD

**Daily High Speed (Single Speed) (hr / day) for residential and commercial applications**

$$= (\,Mean\ Pool\ Size * Number\ of\ Daily\ Turnovers\,)/\,(\,High\ Speed\ Flow(gpm) * 60\,)$$

$$5.31\ \frac{hr}{day} = (\,13{,}000 * 1.47)/\,(\,60 * 60)$$

Where:

High-Speed Flow is from Table 5.6.5

**Daily Low Speed (Half)(hr / day)**

$$= (\,Mean\ Pool\ Size * Number\ of\ Daily\ Turnovers)/\,(\ Low\ Speed\ Flow(gpm) * 60) - 2$$

$$8.62\ = (\,13{,}000 * 1.47)/(\,30 * 60) - 2$$

Where:

Low-Speed Flow (gpm) is from Table 5.6.5

**Daily Low Speed (Half) Min**

See equation above. Just substitute Low-Speed Flow (gpm) with EL 6 Low-Speed flow from Table 5.6.5

**High Speed (hrs/yr)**

$$= Daily\ High\ Speed(hr/day) * 365\ days$$

$$730.00 = 2.00 * 365$$

**Daily High Speed (Single Speed (hr/day))**

See equation above. Just substitute Daily High Speed with the Daily High Speed (Single Speed)

**Low Speed (half) (hr / day)**

See High Speed equation. Just substitute Daily High Speed with Low Speed (half)

**Low Speed (Min) (hr / day)**

See High Speed equation. Just substitute Daily High Speed with Low Speed (Min)

## Baseline Energy Use

The power consumption assumptions for replacement pool pump motors are taken from the U.S. DOE TSD. The baseline usage was calculated for single-speed, dual-speed, and variable-speed at various motor sizes by the U.S. DOE and is shown in Tables A-5 through A-10. Estimated annual energy consumption per replacement pool pump motor 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-11**.

**High Speed (kW)**

$$= \left( \sum EL\,0 - EL\,3 * \; IP_{EL3} * Daily\ High\ Speed \right) + (\ EL\,4 * \; IP_{EL4} * Daily\ High\ Speed) \\ + (\ EL\,5 * \; IP_{EL5} * Daily\ High\ Speed) \\ + (EL\,6 * \; IP_{EL6} * Daily\ High\ Speed)(EL\,7 * \; IP_{EL7} * Daily\ High\ Speed) \\ \div (\ Daily\ High\ Speed * 1{,}000)$$

$$1.61 = (.72 * 1866 * 2.00) + (.02 * 1682 * 2.00) + (.02 * 1636 * 2.00) + (\,.08 * 940 * 2.00) \\ + (.16 * 754 * 2.00) \;\div (2.00 * 1{,}000)$$

EL 0-7 = Is the percentage of market shares at the Efficiency Level (EL), for standard size (0.95 hpp) pool pumps from Table A-3.

$IP_{ELn}$ = Input Power based on Efficiency Level n where n is an integer between 3 – 7.

*Daily High Speed* = The calculated Daily High Speed duty cycle in hours as calculated in Table A-11.

**Low Speed (kW)**

$$= \frac{(\sum_{i-0}^{n=3} EL_i * IP_{EL3} * DailyLowSpeed(half)) + (\sum_{i=4}^{n=5} EL_i * IP_{LELi} * DailyLowSpeed(half)) + (\sum_{i=6}^{n=7} EL_i * IP_{LELi} * DaiyLowSpeed(min))}{[(DailyLowSpeed(half) * \sum_{i=0}^{n=5} EL_i) + (DailyLowSpeed(min) * \sum_{i=6}^{n=7} ELi)] * 1000}$$

$$0.33 = \frac{(0.72 * 404 * 10.56) + (0.02 * 334 * 10.56) + (\ 0.02 * 301 * 10.56) + (\ 0.08 * 170 * 13.81) + (\ 0.16 * 136 * 13.8)}{[(\ 0.76 * 10.56) + (\ 13.81 * 0.24 *)] * 1000}$$

Where:

$EL_i$= The Market Share of Pool Pumps at Efficiency Level (EL) at index i

$IP_{EL3}$= Input Power At Efficiency Level at index i from table 5.6.6

*Daily Low Speed (half)* = The Daily Low Speed duty cycle in hours at half speed calculated from Table A-11.

*Daily Low Speed (min)* = The Daily Low Speed duty cycle in hours at minimum speed calculated from Table A-11.

**Annual Energy Consumption ( kWh/yr per Appliance)**

AEC=kWh/yr=

$$= \frac{(HighSpeed(hrs/yr) * IP_{EL3} * \sum_{i=0}^{n=3} * EL_i) + (\sum_{i=4}^{n=7} EL_i * IP_{ELi} * HighSpeed(hrs/yr))/1000}{[\sum_{i=0}^{n=3} EL_i * IP_{LEL3} * LS(Half) + (\sum_{i=4}^{n=5} EL_i * IP_{LELi} * LS(Half)) + (\sum_{i=6}^{n=7} EL_i * IP_{LELi} * LS(min))]}$$

$$2{,}521 = \frac{[\left((45\% + 15\% + 10\% + 2\%) * 1{,}866 * 730\right) + (\ 2\% * 1{,}682 * 730) + (\ 2\% * 1{,}636 * 730) + (\ 8\% * 940 * 730) + (\ 16\% * \ 754 * 730)]/1{,}000}{[\left((45\% + 15\% + 10\% + 2\%) * 404 * 3{,}855.90\right) + (\ 2\% * 334 * 3{,}855.90) + (\ 2\% * 301 * 3{,}855.90) + (\ 8\% * 170 * 5{,}039.35) + (\ 16\% * 136 * 5{,}039.35)\ ]/1{,}000}$$

Where:

High Speed (hrs/yr) = Value calculated from Table A-11.

$IP_{ELi}$= The High Speed Input Power at Efficiency Level index i from Table A-7.

$EL_i$ = The market share in percentage of the Efficiency Level at index i from Table A-3

$IP_{LELi}$ = The Low Speed Input Power at Efficiency Level at index i from Table A-7

*LS* (Half) = The Low Speed(Half) value calculated from Table A-11.

*LS* (min) = The Low Speed (min) value calculated from Table A-11.

**Total Annual Stock Energy Use (GWh/yr)**

$$Total\ Annual\ Stock\ Energy\ Use\ (\frac{GWh}{yr}) = AEC * CRMTS$$

$$494\ \text{GWh} = 2{,}521\ kWh/yr * 196{,}151\ units$$

Where:

*AEC* = The Annual Energy Consumption (kWh/yr) from Table A-13.

*CRMTS* = California Replacement Motor Total Stock in 2019 calculated from Table A-1.

**Table A-13** and A-14 presents baseline energy consumption prior to the motor WEF standard.

**Table A-13: Baseline Energy Consumption – Residential**

| Product | High Speed (kW) | Low Speed (kW) | Annual Energy Consumption (kWh per Appliance) | Total Annual Stock Energy Use (GWh/yr) |
|---|---|---|---|---|
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 1.61 | 0.33 | 2,521 | 494 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 2.63 | 0.38 | 3,392 | 665 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 1.13 | 0.12 | 1,917 | 97 |
| Non-Self Priming Pool Filter Pump (0.52 hhp) | 1.17 | 0.27 | 1,972 | 176 |
| Waterfall Pump (0.40 hhp) | N/A | 0.72 | 528 | 4 |
| Pressure Cleaner Booster Pump (0.31 hhp) | 1.47 | N/A | 1,342 | 84 |

Source: Staff calculation

**Table A-14: Baseline Energy Consumption – Commercial**

| Product | High Speed (kW) | Low Speed (kW) | Annual Energy Consumption (kWh per Appliance) | Total Annual Stock Energy Use (GWh/yr) |
|---|---|---|---|---|
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 1.61 | N/A | 14,066 | 145 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 2.63 | N/A | 23,021 | 238 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 1.14 | N/A | 10,015 | 27 |

Source: Staff calculation

## Compliant Energy Use

The power consumption of compliant products is estimated based on minimum requirements to meet the proposed regulations. Products were assumed to consume exactly the bare minimum power to accomplish the 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-15 and A-16** show predicted energy consumption of compliant units and stock.

**Table A-15: Compliant Energy Consumption – Residential**

| Product | High Speed (kW) | Low Speed (kW) | Annual Energy Consumption (kWh per Appliance) | Total Annual Stock Energy Use |
|---|---|---|---|---|
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 0.91 | 0.16 | 1,494 | 293 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 1.54 | 0.17 | 2,086 | 409 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 0.91 | 0.12 | 1,567 | 80 |
| Non-Self Priming Pool Filter Pump (0.52 hhp) | 1.08 | 0.27 | 1,821 | 162 |
| Waterfall Pump (0.40 hhp) | N/A | 0.72 | 528 | 4 |
| Pressure Cleaner Booster Pump (0.31 hhp) | 1.42 | N/A | 1,295 | 81 |

Source: Staff calculation

**Table A-16: Compliant Energy Consumption – Commercial**

| Product | High Speed (kW) | Low Speed (kW) | Annual Energy Consumption (kWh per Appliance) | Total Annual Stock Energy Use (GWh/yr) |
|---|---|---|---|---|
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 0.91 | N/A | 7,974 | 82 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 1.54 | N/A | 13,518 | 140 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 0.96 | N/A | 8,436 | 23 |

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

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

where:

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

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

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

### First-Year Energy Savings

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

where:

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

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

L = Product lifetime in years

**Table A-17: Statewide Cost and Energy Savings – Residential**

| | First Year Savings | | Annual Existing and Incremental Stock Savings | |
|---|---|---|---|---|
| **Product** | **Electricity Savings (GWh/yr)** | **Savings ($M)** | **Electricity Savings (GWh/yr)** | **Savings ($M)** |
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 27.6 | $5.1 | 201 | $37.4 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 35.1 | $6.5 | 256 | $47.5 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 2.4 | $0.5 | 18 | $3.3 |
| Non-Self Priming Pool Filter Pump (0.52 hhp) | 2.5 | $0.5 | 13 | $2.5 |
| Waterfall Pump (0.40 hhp) | 0.0 | $0.0 | 0 | $0.0 |
| Pressure Cleaner Booster Pump (0.31 hhp) | 0.6 | $0.1 | 3 | $0.5 |
| **Total Savings** | **68.2** | **$12.7** | **492** | **$91.2** |

Source: Staff calculation

**Table A-18: Statewide Cost and Energy Savings – Commercial**

| | First Year Savings | | Annual Existing and Incremental Stock Savings | |
|---|---|---|---|---|
| **Product** | **Electricity Savings (GWh/yr)** | **Savings ($M)** | **Electricity Savings (GWh/yr)** | **Savings ($M)** |
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 8.6 | $1.6 | 63 | $11.7 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 13.4 | $2.5 | 98 | $18.2 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 0.6 | $0.1 | 4 | $0.8 |
| **Total Savings** | **22.6** | **$4.2** | **165** | **$30.6** |

Source: Staff calculation

**Table A-19: Combined 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)** |
| Residential | **68.2** | **$12.7** | **492** | **$91.2** |
| Commercial | **22.6** | **$4.2** | **165** | **$30.6** |
| Total Savings | **90.8** | **$16.9** | **657** | **$121.8** |

Source: Staff calculation

Unit cost savings (benefits) are calculated by multiplying the annual energy savings by $0.1855 per kWh and by the design life.

### Annual unit energy savings

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

where:

$E_{annual\ savings}$ = Annual unit energy savings

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

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

### Lifetime unit energy savings

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

where:

$B_{energy\ savings}$ = Lifetime unit energy savings

$E_{annual\ savings}$ = Annual unit energy savings

L = Product lifetime in years

Net unit savings are calculated by subtracting costs from benefits.

### Net energy savings:

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

where:

$B_{net}$ = Net energy savings

$B_{energy\ savings}$ = Lifetime unit energy savings

$C_{incremental}$ = Incremental cost

**Table A-20: Average Consumer Price for Standard-Size Self-Priming Pool Filter Pumps (0.95 hhp)**

| Efficiency Level | Average Consumer Price 2015 ($) | Incremental Cost 2015 ($) |
|---|---|---|
| Baseline | $354.40 | -- |
| 1 | $393.67 | $39.26 |
| 2 | $426.73 | $72.32 |
| 3 | $428.79 | $74.39 |
| 4 | $463.92 | $109.52 |
| 5 | $501.12 | $146.71 |
| 6 | $712.54 | $358.13 |
| 7 | $712.54 | $358.13 |

Source: U.S. DOE TSD Table 8.2.13

**Table A-21: Average Consumer Price for Standard-Size Self-Priming Pool Filter Pumps (1.88 hhp)**

| **Efficiency Level** | **Average Consumer Price 2015 ($)** | **Incremental Cost 2015 ($)** |
|---|---|---|
| Baseline | $601.31 | -- |
| 1 | $674.22 | $72.91 |
| 2 | $718.12 | $116.81 |
| 3 | $775.78 | $174.47 |
| 4 | $803.40 | $202.09 |
| 5 | $831.03 | $229.71 |
| 6 | $948.98 | $347.67 |
| 7 | $948.98 | $347.67 |

Source: U.S. DOE TSD Table 8.2.14

**Table A-22: Average Consumer Price for Small-Size Self-Priming Pool Filter Pumps (0.44 hhp)**

| Efficiency Level | Average Consumer Price 2015 ($) | Incremental Cost 2015 ($) |
|---|---|---|
| Baseline | $320.00 | -- |
| 1 | $346.76 | $26.76 |
| 2 | $385.63 | $65.63 |
| 3 | $391.31 | $71.31 |
| 4 | $413.23 | $93.24 |
| 5 | $435.14 | $115.14 |
| 6 | $700.20 | $380.20 |
| 7 | $700.20 | $380.20 |

Source: U.S. DOE TSD Table 8.2.15

**Table A-23: Average Consumer Price for Standard-Size Non-Self-Priming Pool Filter**

| Efficiency Level | Average Consumer Price 2015 ($) | Incremental Cost 2015 ($) |
|---|---|---|
| Baseline | $199.22 | -- |
| 1 | $208.19 | $8.98 |
| 2 | $233.80 | $34.58 |
| 3 | $241.43 | $42.21 |
| 4 | $267.73 | $68.52 |
| 5 | $294.04 | $94.83 |
| 6 | $566.26 | $367.05 |
| 7 | $566.26 | $367.05 |

Source: U.S. DOE TSD Table 8.2.16

**Table A-24: Average Consumer Price for Extra-Small Non-Self-Priming Pool Filter Pumps**

| Efficiency Level | Average Consumer Price 2015 ($) | Incremental Cost 2015 ($) |
|---|---|---|
| Baseline | $134.96 | -- |
| 1 | $146.35 | $11.39 |
| 2 | $157.74 | $22.78 |

Source: U.S. DOE TSD Table 8.2.17

**Table A-25: Average Consumer Price for Waterfall Pumps**

| Efficiency Level | Average Consumer Price 2015 ($) | Incremental Cost 2015 ($) |
|---|---|---|
| Baseline | $312.96 | -- |
| 1 | $334.99 | $22.02 |
| 2 | $374.55 | $61.59 |
| 3 | $374.55 | $61.59 |

Source: U.S. DOE TSD Table 8.2.18

**Table A-26: Average Consumer Price for Pressure Cleaner Booster Pumps**

| Efficiency Level | Average Consumer Price 2015 ($) | Incremental Cost 2015 ($) |
|---|---|---|
| Baseline | $255.40 | -- |
| 1 | $275.77 | $20.36 |
| 2 | $312.35 | $56.95 |
| 3 | $611.45 | $356.05 |
| 4 | $611.45 | $356.05 |

Source: U.S. DOE TSD Table 8.2.19

**Table A-27: Annual Energy and Monetary Savings - Residential**

| Product | Design Life (years) | Electricity Savings (kWh/yr) | Incremental Cost ($) | Average Annual Savings ($) | Life Cycle Savings ($) | Life-Cycle Benefit ($) |
|---|---|---|---|---|---|---|
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 7.3 | 1,027 | $284 | $191 | $1,391 | $1,107 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 7.3 | 1,306 | $173 | $242 | $1,769 | $1,595 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 7.3 | 349 | $66 | $65 | $473 | $407 |
| Non-Self Priming Pool Filter Pump (0.52 hhp) | 5.3 | 151 | $9 | $28 | $148 | $139 |
| Waterfall Pump (0.40 hhp) | 7.3 | 0 | $0 | $0 | $0 | $0 |
| Pressure Cleaner Booster Pump (0.31 hhp) | 5.3 | 47 | $20 | $9 | $46 | $26 |

Source: Staff calculation

**Table A-28: Annual Energy and Monetary Savings – Commercial**

| Product | Design Life (years) | Electricity Savings (kWh/yr) | Incremental Cost ($) | Average Annual Savings ($) | Life Cycle Savings ($) | Life-Cycle Benefit ($) |
|---|---|---|---|---|---|---|
| Self-Priming Pool Filter Pump, standard-size (0.95 hhp) | 7.3 | 6,092 | $284 | $1,130 | $8,250 | $7,966 |
| Self-Priming Pool Filter Pump, standard-size (1.88 hhp) | 7.3 | 9,502 | $173 | $1,763 | $12,868 | $12,695 |
| Self-Priming Pool Filter Pump, small-size (0.44 hhp) | 7.3 | 1,579 | $66 | $293 | $2,139 | $2,073 |

Source: Staff calculation

## Derivation of Motor-Weighted Energy Factor

Staff presents the derivation of the motor-weighted energy factor equation and test point conditions to provide replacement motor testing that would provide conditions analogous to those conditions a motor would experience if installed and tested within a dedicated-purpose pool pump.

The method shown below provides a derivation that the motor output power is a function of the pump hydraulic power. Due to this relationship, the U.S. DOE DPPP WEF equation can be algebraically manipulated to provide an equivalent Commission replacement motor WEF equation.

## Motor WEF Derivation

### Equation 18.24 Centrifugal Pump from the Mechanical Engineer's Reference Manual[203]

$$T_{ft-lbf} = \frac{5252 * BHP}{N}$$

5252 = Conversion factor for units of horsepower and RPM to ft-lbf

BHP = Brake Horse Power – Motor Output (hp)

N = Motor Speed Rotations per Minute (RPM)

***Equation 1***

### Equation 18.11 from the Mechanical Engineer's Reference Manual

$$BHP = \frac{WHP}{n_{pump}}$$

WHP = Water Horse Power (hp)

$n_{pump}$ = Pump Efficiency

***Equation 2***

---

203 Lindeburg, Michael, R. PE, *Mechanical Engineering Reference Manual for the PE Exam, 13th Edition*, 2013, pp. 18-7 to 18-19.

**From Table 18.5 from the Mechanical Engineering Reference Manual**

$$WHP = \frac{h_A * Q * SG}{3956}$$

3956 = Conversion factor for units of feet, gallons per minute and horsepower

Q = Flow – Gallons per Minute

$h_A$ = head – feet (water pressure due to height of water)

SG = Specific Gravity

**Equation 3**

Curve C System Curve from the California Code of Regulations, Section 1604(g)

$$h_A = 0.0082 * Q^2$$

**Equation 4**

Derivation of motor weighted energy factor express flow (Q) in terms of T and N (torque and motor speed)

Substitute Equation 4 into Equation 3

$$WHP = \frac{0.0082 * Q^2 * Q * SG}{3956} = \frac{0.0082 * Q^3 * SG}{3956}$$

**Equation 5**

Substitute Equation 5 into Equation 2

$$BHP = \frac{0.0082 * Q^3 * SG}{3956 * n_{pump}}$$

**Equation 6**

Substitute Equation 6 into Equation 1

$$T_{ft-lbf} = \frac{5252 * (0.0082) * Q^3 * SG}{N * 3956 * n_{pump}}$$

**Equation 7**

Solve for Q $Q = \sqrt[3]{\frac{3956 * T * N * n_{pump}}{SG * (5252) * (0.0082)}} = \sqrt[3]{\frac{(T * N * n_{pump})}{SG} * 91.8}\Bigg|_{SG=1} = \sqrt[3]{T * N * n_{pump} * 91.8}$

**Equation 8**

The U.S. DPPP WEF equation.

WEF is (kgal/hr)/kW

$P_i$ = Power Input (kW)

$Q_i$ = Gallons per minute (GPM) –flow

$$WEF = \frac{\sum_i W_i * \frac{Q_i}{1,000} * 60}{\sum_i W_i * \frac{P_i}{1,000}}$$

**Equation 9**

Substitute Equation 8 into Equation 9 to determine the equivalent motor WEF equation.

$$MotorWEF = \frac{\sum_i W_i * \sqrt[3]{T_i * N_i * n_{pump} * 91.8} * \frac{60}{1,000}}{\sum_i W_i * \frac{P_i}{1,000}}$$

**Equation 10**

## Motor Test Points

Torque and speed are determined per the requirements of the proposed test procedure CSA 747-09

### Two-Speed and Single-Speed Motor Test Point Calculations (High Speed)

N = maximum speed, T = as measured, Full load

$P_i$ = P as measured

### Variable-Speed and Two-Speed Motor Test Point Calculations (Low Speed)

The proposed test procedure allows for testing of a variable-speed and two-speed motors at the minimum speed that achieves the required motor output power and that the motor can provide. The derivation below shows the method used to achieve a test condition where the replacement motor power output would roughly equal the motor power output of a dedicated-purpose pool pump motor.

$$WHP = \frac{h_A * Q(SG)}{3956}$$

Equation (2)

$$T_{ft-lhf} = \frac{5252 * 0.0082 * Q^3 * SG}{N_{low} * 3956 * n_{pump}}$$

Equation (7)

Q is known from the requirements found in the U.S. DOE DPPP Test Procedure

$24.7 \text{ if } WHP \leq 0.75$

$31.1 \text{ if } WHP > 0.75$

$N_{pump}$ assume 55%

SG = 1

**N (Motor Speed) Calculation**

$$T_{full\,speed} = \frac{5252 * BHP_{full\,speed}}{N_{full\,speed}}$$

Equation 1

$$\frac{T_{full\,speed}}{T_{low\,speed}} = (\frac{N_{full}}{N_{low}})^2$$

Equation 11 by pump affinity laws

$$(\frac{WHP_{full}}{WHP_{low}}) = (\frac{N_{full}}{N_{low}})^3$$

Equation 12 by pump affinity laws

$$(\frac{BHP_{full}}{BHP_{low}}) = (\frac{N_{full}}{N_{low}})^3$$

Substitute Equation 2 into Equation 12. Assume pump hydraulic efficiency does not vary with speed. Therefore pump hydraulic efficiencies cancel

Equation 13

$$\sqrt[3]{\frac{BHP_{full}}{BHP_{low}}} = \frac{N_{full}}{N_{low}}$$

Equation 14 Solving for $N_{low}$

$$N_{low} = N_{full} \sqrt[3]{\frac{BHP_{low}}{BHP_{full}}}$$

Equation 15 Solving for $N_{low}$

$$N_{low} = N_{full} \sqrt[3]{\frac{0.0082 * Q^3 * SG}{BHP_{full} * 3956 * n_{pump}}}$$

Equation 16. Substitute Equation 6 into Equation 15 to determine minimum motor speed.

Q is the minimum flow as required by the U.S. DOE DPPP test procedure.

$$BHP_{low} = \left. \frac{0.0082 * Q^3 * SG}{3956 * n_{pump}} \right|_{31.1} = \frac{0.062}{n_{pump}}$$

Equation 16 Evaluating Equation 6 at the 31.1 GPM flow rate and assuming a pump efficiency of 55%.

$$T_{ft-lbf} = \left. \frac{327}{N_{low} * n_{pump}} \right|_{Q=31.1GPM}$$

Equation 7 evaluated at Q=31.1 GPM

$$N_{low} = N_{full} \left. \sqrt[3]{\frac{0.062}{n_{pump} * BHP_{full}}} \right|_{Q=31.1GPM}$$

**Equation 16 evaluated at Q = 31.1 GPM**

Substituting result of Equation 20 into Equation 2 to determine test conditions are equivalent to the Q=24.7 GPM.

$$T_{ft-lbf} = \frac{164}{N_{low} * n_{pump}}\bigg|_{Q=24.7GPM}$$

Equation 7 evaluated at Q=24.7 GPM

$$N_{low} = N_{full}\sqrt[3]{\frac{0.031}{n_{pump} * BHP_{full}}}\bigg|_{Q=24.7GPM}$$

Equation 16 evaluated at Q=24.7 GPM

### Variable Speed Test Point Calculation High Setting

The proposed test procedure allows for a test point at 80% of the motor's maximum speed. Using the pump affinity laws, the motor torque and speed may be calculated for this test point.

$$T_{80\%} = T_{full}(\frac{N_{80}}{N_{full}})^2 \quad N_{80} = 0.8N_{full}$$

**Equation 17 Calculation from pump affinity laws as shown in equation 11**

$$T_{80} = T_{full}(\frac{.8}{1})^2 = T_{full}(\frac{64}{100})$$

**Equation 18**

# 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, 2019. 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, 2019.

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

| Value | Description | Source |
|---|---|---|
| 5.1 % | Average Percent of New Units in California | APSP, 2012-2013 and 2015 (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 |
| 10 | Number of inflatable spa manufacturers used in staff analysis | Staff research, March 2017 |
| 50 | Number of inflatable spa models used in staff analysis | Staff research, March 2017 |
| 35% | Estimated percentage of the standby power for inflatable spas | Intex Inflatable Portable Electric Spa Test Report, Docket 15-AAER-02 TN 212386 |
| 0 GWh | Inflatable spas' statewide energy consumption for 2019 (baseline consumption) | Assumption made by staff due to 0% compliance rate |
| 5,040 hrs./yr. | Inflatable Spa Seasonal Duty Cycle | APSP, Docketed Comments, Docket 15-AAER-02 TN 212761, 08/12/16 |
| 5 | Number of Manufacturers who have certified combo spas in MAEDBS | MAEDBS March 2017 |
| 10 | Number of combo spas certified in MAEDBS (6 of these models are certified with two separate values, one for each spa portion) | MAEDBS March 2017 |
| 7 | Number of combo spa models used in staff calculations after removing irregularities from data set | Data altered by Staff based on MAEDBS March 2017 data |
| 8,760 hrs./yr. | Standby mode operating hours | Worth & Fernstrom, 2014 |
| 46 | Number of Manufacturers who have certified portable electric spas in the MAEDBS | MAEDBS March 2017 |
| 1,334 | Number of certified entries in MAEDBS | MAEDBS March 2017 |
| 961 | Number of models used in staff calculations after removing irregularities from data set | Data altered by Staff based on MAEDBS March 2017 data |
| 0.1855 $/kWh | Average Residential Retail Price in California for Electricity | U.S. Energy Information Administration, February 2017, Retrieved May 4, 2017 |
| 5.0% | Label Impact Rate Savings | Assumption by CASE Team, Portable Electric Spas CASE Report 2014 |

Source: California Energy Commission

## 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 | 75,106 | 5.0% |
| 2012 | 1,142,352 | 58,922 | 5.2% |
| 2014 | 1,197,471 | - | - |
| | | Average | 5.1% |

Source: APSP - U.S. Swimming Pool and Hot Tub 2012, 2013 and 2015 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] |
|---|---|---|---|
| 2014 | 1,197,471 | 532,565 | 27,175 |
| 2015 | 1,232,059 | 547,948 | 27,960 |
| 2016 | 1,266,647 | 563,331 | 28,745 |
| 2017 | 1,301,235 | 578,713 | 29,530 |
| 2018 | 1,335,823 | 594,096 | 30,315 |
| 2019 | 1,370,411 | 609,479 | 31,100 |
| 2020 | 1,404,999 | 624,862 | 31,885 |
| 2021 | 1,439,587 | 640,244 | 32,670 |
| 2022 | 1,474,175 | 655,627 | 33,455 |
| 2023 | 1,508,763 | 671,010 | 34,239 |
| 2024 | 1,543,351 | 686,392 | 35,024 |
| 2025 | 1,577,939 | 701,775 | 35,809 |
| 2026 | 1,612,527 | 717,158 | 36,594 |
| 2027 | 1,647,115 | 732,541 | 37,379 |
| 2028 | 1,681,703 | 747,923 | 38,164 |

**[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 from APSP's docketed comments and are shown in **Table B-5**.

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

| Component | Design Life (years) |
|---|---|
| Spa Cover | 5 |
| Portable Electric Spas | 10 |
| Inflatable Spas | 3 |

Source: Portable Electric Spa CASE Report 2014 and APSP's docketed comments (Docket 15-AAER-02, TN 210390)

## 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.

The standard for portable electric spas is a powered function where the variable is the volume of portable electric spas. That is, as the volume (input) increases, the standby power (output) increases. Staff grouped portable electric spas into zones by volume to reflect the function of the standard and the variability of spa sizes. Zones are shown in **Figure 16-1** on the horizontal axis of the chart and the average volume for each zone used in these calculations is shown in **Table B-10**. Combination spas were classified as a group because the data in MAEDBS were entered either separately for each reservoir [portion] or for the whole unit.

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

| | Zones | Compliant (%) | Non-Compliant (%) |
|---|---|---|---|
| Portable Spas | 1AB to 3 | 78.6 | 21.4 |
| Exercise Spas | 4 to 8 | 58.3 | 41.7 |
| Combo Spas | - | 42.9 | 57.1 |
| All Certified Units | | 77.3 | 22.7 |

Source: MAEDBS, California Energy Commission

The compliance rate for combination spas was determined as follows: if either the spa portion or the swim portion of the combination spa *did not* meet the proposed standard, then the entire unit did not meet the proposed standard as shown in **Table B-7**.

**Table B-7: Compliance Rate for Combination Spas**

| Model | Test - Spa Portion | Test - Swim Portion | Test - Whole Unit |
|---|---|---|---|
| 1* | PASS | FAIL | FAIL |
| 2 | PASS | PASS | PASS |
| 3 | FAIL | PASS | FAIL |
| 4* | PASS | PASS | PASS |
| 5 | PASS | PASS | PASS |
| 6 | FAIL | FAIL | FAIL |
| 7 | FAIL | FAIL | FAIL |
| | | Total Fail | 4 (42.9%) |
| | | Total Pass | 3 (57.1%) |

***Volume of each portion was estimated as the volume for this model was entered for the whole unit.**

Source: MAEDBS, California Energy Commission

**Table B-8** lists the estimated compliances rates for each zone and combination spas.

**Table B-8: Unit Population and Compliance Rate for Each Zone**

| Zones | Compliant Units | Non-Compliant Units | Total Units | Units per Zone (%) | Compliant (%) | Non-Compliant (%) |
|---|---|---|---|---|---|---|
| 1A | 47 | 0 | 47 | 4.9 | 100 | 0 |
| 1B | 269 | 30 | 299 | 31.1 | 90 | 10 |
| 2 | 388 | 158 | 546 | 56.8 | 71 | 29 |
| 3 | 8 | 6 | 14 | 1.5 | 57 | 43 |
| 4 | 0 | 4 | 4 | 0.4 | 0 | 100 |
| 5 | 10 | 2 | 12 | 1.2 | 83 | 17 |
| 6 | 10 | 6 | 16 | 1.7 | 63 | 37 |
| 7 | 5 | 5 | 10 | 1.0 | 50 | 50 |
| 8 | 3 | 3 | 6 | 0.6 | 50 | 50 |
| Combo Spas | 3 | 4 | 7 | 0.7 | 43 | 57 |

Source: MAEDBS, California Energy Commission, and staff assumptions

# 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-9**) is taken directly from the CASE report and APSP's docketed comments and applied to portable electric spas and exercise spas, and inflatable spas, respectively.

**Table B-9: Duty Cycle**

| Unit | Operating Hours |
|---|---|
| Portable Electric Spas | 8,760 hrs/yr |
| Exercise Spas | 8,760 hrs/yr |
| Inflatable/Easy-Storage Spas | 5,040 hrs/yr |

Source: Portable Electric Spas CASE Report 2014 and APSP's docketed comments (Docket 15-AAER-02, TN 210390)

## 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 that 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 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 MAEDBS. 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-10** lists the volume used in the equations above and is the average volume of the volume range in each zone.

**Table B-10: 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 |
| Combo Spas | - | 1,920 |

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:

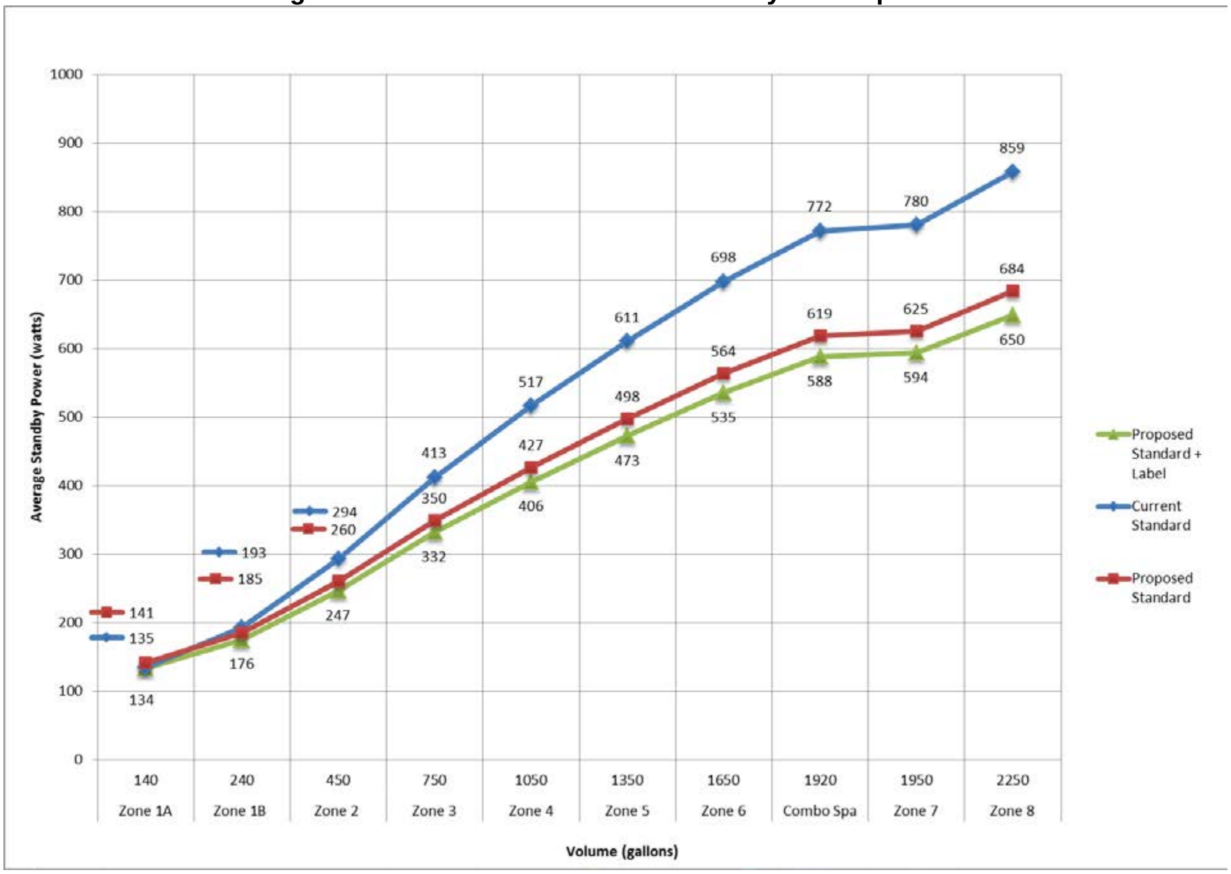
$$P = \left(3.75 \times V^{2/3}\right) + 40$$
$$P = \left(3.75 \times (450\ gallons)^{2/3}\right) + 40 = 260.21\ watts \approx 260\ watts$$

Proposed Standard + Label:

$$P = \left(3.75 \times V^{2/3}\right) + 40$$
$$Unit_{Label\ Savings} = P \times 5\%\ Potential\ Savings$$
$$P_{Label} = P - Unit_{Label\ Savings}$$
$$P = \left(3.75 \times (450\ gallons)^{2/3}\right) + 40 = 260.21\ watts$$
$$Unit_{Label\ Savings} = 260.21\ watts \times 5\%\ Potential\ Savings = 13.01\ watts$$

$$P_{Label} = 260.21 - 13.01 = 247.20\ watts \approx 247\ watts$$

**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-11** lists the baseline energy consumption without the labeling impact for explaining the calculations in this study.

**Table B-11: 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 | 1,236,102 | 0 | 1,236,102 | 60,454 |
| 1B | 1,456,606 | 169,719 | 1,626,326 | 506,006 |
| 2 | 1,619,830 | 744,298 | 2,364,128 | 1,343,198 |
| 3 | 1,749,776 | 1,549,547 | 3,299,323 | 48,065 |
| 4 | 0 | 4,524,810 | 4,524,810 | 18,834 |
| 5 | 3,635,823 | 891,686 | 4,527,509 | 56,535 |
| 6 | 3,085,848 | 2,293,479 | 5,379,327 | 89,562 |
| 7 | 2,738,868 | 3,418,224 | 6,157,092 | 64,070 |
| 8 | 2,995,490 | 3,760,386 | 6,755,876 | 42,180 |
| Combo Spas | 2,325,005 | 3,866,371 | 6,191,376 | 45,098 |

Source: California Energy Commission

Zone 2 in **Table B-11** will be used as the basis of explaining the calculations in this report. The results in the sample calculations will not match the values in **Table B-11** due to rounding, but the steps are equivalent.

Sample Calculations (Zone 2):

Proposed Standard:

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

$$E_{Annual} = (260\ watts) \times \left(8{,}760 \frac{hr}{yr}\right) \times\ (0.711) = 1{,}619{,}373\ Wh/yr$$

Current Standard:

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

$$E_{Annual} = (294\ watts) \times \left(8{,}760 \frac{hr}{yr}\right) \times\ (0.289) = 744{,}302\ Wh/yr$$

Total Energy Consumption for Zone 2:

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

$$E_{Annual} Zone\ 2 = (1{,}619{,}373 + 744{,}302) = 2{,}363{,}675 Wh/yr$$

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

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

Sample Calculations (Zone 2):

$$Average\ Energy\ Consumption_{Zone2} = (2{,}363{,}675\ Wh/yr) \times (0.568) = 1{,}342{,}567\ Wh/yr$$

The annual stock energy consumption for portable electric spas is the product of average energy consumption and the annual stock in 2018.

$$Annual\ Stock\ Energy\ Consumption_{Zone} = (Ave.Energy\ Consumption_{Zone}) \times (2019\ Stock) \times 10^{-9}$$

Sample Calculations (Zone 2):

$$Annual\ Stock\ Energy\ Consumption_{Zone2} = \left(1{,}342{,}567\ \frac{Wh}{yr}\right) \times (609{,}479\ units) \times 10^{-9} = 818\ \frac{GWh}{yr}$$

The total annual stock energy consumption is the addition of the annual stock energy consumption for each zone. **Table B-12** lists the baseline total annual stock energy consumption for 2019 and 2028. Calculations for 2028, when full implementation is complete, are similar.

**Table B-12: Baseline Energy Use**

| Year | Stock | Total Annual Energy Consumption (GWh/yr) |
|---|---|---|
| 2019 | 609,479 | 1,386 |
| 2028 | 747,923 | 1,701 |

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, 2019, effective date, the compliance rate and stock for 2018 would also be zero. Unless noncompliant models are still being sold, this equals no additional state energy usage for 2018, as well as in 2019 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 method as baseline energy use. **Table B-13** lists the compliant total annual stock energy consumption for 2019 and 2028.

**Table B-13: Compliant Energy Use**

| Year | Stock | Total Annual Energy Consumption (GWh/yr) |
|---|---|---|
| 2019 | 609,479 | 1,381 |
| 2028 | 747,923 | 1,638 |

Source: Staff calculation

## Cost and Savings

**Table B-14** lists the energy savings for portable electric spas once the proposed standard becomes effective in 2019 and when complete implementation has occurred in 2028.

**Table B-14: 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 | 3.3 (64%) | 0.61 | 40.3 (64%) | 7.4 |
| Exercise Spas | 1.5 (29%) | 0.28 | 18.3 (29%) | 3.4 |
| Combo Spas | 0.3 (7%) | 0.06 | 4.2 (7%) | 0.8 |
| Total | 5.1 (100%) | 0.95 | 62.8 (100%) | 11.6 |

Source: Staff calculation

The energy savings are calculated by subtracting the compliant energy use from the baseline energy use. The results in the sample calculations will not match the values in **Table B-14** due to rounding, but the steps are equivalent.

$$E_{Annual\ Savings} = E_{Annual\ Baseline} - E_{Annual\ Compliant}$$

Sample Calculation:

$$E_{Annual\ Savings} = (1{,}386 - 1{,}381)\frac{GWh}{yr} = 5\frac{GWh}{yr}$$

The cost savings (benefits) are calculated by multiplying the annual energy savings by $0.1619 per kWh.

$$B_{Savings} = \frac{\$0.1855}{kWh} \times E_{Annual\ Savings}$$

Sample Calculation:

$$B_{Savings} = \frac{\$0.1855}{kWh} \times 5\frac{GWh}{yr} \times \frac{10^6 kWh}{1GWh} = \$927{,}500\ or\ \$0.93\ Million$$

The cumulative energy and costs savings when the proposed standard has reached complete implementation are the summation of savings from each year beginning in 2019 and ending in 2028.

**Table B-15** lists the energy savings and cost savings for labeled portable electric spas once the proposed standard becomes effective in 2019 and when complete implementation has occurred in 2028. The savings in the table below assumes the standard is completely implemented for the first year and after complete turnover.

**Table B-15: 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 | 4.4 (64%) | 0.82 | 52.5 (64%) | 9.7 |
| Exercise Spas | 2.0 (29%) | 0.37 | 23.9 (29%) | 4.4 |
| Combo Spas | 0.5 (7%) | 0.09 | 5.5 (7%) | 1.0 |
| Total | 6.9 (100%) | 1.28 | 81.9 (100%) | 15.1 |

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 2019 and 2028 (**Table B-13**).

$$First - Year\ Energy\ Consumption\ Savings = Compliant\ AEC \times 100\%\ Standard\ Implementation \times 5\%\ Label\ Savings \times 10\%\ Design\ Life\ Rate$$

$$Complete\ Turnover\ Energy\ Consumption\ Savings = Compliant\ AEC \times 100\%\ Standard\ Implementation \times 5\%\ Label\ Savings$$

Sample Calculation:

$$First - Year\ Energy\ Consumption\ Savings = 1{,}381\frac{GWh}{yr} \times \frac{100\%}{100} \times \frac{5\%}{100} \times \frac{10\%}{100} \approx 6.9\frac{GWh}{yr}$$

$$Complete\ Turnover\ Energy\ Consumption\ Savings = 1{,}638\frac{GWh}{yr} \times \frac{100\%}{100} \times \frac{5\%}{100} \approx 81.9\ \frac{GWh}{yr}$$

Staff then calculated the energy consumption savings for each type of portable electric spa (that is, portable electric spas, exercise spas, and combo 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 (**Table B-14**) and then applying it to the total energy consumption savings from the label savings (**Table B-15**). **Table B-16** summarizes the ratio for each type of portable electric spa.

**Table B-16: Percentage of Energy Consumption after Applying the Standby Power Standard**

| Type | Percentage |
|---|---|
| Portable Electric Spas | 64% |
| Exercise Spas | 29% |
| Combo Spas | 7% |

Source: Staff calculation

$$Portable\ Electric\ Spa\ Energy\ Consumption\ Savings = Total\ Energy\ Consumption\ \times 64\%$$

$$Exercise\ Spa\ Energy\ Consumption\ Savings = Total\ Energy\ Consumption\ \times 29\%$$

$$Combo\ Spa\ Energy\ Consumption\ Savings = Total\ Energy\ Consumption\ \times 7\%$$

Sample Calculation:

$$Exercise\ Spa\ Energy\ Consumption\ Savings_{CompleteTurnover} = 81.9\frac{GWh}{yr} \times \frac{29\%}{100} = 23.8\frac{GWh}{yr}$$

The cost savings are calculated by multiplying the energy consumption savings by the California retail price of electricity.

$$Cost\ Savings = Energy\ Consumption\ Savings\ \times \frac{\$0.1855}{kWh} \times Unit\ Converter$$

Sample Calculation:

$$Cost\ Savings_{TotalAfterCompleteTurnover} = 81.9\frac{GWh}{hr} \times \frac{\$0.1855}{kWh} \times \approx \$15\ Million$$

**Table B-17** lists the weighted unit energy savings, life-cycle costs, and life-cycle benefits.

**Table B-17: 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 | 307 | $ 100.38 | $ 569 | 6 |
| Exercise Spas | 10 | 1,426 | $ 230.38 | $ 2,645 | 11 |
| Combo Spas | 10 | 1,612 | $ 232.50 | $ 2,991 | 13 |

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 the unit, and the average retail price of electricity.

The total setup cost is calculated by multiplying the setup 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 2018.

$$Total\ Printing\ Costs\ to\ Label\ Stock = (printing\ cost\ per\ label) \times (2019\ stock)$$

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.

$$Total\ Labor\ Costs = (2019\ Stock) \times (Time\ to\ adhere\ label) \times (Operator\ Hourly\ Wage)$$

The total cost to label stock is the addition of total setup cost, total printing costs, and total 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 2018 stock.

$$Label\ Cost\ per\ Unit = \frac{Total\ Cost\ to\ Label\ Stock}{2019\ Stock}$$

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, 2019, 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, 2019, effective date is determined by assuming how many hours per season (each year) and how many heating watts are required for the standby mode.

$$First - Year\ Energy\ Consumption = (Heating\ Power) \times (Estimated\ Standby\ Power\ Percentage)(Estimated\ Duty\ Cycle) \times (Estimated\ Annual\ Stock)$$

Where,
Heating Power $\approx$ 1,495 (watts/unit)[204]
Estimated Standby Power Percentage = 35%
Duty Cycle=5,040 (hours/year) = 210 (days/year)
Estimated Annual Stock (used from 2015) $\approx$ 15,000 (units)[205]

$$First - Year\ Energy\ Consumption = 1{,}495\ \frac{watts}{unit} \times \frac{35\%}{100} \times \frac{24\ hours}{1\ day} \times \frac{210\ days}{1\ year} \times \frac{1GWh}{10^9Wh} \times 15{,}000\ units \approx 39.6\ GWh/yr$$

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 featured an automatic shutoff switch that 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.

$$Reduced\ First - Year\ Energy\ Consumption = (Heating\ Power) \times (Estimated\ Standby\ Power\ Percentage) \times (Impacted\ Duty\ Cycle) \times (Annual\ Stock)$$

Where,
Heating Power $\approx$ 1,495 (watts/unit)
Estimated Standby Power Percentage = 35%
Reduced Duty Cycle $\approx$ one 72-hour cycle per week during season (hours/week)
Annual Stock $\approx$ 15,000 (units) estimated by The Association of Pool and Spa Professionals

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204 Average heating power from 51 inflatable spa models across 10 inflatable spa manufacturers: Bestway, Canadian Spa Company, CLP, Insta Spa, Intex, Jilong, ORPC, Radiant Saunas, Therma Spa, and First Spa USA as of March 2017.
205 Ibid.

With 210 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.

$$\begin{aligned}&Reduced\ First-Year\ Energy\ Consumption\\&\quad=1{,}495\ \frac{watts}{unit}\times\frac{35\%}{100}\times\frac{210\ days}{1\ year}\times\frac{30\ weeks}{210\ days}\times\frac{72\ hours}{1\ week}\times\frac{1GWh}{10^9Wh}\times15{,}000\ units\\&\quad\approx17.0\ GWh/yr\end{aligned}$$

Creating a provision for a design requirement still results in about 17.0 GWh of additional statewide energy use during the first year.

## Sample Calculations for Inflatable Spa Monthly Cost Example

Staff calculated the seasonal cost and the monthly cost averaged over a year for an inflatable spa. The data used to perform these calculations are from a docketed test lab report under current Title 20 requirements for portable electric spas submitted by IAPMO EGS for an Intex model.[206]

The measured standby power is calculated by dividing the total energy by the total length of the test.

$$Measured\ Standby\ Power\ (watts)=\frac{Total\ Energy\ (Wh)}{Total\ Test\ Time\ (h)}$$

Where,

Total Energy = 36,831.7 Wh

Total Test Time = 72.783 hours

Sample Calculation:

$$Measured\ Standby\ Power=\frac{36{,}831.7\ Wh}{72.783\ h}=506\ Watts$$

The monthly energy consumption is calculated by multiplying the measured standby power by a full month.

$$Energy\ Consumption\ (Wh)=Measured\ Standby\ Power(watts)\ \times30\ days\times\frac{24\ hours}{1\ day}$$

Sample Calculation:

$$Energy\ Consumption\ =506\ watts\ \times30\ days\times\frac{24\ hours}{1\ day}=364.320\ Wh\ per\ month$$

The monthly cost is calculated by multiplying the monthly energy consumption by $0.1619 per kWh.

$$Monthly\ Cost=Energy\ Consumption\ \times\frac{\$0.1619}{kWh}$$

206 Intex Inflatable Portable Electric Spa Test Report, IAPMO EGS, Docket 15-AAER-02 TN 212386, July 16, 2016.

Sample Calculation:

$$Monthly\ Cost = 364{,}320\ Wh \times \frac{1kWh}{1000\ watts} \times \frac{\$0.1619}{kWh} = \$59\ per\ month$$

The total cost during seasonal use is calculated by multiplying the monthly cost by the seasonal duty cycle of 7 months.

$$Seasonal\ Use\ Cost = Monthly\ Cost\ \times Duty\ Cycle$$

Sample Calculation:

$$Seasonal\ Use\ Cost = \frac{\$59}{month} \times 7\ months = \$413$$

The monthly cost averaged over a year is calculated by dividing the seasonal use cost by 12 months.

$$Average\ Monthly\ Cost = \frac{Seasonal\ Use\ Cost\ (\$)}{12\ months}$$

Sample Calculation:

$$Average\ Monthly\ Cost = \frac{\$413}{12\ months} \approx \$34.41\ per\ month$$

## Sample Calculations for Comparing the Energy Consumption of Different Portable Electric Spas

**Figure 16-1** compares the normalized standby power (normalizes the measured standby power to the ideal difference and the measured difference between the water and ambient temperatures) under the current Title 20 test method and the resulting energy consumption over different periods for different types of portable electric spas at specific volumes.

The normalized standby power for the portable electric spa is an average of 12 spas in MAEDBS with a volume of 210 gallons, the inflatable spa is taken from the docketed test lab report submitted by IAPMO EGS for an Intex model with a volume of 210 gallons, the exercise spa is the average for all Zone 8 models with an average volume of 2,300 gallons, the combo spa portion is the average of the 7 combo spas in MAEDBS with an average volume of 270 gallons, and the combo swim portion is the average of the 7 combo spas in MAEDBS with an average volume of 1,685 gallons.

The energy consumption for the 72-hour period is calculated by multiplying the normalized standby power by 72 hours.

Sample Calculation for the Portable Electric Spa:

$$72 - hour\ Energy\ Consumption\ (kWh) = Normalized\ Standby\ Power\ (watts) \times 72\ hours \times \frac{1kW}{1000W}$$

$$72 - hour\ Energy\ Consumption\ (kWh) = 149\ watts \times 72\ hours \times \frac{1kW}{1000W} \approx 11kWh$$

The annual energy consumption is calculated by multiplying the normalized standby power by the duty cycle. For portable electric spas, the duty cycle is 8,760 hours per year, and for inflatable spas, the duty cycle is 5,040 hours per year.

Sample Calculation for the Portable Electric Spa:

$$Annual\ Energy\ Consumption\ (kWh) = Normalized\ Standby\ Power\ (watts) \times Duty\ Cycle \times \frac{1kW}{1000W}$$

$$Annual\ Energy\ Consumption\ (kWh) = 149\ watts \times 8{,}760\frac{hours}{year} \times \frac{1kW}{1000W} \approx 1{,}305\frac{kWh}{year}$$

The per-month energy consumption is calculated by dividing the annual energy consumption by 12 months.

Sample Calculation for the Portable Electric Spa:

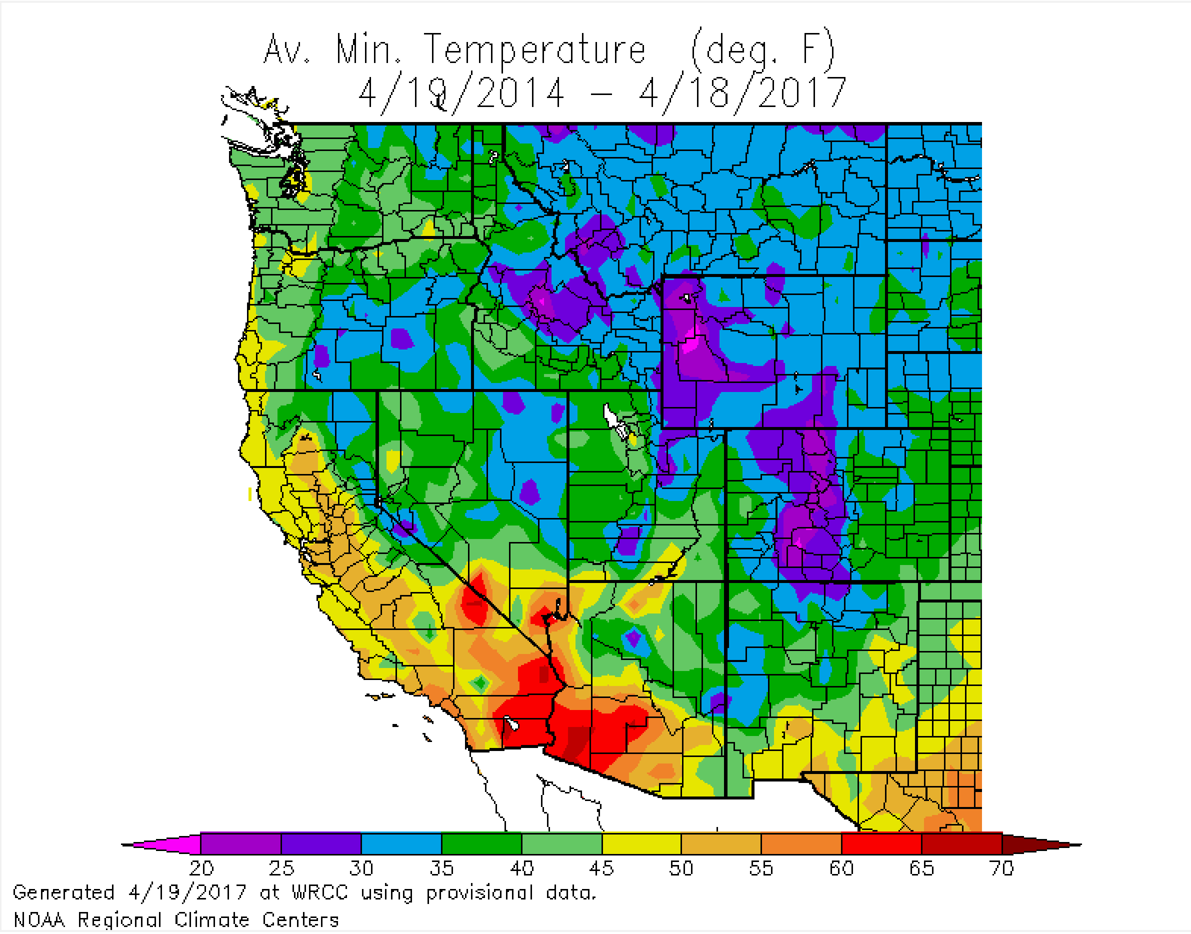
$$Average\ Per\ Month\ Energy\ Consumption\ (kWh) = Annual\ Energy\ Consumption\ (kWh) \div 12\ months$$

$$Average\ Per\ Month\ Energy\ Consumption\ (kWh) = 1{,}305\frac{kWh}{year} \times \frac{1\ year}{12\ months} = 109\frac{kWh}{month}$$

## Average Temperatures in California

**Figure B-2** shows the average minimum temperature for the last 36 months in the western region of the United States as of April 18, 2017. The figure also shows the majority of California has an average minimum temperature that is above 40°F.

**Figure B-2: Average Minimum Temperature in the Western Region**




Source: Western Regional Climate Center

# APPENDIX C: Acronyms

| Acronym | Description |
|---|---|
| AB | Assembly Bill |
| AC | Alternating Current |
| ANSI | American National Standards Institute |
| APSP | The Association of Pool & Spa Professionals |
| CARB | California Air Resources Board |
| ASRAC | Appliance Standards and Rulemaking Federal Advisory Committee |
| BHP | Brake Horsepower |
| CASE Team | Codes and Standards Enhancement Team |
| CDC | Centers for Disease Control and Prevention |
| CO | Carbon monoxide |
| CPUC | California Public Utilities Commission |
| CSA | Canadian Standards Association |
| DOE | Department of Energy |
| DPPP | Dedicate- purpose pool pump |
| ECM | Electrically Commutated Motor |
| EF | Energy Factor |
| EPA | Environmental Protection Agency |
| EPS | Expanded Polystyrene |
| GHG | Greenhouse Gas |
| GPM | Gallons per minute |
| 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 |
| ISPSC | International Swimming Pool and Spa Code |
| kWh | Kilowatt-hour |
| 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 |
| SB | Senate Bill |
| SCE | Southern California Edison |
| SDG&E | San Diego Gas & Electric |
| SF | Service factor |
| SG | Specific Gravity |
| SOx | Oxides of sulfur |
| UV | Ultraviolet |
| WHP | Water Horsepower |
| XPS | Extruded Polystyrene |
| ZNE | Zero Net Energy |