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California Energy Commission

DRAFT STAFF REPORT

Third Revised Analysis of Efficiency Standards for Replacement Pool Pump Motors

2015 Appliance Efficiency Pre-Rulemaking

Docket Number 15-AAER-02

California Energy Commission

Edmund G. Brown Jr., Governor

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California Energy Commission

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PREFACE

On March 14, 2012, the California Energy Commission issued an order instituting rulemaking to begin considering standards, test procedures, labeling requirements, and other efficiency measures to amend the *Appliance Efficiency Regulations* (California Code of Regulations, Title 20, Sections 1601 through 1609). In this order, the Energy Commission identified appliances with the potential to save energy or water or both. 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 on
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. On February 18, 2016, the Commission held a staff workshop 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.

On July 12, 2017, the Commission revised the report based on comments received at the workshop and in writing in the Commission docket. On August 3, 2017, 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 pool pumps motors, with updates based on comments received at the workshops 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 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. Statewide energy use and savings and related environmental impacts and benefits are also included.

Staff proposes standards for pool pump motors sold separately from the pumps as replacements. The standards would take effect on July 19, 2021, for all replacement pool pump motors 5 horsepower or less and that are not waterfall pump motors, rigid spa pump motors, or three-phase motors sold without an inverter. In addition, staff proposes to amend and add definitions and update test procedures so that the standards can be enforced effectively. Staff also seeks to incorporate changes to the appliance regulations due to the U.S Department of Energy dedicated-purpose pool pump standards and test procedures.

The proposed updates would save about 65 gigawatt-hours the first year the standard is in effect. By the year that stock turns over in 2029, the proposed standards would have an annual savings of about 472 gigawatt-hours. This amount equates to roughly $88 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 would significantly reduce energy consumption and are technically feasible and cost-effective.

Keywords: Appliance Efficiency Regulations, appliance regulations, energy efficiency, replacement pool pump motors

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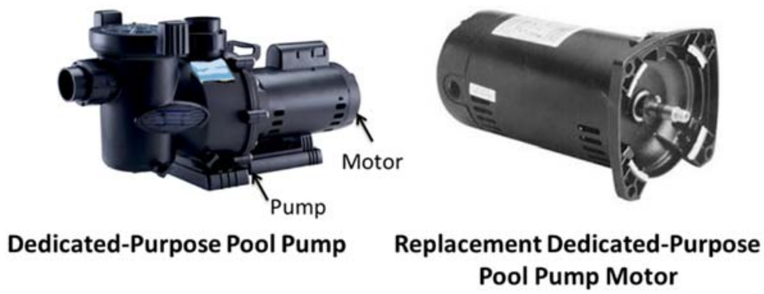
EXECUTIVE SUMMARY

The California Energy Commission intends to take advantage of significant energy efficiency opportunities for replacement pool pump motors through the Title 20 Appliance Efficiency Standards. Staff's revised analysis demonstrates that the proposed replacement dedicated-purpose pool pump motor standards are technically feasible for the industry and cost-effective for consumers.

Figure ES-1: Pool Pump and Replacement Motor



Source: Century A.O. Smith

Staff proposes to expand the existing scope of replacement pool pump motors (stand-alone motors) to include motors that are used for filtration and circulation, as well as motors that are used to run water features and for booster pumping. This proposal extends the savings of the U.S. Department of Energy's dedicated-purpose pool pump (DPPP) rule to replacement motors while creating a simple framework to implement and enforce a standard.

Test procedures are proposed for replacement pool pump motors using Energy Efficiency Test Methods for Small Motors, CSA 747-2009. Staff proposes minimum motor efficiencies with a prescriptive variable-speed motor requirement for motors from 0.5 to 5.0 total horsepower. The proposed standard would take effect July 19, 2021.

Table ES-1: Proposed Standards for Replacement DPPP Motors

Replacement Pool Pump Motor Unit Type	Total Motor Capacity	Prescriptive Requirements	Motor Phase	Minimum Motor Efficiency
Replacement Dedicated-Purpose Pool Pump Motors	Motor hp < 0.5 hp	None	Any	66%
Replacement Dedicated-Purpose Pool Pump Motors	0.5 hp ≤ Motor hp <1.0 hp	Variable Speed	Any	72%
Replacement Dedicated-Purpose Pool Pump Motors	1.0 hp ≤ Motor hp <5.0 hp	Variable Speed	Any	80%

Source: California Energy Commission

The proposal is cost-effective. Staff found significant savings for the various replacement dedicated-purpose pool pump motors to a reduced electrical utility bill. The life-cycle benefit reflects a 3 percent annual discount rate applied to the savings, so the incremental costs and savings can be compared in terms of net present value.

The proposal is technically feasible. Commission staff reviewed replacement residential pool pump motors certified to the Commission and found compliant models, demonstrating the technical feasibility of staff's proposal.

Finally, the proposal will deliver significant electricity and monetary savings to California. The proposed standards would result in an estimated 65 gigawatt-hours of first-year energy savings and an estimated 472 gigawatt-hours per year of energy savings after full stock turnover in 2029, resulting in $88 million in annual cost savings. **Table ES-2** provides estimates for first-year and stock turnover savings.

Table ES-2: 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	44.1	$8.2	322	$59.8
Commercial	20.6	$3.8	150	$27.9
Total Savings	64.7	$12.0	472	$87.7

Source: California Energy Commission staff calculation

The proposal will have a significant positive impact on the environment by reducing the energy required to pump pool water, with an associated reduction in greenhouse gas emissions.

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 or 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 Energy 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 gigawatt-hours (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 megawatts (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.

Reducing Electrical Energy Consumption to Address Climate Change

Appliance energy efficiency is identified as a key to achieving the greenhouse gas (GHG) emission reduction goals of Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006)[6] and

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 Kavalec, Chris, Nick Fugate, Cary Garcia, Asish Gautam, and Mehrzad Soltani Nia. California Energy Commission. January 2016. *California Energy Demand 2016-2026 Revised Electricity Forecast.* 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.

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 Energy Commission's *2015 Integrated Energy Policy Report* (*IEPR*)[9] and the 2011 update to the CPUC's *Energy Efficiency Strategic Plan.*[10] 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 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 approach of the plan to reduce plug-load energy consumption in existing buildings.

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 2008 Update* 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]

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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 https://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/.

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.

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]

Zero-Net-Energy Goals

On April 25, 2012, Governor Brown further targeted ZNE consumption for state-owned buildings. Executive Order B-18-12[17] 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.[18] 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*.[19]

Governor's Clean Energy Jobs Plan

On June 15, 2010, as a part of his campaign, Governor Brown proposed the *Clean Energy Jobs Plan*,[20] 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 this area.

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

17 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.

18 California Energy Commission and CPUC, *Long-Term Energy Efficiency Strategic Plan*, p. 64.

19 California Energy Commission, *2013 IEPR*, pp. 21-26.

20 Office of Edmund G. Brown Jr., *Clean Energy Jobs Plan,* available at http://gov.ca.gov/docs/Clean_Energy_Plan.pdf.

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 of 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,[21] 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 aesthetic and safety requirements.[22]

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 salt water pool system works similarly with the use of salt and a conversion cell rather than chlorine and a chlorinator. 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.[23] Commercial pool systems are designed to complete circulation or turnover in six hours due to higher level of use.[24] A common pool system configuration including these components is seen in **Figure 3-1** for chlorine pools and **Figure 3**-2 for salt water pools**.**

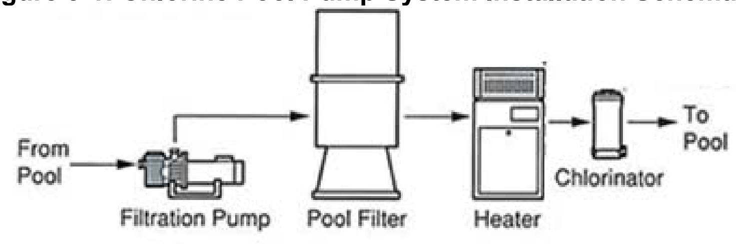
21 Olsen, Kevin. "Clear Waters and a Green Gas: A History of Chlorine as a Swimming Pool Sanitizer in the United States." *Bulletin for the History of Chemistry*, Volume 32, Number 2, pp. 129-140, 2007.

22 U.S. EPA. February 2000. *The History of Drinking Water Treatment.* Available at http://www.epa.gov/safewater/consumer/pdf/hist.pdf.

23 *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, *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, *Pool Pump Sizing*, poolplaza.com, 2015, available at https://www.poolplaza.com/pool-pump-sizing.

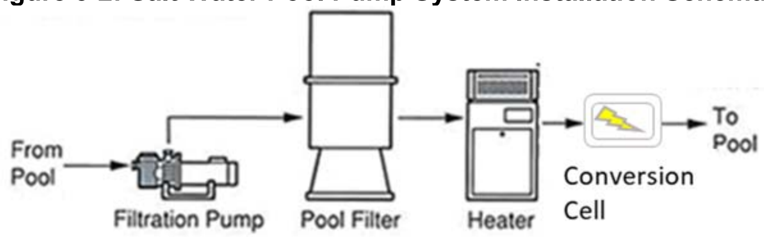
24 California Health and Safety Code Section 116064.2(b)(2)(E).

Figure 3-1: Chlorine Pool Pump System Installation Schematic



Source: epoolshop.com

Figure 3-2: Salt Water Pool Pump System Installation Schematic



Source: epoolshop.com with Energy Commission Staff

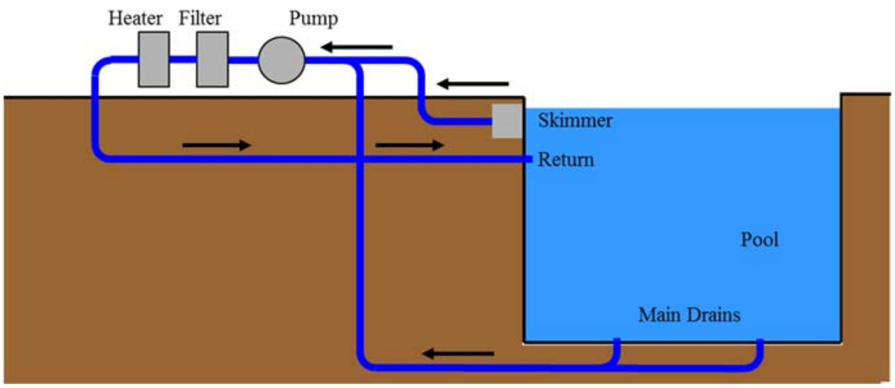
Pool maintenance programs are typically broken up into filtering, heating, and cleaning applications. An in-ground spa will require an additional application to provide high-speed jets. These maintenance applications, as well as the pool equipment types, pool plumbing design, and pool volume, influence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

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.

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 3-3: 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.[25] Some pool systems may employ a second pool pump motor combination, commonly referred to as a *pool booster pump*, to provide high pressure to drive the pool sweeper and vacuum. An additional pool pump motor combination, known as a *waterfall pump*, may be added to the system to supply water to a waterfall.

A pool owner can achieve significant energy savings by running the pool pump and motor combination at the lowest available motor speed that meets the minimum water flow requirements of the task.[26] Different motor technologies exist to allow the consumer to select the speed adequate to the pool maintenance task to achieve energy savings. Variable-speed pool pump and motor combinations provide the most flexibility and 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 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 exclusively use end-suction centrifugal pump designs due to the low initial

25 U.S. DOE, *Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings*, pp. 2-3, available at http://www.nrel.gov/docs/fy12osti/54242.pdf.

26 *Variable Speed Pumping, A Guide to Successful Applications*, Executive Summary, pp. 4-5 available at http://www.energy.gov/sites/prod/files/2014/05/f16/variable_speed_pumping.pdf.

cost, low complexity, and moderate energy efficiency when compared to double-suction centrifugal pumps or positive displacement pumps.[27]

An electric motor powers the pump by converting electrical energy to rotational energy. The electric motor is typically sized between 0.1 and 5.0 nameplate horsepower (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** and as modified by Commission staff.[28] Since staff expects similar if not the same variable-speed motors for self-priming, non-self-priming, and pressure cleaner booster pumps, staff assumed the average lifetime to be 7.3 years for these pump types. **Figure 3-4** shows a typical pool pump and motor combination. **Figure 3-5** shows a typical replacement pool pump motor.

Table 3-1: Average Product Lifetime

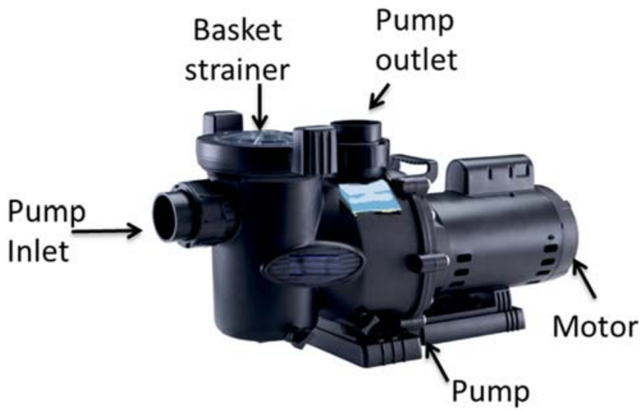
	Average Lifetime (years)		
Pump Type	**Single-Speed**	**Dual-Speed**	**Variable-Speed**
Self-priming filter pumps	7.3	7.3	7.3
Non-self-priming filter pumps	5.3	5.3	7.3*
Waterfall pumps	7.3	Not Available	Not Available
Pressure cleaner booster pumps	5.3	Not Available	7.3*
Integral cartridge/sand filter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

Source: U.S. Department of Energy, Building Technologies Office and *Commission staff

27 *Improving Pumping System Performance, A Sourcebook for Industry*, U.S. DOE Second Edition, pp. 13-14, available at http://energy.gov/sites/prod/files/2014/05/f16/pump.pdf.

28 *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.

Figure 3-4: Pool Pump and Motor Combination



Source: Hayward Pools

Figure 3-5: 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 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 Regulations, 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, or 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 the plumbing system.[29] The energy loss phenomenon is similar to the energy losses encountered by a car from wind resistance. Just as a car will achieve better fuel economy at lower speeds by reducing the wind resistance, a pool system will achieve greater efficiency by reducing the resistance in the plumbing system at lower flow rates. The phenomenon is described by the three pump affinity laws (shown below) that 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 speed, the electrical power demanded by the motor would be reduced to one-eighth of the maximum power. The pump affinity laws also state that the volumetric flow rate is directly proportional to the speed of the motor. For example, the volumetric flow rate through a pump would be reduced by half if the rotational speed of the attached pump is reduced by half.[30] To achieve the same volume of flow, the pump must be run twice as long at half-speed. The total energy consumed then, as defined by power

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29 U.S. DOE, *Measure Guideline: Replacing Single-Speed Pool Pumps With Variable Speed Pumps for Energy Savings*, pp. 3-4, available at http://www.nrel.gov/docs/fy12osti/54242.pdf.

30 *Pump Affinity Laws*, The Engineering Toolbox, available at https://www.engineeringtoolbox.com/affinity-laws-d_408.html.

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 pool maintenance.

Motor Energy Consumption and Efficiency

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

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 Energy Commission's Modernized Appliance Efficiency Database System (MAEDbS) as of September 2018. 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. Many pools do not require a pool pump with a motor capacity over 1 total horsepower due to the small size.[32] Single-speed pool pumps under 1 hp total capacity can meet California Appliance Regulations. Therefore, most pool pump motors in California are single-speed motors.[33]

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

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

32 Southern California Edison, Pool Pump Demand Response Potential, June 2008, pg. 12, available at https://www.etcc-ca.com/sites/default/files/reports/dr07_01_pool_pump_demand_response_potential_report.pdf.

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

contractors on how to select, install, and configure non-single-speed pump systems to achieve energy savings while maintaining pool cleanliness.[34]

Dual-/Multiple-Speed Pumps

Dual-speed pump motors are powered by single-phase AC induction motors. The motor design allows for dual-speed operation at full and half speeds for the pump and motor. At full speed, equivalent to a single-speed pump operation, the pump generates the highest flow and pressure, but this is the least energy-efficient operational speed due to higher frictional losses within the pool plumbing system. 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.[35] The lower operating speed results in more energy-efficient operation because losses within the pool plumbing system are minimized. 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.

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 waveform to set the motor speed and minimize electrical losses within the motor. A variable-speed motor may provide speeds between a minimum of 1/8 of full speed to full speed.[36]

A variable-speed pool pump motor accrues energy savings exceeding dual- and multiple-speed motors in two ways. First, the user may select a speed slower than half speed or the lowest set speed on a multiple-speed motor to accomplish the circulation and filtering tasks, resulting in energy savings. Second, variable-speed motors use a permanent magnet rotor design that replaces the electromagnetic rotor design in AC induction motors. The variable-speed motor achieves greater efficiency than the AC induction motor while running at the same speed because no current is required to power the rotor magnet, as is required by the AC induction motor.[37]

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34 IBID, pp. 18-20.

35 Davis Energy Group. May 12, 2004. *Analysis of Standards Options for Residential Pool Pumps, Motors, and Controls*, pp. 11-12. Available at https://consensus.fsu.edu/FBC/Pool-Efficiency/CASE_Pool_Pump.pdf.

36 CASE Report. July 29, 2013. *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.

37 *Machine Design, The Difference Between AC Induction, Permanent Magnet, and Servomotor Technologies*. April 1, 2012. Available at https://www.machinedesign.com/motorsdrives/whats-difference-between-ac-induction-permanent-magnet-and-servomotor-technologies.

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 pool constructions.

Figure 3-6: 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 pump 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. The freeze protection 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 freeze protection may be included on pool pump and motor combinations and replacement pool pump motors. The default settings for starting temperature, pump duration, and motor speed vary by manufacturer.[38]

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38 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.

An in-ground filtering pump is shown in **Figure 3-3**. A survey of marketing materials shows manufacturers designate the same in-ground filtering pool pumps for residential and commercial applications for pumps 5 hp total capacity or less.[39]

Above-Ground Filtering Pool Pump and Motor Combinations

Above-ground filtering pumps are similar in design to in-ground filtering pumps except they are non-self-priming because 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 3-7** shows a typical above-ground pool pump and motor combination.

Figure 3-7: 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.[40] 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 3-8** shows an integrated cartridge filter pump and sand filter pump.

Figure 3-8: Portable and Storable Pool Pump Motor Combinations

Source: Intex

39 Pentair product catalog, Section 8 Pumps, p. 168, 2016, https://www.pentairpartners.com/productcatalog/pdf/US2016/sec08_Pumps.pdf.
40 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.

Pressure Cleaner Booster Pump and Motor Combinations

Pressure cleaner booster pump 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[41] and multistage pumps have been introduced to improve the efficiency of pressure cleaner booster pumps.[42] **Figure 3-9** shows a pressure cleaner booster pump.

Figure 3-9: 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 of maximum speed. **Figure 3-10** shows a waterfall pump.

Figure 3-10: Waterfall Pump and Motor Combination

Source: Jandy

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41 Power Defender Booster Pump, Waterway Plastics, Available at http://waterwayplastics.com/products/pool-products/pumps/booster-pumps-2/power-defender-booster-pump/.

42 Polaris PB4SQ, Zodiac Pool Systems, Available at http://www.polarispool.com/en/products/booster-pumps/polaris-pb4sq.

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.[43]

California's regulation requires 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 mandatory federal standards or test procedures for replacement pool pump motors at the writing of this report. The U.S. DOE offered an optional test method for replacement pool pump motors in the final rule for the DPPP test procedure. The optional test pairs a replacement motor with an appropriate DPPP bare pump and then runs the DPPP test procedure. The test method could provide consumers with standardized performance information on replacement motors.[44]

The U.S. Department of Energy (U.S. DOE) has established test procedures and energy conservation standards for dedicated-purpose pool pumps (DPPP).[45] The standards and test

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

44 10 C.F.R. Sections 431.461 to 431.466 and Appendices B and C to subpart Y of Part 431 subsection G.2

45 10 C.F.R. Sections 431.461 to 431.466 and Appendices B and C to subpart Y of Part 431.

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

The U.S. DOE established definitions, test procedures, certification requirements, enforcement testing procedures, and labeling provisions for DPPPs. The test procedure 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.[46]

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).[47]

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.[48]

Dedicated Purpose Pool Pump Motor Negotiation

The Energy Commission participated in a negotiation on potential national standards for DPPP motors beginning in March 2018.[49] The negotiation with pool pump motor industry and energy efficiency advocates resulted in a consensus agreement to present to the U.S. DOE. The agreement set a single equipment class for DPPP motors. Motors with a capacity greater than or equal to 1.15 horsepower would be required to be variable-speed. All motors would also be

46 10 C.F.R. Sections 431.462

47 10 C.F.R. Sections 431.461 to 431.466 and Appendices B and C to subpart Y of Part 431

48 U.S. Department of Energy, Energy Conservation Program: Energy Conservation Standards for Dedicated Purpose Pool Pumps, Direct Final Rule, 82 FR 5652, January 18, 2017, https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0109f.

49 Energy Commission, Memo to Suspend the Replacement Pool Pump Motor Pre-Rulemaking Proceeding, March 12, 2018, available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=223646.

required to not be split-phase or capacitor-start induction-run. The proposed effective date is July 19, 2021, to align with the federal standards for DPPP. The petition is before the U.S. DOE.[50]

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.[51]

The Energy Standards (California Code of Regulations, Title 24, Part 6) incorporate the Title 20 requirements for pool pumps and motor combinations and provide 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.[52]

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 hp total. 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 hp total. 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 effectively eliminates the requirement to use two or more speed pool pumps when replacing a pump for an existing pool.[53] 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 hp total. The law became effective January 1, 2010.

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50 U.S. Department of Energy, Energy Conservation Program: Energy Conservation Standards for Dedicated-Purpose Pool Pump Motors, Notice of Request for Direct Final Rule, 83 FR 45851 to 45860, September 11, 2018, available at https://www.federalregister.gov/documents/2018/09/11/2018-19577/energy-conservation-program-energy-conservation-standards-for-dedicated-purpose-pool-pump-motors.

51 California Building Code. Title 24, Part 2, Chapter 31B, Sections 3101B – 3162, available at https://codes.iccsafe.org/public/chapter/content/10044/.

52 California Energy Code, Title 24, Part 6, Section 150.0(p) Pool Systems and Equipment Installation, available at http://www.energy.ca.gov/2015publications/CEC-400-2015-037/CEC-400-2015-037-CMF.pdf.

53 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.

Connecticut and New York have adopted residential pool pump standards similar to the California Title 20 regulations.[54]

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.[55]

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 DPPP using the U.S. DOE DPPP test procedure. ENERGY STAR Pool Pumps Specification Version 2.0 requires pumps to achieve a weighted energy factor equal to the future U.S. DOE standard beginning on September 17, 2018. ENERGY STAR Pool Pumps Specification Version 3.0 requires pumps to achieve a higher weighted energy factor beginning July 19, 2021.[56]

The U.S. EPA has not set a specification for replacement pool pump motors.

CASE Report

The California IOUs submitted a Codes and Standards Enhancement (CASE) report to the Energy Commission in July 2013. The IOUs revised the proposal for pool pump standards in September 2014.[57] The proposal recommends minimum motor efficiency standards for all pool pump and motor combinations and replacement motors.

54http://library.cee1.org/sites/default/files/library/9986/cee_res_swimmingpoolinitiative_07dec2012_pdf_10557.pdf.

55 http://www.poolspanews.com/legislation/states-introduce-out-of-date-energy-laws.aspx.

56 ENERGY STAR-Certified Pool Pumps, available at https://www.energystar.gov/products/spec/pool_pumps_specification_version_2_0_pdf.

57 CASE Report, July, 29, 2013,*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 five alternatives for state standards for replacement pool pump motors: (1) maintaining current Title 20 standards (no change); (2) incorporating the CASE report suggestions; (3) aligning the replacement pool pump motor standards with the U.S. DOE DPPP test procedure, metric, and standards; (4) incorporating standards from the joint petition to the U.S. DOE; and (5) proposing a minimum motor efficiency and prescriptive speed control standard. Staff also considered comments from interested parties made during the February 18, 2016, staff workshop; the July 13, 2016, staff workshop; the August 3, 2017, 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 alternative 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.

Manufacturers expressed concerns during the U.S. DOE DPPP rulemaking 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.[58] The U.S. DOE standards require performance equivalent to variable-speed pump control for standard-size pool pumps that is higher than the California Appliance Regulations requirement for dual speed. There is an opportunity for lost savings despite the existing California standards if consumers choose the minimally compliant replacement motor per California law. Since the U.S. DOE adopted performance-based regulations for the pump and

58 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, 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, 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., 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, 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.

motor combinations, staff believes amending the replacement pool pump motor regulations will address this concern while leading to greater cost-effective energy savings.

Alternative 2: Incorporate CASE Team Proposal

The CASE team proposes 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. The proposal recommends a new CSA test method C747-09 to verify motor efficiency.[59]

While the CASE team proposal offers significant energy savings, the standard would not provide the additional savings from rightsizing the pump to meet the system need through variable-speed controls.

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

Alternative 3: Harmonize Replacement Pool Pump Motor Standard with the U.S. DOE DPPP Standard

Under Alternative 3, staff would harmonize test procedures and standards for replacement pool pump motors with the U.S. DOE test procedure and standard for DPPP. This alternative 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 measure the motor output power on a dynamometer and apply a weighted energy factor (WEF) standard similar to the U.S. DOE DPPP standard.[60]

While this proposal captures the savings of motor efficiency and variable-speed controls, staff believes Alternative 5 could achieve the greater savings without the complexity of the WEF testing and scoring.

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59 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.

60 Steffensen, Sean, Jessica Lopez, and Ben Fischel. 2017. *Second Revised Staff Analysis of Efficiency Standards for Pool Pump Motors, and Spas.* California Energy Commission. Publication Number: CEC-400-2016-002-SD3, available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=220120.

Alternative 4: Standards per the Joint Stakeholder Proposal to U.S. DOE

Under Alternative 4, staff would propose standards as per the joint stakeholder proposal submitted to the U.S. DOE on August 14, 2018.[61] The proposal sets a prescriptive variable-speed motor control requirement for motors over 1.15 total horsepower and a prohibition like the California Appliance Regulations for split-phase and capacitor-start induction-run motors. Motors with freeze protection capability would need to meet the same requirements as those in the U.S. DOE DPPP standard.

While this proposal captures the savings of motor efficiency and variable-speed controls, staff believes Alternative 5 could achieve greater savings by requiring more motors to have variable-speed control and achieve a minimum motor efficiency.

Alternative 5: Prescriptive Variable-Speed Requirement with Minimum Motor Efficiency

Under Alternative 5, staff would propose to establish minimum motor efficiency requirements and a prescriptive variable-speed motor control standard for replacement motors for residential and commercial pools that are less than 5 hp. The motors would need to meet a minimum motor efficiency as shown in **Table 5-2**. Motors between 0.5 hp and 5 hp would need to have variable-speed capability.

This proposal extends the savings of the U.S. DOE's DPPP rule to replacement motors while creating a simple framework to implement and enforce a standard for this product.

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61 U.S. Department of Energy, Energy Conservation Program: Energy Conservation Standards for Dedicated-Purpose Pool Pump Motors, Notice of Request for Direct Final Rule, 83 FR 45851 to 45860, September 11, 2018, available at: https://www.federalregister.gov/documents/2018/09/11/2018-19577/energy-conservation-program-energy-conservation-standards-for-dedicated-purpose-pool-pump-motors.

Table 5-2: Proposed Standards for Replacement DPPP Motors

Replacement Pool Pump Motor Unit Type	Total Motor Capacity	Prescriptive Requirements	Motor Phase	Minimum Motor Efficiency
Replacement Dedicated-Purpose Pool Pump Motors	Motor hp < 0.5 hp	None	Single-phase or three-phase	66%
Replacement Dedicated-Purpose Pool Pump Motors	0.5 hp ≤ Motor hp <1.0 hp	Variable-Speed	Single-phase or three-phase	72%
Replacement Dedicated-Purpose Pool Pump Motors	1.0 hp ≤ Motor hp <5.0 hp	Variable-Speed	Single-phase or three-phase	80%

Source: California Energy Commission

CHAPTER 6:
Staff-Proposed Standards for 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 DPPP, is a replacement DPPP motor.

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 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 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 are 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.

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 out of the scope of the rulemaking if the motor is sold or offered for sale without a drive to convert single-phase power to three-phase power.

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.

Variable Speed Control with Minimum Motor Efficiency

Staff proposes a prescriptive variable-speed control requirement and a minimum motor efficiency at full speed and full load. All replacement pool pump motors that are a total horsepower of five hp or less, manufactured on or after July 19, 2021, shall meet the efficiency standards outlined in **Table 6-1**.

Table 6-1: Proposed Standards for Replacement DPPP Motors

Replacement Pool Pump Motor Unit Type	Total Motor Capacity	Prescriptive Requirements	Motor Phase	Minimum Motor Efficiency
Replacement Dedicated-Purpose Pool Pump Motors	Motor hp < 0.5 hp	None	Single-phase or three-phase	66%
Replacement Dedicated-Purpose Pool Pump Motors	0.5 hp ≤ Motor hp<1.0 hp	Variable-Speed	Single-phase or three-phase	72%
Replacement Dedicated-Purpose Pool Pump Motors	1.0 hp ≤ Motor hp <5.0 hp	Variable-Speed	Single-phase or three-phase	80%

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. The minimum motor efficiencies are comparable to the motor efficiency standards set by the U.S. DOE Small Motor Rule and match values provided in comments to the Commission by industry.[62]

62 U.S. Government Publishing Office, 10 CFR 446 (a) Small electric motors energy conservation standards and the associated effective dates, available at https://www.ecfr.gov/, Association of Pool and Spa Professionals, APSP Comments on Revised Analysis of Efficiency Standards for Pool Pumps, Motors and Spas, August 12, 2016, pg. 6, available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=212760, Nidec Motor Corporation, Nidec Motor Corp. Comments on CEC Proposed Changes to Pool Pumps and Spa Labeling, July 29, 2016, pg. 4, available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=212507.

Losses in the system are proportional to the operational speed of the pump. Variable-speed control allows the user to set the pump at the lowest speed that can achieve the cleaning and filtering tasks. By reducing the pump speed, the pump user can achieve energy savings.

Replacement pool pump motors below 0.5 total horsepower will not be required to be variable-speed. As the motor size decreases, the energy-saving opportunity from the ability to turn down the motor speed decreases. Staff found a 0.5 hp motor could deliver cost-effective savings from variable-speed control. The analysis assumed a 5,000-gallon pool and a duty cycle and lifetime similar to the U.S. DOE analysis. While staff found additional cost-effectiveness for replacement motors below 0.5 hp, staff chose to not apply the variable-speed requirement below 0.5 hp to align with the motor efficiency size categories of 0 to 0.5 hp, 0.5 to 1.0 hp and 1.0 hp and greater.

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 standard.[63] The previously banned motor types could be sold in California under the proposed standard as long as they meet the minimum motor efficiency 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.

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

At restricted flow, the torque on the shaft is at a minimum, while at unrestricted flow, the torque rises to a maximum.[64] To be consistent with the U.S. DOE's selection of the pool system Curve C where flow is less restricted, therefore, all test points will require the motor to perform at maximum speed and full load.

64 Girdhar, Paresh and Octo Moniz, *Practical Centrifugal Pumps*, 2011, pg. 108-110.

CHAPTER 7: Savings and Cost Analysis

The proposed standards would significantly reduce energy consumption. The cost analysis uses the U.S. DOE data developed during the ASRAC DPPP negotiation.[65] 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. Although there will be only one standard regardless of pump style, staff provides a savings analysis to show cost-effectiveness for each application.

The relatively low savings and incremental cost for the 1.90 hp and 3.76 hp replacement motors in a residential application is due to the assumption that most replacement motors over 1 hp are already variable speed and compliant with the proposed standard. The small percentage of noncompliant motors at this size are assumed to be two-speed.

Commercial applications achieve the savings shown through reducing the motor operation from maximum speed to the minimum speed that achieves the water turnover required by the health code. Staff assumed the minimum speed to be 80 percent of maximum speed.

See **Appendix A** for a detailed calculation.

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65 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.

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

Product	Application	Design Life (years)	Electricity Savings (kWh/yr)	Average Incremental Cost	Average Annual Savings	Life-Cycle Savings	Life-Cycle Benefit
Replacement SP Pool Filter Pump Motor, (1.90 hp)	Residential	7.3	63	$17	$12	$76	$59
Replacement SP Pool Filter Pump Motor, (3.76 hp)	Residential	7.3	86	$10	$16	$103	$93
Replacement SP Pool Filter Pump Motor, small-size	Residential	7.3	1,410	$289	$261	$1,692	$1,403
Replacement NSP Pool Filter Pump Motor	Residential	7.3	1,520	$367	$282	$1,825	$1,458
Replacement Pressure Cleaner Booster Pump Motor (1.24 hp)	Residential	7.3	361	$356	$67	$433	$77
Replacement SP Pool Filter Pump Motor, (1.90 hp)	Commercial	7.3	6,092	$358	$1,130	$7,314	$6,956
Replacement SP Pool Filter Pump Motor, (3.76 hp)	Commercial	7.3	9,502	$348	$1,763	$11,408	$11,061
Replacement SP Pool Filter Pump Motor, small-size	Commercial	7.3	1,579	$380	$293	$1,896	$1,516

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 2018 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.[66] 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 compliant 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.[67] 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.[68] Assuming a 14 percent replacement rate based on a 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.[69] The California and nationwide estimates seem consistent and proportional.[70] Staff assumed 26 percent of in-ground pools and 13 percent of the above-ground pools in the United States are in California.

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.[71] That is somewhat higher than the previous CASE team estimate of 5,000 pool pump shipments per year.[72] 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.

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

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66 Energy Information Administration – Residential Electricity Prices for 2017 Through February 2017, retrieved May 4, 2017. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_b.

67 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.

68 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.

69 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.

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

71 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.

72 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.

pump and motor combination, rather than replace the entire system, between 25 percent and 60 percent of the time.[73, 74] 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.[75]

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.[76]

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 472 gigawatt-hours (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 $88 million a year in reduced utility costs.

Staff determined the peak power demand reduction of 39 MW by multiplying the total number of motors operating during peak power demand by reduction in input power due to the improved efficiency. Southern California Edison provided an estimate for pool pumps that

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73 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.

74 Energy Commission staff assumption of 25 percent market share based upon Commission phone survey of California pool pump and motor retailers conducted June 2016.

75 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.

76 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.

would be on during peak demand.[77] The California Independent System Operator shows peak demand occurs on a summer day between 3 and 5 p.m.[78]

77 Southern California Edison, Pool Pump Demand Response Potential, June 2008, pg. 2, available at Pool https://www.etcc-ca.com/sites/default/files/reports/dr07_01_pool_pump_demand_response_potential_report.pdf.

78 California Independent System Operator. California ISO Peak Load History 1998 through 2017. Available at https://www.caiso.com/documents/californiaisopeakloadhistory.pdf.

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	2.6	$0.5	19	$3.5
Replacement Self-Priming Pool Filter Pump Motor, standard-size (3.76 hp)	Residential	1.2	$0.2	9	$1.6
Replacement Self-Priming Pool Filter Pump Motor, small-size (0.88 hp)	Residential	10.0	$1.9	73	$13.5
Replacement Non-Self-Priming Pool Filter Pump Motor (1.04 hp)	Residential Commercial	26.0	$4.8	190	$35.3
Replacement Pressure Cleaner Booster Pump Motor (1.24 hp)	Residential Commercial	4.3	$0.8	2	$5.9
Replacement Self-Priming Pool Filter Pump Motor, standard-size (1.90 hp)	Commercial	13.2	$2.4	96	$17.8
Replacement Self-Priming Pool Filter Pump Motor, standard-size (3.76 hp)	Commercial	6.8	$1.3	50	$9.3
Replacement Self-Priming Pool Filter Pump Motor, small-size (0.88 hp)	Commercial	0.6	$0.1	4	$0.8
Total Savings		64.7	$12.0	472	$87.7

Source: California 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.[79]

The CASE team estimated the cost of software changes to be less than $1 per unit in mass production for other appliance types.[80] 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.

79 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.

80 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

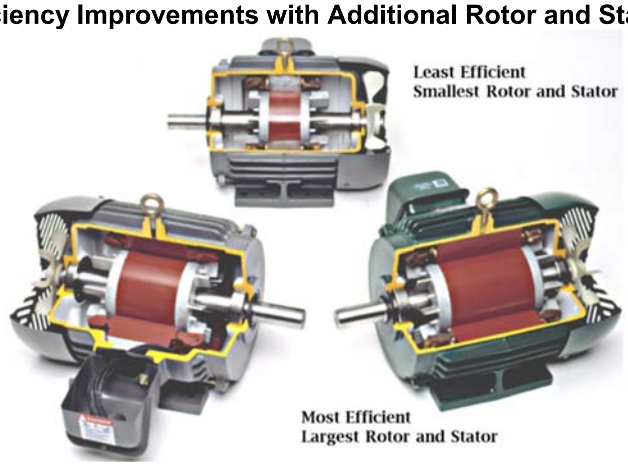
Motor Efficiency

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.

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

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

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

rotates through air).[82] Hysteresis and eddy currents are due to the interaction between alternating electrical currents and magnetic materials within AC induction and ECM motor stators and rotors. Hysteresis occurs as the changes in the magnetic flux lags behind the magnetic force. Eddy currents occur as a voltage builds within the magnetic field. The voltage drives currents through the material of the motor. 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.[83]

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.

Motor Efficiency and Speed Capability Market Survey

Staff reviewed data from the Commission's Modernized Appliance Efficiency Database System for residential pool pump and motor combinations and replacement residential pool pump motors. The certifications provide motor performance data showing motor power output, motor efficiency, and motor speed capability. 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.

Figures 8-1 and **8-2** show existing pool pump motors compliant with the proposed motor efficiency and variable-speed standard in the Energy Commission database as of February 2018. 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 "rightsized" 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.[84] The number of models that already comply shows that the proposed standards are technically feasible for the pool pump motor industry. Although no replacement residential pool pump motor models are certified in the range of 0.0 to 0.5 hp, there is no technical issue that would prevent a manufacturer from introducing a replacement pool pump motor in this size, given that many motors in this size are certified pool pump and motor combinations.

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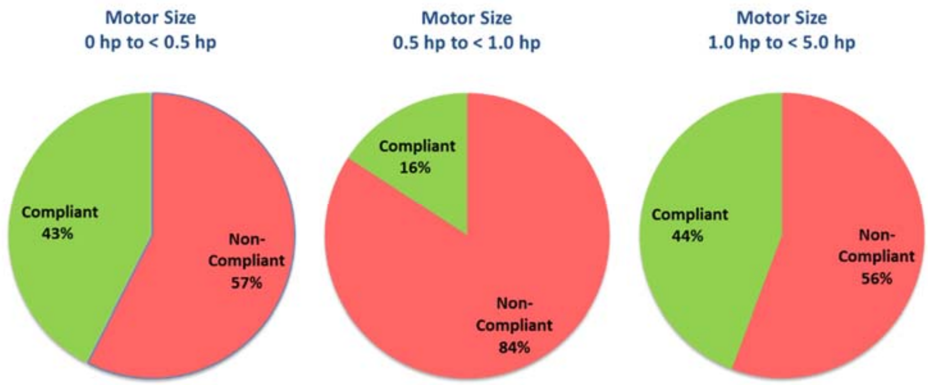
82 Vrancik, James E. 1968. *Prediction of Windage Power Loss in Alternators.* NASA Technical Note D-4849, p. 4.

83 Tong, Wei. 2014. *Mechanical Design of Electric Motors*, CRC Press, p. 402.

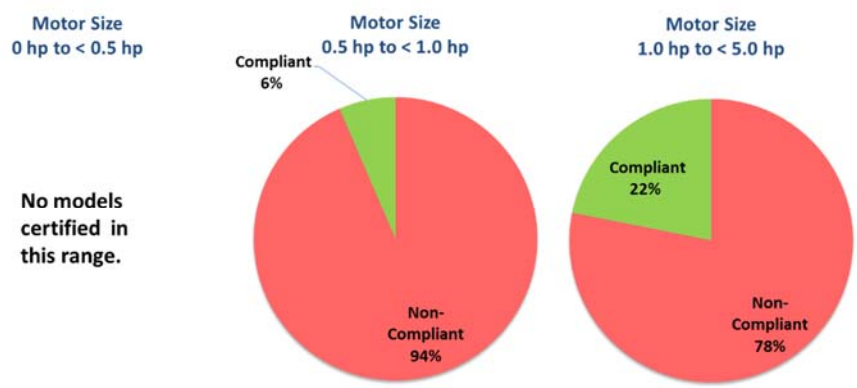
84 Century Electric Motor, VGreen 165 Product Brochure, VGreen165_Bulletin_2751CS.pdf available at https://www.centuryelectricmotor.com/MotorCategory.aspx?LangType=1033&id=6442450977.

Figure 8-2: Residential Pool Pump and Motor Combinations in Energy Commission Database – February 2018



Source: Energy Commission Appliance Database, February 5, 2018

Figure 8-3: Replacement Residential Pool Pump Motors in Energy Commission Database – February 2018



Source: Energy Commission Appliance Database, February 5, 2018

In-ground, above-ground, and pressure cleaner booster pumps rely upon similar motor total capacities, types, and construction. Manufacturers may choose to adapt the pump housing, shaft seal, and impellor to meet the existing compliant motor interfaces, if needed. The adaptations to the interfaces can be made so that compliant 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.[85] 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. In addition,

85 Worth, Chad and Gary Fernstrom. CA IOU Booster Pump Presentation 3-21-2016, Comment to U.S. 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.

manufacturers have introduced variable-speed pool pumps for pressure cleaner booster pump and above-ground pool applications. **Table 8-1** shows overlap of the motor capacities used in the various pool pump types.

Table 8-1: Pool Pump Motor Sizes

Pool Pump Type	Motor Capacity Range (thp)
In-ground pool filter pump	0.5 to 5.0
Above-ground pool filter pump	0.5 to 2.0
Pressure cleaner booster pump	0.9 to 1.25

Source: California Energy Commission staff

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 freeze protection. The CASE team 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.[86]

86 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.

The proposed standards are a motor efficiency performance standard and a variable-speed capability prescriptive standard and do not require the use of any specific material to improve the efficiency of the product. Since motor improvements are already common practice, updating the energy efficiency of replacement dedicated-purpose pool pump motors is not likely to change industry practice, the replacement dedicated-purpose pool pump motor design, or the material composition of these replacement dedicated-purpose pool pump motors. In addition, the nonhazardous materials found in the final product do not pose any harm to the user and would not cause a significant environmental impact.

Benefits

Improving the efficiency of replacement dedicated-purpose pool pump motors through mandatory appliance standards will reduce overall energy consumption statewide, providing important air quality and climate benefits.

The proposed regulations will lead to improved environmental quality in California. Saved energy from more efficient pool water pumping translates to fewer power plants built and less pressure on the limited energy resources, land, and water use associated with them. In addition, lower electricity consumption results in reduced greenhouse gas and criteria pollutant emissions, primarily from lower generation in hydrocarbon-burning power plants, such as natural gas power plants.

CHAPTER 10: Regulatory Language

Proposed new language appears as underline (<u>example</u>) and proposed deletions appear as strikeout (~~example~~). Existing language appears as plain text. Three dots or "…" represents the substance of the regulations that exists between the proposed language and current language.

Section 1601. Scope.

…

(g) Pool heaters, residential pool pump and motor combinations, <u>dedicated-purpose pool pumps,</u> replacement residential pool pump motors, portable electric spas, ~~and~~ pumps<u>, and replacement dedicated-purpose pool pump motors and excluding:</u>

1. <u>Replacement polyphase pump motors capable of operating without a drive and distributed in commerce without a drive that converts single-phase power to polyphase power.</u>
2. <u>Replacement waterfall pump motors.</u>
3. <u>Replacement rigid electric spa pump motors.</u>

…

Section 1602. Definitions.

…

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

~~"Bare pump" means a pump excluding mechanical equipment, driver, and controls.~~

~~"Basic model" of a federally regulated pump means all units of a given class of pump manufactured by one manufacturer, having the same primary energy source, and having essentially identical electrical, physical, and functional (or hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency; except that:~~

~~(1) for RSV and ST pumps, all variations in numbers of stages of the bare pump must be considered a single basic model;~~

~~(2) pump models for which the bare pump differs in impeller diameter, or impeller trim, may be considered a single basic model; and~~

~~(3) pump models for which the bare pump differs in number of stages or impeller diameter and which are sold with motors (or motors and controls) of varying horsepower may only be considered a single basic model if:~~

(i) for ESCC, ESFM, IL, and RSV pumps, each motor offered in the basic model has a nominal full load motor efficiency rated at the federal minimum (see the current table for NEMA Design B motors at Table S-1 of this Article) or the same number of bands above the federal minimum for each respective motor horsepower (see Table 3 of Appendix A to subpart Y of 10 C.F.R. part 431); or

(ii) for ST pumps, each motor offered in the basic model has a full load motor efficiency at the default nominal full load submersible motor efficiency shown in Table 2 of Appendix A to subpart Y of 10 C.F.R. part 431 or the same number of bands above the default nominal full load submersible motor efficiency for each respective motor horsepower (see Table 3 of Appendix A to subpart Y of 10 C.F.R. part 431).

"Best efficiency point (BEP)" means the pump hydraulic power operating point (consisting of both flow and head conditions) that results in the maximum efficiency.

"Bowl diameter" means the maximum dimension of an imaginary straight line passing through and in the plane of the circular shape of the intermediate bowl of the bare pump that is perpendicular to the pump shaft and that intersects the outermost circular shape of the intermediate bowl of the bare pump at both of its ends, where the intermediate bowl is as defined in ANSI/HI 2.1-2.2-2014.

"Capacitor start-capacitor run" means a capacitor start single phase motor that has a capacitor in series with the starting winding.

"Capacitor start-induction run" means a motor that uses a capacitor via the starting winding to start an induction motor, where the capacitor is switched out by a centrifugal switch once the motor is up to speed

"Clean water pump" means a pump that is designed for use in pumping water with a maximum non-absorbent free solid content of 0.016 pounds per ft^3, and with a maximum dissolved solid content of 3.1 pounds per ft^3, provided that the total gas content of the water does not exceed the saturation volume, and disregarding any additives necessary to prevent the water from freezing at a minimum of 14°F.

"Close-coupled pump" means a pump in which the motor shaft also serves as the impeller shaft for the bare pump.

"Coefficient of performance (COP)" of a heat pump pool heater means the ratio of heat output to the total power input in consistent units, as determined using the applicable test method in Ssection 1604(g) of this Article.

"Combination spa" means a portable electric spa with two separate distinct reservoirs, where (1) one reservoir is an exercise spa; (2) the second reservoir is a standard spa; and (3) each reservoir has an independent water temperature setting control.

"Continuous control" means a control that adjusts the speed of the pump driver continuously over the driver operating speed range in response to incremental changes in the required pump flow, head, or power output.

~~“Control” means any device that can be used to operate the driver. Examples include, but are not limited to, continuous or non-continuous controls, schedule-based controls, on/off switches, and float switches.~~

~~“Default speed” means the low speed, having a rotation rate that is no more than one-half of the motor's maximum rotation rate.~~

~~“Driver” means the machine providing mechanical input to drive a bare pump directly or through the use of mechanical equipment. Examples include, but are not limited to, an electric motor, internal combustion engine, or gas/steam turbine.~~

~~“Dry rotor pump” means a pump in which the motor rotor is not immersed in the pumped fluid.~~

~~“Electric heat pump pool heater” means an appliance designed for heating nonpotable water and employing a compressor, water-cooled condenser, and outdoor air coil.~~

~~“Electric resistance pool heater” means an appliance designed for heating nonpotable water and employing electric resistance heating elements.~~

~~“Electronically commutated motor (ECM)” means a brushless DC motor that utilizes a permanent magnet rotor and built in inverters.~~

~~“End suction close-coupled (ESCC) pump” means a close-coupled, dry rotor, end suction pump that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter and that is not a dedicated-purpose pool pump. Examples include, but are not limited to, pumps within the specified horsepower range that comply with ANSI/HI nomenclature OH7, as described in ANSI/HI 1.1-1.2-2014.~~

~~“End suction frame mounted/own bearings (ESFM) pump” means a mechanically coupled, dry rotor, end suction pump that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter and that is not a dedicated-purpose pool pump. Examples include, but are not limited to, pumps within the specified horsepower range that comply with ANSI/HI nomenclature OH0 and OH1, as described in ANSI/HI 1.1-1.2-2014.~~

~~“End suction pump” means a single-stage, rotodynamic pump in which the liquid enters the bare pump in a direction parallel to the impeller shaft and on the side opposite the bare pump's driver- end. The liquid is discharged through a volute in a plane perpendicular to the shaft.~~

~~“Exercise spa” (also known as a “swim spa”) means a portable electric spa that includes specific features and equipment to produce water flow for water physical therapy or physical fitness activity, including, but not limited to, swimming in place.~~

~~“Exercise spa portion” means the reservoir of a combination spa that is an exercise spa.~~

~~“Fill volume” means the 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 skimmer opening. In the~~

~~absence of a skimmer, the fill volume is six inches below the overflow level of the spa as defined in the test method in section 1604(g)(2)(B)1.~~

~~“Fire pump” means a pump that is compliant with NFPA 20-2016 “Standard for the Installation of Stationary Pumps for Fire Protection,” and is either:~~

~~(1) UL listed under ANSI/UL 448-2013 “Standard for Safety Centrifugal Stationary Pumps for Fire-~~

~~Protection Service,” or~~

~~(2) FM Global (FM) approved under the January 2015 edition of FM Class Number 1319, “Approval Standard for Centrifugal Fire Pumps (Horizontal, End Suction Type).”~~

~~“Fossil fuel-fired pool heater” means an appliance designed for heating nonpotable water and employing natural gas or oil burners.~~

~~“Full impeller diameter” means the maximum diameter impeller with which a given pump basic model is distributed in commerce.~~

~~“Horizontal motor” means a motor that requires the motor shaft to be in a horizontal position to function as designed, as specified in the manufacturer literature.~~

~~“Hybrid pool heater” means an appliance designed for heating nonpotable water and employing both a heat pump (compressor, water-cooled condenser, and outdoor air coil) and a fossil fueled burner as heating sources.~~

~~“Inflatable spa” means a portable electric spa where the structure is collapsible and is designed to be filled with air to form the body of the spa.~~

~~“In-line (IL) pump” means a pump that is either a twin-head pump or a single-stage, single-axis flow, dry rotor, rotodynamic pump that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter, in which liquid is discharged through a volute in a plane perpendicular to the shaft. Such pumps do not include pumps that are mechanically coupled or close-coupled, have a pump power output that is less than or equal to 5 hp at BEP at full impeller diameter, and are distributed in commerce with a horizontal motor. Examples of in-line pumps include, but are not limited to, pumps within the specified horsepower range that comply with ANSI/HI nomenclature OH3, OH4, or OH5, as described in ANSI/HI 1.1-1.2- 2014.~~

~~“Magnet driven pump” means a pump in which the bare pump is isolated from the motor via a containment shell and torque is transmitted from the motor to the bare pump via magnetic force. The motor shaft is not physically coupled to the impeller or impeller shaft.~~

~~“Mechanical equipment” of a federally regulated pump means any component of a pump that transfers energy from the driver to the bare pump.~~

~~“Mechanically coupled pump” means a pump in which the bare pump has its own impeller shaft and bearings and so does not rely on the motor shaft to serve as the impeller shaft.~~

"Multi speed motor" means a motor whose speed may be selected from several different pre-set ranges.

"Nameplate HP" means the HP displayed on the nameplate mounted on the motor.

"Non-continuous control" means a control that adjusts the speed of a driver to one of a discrete number of non-continuous preset operating speeds, and does not respond to incremental reductions in the required pump flow, head, or power output.

"PEI_{CL}" means the constant load pump energy index of a pump tested using the applicable test method in section 1604(g)(4) of this Article.

"PEI_{VL}" means the variable load pump energy index of a pump tested using the applicable test method in section 1604(g)(4) of this Article.

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

"Permanent split capacitor (PSC)" means a two-phase motor operated from a single-phase voltage source with a capacitor connected in series with either one of the two windings.

"Pool heater" means an appliance designed for heating non-potable water contained at atmospheric pressure, including heating water in swimming pools, spas, hot tubs, and similar applications.

"Pool pump motor capacity" means a value equal to the product of motor's nameplate HP and service factor.

"Portable electric spa" means a factory-built electric spa or hot tub, supplied with equipment for heating and circulating water at the time of sale or sold separately for subsequent attachment.

"Prime-assist pump" means a pump that:

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

(2) Requires no manual intervention to prime or re-prime from a dry-start condition; and

(3) Includes a device, such as a vacuum pump or air compressor and venturi eductor, to remove air from the suction line in order to automatically perform the prime or re-prime function at any point during the pump's operating cycle.

"Pump" means equipment designed to move liquids (which may include entrained gases, free solids, and totally dissolved solids) by physical or mechanical action and includes a bare pump and, if included by the manufacturer at the time of sale, mechanical equipment, driver, and controls.

"Radially split, multi-stage, vertical, in-line diffuser casing (RSV) pump" means a vertically suspended, multi-stage, single axis flow, dry rotor, rotodynamic pump:

(1) that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter and at the number of stages required for testing and

(2) in which liquid is discharged in a place perpendicular to the impeller shaft; and (3) for which each stage (or bowl) consists of an impeller and diffuser;

(4) for which no external part of such a pump is designed to be submerged in the pumped liquid; and

(5) examples include, but are not limited to, pumps complying with ANSI/HI nomenclature VS8, as described in ANSI/HI 2.1-2.2-2014.

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

“Rated voltage” of a portable electric spa means the voltage, in volts, as it appears on the nameplate of the spa.

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

“Readily accessible on-off switch” of a pool heater means an on-off switch located in a place that can be easily used without the need for tools to remove any covering when the pool heater is on display in a store or when it is installed.

“Replacement residential pool pump motor” means a replacement motor 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.

“Residential pool pump” means an impeller attached to a motor that is used to circulate and filter pool water in order to maintain clarity and sanitation.

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

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

“Rotodynamic pump” means a pump in which energy is continuously imparted to the pumped fluid by means of a rotating impeller, propeller, or rotor.

“Self-priming pump” means 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 re-prime after the initial start-up without the use of external vacuum sources, manual filling, or a foot valve.

"Service factor (of an AC motor)" means a multiplier which, when applied to the rated horsepower, indicates a permissible horsepower loading which can be carried under the conditions specified for the service factor.

"Skimmer" means a suction opening intended to remove floating debris from the water surface and installed where part of the water intake opening is open to atmospheric pressure.

"Single axis flow pump" means a pump in which the liquid inlet of the bare pump is on the same axis as the liquid discharge of the bare pump.

"Speed" means the number of revolutions of the motor shaft in a given unit of time. Speed is expressed in revolutions per minute (RPM).

"Split phase start" means a motor that employs a main winding with a starting winding to start the motor. After the motor has attained approximately 75 percent of rated speed, the starting winding is automatically disconnected by means of a centrifugal switch or by a relay.

"Standard spa" means a portable electric spa that is not an inflatable spa, an exercise spa, or the exercise spa portion of a combination spa.

"Standard spa portion" means the reservoir of a combination spa that is a standard spa.

"Standby mode" of a portable electric spa 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.

"Submersible turbine (ST) pump" means a single-stage or multi-stage, dry rotor, rotodynamic pump that is designed to be operated with the motor and stage(s) fully submerged in the pumped liquid; that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter and at the number of stages required for testing; and in which each stage of this pump consists of an impeller and diffuser, and liquid enters and exits each stage of the bare pump in a direction parallel to the impeller shaft. Examples include, but are not limited to, pumps within the specified horsepower range that comply with ANSI/HI nomenclature VS0, as described in ANSI/HI 2.1-2.2-2014.

"Thermal efficiency" of a pool heater means a measure of the percentage of heat from the input that is transferred to the water, as determined using the applicable test method in Ssection 1604(g) of this Article.

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

"Twin head pump" means a dry rotor, single-axis flow, rotodynamic pump that contains two impeller assemblies, which both share a common casing, inlet, and discharge, and each of which:

(1) Contains an impeller, impeller shaft (or motor shaft in the case of close-coupled pumps), shaft seal or packing, driver (if present), and mechanical equipment (if present);

~~(2) Has a shaft input power that is greater than or equal to 1 hp and less than or equal to 200 hp at best efficiency point (BEP) and full impeller diameter;~~

~~(3) Has the same primary energy source (if sold with a driver) and the same electrical, physical, and functional characteristics that affect energy consumption or energy efficiency;~~

~~(4) Is mounted in its own volute; and~~

~~(5) Discharges liquid through its volute and the common discharge in a plane perpendicular to the impeller shaft.~~

~~"Two speed motor" means a motor designed or intended to be operated at one of two preset speeds.~~

~~"Variable speed motor" means a motor whose speed can vary continuously over a specified range.~~

(1) **Pool Heater Definitions.**

"Coefficient of performance (COP)" of a heat pump pool heater means the ratio of heat output to the total power input in consistent units, as determined using the applicable test method in section 1604(g) of this Article.

"Electric heat pump pool heater" means an appliance designed for heating nonpotable water and employing a compressor, water-cooled condenser, and outdoor air coil.

"Electric resistance pool heater" means an appliance designed for heating nonpotable water and employing electric resistance heating elements.

"Fossil fuel-fired pool heater" means an appliance designed for heating nonpotable water and employing natural gas or oil burners.

"Hybrid pool heater" means an appliance designed for heating nonpotable water and employing both a heat pump (compressor, water-cooled condenser, and outdoor air coil) and a fossil fueled burner as heating sources.

"Pool heater" means an appliance designed for heating non-potable water contained at atmospheric pressure, including heating water in swimming pools, spas, hot tubs, and similar applications.

"Readily accessible on-off switch" of a pool heater means an on-off switch located in a place that can be easily used without the need for tools to remove any covering when the pool heater is on display in a store or when it is installed.

"Thermal efficiency" of a pool heater means a measure of the percentage of heat from the input that is transferred to the water, as determined using the applicable test method in section 1604(g) of this Article.

(2) **Portable Electric Spas Definitions.**

"Combination spa" means a portable electric spa with two separate distinct reservoirs, where (1) one reservoir is an exercise spa; (2) the second reservoir is a standard spa; and (3) each reservoir has an independent water temperature setting control.

"Exercise spa" (also known as a "swim spa") means a portable electric spa that includes specific features and equipment to produce water flow for water physical therapy or physical fitness activity, including, but not limited to, swimming in place.

"Exercise spa portion" means the reservoir of a combination spa that is an exercise spa.

"Fill volume" means the 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 skimmer opening. In the absence of a skimmer, the fill volume is six inches below the overflow level of the spa as defined in the test method in section 1604(g)(2)(B)1.

"Inflatable spa" means a portable electric spa where the structure is collapsible and is designed to be filled with air to form the body of the spa.

"Portable electric spa" means a factory-built electric spa or hot tub, supplied with equipment for heating and circulating water at the time of sale or sold separately for subsequent attachment.

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

"Rated voltage" of a portable electric spa means the voltage, in volts, as it appears on the nameplate of the spa.

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

"Skimmer" means a suction opening intended to remove floating debris from the water surface and installed where part of the water intake opening is open to atmospheric pressure.

"Standard spa" means a portable electric spa that is not an inflatable spa, an exercise spa, or the exercise spa portion of a combination spa.

"Standard spa portion" means the reservoir of a combination spa that is a standard spa.

"Standby mode" of a portable electric spa 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.

(3) **Residential Pool Pump and Motor Combinations and Replacement Residential Pool Pump Motors Definitions.**

"Capacitor start-capacitor run" means a capacitor start single-phase motor that has a capacitor in series with the starting winding.

"Capacitor start-induction run" means a motor that uses a capacitor via the starting winding to start an induction motor, where the capacitor is switched out by a centrifugal switch once the motor is up to speed.

“Default speed” means the low speed, having a rotation rate that is no more than one-half of the maximum rotation rate of the motor.

“Electronically commutated motor (ECM)” means a brushless direct current motor that uses a permanent magnet rotor and built-in inverters.

“Multispeed motor” means a motor whose speed may be selected from several preset ranges.

“Nameplate HP” means the HP displayed on the nameplate mounted on the motor.

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

“Permanent split capacitor (PSC)” means a two-phase motor operated from a single-phase voltage source with a capacitor connected in series with either one of the two windings.

“Pool pump motor capacity” means a value equal to the product of the nameplate HP and service factor of the motor.

"Replacement residential pool pump motor” means a replacement motor manufactured before July 19, 2021, and intended to be coupled to an existing residential pool pump that is used to circulate and filter pool water to maintain clarity and sanitation.

“Residential pool pump” means an impeller attached to a motor that is used to circulate and filter pool water to maintain clarity and sanitation.

“Residential pool pump and motor combination” means a residential pool pump motor coupled to a residential pool pump and includes self-priming pool filter pumps, non-self-priming pool filter pumps, integral cartridge filter pool pumps, and integral sand-filter pool pumps.

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

“Service factor (of an AC motor)” means a multiplier that, when applied to the rated horsepower, indicates a permissible horsepower loading that can be carried under the conditions specified for the service factor.

“Speed” means the number of revolutions of the motor shaft in a given unit of time. Speed is expressed in revolutions per minute (RPM).

“Split phase start” means a motor that employs a main winding with a starting winding to start the motor. After the motor has attained about 75 percent of rated speed, the starting winding is automatically disconnected by means of a centrifugal switch or by a relay.

“Total horsepower” of an AC motor means a value equal to the product of the service factor and the nameplate (rated) horsepower of the motor.

“Two-speed motor” means a motor designed or intended to be operated at one of two preset speeds.

“Variable-speed motor” means a motor whose speed can vary continuously over a specified range.

(4) **Federally Regulated Pumps and Dedicated-Purpose Pool Pumps Definitions.**

“Bare pump” means a pump excluding mechanical equipment, driver, and controls.

“Basic model” of a federally regulated pump means all units of a given class of pump manufactured by one manufacturer, having the same primary energy source, and having essentially identical electrical, physical, and functional (or hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency; except that:

(1) For RSV and ST pumps, all variations in numbers of stages of the bare pump must be considered a single basic model;

(2) Pump models for which the bare pump differs in impeller diameter, or impeller trim, may be considered a single basic model; and

(3) Pump models for which the bare pump differs in number of stages or impeller diameter and which are sold with motors (or motors and controls) of varying horsepower may only be considered a single basic model if:

(i) For ESCC, ESFM, IL, and RSV pumps, each motor offered in the basic model has a nominal full-load motor efficiency rated at the federal minimum (see the current table for NEMA Design B motors at Table S-1 of this article) or the same number of bands above the federal minimum for each respective motor horsepower (see Table 3 of Appendix A to subpart Y of 10 C.F.R. part 431); or

(ii) For ST pumps, each motor offered in the basic model has a full-load motor efficiency at the default nominal full-load submersible motor efficiency shown in Table 2 of Appendix A to subpart Y of 10 C.F.R. part 431 or the same number of bands above the default nominal full load submersible motor efficiency for each respective motor horsepower (see Table 3 of Appendix A to subpart Y of 10 C.F.R. part 431).

“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 millimeter (mm) in diameter and can be removed by hand or using only simple tools such as a screwdriver, pliers, or an open-ended wrench.

“Best efficiency point (BEP)” means the pump hydraulic power operating point (consisting of both flow and head conditions) that results in the maximum efficiency.

“Bowl diameter” means the maximum dimension of an imaginary straight line passing through and in the plane of the circular shape of the intermediate bowl of the bare pump that is perpendicular to the pump shaft and that intersects the outermost circular shape of the intermediate bowl of the bare pump at both ends, where the intermediate bowl is as defined in ANSI/HI 2.1-2.2-2014.

"Capacitor start-capacitor run" means a capacitor start single-phase motor that has a capacitor in series with the starting winding.

"Capacitor start-induction run" means a motor that uses a capacitor via the starting winding to start an induction motor, where the capacitor is switched out by a centrifugal switch once the motor is up to speed.

"Clean water pump" means a pump that is designed for use in pumping water with a maximum nonabsorbent free solid content of 0.016 pounds per cubic foot (ft^3), and with a maximum dissolved solid content of 3.1 pounds per ft^3, provided that the total gas content of the water does not exceed the saturation volume and disregarding any additives necessary to prevent the water from freezing at a minimum of 14° Fahrenheit (F).

"Close-coupled pump" means a pump in which the motor shaft also serves as the impeller shaft for the bare pump.

"Continuous control" means a control that adjusts the speed of the pump driver continuously over the driver operating speed range in response to incremental changes in the required pump flow, head, or power output.

"Control" means any device that can be used to operate the driver. Examples include, but are not limited to, continuous or noncontinuous controls, schedule-based controls, on/off switches, and float switches.

"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.

"Dedicated-purpose pool pump motor total horsepower" means the product of the dedicated-purpose pool pump nominal motor horsepower and the dedicated-purpose pool pump service factor of a motor used on a dedicated-purpose pool pump based on the maximum continuous duty motor power output rating allowable for the motor's nameplate ambient rating and insulation class.

"Dedicated-purpose pool pump service factor" means a multiplier applied to the rated horsepower of a pump motor to indicate the percent above nameplate horsepower at which the motor can operate continuously without exceeding its allowable insulation class temperature limit.

"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.

“Driver” means the machine providing mechanical input to drive a bare pump directly or through the use of mechanical equipment. Examples include, but are not limited to, an electric motor, internal combustion engine, or gas/steam turbine.

“Dry rotor pump” means a pump in which the motor rotor is not immersed in the pumped fluid.

"Electronically commutated motor (ECM)” means a brushless direct current motor that utilizes a permanent magnet rotor and built in inverters.

“End suction close-coupled (ESCC) pump” means a close-coupled, dry rotor, end suction pump that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter and that is not a dedicated-purpose pool pump. Examples include, but are not limited to, pumps within the specified horsepower range that comply with ANSI/HI nomenclature OH7, as described in ANSI/HI 1.1-1.2-2014.

“End suction frame mounted/own bearings (ESFM) pump” means a mechanically coupled, dry rotor, end suction pump that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter and that is not a dedicated-purpose pool pump. Examples include, but are not limited to, pumps within the specified horsepower range that comply with ANSI/HI nomenclature OH0 and OH1, as described in ANSI/HI 1.1-1.2-2014.

“End suction pump” means a single-stage, rotodynamic pump in which the liquid enters the bare pump in a direction parallel to the impeller shaft and on the side opposite the bare pump's driver- end. The liquid is discharged through a volute in a plane perpendicular to the shaft.

“Fire pump” means a pump that is compliant with NFPA 20-2016 “Standard for the Installation of Stationary Pumps for Fire Protection,” and is either:

(1) UL listed under ANSI/UL 448-2013 “Standard for Safety Centrifugal Stationary Pumps for Fire-Protection Service,” or

(2) FM Global (FM) approved under the January 2015 edition of FM Class Number 1319, “Approval Standard for Centrifugal Fire Pumps (Horizontal, End Suction Type).”

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

“Full impeller diameter” means the maximum diameter impeller with which a given pump basic model is distributed in commerce.

“Horizontal motor” means a motor that requires the motor shaft to be in a horizontal position to function as designed, as specified in the manufacturer literature.

“In-line (IL) pump” means a pump that is either a twin-head pump or a single-stage, single-axis flow, dry rotor, rotodynamic pump that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter, in which liquid is discharged through a volute in a plane perpendicular to the shaft. Such pumps do not include pumps that are mechanically coupled or close-coupled, have a pump power output that is less than or equal to 5 hp at BEP at full impeller diameter, and are distributed in commerce with a horizontal motor. Examples of in-line pumps include, but are not limited to, pumps within the specified horsepower range that comply with ANSI/HI nomenclature OH3, OH4, or OH5, as described in ANSI/HI 1.1-1.2- 2014.

"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.

"Magnet driven pump" means a pump in which the bare pump is isolated from the motor via a containment shell and torque is transmitted from the motor to the bare pump via magnetic force. The motor shaft is not physically coupled to the impeller or impeller shaft.

"Mechanical equipment" of a federally regulated pump means any component of a pump that transfers energy from the driver to the bare pump.

"Mechanically coupled pump" means a pump in which the bare pump has its own impeller shaft and bearings and so does not rely on the motor shaft to serve as the impeller shaft.

"Multi-speed dedicated-purpose pool pump" means a dedicated-purpose pool pump 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-continuous control" means a control that adjusts the speed of a driver to one of a discrete number of non-continuous preset operating speeds, and does not respond to incremental reductions in the required pump flow, head, or power output.

"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)(B), and is not a waterfall pump.

"PEI_{CL}" means the constant load pump energy index of a pump tested using the applicable test method in section 1604(g)(4)(A) of this article.

“PEI_{VL}” means the variable load pump energy index of a pump tested using the applicable test method in section 1604(g)(4)(A) of this article.

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

"Permanent split capacitor (PSC)” means a two-phase motor operated from a single-phase voltage source with a capacitor connected in series with either one of the two windings.

“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.

“Pool pump timer” means a pool pump control that automatically turns off a dedicated-purpose pool pump after a run-time of no longer than 10 hours.

“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”.

“Prime-assist pump” means a pump that:

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

(2) Requires no manual intervention to prime or re-prime from a dry-start condition; and

(3) Includes a device, such as a vacuum pump or air compressor and venturi eductor, to remove air from the suction line in order to automatically perform the prime or re-prime function at any point during the pump's operating cycle.

“Pump” means equipment designed to move liquids (which may include entrained gases, free solids, and totally dissolved solids) by physical or mechanical action and includes a bare pump and, if included by the manufacturer at the time of sale, mechanical equipment, driver, and controls.

“Radially split, multi-stage, vertical, in-line diffuser casing (RSV) pump” means a vertically suspended, multi-stage, single axis flow, dry rotor, rotodynamic pump:

(1) That has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter and at the number of stages required for testing and

(2) In which liquid is discharged in a place perpendicular to the impeller shaft; and

(3) For which each stage (or bowl) consists of an impeller and diffuser;

(4) For which no external part of such a pump is designed to be submerged in the pumped liquid; and

(5) Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature VS8, as described in ANSI/HI 2.1-2.2-2014.

"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, or open-ended wrench.

"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.

"Rotodynamic pump" means a pump in which energy is continuously imparted to the pumped fluid by means of a rotating impeller, propeller, or rotor.

"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, when tested with section 1604(g)(4)(B), 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 axis flow pump" means a pump in which the liquid inlet of the bare pump is on the same axis as the liquid discharge of the bare pump.

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

"Speed" means the number of revolutions of the motor shaft in a given unit of time. Speed is expressed in revolutions per minute (RPM).

"Split phase start" means a motor that employs a main winding with a starting winding to start the motor. After the motor has attained approximately 75 percent of rated speed, the starting winding is automatically disconnected by means of a centrifugal switch or by a relay.

"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.

"Submersible turbine (ST) pump" means a single-stage or multi-stage, dry rotor, rotodynamic pump that is designed to be operated with the motor and stage(s) fully submerged in the pumped liquid; that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter and at the number of stages required for testing; and in which each stage of this pump consists of an impeller and diffuser, and liquid enters and exits each stage of the bare pump in a direction parallel to the impeller shaft. Examples include, but are not limited to, pumps within the specified horsepower range that comply with ANSI/HI nomenclature VS0, as described in ANSI/HI 2.1-2.2-2014.

"Twin head pump" means a dry rotor, single-axis flow, rotodynamic pump that contains two impeller assemblies, which both share a common casing, inlet, and discharge, and each of which:

(1) Contains an impeller, impeller shaft (or motor shaft in the case of close-coupled pumps), shaft seal or packing, driver (if present), and mechanical equipment (if present);

(2) Has a shaft input power that is greater than or equal to 1 hp and less than or equal to 200 hp at best efficiency point (BEP) and full impeller diameter;

(3) Has the same primary energy source (if sold with a driver) and the same electrical, physical, and functional characteristics that affect energy consumption or energy efficiency;

(4) Is mounted in its own volute; and

(5) Discharges liquid through its volute and the common discharge in a plane perpendicular to the impeller shaft.

"Two-speed dedicated-purpose pool pump" means a dedicated-purpose pool pump 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:

(1) With a pool pump control (e.g., variable speed drive and user interface or switch) that is capable of changing the speed in response to user preferences; or

(2) Without a pool pump control that has the capability to change speed in response to user preferences, but is unable to operate without the presence of such a pool pump control.

"Variable-speed dedicated-purpose pool pump" means a dedicated-purpose pool pump 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 pump must include a variable speed drive and be distributed in commerce either:

(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 and/or the on/off times; or

(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 and/or the on/off times, but is unable to operate without the presence of a user interface.

"Variable speed drive" means equipment capable of varying the speed of the motor.

"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.

(5) **Replacement Dedicated-Purpose Pool Pump Motors Definitions.**

"Capacitor start-capacitor run" means a capacitor start single -phase motor that has a capacitor in series with the starting winding.

"Capacitor start-induction run" means a motor that uses a capacitor via the starting winding to start an induction motor, where the capacitor is switched out by a centrifugal switch once the motor is up to speed.

"Dedicated-purpose pool pump motor total horsepower" means the product of the dedicated-purpose pool pump nominal motor horsepower and the dedicated-purpose pool pump service factor of a motor used on a dedicated-purpose pool pump based on the maximum continuous duty motor power output rating allowable for the motor's nameplate ambient rating and insulation class.

"Dedicated-purpose pool pump service factor" means a multiplier applied to the rated horsepower of a pump motor to indicate the percent above nameplate horsepower at which the motor can operate continuously without exceeding its allowable insulation class temperature limit.

"Default speed" means the low speed, having a rotation rate that is no more than one-half of the motor's maximum rotation rate.

"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.

"Designed or marketed" means that the equipment is designed to fulfill the intended application or, 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.

"Drive" means a power converter (such as a variable-speed drive or phase converter) that converts single-phase power to polyphase power.

"Electronically commutated motor (ECM)" means a brushless direct current motor that utilizes a permanent magnet rotor and built in inverters.

"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.

"Maximum operating speed" means the rated full-load speed of a motor powered by a 60 Hertz (Hz) alternating current (AC) source.

"Multispeed replacement dedicated-purpose pool pump motor" means a replacement dedicated-purpose pool pump motor that is capable of operating at more than two discrete, predetermined 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 preprogrammed user preferences and allows the user to select the duration of each speed or the operational times or both.

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

"Permanent split capacitor (PSC)" means a two-phase motor operated from a single-phase voltage source with a capacitor connected in series with either one of the two windings.

"Replacement dedicated-purpose pool pump motor" means an electric motor that is single-phase or polyphase less than or equal to 5 hp, complies with and is certified to UL 1004-10 or is designed, or is marketed for use in dedicated-purpose pool pump applications.

"Replacement rigid electric spa pump motor" means a replacement dedicated-purpose pool pump motor that does not have a C-flange or square flange mounting and that is labeled and designed and marketed for use only in rigid electric spas as defined at 10 CFR 431.462.

"Replacement waterfall pump motor" means a replacement dedicated-purpose pool pump motor with a maximum speed less than or equal to 1,800 rpm that is designed and marketed for waterfall pump applications and labeled for use only with waterfall pumps.

"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.

"Speed" means the number of revolutions of the motor shaft in a given unit of time. Speed is expressed in revolutions per minute (RPM).

"Split-phase start" means a motor that employs a main winding with a starting winding to start the motor. After the motor has attained approximately 75 percent of rated speed, the starting winding is automatically disconnected by means of a centrifugal switch or by a relay.

"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:

(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

(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.

"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:

(1) With a user interface that changes the speed in response to preprogrammed user preferences and allows the user to select the duration of each speed, the operational times, or both; or

(2) Without a user interface that changes the speed in response to preprogrammed 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.

…

[skipping rest of 1602]

Section 1604. Test Methods for Specific Appliances.

…

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

…

(2) **Test Method for Portable Electric Spas.**

(A) The test method for portable electric spas manufactured on or after January 1, 2006, and before June 1, 2019, is as follows:

…

(B) The test method for portable electric spas manufactured on or after June 1, 2019, is ANSI/APSP/ICC-14 2014, excluding section 8.2, and with the following modifications:

…

(3) **Test Method for Residential Pool Pumps.**

The test method for residential pool pumps is as follows:

(A) Reported motor efficiency shall be verifiable by test method IEEE 114-2001.

(B) ANSI/HI 1.6-2000 shall be used for the measurement of pump efficiency.

(C) Three curves shall be calculated:

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

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

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

Where:

H is the total system head in feet of water.

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

(D) For each curve (A, B, or C), the pump head shall be adjusted until the flow and head lie on the curve. The following shall be tested and reported (i) for each curve for single-speed pumps or (ii) for each curve at both highest and lowest speeds for two-, multi-, or variable-speed pumps:

1. Motor nominal speed (RPM)

2. Flow (gallons per minute)

3. Power (watts and volt amps)

4. Energy Factor (gallons per watt hour)

Where the Energy Factor (EF) is calculated as:

EF = Flow (gpm) * 60 / Power (watts)

(4) **Test Method for Pumps and Dedicated-Purpose Pool Pumps.**

(A) The test method for pumps is 10 C.F.R. section 431.464(a) (Appendix A to subpart Y of part 431).

(B) The test method for dedicated-purpose pool pumps manufactured on or after July 19, 2021, is 10 C.F.R. 431.464(b) (Appendix C to subpart Y of part 431).

(5) 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 19, 2021, shall be tested in accordance with CSA-C747-2009 (Reaffirmed 2014), (CSA C747-2009 [RA2014], "Energy Efficiency Test Methods for Small Motors" at full load and maximum speed. If a drive is sold or offered for sale with the replacement dedicated-purpose pool pump motor, the input power of the drive while the drive is connected to the motor shall be used to determine motor efficiency and power factor per the test procedure.

(1) Motor torque shall be recorded in lb-ft, motor speed in rotations per minute, and input power in watts.

(2) Power factor shall be calculated as:

Single phase motors:
Power Factor (%)= Input Power (W)/(Voltage(V) x Amps (A)) x 100
Three phase motors:
Power Factor (%)= Input Power (W)/(Voltage(V) x Amps(A) x 1.73) x 100
where Voltage and Amps are the measured root mean square (rms) voltage and current.

...

The following documents are incorporated by reference in Section 1604.

…

CANADIAN STANDARDS ASSOCIATION (CSA)

…

CSA C747-2009(RA2014)	Energy efficiency test methods for small motors
Copies available from:	Canadian Standards Association 178 Rexdale Blvd. Toronto, Ontario, Canada M9W 1R3 Phone: (416) 747-4044 http://shop.csa.ca/ …

[skipping rest of 1604]

Section 1605. Energy Performance, Energy Design, Water Performance, and Water Design Standards: In General.

…

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

…

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

…

(2) **Energy Efficiency Standards for Electric Heat Pump Pool Heaters.** See section 1605.3(g) of this article for energy efficiency standards for electric heat pump pool heaters.

…

(6) **Energy Efficiency Standards for Pumps.**

(A) For the purposes of section 1605.1(g)(6)(B) of this Article, "PEI_{CL}" means the constant load pump energy index and "PEI_{VL}" means the variable load pump energy index, both as determined in accordance with the test procedure in section 1604(g)(4)(A) of this Article. For the purposes of section 1605.1(g)(6)(€D) of this Article, "BEP" means the best efficiency point as determined in accordance with the test procedure in section 1604(g)(4)(A) of this Article.

(B) **Pump Efficiency Standards.** Each pump that is manufactured on or after January 27, 2020, and that:

1. is in one of the equipment classes listed in Table G-2 in section 1605.1(g)(6)(B)4 of this Article;

2. meets the definition of a "clean water pump" in section 1602(g)(4) of this Article;

3. is not listed in section 1605.1(g)(6)(C) of this Article; and

4. conforms to the characteristics listed in section 1605.1(g)(6)(D) of this Article must have a PEI_{CL} or PEI_{VL} rating of not more than 1.00 using the appropriate C-value in Table G-2:

Table G-2: Standards for Pumps Manufactured On or After January 27, 2020

…

(7) **Energy Efficiency Standards for Dedicated-Purpose Pool Pumps.**

(A) For the purposes of 1605.1 (g) (7) (B) of this article, "WEF" means the weighted energy factor and "hhp" means the rated hydraulic horsepower, as determined in accordance with the test procedure in section 1604(g)(4)(B) and applicable sampling plans in 10 C.F.R Section 429.59.

(B) Each dedicated-purpose pool pump that is not a submersible pump and is manufactured on or after July 19, 2021, shall have a WEF rating that is not less than the value calculated from the following table:

Table G-3: Standards for Dedicated-Purpose Pool Pumps Manufactured On or After July 19, 2021

Equipment class		**Minimum allowable WEF score [kgal/kWh]**	**Minimum allowable WEF score [kgal/kWh]**
Dedicated-purpose pool pump variety	**hhp Applicability**	**Motor phase**	
Self-priming pool filter pumps	0.711 hp ≤hhp <2.5 hp	Single	WEF = −2.30 * ln (hhp) + 6.59.
Self-priming pool filter pumps	hhp <0.711 hp	Single	WEF = 5.55, for hhp ≤0.13 hp −1.30 * ln (hhp) + 2.90, for hhp >0.13 hp.
Non-self-priming pool filter pumps	hhp <2.5 hp	Any	WEF = 4.60, for hhp ≤0.13 hp −0.85 * ln (hhp) + 2.87, for hhp >0.13 hp.
Pressure cleaner booster pumps	Any	Any	WEF = 0.42.

(C) Each integral cartridge filter pool pump and integral sand filter pool pump that is manufactured on or after July 19, 2021, shall be distributed in commerce with a pool pump timer that is either integral to the pump or a separate component that is shipped with the pump.

(D) For all dedicated-purpose pool pumps distributed in commerce with freeze protection controls, the pump shall be shipped with freeze protection disabled or with the following default, user-adjustable settings:

1. The default dry-bulb air temperature setting shall be no greater than 40 ˚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 the maximum available speed.

(~~7~~8) 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) of this Article 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.

…

Section 1605.2 State Standards for Federally-Regulated Appliances.

…

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

…

(2) Portable Electric Spas, 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 portable electric spas, residential pool pump and motor combinations, replacement dedicated-purpose pool pump motors, and replacement residential pool pump motors.

…

(4) Dedicated-Purpose Pool Pumps. See section 1605.1(g)(7) for energy efficiency standards for federally regulated dedicated-purpose pool pumps that are manufactured on or after July 19, 2021.

…

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

…

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

…

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

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

…

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

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

(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.

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.

(6) **Replacement Dedicated-Purpose Pool Pump Motors.**

(A) All replacement dedicated-purpose pool pump motors manufactured on or after July 19, 2021, shall meet a nominal full-load efficiency at maximum speed of no less than the value shown in Table G-4,

Table G-4

Standards for Replacement Dedicated-Purpose Pool Pump Motors Manufactured on or After July 19, 2021

Total Horsepower	**Motor Phase**	**Minimum Motor Efficiency**
Motor hp < 0.5 hp	Single- or three-phase	66%
0.5 hp ≤ Motor hp<1.0 hp	Single- or three-phase	72%
1.0 hp ≤ Motor hp <5.0 hp	Single- or three-phase	80%

(B) Replacement dedicated-purpose pool pump motors with a total horsepower greater than or equal to 0.5 hp manufactured on or after July 19, 2021, shall be variable-speed replacement dedicated-purpose pool pump motors.

(C) Freeze Protection. All replacement dedicated-purpose pool pump motors distributed in commerce with freeze protection controls manufactured on or after July 19, 2021, shall be shipped with freeze protection disabled or with the following default, user-adjustable 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 one half of the maximum available speed of the motor.

(D) **Dedicated-Purpose Pool Pump Motor Controls.** Pool pump motor controls manufactured on or after July 19, 2021, that are sold with a two- or more speed replacement dedicated-purpose pool pump motor shall have the capability of operating the pool pump at least at two speeds. The default speed setting of the control shall be no more than one-half of the maximum speed of the motor. Any high-speed override capability shall be for a temporary period not to exceed one 24-hour cycle without resetting to default settings.

(~~6~~7) Portable Electric Spas.

(A) The normalized standby power, as defined in Section 1604(g)(2)(A)9., of portable electric spas manufactured on or after January 1, 2006, shall be no greater than $5(V^{2/3})$ watts, where V = the fill volume, in gallons.

(B) The normalized standby power, as defined in Table G-~~3~~5, of portable electric spas manufactured on or after June 1, 2019, shall be no greater than the applicable values shown in Table G-~~3~~5.

Table G-~~3~~5

Standards for Portable Electric Spas

…

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 July 19, 2021.	Motor Construction	PSC, Capacitor Start-Capacitor Run, ECM, Capacitor Start-induction run, split-phase, Permanent Magnet Synchronous, Other
		Motor Design	Single-speed, dual-speed, multispeed, 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	*True, False*
		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. *of this Article*)	*True, False*
		Flow for Curve 'A' (in gpm)	
		Power for Curve 'A' (in watts)	
		Energy Factor for Curve 'A' (in gallons per watt-hour)	

	Appliance	Required Information	Permissible Answers
		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)	
	Dedicated-Purpose Pool Pumps manufactured on or after July 19, 2021.	Dedicated-purpose pool pump unit type	Self-priming pool filter pump, Non-self-priming pool filter pump, Pressure cleaner booster pump, Waterfall pump, Integral cartridge filter pump, Integral sand filter pump
	Self-Priming Pool Filter Pumps and Non-Self-Priming Pool Filter Pumps	Served by single-phase or three-phase power	Single-phase, three-phase
		Freeze protection is shipped enabled	True, False, Not Applicable
		If freeze protection enabled- dry bulb air temperature setting	True, False, Not Applicable
		If freeze protection enabled- default motor speed (rpm)	True, False, Not Applicable
		If freeze protection enabled- default run time (in minutes)	True, False, Not Applicable
		Weighted energy factor (WEF) in kilogallons per kilowatt-hour (kgal/kWh)	
		Rated hydraulic horsepower in horsepower (hp)	
		Speed configuration for which the pump is being rated (i.e., single-speed, two-speed, multispeed, or variable-speed)	single-speed, two-speed, multispeed, or variable-speed
		True power factor (PFm) at maximum speed on curve 'C' (single-speed, two-speed, multispeed, variable-speed)	

	Appliance	Required Information	Permissible Answers
		True power factor (PFh) at high speed on curve ‘C’ (multispeed, variable-speed)	
		True power factor (PFl) at low speed on curve ‘C’ (two-speed, multispeed, variable-speed)	
		Speed at maximum speed (rpm) (single-speed, two-speed, multispeed, variable-speed)	
		Dedicated-purpose pool pump nominal motor horsepower in horsepower (hp)	
		Dedicated-purpose pool pump motor total horsepower in horsepower (hp)	
		Dedicated-purpose pool pump service factor (dimensionless)	
		The maximum head (in feet)	
		Input power at maximum speed on curve ‘C’ (single-speed, two-speed, multispeed, variable-speed)	
		Flow rate at maximum speed on curve ‘C’ (single-speed, two-speed, multispeed, variable-speed)	
		Input power at high speed on curve ‘C’ (multispeed, variable-speed)	
		Flow rate at high speed on curve ‘C’ (multispeed, variable-speed)	
		Speed at high speed (rpm) (multispeed, variable-speed)	
		Input power at low speed on curve ‘C’ (multispeed, variable-speed)	
		Flow rate at low speed on curve ‘C’ (two-speed, multispeed, variable-speed)	
		Speed at low speed (rpm) (two-speed, multispeed, variable-speed)	
		For self-priming filtering pumps only -pump is certified with NSF/ANSI 50-2015 (yes/no)	Yes, no

	Appliance	Required Information	Permissible Answers
		If not certified to NSF/ANSI 50 then report priming time in minutes	
		If not certified to NSF/ANSI 50 then report vertical lift in feet	
		Motor construction	PSC, Capacitor Start-Capacitor Run, ECM, Capacitor Start-induction run, split-phase, Permanent Magnet Synchronous, Other
		Frame	
		Motor efficiency (%) on curve C at high speed	
		Flow for curve 'A' at max speed (in gpm) (single-speed, two-speed, multispeed, variable-speed)	
		Power for curve 'A' at max speed (in watts) (single-speed, two-speed, multispeed, variable-speed)	
		Flow for curve 'B' at max speed (in gpm) (single-speed, two-speed, multispeed, variable-speed)	
		Power for curve 'B' at max speed (in watts) (single-speed, two-speed, multispeed, variable-speed)	
		Motor efficiency (%) on curve C at low speed	
		Flow for curve 'A' at low speed (in gpm) (two-speed, multispeed, variable-speed)	
		Power for curve 'A' at low speed (in watts) (two-speed, multispeed, variable-speed)	
		Flow for curve 'B' at low speed (in gpm) (two-speed, multispeed, variable-speed)	
		Power for curve 'B' at low speed (in watts) (two-speed, multispeed, variable-speed)	
	Pressure Cleaner Booster Pumps	Served by single-phase or three-phase power	Single-phase, three-phase
		Freeze protection is shipped enabled	True, False, Not Applicable

	Appliance	Required Information	Permissible Answers
		If freeze protection enabled – dry bulb air temperature setting (F)	
		If freeze protection enabled – default motor speed (rpm)	
		If freeze protection enabled – default run time (in minutes)	
		Weighted energy factor (WEF) in kilogallons per kilowatt-hour (kgal/kWh)	
		Rated hydraulic horsepower in horsepower (hp)	
		True power factor (PF) at flow rate of 10 gpm at the minimum speed that results in a head value at or above 60 feet.	
		Speed at maximum speed (rpm) (single-speed, two-speed, multispeed, variable-speed)	
		Dedicated-purpose pool pump nominal motor horsepower in horsepower (hp)	
		Dedicated-purpose pool pump motor total horsepower in horsepower (hp)	
		Dedicated-purpose pool pump service factor (dimensionless)	
		Input power at flow rate of 10 gpm at the minimum speed that results in a head value at or above 60 feet.	
		Head at flow rate of 10 gpm at the minimum speed that results in a head value at or above 60 feet.	
		Motor speed that results flow rate of 10 gpm and a head value at or above 60 feet. (rpm)	
		Motor construction	PSC, capacitor start-capacitor run, ECM, capacitor start-induction run, split-phase, permanent magnet synchronous, other
		Frame	

	Appliance	Required Information	Permissible Answers
		Motor efficiency (%) at flow rate of 10 gpm at the minimum speed that results in a head value at or above 60 feet.	
	Waterfall Pumps	Served by single-phase or three-phase power	Single-phase, three-phase
		Freeze protection is shipped enabled or disabled	True, False, Not Applicable
		If freeze protection enabled – dry bulb air temperature setting (F)	
		If freeze protection enabled – default motor speed (rpm)	
		If freeze protection enabled – default run time (in minutes)	
		Weighted energy factor (WEF) in kilogallons per kilowatt-hour (kgal/kWh)	
		Rated hydraulic horsepower in horsepower (hp)	
		Speed configuration for which the pump is being rated (i.e., single-speed, two-speed, multispeed, or variable-speed)	single-speed, two-speed, multi-speed, or variable-speed
		True power factor (PF) at maximum speed and 17 ft of head	
		Dedicated-purpose pool pump nominal motor horsepower in horsepower (hp)	
		Dedicated-purpose pool pump motor total horsepower in horsepower (hp)	
		Dedicated-purpose pool pump service factor (dimensionless)	
		The maximum head (in feet)	
		Input power at maximum speed and 17 ft of head	
		Flow rate at maximum speed and 17 ft of head	
		Speed at maximum speed (rpm)	

	Appliance	Required Information	Permissible Answers
		Motor construction	PSC, capacitor start-capacitor run, ECM, capacitor start-induction run, split-phase, permanent magnet synchronous, other
		Frame	
		Motor efficiency (%) at maximum speed and 17 ft of head	
	Integral Cartridge Filter Pump and Integral Sand Filter Pump	Served by single-phase or three-phase power	Single-phase, three-phase
		Freeze protection is shipped enabled	True, False, Not Applicable
		If freeze protection enabled- dry bulb air temperature setting (F)	
		If freeze protection enabled- default motor speed (rpm)	
		If freeze protection enabled- default run time (in minutes)	
		Maximum run-time (in hours) of pool pump control	
		Motor construction	PSC, capacitor start-capacitor run, ECM, capacitor start-induction run, split-phase, permanent magnet synchronous, other
		Motor design	Single-speed, two-speed, multi-speed, variable-speed
		Frame	
	Replacement Dedicated Purpose Pool Pump Motors manufactured on or after July 19, 2021	Replacement dedicated-purpose pool pump motor design	Single-speed, two-speed, multi-speed, variable-speed
		Served by single-phase or three-phase power	Single-phase, three-phase

	Appliance	Required Information	Permissible Answers
		Motor construction	PSC, capacitor start-capacitor run, ECM, capacitor start-induction run, split-phase, permanent magnet synchronous, other
		Frame	
		Dedicated-purpose pool pump motor total horsepower in horsepower (hp)	
		Dedicated-purpose pool pump service factor (dimensionless)	
		Dedicated-purpose pool pump nominal motor horsepower in horsepower (hp)	
		Motor efficiency at maximum speed and full load (%)	
		Motor speed (RPM) (maximum speed)	
		Motor torque (maximum speed) (lb-ft)	
		Input power (maximum speed) (watts)	
		Power factor (%) (maximum speed and full load)	
		Line voltage (V)	
		Line current (A)	
		Freeze protection is shipped enabled	True, False, Not Applicable
		If freeze protection enabled - default dry bulb air temperature setting (F)	
		If freeze protection enabled - default motor speed (rpm)	
		If freeze protection enabled - default run time (minutes)	

[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 of this article, and, for the following appliances, are marked as follows:

…

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

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

i. for replacement dedicated-purpose pool pump motors manufactured on or after July 19, 2021, each replacement dedicated purpose pool pump motor is marked permanently with the pool pump motor capacity of the motor.

…

Section 1607. Marking of Appliances.

…

(d) Energy Performance Information.

…

(2) Federally Regulated Commercial and Industrial Equipment.

Unless otherwise specified in Table Y, each unit of an appliance listed in Table Y that is federally regulated commercial and industrial equipment shall be marked, permanently and legibly on an accessible and conspicuous place on the unit, with the applicable energy performance information shown in Table Y, and such information shall also be included on all printed material that is displayed or distributed at the point of sale.

Table Y

Requirements for Marking of Federally-Regulated Commercial and Industrial Equipment

Class	Energy Performance Information
Split system central air conditioners (on printed material only)	Split system central air conditioners (on printed material only)
Single package central air	Cooling capacity, SEER, EER
Split system heat pumps (on printed material only)	Cooling capacity, heating capacity, SEER, EER, HSPF, COP
Single package heat pumps	Cooling capacity, heating capacity, SEER, EER, HSPF, COP
Package terminal air conditioners	Cooling capacity, EER
Package terminal heat pumps	Cooling capacity, heating capacity, EER, COP
Warm air furnaces	Input rating, thermal efficiency
Packaged boilers	Input rating, thermal efficiency, combustion efficiency (combustion efficiency marking requirement applies only to boilers with input ratings greater than 2,500,000 Btu/h.)
Water heaters	Input rating, rated storage volume, measured storage volume, thermal efficiency, standby loss (%/hr), standby loss (Btu/hr)
Hot water supply boilers	Rated input, rated storage volume, measured storage volume, thermal efficiency, standby loss
Dedicated-purpose pool pumps	WEF, dedicated-purpose pool pump total horsepower

…

(9) Residential Pool Pumps~~.~~ and Motor Combinations and Replacement Residential Pool Pump Motors.

(A) Each residential pool pump and motor combination shall be marked, permanently and legibly on an accessible and conspicuous place on the unit, in characters no less than 1/4″, the nameplate HP of the pump.

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

(C) Two-, multi-, or variable-speed residential pool pump~~s~~ and motor combinations 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,"

…

(14) Replacement Dedicated-Purpose Pool Pump Motors.

Each replacement dedicated-purpose pool pump motor shall be marked, permanently and legibly with the dedicated-purpose pool pump motor total horsepower and motor efficiency.

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 California Energy Commission by the IOUs. All calculations were based on the assumption of an effective date of July 19, 2021.

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 reported by the U.S Department of Energy (U.S. DOE). Staff updated the non-self-priming pool filter pump motor and pressure cleaner booster pump motor expected life to match the self-priming pool filter pump motor life due to the similarity of requirements imposed by the proposed appliance standards.

Table A-1: Residential Stock and Sales

Product	National Pump Shipments 2015 (Thousand)	Percentage Pump Shipments to CA	CA Pump Shipments 2015 (Thousand)	Pump Shipment Growth per Year (Thousand)	CA Pump Shipments 2021(Thousand)	CA Repl. Motor Shipments (Thousand)	CA Pump and Motors Total Stock 2021 (Thousand)	CA Repl. Motor Total Stock 2021 (Thousand)	Design Lifetime (years)
SP Pool Filter Pump, standard-size (1.90 hp)	440	26.4%	116	1.16	123	41	1,200	300	7.3
SP Pool Filter Pump, standard-size (3.76 hp)	147	26.4%	39	0.39	41	14	400	100	7.3
SP Pool Filter Pump, small-size (0.88 hp)	76	26.4%	20	0.20	21	7	207	52	7.3
NSP Pool Filter Pump (1.04 hp)	373	13.0%	48	0.48	51	17	500	125	7.3
Pressure Cleaner Booster Pump (1.24 hp)	129	26.4%	34	0.34	36	12	350	88	7.3
Total Pool Pump and Motors	1,165		258		273	91	2,657	664	

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 (Thousand)	Percentage Pump Shipments to CA	CA Pump Shipments 2015 (Thousand)	Pump Shipment Growth per Year (Thousand)	CA Pump Shipments 2021(Thousand)	CA Repl. Motor Shipments (Thousand)	CA Pump and Motors Total Stock 2021 (Thousand)	CA Repl. Motor Total Stock 2021 (Thousand)	Design Lifetime (years)
SP Pool Filter Pump, standard-size (1.90 hp)	23.18	26.4%	6.12	0.06	6.49	2.16	63.13	15.78	7.3
SP Pool Filter Pump, standard-size (3.76 hp)	7.73	26.4%	2.04	0.02	2.16	0.72	21.04	5.26	7.3
SP Pool Filter Pump, small-size (0.88 hp)	4.00	26.4%	1.06	0.01	1.12	0.37	10.90	2.72	7.3
Total Pool Pump and Motors	35		9		10	3	95	24	

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 Technical Support Document (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 2021 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 one percent growth rate is based upon the California population forecast increase of about one percent.[87] Staff estimated the distribution of motor sizes among the standard size self-priming pool filter pump motors by reviewing survey data collected by Southern California Edison.[88]

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

87 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.

88 Southern California Edison, Pool Pump Demand Response Potential, DR 07.01 Report, June 2008, pg. 12

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 2021

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

116,260 = 440,400 X 26.4%

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

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

1,163 = 116,260 X 1%

Where:

G = Growth in Pump Shipments per Year

1% = The Estimated Growth in Pump Shipments

P_{2015} = California Pump Shipments in 2015

California Pump Shipments 2021

$$P_{2021} = P_{2015} + (G \times 6)$$

123,240 = 116,260+1,163 X 6

Where:

P_{2015} = California Pump Shipments in 2015

P_{2021} = California Pump Shipments in 2021

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.

$RM = P_{2021}/3$

41,080 = 123,240/3

Where:

RM = Replacement Motor

P_{2021} = California Pump Shipments in 2021

California Pump and Motors Total Stock

$$Stock_{Total} = (P_{2021} + RM) * DL$$

$$1{,}199{,}540 = (\ 123{,}240 + 41{,}080) * 7.3$$

Where:

$Stock_{Total}$ = Total Stock 2021

P_{2020} = California Pump Shipments 2021

RM = California Replacement Motor Shipments

DL = Design Lifetime

California Replacement Motor Total Stock 2021

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

$$299{,}890 = 41{,}080 * 7.3$$

Where:

RM_{ts} = California Replacement Motor Total Stock 2021

RM = Replacement Motor Shipments

DL = Design Lifetime

Compliance Rates

Staff used the U.S. DOE TSD estimates for compliance with the proposed motor efficiency standards. The compliance rates were estimated based on the U.S. DOE DPPP TSD. The market share represents the national market. California market share will differ from the national market share because single-speed pumps (EL0-EL2) are prohibited for motor sizes 1 hp or greater. Staff assumed the market share of single-speed would be added to the market share of variable-speed to calculate the compliance rate for the 1.90 and 3.76 hp motors. **Tables A-4 and A-5** list current compliance rates for the proposed standards.

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 motor(1.90 hp)	45%	15%	10%	2%	2%	2%	8%	16%
SP Pool Filter Pump, standard-size motor(3.76 hp)	45%	15%	10%	2%	2%	2%	8%	16%
SP Pool Filter Pump, small-size motor(0.88 hp)	45%	15%	10%	2%	2%	2%	8%	16%
NSP Pool Filter Pump motor(1.04 hp)	32%	32%	32%	2%	1%	1%	0%	0%
Pressure Cleaner Booster Pump motor(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: Residential Compliance Rates

Product	Non-Compliant (%)	Compliance (%)	Non-Compliant EL	Compliant EL
SP Pool Filter Pump, motor (1.90 hp)	6%	94%	(EL3-EL5)	(EL0-EL2 and EL6-EL7)
SP Pool Filter Pump, motor (3.76 hp)	6%	94%	(EL3-EL5)	(EL0-EL2 and EL6-EL7)
SP Pool Filter Pump, motor (0.88 hp)	76%	24%	(EL0-EL5)	(EL6-EL7)
NSP Pool Filter Pump motor (1.04 hp)	100%	0%	(EL0-EL5)	(EL6-EL7)
Pressure Cleaner Booster Pump motor(1.24 hp)	100%	0%	(EL0-EL3)	(EL4)

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

Table A-5 Commercial Compliance Rates

Product	Non-Compliant (%)	Compliance (%)	Non-Compliant EL	Compliant EL
SP Pool Filter Pump, motor (1.90 hp)	76%	24%	(EL0-EL5)	(EL6-EL7)
SP Pool Filter Pump, motor (3.76 hp)	76%	24%	(EL0-EL5)	(EL6-EL7)
SP Pool Filter Pump, motor (0.88 hp)	76%	24%	(EL0-EL5)	(EL6-EL7)

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

Noncompliant %

$$\sum Pool\ Pumps\ Efficiency\ Level\ (EL\,3 - EL5)$$

$$6\% = 2\% + 2\% + 2\%$$

Compliance %

$$\sum Pool\ Pumps\ Efficiency\ Level\ (EL0 - EL\,2\ and\ EL\,6 - EL\,7)$$

$$94\% = 45\% + 15\% + 10\% + 8\% + 16\%$$

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 were 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-6: 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-7: 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-8: 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-9: 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-10: 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-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, motor (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, motor (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, motor (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 motor (0.52 hhp)	12,000	1.47	2.0	4.7	7.2	9.8	730	1703	2623	3562
Pressure Cleaner Booster Pump motor(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, motor (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, motor (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, motor (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 A-6

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 A-6

Daily Low Speed (Half) Min

See equation above. Substitute Low-Speed Flow (gpm) with EL 6 Low-Speed flow from Table A-6

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. Substitute Daily High Speed with the Daily High Speed (Single Speed)

Low Speed (half) (hr / day)

See High Speed equation. Substitute Daily High Speed with Low Speed (half)

Low Speed (Min) (hr / day)

See High Speed equation. 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-6 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 **Tables A-11 and A-12**.

High Speed (kW)

$$\begin{aligned} = & (EL\,3 * IP_{EL3} * Daily\ High\ Speed) + (EL\,4 * IP_{EL4} * Daily\ High\ Speed) \\ & + (EL\,5 * IP_{EL5} * Daily\ High\ Speed) \\ & + \left(\sum EL\,0, \quad EL1, E2, EL\,6 * IP_{EL6} * Daily\ High\ Speed\right)(EL\,7 * IP_{EL7} \\ & * Daily\ High\ Speed) \div (Daily\ High\ Speed * 1{,}000) \end{aligned}$$

$$\begin{aligned} 0.96 = & (.02 * 1682 * 2.00) + (.02 * 1636 * 2.00) + (.45 + .15 + .10 + .08 * 940 * 2.00) \\ & + (.16 * 754 * 2.00) \div (2.00 * 1{,}000) \end{aligned}$$

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-10.

Low Speed (kW)

$$\frac{(EL_3 * IP_{LEL3} + EL_4 * IP_{LEL4} + EL_5 * IP_{LEL5}) * Daily\ Low\ Speed\ (half) + [\{(EL_0 + EL_1 + EL_2 + EL_6) * IP_{LEL6}\} + (EL_7 * IP_{LEL7})] * Daily\ Low\ Speed\ (\mathrm{min})}{[Daily\ Low\ Speed\ (half) * (EL\ 3 + EL\ 4 + EL\ 5) + Daily\ Low\ Speed\ (\mathrm{min}) * (EL\ 0 + EL\ 1 + EL\ 2 + EL\ 6 + EL\ 7)] * 1000}$$

$$0.17 = \frac{\big((0.02 + 404) + (0.02 * 334) + (0.02 * 301)\big) * 10.56 + (((0.45 + 0.15 + 0.10 + 0.08) * 170) + (0.16 * 136)) * 13.8}{[(0.02 + 0.02 + 0.02 * 10.56) + (13.81 * (0.45 + 0.10 + 0.08 + 0.16)] * 1000}$$

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 A-6

Daily Low Speed (half) = The Daily Low Speed duty cycle in hours at half speed calculated from Table A-10.

Daily Low Speed (min) = The Daily Low Speed duty cycle in hours at minimum speed calculated from Table A-10.

Annual Energy Consumption (kWh/yr per Appliance)

AEC=kWh/yr=

$$= \begin{array}{l} \{\sum_{i=3}^{n=5}(EL_i * IP_{ELi}) + (EL_0 + EL_1 + EL_2 + EL_6) * IP_{EL6}) + (EL_7) * IP_{EL7})\} * High\ Speed\ (hrs/yr)/1000 \\ +[\left(\sum_{i=3}^{n=5} EL_i * IP_{LELi} * LS(Half)\right) + \{(EL_0 + EL_1 + EL_2 + EL_6) * IP_{LEL6} + EL_7 * IP_{LEL7}) * LS(min)\}] \Big/ 1000 \end{array}$$

$$1{,}557 = \begin{array}{c} [((2\%) * 1{,}866 * 730) + (2\% * 1{,}682 * 730) + (2\% * 1{,}636 * 730) + (45\% + 15\% + 10\% + 8\% * 940 * 730) + (16\% * 754 * 730)]/1{,}000 \\ [(2\% * 404 * 3{,}855.90) + (2\% * 334 * 3{,}855.90) + (2\% * 301 * 3{,}855.90) + (45\% + 15\% + 10\% + 8\% * 170 * 5{,}039.35) + (16\% * 136 * 5{,}039.35)]/1{,}000 \end{array}$$

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-6.

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-6

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)

$$= \frac{AEC * CRMTS}{1{,}000}$$

$$467 = \frac{1{,}557 * 299.89}{1{,}000}$$

Where:

AEC = The Annual Energy Consumption (kWh/yr) from Table A-11.

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

Table A-12 and **A-13** presents baseline energy consumption prior to the motor WEF standard.

Table A-12: 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, motor (0.95 hhp)	0.96	0.17	1,557	467
Self-Priming Pool Filter Pump, motor (1.88 hhp)	1.62	0.18	2,172	217
Self-Priming Pool Filter Pump, motor (0.44 hhp)	1.13	0.12	1,917	99
Non-Self Priming Pool Filter Pump motor(0.52 hhp)	1.17	0.27	1,972	247
Pressure Cleaner Booster Pump motor(0.31 hhp)	1.47	N/A	1,342	118

Source: California Energy Commission

Table A-13: 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, motor (0.95 hhp)	1.61	N/A	14,066	222
Self-Priming Pool Filter Pump, motor (1.88 hhp)	2.63	N/A	23,021	121
Self-Priming Pool Filter Pump, motor (0.44 hhp)	1.14	N/A	10,015	27

Source: California Energy Commission

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-14 and A-15** show predicted energy consumption of compliant units and stock.

Table A-14: 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, motor (0.95 hhp)	0.91	0.17	1,494	448
Self-Priming Pool Filter Pump, motor(1.88 hhp)	1.54	0.18	2,086	209
Self-Priming Pool Filter Pump, motor(0.44 hhp)	0.91	0.08	507	26
Non-Self Priming Pool Filter Pump motor(0.52 hhp)	0.59	0.10	452	57
Pressure Cleaner Booster Pump motor(0.31 hhp)	1.08	N/A	981	86

Source: California Energy Commission

Table A-15: 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, motor(0.95 hhp)	0.91	N/A	7,974	126
Self-Priming Pool Filter Pump, motor (1.88 hhp)	1.54	N/A	13,518	71
Self-Priming Pool Filter Pump, motor (0.44 hhp)	0.96	N/A	8,436	23

Source: California Energy Commission

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-16: 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, motor (0.95 hhp)	2.6	$0.5	19	$3.5
Self-Priming Pool Filter Pump, motor(1.88 hhp)	1.2	$0.2	9	$1.6
Self-Priming Pool Filter Pump, motor(0.44 hhp)	10.0	$1.9	73	$13.5
Non-Self Priming Pool Filter Pump motor(0.52 hhp)	26.0	$4.8	190	$35.3
Pressure Cleaner Booster Pump motor(0.31 hhp)	4.3	$0.8	32	$5.9
Total Savings	**44.1**	**$8.2**	**322**	**$59.8**

Source: California Energy Commission

Table A-17: 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, motor (0.95 hhp)	13.2	$2.4	96	$17.8
Self-Priming Pool Filter Pump, motor (1.88 hhp)	6.8	$1.3	50	$9.3
Self-Priming Pool Filter Pump, motor (0.44 hhp)	0.6	$0.1	4	$0.8
Total Savings	**20.6**	**$3.8**	**150**	**$27.9**

Source: California Energy Commission

Table A-18: 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	**44.1**	**$8.2**	**322**	**$59.8**
Commercial	**20.6**	**$3.8**	**150**	**$27.9**
Total Savings	**64.7**	**$12.0**	**472**	**$87.7**

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-19: 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-20: 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-21: 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-22: 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-23: 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-24: 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-25: 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-26: Annual Energy and Monetary Savings - Residential

Product	Design Life (years)	Electricity Savings (kWh/yr)	Average Incremental Cost ($)	Average Annual Savings ($)	Life Cycle Savings ($)	Life-Cycle Benefit ($)
Self-Priming Pool Filter Pump, motor (0.95 hhp)	7.3	63	$17	$12	$76	$59
Self-Priming Pool Filter Pump, motor(1.88 hhp)	7.3	86	$10	$16	$103	$93
Self-Priming Pool Filter Pump, motor(0.44 hhp)	7.3	1,410	$289	$261	$1,692	$1,403
Non-Self Priming Pool Filter Pump motor(0.52 hhp)	7.3	1,520	$367	$282	$1,825	$1,458
Pressure Cleaner Booster Pump motor(0.31 hhp)	7.3	361	$356	$67	$433	$77

Source: California Energy Commission

Table A-27: Annual Energy and Monetary Savings – Commercial

Product	Design Life (years)	Electricity Savings (kWh/yr)	Average Incremental Cost ($)	Average Annual Savings ($)	Life Cycle Savings ($)	Life-Cycle Benefit ($)
Self-Priming Pool Filter Pump, motor (0.95 hhp)	7.3	6,092	$358	$1,130	$7,314	$6,956
Self-Priming Pool Filter Pump, motor1.88 hhp)	7.3	9,502	$348	$1,763	$11,408	$11,061
Self-Priming Pool Filter Pump motor (0.44 hhp)	7.3	1,579	$380	$293	$1,896	$1,516

Source: California Energy Commission

Net present worth (NPW) of savings = Σ [(annual savings) / (1+discount rate) ^ year]

Life-Cycle Benefit = Net present worth savings – Incremental Cost

Life-Cycle Benefit = $76 - $17 = $59

Table A-28: Net Present Worth Calculation Result by Year (Residential)

Year	1	2	3	4	5	6	7	7.3	Total
Self-Priming Pool Filter Pump motor (0.95 hhp)	$11.39	$11.06	$10.74	$10.42	$10.12	$9.82	$ 9.54	$2.84	$75.92
Self-Priming Pool Filter Pump, motor (1.88 hhp)	$15.51	$15.06	$14.62	$14.20	$13.78	$13.38	$12.99	$3.86	$103.41
Self-Priming Pool Filter Pump, motor (0.44 hhp)	$253.85	$246.46	$239.28	$232.31	$225.54	$218.97	$212.60	$63.22	$1,692.22
Non-Self Priming Pool Filter Pump (0.52 hhp)	$273.77	$265.79	$258.05	$250.54	$243.24	$236.15	$229.28	$68.18	$1,824.99
Pressure Cleaner Booster Pump (0.31 hhp)	$65.01	$63.12	$61.28	$59.49	$57.76	$56.08	$54.44	$16.19	$433.36

Source: California Energy Commission

Table A-29: Net Present Worth Calculation Result by Year (Commercial)

Year	1	2	3	4	5	6	7	7.3	Total
Self-Priming Pool Filter Pump motor (0.95 hhp)	$1,097	$1,065	$1,034	$1,004	$975	$946	$919	$273	$7314
Self-Priming Pool Filter Pump, motor (1.88 hhp)	$1,711	$1,662	$1,613	$1,566	$1,521	$1,476	$1,433	$426	$11,408
Self-Priming Pool Filter Pump, motor (0.44 hhp)	$284	$276	$268	$260	$253	$245	$238	$71	$1,896

Source: California Energy Commission

Peak Demand Reduction

Staff determined the peak power demand reduction of 39 MW by multiplying the total number of motors operating during the peak power demand by reduction in input power due to the improved efficiency. Southern California Edison provided an estimate for pool pumps that would be on during the peak demand.[89] California Independent System Operator shows the peak demand occurs on a summer day between 3 and 5 p.m.[90]

Example calculation:

39 MW = 594,540 motors x.18 kW power reduction x 35% of motors operating at peak

89 Southern California Edison, Pool Pump Demand Response Potential, June 2008, pg. 2, available at Pool https://www.etcc-ca.com/sites/default/files/reports/dr07_01_pool_pump_demand_response_potential_report.pdf.

90 California Independent System Operator, California ISO Peak Load History 1998 through 2017, available at https://www.caiso.com/documents/californiaisopeakloadhistory.pdf.

APPENDIX B: 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	Dedicated-purpose pool pump
ECM	Electrically Commutated Motor
EF	Energy Factor
EPA	Environmental Protection Agency
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
ZNE	Zero net energy