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FINAL STAFF REPORT

Final Analysis of Efficiency Standards for Replacement Dedicated-Purpose Pool Pump Motors

2019 Appliance Efficiency Rulemaking
Docket Number 19-AAER-02

Gavin Newsom, Governor

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California Energy Commission

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PREFACE

On March 14, 2012, the California Energy Commission (CEC) 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 CEC 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 CEC released an invitation to participate to interested parties to inform the CEC about the products, markets, and industry characteristics of the appliances identified. The CEC 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 CEC released an invitation to submit 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 CEC 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 CEC published a draft staff report proposing performance standards for pool pump motors. On February 18, 2016, the CEC held a staff workshop to review the report with interested parties and to gather public comment.

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

On July 12, 2017, the CEC revised the report based on comments received at the workshop and in writing in the CEC docket. On August 3, 2017, the CEC held a staff workshop to review the revised report with interested parties and to gather public comment.

On November 14, 2018, the CEC revised the report based on comments received at the workshop and in writing in the CEC docket. On November 28, 2018, the CEC held a staff workshop to review the revised report with interested parties and to gather public comment.

The CEC reviewed all the information received. This report contains the proposed regulations for replacement dedicated-purpose pool pumps motors, with updates based on comments received at the workshops and in writing in the CEC 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 #19-AAER-02). CEC staff analyzed the cost-effectiveness and technical feasibility of proposed efficiency standards for replacement dedicated-purpose pool pump motors. Statewide energy use and savings and related environmental impacts and benefits are also included.

Staff proposes standards for replacement pool pump motors sold separately from the pumps as replacements. The standards would take effect on July 19, 2021, for all replacement dedicated-purpose 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 61 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 451 gigawatt-hours. This amount equates to roughly $82 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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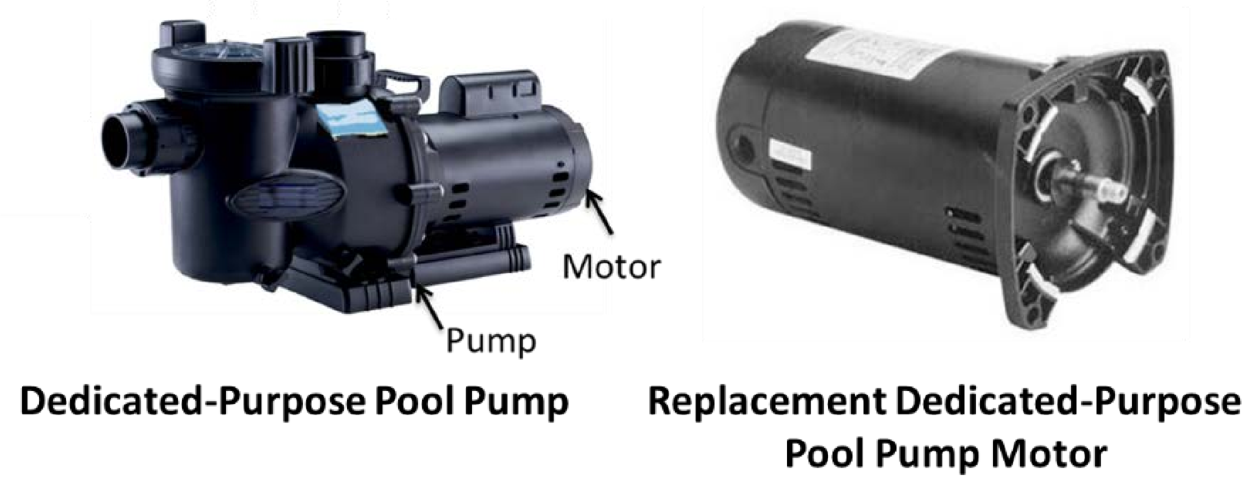
EXECUTIVE SUMMARY

Since 1976, the CEC has adopted cost-effective and technically feasible appliance standards that set a minimum level of energy or water efficiency, as part of the CEC's mandate to reduce the wasteful, uneconomic, inefficient, or unnecessary consumption of energy or water.

Figure ES-1: Pool Pump and Replacement Motor



Source: Century A.O. Smith

Pool owners must use a pool pump to maintain the cleanliness and sanitation of their pools. When a pool pump motor breaks, a common repair option is to replace the motor with a replacement dedicated-purpose pool pump motor (RDPPPM). Improving the efficiency and operational flexibility of RDPPPM represents an opportunity to save energy. RDPPPM consume more than 1,500 gigawatt-hours per year in California, equivalent to the energy use of the City of San Francisco.

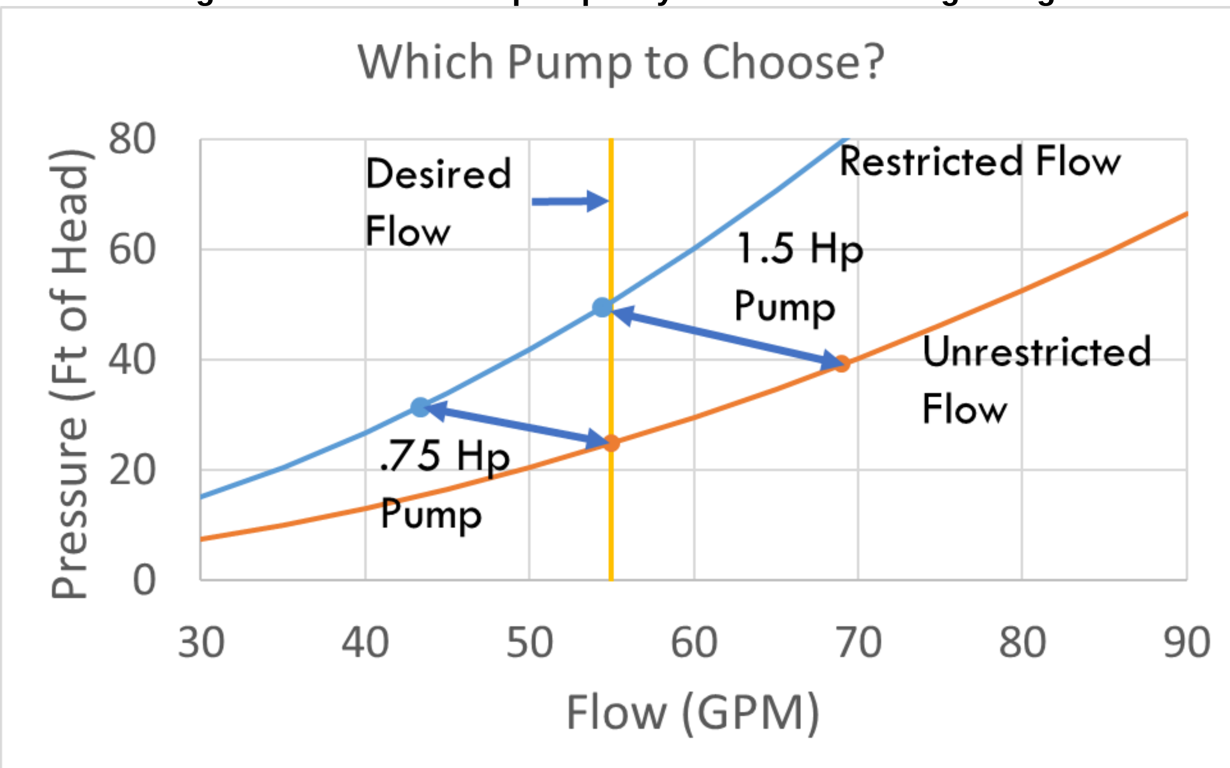
A common problem pool owners face is determining the required RDPPPM size. Every pool is different and the pool plumbing layouts can add complexity that make it difficult for a pool owner to predict what size motor is needed. Pool owners do not want a pool pump motor that cannot meet the demands of the pool. A common solution is to oversize the pool pump motor. If the pump is single or two speed, the pool owner is left with excess capacity–and excess energy consumption every time the pool pump is used.

Figure ES-2 illustrates the complexity of selecting the size of a RDPPPM. Each blue dot represents a pool pump's performance under restricted flow while each orange dot represents the pool pump's performance under unrestricted flow. The pairing of the performance of two example pumps is shown by the blue arrows connecting the blue and orange dots.

A pool owner may desire a flow of 55 gallons per minute as shown by the gold line. The flow the owner receives will depend upon the size of the motor the owner chooses and whether the flow is free or restricted. Many owners may not know the nature of the flow and they will choose the larger 1.5 hp motor because they believe it will perform adequately regardless of whether the flow is restricted. This choice requires that they pay for the excess capacity and excess energy consumption.

Variable speed control solves this dilemma. A pool owner can select an oversize replacement motor to protect against unknowns but not be forced to use this excess capacity. Variable speed RDPPPM provide the flexibility to provide the lowest flow necessary for the pool pump task while using the least energy. Even small adjustments in speed such as reducing from 100 percent motor speed to 80 percent speed can reduce energy consumption of the motor by 35 percent while still maintaining pool sanitation.

Figure ES-2: Pool Pump Capacity vs. Pool Plumbing Design



Source: CEC

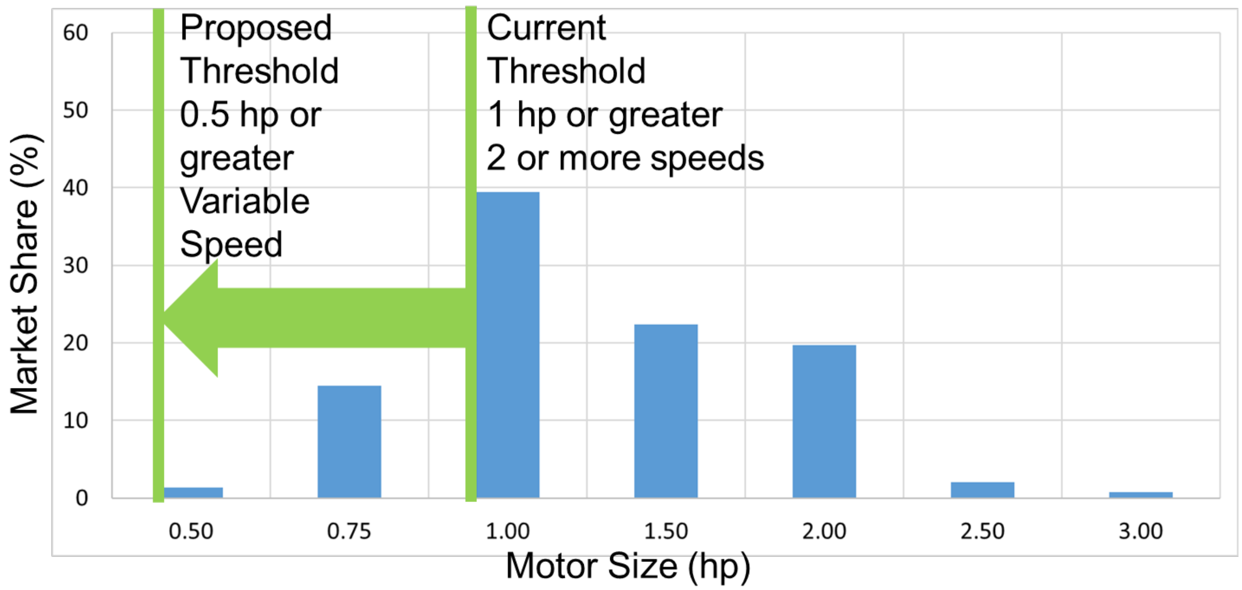
CEC staff analyzed the cost-effectiveness, technical feasibility, and statewide energy savings of the proposed update to the RDPPPM standard. Cost effectiveness is a measure of the benefits to the consumer, compared to the costs to the consumer, due to requiring the appliance to be more water- or energy-efficient. The benefit to the consumer must exceed the cost to the consumer for the proposed standard to be cost effective. To determine cost effectiveness, staff must determine the value of the energy saved, the effect of the standard on the usefulness of the device, and the life-cycle cost to the consumer of the efficient device.

Technical feasibility means that products are technologically capable of meeting the proposed standard by the effective date. The CEC must also consider other relevant factors, including the effect on housing costs, the total statewide costs and benefits of the standard over the lifetime of the product, economic impact on California businesses, and alternative approaches and associated costs.

Staff proposes to lower the threshold for the speed control requirement as shown in **Figure ES-3**. The RDPPPM pool pump motor design standard will be updated to require motors with a capacity of one half or more horsepower to have variable speed. Lowering the motor capacity threshold will extend the variable speed standard to a significant RDPPPM marketshare where there is a significant opportunity for energy savings. The graph shows a Southern California

Edison utility survey of pool pump motor sizes. Over half of the motors are either 1 hp or below.

Figure ES-3: Market Share of Pool Filter Pumps



Source: CEC with market share data from Southern California Edison

Staff proposes to expand the existing scope of regulations 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 builds on the savings of the U.S. Department of Energy's dedicated-purpose pool pump (DPPP) rule to RDPPPM while creating a simple framework to implement and enforce a standard.

Test procedures are proposed for RDPPPM 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

Total Motor Capacity	Prescriptive Requirements	Motor Phase	Minimum Motor Efficiency
Motor hp < 0.5 hp	None	Any	66%
0.5 hp ≤ Motor hp <1.0 hp	Variable Speed	Any	72%
1.0 hp ≤ Motor hp ≤5.0 hp	Variable Speed	Any	80%

Source: CEC

The proposal is cost effective. Staff found significant savings due to reduced electrical use.

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

Finally, the proposal will deliver significant electricity and monetary savings to California. The proposed standards would result in an estimated 62 gigawatt hours of first-year energy savings and an estimated 451 gigawatt-hours per year of energy savings after full stock turnover in 2029, resulting in $82 million in annual cost savings. All monetary figures presented in 2018 dollars unless shown otherwise. **Table ES-2** provides estimates for first-year and stock turnover savings.

Table ES-2: Combined Statewide Cost and Energy Savings

Application	First Year Electricity Savings (GWh/yr)	First Year Savings ($M)	Annual Stock Electricity Savings (GWh/yr)	Annual Stock Savings ($M)
Residential	39.9	$7.7	291	$56.2
Commercial	22.0	$3.6	160	$26.3
Total Savings	61.9	$11.3	451	$82.5

Source: CEC 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 (CEC) reduce the inefficient consumption of energy and water by prescribing efficiency standards and other cost-effective measures for appliances whose use requires a significant amount of energy or water statewide. 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 CEC 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 CEC 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.

CHAPTER 2: Efficiency Policy

The Warren-Alquist Act[1] establishes the CEC as California's primary energy policy and planning agency. The act mandates that the CEC 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 over 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)[2] of electricity in 2015 alone, resulting in about $4.84 billion in savings[3] 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.[4] The potential for additional savings remains by increasing the energy efficiency and improving the use of appliances.

1 The Warren-Alquist State Energy Resources Conservation and Development Act, Division 15 of the Public Resources Code, § 25000 et seq., The Warren-Alquist State Energy Resources Conservation and Development Act, available at http://www.energy.ca.gov/2017publications/CEC-140-2017-001/CEC-140-2017-001.pdf.

2 CEC, *California Energy Demand 2016-2026 Revised Electricity Forecast*, January 2016, available at 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

3 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.

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

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)[5] and Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016),[6] as well as the recommendations contained in the California Air Resources Board's *Climate Change Scoping Plan.*[7] Energy efficiency regulations are also identified as key components in reducing electrical energy consumption in the CEC's *2018 Integrated Energy Policy Report Update* (*IEPR*)[8] and the 2011 update to the CPUC's *Energy Efficiency Strategic Plan.*[9] Strengthening appliance efficiency standards has been identified as a strategy 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,[10] a commitment made to the Subnational Global Climate Leadership Memorandum of Understanding (Under2 MOU) agreement along with 167 jurisdictions representing 33 countries.[11]

On October 7, 2015, Senate Bill 350, the Clean Energy and Pollution Reduction Act of 2015, (De León, Chapter 547, Statutes of 2015) was signed into law, requiring the CEC 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.[12] Appliance efficiency standards will be critical in meeting this goal. In addition, the CEC adopted the *Existing Buildings Energy Efficiency Action Plan* in September 2015 and updated it in August 2019 to transform existing residential, commercial, and public buildings into energy-efficient

5 AB 32, California Global Warming Solutions Act of 2006, California Global Warming Solutions Act of 2006, available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.

6 SB 32, California Global Warming Solutions Act of 2006, California Global Warming Solutions Act of 2006, available at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB32.

7 *Climate Change Scoping Plan* Climate Change Scoping Plan, available at https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.

8 CEC, *2018 Integrated Energy Policy Report Update*, 2018, https://www.energy.ca.gov/2018 energypolicy/.

9 CPUC, *Energy Efficiency Strategic Plan,* updated January 2011, available at https://www.cpuc.ca.gov/General.aspx?id=4125.

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

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

12 *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.

buildings.[13] The plan will be updated every three years. The CEC approved the 2019 California Energy Efficiency Action Plan, which addresses building energy efficiency, efficiency in the industrial and agricultural sectors, barriers to energy efficiency for low-income and disadvantaged communities, and using efficiency to reduce greenhouse gas emissions in 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 Plan 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]

For the past 30 years, while per-capita electricity consumption in the United States has increased by nearly 50 percent, California's per-capita electricity use has been nearly flat. Continued progress in cost-effective building and appliance standards and ongoing enhancements to efficiency programs implemented by investor-owned utilities (IOUs), publicly-owned utilities, and other entities have contributed significantly to this achievement.[16]

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13 *California Existing Buildings Energy Efficiency Action Plan – 2019 Draft Staff Report*, available at https://efiling.energy.ca.gov/getdocument.aspx?tn=229496.

14. *2019 California Energy Efficiency Action Plan*. California Energy Commission. Publication Number: CEC400-2019-010-SF, available at: https://ww2.energy.ca.gov/business_meetings/2019_packets/2019-12-11/Item_06_2019%20California%20Energy%20Efficiency%20Action%20Plan%20(19-IEPR-06).pdf

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

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

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,[17] 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.[18]

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.[19] Commercial pool systems are designed to complete circulation or turnover in six hours due to higher level of use.[20] 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.

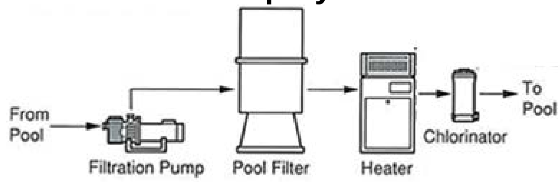
17 Olsen, Kevin. "Clear Waters and a Green Gas: A History of Chlorine as a Swimming Pool Sanitizer in the United States." *Bulletin for the History of Chemistry*, Volume 32, Number 2, pp. 129-140, 2007.

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

19 *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.

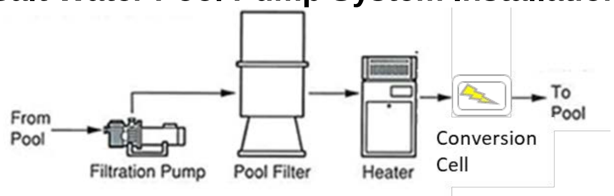
20 California Health and Safety Code Section 116064.2(b)(2)(E).

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 CEC 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 that will ensure adequate water turnover (that is, the entire pool water volume will be filtered once per day) should be selected. 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.

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.[21] 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

21 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.

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.[22] 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 of 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 cost, low complexity, and moderate energy efficiency when compared to double-suction centrifugal pumps or positive displacement pumps.[23]

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 and 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,

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22 *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.

23 *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.

as shown in **Table 3-1** and as modified by CEC staff.[24] 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 3-3** shows a typical pool pump and motor combination. **Figure 3-4** shows a typical replacement pool pump motor.

Table 3-1: Average Product Lifetime

Pump Type	Single-Speed Lifetime (yrs)	Dual-Speed Lifetime (yrs)	Variable-Speed Lifetime (yrs)
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 *CEC staff

Figure 3-3: Dedicated-Purpose Pool Pump

Source: Hayward Pools

Figure 3-4: Replacement Dedicated-Purpose Pool Pump Motor

Source: Century A.O. Smith

24 *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.

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.[25] 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)

25 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.

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.[26] To achieve the same volume of flow, the pump must be run twice as long at half-speed. The total energy consumed then, as defined by power multiplied by time, is 25 percent of the energy to move the same quantity of water at the full speed of the pump. Substantial energy savings can be realized by running the motor at the lowest speed adequate to meet the needs of 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.[27] 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.

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

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

Pool Pump and Motor Categories

Single-Speed Pumps

Single-speed pool pumps are powered by single-phase or three-phase AC induction motors and permanent magnet synchronous motors. ECM motors could also power single-speed pool pumps, although none were certified in the CEC's Modernized Appliance Efficiency Database System (MAEDbS) as of September 2019. 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.[28] 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.[29]

Single-speed pumps are the least energy-efficient pool pump type because the pump and motor must be run at full speed for all pool operations. Single-speed pump and motors persist in the market due to a lack of awareness among consumers and contractors regarding the regulation and energy savings of more efficient pump designs. Another barrier is a need to educate pool contractors on how to select, install, and configure non-single-speed pump systems to achieve energy savings while maintaining pool cleanliness.[30]

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.[31] 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.

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28 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.

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

30 IBID, pp. 18-20.

31 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.

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.[32]

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.[33]

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 3-5** shows a comparison of pool constructions.

Figure 3-5: Representative In-Ground, Above-Ground and Portable/Storable Pools

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

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32 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.

33 *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.

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.[34]

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.[35]

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 3-6** shows a typical above-ground pool pump and motor combination.

34 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.

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

Figure 3-6: 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.[36] 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 3-7** shows an integrated cartridge filter pump and sand filter pump.

Figure 3-7: Portable and Storable Pool Pump Motor Combinations

Source: Intex

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[37] and

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36 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.

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

multistage pumps have been introduced to improve the efficiency of pressure cleaner booster pumps.[38] **Figure 3-8** shows a pressure cleaner booster pump.

Figure 3-8: 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 3-9** shows a waterfall pump.

Figure 3-9: Waterfall Pump and Motor Combination

Source: Jandy

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

CHAPTER 4: Regulatory Approaches

Historical Approach

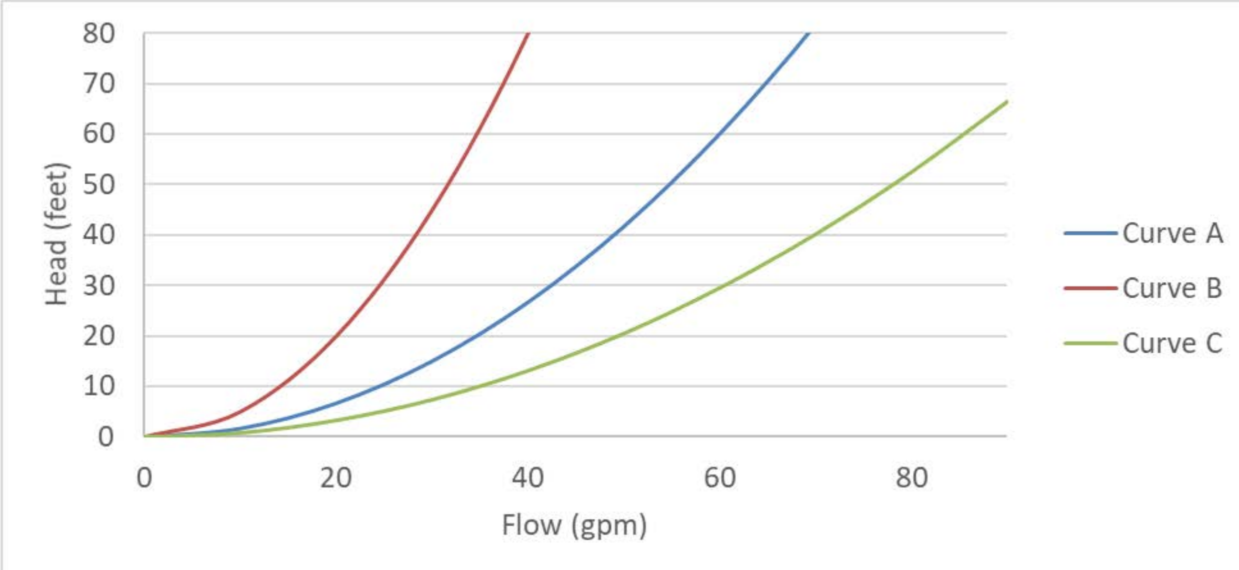
The CEC did not regulate pool pumps and motors before 2004. Most pool pump and motor systems used single-speed motors, with some systems using inefficient electric motor types. In 2004, the CEC adopted standards for residential pool pumps and motors, which included a prohibition on inefficient split-phase 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 CEC 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.[39]

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.

39 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.

Figure 4-1: Pool System Curves



Source: CEC

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.[40]

The U.S. Department of Energy (U.S. DOE) has established test procedures and energy conservation standards for dedicated-purpose pool pumps (DPPP).[41] The standards and test procedures were negotiated through a working group formed by the Appliance Standards and Rulemaking Federal Advisory Committee. The CEC 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,

40 10 C.F.R. Sections 431.461 to 431.466 and Appendices B and C to subpart Y of Part 431 subsection G.2

41 10 C.F.R. Sections 431.461 to 431.466 and Appendices B and C to subpart Y of Part 431.

storable electric spa pumps, or rigid electric spa pumps and whether a test procedure applies to measure pump performance.[42]

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).[43]

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.[44]

Dedicated Purpose Pool Pump Motor Negotiation

The CEC participated in a negotiation on potential national standards for DPPP motors beginning in March 2018.[45] The negotiation with pool pump motor industry and energy efficiency advocates resulted in a consensus agreement presented 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 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.[46]

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42 10 C.F.R. Sections 431.462

43 10 C.F.R. Sections 431.461 to 431.466 and Appendices B and C to subpart Y of Part 431

44 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.

45 CEC, 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.

46 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.

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.[47]

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.[48]

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 CEC 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.[49] 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.

Connecticut and New York have adopted residential pool pump standards similar to the California Title 20 regulations.[50]

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

48 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.

49 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.

50 Consortium for Energy Efficiency, CEE High Efficiency Residential Swimming Pool Initiative, https://library.cee1.org/content/cee-high-efficiency-residential-swimming-pool-initiative/.

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.[51]

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.[52]

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

CASE Report

The California IOUs submitted a Codes and Standards Enhancement (CASE) report to the CEC in July 2013. The IOUs revised the proposal for pool pump standards in September 2014.[53] The proposal recommends minimum motor efficiency standards for all pool pump and motor combinations and replacement motors.

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51 Pool and Spa News, States Introduce Out-of-Date Energy Laws, April 30, 2009, http://www.poolspanews.com/legislation/states-introduce-out-of-date-energy-laws.aspx.

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

53 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 RDPPPM: (1) maintaining current Title 20 standards (no change); (2) incorporating the CASE report suggestions; (3) aligning the RDPPPM 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, the November 28, 2018 staff workshop; and in written comments submitted to CEC 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 RDPPPM.

Alternative 1: Maintain Current Title 20 Appliance Standards

Under this alternative, staff would not amend the appliance efficiency standards for residential pool pump and motor combinations and replacement residential 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 residential pool pump and motor combinations and replacement residential 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 RDPPPM 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.[54] 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

54 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.

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 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 1 year from adoption. The proposal recommends a new CSA test method C747-09 to verify motor efficiency.[55]

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, September 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 RDPPPM 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.[56]

55 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.

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

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

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.[57] 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. The proposal would expand the scope to include motors less than 5 total horsepower for self-priming and non-self-priming pool filter pumps and pressure cleaner booster pumps. The standard would apply to motors within DPPP and motors sold as replacements. Motors with freeze protection capability would need to meet the same requirements as those in the U.S. DOE DPPP standard. The petition proposed a compliance date for July 19, 2021.

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 an update to the California Appliance Efficiency Standards to:

- Align residential pool pump and motor combination regulations with the U.S. DOE DPPP regulations by repealing the state test method and performance data reporting requirements.
- Add U.S. DOE DPPP definitions, test methods, standards, certification, data reporting, and appliance labeling to reflect current federal law.
- Simplify existing replacement residential pool pump motor regulations by repealing the state test method, and motor construction and performance data reporting requirements.
- Add RDPPPM definitions, test methods, standards, certification, data reporting, and appliance labeling requirements. The proposal includes RPDPPM for self-priming and non-self-priming pool filter pumps, pressure cleaner booster pumps and waterfall pumps under 5 total horsepower. The proposal includes motors for residential and

57 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.

commercial applications. The proposal establishes a new state test method and minimum motor efficiency requirements as shown in **Table 5-2**. Motors between 0.5 hp and 5 hp would need to have variable-speed capability.

Table 5-2: Proposed Standards for Replacement DPPP Motors

Total Motor Capacity	Prescriptive Requirements	Motor Phase	Minimum Motor Efficiency
Motor hp < 0.5 hp	None	Any	66%
0.5 hp ≤ Motor hp <1.0 hp	Variable Speed	Any	72%
1.0 hp ≤ Motor hp ≤5.0 hp	Variable Speed	Any	80%

Source: CEC

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.

The effective date for the repeal of the state test method and performance data reporting requirements would be immediately after adoption, anticipated to be February 1, 2020. The effective date for the U.S. DOE DPPP and CEC RDPPPM standards would be July 19, 2021, to align to the compliance date for the DPPP energy conservation standards.

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

Alternative 5 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.

Updates to Existing Pool Pump and Replacement Motor Regulations

The state test method and performance data reporting requirements for residential pool pump and motor combinations and replacement residential pool pump motors are proposed to be repealed immediately after adoption. For this proposal adoption is estimated to be about February 1, 2020. The original test method and performance data gathering was intended to inform consumers of the pool pump performance. Since the U.S. DOE has created regulations using a new test method and performance metric, the reporting of performance to the old test method and performance metric is no longer required.

The motor construction reporting requirement is being updated to clarify the prohibition on split-phase and capacitor-start induction-run motors. Motors without a run capacitor, a capacitor that improves the power factor of the motor by balancing the inductance of the motor coil, are prohibited from being sold. All other motor types are allowed. The prescriptive standard will remain in effect until the federal DPPP standards take effect on July 19, 2021.

The replacement residential pool pump motor standard will be retained for replacement residential pool pump motors manufactured before the effective date of the proposed standards for RDPPPM of July 19, 2021.

Additions for DOE DPPP Regulations

The proposal adds the U.S. DOE DPPP regulations including definitions, test method, energy conservation standards, data reporting, and appliance labeling. The update is needed so that the California appliance efficiency regulations properly and accurately reflect current federal law. The update provides to regulated parties and consumers more clarity, accessibility, and regulatory certainty with respect to the federal regulatory language in the California appliance efficiency regulations. The proposed changes are intended to replace the current definitions and standards for pool pumps on July 19, 2021.

Additions for New RDPPPM Regulations

Scope and Definitions

Staff proposes to align the scope and definitions for RDPPPM 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 RDPPPM.

Expanding the existing scope of RDPPPM will ensure that the standards can be enforced effectively. RDPPPM (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 RDPPPM that would distinguish the motors from motors intended for other water pumps such as irrigation or well pumping. The RDPPPM definitions will rely upon the “designed and marketed” definition that will identify 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.

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 5 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 RDPPPM

Total Motor Capacity	Prescriptive Requirements	Motor Phase	Minimum Motor Efficiency
Motor hp < 0.5 hp	None	Any	66%
0.5 hp ≤ Motor hp <1.0 hp	Variable Speed	Any	72%
1.0 hp ≤ Motor hp ≤5.0 hp	Variable Speed	Any	80%

Source: CEC

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 CEC by industry.[58]

Losses in the pool plumbing 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.

RDPPPM 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 energy savings from variable speed 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.[59] 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

RDPPPM 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.

58 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.

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

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.

At restricted flow, the torque on the shaft is at a minimum, while at unrestricted flow, the torque rises to a maximum.[60] To be consistent with the U.S. DOE's selection of the pool system Curve C where flow is less restricted, all test points will require the motor to perform at maximum speed and full load.

60 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.[61] 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.

Most savings for this proposal are due to requiring variable-speed capability in market areas where single-speed capability is dominant such as self-priming and non-self-priming pool filter pumps below 1 horsepower and pressure cleaner booster pump applications.

A common problem pool owners face is determining the required pool pump motor size. Every pool is different and the pool plumbing layouts can add complexity that make it difficult for a pool owner to predict what size motor is needed. In addition, the pool may operate in one of several modes to allow for bypassing the pool heater or for providing flow to the pool cleaner.[62] A pool owner would not want a pump that cannot meet the demands of the pool. A common solution is to oversize the pool pump motor. If the pump is single or two speed the pool owner is left with excess capacity – and excess energy consumption every time the pool pump is used. **Figures 7-1** and **7-2** illustrates the complexity of how a real world pool design complicates the selection of the size of a pool pump motor because of the complexity of the pool plumbing.

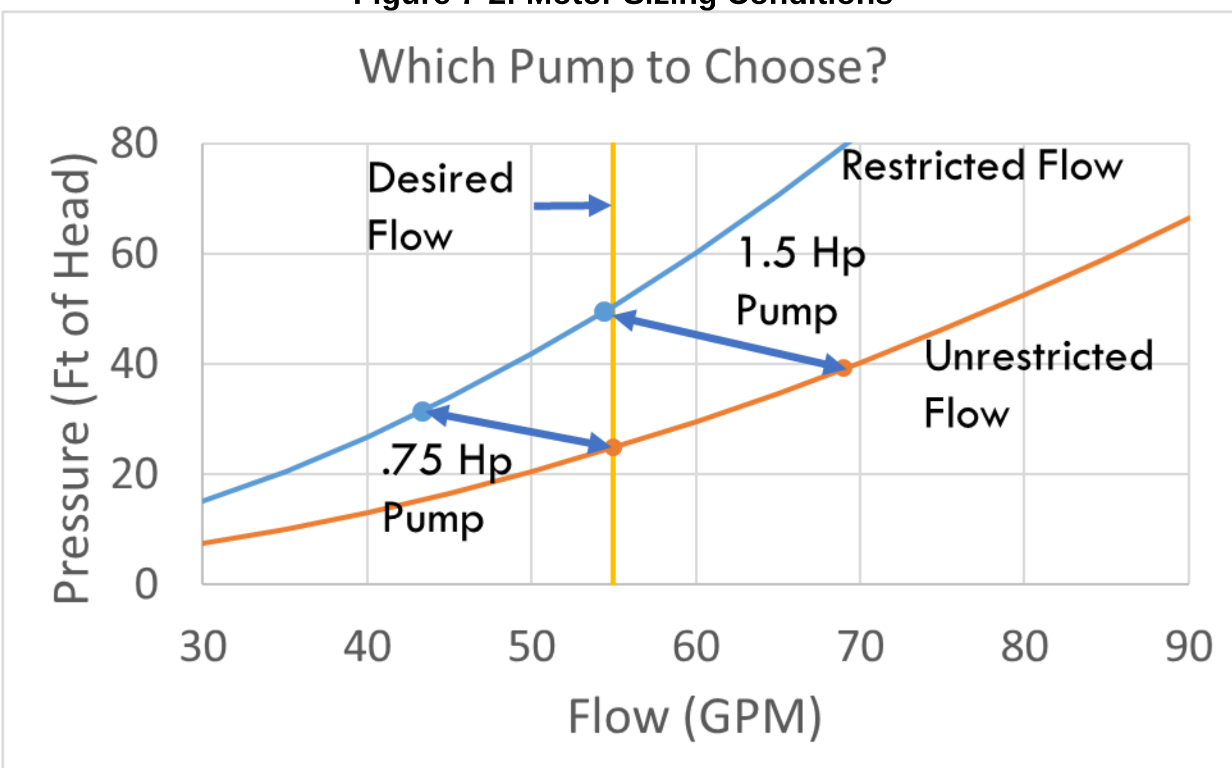
61 U.S. Department of Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated-Purpose Pool Pumps*, December 2016, Table 8.2.13-8.2, 19 page 8-15 to 8-17, EERE-2015-BT-STD-0008-0105, https://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-STD-0008-0105.

62 Robledo, Rebecca, *Designing Energy Efficient Pools*, Pool and Spa News, July 10, 2014, available at: https://www.poolspanews.com/how-to/designing-energy-efficient-pools_o.

Figure 7-1: Swimming Pool Plumbing Complexity

Source: Pool and Spa News

Figure 7-2: Motor Sizing Conditions



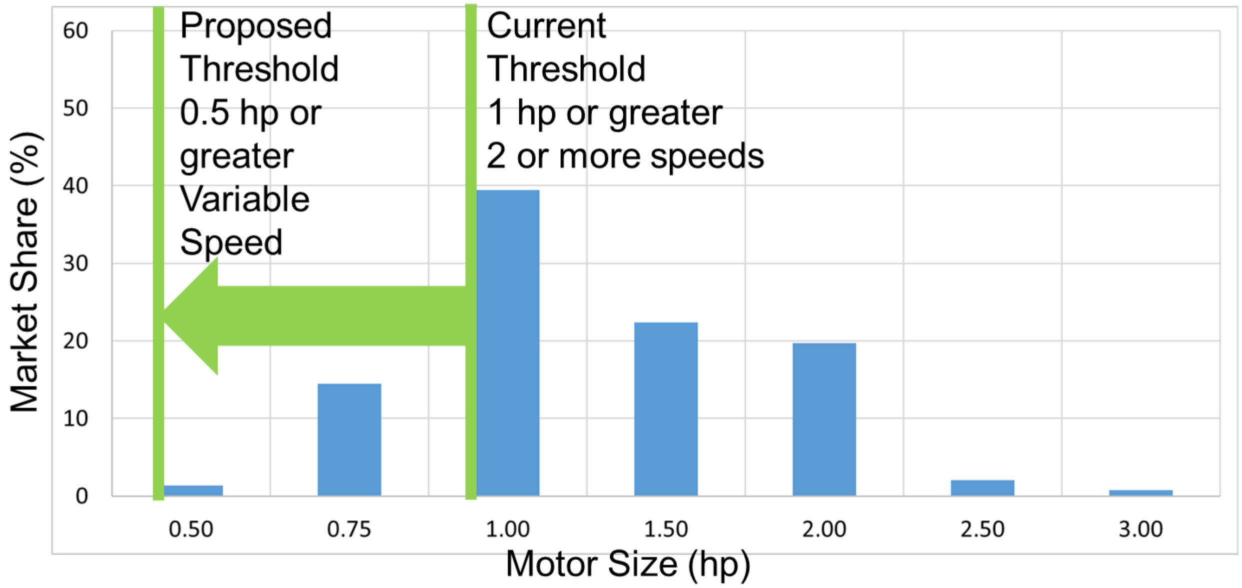
Source: CEC

Variable speed control solves this dilemma. A pool owner can select an oversize motor to protect against unknowns but not be forced to use this excess capacity. Variable speed pool pump motors provide the flexibility to provide the lowest flow necessary for the pool pump task while using the least energy. Even small adjustments in speed such as 100 percent motor speed to 80 percent speed can reduce energy consumption of the motor by 35 percent while still maintaining pool sanitation.

The proposal seeks to extend savings to the significant number of pools that have less than 1 hp pool pump motors as shown in **Figure 7-3**. More than fifty percent of pool filter pumps are

1 hp or less per a study performed by Southern California Edison of pools located within Southern California.[63]

Figure 7-3: Market Share of Pool Filter Pumps



Source: CEC with market share data from Southern California Edison

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.

63 Southern California Edison, *Pool Pump Demand Response Potential*, June 2008, pg. 14, available at: https://www.etcc-ca.com/sites/default/files/reports/dr07_01_pool_pump_demand_response_potential_report.pdf.

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

Replacement Motor Application	Application	Design Life (years)	Electricity Savings (kWh/yr)	Average Incremental Cost	Average Annual Savings	Life-Cycle Savings	Life-Cycle Benefit
SP Pool Filter Pump, (1.90 hp)	Residential	7.3	63	$19	$12	$89	$70
SP Pool Filter Pump, (3.76 hp)	Residential	7.3	86	$12	$17	$121	$109
SP Pool Filter Pump, small	Residential	7.3	1,410	$301	$272	$1,986	$1,685
NSP Pool Filter Pump	Residential	7.3	1,520	$390	$293	$2,142	$1,752
Pressure Cleaner Booster Pump(1.24 hp)	Residential	7.3	361	$398	$70	$509	$110
SP Pool Filter Pump, (1.90 hp)	Commercial	7.3	6,092	$401	$998	$7,286	$6,885
SP Pool Filter Pump, (3.76 hp)	Commercial	7.3	9,502	$390	$1,557	$11,363	$10,974
SP Pool Filter Pump, small	Commercial	7.3	1,579	$424	$862	$6,294	$5,870

Source: U.S. DOE Technical Support Document, as modified by CEC 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 $0.193 per kWh for residential applications and $0.164 for commercial applications.[64] 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

64 Lynn Marshall, CEC, Revised 2019 Integrated Energy Policy Report Statewide Electric Rates, September 30, 2019.

pools are in use in California.[65] Staff assumed a 1 percent growth rate for new pool installation based upon the CEC's energy demand forecast and information from the CASE team.[66] 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.[67] The California and nationwide estimates seem consistent and proportional.[68] 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.[69] That is somewhat higher than the previous CASE team estimate of 5,000 pool pump shipments per year.[70] 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 CEC docket and the results of a staff survey of California pool pump and motor retailers, consumers will choose to replace the motor of an existing pool pump and motor combination, rather than replace the entire system, between 25 percent and

65 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.

66 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,* CEC, Publication Number CEC-200-2013-004-SD-V1, p. 30.

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

68 Eaton, Eileen. December 2012. Table 2-2, p. 6, CEE High Efficiency Residential Swimming Pool Initiative, https://library.cee1.org/content/cee-high-efficiency-residential-swimming-pool-initiative/.

69 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.

70 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.

60 percent of the time.[71, 72] Staff present 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.[73]

Above-ground RDPPPM 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.[74]

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, 1 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 451 gigawatt-hours (GWh) of energy per year. Using a residential electricity rate of $0.193 per kWh and a commercial electricity rate of $0.164, full implementation of the proposed

71 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.

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

73 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.

74 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.

standards for pool pumps and motors would achieve roughly $82 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 would be on during peak demand.[75] The California Independent System Operator shows peak demand occurs on a summer day between 3 and 5 p.m.[76]

Table 7-2: Statewide Annual Savings

Replacement Motor Application	Application	First-Year Electricity Savings (GWh/yr)	First-Year Savings ($M)	Full-Stock Electricity Savings (GWh/yr)	Full-Stock Savings ($M)
Self-Priming Pool Filter Pump, standard-size (1.90 hp)	Residential	2.6	$0.5	19	$3.7
Self-Priming Pool Filter Pump, standard-size (3.76 hp)	Residential	1.2	$0.2	9	$1.7
Self-Priming Pool Filter Pump, small-size (0.88 hp)	Residential	10.0	$1.9	73	$14.1
Non-Self-Priming Pool Filter Pump (1.04 hp)	Residential Commercial	26.0	$5.0	190	$36.7
Pressure Cleaner Booster Pump (1.24 hp)	Residential Commercial	0.1	$0.0	0.6	$0.1
Self-Priming Pool Filter Pump, standard-size (1.90 hp)	Commercial	13.2	$2.2	96	$15.8
Self-Priming Pool Filter Pump, standard-size (3.76 hp)	Commercial	6.8	$1.1	50	$8.2
Self-Priming Pool Filter Pump, small-size (0.88 hp)	Commercial	2.0	$0.3	14	2.3
Total Savings	N/A	61.9	$11.3	451	$82.5

Source: CEC 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

75 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.

76 California Independent System Operator. California ISO Peak Load History 1998 through 2018. Available at https://www.caiso.com/documents/californiaisopeakloadhistory.pdf.

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 $81 per year with a $0.193 per kWh electricity cost.[77]

The CASE team estimated the cost of software changes to be less than $1 per unit in mass production for other appliance types.[78] 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.

Staff's proposal will require a variable speed RDPPPM where the DOE DPPP rule will require a single speed pool pump. Staff evaluated options available to consumers to replace the failed motor of a small pool filter pump absent an update to California's replacement pool pump motor standard as shown in **Table 7-3**. A consumer may choose to replace the motor only or the entire pool pump and may additionally select between single-speed and variable-speed capability. While a single speed pool pump would be the least expensive to purchase, a consumer making this choice would pay significantly more lifetime energy costs than a consumer that purchased a variable-speed RDPPPM. The compliant variable speed RDPPPM is the lowest cost alternative available to the consumer prior to and after the implementation of the standard. The variable-speed options will yield over $1,600 in lifetime savings. A white paper prepared by a replacement pool pump motor manufacturer describes similar energy and cost savings for replacing a small single-speed motor with a variable-speed motor.[79]

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77 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.

78 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.

79 Regal Beloit Corporation, *Understanding the Relationship Between Horsepower and Speed*, December 19, 2017, available at https://regalbeloitliterature.callmss.com/filedownload.php?S_card=MCWR17052E.

Table 7-3: Consumer Options to Replace a Failed less than 1 THP Pool Pump Motor




Baseline Options	Single Speed Pool Pump	Variable Speed Pool Pump	Single Speed Replacement Pool Pump Motor	Variable Speed Replacement Pool Pump Motor
Retail Price	$320	$700	$192*	$481*
Lifetime Energy Cost	$2,596	$686	$2,596	$686
Total Lifetime Cost	$2,916	$1,387	$2,788	$1,167

Source: CEC with data from U.S. DOE TSD
***Price survey by CEC staff**

In conclusion, the proposed standards are clearly cost-effective, as consumers will receive a net savings from the installation of compliant RDPPPM over the life of the motor.

CHAPTER 8: Technical Feasibility

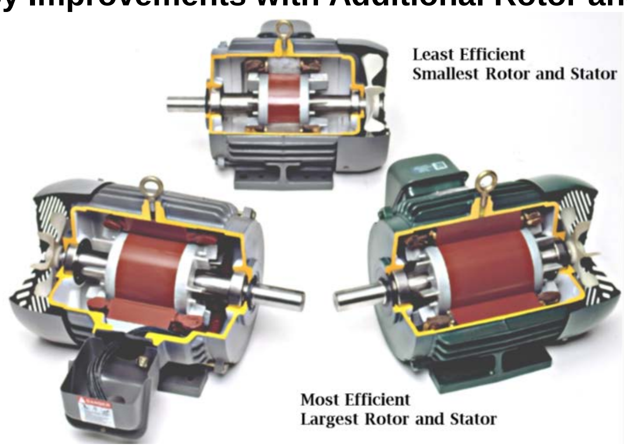
Motor Efficiency

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.[80] 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

80 "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).[81] 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.[82]

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 CEC's Modernized Appliance Efficiency Database System (MAEDbS) 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.

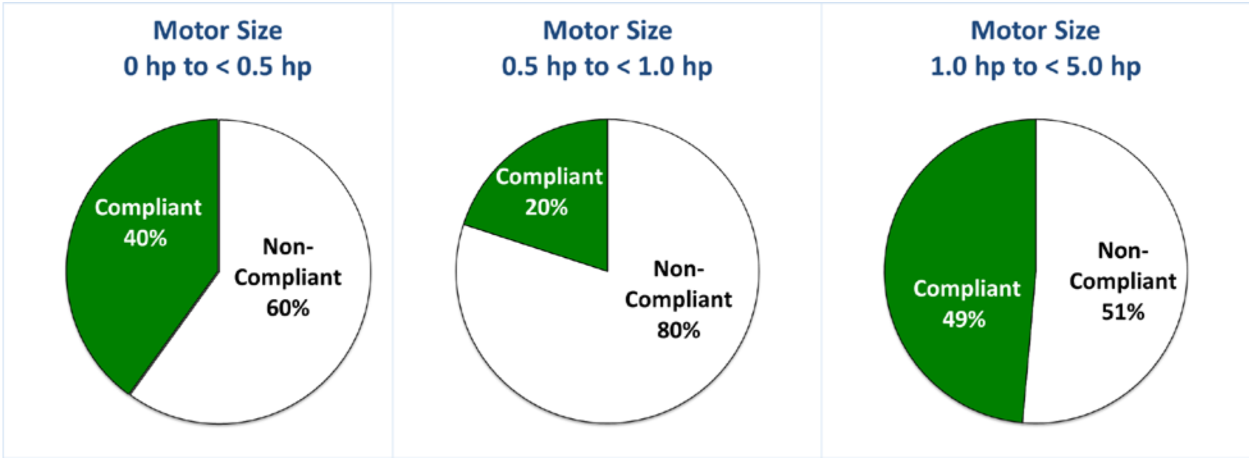
Figures 8-1 and **8-2** show existing pool pump motors compliant with the proposed motor efficiency and variable-speed standard in the CEC database as of February 2018. The small number of compliant replacement residential pool pump motors indicates the stringency of the standard as well as recent market 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 several variable-speed models to cover a variety of size applications where many more dual- or single-speed models would be required.[83] 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.

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

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

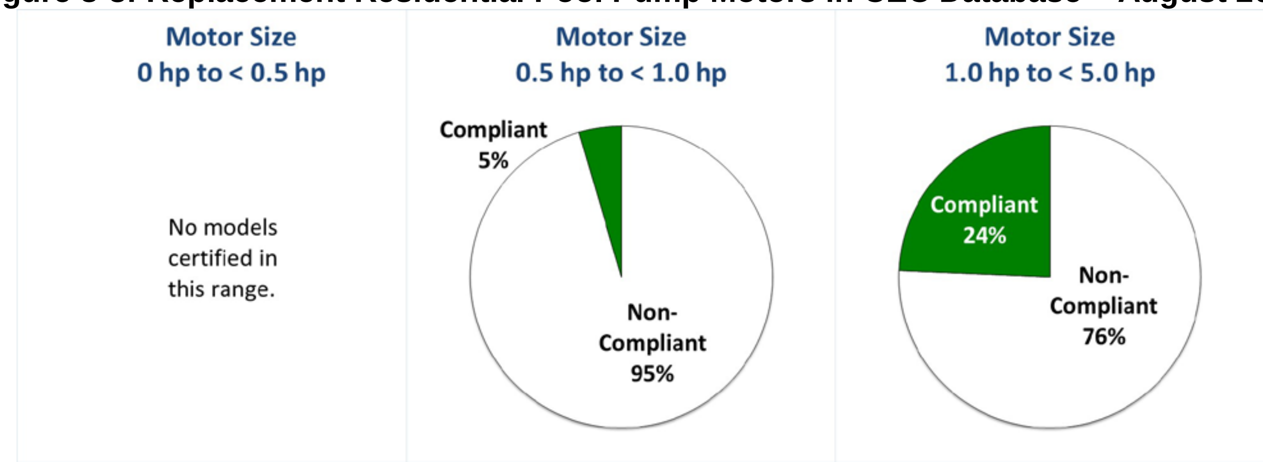
83 Century Electric Motor, VGreen 165 Product Brochure, VGreen165_Bulletin_2751CS.pdf available at https://www.centuryelectricmotor.com/MotorCategory.aspx?LangType=1033&id=6442450977.

Figure 8-2: Residential Pool Pump and Motor Combinations in CEC Database – August 2019



Source: CEC Appliance Database, August 23, 2019

Figure 8-3: Replacement Residential Pool Pump Motors in CEC Database – August 2019



Source: CEC Appliance Database, August 23, 2019

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.[84] 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, manufacturers have introduced variable-speed pool pumps for pressure cleaner

84 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.

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: CEC 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.[85]

85 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 their 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 of the pool pump motors.

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 compliant motors are already commonly available, increasing the minimum energy efficiency of replacement dedicated-purpose pool pump motors is not likely to change industry practice, the RDPPPM design, or the material composition of these replacement dedicated-purpose pool pump motors. A motor manufacturer may choose to pair a single-phase induction motor or an electronically commutated motor with a variable speed drive to achieve variable speed capability.[86] Motor efficiency improvements may be achieved by choosing a more efficient motor construction or by decreasing the electrical resistance in the motor. 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.

Similarly, pool pumps are replaced at the end of their useful lives. The proposed incorporation of the U.S. DOE DPPP regulations will not additionally impact the environment due to the same reasons the proposed RDPPPM regulations do not impact the environment. The most likely compliance path for pool pumps will be to upgrade the motor efficiency and speed capability of the pool pump.

Benefits

Improving the efficiency of RDPPPM through mandatory appliance efficiency 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. Avoided energy consumption 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

86 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, pp. 3-26, EERE-2015-BT-STD-0008-0105.

pollutant emissions, primarily from lower generation in hydrocarbon-burning power plants, such as natural gas power plants.

Incorporating the U.S. DOE DPPP regulations will provide similar benefits as the proposed replacement pool pump motor regulations.

Chapter 10: Economic and Fiscal Impacts

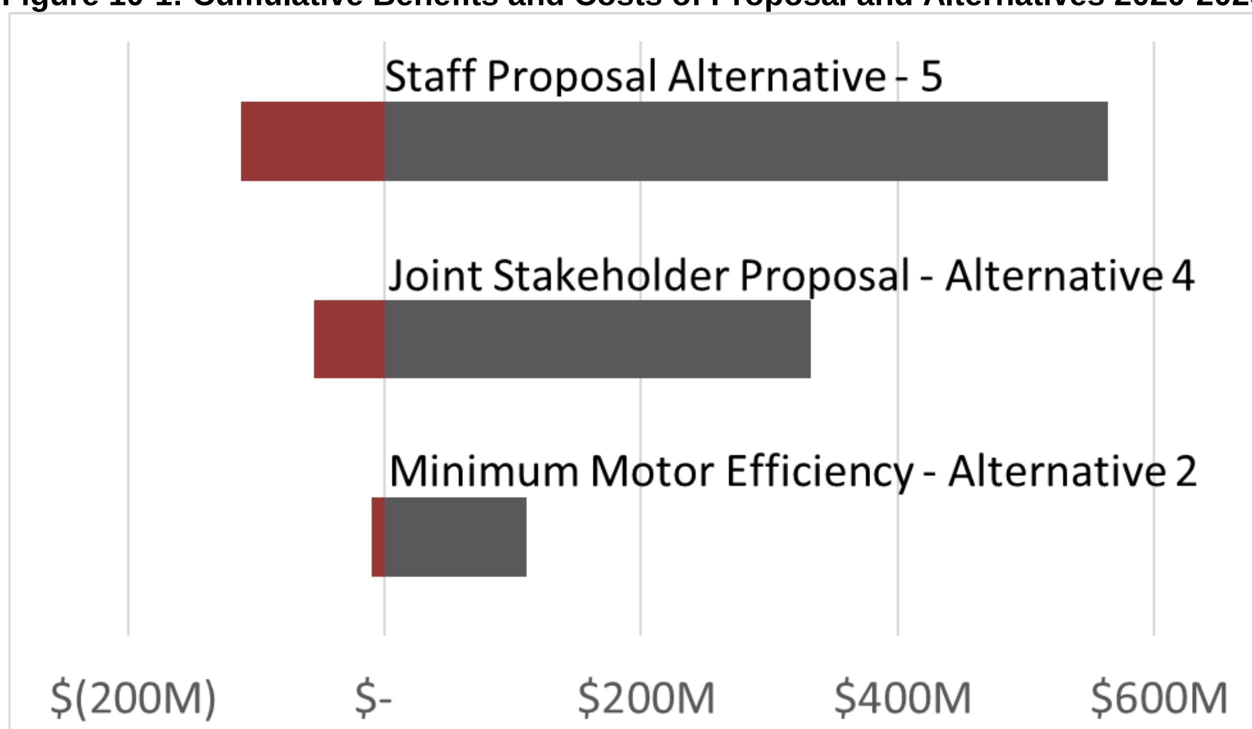
Introduction

The analysis considers impacts to California jobs, businesses, competitive advantages and disadvantages, and benefits and costs to Californians. In addition, the proposed standards yield an estimated $293 million increase in real disposable personal income between 2021 through 2030, which benefits the California economy. Staff analysis also considers the fiscal impacts to state and local governments. Staff found impacts to local and state governments through increased purchase price of RDPPPM was offset by utility bill savings from lower energy use.

For this report, staff analyzed the proposed regulation and two alternatives: (1) a regulations package with less stringent energy efficiency standards and (2) a regulations package with least stringent standards. Staff modeled and evaluated the three scenarios (least stringent, less stringent, and proposed).

Assumptions and analysis come from the U.S. Department of Energy's (DOE) Technical Support Document for dedicated purpose pool pumps that analyzed the efficiency and cost of the components of pool pumps including the pool pump motor.

Figure 10-1: Cumulative Benefits and Costs of Proposal and Alternatives 2020-2029



Source: CEC staff

Table 10-1: Cumulative Benefits and Costs of Proposal and Alternatives 2020-2029

	Total Benefit	Total Cost
Staff Proposal –Alternative 5	$563.9	$111.7
Joint Stakeholder Proposal - Alternative 4	$332.0	$55.4
Minimum Motor Efficiency - Alternative 2	$110.7	$9.9

Source: CEC staff

Economic Impacts

Estimated Private Sector Cost Impacts

The CEC estimates the total direct and indirect economic impact of this regulation to be $28.0 million in the first year after the regulations are fully implemented. The first year after the regulations are fully implemented is July 21, 2021 to July 20, 2022.

Impacts to Businesses

The CEC estimates that the total number of businesses potentially impacted in California is about 600, which includes distributors and retailers of RDPPPM, and electric utilities. **Table 10-2** provides a breakout of the staff estimate. Staff assume that 10 percent of the retailers and distributors impacted are small businesses. Small businesses are treated the same as other businesses under the regulations.

Table 10-2: Businesses Impacted by Proposed Regulations

Business Type	Estimated Number of Businesses in California
Replacement pool pump motor distributors and retailers	500
Electric Utilities	59

Source: CEC staff

Staff identified only two U.S. manufacturers of pool pump motors: WEG S.A.[87] and Regal Beloit America, Inc. Neither company has a significant presence in California so the impacts to manufacturers are not included in this economic analysis.

Under the appliance efficiency regulations (CCR, Title 20, sections 1608 and 1609), retailers are responsible for ensuring that any covered products they sell appear in the MAEDbS before they are sold or offered for sale in California. Because some RDPPPM are newly covered products, the CEC assumes that retailers will experience some additional costs associated with

87 WEG, WEG announces acquisition of North American Bluffton Motor Works, March 28, 2016, available at http://raemotors.com/news.php.

checking MAEDbS to ensure that the RDPPPM they sell or offer for sale appears in the MAEDbS and are therefore compliant and lawful to sell in California.

Some retailers may choose to incur additional costs if they rebrand an appliance that is not certified to MAEDbS and wish to sell it in California. These retailers are required to certify the appliance meets California standards, and therefore will incur costs associated with reporting to the MAEDbS.

Sellers of electricity, both retail and wholesale, will experience reduced sales of electricity due to the proposed standard. However, any reduction in sales is small compared to total electricity sales of these entities and therefore a negligible economic impact.

Because RDPPPM shipments and sales are not expected to change significantly as a result of the proposed regulations, no new businesses would be created and no existing businesses would be eliminated.

The proposed regulations will not eliminate or create any retail seller of electricity.

Impacts to California Employment

In previous macroeconomic analysis, staff has found job creation due to the savings that consumers receive on their electricity bills as a result of the efficiency standards.[88] These savings are reallocated from consumer spending on electricity to spending on other goods and services within the California economy, which translates into jobs. Utility sector jobs are expected to decrease due to lower electricity retail sales. However, increases in personal disposable income and reduction in commercial operating costs of businesses more than offset this loss and yield positive job growth numbers.

Estimated Costs

Entities that purchase compliant RDPPPM do not have any compliance obligations under the proposed regulations. However, the CEC assumes that the incremental cost to improve the efficiency of a RDPPPM is passed through from out-of-state manufacturers to the in-state purchasers of RDPPPM via retailers. This total cost is estimated to be $11.2 million per year.

Small Businesses

The initial and ongoing costs to California small businesses are the same as the costs for a typical business. Staff used the small business definition that a business is independently owned and operated; not dominant in its field of operation; and has fewer than 100 employees.[89] Small businesses that will be affected are those that sell RDPPPM such as pool supply companies and small retailers. Other small businesses would be the operators of pools as part of their businesses such as the owners of motels or apartment buildings. CEC staff

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88 Roland-Holst, David, Samuel Evans, Cecilia Han Springer, Tessa Emmer. 2016. *Standardized Regulatory Impact Assessment: Computers, Computer Monitors, and Signage Displays.* CEC: CEC-400-2016-008.

89 California Government Code 11346.3(b)(4)(B)

assumes that RDPPPM are typically purchased by individuals, businesses or small businesses that own swimming pools. Business and small businesses that purchase RDPPPM would pay an additional $389 to $424 per motor. The businesses would incur this additional cost once every 7 years, the design life of the product, but would see the initial increased cost repaid in less than two years due to energy savings.

Retailers will be required to verify that the RDPPPM they sell or offer for sale appear in the MAEDbS both when the standards first take effect (initial) and an ongoing basis. Retailers may do this either by verifying that the product appears in MAEDbS themselves, or negotiate contracts with manufacturers or distributors to ensure that the product is compliant with California law. To determine the estimated cost of this verification, CEC staff assumes the initial and ongoing annual costs per model per year is equal to approximately thirty-minutes of employee labor time per motor model at $50.00 per hour, costing each retailer ($50 hourly rate / half an hour) $25.00 for the product life-cycle. Based on the CEC's MAEDbS website information, CEC staff estimates approximately 250 in-scope RDPPPM models will require MAEDbS verification. Independently operated stores may carry fewer than ten in-scope RDPPPM models.

Retailers may choose to rebrand the compliant product and certify that model to MAEDbS. This is not a typical response to a change in standards such as the proposed regulations.

Individual Purchasers

The initial incremental costs for an individual purchaser of a compliant RDPPPM is $389-$424. This is a one-time expense with no annual ongoing costs. The CEC estimates that an individual would purchase between one and two RDPPPM per household. The purchases would occur about every 7 years, the design life for an RDPPM.

Manufacturers

The proposed regulations set new efficiency standards that will require manufacturers to produce more efficient RDPPPM. The incremental manufacturing costs to improve the product, which the CEC assumes will be entirely passed on to the end-user, are exceeded by the lifetime monetary savings that the end-user will receive through reduced electricity bills due to the energy efficiency improvements, resulting in overall monetary savings and economic benefits in California.

Although the proposed standard imposes new data reporting requirements on manufacturers of RDPPPM, none of these manufacturers are located in the California. Some retailers may choose to stand in as manufacturers when they rebrand a product and take on the manufacturer's certification burden for that RDPPPM model. The CEC estimates that the reporting burden for entities that choose to certify their products to MAEDbS is about $100 per motor model certified. This estimate includes record keeping and the cost to complete the template or manual submittal form to MAEDbS. Because rebranding is relatively infrequent and typically only involves one model per retailer, the CEC expects this cost to be absorbed by retailers.

Estimated Benefits

The benefits of proposed efficiency regulations include reductions in energy consumption and production. Reducing energy consumption generally increases the reliability of the electricity supply. Benefits that result from reduced energy production include reductions in criteria air pollutants. Air pollutants associated with electricity production are known carcinogens, such as benzopyrene, and other polycyclic aromatic hydrocarbons, arsenic, beryllium, cadmium, chromium, nickel, lead and formaldehyde that impact the health and quality of life for California residences.[90] Reductions in electricity production also reduce greenhouse gas emissions associated with climate change impacts.

Purchasers of an RDPPPM save money from reduced life-cycle costs for these appliances. The CEC estimates the total statewide net benefits from this regulation over ten years following full implementation to be $452 million.

Alternatives to the Regulation

Description of Alternatives

In the proposed regulations, CEC staff proposes to require minimum motor efficiency level and variable speed capability for motors over 0.5 total horsepower. Under Alternative 4, staff considered the requirements of the Joint Petition to DOE[91] that would require the existing California motor construction prohibitions and variable speed capability for motors over 1.15 total horsepower. Under the Joint Petition, fewer motors would be required to meet the variable speed capability so staff reduced the statewide estimated savings and incremental costs proportional to the market share of the reduced scope of the variable speed requirement. Under Alternative 2, staff considered setting a minimum motor efficiency standard equivalent to the DOE efficiency level 2, while maintaining the existing 2-speed motor capability standard for motors of 1 total horsepower or greater. Staff similarly estimated reduced statewide energy savings and incremental costs due to the less stringent requirements. Savings under Alternative 2 are due to expanding scope to commercial applications and to motors used in pressure cleaner booster pumps and improving the motor efficiency.

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90 Boffetta P, Cardis E, Vainio H, Coleman MP, Kogevinas M, Nordberg G, Parkin DM, Partensky C, Shuker D, Tomatis L., International Agency for Research on Cancer, Cancer risks related to electricity production, 1991.

91 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 10-3: Summary of Economic Impacts – Proposal – Residential Applications

Year	Annual Benefit ($M)	Annual Cost ($M)	Net Benefits ($M)
2021	7.7	9.9	-2.2
2022	15.4	9.9	5.5
2023	23.1	9.9	13.2
2024	30.8	9.9	20.9
2025	38.5	9.9	28.6
2026	46.2	9.9	36.3
2027	53.9	9.9	44.0
2028	56.2	9.9	46.3
2029	56.2	9.9	46.3
2030	56.2	9.9	46.3
Total	384.2	98.7	285.5

Source: CEC staff

Table 10-4: Summary of Economic Impacts – Proposal- Commercial Applications

Year	Annual Benefit ($M)	Annual Cost ($M)	Net Benefits ($M)
2021	3.6	1.3	2.3
2022	7.2	1.3	5.9
2023	10.8	1.3	9.5
2024	14.4	1.3	13.1
2025	18.0	1.3	16.7
2026	21.6	1.3	20.3
2027	25.2	1.3	23.9
2028	26.3	1.3	25.0
2029	26.3	1.3	25.0
2030	26.3	1.3	25.0
Total	179.7	13.1	166.7

Source: CEC staff

Table 10-5: Summary of Economic Impacts - Alternative 4 – Residential Applications

Year	Annual Benefit ($M)	Annual Cost ($M)	Net Benefits ($M)
2021	3.3	4.4	-1.1
2022	6.5	4.4	2.1
2023	9.8	4.4	5.4
2024	13.0	4.4	8.6
2025	16.3	4.4	11.9
2026	19.6	4.4	15.2
2027	22.8	4.4	18.4
2028	23.8	4.4	19.4
2029	23.8	4.4	19.4
2030	23.8	4.4	19.4
Total	162.6	44.0	118.6

Source: CEC staff

Table 10-6: Summary of Economic Impacts - Alternative 4 – Commercial Applications

Year	Annual Benefit ($M)	Annual Cost ($M)	Net Benefits ($M)
2021	3.3	1.1	2.1
2022	6.6	1.1	5.4
2023	10.8	1.1	9.7
2024	14.4	1.1	13.3
2025	18.0	1.1	16.9
2026	21.6	1.1	20.5
2027	23.0	1.1	21.8
2028	23.9	1.1	22.8
2029	23.9	1.1	22.8
2030	23.9	1.1	22.8
Total	169.4	11.5	158.0

Source: CEC staff

Table 10-7: Summary of Economic Impacts - Alternative 2 – Residential Applications

Year	Annual Benefit ($M)	Annual Cost ($M)	Net Benefits ($M)
2021	1.1	0.7	0.4
2022	2.3	0.7	1.6
2023	3.4	0.7	2.7
2024	4.6	0.7	3.9
2025	5.7	0.7	5.0
2026	6.9	0.7	6.2
2027	8.0	0.7	7.3
2028	8.4	0.7	7.7
2029	8.4	0.7	7.7
2030	8.4	0.7	7.7
Total	57.3	7.3	50.1

Source: CEC staff

Table 10-8: Summary of Economic Impacts - Alternative 2 – Commercial Applications

Year	Annual Benefit ($M)	Annual Cost ($M)	Net Benefits ($M)
2021	1.1	0.3	0.8
2022	2.1	0.3	1.9
2023	3.2	0.3	2.9
2024	4.3	0.3	4.0
2025	5.4	0.3	5.1
2026	6.4	0.3	6.2
2027	7.5	0.3	7.2
2028	7.8	0.3	7.5
2029	7.8	0.3	7.5
2030	7.8	0.3	7.5
Total	53.4	2.7	50.8

Source: CEC staff

Fiscal Impact Statement

The proposed regulations would increase the initial purchase cost of an RDPPPM and save money through reduced electricity consumption and lower utility bills over the 7-year life of the replacement dedicated purpose pool pump motor. The proposed regulations are estimated to increase the purchase cost of RDPPPM that a government entity needs. These incremental costs to purchases would most likely arise in the July 1, 2021 – June 30, 2022 fiscal year. The incremental costs of the RDPPPM are more than offset by the resulting energy savings in the form of reduced utility bills. The payback is estimated to be under two years and therefore easily offset the higher incremental cost. The incremental cost is estimated to be $389 to $424 RDPPPM with annual electricity savings of $862 to $1,557 depending on the size and duty cycle of the motor. These costs are not targeted specifically at state or local governments, but rather more broadly at which motors can be offered for sale to any entity in California.

The proposed regulations will not increase state expenditures on enforcement. Rather, enforcement priorities for different appliances, including, but not limited to, RDPPPM, will need to be determined as part of a general strategy on enforcement, and not as a result of any specific appliance efficiency regulation. Therefore, no fiscal impact can be estimated as a result of a change in the enforcement of the proposed regulations.

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 CEC 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 estimate of 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	0.24	350	1.75	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 estimated shipments in California by multiplying the percentage of California motor sales by the national motor sales. Staff projected the 2021 stock numbers by assuming a noncompounded growth rate of one percent per year to the 2015 stock numbers presented in the U.S. DOE TSD. The one percent growth rate is based upon a California population forecast increase of about one percent.[92] Staff estimated the distribution of motor sizes among the standard size self-

92 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*, CEC, Publication Number CEC-200-2013-004-SD-V1, p. 30.

priming pool filter pump motors by reviewing survey data collected by Southern California Edison.[93]

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

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

Residential California Pump Shipments 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% = 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% = 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:

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

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 assumes replacement motor shipments represent 25 percent of the total market except for pressure cleaner booster pump applications where staff assumed replacement motor shipments represent 2 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: CEC 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: CEC with data from U.S. DOE TSD

Noncompliant %

$\sum$ Pool Pump Efficiency Level (EL3 – EL5)

6% = 2% + 2% +2%

Compliance %

$\sum$ Pool Pump Efficiency Level (EL 0 – 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 operation 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 0.44 hhp Self-Priming Pool Filter Pump (High Speed)

EL	Motor Eff. (%)	WtW Eff%	Flow (gpm)	Head (feet H20)	Input Power (W)	WEF
EL 0	55	25	60	30	1331	2.69
EL 1	69	31	60	30	1061	3.37
EL 2	76	34	60	30	963	3.72
EL 3	64	29	60	30	1143	4.68
EL 4	70	31	60	30	1045	5.38
EL 5	73	33	60	30	1002	5.77
EL 6	81	30	48	19	565	8.78
EL 7	81	40	48	19	424	11.71

Source: U.S. DOE TSD Table 5.6.5

Table A-7: Performance of 0.44 hhp Self-Priming Pool Filter Pump (Low Speed)

EL	Motor Eff. (%)	WtW Eff%	Flow (gpm)	Head (feet H20)	Input Power (W)	WEF
EL 0	n/a	n/a	n/a	n/a	n/a	2.69
EL 1	n/a	n/a	n/a	n/a	n/a	3.37
EL 2	n/a	n/a	n/a	n/a	n/a	3.72
EL 3	38	14	30	7	288	4.68
EL 4	46	17	30	7	238	5.38
EL 5	51	19	30	7	215	5.77
EL 6	57	21	25	5	109	8.78
EL 7	57	29	25	5	82	11.71

Source: U.S. DOE TSD Table 5.6.5

Table A-8: Performance of 0.95 hhp Self-Priming Pool Filter Pump (High Speed)

EL	Motor Eff. (%)	WtW Eff%	Flow (gpm)	Head (feet H20)	Input Power (W)	WEF
EL 0	55	33	77	49	2172	2.13
EL 1	69	41	77	49	1731	2.67
EL 2	77	46	77	49	1551	2.98
EL 3	64	38	77	49	1866	3.98
EL 4	71	42	77	49	1682	4.6
EL 5	73	43	77	49	1636	4.88
EL 6	81	39	62	32	940	6.89
EL 7	81	48	62	32	754	8.59

Source: U.S. DOE TSD Table 5.6.6

Table A-9: Performance of 0.95 hhp Self-Priming Pool Filter Pump (Low Speed)

EL	Motor Eff. (%)	WtW Eff%	Flow (gpm)	Head (feet H20)	Input Power (W)	WEF
EL 0	55	n/a	n/a	n/a	n/a	2.13
EL 1	69	n/a	n/a	n/a	n/a	2.67
EL 2	77	n/a	n/a	n/a	n/a	2.98
EL 3	64	22	39	12	404	3.98
EL 4	71	27	39	12	334	4.6
EL 5	73	29	39	12	301	4.88
EL 6	81	27	31	8	170	6.89
EL 7	81	34	31	8	136	8.59

Source: U.S. DOE TSD Table 5.6.6

Table A-10: Performance of 1.88 hhp Self-Priming Pool Filter Pump (High Speed)

EL	Motor Eff. (%)	WtW Eff%	Flow (gpm)	Head (feet H20)	Input Power (W)	WEF
EL 0	n/a	n/a	n/a	n/a	n/a	2.13
EL 1	n/a	n/a	n/a	n/a	n/a	2.67
EL 2	n/a	n/a	n/a	n/a	n/a	2.98
EL 3	49	35	48	19	501	3.98
EL 4	55	39	48	19	446	4.6
EL 5	62	41	48	19	428	4.88
EL 6	57	26	31	8	178	6.89
EL 7	57	35	31	8	133	8.59

Source: U.S. DOE TSD Table 5.6.7

Table A-11: Performance of 1.88 hhp Self-Priming Pool Filter Pump (Low Speed)

EL	Motor Eff. (%)	WtW Eff%	Flow (gpm)	Head (feet H20)	Input Power (W)	WEF
EL 0	75	42	97	77	3344	2.13
EL 1	79	49	97	77	2860	2.67
EL 2	84	52	97	77	2690	2.98
EL 3	74	46	97	77	3053	3.98
EL 4	76	47	97	77	2973	4.6
EL 5	83	57	97	77	2461	4.88
EL 6	83	51	77	49	1608	6.89
EL 7	83	59	77	49	1203	8.59

Source: U.S. DOE TSD Table 5.6.7

Table A-12: Performance of 0.52 hhp Non-Self-Priming Pool Filter Pump (High Speed)

EL	Motor Eff. (%)	WtW Eff%	Flow (gpm)	Head (feet H20)	Input Power (W)	WEF
EL 0	55	28	63	33	1368	2.77
EL 1	69	36	63	33	1091	3.47
EL 2	72	37	63	33	1045	3.62
EL 3	61	31	63	33	1234	4.62
EL 4	68	35	63	33	1107	5.47
EL 5	72	37	63	33	1045	5.8
EL 6	81	42	50	21	589	7.42
EL 7	81	54	50	21	366	11.96

Source: U.S. DOE TSD Table 5.6.9

Table A-13: Performance of 0.52 hhp Non-Self-Priming Pool Filter Pump (Low Speed)

EL	Motor Eff. (%)	WtW Eff%	Flow (gpm)	Head (feet H20)	Input Power (W)	WEF
EL 0	n/a	n/a	n/a	n/a	n/a	2.77
EL 1	n/a	n/a	n/a	n/a	n/a	3.47
EL 2	n/a	n/a	n/a	n/a	n/a	3.62
EL 3	38	16	32	8	306	4.62
EL 4	48	20	32	8	242	5.47
EL 5	51	21	32	8	228	5.8
EL 6	57	15	25	5	154	7.42
EL 7	57	24	25	5	96	11.96

Source: U.S. DOE TSD Table 5.6.9

Table A-14: Performance of 0.31 hhp Pressure Cleaner Booster Pump (High Speed)

EL	Motor Eff. (%)	WtW Eff%	Flow (gpm)	Head (feet H20)	Input Power (W)	WEF
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-15 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: CEC with data from U.S. DOE TSD

Table A-16: 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: CEC with data from U.S. DOE TSD

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

Daily High Speed Hours = (Mean Pool Size * Number of Daily Turnovers / (High Speed Flow (GPM) * 60 Minutes / Hour)

5.31 hours per day = 13,000 gallons * 1.47 turnovers / (60 gpm * 60 minutes per hour)

Where:

High-Speed Flow is from Table A-6

Daily Low Speed (Half)(hr / day)

Daily Low Speed Hours = (Mean Pool Size * Number of Daily Turnovers / (Low Speed Flow (GPM) * 60 Minutes / Hour)– 2 hours

8.62 hours = (13,000 gallons * 1.47 turnovers / (60 gpm * 60 minutes per hour) – 2 hours

Where:

Low-Speed Flow (gpm) is from Table A-7

Daily Low Speed (Half) Min

See equation above. Substitute Low-Speed Flow (gpm) with EL 6 Low-Speed flow from Table A-7

High Speed (hrs/yr)

High speed hours per year = Daily High Speed Hours per day * 365 days per year

730 hours per year = 2 hours per day * 365 days per year

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-14**. 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-17 and A-18**.

High Speed (kW)

= {(EL3 * IP_{EL3} * Daily High Speed) + (EL4 * IP_{EL4} * Daily High Speed) + (EL5 * IP_{EL5} * Daily High Speed) + [(EL0 + EL1 + EL2 + EL6) * IP_{EL6} * Daily High Speed] + (EL7 * IP_{EL7} * Daily High Speed)} / (Daily High Speed * 1,000)

0.96 = {(.02 * 1,682 * 2.00) + (.02 * 1,636 *2.00) + [(.45 + .15 + .10 + .08) * 940 * 2.00] + (.16 * 754 * 2.00)} / (2.00 * 1,000)

EL 0-7 = Is the percentage of market share 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 1 and 7.

Daily High Speed = The calculated Daily High Speed duty cycle in hours as calculated in Table A-10.

Low Speed (kW)

= {(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 (min)} / {[Daily Low Speed (half) * (EL_3 + EL_4 + EL_5) + Daily Low Speed (min) * (EL_0 + EL_1 + EL_2 + EL_6 + EL_7)] * 1000}

0.17 = {(0.02 * 404 + 0.02 * 334 + 0.02 * 301) * 10.56 + [(0.45+0.15+0.10 + 0.08) *170 + 0.16 * 136]*13.8} / {[10.56 * (0.02 + 0.02 + 0.02) + 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_{ELi}= 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-15.

Daily Low Speed (min) = The Daily Low Speed duty cycle in hours at minimum speed calculated from Table A-15.

Annual Energy Consumption (kWh/yr per Appliance)

AEC=kWh/yr=

=(EL_3*IP_{EL3}*HS+EL_4*IP_{EL4}*HS+EL_5*IP_{EL5}*HS+(EL_0+EL_1+EL_2+EL_6)*IP_{EL6}*HS +EL_7*IP_{EL7}*HS)/1000 +

(EL_3*IP_{LEL3}*LS_{half}+EL_4*IP_{LEL4}*LS_{half}+EL_5*IP_{LEL5}*LS_{half}+(EL_0+EL_1+EL_2+EL_6)*IP_{LEL6}*LS_{min} +EL_7*IP_{LEL7}*LS_{min})/1000

1,557=[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*3,856+2%*334*3,856+2%*301*3856+(45%+15%+10%+8%)*170*5,039 +16%*136*5,039]/1000

Where:

HS (hrs/yr) = Value calculated from Table A-15.

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-7

LS (Half) = The Low Speed (Half) hrs/yr value calculated from Table A-15.

LS (min) = The Low Speed (min) hrs/yr value calculated from Table A-15.

Total Annual Stock Energy Use (GWh/yr)

= (AEC * CRMTS) / 1,000

467 = (1,557 * 299.89)/1,000

Where:

AEC = The Annual Energy Consumption (kWh/yr) from Table A-17.

CRMTS = California Replacement Motor Total Stock in 2021 calculated from Table A-1.

Table A-17 and **A-18** presents baseline energy consumption prior to the motor WEF standard.

Table A-17: 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	2

Source: CEC

Table A-18: 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: CEC

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-19 and A-20** show predicted energy consumption of compliant units and stock.

Table A-19: Compliant 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)	0.91	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	2

Source: CEC

Table A-20: 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: CEC

Cost and Energy Savings

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

Stock Energy Savings

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

where:

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

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

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

First-Year Energy Savings

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

where:
$E_{1\ year\ savings}$ = 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-21: Statewide Cost and Energy Savings – Residential

Application	First Year Electricity Savings (GWh/yr)	First Year Savings ($M)	Full Stock Electricity Savings (GWh/yr)	Full Stock Savings($M)
Self-Priming Pool Filter Pump, motor (0.95 hhp)	2.6	$0.5	19	$3.7
Self-Priming Pool Filter Pump, motor(1.88 hhp)	1.2	$0.2	9	$1.7
Self-Priming Pool Filter Pump, motor(0.44 hhp)	10.0	$1.9	73	$14.1
Non-Self Priming Pool Filter Pump motor(0.52 hhp)	26.0	$5.0	190	$36.7
Pressure Cleaner Booster Pump motor(0.31 hhp)	0.1	$0.0	1	$0.1
Total Savings	39.9	$7.7	291	$56.2

Source: CEC

Table A-22: Statewide Cost and Energy Savings – Commercial

Application	First Year Electricity Savings (GWh/yr)	First Year Savings ($M)	Full Stock Electricity Savings (GWh/yr)	Full Stock Savings($M)
Self-Priming Pool Filter Pump, motor (0.95 hhp)	13.2	$2.2	96	$15.8
Self-Priming Pool Filter Pump, motor (1.88 hhp)	6.8	$1.1	50	$8.2
Self-Priming Pool Filter Pump, motor (0.44 hhp)	2.0	$0.3	14	$2.3
Total Savings	22.0	$3.6	160	$26.3

Source: CEC

Table A-23: Combined Statewide Cost and Energy Savings

Application	First Year Electricity Savings (GWh/yr)	First Year Savings ($M)	Full Stock Electricity Savings (GWh/yr)	Full Stock Savings($M)
Residential	39.9	$7.7	291	$56.2
Commercial	22.0	$3.6	160	$26.3
Total Savings	61.9	$11.3	451	$82.5

Source: CEC

Unit cost savings (benefits) are calculated by multiplying the annual energy savings by $0.193 per kWh for residential applications and $0.164 for commercial applications.[94] The result is then multiplied 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

94 Lynn Marshall, CEC, Revised 2019 Integrated Energy Policy Report Statewide Electric Rates, September 30, 2019

$C_{incremental}$ = Incremental cost

Incremental costs of RDPPPM and incremental installation costs are converted from 2015 dollars to 2018 dollars by multiplying the 2015 dollars by the Consumer Price Index for All Urban Consumers (CPI-U). For this conversion the CPI-U factor is 1.06.[95]

$$C_{incremental2018} = C_{incremental2015} * CPI\text{-}U_{2015\text{-}2018}$$

where

$C_{incremental2018}$ = Incremental Cost 2018 dollars

$C_{incremental2015}$ = Incremental Cost 2015 dollars

$CPI\text{-}U_{2015\text{-}2018}$ = Consumer Price Index for All Urban Consumers factor for 2015 to 2018

Table A-24: Average Consumer Price for Self-Priming Pool Filter Pumps (0.95 hhp)

Efficiency Level	Average Consumer Price 2015 ($)	Incremental Cost 2015 ($)	Incremental Installation Cost 2015 ($)	Average Consumer Price 2018 ($)*	Incremental Cost 2018 ($)*	Incremental Installation Cost 2018 ($)*
Baseline	$354.40	--	$0.00	$375.48		$0.00
1	$393.67	$39.26	$0.00	$417.09	$41.61	$0.00
2	$426.73	$72.32	$0.00	$452.12	$76.63	$0.00
3	$428.79	$74.39	$160.00	$454.30	$78.82	$169.52
4	$463.92	$109.52	$160.00	$491.52	$116.04	$169.52
5	$501.12	$146.71	$160.00	$530.93	$155.45	$169.52
6	$712.54	$358.13	$20.00	$754.93	$379.45	$21.19
7	$712.54	$358.13	$20.00	$754.93	$379.45	$21.19

Source: U.S. DOE TSD Table 8.2.13 and as modified by CEC staff*

95 U.S. Department of Labor, Bureau of Labor Statistics, United States Consumer Price Index for All Urban Consumers (CPI-U) 1970 – 2019, available at http://www.dlt.ri.gov/lmi/pdf/cpi.pdf.

Table A-25: Average Consumer Price for Self-Priming Pool Filter Pumps (1.88 hhp)

Efficiency Level	Average Consumer Price 2015 ($)	Incremental Cost 2015 ($)	Incremental Installation Cost 2015 ($)	Average Consumer Price 2018 ($)*	Incremental Cost 2018 ($)*	Incremental Installation Cost 2018 ($)*
Baseline	$601.31	--	$0.00	$637.08		$0.00
1	$674.22	$72.91	$0.00	$714.33	$77.25	$0.00
2	$718.12	$116.81	$0.00	$760.84	$123.76	$0.00
3	$775.78	$174.47	$160.00	$821.93	$184.85	$169.52
4	$803.40	$202.09	$160.00	$851.20	$214.11	$169.52
5	$831.03	$229.71	$160.00	$880.47	$243.39	$169.52
6	$948.98	$347.67	$20.00	$1,005.44	$368.35	$21.19
7	$948.98	$347.67	$20.00	$1,005.44	$368.35	$21.19

Source: U.S. DOE TSD Table 8.2.14 and as modified by CEC staff*

Table A-26: Average Consumer Price for Self-Priming Pool Filter Pumps (0.44 hhp)

Efficiency Level	Average Consumer Price 2015 ($)	Incremental Cost 2015 ($)	Incremental Installation Cost 2015 ($)	Average Consumer Price 2018 ($)*	Incremental Cost 2018 ($)*	Incremental Installation Cost 2018 ($)*
Baseline	$320.00	--	$0.00	$339.04		$0.00
1	$346.76	$26.76	$0.00	$367.39	$28.35	$0.00
2	$385.63	$65.63	$0.00	$408.57	$69.53	$0.00
3	$391.31	$71.31	$160.00	$414.59	$75.55	$169.52
4	$413.23	$93.24	$160.00	$437.81	$98.78	$169.52
5	$435.14	$115.14	$160.00	$461.03	$121.99	$169.52
6	$700.20	$380.20	$20.00	$741.86	$402.82	$21.19
7	$700.20	$380.20	$20.00	$741.86	$402.82	$21.19

Source: U.S. DOE TSD Table 8.2.15 and as modified by CEC staff*

Table A-27: Average Consumer Price for Standard-Size Non-Self-Priming Pool Filter

Efficiency Level	Average Consumer Price 2015 ($)	Incremental Cost 2015 ($)	Incremental Installation Cost 2015 ($)	Average Consumer Price 2018 ($)*	Incremental Cost 2018 ($)*	Incremental Installation Cost 2018 ($)*
Baseline	$199.22	--	$0.00	$211.07		$0.00
1	$208.19	$8.98	$0.00	$220.58	$9.50	$0.00
2	$233.80	$34.58	$0.00	$247.71	$36.64	$0.00
3	$241.43	$42.21	$150.00	$255.79	$44.72	$158.92
4	$267.73	$68.52	$150.00	$283.66	$72.59	$158.92
5	$294.04	$94.83	$150.00	$311.53	$100.46	$158.92
6	$566.26	$367.05	$10.00	$599.95	$388.88	$10.59
7	$566.26	$367.05	$10.00	$599.95	$388.88	$10.59

Source: U.S. DOE TSD Table 8.2.16 and as modified by CEC staff*

Table A-28: Average Consumer Price in 2021 for Pressure Cleaner Booster Pumps

Efficiency Level	Average Consumer Price 2015 ($)	Incremental Cost 2015 ($)	Incremental Installation Cost 2015 ($)	Average Consumer Price 2018 ($)*	Incremental Cost 2018 ($)*	Incremental Installation Cost 2018 ($)*
Baseline	$255.40	--	$0.00	$270.59		$0.00
1	$275.77	$20.36	$0.00	$292.18	$21.58	$0.00
2	$312.35	$56.95	$0.00	$330.93	$60.34	$0.00
3	$611.45	$356.05	$20.00	$647.83	$377.23	$21.19
4	$611.45	$356.05	$20.00	$647.83	$377.23	$21.19

Source: U.S. DOE TSD Table 8.2.19 and as modified by CEC staff*

Table A-29: 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	$19	$12	$89	$70
Self-Priming Pool Filter Pump, motor(1.88 hhp)	7.3	86	$12	$17	$121	$109
Self-Priming Pool Filter Pump, motor(0.44 hhp)	7.3	1,410	$301	$272	$1,986	$1,685
Non-Self Priming Pool Filter Pump motor(0.52 hhp)	7.3	1,520	$390	$293	$2,142	$1,752
Pressure Cleaner Booster Pump motor(0.31 hhp)	7.3	361	$398	$70	$509	$110

Source: CEC

Table A-30: 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	$401	$998	$7,286	$6,885
Self-Priming Pool Filter Pump, motor1.88 hhp)	7.3	9,502	$390	$1,557	$11,363	$10,974
Self-Priming Pool Filter Pump motor (0.44 hhp)	7.3	1,579	$424	$862	$6,294	$5,870

Source: CEC

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.[96] California Independent System Operator shows the peak demand occurs on a summer day between 3 and 5 p.m.[97]

Example calculation:

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

96 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.

97 California Independent System Operator, California ISO Peak Load History 1998 through 2018, 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
CPI-U	Consumer Price Index for All Urban Consumers
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

Acronym	**Description**
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
THP	Total Horsepower
WHP	Water horsepower
ZNE	Zero net energy