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CALIFORNIA ENERGY COMMISSION

California Energy Commission

FINAL STAFF REPORT

Analysis of Flexible Demand Standards for Pool Controls

2023 Flexible Demand Appliance Standards
Docket Number 20-FDAS-01

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California Energy Commission

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PREFACE

On October 14, 2020, the California Energy Commission (CEC) adopted an order instituting rulemaking for flexible demand technologies for appliances to consider standards, test procedures, labeling requirements, and other flexible demand measures. The order instituting rulemaking also authorizes the CEC to investigate and adopt, if appropriate, additional priority measures as determined by the lead commissioner.

On November 19, 2020, the CEC released a notice for a lead commissioner workshop to receive public input on the approach to develop "Flexible Demand Appliance Standards."

On December 9, 2020, the CEC released a staff paper on flexible demand standards for public comment.

On December 14, 2020, the CEC held a lead commissioner workshop to provide interested parties the opportunity to inform the CEC about the product, market, and industry characteristics of the appliances identified in the OIR, as well as additional appliances.

On September 1, 2021, the CEC released a request for information to seek proposals for standards, test procedures, labeling requirements, and other measures to improve the flexible demand of electricity of specified appliances.

On September 30, 2021, the CEC released draft express regulatory language for public comment.

On June 29, 2022, the CEC released a draft staff report analysis of flexible demand standards for pool controls containing proposed regulatory language for public comment.

On July 19, 2022, the CEC held a public staff workshop for flexible demand appliance standards for pool controls.

The CEC reviewed all information received during the workshop and submitted in writing to the CEC's docket for this rulemaking. This staff report proposes standards for pool controls and describes the basis for such standards. The report includes analysis of the cost-effectiveness, technical feasibility, and statewide benefits of the proposed standard per the requirements of Section 25402(f) of the Public Resources Code.

ABSTRACT

Senate Bill 49 (Skinner, Chapter 697, Statutes of 2019) authorizes the California Energy Commission to adopt and periodically update standards for appliances to facilitate the deployment of flexible demand technologies that enable appliance operations to be scheduled, shifted, or curtailed to reduce emissions of greenhouse gases (GHG) associated with electricity generation.

This staff report focuses on pool controls. This report proposes to add flexible demand appliance standards for pool controls to Title 20 of the California Code of Regulations. Staff analyzed the cost-effectiveness and technical feasibility of proposed flexible demand appliance standards for pool controls. Discussion of the projected statewide energy use, flexible demand potential, GHG emission reductions, and other related environmental impacts and benefits are included in this analysis.

The proposed additions to Title 20 would set design standards, consumer consent, certification, cybersecurity, and labelling requirements for pool controls. The proposed standards are collectively referred to as “flexible demand standards” or “flexible demand appliance standards.” The proposal would require pool controls as defined in Section 1691 (b), meaning controls that use single-phase AC power as input power and control pool filter pumps with a rated hydraulic horsepower (hhp) of 2.5hhp or less, to have a default schedule for the operation of pool equipment and internet connectivity to provide flexible demand technologies. The proposed additions also include general enforcement and testing provisions.

The proposed standards are cost-effective, technically feasible, and would reduce GHG emissions associated with electricity production by 394,000 metric tons of carbon dioxide equivalent (CO_2e) in 2033 at full stock turnover. The standards would shift 64 gigawatt-hours (GWh) of electricity off peak during the first year the standard is in effect and 682 GWh of electricity during the year at full stock turnover. Consumers would save an estimated $1,131 per appliance over the life of the device by shifting the time of electricity use.

Keywords: Senate Bill 49, flexible demand technologies, flexible demand appliances, pool controls, greenhouse gas emissions, cybersecurity, consumer consent, equity

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EXECUTIVE SUMMARY

Since 1976, the California Energy Commission (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. With Senate Bill 49 (SB 49, Skinner, Chapter 697, Statutes of 2019), the California Legislature provided the CEC with a new authority to develop standards for flexible demand technologies to reduce greenhouse gas (GHG) emissions from electricity generation. Flexible demand technologies enable an appliance to schedule, shift, or curtail the electrical demand with the consumer's consent. Flexible demand appliance standards must be cost-effective according to criteria SB 49 provides. SB 49 also mandates that the CEC establish cybersecurity standards to protect consumers using flexible demand appliances.

The GHG emissions from electricity generation vary by time of day and season, as shown in **Figure ES-1**. In this figure, shades of green show times of low GHG emissions. The electricity grid is cleanest around mid-day due to supply from renewable energy resources. Curtailing or shifting the load from periods of high GHG emissions to low GHG emissions will support decarbonization of buildings and the energy sector while benefiting electricity ratepayers and the public. Many appliances, including pool controls, can modify the time of operation with few if any inconveniences to the consumer.

Figure ES-1: Marginal Greenhouse Gas Emission Intensity ($MTCO_2e/MWh$)

Hour	Winter			Spring			Summer			Fall		
0	0.37	0.35	0.34	0.26	0.14	0.12	0.15	0.32	0.35	0.36	0.37	0.35
1	0.37	0.36	0.34	0.25	0.16	0.13	0.17	0.32	0.37	0.37	0.37	0.36
2	0.38	0.36	0.34	0.26	0.16	0.15	0.19	0.33	0.38	0.38	0.38	0.36
3	0.38	0.36	0.34	0.26	0.17	0.16	0.21	0.33	0.38	0.38	0.38	0.36
4	0.37	0.36	0.34	0.25	0.17	0.16	0.21	0.33	0.37	0.37	0.37	0.36
5	0.37	0.35	0.34	0.24	0.14	0.14	0.20	0.33	0.37	0.36	0.36	0.35
6	0.35	0.33	0.32	0.24	0.16	0.12	0.13	0.30	0.35	0.36	0.35	0.34
7	0.34	0.32	0.28	0.12	0.05	0.04	0.04	0.12	0.15	0.27	0.28	0.31
8	0.22	0.20	0.10	0.04	0.03	0.03	0.03	0.05	0.06	0.07	0.07	0.10
9	0.08	0.08	0.05	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05
10	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
11	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
12	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
13	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.06	0.05	0.05
14	0.08	0.07	0.04	0.03	0.03	0.03	0.04	0.06	0.07	0.08	0.06	0.06
15	0.29	0.23	0.06	0.04	0.04	0.04	0.04	0.09	0.12	0.21	0.20	0.23
16	0.34	0.33	0.28	0.14	0.05	0.05	0.05	0.11	0.18	0.27	0.30	0.32
17	0.32	0.31	0.30	0.20	0.09	0.08	0.08	0.16	0.23	0.28	0.30	0.31
18	0.31	0.30	0.28	0.19	0.13	0.09	0.13	0.24	0.30	0.31	0.29	0.30
19	0.31	0.29	0.26	0.18	0.13	0.13	0.18	0.28	0.31	0.31	0.29	0.30
20	0.32	0.30	0.27	0.17	0.13	0.12	0.18	0.29	0.31	0.32	0.31	0.31
21	0.33	0.31	0.29	0.18	0.11	0.09	0.15	0.28	0.32	0.33	0.33	0.32
22	0.34	0.33	0.31	0.21	0.11	0.09	0.14	0.30	0.33	0.35	0.35	0.34
23	0.36	0.34	0.32	0.23	0.13	0.12	0.14	0.32	0.34	0.36	0.36	0.35

Source: California Energy Commission

In addition to the GHG emission reductions, utility bill savings are a benefit for consumers that curtail or shift the timing of their electricity load. Most consumers have access to time-of-use (TOU) rates, which are electricity rates that vary by the time of day. Consumers that shift load to reduce GHG emissions may also reduce their electric utility bills by shifting their use from when the electricity rate is high to when it is low.

Staff initially studied a range of appliances to understand technical readiness and benefit potential. This preliminary analysis has identified pool controls, a device that sets the daily schedule of the pool filter pump, pool heater, chlorinator, and pressure cleaner booster pump, as an ideal candidate for the first of California's flexible demand appliance standards using the authority granted by SB 49. **Figure ES-2** shows pool control technologies available with scheduling and connectivity.

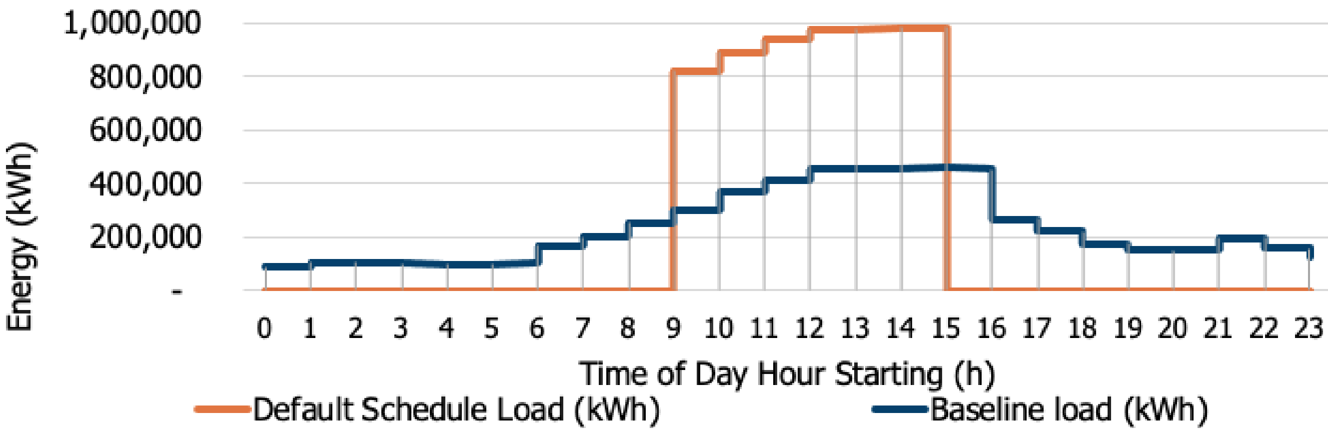
Figure ES-2: Pool Control

Source: California Energy Commission

Staff developed a proposal to align the pool control operation schedule to the average daily period of low GHG emissions between 9 a.m. and 3 p.m. local time and avoid operation from 4 p.m. to 9 p.m. local time to provide permanent load shift away from periods when the electric grid is the most stressed. It is the policy of the state of California to mobilize flexible resources to accommodate current and future grid needs and anticipated growth in electricity demand. Pool pumping is a class of electrical load that lends itself well to this approach.

Figure ES-3 compares how the staff proposal default schedule for pool controls would shift the pool electrical load from the late night and early morning to the middle of the day. The proposal would require all pool controls manufactured on or after the effective date that are sold or offered for sale, rented, imported, distributed, or leased for use in California to be certified to the CEC. The pool controls would be required to ship with a preprogrammed default schedule, be capable of connecting to the internet, and meet cybersecurity and consumer consent requirements. This report proposes (and therefore assumes) an effective date one year after adoption by the CEC at a business meeting, representing the earliest possible implementation date for newly adopted standards.

Figure ES-3: Baseline Load vs. Default 9 A.M. to 3 P.M. Schedule Load



Source: California Energy Commission

Staff analyzed the cost-effectiveness, technical feasibility, and statewide GHG emission reductions of the proposed pool control standard. SB 49 defines cost-effectiveness broadly and includes costs and benefits to the consumer and the state at large in terms of direct costs and benefits, reductions of greenhouse gases, and better alignment of consumer and electric system demand. Staff found the proposal and each of the alternatives considered provide more benefits than costs. SB 49 requires greenhouse gas emissions to be reduced by promoting technologies that enable shifts in the timing of appliance electric load. The staff proposal maximizes avoided GHG emissions and cost-effectiveness to consumers of pool controls. To determine cost-effectiveness, staff must determine the value of the energy shifted, the effect of the standard on the usefulness of the device, and the life-cycle cost to the consumer of the flexible device.

Staff found the proposal cost-effective. **Figure ES-1** shows the costs and benefits considered for the cost-effectiveness for each pool control. A compliant pool control is estimated to cost $70 more than a noncompliant pool control, and the consumer on time-of-use (TOU) rates will save a total of $1,131 over the 10-year estimated lifetime of the product through a reduced electricity bill.

Table ES-1: Costs and Benefits Considered for Cost-Effectiveness Per Control

Proposal	Design Life (years)	Consumer Utility Bill Savings Over the Design Life (In $2022)	Incremental Consumer Costs (In $2022)	Life-Cycle Consumer Savings (In $2022)
Pool Controls	10	1,131	70	1,061

Source: California Energy Commission

"Technical feasibility" means that products will be capable of meeting the proposed standard by the effective date based on feasible and attainable efficiencies or improvements. Many pool controls come with default schedules preprogrammed and the capability to connect to the internet, demonstrating the technical feasibility of the proposal.

The CEC must also consider other relevant factors in the development of proposed standards, including:

- The effect on housing costs.
- The total statewide costs and benefits of the standard over the lifetime of the product.
- The economic impact on California businesses.
- The impacts estimated to result from alternative approaches to the proposed standard.

Staff also found substantial GHG emissions savings could be achieved by requiring that pool controls come preprogrammed with a default schedule to run the energy-intensive operations between 9 a.m. and 3 p.m. (PST) to align with the period of low GHG emissions on California's electrical grid. **Table ES-2** provides estimates for statewide GHG emissions avoided, along with first-year and stock-turnover savings, reported in $2022. Staff estimates that full stock turnover will occur in ten years based on typical product lifespan, with total avoided GHG emissions of 2,135,000 metric tons CO_2e during the ten-year turnover period and annual avoided emissions of 394,000 metric tons CO_2e thereafter. The proposal would have a significant positive impact on the environment by reducing the greenhouse gas emissions from electricity generation, and provide associated consumer energy bill savings.

Table ES-2: Statewide Monetary Savings and GHG Emissions Avoided

Appliance	Total Avoided GHG Emissions During Turnover 2024 - 2033 (Metric Tons CO_2e)	Annual Consumer Savings - First Year in 2024 (M$ 2022)	Annual Consumer Savings - Stock Turnover in 2033 (M$ 2022)
Pool Controls	2,135,000	11	150

Source: California Energy Commission

The staff proposal for pool controls is a first step by the CEC implementing its authority under Senate Bill 49 to encourage the deployment of flexible demand technologies. As the CEC continues this important work, the intent is to transform the marketplace, allowing for innovation by industry to further develop load flexibility resources, reduce greenhouse gases, and advance energy sustainability and grid reliability.

The CEC monitors and is engaged with other states and countries in their approaches to flexible demand as well as the ENERGY STAR® specification development for devices. Staff may incorporate elements of ENERGY STAR product specifications into future standards for flexible demand functionality. Products that meet ENERGY STAR connectivity specifications point toward potential future CEC staff proposals for flexible demand appliances.

CHAPTER 1: Introduction

Prologue to Flexible Demand Appliance Standards

In August 2020, as firefighters battled wildfires burning more than a million acres across the state, Governor Gavin Newsom tweeted, "If you don't believe in climate change, come to California."[1] Climate change is no longer a theory up for debate; it is an active threat impacting California's 40 million residents and its unique and varied environment. The severity of the impacts — more regular and severe wildfires, heat waves, ocean acidification, reduced or shifting habitats, worsening air quality — will continue to grow unless global GHG emissions are dramatically reduced, and the state's economy is decarbonized.

The California Legislature passed Senate Bill 49 (SB 49, Skinner, Chapter 697, Statutes of 2019), which gave the CEC a new authority to develop "standards for appliances that facilitate the deployment of flexible demand technologies" to reduce greenhouse gas (GHG) emissions from electricity generation.[2] Adding flexible demand technologies to an appliance will allow it to schedule, shift, or curtail the electrical demand. SB 49 requires consumers' consent to enable this functionality.

Proposed flexible demand appliance standards must be cost-effective, according to criteria SB 49 provides. **Figure 1-1** shows a recent advertisement for California's Flex Your Power Program that illustrates what demand flexibility means: it asks Californians to use their appliances during off-peak demand hours to lower GHG emissions and the strain on the electric grid. Regulations adopted under the authority introduced by SB 49 will assist Californians in flexing their power by ensuring appliances sold in California include control and automation features that enable appliance operations to be scheduled, shifted, or curtailed directly or by a third party at the discretion of the consumer. The standards will also enhance cybersecurity of internet-connected appliances that are subject to the proposed standards.

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1 Governor Gavin Newsom. 2020. Remarks August 22, 2020. Available at https://twitter.com/gavinnewsom/status/1297364484940431360.

2 Skinner. 2019. Senate Bill 49. Available at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200SB49.

Figure 1-1: Flex Your Power Advertisement

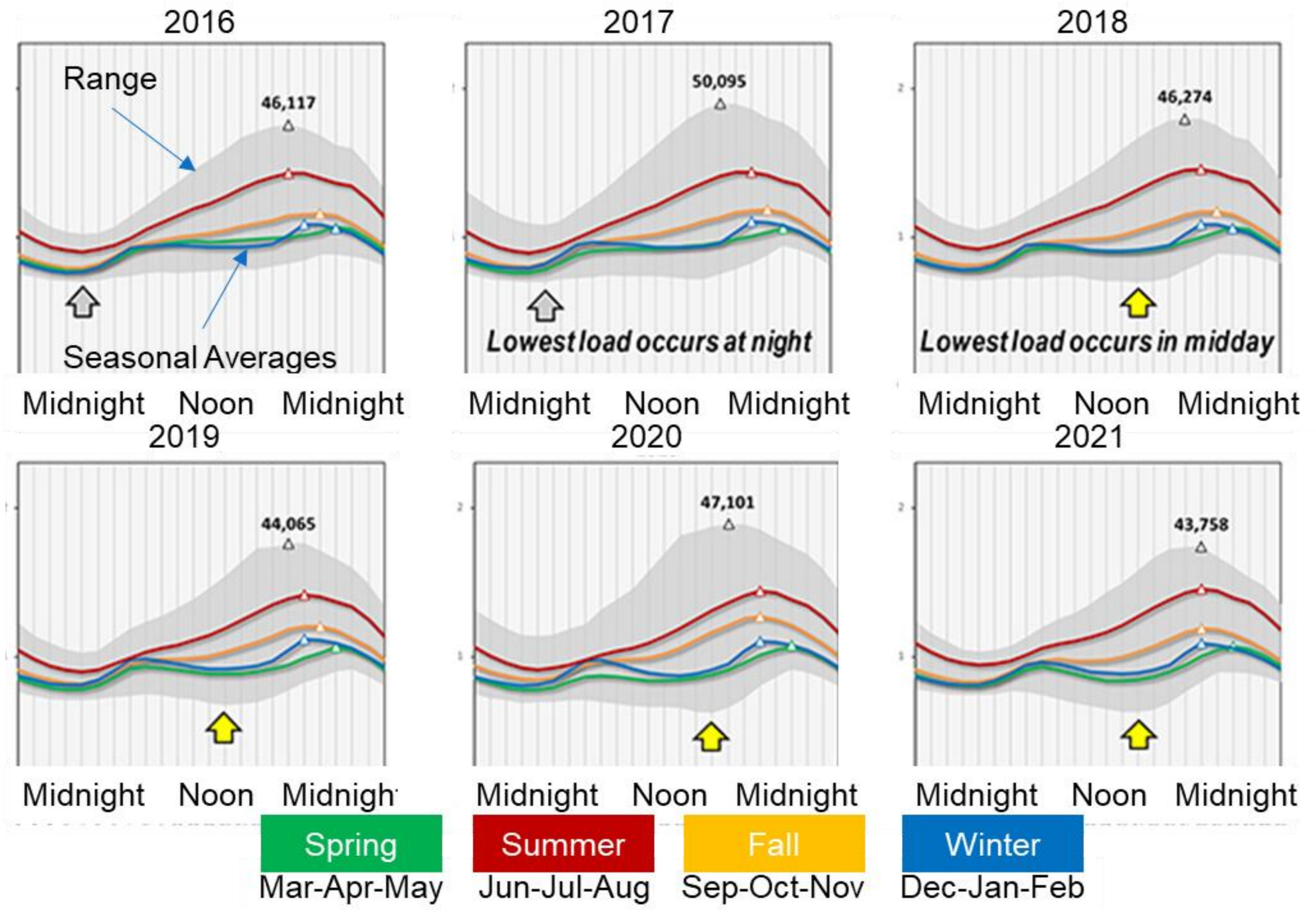
Source: Energy Upgrade CA

Flexible Demand Within an Electrical Grid in Transition

California has set ambitious but attainable goals to transition to 100 percent renewable and zero-carbon electricity by 2045. Many renewable energy sources, such as wind and solar, are intermittent — meaning they are available only at certain times of day. Consumers will benefit from the transition to a decarbonized economy by making smart choices regarding when to operate their appliances. By aligning the use of their appliances to the availability of low-or zero-carbon resources, they will help the environment and save money.

The proliferation of clean energy resources in California has led to new electricity grid operating conditions. **Figure 1-2** illustrates the changes in net load, the difference between the forecasted load and the variable generation resources. The lowest daily net loads have shifted from night to midday in recent years because of the growth of behind-the-meter photovoltaics (PV) and other factors. This excess generation and lower net load contribute to the curtailment of renewable generation typically during the spring when electrical demand is low and solar and wind production is high. Significant ramps in the morning and evening put demands on nonsolar resources. The most challenging operating hours occur in late summer between 7 and 8 p.m. when the sun has set and load from cooling remains high.[3]

Figure 1-2: Net Load in California 2016–2021



Source: California Independent System Operator

Figure 1-3 displays GHG emissions attributable to California's generation of electricity as they vary during the day and night and from season to season for 2030. Green-shaded areas represent low GHG emissions. Low emissions occur when the renewable energy generation is abundant relative to electricity demand. Red-shaded areas represent times when GHG emissions are relatively higher. The arrows indicate how load may be shifted from night into the day and from evening into the afternoon to better align appliance load with low-carbon emissions from the electrical grid.

There are three primary approaches to changing an appliance load: schedule, shift, or curtail. An appliance can be scheduled in a default manner or in reaction to a grid or GHG emission signal. Appliances could also shift load through use of a delay timer. Proposed standards could require that an appliance curtail usage altogether rather than shift it in response to a request

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3 Rothleder, Mark. California Independent System Operator. 2020. "Our Evolving Grid." Available at http://www.caiso.com/about/Pages/Blog/Posts/Our-Evolving-Grid.aspx.

during times of extreme demand or unexpected generation shortfalls. Any combination of these approaches or others suggested by stakeholders can be considered for inclusion in regulations under the authority provided in SB 49.

Figure 1-3: Electricity GHG Emission Intensity by Season in 2030 ($MTCO_2e/MWh$)

Hour	Winter			Spring			Summer			Fall		
0	0.37	0.35	0.34	0.26	0.14	0.12	0.15	0.32	0.35	0.36	0.37	0.35
1	0.37	0.36	0.34	0.25	0.16	0.13	0.17	0.32	0.37	0.37	0.37	0.36
2	0.38	0.36	0.34	0.26	0.16	0.15	0.19	0.33	0.38	0.38	0.38	0.36
3	0.38	0.36	0.34	0.26	0.17	0.16	0.21	0.33	0.38	0.38	0.38	0.36
4	0.37	0.36	0.34	0.25	0.17	0.16	0.21	0.33	0.37	0.37	0.37	0.36
5	0.37	0.35	0.34	0.24	0.14	0.14	0.20	0.33	0.37	0.36	0.36	0.35
6	0.35	0.33	0.32	0.24	0.16	0.12	0.13	0.30	0.35	0.36	0.35	0.34
7	0.34	0.32	0.28	0.12	0.05	0.04	0.04	0.12	0.15	0.27	0.28	0.31
8	0.22	0.20	0.10	0.04	0.03	0.03	0.03	0.05	0.06	0.07	0.07	0.10
9	0.08	0.08	0.05	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05
10	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
11	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
12	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
13	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.06	0.05	0.05
14	0.08	0.07	0.04	0.03	0.03	0.03	0.04	0.06	0.07	0.08	0.06	0.06
15	0.29	0.23	0.06	0.04	0.04	0.04	0.04	0.09	0.12	0.21	0.20	0.23
16	0.34	0.33	0.28	0.14	0.05	0.05	0.05	0.11	0.18	0.27	0.30	0.32
17	0.32	0.31	0.30	0.20	0.09	0.08	0.08	0.16	0.23	0.28	0.30	0.31
18	0.31	0.30	0.28	0.19	0.13	0.09	0.13	0.24	0.30	0.31	0.29	0.30
19	0.31	0.29	0.26	0.18	0.13	0.13	0.18	0.28	0.31	0.31	0.29	0.30
20	0.32	0.30	0.27	0.17	0.13	0.12	0.18	0.29	0.31	0.32	0.31	0.31
21	0.33	0.31	0.29	0.18	0.11	0.09	0.15	0.28	0.32	0.33	0.33	0.32
22	0.34	0.33	0.31	0.21	0.11	0.09	0.14	0.30	0.33	0.35	0.35	0.34
23	0.36	0.34	0.32	0.23	0.13	0.12	0.14	0.32	0.34	0.36	0.36	0.35

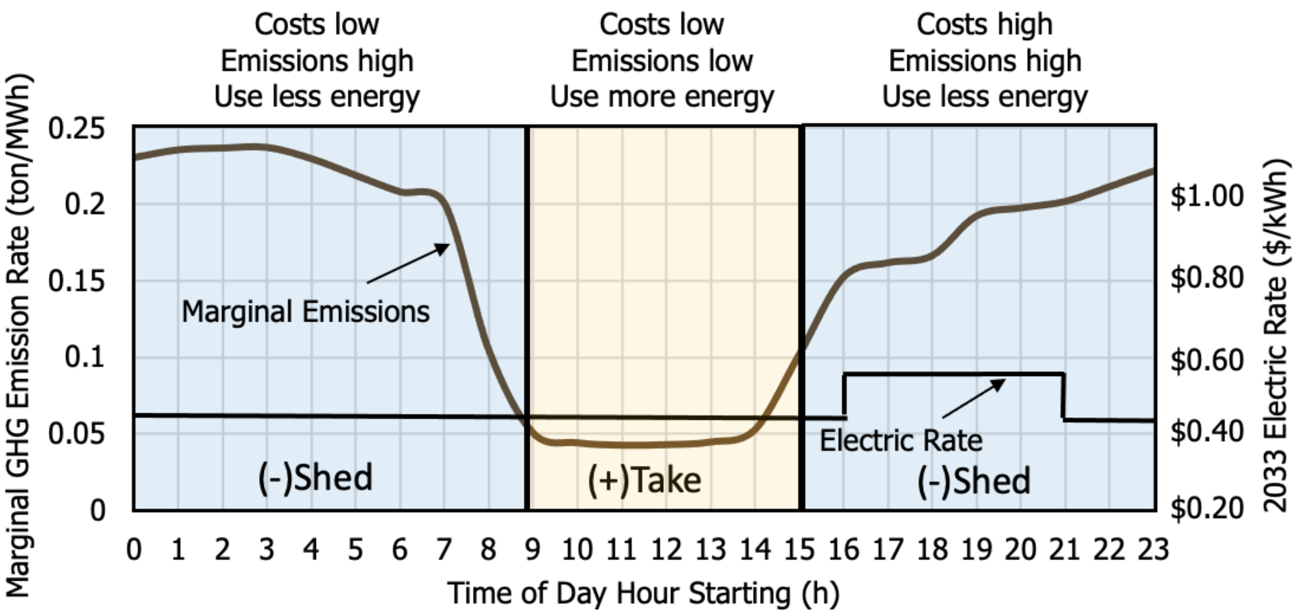
Source: California Energy Commission

Time-of-Use Pricing and Automation Provide Benefits to Consumers

"Time-of-use (TOU) rates" mean the rate consumers pay for electricity that varies by time of day. Most TOU rates vary several times per day and are intended to encourage a consumer to use electricity at off-peak times; for example, the load management standards adopted by the CEC require large utilities and CCAs to provide location-specific, marginal-cost-based rates that vary at least hourly. Advanced metering infrastructure (AMI) allows utilities to collect consumer energy usage in real time. AMI records the time of the electrical use in increments that align with the TOU rates. The combination of TOU rates and AMI enables consumers to benefit by shifting the times when they use their appliances. Both TOU rates and AMI are widely available to consumers in California.[4]

The principles of microeconomics and consumer behavior can predict how consumers may choose to shift load due to TOU electric rates or environmental concerns.[5] Microeconomics weighs the costs and benefits among various alternatives available to consumers. Since the choice of when to run pool equipment during the day presents few inconveniences, consumers will shift load to maximize their benefits according to what they value. The standards offered in this report look toward a day and time when advances in automation and communications technologies serve to maximize energy and air quality benefits to the end user. **Figure 1-4** shows the alignment of a typical daily TOU rate schedule and marginal GHG emission rate. The TOU rate provides a strong signal to the consumer on when not to use energy. Knowledge of the GHG marginal emission rate can inform the consumer when it is best to use energy, typically the middle of the day.

Figure 1-4: Daily GHG and Bill Savings Through Load Scheduling



Source: California Energy Commission

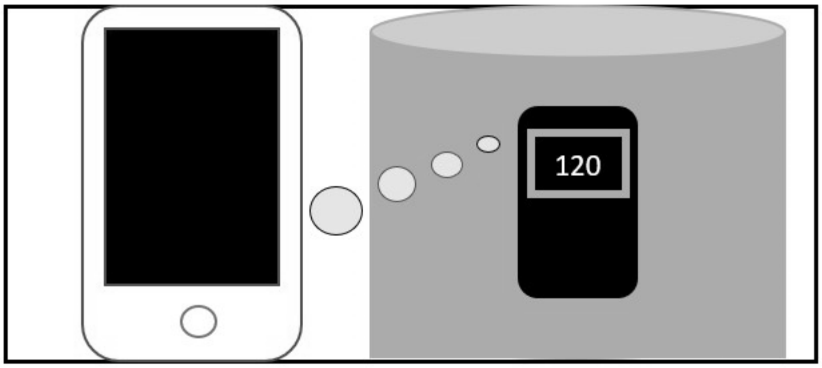
4 Herter, Karen, and Gavin Situ, P.E. 2021. *Analysis of Potential Amendments to the Load Management Standards: Load Management Rulemaking*. Docket Number 21-OIR-03. California Energy Commission. Publication Number CEC-400-2021-003-SF. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=241067&DocumentContentId=74898.

5 Neenan, Bernard and Jiyong Eom (Electric Power Research Institute). 2008. *Price Elasticity of Demand for Electricity: A Primer and Synthesis.* Electric Power Research Institute. Available at https://www.epri.com/research/products/1016264.

Automation

In recent years, manufacturers have introduced automation to a range of appliances to respond to customer preferences and provide greater utility.[6] Automation can provide consumers with a way to make appliances respond to TOU rates or GHG signals to save money on utility bills or reduce GHG emissions or both. **Figure 1-5** illustrates a common approach where an appliance may be paired with a smart phone to provide a user interface.

Figure 1-5: Home Appliance Automation



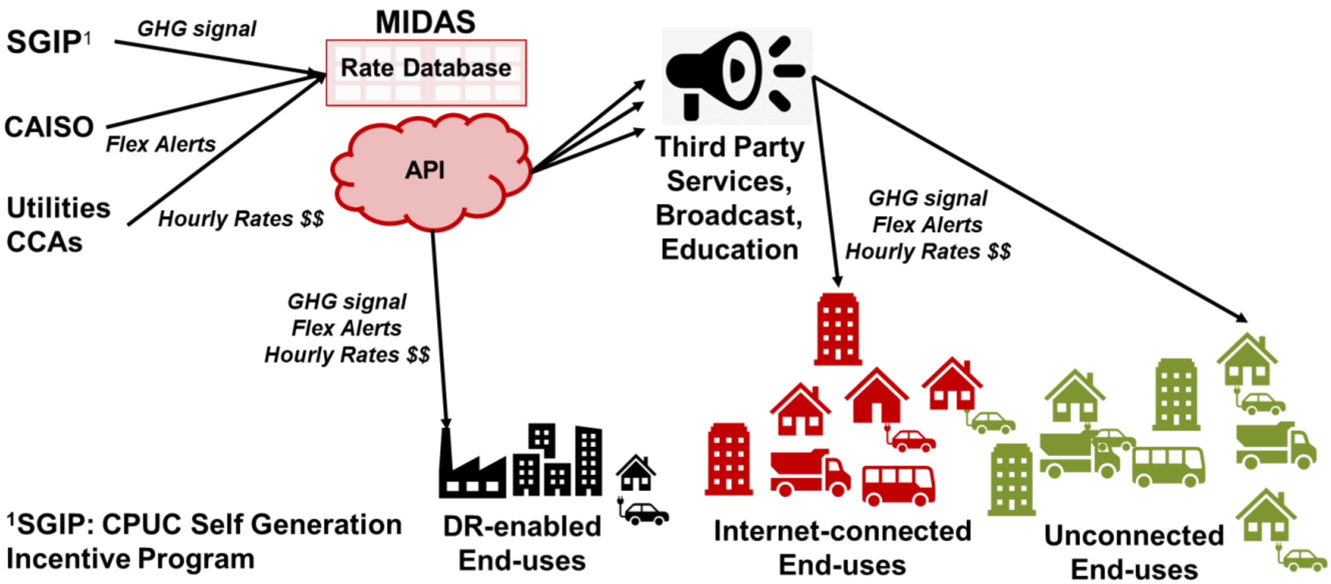
Source: California Energy Commission

The CEC's Market Informed Demand Automation Server (MIDAS) contains both electric utility rates and rates of marginal GHG emissions for most of the state's large utilities in a machine-readable format.[7] MIDAS provides a platform for customers and third-party service providers to obtain information needed for flexible demand-capable appliances to achieve price-based or GHG-based shifts in the timing of electric load. **Figure 1-6** shows examples of general information flows between MIDAS, utilities, automation service providers, consumers, and appliances. Actual communications and pathways will vary as technologies and policies evolve over time.

6 Association of Home Appliance Manufacturers (AHAM). 2016. "Connectivity: New Levels of Convenience." Available at https://www.aham.org/AHAM/Innovation/Connectivity/AHAM/Innovation/Connectivity.aspx?hkey=12ff39f3-ebad-4594-959b-3812ffdfff93.

7 Mateo, Tiffany, Karen Herter, and Morgan Shepard. CEC. 2021. "Market Informed Demand Automation Server Webinar." Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=239454&DocumentContentId=72917.

Figure 1-6: Prices and GHG Signals to Devices



Source: California Energy Commission

Senate Bill 49 Legislative Criteria

Public Resources Code Section 25402(f)(1) directs the CEC to establish standards and labeling requirements "to facilitate the deployment of flexible demand technologies" for appliances. These standards and labeling requirements encompass technical measures taken by consumers of electricity, third parties, load-serving entities, or a grid-balancing authority (with consumer consent) "that will enable appliance operations to be scheduled, shifted, or curtailed to reduce emissions of greenhouse gases associated with energy generation." The flexible demand standards the CEC adopts must be feasible, cost-effective, and adopted in consideration of a list of priorities and factors the bill delineates. As of January 1, 2021, the CEC must describe any actions it has taken following SB 49 in its biennial Integrated Energy Policy Report (IEPR).

The CEC shall consult with the California Public Utilities Commission (CPUC) and load-serving entities to better align the flexible demand standards with demand response programs administered by the state and load-serving entities and to incentivize the deployment of flexible demand appliances.

In determining cost-effectiveness, the CEC may consider factors such as the value of the energy shifted, the effect on efficacy of the appliance for the consumer, and the life-cycle cost to the consumer to comply with the standards. The CEC may consider GHG emissions when determining the cost-effectiveness of an appliance with flexible demand capability. The CEC considers other relevant factors, including the effect of proposed standards on housing costs, the statewide costs and benefits over the lifetime of the standard, the economic impact on California businesses, and costs and benefits associated with alternative approaches considered. Public Resources Code Section 25402(f)(3).

Public Resources Code Section 25402.11 provides the CEC with the authority to establish regulations to enforce violations of flexible demand appliance standards (FDAS). This authority allows an administrative penalty not to exceed $2,500 for each violation.

California Energy Policy

The Warren-Alquist Act establishes the CEC as California's primary energy policy and planning agency.[8] The act mandates that the CEC reduce the wasteful and inefficient consumption of energy and water in the state. California has enacted numerous pieces of legislation to guide local and state policy toward a clean energy future. This section summarizes the major pieces of legislation and executive direction to reduce GHG emissions across the economy with a particular focus on buildings.

Decarbonization of electricity used by appliances is the central focus of the CEC's implementation of the FDAS as conceived under SB 49. In essence, the CEC's *2019 Integrated Energy Policy Report* (*IEPR*) envisions decarbonization of the grid and the resiliency of the grid as a front-and-center issue, stating:

> "The goal is to cut emissions from the electricity sector to zero while meeting an increasing demand and maintaining energy reliability, controlling costs, and ensuring that benefits reach all Californians."[9]

The *2021 IEPR* continues the focus on reliability and includes a volume dedicated to the topic of building decarbonization. The *2021 IEPR* references load flexibility as one of seven broad strategies to reduce GHG emissions associated with California's buildings, along with efficient end use electrification and accelerating the transition to a 100 percent renewable and zero-carbon supply.

> "Technologies that shift the timing of electricity use can optimize building operations, enable customer savings, and allow clean energy supplies to be used rather than curtailed. Policies and regulations that increase the availability of flexible demand resources will support an affordable and reliable grid as the share of carbon-free resources expands."[10]

These specific policy drivers also exist in the broader context of legislative and executive support for aggressive and effective climate legislation. Assembly Bill 1279, described below, is

8 CEC. 2021. *Warren-Alquist Act*. CEC. Available at https://www.energy.ca.gov/sites/default/files/2021-05/CEC-140-2021-001.pdf.

9 CEC. 2019. *2019 Integrated Energy Policy Report*, page 22. CEC. Available at https://efiling.energy.ca.gov/getdocument.aspx?tn=232922.

10 CEC. 2022. *Final 2021 Integrated Energy Policy Report, Volume I: Building Decarbonization*, page 22. CEC. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=241599.

one out of a total of 40 bills signed during the 2021-22 legislative session that work toward achieving California's climate goals[11].

Load Management Standards

The Warren-Alquist Act defines load management as "any utility program or activity that is intended to reshape deliberately a utility's load duration curve" (Public Resources Code Section 25132). Load management strategies, including those established by the CEC's first load management standards, have been used to help balance the supply and demand of energy in California since the 1970s.

The 2022 Load Management Rulemaking culminated in the adoption of amended Load Management Standards that will increase statewide demand flexibility through regulation (California Code of Regulations [CCR] Title 20, Sections 1621–1625).[12] CEC staff and stakeholders agreed on the need for a statewide real-time signaling system, the Market Informed Demand Automation Server (MIDAS), that will enable automation markets to coalesce around agreed-upon principles and technologies for demand flexibility. MIDAS will provide all time-varying rates starting in summer 2023, allowing customers and automation service providers to link flexible loads to this database, enabling the automation of customer end uses in real time.

Further, the Load Management Standards will require that Large IOUs, POUs, and CCAs provide optional rates that are based on locational marginal cost and change at least hourly. Once implemented, these rates will offer the opportunity for customers who choose to shift load to save on their electricity bills by shifting electricity use to low-cost hours of day and avoiding use at higher-cost hours.

Executive Order S-3-05 (2005)

This executive order was signed by then-Governor Arnold Schwarzenegger in 2005 to move the state to combat GHG emissions.[13] It set targets for California to reduce GHG emissions to 2000 levels by 2010, 1990 levels by 2020, and 80 percent below 1990 levels by 2050. These targets were subsequently adopted in future legislation.

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11 Governor Gavin Newsom. 2022. "Governor Newsom Signs Sweeping Climate Measures, Ushering in New Era of World-Leading Climate Action." Available at https://www.gov.ca.gov/2022/09/16/governor-newsom-signs-sweeping-climate-measures-ushering-in-new-era-of-world-leading-climate-action/.

12 CEC. 2022. "Load Management Rulemaking." Available at https://www.energy.ca.gov/proceedings/energy-commission-proceedings/load-management-rulemaking.

13 Governor Arnold Schwarzenegger. 2005. Executive Order S-3-05. Available at https://www.library.ca.gov/wp-content/uploads/GovernmentPublications/executive-order-proclamation/5129-5130.pdf.

Assembly Bill 32 (2006)

AB 32 (Núñez, Chapter 488, Statutes of 2006), known as the Global Warming Solutions Act of 2006, established a goal of to reduce statewide greenhouse gas emissions to 1990 levels by 2020.[14]

Executive Order B-18-12 (2012)

In 2012, then-Governor Edmund G. Brown Jr. directed all state of California agencies, departments, and other entities under direct executive authority to reduce GHG emissions.[15] The Governor specifically directed state entities to exceed energy code requirements for new buildings, reduce grid-based energy purchases, participate in demand-response programs, reduce water use, develop on-site renewable resources, and prioritize many other sustainable and green building measures.

Executive Order B-30-15 (2015)

Governor Brown signed this executive order in 2015 to establish an interim GHG emission reduction target.[16] The interim goal is to achieve 40 percent below 1990 GHG emissions by 2030 to keep the state on track for an 80 percent below 1990 levels by 2050 goal.

Senate Bill 350 (2015)

SB 350 (De León, Chapter 547, Statutes of 2015) codified California's goals of reaching 50 percent procured renewable energy generation, doubling energy efficiency savings in electricity and gas end uses by 2030, and studying barriers to energy efficiency and clean energy for low-income customers and disadvantaged communities.[17]

Senate Bill 32 (2016)

SB 32 (Pavley, Chapter 249, Statutes of 2016) amended the Global Warming Solutions Act of 2006.[18] It called for a statewide reduction of greenhouse gas emissions of 40 percent below 1990 levels by 2030. The bill codified the goal initially set in Governor Brown's Executive Order B-30-15.

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14 Núñez. 2006. Assembly Bill 32. Available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.

15 Governor Edmund G. Brown Jr. 2012. Executive Order B-18-12. Available at https://www.ca.gov/archive/gov39/2012/04/25/news17508/index.html.

16 Governor Edmund G. Brown Jr. 2015. Executive Order B-30-15. Available at https://www.ca.gov/archive/gov39/2015/04/29/news18938/.

17 De León. 2015. Senate Bill 350. Available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350.

18 Pavley. 2016. Senate Bill 32. Available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32.

Assembly Bill 197 (2016)

AB 197 (E. Garcia, Chapter 250, Statutes of 2016) was a companion bill to Senate Bill 32 (2016).[19] The bill emphasized the need to implement all climate change policy equitably so that benefits reach all Californians, including those in disadvantaged communities.

Executive Order B-55-18 (2018)

Governor Brown's 2018 executive order took the additional step of pushing California to a carbon-neutral future.[20] The order set a new statewide goal to achieve economywide carbon neutrality as soon as possible and no later than 2045, as well as maintain net negative emissions thereafter.

Senate Bill 100 (2018)

SB 100 (De León, Chapter 312, Statutes of 2018) increased the Renewables Portfolio Standard (RPS) to 50 percent by 2025 and 60 percent by 2030.[21] Moreover, the bill sets a policy that eligible renewable resources and zero-carbon resources supply 100 percent of retail sales of electricity to end-use customers and 100 percent of electricity procured to serve all state agencies by December 31, 2045. Also, the CEC, CPUC, and the California Air Resources Board (CARB) are required to prepare a joint report addressing the implementation of the policy focused on technologies, forecasts, existing transmission, maintaining safety, environmental protection, affordability, and system and local reliability to the Legislature in 2021 and every four years thereafter.

Senate Bill 1477 (2018)

SB 1477 (Stern, Chapter 378, Statutes of 2018) requires the CPUC to develop two new incentive programs.[22] These programs will provide incentives for low-emission space- and water-heating equipment for new homes and for near-zero-emission building technologies in new and existing homes to reduce GHG emissions.

Assembly Bill 3232 (2018)

AB 3232 (Friedman, Chapter 373, Statutes of 2018) required the CEC to prepare a Building Decarbonization Assessment in consultation with the CPUC, CARB, and the California Independent System Operator.[23] This report assessed the potential for California to reduce greenhouse gases from buildings by 40 percent below 1990 levels by 2030. The assessment

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19 Garcia. 2016. Senate Bill 197. Available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB197.

20 Governor Edmund G. Brown. 2018. Executive Order B-55-18. Available at https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf.

21 De León. 2018. Senate Bill 100. Available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100.

22 Stern. 2018. Senate Bill 1477. Available at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1477.

23 Friedman. 2018. Assembly Bill 3232 (2018). Available at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB3232.

illustrated the state's pathway to decarbonizing single-family, multifamily, and commercial buildings; identified challenges to and opportunities from decarbonizing; estimated the impact of decarbonization activities on the electricity grid; and illustrated topics and data gaps needing additional analysis in future proceedings.

Assembly Bill 1279 (2022)

AB 1279 (Muratsuchi, Statues of 2022) codifies the statewide carbon neutrality goal to dramatically reduce climate pollution.[24] Establishes a clear, legally binding, and achievable goal for California to achieve statewide carbon neutrality as soon as possible, and no later than 2045, and establishes an 85% emissions reduction target as part of that goal.

Equity in Flexible Demand Appliance Standards

SB 350 (De León, Chapter 547, Statutes of 2015) required the formation of the Disadvantaged Communities Advisory Group (DACAG). The DACAG has set an equity framework as a guide as it discusses and comments on proceedings at the CPUC and CEC.[25] The DACAG reviews and provides advice on proposed clean energy and pollution reduction programs. DACAG also determines whether those proposed programs will be effective and useful in disadvantaged communities. The CEC is committed to reducing barriers preventing low-income, disadvantaged, and tribal communities from accessing clean energy opportunities. Many of the effects of climate change are expected to hit those communities the hardest.[26] CEC staff working on the flexible demand appliance standards have a focus on the equity framework goals discussed below, as the CEC proposes flexible demand standards for a range of appliances in the coming years.

Health and Safety

GHG emission reductions are the primary goal of SB 49. Electricity generation from combustion sources emits GHGs and criteria air pollutants such as particulate matter, sulfur oxides, carbon monoxide, nitrogen oxides, and volatile organic compounds – the latter two of which are also precursors of ground-level ozone.[27] People of color are more than three times more likely to be breathing the most polluted air than white people.[28] People living in poverty are most likely to live near sources of pollution and more likely to be vulnerable to the health impacts of air pollution, including asthma, diabetes, and heart disease.[29] Requiring the deployment of flexible

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24 Myratsuchi. 2022. "The California Climate Crisis Act." Available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB1279.

25 CEC. 2018. "Equity Framework." Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=224742.

26 CEC. 2022. "Commitment to Diversity." Available at https://www.energy.ca.gov/programs-and-topics/topics/research-and-development/commitment-diversity.

27 California Air Resources Board. 2021. "Criteria Pollutant Emission Inventory Data." Available at https://ww2.arb.ca.gov/criteria-pollutant-emission-inventory-data.

28 American Lung Association. 2021. *State of the Air 2021 Report*. Available at https://www.lung.org/getmedia/17c6cb6c-8a38-42a7-a3b0-6744011da370/sota-2021.pdf.

29 PSE Healthy Energy. 2020. "California Peaker Power Plants Energy Storage Replacement Opportunities," page 2-3. Available at https://www.psehealthyenergy.org/wp-content/uploads/2020/05/California.pdf.

demand technologies will reduce GHG emissions and criteria air pollutants and bring health benefits to residents living within disadvantaged communities.

Access and Education

Access and education are key to ensuring that disadvantaged communities benefit from clean energy technologies, energy efficiency, and other environmental investments. SB 49 requires the CEC to consult with the CPUC to better align the staff proposal with demand-response programs administered by state and load-serving entities. Many programs administered by the CPUC and CEC provide incentives for customers in disadvantaged communities to upgrade their appliances with efficient and flexible demand technologies.[30] Staff continues work within the CEC, the CPUC, and DACAG to create outreach efforts on these programs.[31]

Financial Benefits

Flexible demand standards can address a key barrier that prevents residents of disadvantaged communities from receiving benefits from appliances with flexible demand technologies. Manufacturers may include advanced features such as connectivity and programmability with features that enhance the look of the appliance. Advanced features also tend to appear on larger appliances. This practice by manufacturers means advanced features are more common on more expensive models and rarely on entry-level models. Another key barrier is that appliances with advanced features tend not to be ready for sale.[32] The proposed standards can begin to address these barriers by requiring the connectivity and programmability features to be on every model offered for sale in California.

Building owners often require renters to pay the energy costs of the home or apartment. Building owners may also decide to replace appliances with inefficient or inflexible models to save on the purchase price without input from renters. This split incentive, or instance where the motivations of the renter and owner do not align, is a significant barrier, affecting 45 percent of renter households in California.[33] Because 60 percent of low-income households are renters, split incentives disproportionally affect disadvantaged communities.[34] Flexible demand

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30 Ammon, Scott J. (CPUC). 2019. *CPUC Program Options to Promote Clean Energy and Reduce Air Pollution in AB 617 Environmental and Social Justice Communities*, page 40-41. Available at https://www.cpuc.ca.gov/-/media/cpuc-website/industries-and-topics/reports/ab617-report-final-11252019.pdf.

31 Chac, Erica, Geoffrey Dodson, and Tiffany Mateo (CEC). 2020. *Building Initiative for Low Emissions Development Program Implementation Plan.* CEC. Publication Number CEC-300-2020-010-REV. Available at https://efiling.energy.ca.gov/getdocument.aspx?tn=234936.

32 Peters, Jane S., Marti J. Frank, and Caroline Chen. 2012. *Home Appliance Programs Hit the Wall*. Available at https://energy-evaluation.org/wp-content/uploads/2019/06/2012-iepec-session21-home-appliance-programs-hit-the-wall-peters-and-frank.pdf.

33 Greenlining. 2019. *Equitable Building Electrification*, page 18. Available at https://greenlining.org/publications/reports/2019/equitable-building-electrification-a-framework-for-powering-resilient-communities/.

34 Evergreen Economics. December 2016. *Needs Assessment for the Energy Savings Assistance and the California Alternate Rates for Energy Programs,* page 43. Available at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/energy-efficiency/iqap/2016-linafrvol1.pdf.

standards can overcome the split incentive by requiring that all new appliances include flexible demand technologies.

Consumer Protection

The Legislature provided customer privacy and protection measures in SB 49 by emphasizing consumer consent and cybersecurity. Staff proposes regulations to provide protections to all customers, including those in disadvantaged communities.

The proposed consumer standards would create requirements that manufacturers and third parties inform and receive consent from consumers to enable flexible demand services. Consent allows the consumer to choose their level of participation in flexible demand that balances their needs and preferences from the appliance with the financial and environmental benefits. A key component of consent is providing consumers with information on the flexible capabilities of the appliances through labeling and marking. Another key component of the regulation is the ability of the consumer to override the flexible demand settings or requests. Further discussion of consumer protection is in Chapter 2, "Implementation."

Staff proposes cybersecurity regulations to require appliances to meet minimum standards to protect consumers. The standards include requirements for default settings and functions, so the appliance is better secured as the consumer begins their use. Further discussion of consumer protection is in Chapter 2, "Implementation."

CHAPTER 2: Implementation

Flexible Demand Appliance Standards Framework

The CEC proposes a framework for implementing the FDAS to meet the statutory requirements of SB 49. The regulations are organized into 10 parts shown in **Table 2-1**. **Chapter 2** describes these parts as they apply within the scope of the proposed regulations. **Chapter 5** describes the specific standards that apply to pool controls.

Table 2-1: Implementation Framework

Scope and Definitions
Test Methods
Flexible Demand Standards
Labeling and Marking Standards
Connectivity Standards
Cybersecurity Standards
Consumer Consent Standards
Appliance Certification Procedures
Enforcement Procedures
Administration of Civil Penalties

Source: California Energy Commission

Scope and Definitions

The scope describes which appliances are subject to the regulations. Staff chose existing United States Department of Energy (U.S. DOE) and CEC definitions to provide clarity to the scope of the new regulation. **Chapters 5** describes the proposed scope for pool controls.

The scope applies to pool controls manufactured on or after the effective date that are sold or offered for sale, rented, imported, distributed, or leased for use in California. There are no load flexibility requirements for existing appliances in California manufactured before the effective date.

Test Methods

Test methods enable uniform assessment of appliance performance. Staff does not propose a specific required test method for pool controls at this time. The proposed standards will be verified by the CEC's enforcement unit using inspection of the pool control, associated packaging, and marketing materials.

Future proposals may require the use of test standards or procedures to verify behavior or performance. The general testing requirements proposed in the regulation establish a framework and set of criteria for test laboratories that would potentially be responsible for conducting testing should test procedures be adopted for particular appliances.

By adopting these generalized testing requirements now, testing centers have advance notice of the requirements pertaining to such testing. Advance notice helps laboratories make informed decisions on allocating resources to develop the testing capability when a testing requirement is adopted in the future.

Flexible Demand Standards

The proposed standards will become effective for compliance purposes no sooner than one year after the date of adoption. Staff assumed an effective date of January 1, 2024, as the basis for analyses provided in this staff report.[35] The standards will apply to appliances manufactured on or after the effective date that are sold or offered for sale, rented, imported, distributed, or leased for use in California.

While statutes require at least one year between adoption by the CEC and effective date of the standards, staff recognizes that stakeholders requested later effective dates or alignment with U.S. DOE appliance efficiency updates.[36] CEC staff considers the proposed effective date feasible after reviewing available pool controls on the market that would meet the proposed standard.

Alternatives Considered From Stakeholders

Stakeholders commented that FDAS should be voluntary. Other comments stated the scope should include only appliances marketed as capable of flexible demand.[37] Staff believes proposing voluntary standards would duplicate existing voluntary programs such as the U.S. EPA's ENERGY STAR®-connected criteria. Setting voluntary standards would be a lost opportunity to reduce GHG emissions in California and would not address the split incentive issue by requiring all new appliances include flexible demand technologies. Moreover, SB 49 requires that potential standards be adopted "by regulation," meaning they are to be adopted as mandatory standards and would be more equitable because they will apply across the board.

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35 The requirement for soonest effective date of adopted FDAS is codified in the Public Resources Code, Section 25402(c)(1)(A).

36 Pool & Hot Tub Alliance. 2022. Comments to Docket 20-FDAS-01, TN 245759, Aug. 31, 2022, page 6-6. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=245759&DocumentContentId=79964
Fluidra. 2022. Comments to Docket 20-FDAS-01, TN 245770, Aug. 31, 2022, page 1-1. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=245770&DocumentContentId=79975.

37 AHAM. 2021. Comments to Docket 20-FDAS-01, TN 236600, Feb. 3, 2021, page 4-5. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236600&DocumentContentId=69604.
California Investor-Owned Utilities. 2021. Comments to Docket 20-FDAS-01, TN 236618, Feb. 3, 2021, page 1-1. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236618&DocumentContentId=69626.
AHRI. 2021. Comments to Docket 20-FDAS-01, Feb. 3, 2021, TN 236601, page 2-3. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236601&DocumentContentId=69607.

Labeling and Marking Requirements

All appliances will need to be marked with the manufacturer name, brand name or trademark, the model number, and the date of manufacture — permanently, legibly, and conspicuously — on an accessible place on each unit. Additional requirements for labeling and marking are in the "Consumer Consent Standards" section of the report. The date of manufacture marking shall provide at a minimum the month and year that the product was produced. The marking will enable effective enforcement by requiring appliances within the scope of the regulations to be identifiable.

Connectivity Standards

Introduction to Connectivity for Appliances

Connectivity is the ability to connect systems or application programs. Modern networks commonly have many different devices that operate with different programming languages, processors, and operating systems. Connectivity standards establish common rules to enable communications between devices.[38]

Proposal: Basic Connectivity

Staff proposes requiring basic connectivity for pool controls. A pool control shall be capable of receiving data from a modern digital network. Staff proposes the data format follow the Internet Protocol Suite also known as Transmission Control Protocol/Internet Protocol Suite (TCP/IP) due to it being open source, interoperable, and widely accepted across nearly all internet devices. The proposal will ensure that pool controls will be able to receive messages from the internet. Potential applications could include receiving California independent System Operator (California ISO) Flex Alerts to curtail use during a grid emergency per the pool control owner's preference. Other uses would allow the appliance to automatically retrieve electricity price data, retrieve GHG data, and customize appliance operations based on publicly available information, such as that contained within MIDAS. Connectivity would enable clock synchronization, a service that keeps the system clock aligned to universal time.

The connectivity requirement of FDAS is defined in part through defining the term "connected device." A connected device means any device that can receive TCP/IP signals, with or without connection through home network equipment or radio broadcasting, by means of integrated or separate communications module.

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38 IBM. 2021. "What Is Connectivity?" Available at https://www.ibm.com/docs/en/zvm/7.1?topic=connectivity-what-is.

Table 2-2 lists connectivity standards reviewed by staff to illustrate the availability and flexibility of applicable technologies to meet the connectivity requirements.[39]

Table 2-2: Connectivity Standards

Connectivity Standard	Organization	Description
TCP/IP	Defense Advanced Research Projects Agency (DARPA)	Internet protocol suites
OpenADR	Open Automated Demand Response (OpenADR) Alliance	Smart grid standard
CTA-2045	Consumer Technology Association (CTA)	Modular communications interface standard
IEEE 802 standards	Institute of Electrical and Electronics Engineers (IEEE)	Common data link and physical layer protocols
Z-Wave	Z-Wave Alliance	908.42 MHz wireless communications protocol
LoRaWAN	LoRa Alliance	US915 International Safety Management (ISM) wireless communications protocol
Matter	Connectivity Standards Alliance	Home automation connectivity standard
Radio Broadcast Data System	National Radio Systems Committee	Standard protocol for radio stations to broadcast digital data NRAC-4-B, NRSC-5-B

Source: California Energy Commission

39 Internet Society. 2021. "A Brief History of the Internet & Related Networks." Available at https://www.internetsociety.org/internet/history-internet/brief-history-internet-related-networks/;
OpenADR Alliance. 2022. "OpenADR Resources." Available at https://www.openadr.org/general-resources;
IEEE. 2022. "IEEE 802 Standards." Available at https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=68;
Z-Wave Alliance. 2022. "Learn About Z-Wave." Available at https://www.z-wave.com/learn;
LoRa Alliance. 2022. "What Is LoRaWAN Specification." Available at https://lora-alliance.org/about-lorawan/.
Connectivity Standards Alliance. 2022. "Build With Matter." Available at https://csa-iot.org/all-solutions/matter/#:~:text=Matter%20is%20a%20unifying%2C%20IP,and%20accelerating%20paths%20to%20market;
National Radio Systems Committee. 2022. *United States RBDS Standard*. Available at https://www.nrscstandards.org/standards-and-guidelines/documents/archive/nrsc-4-b-standard-2005.pdf.

No Connectivity Alternative

Many pool controls may be programmed manually to follow schedules per the consumer's preferences. The programming does not require connectivity to the internet. Manual scheduling offers a simple way for a consumer to schedule, shift, or curtail the electrical demand of an appliance to the consumer's preference. Although manually scheduling load will bring the potential to reduce GHG emissions, not proposing connectivity would be a lost opportunity for more significant GHG emission reductions.

OpenADR Connectivity Alternative

Open automated demand response (OpenADR) is a connectivity standard used to send price and event messages to many types of residential and commercial appliances and systems. OpenADR has wide acceptance in the energy market. OpenADR is one of two connectivity standards used by the U.S. EPA Pool Pump Specification connected criteria.[40] Staff chose basic connectivity over OpenADR connectivity because it meets the needs to establish communication for pool control using the least burdensome approach.

Discussion of Stakeholder Proposals for a Connectivity Standard

Many stakeholders commented that the CEC should use OpenADR for communications. Stakeholders requested two-way communications between utility or grid operator and the end node receiving the signal. Stakeholders also provided support for test methods and standards based upon the U.S. EPA ENERGY STAR Connected Criteria specifications.[41] Some stakeholders supported, while other stakeholders opposed, standards based upon the CTA-2045 communication protocol.[42] Other stakeholders proposed that devices receive digital data broadcasts from radio stations.[43] The radio broadcasts of information on grid conditions and real-time electric rates could be received by modules integrated into the appliances or by modules compliant with the CTA-2045 standard. The staff proposal does not prescribe the use of a specific physical layer protocol or demand-response data model such as OpenADR, which may eventually support more progress in market developments.

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40 U.S. EPA. 2022. "Connected Criteria Overview." Available at https://www.energystar.gov/products/smart_home_tips/about_products_connected_functionality/connected_criteria_partners.

41 California Investor-Owned Utilities. 2021. Comments to Docket 20-FDAS-01, Feb. 3, 2021, TN 236618, page 3.
AHRI, Comments to Docket 20-FDAS-01, TN 236601, page 3,
OpenADR, Comments to Docket 20-FDAS-01, TN 236599. page 2-3. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236618&DocumentContentId=69626.

42 Bradford White Corporation. 2021. Comments to Docket 20-FDAS-01, Feb. 3, 2021, TN 236580, page 4. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236580&DocumentContentId=69585.
AHAM, Comments to Docket 20-FDAS-01, TN 236600, page 3. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236600&DocumentContentId=69604.

43 Xperi Communications. 2021. Comments to Docket 20-FDAS-01, Jan. 4, 2021, TN 236206, page 1-2. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236206&DocumentContentId=69179.
E-Radio. 2021. Presentation by eRadio on FM broadcast system used with CTA-2045, Nov. 1, 2021, TN 240185, page 1-19. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=240185&DocumentContentId=73639.

Some stakeholders commented that machine-readable signals exist to provide current and forecasted marginal GHG emission rates for California and have been used to optimize charge/discharge cycles for energy storage systems.[44] The marginal GHG emission signals can also be combined with TOU rates to optimize load while the electricity rate remains constant. Staff analyzed the benefits of shifting based on a GHG signal. While there are significant benefits, staff found that the less burdensome approach of basic connectivity combined with a default schedule achieves roughly the same GHG emission reductions as would be achieved by bidirectional communications.

California ISO launched a new Flex Alert system to communicate with appliances through text messaging. The system relies on secured blockchain to protect user data and response history.[45] The new Flex Alert will provide California ISO the ability to view aggregated data about how many subscribers in a county responded to a recent Flex Alert. The staff proposal will enable more appliances to participate in the new California ISO Flex Alert system through the support of the TCP/IP protocol.

Cybersecurity Standards

Introduction to Cybersecurity for Appliances

"Cybersecurity" is a set of practices to protect computers, digital devices, and networks from digital attack. Digital attacks can result in compromises to personal data, unauthorized control of devices, and damage to information. Secure devices prevent unauthorized rewriting of software, secure communications, protect data, and authenticate users. Many attacks begin by exploiting the device with the weakest security practices. Therefore, appliances with network capabilities must implement minimum cybersecurity features to protect the consumer and the integrity of the network.[46]

SB 49 requires the North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) standards be used as the minimum cybersecurity requirement for FDAS standards. Staff reviewed the NERC standards and determined that since they deal with critical energy infrastructure, not consumer appliances, the NERC standards have limited application to the proposed regulation. Staff incorporated those standards found to be applicable to consumer appliances into the proposed regulatory language.

Staff also reviewed cybersecurity frameworks implemented by OpenADR, national standards and methods referenced in the National Institute of Standards and Technology (NIST) 8259A,

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44 WattTime. 2021. Comments to Docket 20-FDAS-01, Feb. 3, 2021, TN 236594, page 3. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236594&DocumentContentId=69594.

45 Energy Web. 2021. "California Grid Operator Launches New Demand Flexibility Platform Enhancements to Flex Alert System, Leveraging Energy Web Technology." Available at https://medium.com/energy-web-insights/california-grid-operator-launches-new-demand-flexibility-platform-enhancements-to-flex-alert-system-e01ae8030da0.

46 West, David (Icon Labs). 2022. "How to Protect Connected Home Devices and Appliances From Cyber Attacks. 2015." Available at https://www.iotsecurityfoundation.org/how-to-protect-connected-home-devices-and-appliances-from-cyber-attacks/.

and NIST Internet Report 7628 Rev1.[47] **Table 2-3** lists standards staff reviewed to propose minimum cybersecurity requirements. [48]

Table 2-3: National and Industry Cybersecurity Standards

Cybersecurity Standard	Organization	Description
NERC Critical Infrastructure Standards	North American Electric Reliability Corporation (NERC)	Minimum cybersecurity standards for critical grid infrastructure
NIST 1108r4, Appendix J	National Institute of Standards and Technology (NIST)	List of reviewed smart grid interoperability standards
NIST 8259A	National Institute of Standards and Technology (NIST)	Cybersecurity for internet of things (IoT) device manufacturers
PAS 1878:2021 and 1879:2021	British Standards Institute	British standards for smart appliances
SB 327, Jackson, 2018	California State Government	CA statute on connected devices and information privacy
UL 2900-1 Standards	Underwriters Laboratories	Minimum standards for network-connectable products
ETSI TS 103 645	Cyber Security for Consumer Internet of Things	Good practices for IoT devices

Source: California Energy Commission

Staff proposed the following required cybersecurity features listed on **Table 2-4** to provide consumer data protection for data storage, management, and access. **Table 2-4** shows the first staff proposed regulatory content for baseline cybersecurity standards that apply to appliances in all phases of FDAS development.

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43 OpenADR Alliance. 2022. "OpenADR and Cyber Security." Available at https://www.openadr.org/index.php?option=com_content&view=article&id=94:cybersecurity&catid=20:general-site-content&Itemid=154;
NIST. 2022. "Guidelines for Smart Grid Cybersecurity." Available at https://nvlpubs.nist.gov/nistpubs/ir/2014/NIST.IR.7628r1.pdf.

48 NERC. 2022. "US Reliability Standards." Available at https://www.nerc.com/pa/Stand/Pages/USRelStand.aspx; NIST. 2022. *IoT Device Cybersecurity Capability Core Baseline.* Available at https://nvlpubs.nist.gov/nistpubs/ir/2020/NIST.IR.8259A.pdf; British Standards Institution. 2021. *PAS 1878:2021 Energy Smart Appliances – System Functionality and Architecture – Specification*. Available at https://www.bsigroup.com/globalassets/localfiles/en-gb/energy-smart-appliances-programme/pas1878.pdf; British Standards Institution. 2021. *PAS 1879:2021 Energy Smart Appliances – Demand Side Response Operation – Code of Practice.* Available at https://www.bsigroup.com/globalassets/localfiles/en-gb/energy-smart-appliances-programme/pas1879.pdf; State of California. 2018. Senate Bill 327. Available at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB327; UL. 2020. *ANSI/CAN/UL Standard for Software Cybersecurity for Network-Connectable Products, Part 1: General Requirements.* Available at https://standardscatalog.ul.com/ProductDetail.aspx?productId=UL2900-1; ETSI. 2020. *Cyber Security for Consumer Internet of Things: Baseline Requirements.* Available at https://www.etsi.org/deliver/etsi_ts/103600_103699/103645/02.01.02_60/ts_103645v020102p.pdf.

Table 2-4: Proposed Cybersecurity Standards

Topic	Description	Threat/Benefit/Necessity
NERC CIP–007-1 R5.3	Critical Infrastructure Protection standards	Password minimum complexity requirements
Device Identification	The manufacturer shall assign a unique logical identification to the connected device	Asset management
Device Configuration	The configuration of the software of the connected appliance shall be changed by authorized entities only	Reduces risk of compromised software
Data Protection	The stored credentials should not be displayed in plain text on the user interface	Reduces risk of compromised consumer data
Passwords	All connected appliance passwords shall be unique from the factory	Default passwords are a major contributing factor to large-scale security compromises
Software Update	The known software vulnerability of the connected device shall be patched	Reduces risk of compromised software
Restart Settings	Upon appliance restart, the appliance shall automatically restore the most recently programmed settings, including reconnection to a network	Maintains installation settings after power interruptions of up to 72 hours for the lifetime of the appliance
Automatic Rejoin	The appliance shall automatically attempt to rejoin the physical or logical communication	Ease of use to consumer for network or power interruptions
Consumer Override	The appliance shall allow occupants to change the event responses and settings or setpoints at any time	Ensures consumer-centric features are incorporated into designs

Source: California Energy Commission

Appliance device identification allows a consumer or network entity to identify an appliance uniquely. The device identification must be logical, meaning readable by other devices. Device identification supports asset management, which in turn supports vulnerability management, access management, data protection, and incident detection.[49]

Appliances must have security measures implemented when the appliance is configured and installed for the end user. Security misconfigurations are common gaps that can be exploited. While an analysis of system vulnerabilities reveals a variety of potential causes, many vulnerabilities can be traced to software flaws and misconfigurations of system components.[50] Manufacturers often set default software configurations and devices to be as open and multifunctional as possible. The standard proposed by staff addresses these issues.

Personal data or credentials displayed in plaintext on the user interface are a common security risk for unauthorized users to gain credentials and personal data. The minimum requirement to protect the sensitive information stored in the connected device is to prevent personal data and credentials in plaintext from being displayed on software interfaces. Disallowing plaintext displays of personal credentials on the user interface provides an additional level of security in the event an unauthorized user accesses the data.

All appliances must implement password security that meets the minimum complexity requirements set by NERC CIP–007-1 R5.3.[51]

The device must be able to update to the latest available software version automatically. Consumers shall be informed of all software updates by the appropriate entity, and all updates must be easy to implement, understandable, and timely for the consumer. Updates must be delivered over a secure channel and not reduce the functionality of the device from the initial installed functionality.

Upon appliance restart, the appliance shall automatically restore the most recently programmed settings, including reconnecting to the network. Should the appliance lose physical or logical communication from the network, the appliance shall automatically attempt to rejoin the physical or logical communication. The appliance shall also have an override function for consumer use. The override function shall allow consumers to opt out of a flexible demand program and change the event responses and settings anytime.

Discussion of Stakeholder Proposals for Cybersecurity Standards

Stakeholders have commented that OpenADR specifies the necessary level of security essential to meet the U.S. cybersecurity requirements for data confidentiality, integrity, authentication, and message-level security.[52] Comments received from stakeholders indicated that standards and guidelines should be based upon NIST under the Cybersecurity Improvement Act of

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49 NIST. 2020. *IoT Device Cybersecurity Capability Core Baseline*. Available at https://nvlpubs.nist.gov/nistpubs/ir/2020/NIST.IR.8259A.pdf.

50 NIST. 2011. *Guide for Security-Focused Configuration Management of Information Systems*. Available at https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-128.pdf.

51 NERC. 2006. "CIP-007-1." Available at https://www.nerc.com/pa/Stand/Reliability%20Standards/CIP-007-1.pdf#search=CIP%2D007.

52 CEC. 2021. "Docket Log 20-FDAS-01." Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236608&DocumentContentId=69617.

2020.[53] NISTIR 8259 *Foundational Cybersecurity Activities for IoT Device Manufacturers* is intended to inform the manufacturing of new devices by helping document the cybersecurity capabilities that manufactures could offer and what cybersecurity information they could provide to consumers.[54] The U.S. Cyberspace Solarium Commission Report 2020 and subsequent reports provide a collection of strategic recommendations based on an assessment of the cyberthreat landscape.[55] Staff continues to review stakeholder comments and the work of state and federal authorities on cybersecurity requirements.

Consumer Consent

"Consent" means a customer's permission or agreement to use the flexible demand capabilities of an appliance to schedule, shift, or curtail the use of the appliance through direct action by the customer or by a third party, load-serving entity, or grid balancing authority. Consent may be expressed or implied. Furthermore, consent may be incorporated into opt-in programs or opt-out default settings.

Requirements for customer consent help ensure that end users of regulated appliances are aware of the networking capabilities of the device and provide methods for customers to decline participation in data sharing and flexible demand programs. The manufacturer must thoroughly explain the capabilities of the appliance and offer opt-in or opt-out choices to the end user, depending on the product-specific requirements.

Appliance Certification Procedures

The CEC proposes the requirement for manufacturers to certify each model of appliance within the scope of the regulation to the CEC's flexible appliance database Section 1695 of the proposed language. Certifying a model as compliant with the flexible demand standards allows effective enforcement by providing regulators with a list of products that could be legally sold or offered for sale, rented, imported, distributed or leased for use in California. Certifying will also allow distributors and retailers to verify that products can be legally sold prior to sale.

Procedure for Manufacturer to Alter CEC Database

To submit an appliance for certification, manufacturers would first need to set up a company account in the CEC's Flexible Appliance Database and request access. Their company account would include basic information about their company. The request for a company account would then be reviewed and approved by CEC staff. If the CEC rejects the account request, a notification explaining the rejection will be sent to the person who submitted the request.

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53 CEC. 2021. "AHRI Comments in Response to the CEC Flexible Demand." Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=236601&DocumentContentId=69607.

54 NIST National Institute of Standards and Technology. 2020. *Foundational Cybersecurity Activities for IoT Device Manufacturers.* Available at https://nvlpubs.nist.gov/nistpubs/ir/2020/NIST.IR.8259.pdf.

55 Cyberspace Solarium Commission. 2021. *2021 Annual Report on Implementation*. Available at https://www.solarium.gov/public-communications/2021-annual-report-on-implementation.

Data Submittal Requirements

Data submission regulations specify the certification information to be submitted to the CEC's database. There are a few parameters that are required for all appliances: model number, manufacturer name, and brand name. Additional data submittal requirements are in **Table A-1**, **Table A-2**, and **Table A-3**. The required information is necessary to determine whether the appliance meets the applicable regulatory standards and helps describe the characteristics and design of the product.

Procedure for the Manufacturer to Submit Data

The manufacturer would have the option to submit the data using an online template or manually through the database. As part of the submission, the manufacturer would be required to sign electronically a declaration stating that the appliance meets all applicable regulations and that the submitted information is accurate. The certification procedures ensure that all manufacturers submit data to the CEC's database in the same manner.

Procedure for CEC to Review Data

Staff will review all submitted data to determine if the appliance meets the applicable standards. If found to comply, the model or models submitted would be listed in the CEC's database and can legally be sold or offered for sale, rented, imported, distributed, or leased for use in California. If not found compliant, the models will not be listed in the CEC's database and the reason for the rejection of those models will be sent to the submitter. If needed, the submitter may resubmit the information if there was mistake in their original submission.

Procedure for a Manufacturer to Amend or Correct Data

For models that have been successfully added to the CEC's database, the manufacturer will have the ability to remove or amend the models by a data submission to the CEC. Once the new submission is reviewed and approved by the CEC, the change or deletion will immediately be made to the database.

Procedure for Displaying and Handling Submitted Data

Anyone from the public would be able to view, search, and download information for models listed in the CEC's database. This access is necessary for retailers, installers, distributors, consumers, and others to confirm if a specific model complies with the regulations. All the information submitted for a specific model would be available to the public. Models compliant with the most current requirements would be listed as "Active." If a model is listed as approved but then a new standard or testing requirement for that appliance goes into effect, the CEC will archive the models in these instances and notify the affected manufacturers. The CEC will then list the model as "Archived."

Procedure for Test Laboratories

Test laboratories must be used if an appliance has applicable testing requirements. The manufacturer may work with any third-party lab to conduct the test, or they may conduct the test themselves. In either case, to be included in the CEC's list of approved labs, the lab must be capable of following the specific testing requirements outlined in the regulations. When submitting data to the CEC's database, the manufacturer would need to identify the test lab that was used from a list of approved test labs. To become an approved test lab in the CEC's database, the lab will first need to create a company account and submit a test laboratory application through the CEC's database. Once the application is approved by the CEC, the test lab will then be listed as an approved test lab in the CEC's database, and the manufacturer will be able to choose that test lab when submitting data for an appliance. The general testing requirements proposed in the regulation set the standards for test laboratories that will be conducting testing in the future when test procedures are adopted for particular appliances. It is necessary to adopt these generalized testing requirements now so that testing laboratories are given advance notice of the procedural requirements. Laboratories may make informed decisions on allocating resources to develop the testing capability if testing is required in the future.

Procedure for Third-Party Submittal

The manufacturers would be responsible for ensuring their regulated appliances are listed in the CEC's database. However, they may delegate a third party to submit the data on their behalf. For this process to occur, the third party must first create a company account in the CEC's database. Next, the third party would submit a "third-party certifier application" through the CEC's database to become approved to submit data for other companies. The application would include signing a declaration stating that they understand the certification requirements, they are capable of certifying data, and that the information submitted is accurate. Once the application is approved by the CEC, the third party will then be listed as an approved third-party certifier in the CEC's database. On the manufacturer's side, they would need to submit a "delegation of authority" through the CEC's database for the third party to submit data on their behalf.

Enforcement Procedures

Requirements for Compliance

An appliance complies with the regulations if it meets all the applicable flexible demand standards and other requirements, including testing and marking for that specific appliance type, and has been properly certified to the CEC's database. Compliant products can then be sold or offered for sale, rented, imported, distributed, or leased for use in California. When manufacturers certify their products to the CEC's database, the products would not be listed as approved unless the submitted information complies with the applicable requirements in the regulations. The manufacturers would be required to declare that the submitted information is accurate when certifying products.

Authority to Enforce

The CEC has authority to enforce the regulations under Public Resources Code Section 25402.11.

Inspection Procedures

The CEC intends to periodically inspect regulated appliances being sold or offered for sale, rented, imported, distributed, or leased for use in California to determine if the products comply with the regulations. If the unit does not comply with the applicable flexible demand standards or marking requirements, or if the unit is not properly certified to the CEC's database, the CEC may pursue enforcement actions, including civil penalties for the responsible person.

Submittal of Test Report Procedures

A manufacturer may be asked at any time to send copies of test reports to the CEC, if test reports are required for their appliances listed in CEC's database. Information contained in the test report is submitted to the CEC's database by the manufacturer as part of the proposed appliance certification. The test report should demonstrate that the applicable testing requirements were met, and the information should align with the information that was submitted to the CEC's database for that appliance. If test report copies are requested, the CEC would send the request via email to the manufacturer and include the reason for the request. If the test report shows that the appliance is not compliant with the regulations, the appliance may be removed from the CEC's database.

Testing Procedures

The proposed regulatory language for flexible demand standards does not include testing procedures for pool controls.

Administrative Civil Penalties

The proposed administrative civil penalties would be a necessary tool used to improve rates of compliance with the regulations. Any person, including a manufacturer, retailer, contractor, importer, distributor, or lessor who sells or offers for sale, rents, imports, distributes, or leases for use in California appliances that are noncompliant with the regulations may be subject to civil penalties from the CEC. Noncompliance with the regulations falls into three categories:

- The appliance does not meet the applicable testing, marking, cybersecurity, consumer consent, or flexible demand requirements in the regulations for that specific appliance.
- The appliance is not certified to the CEC's database.
- The information submitted by the manufacturer to the CEC's database for a specific model is later revealed to be false.

Enforcement Penalties, Judicial Review

Violations are proposed to be subject to administrative civil penalties of up to $2,500 for each unit that is not compliant with the regulations and is sold or offered for sale, rented, imported, distributed, or leased for use in California, regardless of the physical location of the parties or whether the transaction occurs by phone or over the internet. The penalty amount may vary depending on the severity of the violation, the number of noncompliant units, and the cooperation of the responsible person.

Notices of Violation

If an appliance is found noncompliant with the regulations, the CEC could send a written "violation letter" containing staff findings and steps to correct the situation and resolve the matter. Failure to adequately respond to this letter may lead to the issuance of a formal "notice of violation" and the commencement of adjudicative proceedings to impose civil penalties under Title 20, CCR, Section 1609. The notice of violation would be sent by certified mail or other means to the responsible person. The notice will contain the name and address of the responsible person, the regulation that the notice of violation is based upon, facts describing the violation, and other information.

Administrative Proceedings

An adjudicative proceeding may be held if the CEC determines that the responsible person has not made sufficient progress in addressing the violations noted in the notice of violation. At the earliest, the proceeding would be held as soon as 30 calendar days after the notice of violation has been issued.

Settlement

The CEC may at any time enter a settlement with a responsible person. The settlement agreement may include appropriate sanctions and remedies to address violations and promote compliance.

CHAPTER 3:
Regulatory Approaches

CEC staff considered and studied regulatory pathways to achieve flexible demand technologies in pool controls. Staff evaluated the CEC Load Management Standards (LMS), federal and international regulations, and the U.S. Environmental Protection Agency (U.S. EPA) ENERGY STAR Pool Pump Specification.

Historical Approach

There are no flexible demand appliances standards for pool controls, pool pumps, or other pool equipment.

In 1979, the CEC adopted four load management standards for the five largest electric utilities in the state: Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), Los Angeles Department of Water and Power (LADWP), and Sacramento Municipal Utility District (SMUD). The four standards addressed rate structures, residential load control, swimming pool pump time control, and commercial building audits.[56]

The swimming pool filter pump load management standard (CCR, Title 20, Section 1624) required a large-scale effort to educate customers about the efficient operation of swimming pool filter pumps. Customers were encouraged to install timers that would shut off the pumps during designated peak hours each day while maintaining sufficient filtration and circulation. The LMS standard does not establish any mandatory flexible demand appliance standards for pool controls, pool pumps, or other pool equipment.[57]

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

56 CEC. 1979. § 1621. General Provisions. Available at https://govt.westlaw.com/calregs/Document/ID6C1B4835CCE11EC9220000D3A7C4BC3?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default).
CEC. 1979. § 1622. Residential Load Management Standard. Available at https://govt.westlaw.com/calregs/Document/ID6D3DCF35CCE11EC9220000D3A7C4BC3?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default).
CEC. 1979. § 1623. Load Management Tariff Standard. Available at https://govt.westlaw.com/calregs/Document/ID6DF00835CCE11EC9220000D3A7C4BC3?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default).

57 CEC. 1979. § 1624. Swimming Pool Filter Pump Load Management Standard. Available at https://govt.westlaw.com/calregs/Document/ID6E78C035CCE11EC9220000D3A7C4BC3?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default).

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.[58]

California Health and Safety Code (CCR, Title 22, Sections 65525–65533) provides water quality and bather safety standards. The staff proposal does not impose any requirements on pool controls, pool pumps, or pool equipment inconsistent with these Title 22 standards.

The CEC's Appliance Efficiency Standards (CCR, Title 20, Sections 1601–1609) have requirements for replacement dedicated-purpose pool pump motors. The Building Energy Efficiency Standards (CCR, Title 24, Part 6) incorporate the Title 20 requirements and place requirements on system piping, filters, and valves to ensure energy-efficient operation.[59] The staff proposal does not prevent a pool control from meeting the Title 24 and Title 20 requirements for pool pump sizing and motor speeds.

Federal Regulations

There are no federal flexible demand appliance standards for pool controls, pool pumps, or other pool equipment.

Existing Federal Standards

In 2016, the U.S. DOE created test methods and energy conservation standards for dedicated-purpose pool pumps (DPPP). The regulations established a weighted energy factor to measure a weighted average of the water flow over the input power of the DPPP. The test method and standards vary by the DPPP type and number of operating speeds. The standards do not establish any requirements for scheduling the start and stop times of a pool pump or for connectivity to the internet.[60]

On January 23, 2022, U.S. DOE opened a rulemaking proceeding to determine whether to amend the existing DPPP standards.[61] Based on U.S. DOE's request for information, the scope of a possible DPPP standards rulemaking does not appear to include scheduling or connectivity requirements.

In 2007, the U.S. Congress passed the *Virginia Graeme Baker Pool & Spa Safety Act* that requires pools to have certain suction entrapment avoidance requirements.[62] The staff proposal does not impose any requirements inconsistent with this act.

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58 California Building Code. 2016. Title 24, Part 2, Chapter 31B, Sections 3101B–3162. Available at https://codes.iccsafe.org/public/chapter/content/10044/.

59 CEC. 2016. California Energy Code Title 24, Part 6, section 150.0(p), Pool Systems and Equipment Installation. available at https://www.energy.ca.gov/sites/default/files/2021-06/CEC-400-2015-037-CMF.pdf.

60 U.S. DOE. Office of Energy Efficiency and Renewable Energy. 2021. "Energy Conservation Program: Energy Conservation Standards for Dedicated-Purpose Pool Pumps." pg. 38-45. Available at https://www.energy.gov/sites/prod/files/2016/12/f34/DPPP_ECS_Direct_Final_Rule.pdf.

61 87 Fed. Reg. 3461. Jan. 23, 2022.

62 Consumer Product Safety Commission. 2021. "Virginia Graeme Baker Pool and Spa Safety Act." Available at https://www.federalregister.gov/documents/2019/05/24/2019-10845/virginia-graeme-baker-pool-and-spa-safety-act-incorporation-by-reference-of-successor-standard.

Voluntary Federal Standards

The U.S. EPA ENERGY STAR program established the connected criteria for large-load appliances, including pool pumps. The program recognizes appliances that meet criteria for energy consumption reporting, demand response, and open access. The U.S. EPA amended the *Pool Pumps Specification* in June 2021, including updates to the connected criteria and an update to the *Pool Pumps Test Method to Validate Demand Response*.[63] The connected criteria encourage the use of OpenADR and other communication protocols to allow pool pumps to curtail load to demand response signals. Staff looked closely at this specification in the Chapter 5 discussion of the "Alternative Options for Pool Control Standards."

International Regulations

The British Standards Institution published *PAS 1878: 2021 Energy Smart Appliances — System Functionality and Architecture — Specification* and *PAS 1879: 2021 Energy Smart Appliances — Demand Side Response Operation — Code of Practice*. These standards propose a technical specification for energy-smart appliances and demand-side response service providers to document a method to enable standardized control, subject to an explicit consumer consent, of an energy-smart appliance in an electricity network. The standards have four principles for consumer demand-side response:[64]

1. Interoperability
2. Data privacy
3. Grid stability
4. Cybersecurity

Australian and New Zealand Standards AU/NZS 4755 provide a demand-response framework for demand-response-enabling devices. The standards specify minimum physical requirements, minimum levels of functionality, various means for communications and connections, and labeling and marking requirements. The standards include pool pumps.[65] The AU/NZS 4755 standard focuses on a mandatory demand response with a similar pool control scope. The CEC proposal allows consumer override and a default schedule more focused on avoiding GHGs.

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63 U.S. EPA ENERGY STAR Program. 2021. "Pool Pumps Specification Versions 3.1. and 2.0." Available at https://www.energystar.gov/products/spec/pool_pumps_specification_version_2_0_pd.

64 British Standards Institute. 2021. *PAS 1878:2021 Energy Smart Appliances. System Functionality and Architecture – Specification*. Available at https://www.bsigroup.com/en-GB/about-bsi/uk-national-standards-body/about-standards/Innovation/energy-smart-appliances-programme/pas-1878/;
British Standards Institute. 2021. *PAS 1879:2021 Energy Smart Appliances. Demand Side Response Operation – Code of Practice*. Available at https://www.bsigroup.com/en-GB/about-bsi/uk-national-standards-body/about-standards/Innovation/energy-smart-appliances-programme/pas-1878/.

65 Australian Energy Market Operator. 2020. "AS 4755 Demand Response Standard." Available at https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/standards-and-connections/as-4755-demand-response-standard.

Industry Standards

The ANSI/APSP/ICC-11 2011 *American National Standard for Water Quality in Public Pools and Spas* sets requirements for turnover of pool water, the minimum times daily the water must pass through the pool filter, and water clarity.[66] The standard provides specification for water quality but does not specify the technologies needed to achieve these values. The staff proposal does not impose any requirements inconsistent with this standard as the default schedule may be overridden by the consumer to meet the unique needs of a consumer's pool.

ANSI/APSP/ICC-5 2011 *American National Standard for Residential Inground Swimming Pools* sets similar requirements to ANSI/APSP/ICC-11 for residential pools.[67] The staff proposal also does not impose any requirements inconsistent with this standard.

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66 ANSI/APSP/ICC. 2019. *American National Standard for Water Quality in Public Pools and Spas.* Available at https://webstore.ansi.org/preview-pages/APSP/preview_APSP-11_2019.pdf#:~:text=The%20ANSI%2FAPSP%2FICC-11%202019%2C%20Standard%20for%20Water%20Quality%20in,as%20a%20new%20standard%20on%20June%2015%2C%202009.

67 ANSI/APSP/ICC. 2011. "American National Standard for Residential Inground Swimming Pools." Available at https://codes.iccsafe.org/content/ANSIAPSPICC52011/section-1-scope-section-2-general-design-criteria-section-3-plans-and-permits-and-section-4-structural-design.

CHAPTER 4: Pool Controls

Pool controls schedule the start and stop of the pool pump and other maintenance operations. Pool controls may be integral to the pool pump or may be separate devices that remotely control pool operations.

Overview of Pool Water Maintenance

Pool water maintenance incorporates technological advances in filtering and chlorination introduced to reduce frequent outbreaks of waterborne illness in the water 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, health codes began to require chlorine as a pool disinfectant in response to polio outbreaks in the 1960s.[68] The pool circulation system functions to meet aesthetic and safety requirements.[69]

The first pool controls were similar in design to irrigation sprinkler timers that relied on motors to switch off and on pool equipment. Digital pool controls were introduced in the 1990s, followed by pool controls that could communicate remotely with pool owners.[70]

A *pool pump* circulates pool water through a filter and ensures adequate chlorination to maintain clarity and sanitation. Many pool pump vendors recommend that residential pool systems be designed to circulate the entire pool water volume in 8 to 12 hours.[71] Commercial pool systems are designed to complete circulation or turnover in six hours because of higher level of use.[72] A common pool system configuration including these components is seen in **Figure 4-1** for chlorine pools and **Figure 4-2** for saltwater pools.

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68 Olsen, Kevin. 2007. "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. Available at http://acshist.scs.illinois.edu/bulletin_open_access/v32-2/v32-2%20p129-140.pdf.

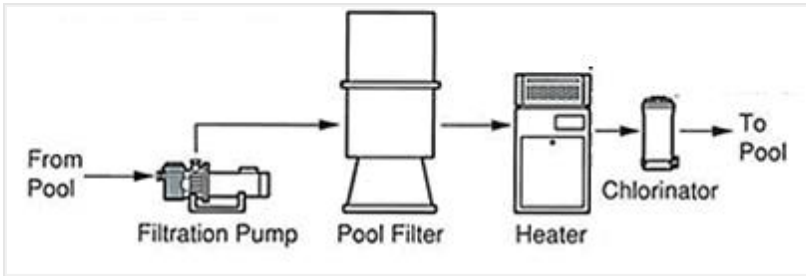
69 U.S. EPA. 2000. "The History of Drinking Water Treatment." Available at https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1002SMN.txt.

70 Your Pool Help. 2022. "What Is Swimming Pool Automation?" Available at https://yourpoolhelp.com/what-is-swimming-pool-automation/.

71 Hayward Industries. 2011. "Hayward Hydraulics and Pump Sizing for Existing Pools," page 7. Available at https://hayward-pool-assets.com/assets/documents/pools/pdf/manuals/HydraulicPumpSizingDiagnostics.pdf?fromCDN=true. INYO Pools. 2015. "How to Size a Pool Pump for Your In-Ground Pool." Available at https://www.inyopools.com/HowToPage/how_to_size_a_pool_pump_for_your_in_ground_pool_.aspx.

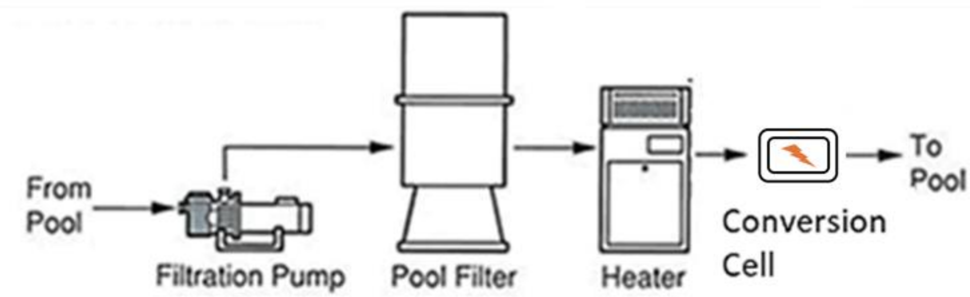
72 California Health and Safety Code. 2021. Chapter 5, Section 116064.2(b)(2)(E). Available at https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=116064.2.

Figure 4-1: Chlorine Pool System Installation Schematic



Source: epoolshop.com

Figure 4-2: Saltwater Pool System Installation Schematic



Source: epoolshop.com with CEC Staff

Pool maintenance programs may have filtering, heating, and cleaning functions. The pool pump may also provide water flow to the pool sweeper, waterfall, or fountain. Some pool systems may employ a second pool pump, commonly referred to as a *pool booster pump*, to provide high pressure to drive the pool sweeper. A *waterfall pump* may be added to the system to supply water to a waterfall.[73] Many pool controls can provide a user interface on a computer, tablet, or mobile phone. Some controls also control the operation of the pool heater, sanitizer, valves, water features, and lights.[74]

Pool Pump and Pool Control Equipment Description

A pool pump relies on an end suction centrifugal rotor design to move water through the system.[75] 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).

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73 U.S. DOE. 2016. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Dedicated Purpose Pool Pumps,* pp. 3-1–3.13. Available at https://www.regulations.gov/document/EERE-2015-BT-STD-0008-0105.

74 Giovanisci, Matt. Swim University. 2019. "The Complete Guide to Pool Automation." Available at https://www.swimuniversity.com/pool-automation/.

75 U.S. DOE. 2006. *Improving Pump System Performance, A Sourcebook for Industry*, page 13–14. Available at http://energy.gov/sites/prod/files/2014/05/f16/pump.pdf.

The motor may provide single-speed, dual-speed, multiple-speed, or variable-speed operation, depending upon the electric motor design.

Manufacturers have developed varieties of pool pumps for various uses. In-ground, above-ground, integral pool filtration pumps, specialty pressure cleaner booster pumps, and waterfall pumps are not interchangeable and would not offer satisfactory operation if not used for the intended purpose. **Figure 4-3** shows a comparison of pool constructions.

Figure 4-3: Representative In-Ground, Above-Ground and Portable/Storable Pools

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

Dedicated-purpose pool pumps (DPPP) are typically sold when a consumer installs a pool or upgrades an existing pool pump from a single-speed to a dual-speed or variable-speed system. DPPPs are also sold with above-ground and storable pools. As a low-cost alternative to replacing the pool pump, electric motor manufacturers sell replacement pool pump motors since the motor typically fails before the pump. **Figure 4-4** shows typical pool pump types and replacement pool pump motors.

Figure 4-4: Pool Pump and Motor Types

Source: Hayward, Regal Beloit, Intex, Jandy, and Polaris

Integral Pool Pump Controls

Integral controls provide the ability to schedule start and stop times and choose available pump speeds. A manufacturer may or may not include an integral pool pump control on a pool pump or replacement pool pump motors.

Integral pool pump controls are typically found on variable-speed pool pumps and replacement pool pump motors.[76] Single-, dual-, or multispeed pool pumps or replacement pool pump motors are typically not sold with an integral control. Some controls may include communication abilities to provide the status of the pool pump and allow remote control of the pool pump. **Figure 4-5** shows an integral pool pump control.

Figure 4-5: Integral Pool Pump Control

Source: Regal

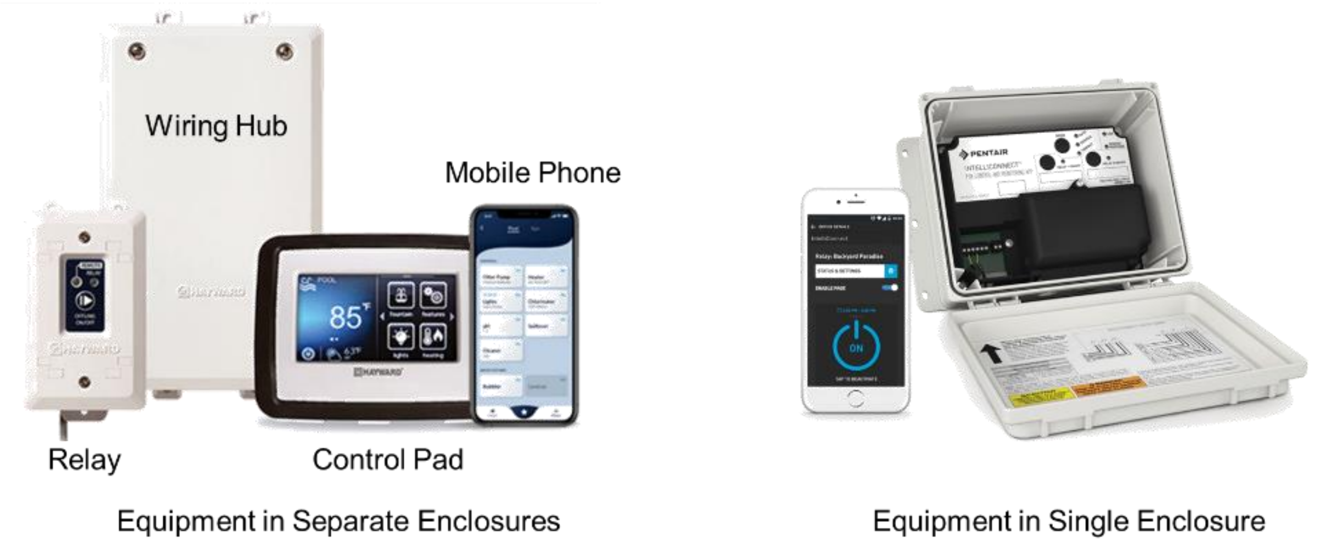
Pool Automation Systems

Manufacturers offer pool automation systems to provide control of the pool pump, pool sanitation, pool heater, pressure cleaner booster pump, water features, and pool lights. The automation systems can have a user interface, control circuit, relays, and flow and temperature sensors. The equipment may be housed in one enclosure. Alternatively, the control panel, wiring hub, and relays may be in separate enclosures. Many systems can provide the status of the equipment to a remote user through a mobile phone or computer. Some systems can participate in demand-response programs.[77] **Figure 4-6** shows typical pool automation components from Hayward Industries, Inc., and Pentair.

76 Cox, Rob. 2021. "5 Benefits of a Variable-Speed Pool Pump in the Swim Pool Blog." Available at https://blog.intheswim.com/variable-speed-pool-pump-benefits/#:~:text=5%20Benefits%20of%20a%20Variable%20Speed%20Pool%20Pump,switch%20on%20a%20post%20next%20to%20the%20pump.

77 The Pool Boys. 2021. "Pool Automation and Control Systems." Available at https://poolboys.com/pool-equipment-services/automation-control-systems.

Figure 4-6: Pool Controls



Source: Hayward Industries, Inc., and Pentair

Pool Timers and Switches

The *pool timers* set the on and off times for pool equipment. The timer may control power for the pool pump or may coordinate the schedule of a pool pump and pool heater. The pool timers may be digital, but many are electromechanical. Many pool timers do not require a connection to the internet. Pool timers control the operation of up to half the pools in California.[78] **Figure 4-7** shows typical pool timers.

78 San Diego Gas & Electric Company. 2013. *Demand Response Enabled Pool Pump Analysis*, page 38–39. Available at https://www.etcc-ca.com/sites/default/files/reports/DR13SDGE0004_DR-enabled%20Pool%20Pumps%20Final%20Report.pdf.

Figure 4-7: Pool Timer

Mechanical Pool Timer

Z-Wave Pool Pump Smart Switch

Source: Woods Home Products

Direct Load Control Switches

Direct load control switches allow a utility or third-party aggregator to manage large electric loads. The devices can receive demand-response signals and provide status of energy use. The devices are typically installed as part of a utility rebate program.[79] **Figure 4-8** shows a typical direct load control switch.

Figure 4-8: Direct Load Control Switches

Source: Energate Inc.

79 Energy Solutions. 2020. *Connected Pool Pump Market Assessment*, page 13. Available at https://www.etcc-ca.com/reports/connected-pool-pump-market-assessment.

CHAPTER 5: Staff Proposal

CEC staff has analyzed the equipment and practices of pool maintenance, as well as the cost-effectiveness and technical feasibility of regulating pool controls. Staff has determined that the reduced GHG emissions and utility bill savings under the proposed standard are significant while imparting a small incremental cost to consumers. The proposed standard is attainable by the proposed effective date.

Scope and Definitions

CEC staff reviewed the readiness of the various types of pool controls discussed in this report for flexible demand capabilities. Staff proposed regulations for pool controls as a result of the availability of currently compliant products and significant cost-effective GHG emission reductions through flexible demand. **Table 5-1** shows examples of the pool control devices that are covered by the proposed regulation.

Staff defined the scope to include devices that control the pool filter pump and at least one other piece of electric pool equipment like the electric pool heater, pressure cleaner booster pump, or chlorinator. Pool controls coordinate the activities of the pool equipment to ensure proper operation. The pool heater, pressure cleaner booster pump, and chlorinator require the pool filter pump to run during the operation of these devices for adequate water flow. Proposing standards on the pool control will ensure any changes to operation will be coordinated by the pool control.

Some manufacturers offer pool controls powered by three-phase power for use at homes and commercial facilities where three-phase alternating current (AC) power is available. Other controls are intended to control pool pumps larger than 2.5 hydraulic horsepower (hhp), typically found in commercial settings. Pool controls that are marketed exclusively to control pool pumps with a hydraulic horsepower of more than 2.5 hhp total capacity are considered out of the scope of this rulemaking. Pool controls with three-phase input power are also out of the scope for the rulemaking.

The staff proposal defines pool filter pump, dedicated-purpose pool pump, and pressure cleaner booster pump in alignment with existing U.S. DOE and CEC appliance efficiency definitions to clarify the scope.[80]

80 10 C.F.R. Sections 431.461 to 431.466 and Appendices B and C to subpart Y of Part 431.

Table 5-1: Examples of In-Scope and Out-of-Scope Pool Control Devices

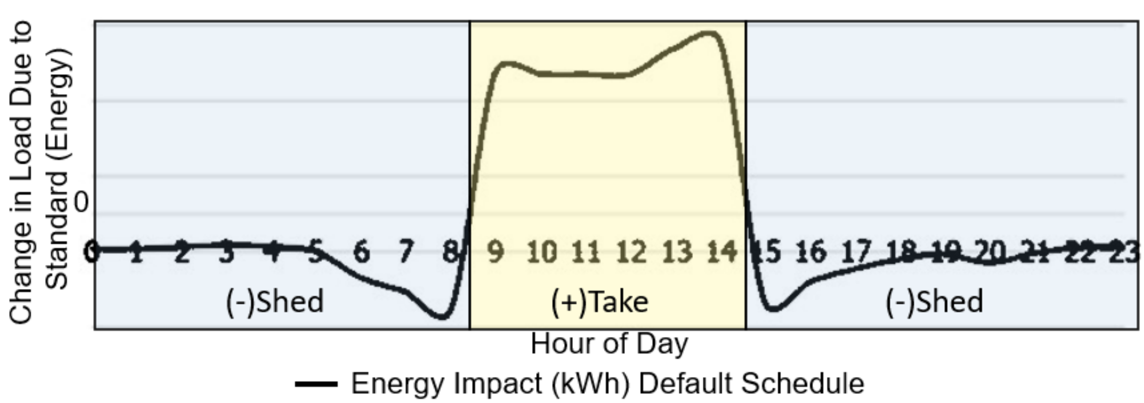
In-Scope Devices	Out-of-Scope Devices
Controls of pool automation systems Pool timers Pool pump and heater switches Integral pool pump controls on pool filter pumps capable of controlling other pool equipment Direct load control switches	Integral pool pump controls on pool filter pumps not capable of controlling other pool equipment Integral pool pump controls on replacement pool pump motors Pool controls with three-phase input power Pool controls intended for pool filter pumps greater than 2.5 hhp Solar only pool water heating control system

Source: California Energy Commission

Proposed Standards

Staff proposes to set a default schedule for major pool operations. The default schedule would command the pool heater, pressure cleaner booster pump, and high-speed pool filter pump to begin and complete operations between 9 a.m. and 3 p.m. local time. Additionally, the default schedule shall not automatically operate the pool filter pump, pressure cleaner booster pump, or electric-pool-water-heater between 4 p.m. local time and 9 p.m. local time. The alignment minimizes GHG emissions from electricity generation and is advantageous to consumer utility bill savings. **Figure 5-1** shows how load is shifted during an average day. Times of day labeled “shed” mean that load is reduced, and times of day labeled “take” mean that load is added.

Figure 5-1: Load Shifting Based on Default Schedule



Source: California Energy Commission

Staff proposes to require the pool controls to have the ability to receive TCP/IP signals as described in **Chapter 2**.

Staff proposes to require pool controls to have timekeeping ability to maintain the local clock time. Pool controls shall also be able to maintain the system settings, operating schedule, and local clock time in the event of a power loss lasting up to 72 hours. Staff proposes a 72-hour length to maintain the settings during significant disruptions to power that may occur because of extreme weather, wildfire, or other sources of prolonged loss of power. Requiring these timekeeping abilities will keep the pool control's operating schedule aligned with the customer's utility rate schedule and ensure the default schedule is aligned with the low-GHG-emissions hours during the middle of the day.

Pool controls will also need to meet the cybersecurity, consumer consent standards, certification, and marking requirements as described in Chapter 2. Staff proposes no specific test procedures for pool controls at this time.

The standards proposed by staff will apply to all new pool controls sold or offered for sale, rented, imported, distributed, or leased for use in California. Specifically, the standards apply to all pool controls manufactured no later than one year after they are adopted or updated.[81] and must be certified to the CEC as meeting the proposed standards.

Alternative Options for Pool Controls Standards

CEC staff analyzed the proposal to determine whether it meets the legislative criteria for the CEC's prescription of flexible demand appliance standards. Staff also reviewed and analyzed the U.S. EPA Pool Pump specification, as well as other state and local standards. Staff will continue to analyze and consider alternative proposals as they are provided to the CEC.

Alternative One: Shift Operation to Align to TOU Electric Rate

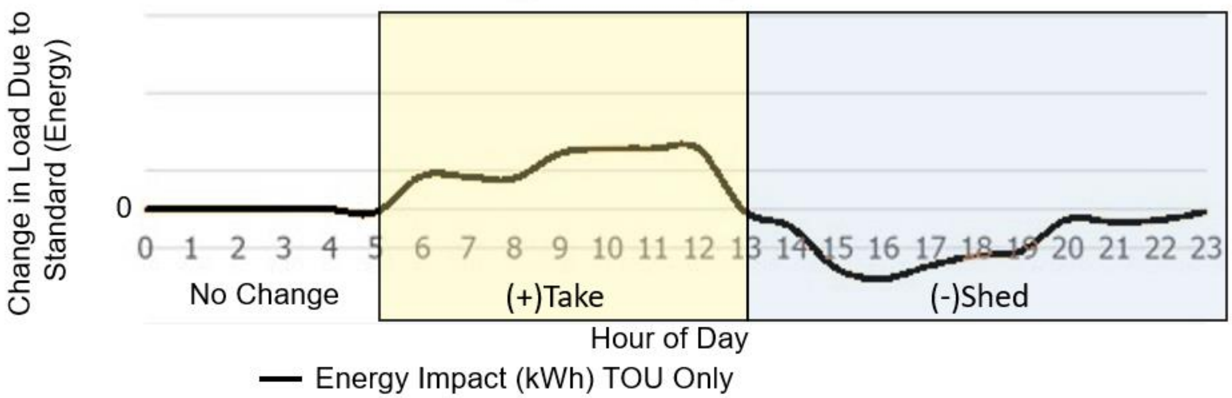
Alternative One would require connectivity capability as specified in this proposal. The pool control would default to a schedule to minimize utility bill costs per the consumer's TOU electric rate. The device would connect with the CEC's MIDAS rate database to obtain the consumer's rate.

The alternative would provide consumers with utility bill savings, but because the TOU rate lacks information on GHG emissions intensities, it does not achieve the GHG emissions reductions of the other alternatives or the proposal. This would be a lost opportunity for flexible demand appliance technology to reduce GHG emissions in California.

Figure 5-2 shows how pool control load is shifted to TOU electric rates. Alternative One is not the preferred option because it will achieve a minimal reduction of GHG emissions compared to the staff proposal.

81 For this analysis, staff assumes a January 1, 2024, effective date but recognizes that standards may not become effective sooner than one year from the CEC adoption date.

Figure 5-2: Load Shifting Based on TOU Electric Rates



Source: California Energy Commission

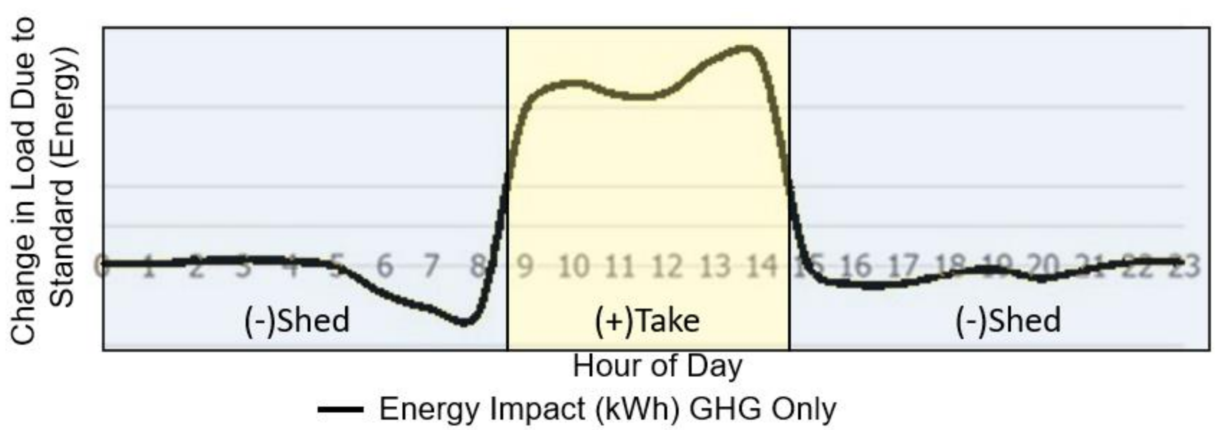
Alternative Two: Shift Operation to Align to GHG Marginal Emission Rate

Alternative Two also requires connectivity capability. The pool control would default to a schedule to minimize GHG emissions per the marginal GHG emission day-ahead forecast.

This alternative would provide consumers with utility bill savings and reduce GHG emissions, but the overall utility bill savings for consumers from this alternative would be significantly less than the proposal. Pool controls operating on a marginal GHG emissions schedule may also not meet consumer expectations, as the controls may come on at unexpected times to access the lowest GHG emission rate.

Figure 5-3 shows how pool control load is shifted per the marginal GHG emission rate option. Alternative Two is not the preferred option because the significant tradeoff in consumer utility bill savings for additional GHG emissions reductions is less cost-effective than the staff proposal.

Figure 5-3: Load Shifting Based on Marginal GHG Emission Rates



Source: California Energy Commission

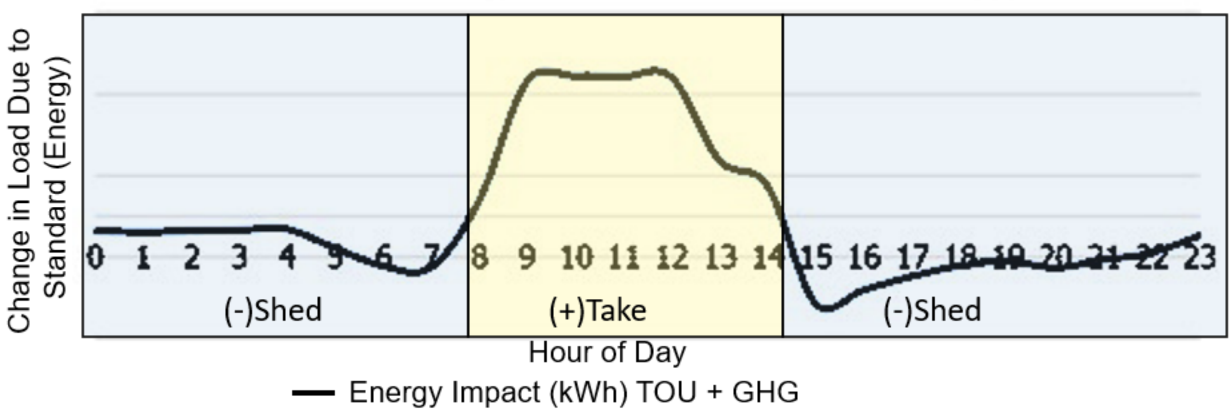
Alternative Three: Shift Operation to Align With TOU Electric Rates and Marginal GHG Emissions Rate

Alternative Three would require connectivity similar to previously described options. The pool control would default to a schedule based upon the TOU rate and the day-ahead marginal GHG emission forecast. The TOU and marginal GHG emission rates would be combined through consideration of the social cost of carbon.[82]

This alternative achieves the best overall monetized benefit but with lower avoided GHG emissions than Alternative Two and the staff proposal. Because the schedule would be based, in part, on marginal GHG emission rates, the pool controls may operate equipment at unexpected times, leading to less consumer acceptance.

Figure 5-4 shows how load is shifted to a combined TOU electric rate and marginal GHG emission rate option. Alternative Three is not the preferred option because the significant tradeoff in GHG emissions reduction for additional utility bill savings is less cost-effective than the staff proposal.

Figure 5-4: Load Shifting Based on Combined TOU and GHG Signal



Source: California Energy Commission

Alternative Four: U.S. EPA ENERGY STAR Pool Pump Connected Criteria

Alternative Four would use the United States Environmental Protection Agency (U.S. EPA) ENERGY STAR program specifications for minimum communication, interoperability, and demand-response requirements. This alternative is similar to Alternative One, but it adds specific performance criteria for demand-response signals.

The U.S. EPA ENERGY STAR flexible demand requirements include requiring the pool pumps to have either OpenADR, CTA-2045-A, or CTA-2045-B functionality. The pool pumps must show a response to shed and load-up commands under the ENERGY STAR test method.

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82 White House. 2021. *Technical Support Document: Social Cost of Carbon Methane, and Nitrous Oxide*. Available at https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

The CEC monitors and is engaged in the specification development for ENERGY STAR devices and may incorporate elements of ENERGY STAR product specifications into the standards for flexible demand functionality. Products that meet ENERGY STAR connectivity specifications point toward future CEC staff proposals for flexible demand appliances.

Staff has determined not to recommend this alternative because staff determined that using a default schedule aligned to when GHG emission rates are lowest would result in equivalent avoidance of GHG emissions with greater certainty and lower cost. In addition, staff observes that the OpenADR Alliance and many DR software developers are in the process of adapting more contemporary standards (e.g, updates to OpenADR versions), and staff determined that requiring current ENERGY STAR product specifications at this point may interfere with market adoptions of the upcoming standard.

Alternative Five: EcoPort

Alternative Five requires all pool controls to have an EcoPort. This alternative allows an alternate path to original equipment manufacturer-provided connectivity. Staff has determined not to include Alternate Five as a flexible demand standard because simply using a default schedule aligned to when GHG emission rates are lowest would result in a greater avoidance of GHG emissions and remain unbiased toward the use of different technology.

Alternative Six: FM Connectivity With Optional Wi-Fi

Alternative Six would require default connectivity through authenticated FM broadcast with optional remote control and data reporting via Wi-Fi, LTE, cable or other technology. This alternate would use FM broadcast to notify homes of electricity prices and other grid signals using the optional data reporting method to provide an outbound confirmation of response.

Staff has determined not to include Alternate Six as a flexible demand standard because simply using a default schedule aligned to when GHG emission rates are lowest would result in a greater avoidance of GHG emissions and remain unbiased toward the use of different technology.

CHAPTER 6: Technical Feasibility

CEC staff reviewed the pool pump control market and appliances with similar flexible demand features to those proposed by staff. Staff concludes that the default scheduling capability and the internet connectivity standards proposed are technically feasible.

Default Schedule Function

Staff reviewed product literature on a variety of pool controls. Many pool controls come with default settings preprogrammed. **Figure 4-6** shows pool controls that have software scheduling. To comply with the standard, the pool controls would need to change some minor software settings to align with the prescribed schedule. Staff determined it is technically feasible for manufacturers to incorporate the scheduling functions into a wide variety of in-scope products by the proposed effective date.

Connectivity Feasibility

Staff reviewed the pool pump controls offered by manufacturers and found pool pump controls with the ability to interoperate with TCP/IP signals with various wired or wireless technologies to respond to the information on the internet. Connectivity standards and protocols for connected control devices in **Table 2-2** are also examples that demonstrate technical feasibility. Therefore, staff concludes that the connectivity standard is technically feasible.

Load-Shifting Strategy Technical Feasibility

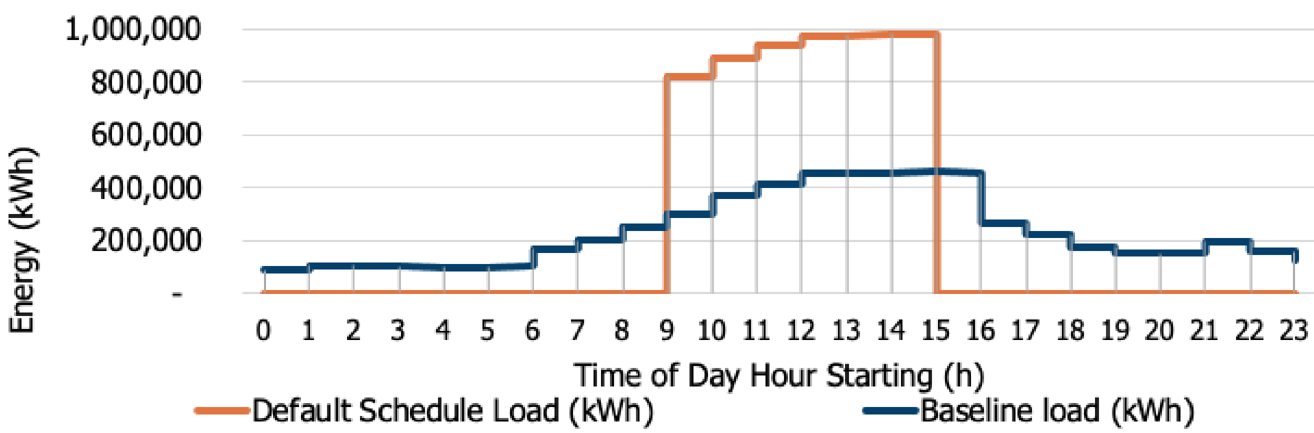
Staff has demonstrated through the analysis in this report and examples located in Appendix A that a default schedule and connectivity enable a pool control to achieve significant GHG emission reductions from the baseline operation. Therefore, the pool control proposal meets the statutory requirement to lower GHG emissions through flexible demand technologies. GHG emission reductions will be discussed in **Chapter 8**.

CHAPTER 7: Savings and Cost Analysis

Pool Controls Load-Shifting Savings

The proposed standard for pool controls would significantly reduce GHG emissions while generating significant consumer and statewide benefits. Staff estimated the per device savings by calculating the shifts in time of electricity load due to the proposal and the identified alternatives. **Figure 7-1** compares the average daily load for a pool control with a default schedule and one without a default schedule, known as the "baseline." Staff calculated the savings by assuming that noncompliant devices are improved to comply only minimally to the standard. **Appendix A** describes the staff analysis.

Figure 7-1: Estimated Day Load Shift for PG&E Territory With Default Schedule



Source: California Energy Commission

The annual utility savings of each unit are calculated by taking the difference in the cost of the electrical load after it has been shifted versus the cost of the load before it had been shifted. The calculation was performed using the TOU or time-of-day (TOD) rates from each of the four load-serving entities (LSEs) —SDG&E, SCE, PG&E, SMUD — and fixed tiered rates from LADWP.

Incremental Cost to Consumers

Staff estimated the incremental cost to consumers as the difference in purchase price between a noncompliant pool control and a compliant pool control.

Market Research

Staff estimated incremental costs of pool controls that meet the proposal by gathering retail price data on outdoor smart switches designed to control pool pumps and pool heaters. Staff analyzed the data to estimate the cost difference to consumers with the addition of the connectivity and scheduling features. Staff also studied the typical components required to manufacture a compliant Internet of Things (IOT) device.

Staff reviewed retail pool equipment product features and size of the electric load to determine the incremental cost of meeting the proposed standard. Staff chose to study the incremental cost of a pool equipment switch and a simplified pool control to make an easier comparison between the costs of the compliant and noncompliant equipment. **Table 7-1** presents an abridged summary of the staff research.

Staff considered the retail costs for currently available models, estimating the incremental cost to add connectivity and a default control is approximately $70. All figures in this report are in $2022.

Table 7-1: Retail Cost of a Heavy-Duty Pool Equipment Switch

Pool Equipment Switch Type	Compliant/Noncompliant	Price Range (In $2022)
Mechanical	Non-compliant	$60-$120
Electronic Without Wi-Fi	Non-compliant	$130-$150
Electronic With Wi-Fi	Compliant	$130-$170

Source: California Energy Commission

Default Schedule Cost

The California utility Codes and Standards Enhancement (CASE) team estimated the cost of software changes to be less than $1 per unit in mass production for other appliance types.[83] Since the settings are typically determined by the user through software, implementing a uniform default schedule will deliver significant GHG emission reductions and bill savings to consumers with modest, if any, costs to manufacturers.

Pool Control Cost-Effectiveness

Staff compared the costs and the benefits shown in **Table 7-2** from the perspective of a consumer. The costs and benefits are calculated for a single pool control. Staff divided the estimated statewide benefits shown in **Table 7-3** by the estimated stock of pool controls in 2024. Staff estimated the pool controls stock from data resulting from the *2019 California Residential Appliance Saturation Survey*[84] and by assuming a growth rate equal to the California population forecast prepared by the California Department of Finance.[85]

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83 Donnelly, Clancy, Katherinne Dayem, and Brendan Trimboli. California Investor-Owned Utilities. 2014. *Electronic Displays Technical Report – Engineering and Cost Analysis*, page 37. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=72475.

84 California Residential Appliance Saturation Study. 2019. *2019 California Residential Appliance Saturation Study - Executive Summary (dnv.com)*. Available at https://webtools.dnv.com/CA_RASS/.

85 Demographic Research Unit California Department of Finance. 2021. "Report P-1A: Total Population Projections, California, 2010-2060 (Baseline 2019 Population Projections; Vintage 2020 Release)." Available at https://dof.ca.gov/wp-content/uploads/Forecasting/Demographics/Documents/P1A_State_Total.xlsx.

Based upon staff research regarding the average useful life of pool controls, this analysis assumes a 10-year useful lifetime for regulated pool control equipment.[86]

The life-cycle benefit represents the savings the consumer will receive over the life of the appliance, estimated by multiplying the annual utility bill savings by the expected design life of the unit. The life-cycle benefits are the differences between the value of the savings and the incremental cost of each compliant unit. **Appendix A** provides details on how staff performed this analysis.

Table 7-2: Costs and Benefits Considered for Cost-Effectiveness per Control

Proposal or Alternative	Design Life (years)	Consumer Utility Bill Savings Over the Design Life (In $2022)	Incremental Consumer Costs (In $2022)	Total Life-Cycle Benefit (In $2022)
Staff Proposal: Default Schedule	10	1,131	70	1,061
Alternative 1: Load Shifting Based on TOU Rate	10	1,200	70	1,130
Alternative 2: Load Shifting Based on GHG Rate	10	620	70	550
Alternative 3: Load Shifting Based on Combined TOU and GHG Rate	10	1,200	70	1,130

Source: California Energy Commission

Statewide Benefits

The results of the statewide benefit calculations are shown in **Table 7-3**. The savings estimates are based upon a comparison of the pool controls baseline hourly energy consumption and the proposed standard pool controls hourly energy consumption. For statewide estimates, these savings are multiplied by pool control sales and by total compliant California stock. Benefits of the energy load shifts are further separated into first-year savings (2024) and annual consumer savings at full stock turnover (2033). *First-year savings* are the

86 Texas Instruments. 2015. "AM335x Reliability Considerations in PLC Applications." Available at https://www.ti.com/lit/an/sprabv9a/sprabv9a.pdf?ts=1652214808474.

annual benefits of energy shifts associated with the initial year of pool control sales once the standards have been in effect. *Annual savings at stock turnover* are the annual utility bill savings achieved after all existing stock of pool controls complies with the proposed standards.

Appendix A provides staff calculations and assumptions used to estimate first-year savings (2024) and annual consumer savings at stock turnover (2033). As provided in **Table 7-3**, when all pool controls comply with the proposed standards in 2033, California consumers would receive roughly $150 million a year in reduced electric utility costs.

Table 7-3: Annual California Statewide Benefits of Pool Control Standards

Proposal or Alternative	Annual Consumer Savings First Year (2024) (M$)	Annual Consumer Savings at Stock Turnover (2033) (M$)
Staff Proposal: Default Schedule	11.0	150.0
Alternative 1: Load Shifting Based on TOU Rate	11.0	159.0
Alternative 2: Load Shifting Based on GHG Rate	2.4	119.0
Alternative 3: Load Shifting Based on Combined TOU and GHG Rate	11.0	159.0

Source: California Energy Commission

Grid Reliability Benefits

Pool controls on a default schedule and the other load-shifting strategies contribute to greater grid reliability by permanently shifting load away from critical hours of the day. Critical hours are typically the late afternoon and early evening during late summer and early fall. Staff estimates the permanent load shifts at stock turnover, as shown in **Table 7-4**. The permanent load shifts will benefit consumers by reducing the need to procure additional demand-side resources such as batteries or supply-side resources such as additional electrical generation procurement. In addition to a default schedule for pool controls, appliances with the capability to respond to communications that signal lower prices (avoid peak demand) or lower GHG emissions (higher renewables) provide a demand-side capability to support grid reliability while reducing consumer electric utility bills.

The CEC's *2021 Integrated Energy Policy Report (IEPR)* describes the importance of combining building energy efficiency with demand flexibility. Homes with a grid-interactive pool can act like a grid-interactive building and use demand flexibility technologies to shift timing of appliance use, with customer consent, that will "...minimize grid strain and maximize renewable energy consumption."[87]

Table 7-4: Estimated Permanent Load Shift in 2033

Proposal	Permanent Load Shift at 7 PM on a Summer Weekday (MW)
Staff Proposal: Default Schedule	564
Alternative 1: Load Shifting Based on TOU Rate	478
Alternative 2: Load Shifting Based on GHG Rate	564
Alternative 3: Load Shifting Based on Combined TOU and GHG Rate	564

Source: California Energy Commission

CEC staff has monitored efforts by the CPUC and California load-serving entities to estimate statewide electric grid benefits of energy efficiency programs using the "total system benefits" (TSB) metric. This TSB metric allows assessments of programs to better capture the impacts of efficiency measures on policy goals related to lower GHG emissions, equity across utility ratepayers, and long-term contributions toward increased grid reliability. As the CPUC states "[T]he new 'total system benefit' is an expression, in dollar value, of the lifecycle energy, capacity, and GHG benefits of a utility's energy efficiency program portfolio."[88]

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87 California Energy Commission staff. 2022. *2021 Integrated Energy Policy Report, Volume I: Building Decarbonization*, page 12. Publication Number: CEC-100-2021-001-V1 Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=241599.

88 CPUC. 2021. "CPUC Better Aligns Energy Efficiency Programs to Reduce GHG Emissions, Support Equity, and Increase Grid Stability (ca.gov)." Available at https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-better-aligns-energy-efficiency-programs-to-reduce-ghg-emissions-and-increase-grid-stability.

CHAPTER 8:
Greenhouse Gas and Pollution Reductions

The proposed regulations would lead to improved environmental quality in California. Improved flexible demand of appliance electricity consumption translates to fewer power plants built and less pressure on California's limited energy resources, land, and water. Reduced GHG and criteria pollutant emissions would occur primarily from lower electricity generation in hydrocarbon-burning power plants, such as gas power plants.

Greenhouse Gas Emissions Reductions

The proposed standards would significantly reduce GHG emissions by shifting pool equipment load from times of relatively high marginal GHG emission rates to times of lower emission rates. **Figure 8-1** shows the alignment between the default 9 a.m. to 3 p.m. Pacific Standard Time schedule and the marginal GHG emission rates.[89] The alignment associated with proposed standards would persist and improve as more existing and newly constructed pools have default schedules and flexible demand technology through all forecasted years.

89 Brook, Martha. 2018. "CEC Building Decarbonization 2018 Update Integrated Energy Policy Report Presentation." Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=223817&DocumentCotentId=54026.

Figure 8-1: Default Schedule Aligned With Low GHG Emissions ($MTCO_2e/MWh$)

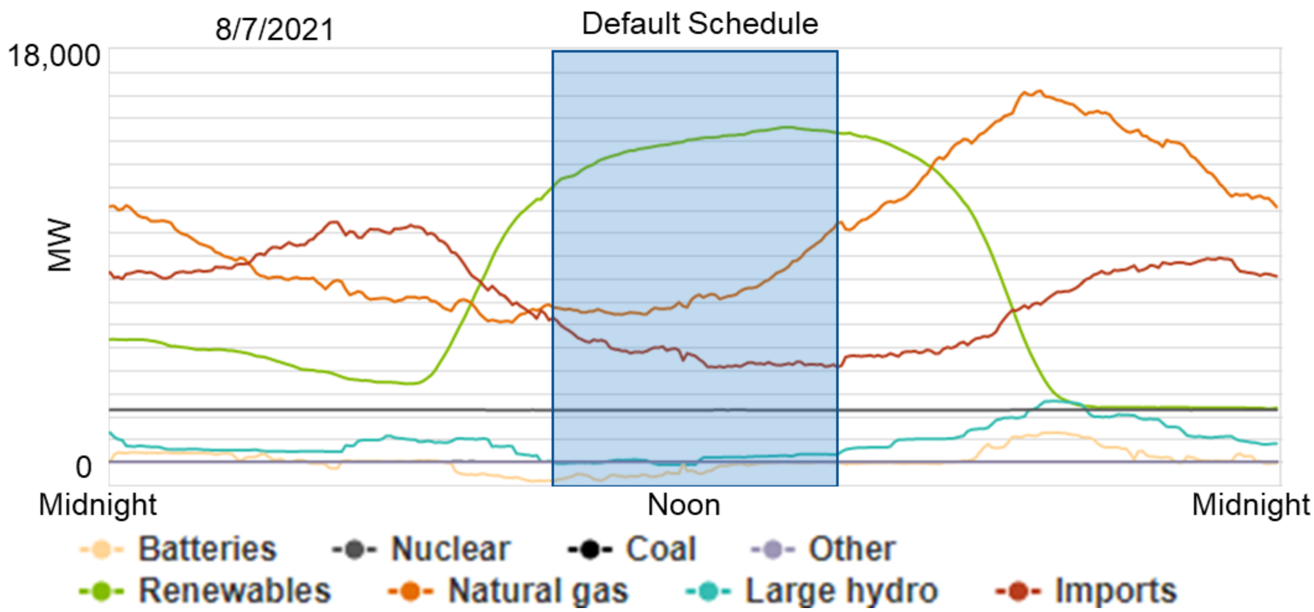
Hours	Winter			Spring			Summer			Fall		
Outside Default Schedule 12 am to 8:59 am	0.37	0.35	0.34	0.26	0.14	0.12	0.15	0.32	0.35	0.36	0.37	0.35
	0.37	0.36	0.34	0.25	0.16	0.13	0.17	0.32	0.37	0.37	0.37	0.36
	0.38	0.36	0.34	0.26	0.16	0.15	0.19	0.33	0.38	0.38	0.38	0.36
	0.38	0.36	0.34	0.26	0.17	0.16	0.21	0.33	0.38	0.38	0.38	0.36
	0.37	0.36	0.34	0.25	0.17	0.16	0.21	0.33	0.37	0.37	0.37	0.36
	0.37	0.35	0.34	0.24	0.14	0.14	0.20	0.33	0.37	0.36	0.36	0.35
	0.35	0.33	0.32	0.24	0.16	0.12	0.13	0.30	0.35	0.36	0.35	0.34
	0.34	0.32	0.28	0.12	0.05	0.04	0.04	0.12	0.15	0.27	0.28	0.31
	0.22	0.20	0.10	0.04	0.03	0.03	0.03	0.05	0.06	0.07	0.07	0.10
Default Schedule 9am to 3pm	0.08	0.08	0.05	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05
	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.06	0.05	0.05
	0.08	0.07	0.04	0.03	0.03	0.03	0.04	0.06	0.07	0.08	0.06	0.06
Outside Default Schedule 3:01pm to 12 am	0.29	0.23	0.06	0.04	0.04	0.04	0.04	0.09	0.12	0.21	0.20	0.23
	0.34	0.33	0.28	0.14	0.05	0.05	0.05	0.11	0.18	0.27	0.30	0.32
	0.32	0.31	0.30	0.20	0.09	0.08	0.08	0.16	0.23	0.28	0.30	0.31
	0.31	0.30	0.28	0.19	0.13	0.09	0.13	0.24	0.30	0.31	0.29	0.30
	0.31	0.29	0.26	0.18	0.13	0.13	0.18	0.28	0.31	0.31	0.29	0.30
	0.32	0.30	0.27	0.17	0.13	0.12	0.18	0.29	0.31	0.32	0.31	0.31
	0.33	0.31	0.29	0.18	0.11	0.09	0.15	0.28	0.32	0.33	0.33	0.32
	0.34	0.33	0.31	0.21	0.11	0.09	0.14	0.30	0.33	0.35	0.35	0.34
	0.36	0.34	0.32	0.23	0.13	0.12	0.14	0.32	0.34	0.36	0.36	0.35
Move Electric Energy Use to times of peak solar production and lowest emissions (green fill)												

Source: California Energy Commission

The low emissions during the midday hours are due to the increasing renewable energy generation from solar in California. The solar electricity generation resources produce the maximum output while the sun is high overhead in California from 9 a.m. to 3 p.m. Pacific Standard Time. **Figure 8-2** shows the electricity generation by resource for a summer day, while **Figure 8-3** shows electricity generation by resource for a winter day.[90] The default schedule for pool controls aligns with California's peak renewable generation.

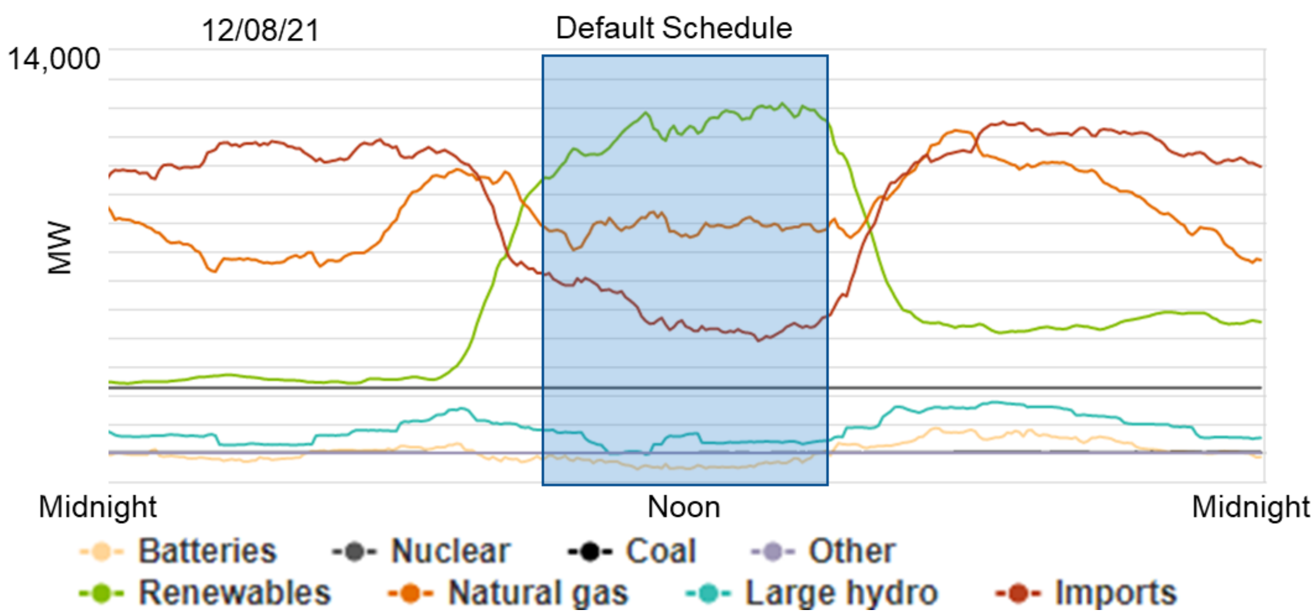
90 California Independent System Operator. 2022. "Today's Outlook, Supply and Renewables." Available at https://www.caiso.com/todaysoutlook/Pages/supply.aspx.

Figure 8-2: Electricity Generation Supply by Resource 8/7/2021



Source: California ISO

Figure 8-3: Electricity Generation Supply by Resource 12/8/2021



Source: California ISO

The proposed standards would address two issues for pool owners. Many pool owners may prioritize other activities and chores and not be aware of the schedule their pool equipment keeps. Pool owners may also not be aware of strategies to lower GHG emissions from the electricity used to maintain their pools and realize associated bill savings by shifting demand. By requiring the pool controls to operate the pool equipment on a default schedule, the scheduling burden facing pool owners is removed with significant environmental benefits.

Staff calculates the value of avoided GHG emissions by comparing the estimated marginal emission factors for the electricity consumed by the shifted load versus the marginal emission factors for the electricity consumed by the load before it was shifted. The difference in emissions was multiplied by the social cost of carbon to estimate a monetary value for this environmental benefit of avoided climate change damages. Current research led by CARB is assessing expected climate change impacts to California as part of staff activities to update the *2022 Climate Change Scoping Plan*. Researchers from the University of California at Santa Barbara and the Rhodium Group are examining regions of the state that face disproportionate adverse impacts from climate change, supporting CARB's actions to update values of the social cost of carbon.[91]

Table 8-1 shows the annual California statewide benefits from GHG emissions avoided due to proposed standards in the first year and at full stock turnover of pool controls.

Table 8-1: Annual California Statewide Benefits From GHGs Avoided

Proposal or Alternative	**Value of GHGs Avoided in 2024 (M $/yr)[92]**	**Value of GHGs Avoided in 2033 (M $/yr)[93]**
Staff Proposal: Default Schedule	2.0	27.0
Alternative 1: Load Shifting Based on TOU Rate	0.4	6.5
Alternative 2: Load Shifting Based on GHG Rate	2.4	28.4
Alternative 3: Load Shifting Based on Combined TOU and GHG Rate	2.2	26.3

Source: California Energy Commission

Figure 8-4 compares the GHGs avoided under the four load-shifting strategies analyzed by staff. Shifting load to TOU electric rates yields the smallest GHG emissions avoided. The smaller reduction is due to the TOU electric rates not being aligned with marginal GHG emission rates of California's electricity supply. Shifts of energy demand tied to marginal GHG emission rates yield the most GHG reduction because the pool controls will find the lowest GHG emission hours each day to operate. Following a combined TOU and GHG emissions signal leads to GHG emissions avoided between shifting based on either signal alone. The default schedule creates nearly the same GHG emissions avoided as a shift tied exclusively to

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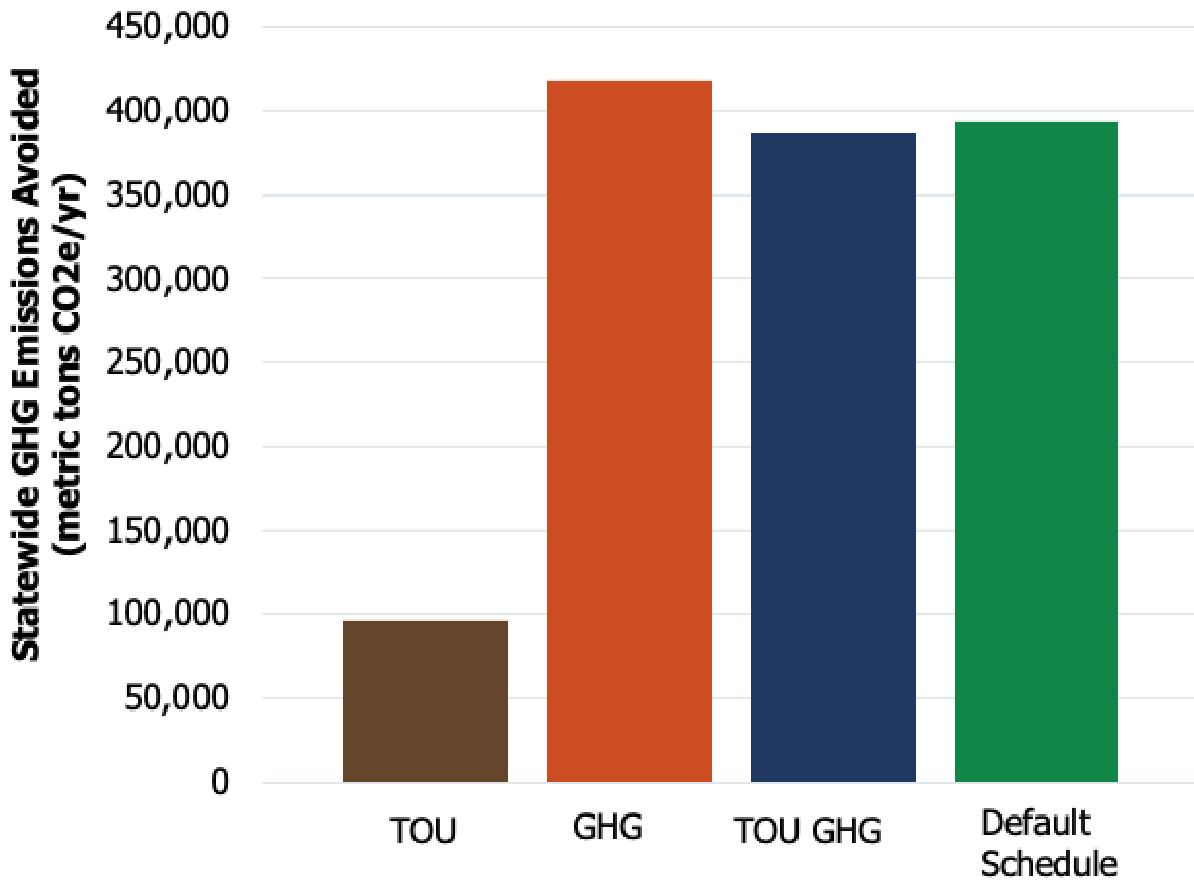
91 California Air Resources Board. 2022. "2022 Scoping Plan Update — Initial Modeling Results Workshop." Available at https://ww2.arb.ca.gov/resources/documents/2022-scoping-plan-update-initial-modeling-results-workshop.

92 White House. 2021. *Technical Support Document: Social Cost of Carbon Methane, and Nitrous Oxide*. Available at https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

93 Ibid.

GHG emission rates, which is due to the consistent hours when GHG emission rates are low. Staff proposes the default schedule option because it achieves most of the potential GHG avoided, provides consumers with significant utility bill savings, and is relatively easy to implement by manufacturers of pool controls. Moreover, the consistent daily schedule will enable high consumer acceptance of the default setting.

Figure 8-4: Statewide GHG Emissions Avoided (During 2033)



Source: California Energy Commission

The projected GHG emissions reductions achieved in 2033 by the proposed standards for pool controls is roughly equivalent to avoiding the average annual emissions of 85,000 passenger vehicles.[94]

Criteria Air Pollutant Reductions

The proposed standards for pool controls will lead to reduced emissions of criteria air pollutants associated with electricity generated from fossil fuel resources. As noted in the previous chapter, statewide grid benefits will result from reduced demand for electricity in the

94 U.S. Environmental Protection Agency. 2022. "Greenhouse Gases Equivalencies Calculator." Available at https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.

late afternoon and early evening, as pool equipment operating schedules are permanently shifted to earlier in the day. Criteria air pollutants have been found to harm human health and the environment. Example air pollutants from fossil fuel power plants include particulate matter ($PM_{2.5}$), nitrous oxides (NO_x), sulfur oxides (SO_x), and carbon monoxide (CO). The staff proposal for pool controls will have a direct effect on the reduction of criteria air pollutants through the increased use of renewable electricity generation over fossil fuel generation. Increased alignment of pool equipment loads with available supplies of renewable generation will decrease environmental hazards statewide, including improved air quality in disadvantaged communities located near natural gas power plants that emit criteria air pollutants.[95]

Future staff analysis of proposed flexible demand standards can use updated tools to assess the expected public health benefits associated with reductions in criteria air pollutants. Analytical resources such as the U.S. Environmental Protection Agency's AVoided Emissions and geneRation Tool (AVERT) and Environmental Benefits Mapping and Analysis (BenMAP) will be evaluated for applicability to quantifying health benefits of proposed FDAS, and staff will consider data availability to use these tools.[96]

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95 Auffhammer, Maximilian. 2021. *Distributional Impacts of Climate Change From California's Electricity Sector*. California Energy Commission. Publication Number: CEC-500-2021-038. Available at https://www.energy.ca.gov/sites/default/files/2021-07/CEC-500-2021-038.pdf.

96 U.S. Environmental Protection Agency. 2022. AVERT and BenMAP tools. Available at https://www.epa.gov/avert and https://www.epa.gov/benmap.

CHAPTER 9: Statewide Benefits and Costs

Introduction

Staff analysis includes estimates of the proposed regulation's annual impacts to California jobs, businesses, competitive advantages, and disadvantages, as well as benefits and costs to Californians. Between 2024 and 2033 the proposed standards are expected to yield an increase of roughly $751 million in disposable personal income. This increase in household disposable income, in turn, provides benefits to the California economy.

For this report, staff analyzed the proposed regulations and three alternatives:

1. Regulations with flexible demand requirements focused exclusively on utility bill savings.
2. Regulations with flexible demand requirements focused exclusively on avoiding GHG emissions.
3. Regulations with flexible demand requirements focused on a combination of utility bill savings and avoided GHG emissions.

Staff modeled and evaluated each of these four regulatory options for pool controls. **Table 9-1** shows the cumulative benefits and costs for the proposal and the alternatives for 2024 through 2033. **Table 9-2** shows the net present value of the cumulative benefits and costs for the proposal and the alternatives for 2024 through 2033.[97]

Table 9-1: Cumulative Benefits and Costs for 2024–2033

Pool Controls Option	Total Benefit (In millions $2022)	Total Cost (In millions $2022)
Staff Proposal	805	79
Alternative 1	853	79
Alternative 2	606	79
Alternative 3	853	79

Source: California Energy Commission

97 Staff uses a 3 percent discount rate to estimate net present value of benefits and costs over the period 2024 through 2033.

Table 9-2: Net Present Value of Cumulative Benefits and Costs of Proposal and Alternatives 2024–2033

Pool Controls Option	Total Benefit (In millions $2022)	Total Cost (In millions $2022)
Staff Proposal	675	70
Alternative 1	714	70
Alternative 2	505	70
Alternative 3	714	70

Source: California Energy Commission

The above monetary estimates of cumulative benefits of proposed and alternative standards highlight three important points. The first point is that all options assessed by staff are cost-effective and technically feasible. The second point is that current TOU rates align more closely with peak electricity demand than they do with marginal GHG emissions rates. The final point is that monetized aggregate reductions in GHG emissions valued at the social cost of carbon are outweighed by consumer utility bill savings due to shifts in the timing of the electricity consumption for pool controls. The staff proposal maximizes reductions in GHG emissions consistent with the direction in SB 49 while providing significant cost-effective utility bill savings for consumers.

Statewide Impacts

The first year the proposed regulations are in effect, the flexible demand standards would avoid GHG emissions from electricity production of about 33,000 metric tons of CO_2e and shift a total of 64 gigawatt-hours (GWh) of electricity off peak. "Peak" for the staff analysis is defined as the hours between 6 p.m. and 9 p.m. Over time as batteries and other technologies are introduced into the generation system, peak demand is expected to shift to later in the day. The regulations would shift 682 GWh of electricity per year at full stock turnover. Consumers on TOU rates would save about $1,131 per appliance over the life of the device through shifted electricity use.

The maximum predicted values of annual avoided GHGs and permanent load shift in 2033 are displayed in **Table 9-3** and **Table 9-4**. See **Appendix A** for supporting calculations.

Table 9-3: Pool Controls Statewide Annual Avoided GHGs

Pool Controls	Avoided GHG Emissions in 2024 (metric tons CO_2e)	Value of GHGs Avoided in 2024 (M $/yr)[98] (In millions $2022)	Avoided GHG Emissions in 2033 (metric tons CO_2e)	Value of GHGs Avoided in 2033 (M $/yr)[99] (In millions $2022)
Staff Proposal: Default Schedule	33,000	2.0	394,000	27.0
Alternative 1: TOU Scheduling	7,000	0.4	96,000	6.6
Alternative 2: GHG Scheduling	40,000	2.4	418,000	28.0
Alternative 3: GHG & TOU Scheduling	35,000	2.2	387,000	26.0

Source: California Energy Commission

Table 9-4: Pool Controls Statewide Permanent Load Shift From Peak

Proposal	Permanent Load Shift Single Day at 6 p.m. to 10 p.m. Summer Weekday 8/18/2033 (GWh)	Permanent Load 6 p.m. to 10 p.m. Daily, August 2033 (GWh)	Permanent Load 6 p.m. to 10 p.m. Daily, 2033 (GWh)
Staff Proposal: Default Schedule	2	72	682
Alternative 1: TOU Scheduling	2	44	466
Alternative 2: GHG Scheduling	2	72	679
Alternative 3: GHG & TOU Scheduling	2	72	680

Source: California Energy Commission

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98 White House. 2021. *Technical Support Document: Social Cost of Carbon Methane, and Nitrous Oxide*. Available at https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

99 Ibid.

Economic and Fiscal Impacts

CEC staff estimates the proposed regulation will not have an economic impact on California business enterprises and individuals in an amount exceeding $50,000,000 in any 12-month period between the date the regulation is estimated to be filed with the Secretary of State through 12 months after the regulation is estimated to be fully implemented, computed without regard to any offsetting benefits or costs that might result directly or indirectly from the adoption of the regulation. Staff expects that the proposed regulation will be fully implemented 10 years after it is adopted when full stock turnover will have taken place.

Estimated Private Sector Costs

The CEC estimates total direct costs of this regulation in 2024 will be $7.8 million. Staff estimates total direct annual costs of this regulation in 2033 to be $8.1 million. The higher direct costs result from an increase in the purchase price of pool controls as a result of proposed flexible demand standards.

Estimated Private Sector Benefits

The CEC estimates total direct benefits of this regulation in 2024 to be $11 million. Staff estimates total direct annual benefits of this regulation in 2033 to be $150 million. These estimates of direct benefits are based upon consumer electric utility bill savings.

Purchasers of a pool controls will save money from reduced utility bills. The CEC estimates the total statewide net benefits from this regulation over the 10 years to reach full stock turnover is $726 million.

Impacts to Businesses

The CEC estimates that about 1,300 businesses will potentially be affected in California with this figure based upon hardware store locations in California.[100] Additional businesses likely affected include pools control distributors, third-party aggregators of flexible demand, and electric utilities. **Table 9-5** provides a breakdown of business types that will be affected by the proposed regulations. Staff estimates that 10 percent of the retailers and distributors impacted are small businesses. Small businesses are treated the same as other businesses under the proposed regulations.

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100 IBISWorld. 2021. "Hardware Stores in the US — Number of Businesses 2002–2027." Available at https://www.ibisworld.com/industry-statistics/number-of-businesses/hardware-stores-united-states/.

Table 9-5: Businesses Affected by Proposed Regulations

Business Type	Estimated Number of Businesses in California
Pool controls distributors and retailers	1,300
Electric utilities	59
Third-party aggregators	30

Source: California Energy Commission

Under the proposed flexible demand standards, retailers are responsible for ensuring that any covered products they sell appear in the CEC database before they are sold or offered for sale, rented, imported, distributed, or leased for use in California. Because flexible demand appliances are newly covered products, the CEC assumes that retailers will experience some additional costs associated with checking the CEC database to ensure that the flexible demand appliance they sell or offer for sale appears in the CEC database 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 the CEC database 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 CEC database.

Sellers of electricity, retail and wholesale, will experience electricity sales reduction at peak demand times because of the proposed standard. Expected changes in total electricity demand is small compared to total electricity sales of these entities. Shifts in demand away from higher-priced peak periods reduce revenues to utilities by an estimated $150 million in 2033 at full stock turnover, while utilities benefit from cost savings that result from reduced peak load procurement and reduced investment in infrastructure to accommodate an otherwise increasing peak load.

Because flexible demand appliance shipments and sales are not expected to change significantly because 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, Income, and Output

Staff estimates the proposed regulations will have an overall positive employment impact for California. Jobs created by household utility bill savings leads to greater job creation than reduction of jobs in the electric utility sector because of reduced spending on utility bills. Consumers will have an increase in disposable income of $150 million due to annual reduced electricity bills in 2033. These consumers spend an additional $8.1 million in higher purchase price for pool controls in 2033, which yields a net increase in household disposable income of $142 million to be spent on other goods and services. The utility sector is estimated to reduce employment by 707 jobs, while an additional 3,459 jobs will be created as a result of the change in discretionary spending of households with flexible demand pool controls. Net employment is estimated to increase by 2,752 jobs at full stock turnover resulting from proposed regulations.

At full stock turnover, the proposed regulations will increase statewide earned income by nearly $142 million annually. Reduced income in the utility sector of $150 million is offset by increases in earned income of $59 million due to increased spending of households on goods and services other than electricity.

California's output or gross state product in 2033 at full stock turnover is estimated to increase by $60 million, as reduced production in the electricity sector of $150 million is offset by increased spending and the associated output in other sectors of $308 million. See Appendix A for details of these estimates of macroeconomic impacts.

Estimated Costs

Entities that purchase compliant flexible demand appliances do not have any compliance obligations under the proposed regulations. However, the CEC assumes that the incremental cost to create the features of a flexible demand appliance are passed on fully to consumers by out-of-state manufacturers and the retailers selling pool controls to California consumers. As noted above, staff estimates that at full implementation in 2033, consumers will pay $8.1 million in higher purchase prices for pool controls. This higher upfront cost of pool controls is more than offset by utility bill savings to the consumer over the estimated useful life of the pool controls.

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, is not dominant in its field of operation, and has fewer than 100 employees.[101] Small businesses that will be affected are those that sell flexible demand appliances such as retail home appliance stores, 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 assumes that pool controls are typically purchased by individuals, large businesses, or small businesses that own swimming pools. Large and small businesses that purchase flexible demand pool controls would pay an additional $70 per pool. The businesses would incur this additional cost once every 10 years, the estimated design life of the product, but would see the initial increased cost repaid in less than five years because of savings from optimized time-of-use of electricity.[102]

Retailers will be required to verify that the flexible demand appliance they sell, offer for sale, or lease appear in the CEC database, both when the standards take effect (initial) and on an

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101 California Government Code 11346.3(b)(4)(B).

102 Texas Instruments. 2022. *AM335x Reliability Considerations in PLC Applications*. Available at https://www.ti.com/lit/an/sprabv9a/sprabv9a.pdf?ts=1652214808474.

ongoing basis. Retailers may do this either by verifying that the product appears in the CEC database themselves or negotiate contracts with manufacturers or distributors to ensure that the product complies 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 about 30 minutes of employee labor time per pool control 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 database website information, CEC staff estimates roughly 1,000 in-scope flexible demand appliance models will require CEC database verification. Independently operated stores may carry fewer than 10 in-scope flexible demand appliance models.

Retailers may choose to rebrand the compliant product and certify that model to the CEC database. This choice is not a typical response to a change in standards such as the proposed regulations for pool controls.

Individual Purchasers

The incremental costs for a purchaser of a compliant pool control would be $70. This is a one-time expense with no annual ongoing costs. The CEC estimates that an individual would purchase one pool control per pool. The purchases would occur about every 10 years, the average design life for a pool control. Consumers on TOU rates would save $1,131 in electric utility bills over the expected life of the appliance.

Manufacturers

The proposed regulations would set new standards that will require manufacturers to produce pool controls that have flexible demand capabilities. The incremental manufacturing costs to improve the pool control are exceeded by the lifetime monetary savings that the end user will receive through reduced electricity bills.

Although the proposed standard would impose new data reporting requirements on manufacturers of flexible demand appliances, one of these manufacturers is in 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 flexible demand model. The CEC estimates that the reporting burden for entities that choose to certify their products to the CEC database is about $100 per model certified. This estimate includes recordkeeping and the cost to complete the template or manual submittal form to the CEC database. Because rebranding is relatively infrequent and typically only involves one model per retailer, the CEC expects this cost to be absorbed by retailers.

Utilities' Costs

Staff has not identified any direct costs to utilities due to the staff proposal. Staff has estimated reduced revenues to utilities due to shifts in the timing of pool control operations. Utilities will see an indirect impact of a decline in revenues from electricity ratepayers as stated above regarding impacts to statewide employment. Utilities will see decreased costs to supply electricity with a reduced need for infrastructure investment and the avoided higher costs of supply, as demand is shifted away from peak hours of the day due to the proposed regulation.

Utilities' Benefits

The benefits of proposed flexible demand appliance regulations include reductions in energy consumption from fossil fuel generation and permanent load shifts from peak-demand times found in the late afternoon and early evening. Reducing energy consumption at peak times generally increases the reliability of the electricity supply. Benefits that result from reduced energy production from fossil fuels include reductions in criteria air pollutants such as particulate matter, ground-level ozone, lead, carbon monoxide, nitrogen oxides, and sulfur oxides. Air pollutants associated with electricity production include criteria pollutants, as well as carcinogens, such as benzopyrene, and other polycyclic aromatic hydrocarbons, arsenic, beryllium, cadmium, chromium, nickel, lead and formaldehyde that adversely impact the health and quality of life for California homes.[103] Reductions in electricity production from fossil fuels reduce GHG emissions, which will reduce the need for California utilities to purchase allowances in the Cap-and-Trade Program.

Fiscal Impact Statement

The proposed regulations would increase the initial purchase cost of pool controls and save money through lower electric utility bills over the 10-year life of the pool controls. Staff anticipates there will not be an impact to state and local agencies because typical public and municipal pools use three-phase equipment, which is excluded from the regulation. For any single-phase applications, these incremental costs to purchases would most likely arise in the July 1, 2024–June 30, 2025, fiscal year. The incremental costs of the pool controls are more than offset by the resulting reduced electric utility bills. The payback is estimated to be under one year and, therefore, easily offsets the higher incremental cost. The incremental cost is estimated to be $70 with average annual electric utility bill savings of $79. These costs are not targeted specifically at state or local governments, but rather more broadly at which pool controls 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, pool controls, will need to be determined as part of a general strategy on enforcement and not as a result of any specific appliance flexible demand regulation. Therefore, no fiscal impact can be estimated as a result of a change in the enforcement of the proposed regulations.

103 Boffetta P., E. Cardis, H. Vainio, M. P. Coleman, M. Kogevinas, G. Nordberg, D. M. Parkin, et al. International Agency for Research on Cancer. 1991. "Cancer Risks Related to Electricity Production." *European Journal of Cancer,* Volume 22, Issue 11. Available at https://www.ejcancer.com/article/0277-5379(91)90040-K/fulltext.

CHAPTER 10: Environmental Assessment

Environmental Impacts Analysis

None of the proposed regulations from the flexible demand appliance standards would cause a direct or reasonably foreseeable indirect physical change in the environment.

Proposed Notice of Exemption Finding

Categorial Exemptions, Classes 7 and 8 Exemptions

California Code of Regulations, Title 14, Sections 15307 and 15308, exempt actions taken by a regulatory agency to "assure the maintenance, restoration, or enhancement of a natural resource" and actions taken to "assure the maintenance, restoration, enhancement, or protection of the environment where the regulatory process involves procedures for protection of the environment." As demonstrated in this report, the proposed flexible demand appliance standards will have no significant effect on the environment and fall squarely within the categorical exemptions of Sections 15307 and 15308. The activities of this project are being undertaken in furtherance of the CEC's flexible demand appliance standards program to ensure that energy demand is sufficiently flexible to bolster grid reliability and maximize the amount of load met with carbon-free resources. As noted above in Chapter 8, grid instability and electricity production from fossil-fuel resources is associated with significant environmental impacts. This rulemaking directly addresses these issues and is an action to assure the maintenance, restoration, or enhancement of a natural resource and to assure the maintenance, restoration, enhancement, or protection of the environment. Further, none of the exceptions to exemptions listed in the California Environmental Quality Act (CEQA) Guidelines Section 15300.2 apply to this project. Furthermore, there is no reasonable possibility that the activity will have a significant effect on the environment because of unusual circumstances. For these reasons, staff proposes that this project is exempt from CEQA.

Useful Life

The proposed standards will not affect the replacement of an appliance at the end of useful life. There is no sales prohibition against pool controls manufactured before the effective date. The regulation would not require early replacement of a pool control. There will be no additional impact to the environment beyond the natural life cycle of the appliance.

Materials

The standards do not force an undue burden on the wholesale/retail distribution chain nor cause waste of material and energy.

Typically, pool controls feature timer-controlled operations or elements embedded in the appliance, which can shift the time of operations as set and determined by the consumer. This shift is usually done in hourly increments. With the flexible demand standards, these elements will be connectivity-enabled. The timing of the shift will be determined by the consumer.

Different manufacturers may implement specific schedule features differently and often have patented technologies. The proposed standards do not require the use of any specific material to enable the demand flexibility of the product.

Since inclusion of these elements is already common practice, making them enabled with connectivity is not expected to change industry practice in terms of the body design or the material composition of these appliances. 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.

Marking

The proposed marking requirement would require product information to appear on the appliance. The marking requirement could be accomplished with existing marking techniques and would not cause a significant environmental impact.

Common Sense Exemption

The development and adoption of these flexible demand appliance standards are also exempt from CEQA under the "common sense exemption." CEQA only applies to projects that have the potential for causing a significant effect on the environment (Cal. Code Regs., Tit. 14, Section 15061(b)(3)). "A significant effect on the environment" is defined as a substantial, or a potentially substantial, adverse change in the environment and does not include an economic change by itself (Pub. Resources Code, Section 21068; Cal. Code Regs., Tit. 14, Section 15382.) The goal of the proposed flexible demand appliance standard for pool controls sold, offered for sale, rented, imported, distributed, or leased for use in California is to form the foundation for statewide flexible demand appliance standards. FDAS can automate, shift, or schedule appliance operations for time- and location-dependent signals providing:

- Real-time load flexibility on the electric grid.
- Enabled consumer-supported load management on a mass-market scale.
- Signals and tools to further support the reliability of the grid.
- Reduced reliance on fossil-fuel generated electricity.

No significant adverse impacts to the environment have been identified as resulting from this action. For these reasons, adoption of the proposed standards would not be subject to CEQA under the common sense exemption of Section 15061(b)(3).

Acronyms

AB	Assembly Bill
AMI	advanced metering infrastructure
BEA	Bureau of Economic Analysis
California ISO	California Independent System Operator
CARB	California Air Resources Board
CARE	California Alternate Rates for Energy
CCA	community choice aggregator
CCR	California Code of Regulations
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CO_2	carbon dioxide elemental gas
CO_2e	carbon dioxide equivalent
CPUC	California Public Utilities Commission
DACAG	Disadvantaged Communities Advisory Group
DER	distributed energy resources
DR	demand response
EAD	Energy Assessments Division of the CEC
FAD	Flexible Appliance Database
FDAS	flexible demand appliance standards
GHG	greenhouse gas
GWh	gigawatt-hour
IEPR	Integrated Energy Policy Report
IOU	investor-owned utility

kW	kilowatt
kWh	kilowatt-hour
LADWP	Los Angeles Department of Water and Power
LSE	load-serving entity
MCI	modular communications interface
MIDAS	Market Informed Demand Automation Server
MT	metric ton
MW	megawatt
MWh	megawatt-hour
NO_2	nitrogen dioxide elemental gas
NO_x	oxides of nitrogen
NPV	net present value
OIR	order instituting rulemaking
OpenADR	open automated demand response
PG&E	Pacific Gas and Electric Company
PHTA	Pool and Hot Tub Association
PM	particulate matter
POU	publicly owned utility
PST	Pacific Standard Time
RASS	Residential Appliance Saturation Study
RIMS II	Regional Input-Output Modeling System II
RPS	Renewable Portfolio Standards
SB	Senate Bill
SCC	social cost of carbon (SCC)
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric

SGIP	Self-Generation Incentive Program
SMUD	Sacramento Municipal Utility District
SoCalGas	Southern California Gas Company
TCP/IP	Transmission Control Protocol/Internet Protocol Suite
TDV	time-dependent valuation
TOD	time-of-day
TOU	time-of-use
U.S. DOE	United States Department of Energy
U.S. EIA	United States Energy Information Administration
U.S. EPA	United States Environmental Protection Agency
UC	University of California

Glossary

This glossary includes basic definitions of some of the terms used in this staff report.

ANNUAL STOCK SAVINGS — The annual benefits savings achieved after all existing stock in use complies with the proposed standards, in this case, 2033.

ADVANCED METERING INFRASTRUCTURE (AMI) — An integrated system of smart meters, data management systems, and communication networks that enable two-way communication between the utilities and the customers. AMI makes two-way communications with customers possible and is the backbone of a smart grid.

A BALANCING AUTHORITY is responsible for operating a transmission control area. It matches generation with load and maintains consistent electric frequency of the grid, even during extreme weather conditions or natural disasters. In California, there are eight balancing authorities, the largest of which are the California Independent System Operator, the Balancing Authority of Northern California, and Los Angeles Department of Water and Power.

BLOCKCHAIN is a growing list of records, called *blocks*, that are linked together. Each block contains a hash of the previous block, a time stamp, and transaction data.

BRITISH THERMAL UNIT (BTU) — A unit of heat energy. One Btu is equal to the amount of energy required to raise the temperature of 1 pound of water by 1 degree Fahrenheit at sea level. One Btu is equivalent to 252 calories, 778 foot-pounds, 1,055 joules, or 0.293 watt-hours.

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) is a California statute passed in 1970 that requires disclosure to the public of the significant environmental effects of a proposed discretionary project, through the preparation of an initial study, negative declaration, mitigated negative declaration, or environmental impact report.

CALENVIROSCREEN — A screening method that can be used to help identify California communities that are disproportionately burdened by multiple sources of pollution. The CalEnviroScreen tool combines different types of census tract-specific information into a score to determine which communities are the most burdened or disadvantaged.

CO_2e (CARBON DIOXIDE EQUIVALENT) — A measure used to compare emissions from various greenhouse gases based upon the related global warming potential. The carbon dioxide equivalent for a gas is derived by multiplying the mass of the gas by the associated global warming potential.

CARBON INTENSITY — A measure of greenhouse gas emissions by weight per unit of energy. A common measure of carbon intensity is grams of carbon dioxide equivalent greenhouse gases per megajoule of energy (gCO_2e/MJ).

CHLORINATOR — A piece of equipment that dispenses chlorine into a pool. Rather than putting the chlorine directly into a pool using a floating chlorinator or by pouring in liquid chlorine, an automatic chlorinator dispenses at a set rate.

CLEAN ENERGY RESOURCE — For this report, sustainable and renewable clean energy resources include solar, wind, geothermal, and hydropower.

COMMUNITY CHOICE AGGREGATOR — Entities as defined in Public Utilities Code Section 331.1.

CRITERIA AIR POLLUTANT — An air pollutant for which acceptable levels of exposure can be determined and for which the U.S. Environmental Protection Agency has set an ambient air quality standard. Examples include ozone (O_3), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matter (PM_{10} and $PM_{2.5}$).

CTA 2045 — ANSI/CTA 2045 specifies a modular communications interface (MCI) to facilitate communications with residential devices for applications such as energy management.

CURTAIL is a temporary and immediate action taken to reduce or restrict use of electricity. Flexible demand standards for appliances provide a means to meaningfully shift load-take to periods where renewable electricity generation is abundant. Current practice is to curtail renewable supply to the grid, favoring nonrenewable generation.

CYBERSECURITY — A set of practices to protect computers, digital devices, and networks from digital attack.

LIFE-CYCLE CONSUMER SAVINGS reflect a 3 percent annual discount rate applied to the savings, allowing incremental costs and savings to be compared in terms of net present value to consumers.

DEMAND FLEXIBILTY, or demand response, is the practice of managing customer electricity usage in response to economic incentives, as well as avoidance of greenhouse gas emissions.

DESIGN LIFE, also referred to as estimated useful life (EUL), is the average period that a product class of appliances or devices will perform the intended function fully, given proper care and maintenance.

DISADVANTAGED COMMUNITIES refers to the areas throughout the state that most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes, as well as high incidence of asthma and heart disease.

EQUITY refers to the fair treatment, meaningful involvement, and strategic investment of resources through clean transportation programs, incentives, and processes for all Californians so that race, color, national origin, or income level are not barriers to increased opportunities and participation.

FLEXIBLE DEMAND means the capability to schedule, shift, or curtail the electrical demand of a load-serving entity's customer through direct action by the customer or through action by a third party, the load-serving entity, or a grid balancing authority, with the customer's consent.

GIGATON is equal to 1 billion tons.

GIGAWATT-HOUR (GWh) — A unit of energy representing 1 billion (1,000,000,000) watt-hours and is equivalent to 1 million kilowatt-hours. A single watt-hour is a measure of electrical energy equivalent to a power consumption of 1 watt for 1 hour. A kilowatt-hour (kWh) is a unit of energy equal to 1 kilowatt of power sustained for 1 hour or to 3,600 kilojoules (3.6 megajoules). 1 million watt-hours = 1 megawatt-hour (MWh).

GLOBAL WARMING POTENTIAL is a metric that allows comparisons of the global warming impacts of different gases. It is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period, relative to the emissions of 1 ton of carbon dioxide. The larger the global warming potential, the more that a given gas warms the Earth compared to carbon dioxide over that period.

GREENHOUSE GAS (GHG) — Any gas that absorbs infrared radiation in the atmosphere. Common examples of greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

GRID is an interconnected network for electricity delivery from the place of generation to end-use devices. The power grid includes the combined transmission and distribution network.

GRID HARMONIZATION refers to strategies and measures that harmonize customer-owned distributed energy resources with the grid to maximize self-utilization of PV array output and limit grid exports to periods beneficial to the grid and the ratepayer.

INCREMENTAL CONSUMER COST is the additional cost (average) at retail that a consumer would pay for an appliance that meets the flexible demand standard. This cost is the difference between an existing base model and the same model that has the added functionality to comply with the new appliance standards for flexible demand.

INVESTOR-OWNED UTILITY — A private company that provides a utility, such as water, natural gas, or electricity, to a specific service area. The California Public Utilities Commission regulates investor-owned utilities that operate in California.

LOAD MANAGEMENT STANDARDS (LMS) are cost-effective programs that result in improved utility system efficiency, reduced or delayed need for new electrical capacity, reduced (fossil) fuel consumption, and lower long-term economic and environmental costs to meet the state's electricity needs. The website for the Load Management Standards is located at https://www.energy.ca.gov/proceedings/energy-commission-proceedings/load-management-rulemaking.

LOW-INCOME COMMUNITIES/HOUSEHOLDS (LIHH) — Defined as the census tracts and households, respectively, that are either at or below 80 percent of the statewide median income or at or below the threshold designated as low-income by the California Department of Housing and Community Developments 2018 Income Limits.

MARGINAL GHG EMISSIONS RATE — Power plants are dispatched by increasing cost. When electricity demand is increased, the first power plant to increase production is the last dispatched one; the electricity requested will come from the cheapest power plant that still has spare capacity. The marginal emissions rate for a given location is calculated by multiplying the average emissions rate for the marginal unit by the corresponding percentage for that unit. These rates are added together to create the marginal emissions rate for the given location.

METRIC TON — A unit of weight equal to 1,000 kilograms (2,205 pounds).

MEGAJOULE — One million joules. A joule is a unit of work or energy equal to the amount of work done when the point of application of force of 1 newton is displaced 1 meter in the direction of the force. One British thermal unit is equal to 1,055 joules.

METHANE — A light hydrocarbon that is the main component of natural gas. It is the product of the anaerobic decomposition of organic matter or enteric fermentation in animals and is a greenhouse gas. The chemical formula is CH_4.

NATURAL GAS — A hydrocarbon gas found in the earth composed of methane, ethane, butane, propane, and other gases.

NET LOAD is the total electric demand in the system minus wind and solar generation. The net load represents the demand that California ISO must meet with other, dispatchable sources such as natural gas, hydropower, and imported electricity from outside the system.

NO_X — Oxides of nitrogen, a chief component of air pollution commonly produced by the burning of fossil fuels.

OpenADR is a research and standards development effort for energy management led by North American research labs and companies. The typical use is to send information and signals to cause electrical power-using devices to curtail or shift during periods of high demand.

PARTICULATE MATTER — Any material, except pure water, that exists in a solid or liquid state in the atmosphere. The size of particulate matter can vary from coarse, wind-blown dust particles to fine-particle combustion products.

POOL CONTROL schedules the start and stop of the pool pump maintenance operations. The pool controls may be integral to the pool pump or may be a separate device that remotely controls the pool pump.

PRESSURE CLEANER BOOSTER PUMP (PCBP) is used to enhance the water pressure and water flow that the main pool pump is producing. This pump can be useful for filtration while ensuring that all the water in a pool moves at a consistent and steady pace.

RENEWABLES PORTFOLIO STANDARD (RPS) is one of California's key programs for advancing renewable energy. The program sets continuously escalating renewable energy procurement requirements for the state's load-serving entities. Generation must be procured from RPS-certified facilities. The website for the Renewables Portfolio Standard program is located at https://www.energy.ca.gov/programs-and-topics/programs/renewables-portfolio-standard.

SCHEDULE — A means to intentionally program operation of a device through use of an onboard astronomical time clock or other such internal mechanism; one that is not necessarily connected or dependent upon a Wi-Fi or FM signal.

SHIFT is an action taken — manually by the consumer, automatically via a signal or through use of a program or schedule — to operate an electric-powered appliance during periods when the price of electricity is cheaper or that power is clean or from a renewable source or both.

SOCIAL COST OF CARBON (SCC) — An estimate, in dollars, of the economic damages that would result from emitting one additional metric ton of carbon dioxide into the atmosphere. The SCC quantifies impacts that result from climate change in economic terms to help policy makers and other decision makers understand the economic impacts of decisions that would either increase or decrease GHG emissions.

TCP/IP (Transmission Control Protocol/Internet Protocol Suite) is a comprehensive set of rules including UDP/IP that governs the connection of computer systems to the internet.

TERAWATT is a unit of power equal to one trillion watts (10^{12} W).

TIME-OF-USE (TOU) RATE — Price consumers pay for electricity that varies by the time of day.

APPENDIX A: Staff Assumptions and Calculation Methods

Appendix A Summary

Appendix A contains the information and calculations used to characterize pool controls in California, their current energy use, and potential for savings. All calculations assumed an effective date of January 1, 2024, for the proposed regulation. Staff estimate the design life of pool controls is 10-years and the stock turnover occurs in 2033. The values in the tables may show differences due to rounding. Staff maintained the unrounded values throughout the calculations. Calculation methods for the year 2024 are similar for the year 2033 and sample calculations provided for a single year for simplicity. The core data sets for the analysis are RASS for current the appliance stock data, HELM for pool electrical load data, 2021 IEPR for GHG emissions from electricity generation data, 2022 IEPR for electrical utility rate data, and the White House Interagency Working Group for the monetary value assigned to GHG's.[104] Staff created a base case scenario to provide a baseline without regulation for staff proposal comparisons. Staff modeled future scenarios using middle case scenario estimates to help visualize and compare the most realistic outcomes for the proposals.

Stock and Sales

Table A-1 lists estimates of annual sales of pool controls, and the total stock of pool controls. Staff scaled the future year stock projections to match projected increases in the state's population by the California Department of Finance (CA DOF).[105] Staff performed RASS data query in the fourth quarter of 2021 surveying for electric utility, pools, and pools size J2.[106]

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104 California Residential Appliance Saturation Study. 2019. "2019 California Residential Appliance Saturation Study - Executive Summary (dnv.com)." Available at https://webtools.dnv.com/CA_RASS/.
Baroiant, Sasha, John Barnes, Daniel Chapman, Steven Keates and Jeffrey Phung (ADM Associates, Inc.). 2019. "California Investor-Owned Utility Electricity Load Shapes." CEC Publication Number: CEC-500-2019-046. Available at https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2019-046.pdf.
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White House, 2021. "Technical Support Document: Social Cost of Carbon Methane, and Nitrous Oxide." Available at https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

105 California Department of Finance. Demographic Research Unit. 2021. "Report P-1A: Total Population Projections, California, 2010-2060 (Baseline 2019 Population Projections; Vintage 2020 Release)." Available at https://dof.ca.gov/wp-content/uploads/Forecasting/Demographics/Documents/P1A_State_Total.xlsx.

106 California Residential Appliance Saturation Study. 2019. "2019 California Residential Appliance Saturation Study - Executive Summary (dnv.com)." Available at https://webtools.dnv.com/CA_RASS/.

Table A-1: Residential Stock and Sales

Utility	Pool Controls Per Utility (2020)	Pool Controls Per Utility Shipments (2024)	Pool Controls Per Utility Stock (2024)	Pool Controls Per Utility Shipments (2033)	Pool Controls Per Utility Stock (2033)
SMUD	68,087	6,944	69,442	7,257	72,572
SCE	460,851	47,002	470,023	49,121	491,210
LADWP	108,837	11,100	111,003	11,601	116,007
PGE	347,859	35,478	354,782	37,077	370,774
SDGE	102,346	10,438	104,383	10,909	109,088
Total	1,087,980	110,963	1,109,634	115,965	1,159,651

Source: 2019 RASS data and CEC staff projection

Table A-2 lists the CA DOF total populations projections from their report P-A1 for the state population year 2020, 2024 and 2033 using a 2019 RASS data baseline.

Table A-2: California State Population Projection

Year	State Population
2020	39,782,419
2024	40,574,215
2033	42,403,084

Source: CA DOF

Example equations for **Table A-1** pool controls total stock and sales calculation:

Pool Control Stock Calculation 2024

$P_{2024} = P_{2020} \text{ x } SP_{2024} / SP_{2020}$

1,109,634 = 1,087,980 X 40,574,215 / 39,782,419

Where:

P_{2020} = Pool Control Stock in 2020

P_{2024} = Pool Control Stock in 2024

SP_{2020} = State Population in 2020

SP_{2024} = State Population in 2024

Pool Control Shipment Calculation 2024

$SH_{2024} = P_{2024}$ / Design Life

110,963 (units/year) = 1,109,634 (units) / 10 years

Where:

SH_{2024} = Pool Control Shipments in 2024

P_{2024} = Pool Control Stock in 2024 (1,109,634 units)

Design Life = Design life of pool control (10 years)

Compliance Rates

Staff used comments received from stakeholders to estimate compliance rates for the proposed standard. Staff assumed 30 percent of devices are compliant and are currently set to shift load to minimize utility bill costs to consumers. Staff assume 0 percent of pool controls are currently shifting based on GHG or combined GHG and TOU rates because of the unavailability of the rate or difficulty in setup. Staff is unaware of any pool controls that are currently shipped with a default schedule aligned to 9 a.m. to 3 p.m. PST (6 hours total). **Table A-3** shows the assumed baseline compliance percentages for the analysis.

Table A-3: Baseline Compliance Rates Without Regulation

Product	Non-compliant or not shifting load (%)	Compliant and Shifting Load based on TOU (%)	Compliant and Shifting Load based on GHG (%)	Compliant and Shifting Load based on TOU and GHG (%)	Compliant and shifting load based on default schedule
Pool Control	70%	30%	0%	0%	0%

Source: California Energy Commission

Pool Control Load Information

Staff gathered individual pool load information from the U.S. DOE Technical Support Document (TSD) on Dedicated-Purpose Pool Pumps (DPPP).[107] The Pool and Hot Tub Association (PHTA) provided additional information on pool equipment load such as the electric pool heater, chlorinator, and pressure cleaner booster pump (PCBP). **Table A-4** shows the information

107 U.S. DOE. 2016. "Technical Support Document: Energy Efficiency Program For Consumer Products And Commercial And Industrial Equipment. Dedicated-Purpose Pool Pumps." Available at https://downloads.regulations.gov/EERE-2015-BT-STD-0008-0105/attachment_1.pdf.

provided by PHTA. Staff reviewed relevant flexible pool pump test results and data to validate average daily pool information.[108]

Table A-4: Pool Equipment Load Information

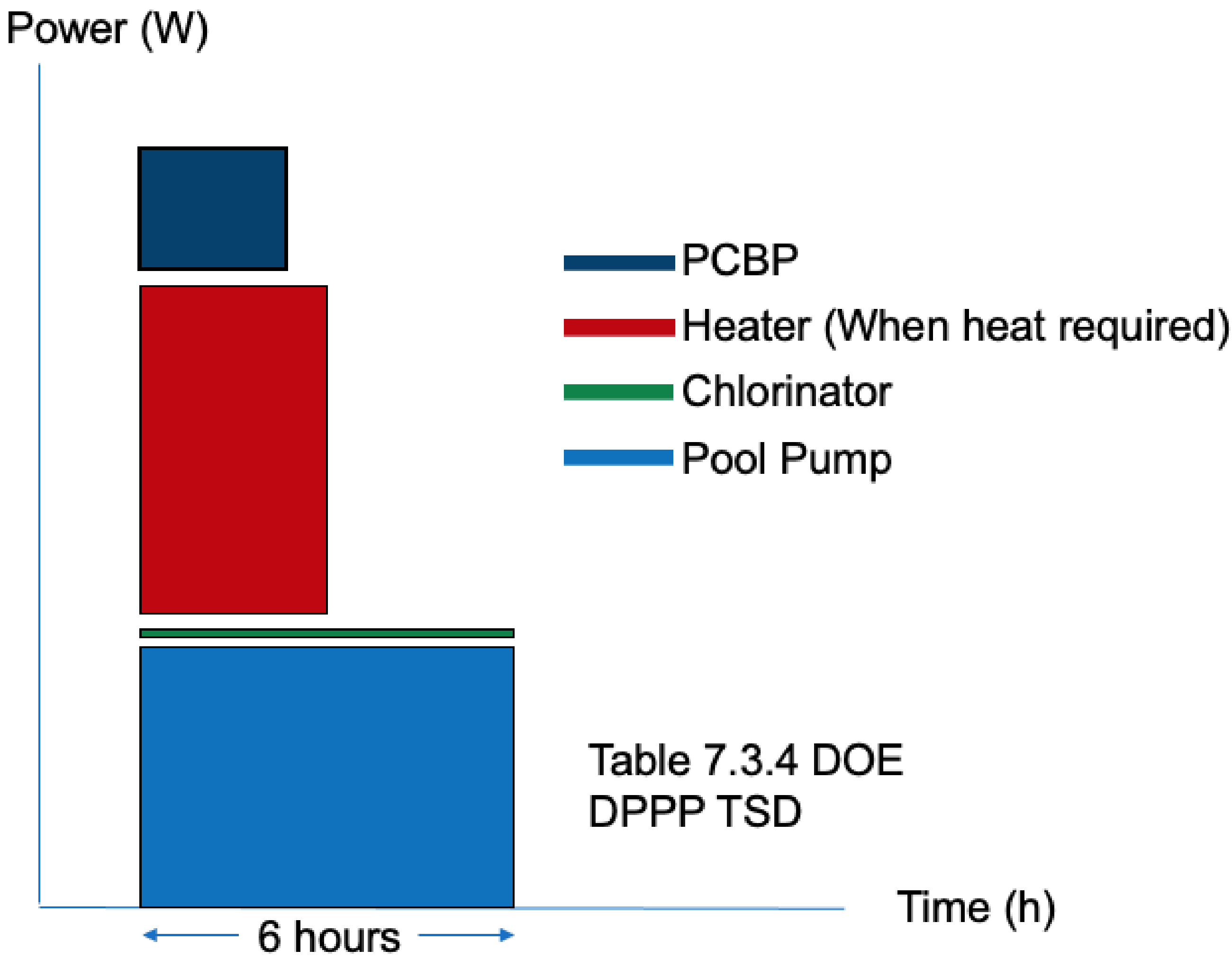
Pool Equipment	Average Daily Operating Time (h)	Daily Energy (kWh)
Salt Chlorinator	12	2.16
Chlorinator (erosion based)	12	0.6
Electric Heat Pump Pool Heater	3	12.6
Pressure Cleaner Booster Pump (PCBP)	2.5	3.7

Source: PHTA

Staff analyzed the individual pool load data to create the pool equipment schedules for individual pools shown in **Figure A-1** and **Figure A-2**. Staff reviewed the pool equipment schedules with stakeholders to understand the potential constraints on shifting the load of the pool equipment. Staff concluded that the pool equipment operating times must be coordinated so that the consumers expectations for pool equipment operation will be maintained. Staff's analysis does not rely on changing the duration, combination, or sequence of the pool equipment operation. Rather the staff's analysis only shifts the overall start and stop times of the pool equipment operations to suit the preference of the consumer.

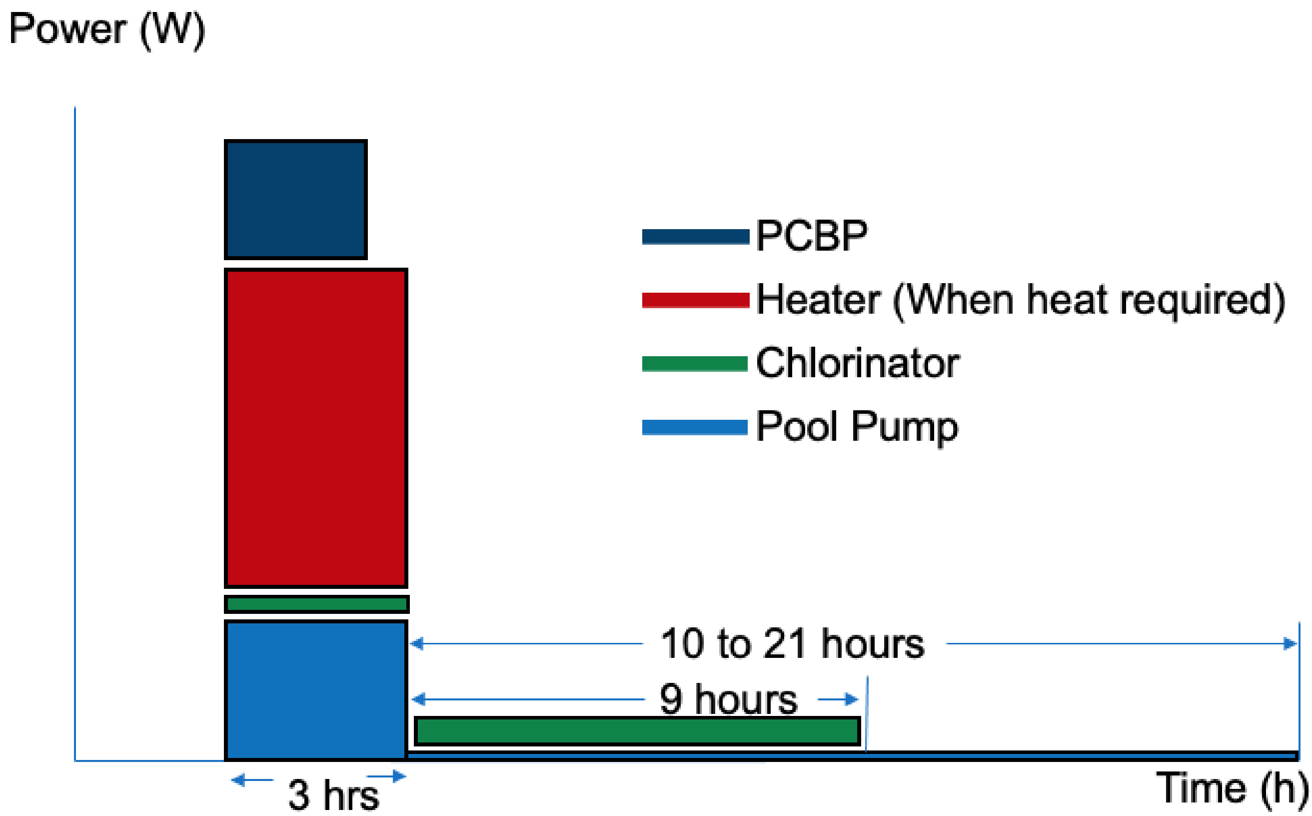
108 Energy Solutions Interim Report. 2020. *Connected Pool Pump Market Assessment*. Available at https://www.etcc-ca.com/reports/connected-pool-pump-market-assessment.

Figure A-1: Load Shape for Pool Control with Single Speed Pool Pump



Source: California Energy Commission

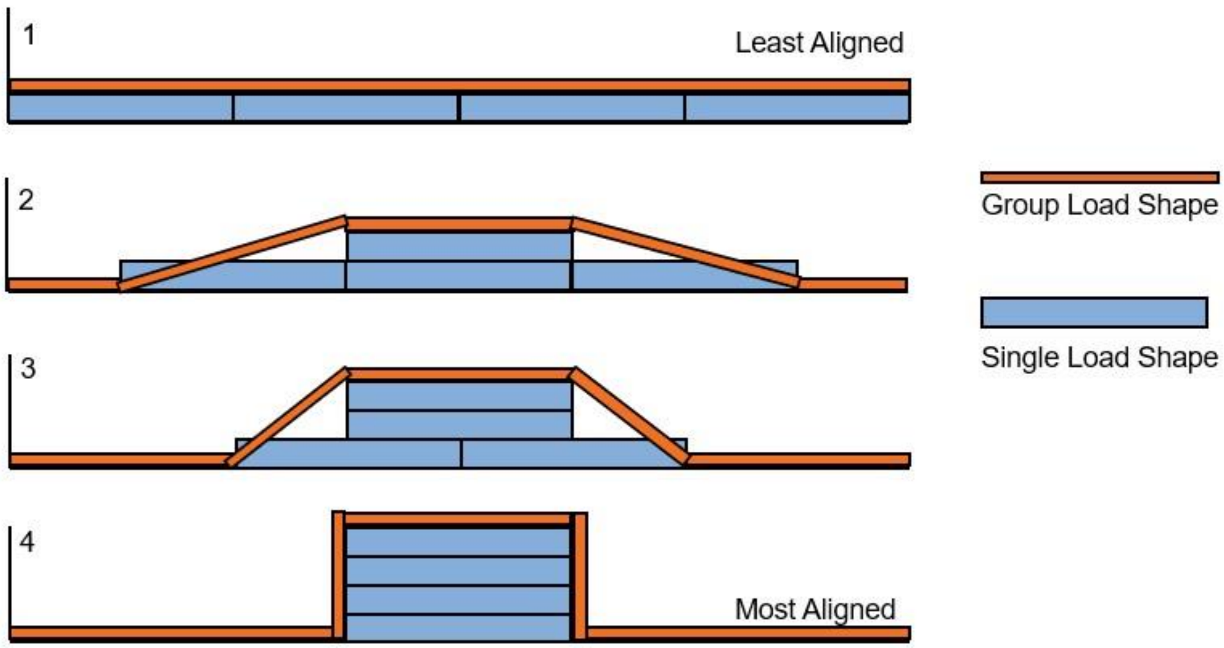
Figure A-2: Load Shape for Pool Control with Variable Speed Pool Pump



Source: California Energy Commission

Figure A-3 illustrates how shifting the overall schedules of individual pools can affect the overall electric load shape at a group level. Scenario one shown in the figure shows the effect on the group load shape if the individual pool schedules are distributed evenly during the day. The group load shape is evenly distributed. As the individual pool loads become more aligned the group load shape become more concentrated as shown in through scenarios two to four. The statewide analysis performed by staff uses this method to shift the start and stop times of pool equipment loads but without modifying the duration, combination, or sequence of the equipment operation.

Figure A-3: Group vs. Individual Pool Load Shape



Source: California Energy Commission

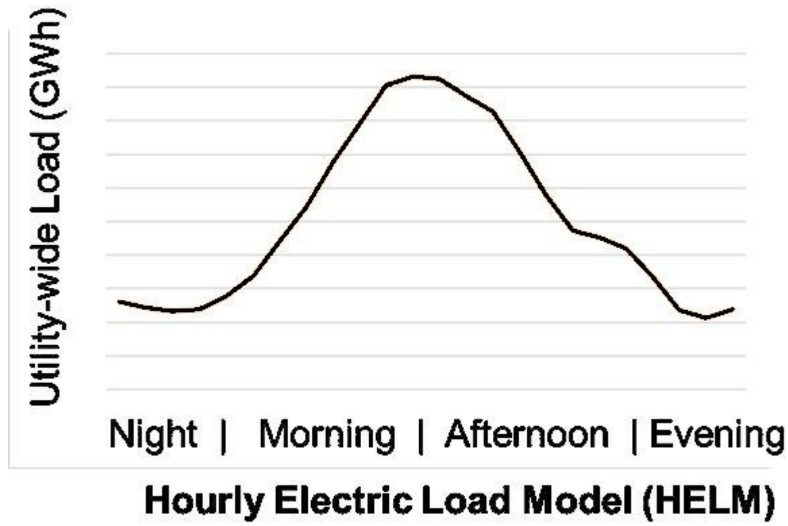
Statewide Pool Control Load Shape

Staff used the Hourly Electric Load Model (HELM) to provide load shape for the pool equipment for the calendar year 2024 and 2033. HELM provides an estimate of the load for each Electric Load Serving Entity (LSE) for each hour of the year. HELM was developed by ADM Associates for the CEC.[109] Staff compared the load shape to other studies and found agreement that pool pump load peaks around midday.[110] **Figure A-4** shows the average daily load shape for a pool pump load in California.

109 Baroiant, Sasha, John Barnes, Daniel Chapman, Steven Keates, and Jeffrey Phung (ADM Associates, Inc.). 2019. "California Investor-Owned Utility Electricity Load Shapes." CEC Publication Number: CEC-500-2019-046. Available at https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2019-046.pdf.

110 Frick, Natalie Mims, et al. 2019. "End-Use Load Profiles for the U.S. Building Stock." U.S. DOE. Available at https://www.nrel.gov/docs/fy20osti/75215.pdf.
Southern California Edison. 2015. "Demand Response Ready Pool Pumps for Residential Retrofit Using ZigBee/Wi-Fi." Available at https://www.dret-ca.com/wp-content/uploads/2019/07/DR12_08_dr_ready_pool_pumps_for_res_retrofit_final.pdf.

Figure A-4: HELM Average Daily Pool Pump Load Shape



Source: CEC and ADM Associates

The HELM model data provides pool pump electric load and pool heater electric load. Staff estimated the total consumption of the other pool equipment controlled by the pool control using a ratio. For the purposes of determining the ratio of the energy used daily by the other pool equipment, staff estimated the average daily pool pump energy used. Staff then found a factor to scale the pool pump HELM load to represent the other pool equipment load controlled by the pool control. The other pool equipment load represents the load from a chlorinator and the PCBP. To determine the total pool control shape, staff totaled the HELM pool pump electric load, the HELM pool heater electric load, and the other pool electric load.

Example equation using information from **Table A-4** and **Figure A-1** to determine a scale factor to calculate the other pool equipment from the HELM model data:

Pool Pump Daily Load = Average Pool Pump Power x Single Speed Hours of Operation

10.2 (kWh) = 1,700 (W) x 6 (Hours)

Where:

Average Pool Pump Power =1,700 (W)

Single Speed Hours of operation = 6 (hours)

Other Pool Equipment Daily Load = Chlorinator (erosion) + PCBP

4.3 (kWh) = 0.6 (kWh) + 3.7 (kWh)

Where:

Chlorinator (erosion) = 0.6 (kWh)

PCBP = 3.7 (kWh)

Scaling Factor = Other Pool Equipment Daily Load / Pool Pump Daily Load

0.4 = 4.3 (kWh) /10.2 (kWh)

Where:

Other Pool Equipment Daily Load = 4.3 (kWh)

Pool Pump Daily Load = 10.2 (kWh)

Utility Time-of-Use Electric Rates

Time of use (TOU) and time of day (TOD) utility rate structures adjust the cost of the electricity through the day. The price of electricity tends to be higher in the late afternoon when solar photovoltaic generation is low or offline because the sun has set. The current peak time recognized by the four major load serving entities is 4 pm to 9 pm. Prices reach their highest peak in the summer season because electric load is high due to air conditioner use. During these times utility producers must switch to expensive generation technologies, which are usually older less efficient power plants. Charging consumers based on the generation costs, is a way to discourage electric energy use at these times. Moving energy use to earlier or later times of the day gives consumers the ability reduce their carbon footprint, save money, or do both. **Figure A-5, Figure A-6, Figure A-7, Figure A-8, Figure A-9, Table A-5, Table A-6, Table A-7, Table A-8, Table A-9, Table A-10, Table A-11, Table A-12, Table A-13, and Table A-14** show the utility electricity rate structures used for the staff analysis.

To develop projections of electric utility rates, staff started with the currently posted tariffs for PG&E TOU-C, SCE D-TOU-4-9, SDGE TOU-DR1, SMUD TOD 5-8, and LADWP R1-A. The forecast-year TOU rates assume the same period definitions and overall rate design as current tariffs, maintaining either the same peak-to-off peak price ratio or cents per kWh differential.

Staff calculated forecasted TOU rates to be revenue-neutral to the forecasted annual average residential class electricity rate. This means the utility collects the same total revenue from the TOU rate as under the flat rate, given the same forecast of usage, number of customers, and fixed charges. The annual average rate used is based on the 2022 IEPR residential electricity rate forecast. The rate forecasts for SDG&E, SMUD, and LADWP are the Planning Area Rates

Tab 1. SCE and PG&E forecasts are shown on the IOU Distribution Service Area Rate Forecast Tab 3.[111]

The forecasted annual rates are derived as the forecasted revenue requirements divided by forecasted sales. The sales forecast used is based on the Additional Transportation Electrification forecast adopted at the May 24, 2022 Business Meeting.[112] By 2033, this sales forecast is significantly higher than the 2021 IEPR mid case, diluting the per-kwh rate impact of those revenue requirement elements that don't increase proportionately with usage, resulting in a lower electricity rate forecast.

Staff used hourly load profiles from the 2019 California Residential Appliance Saturation Study (RASS) to allocate shares of usage to time periods. For SCE, SDGE, and SMUD, staff held the peak-to off peak ratio fixed for forecast years. For PG&E, the CPUC decision D.21-11-016 has approved a settlement specifying that the Schedule E-TOU-C peak to off-peak cents per kWh differentials are kept at their current levels until twelve months after the last cohort of PG&E's customers is migrated to default TOU rates. After that, the differentials increase gradually from 6.3 to 8.3 cents per kWh in summer, and from 1.7 to 2.8 cents per kWh in winter. The forecasted PG&E TOU-C rates incorporate the specified differentials.

Because the staff input assumptions, such as sales and RASS usage statistics used to calculate total revenue requirements are likely to differ from that used by the utility in setting rates, staff applied a calibration factor to align the modeled rate and revenue requirement with the posted tariff in 2022. Staff applied the same calibration factor for to all forecast years. Finally, the forecasted rates for each time period are mapped to each hour in the year, as specified by the utility tariff.

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111 CEC. 2021. "IOU Distribution Service Area Rate Forecast." Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=242432&DocumentContentId=75933.

112 CEC. 2022. "Adoption of the Demand Scenario Results, Updated May 31, 2022." Available at https://www.energy.ca.gov/event/workshop/2022-04/iepr-staff-workshop-demand-scenarios.

Table A-5: LADWP Electricity Rates 2024

Season	Rate ($2022)
Winter	0.23
April /May	0.22
June	0.22
Summer	0.24
Winter	0.24

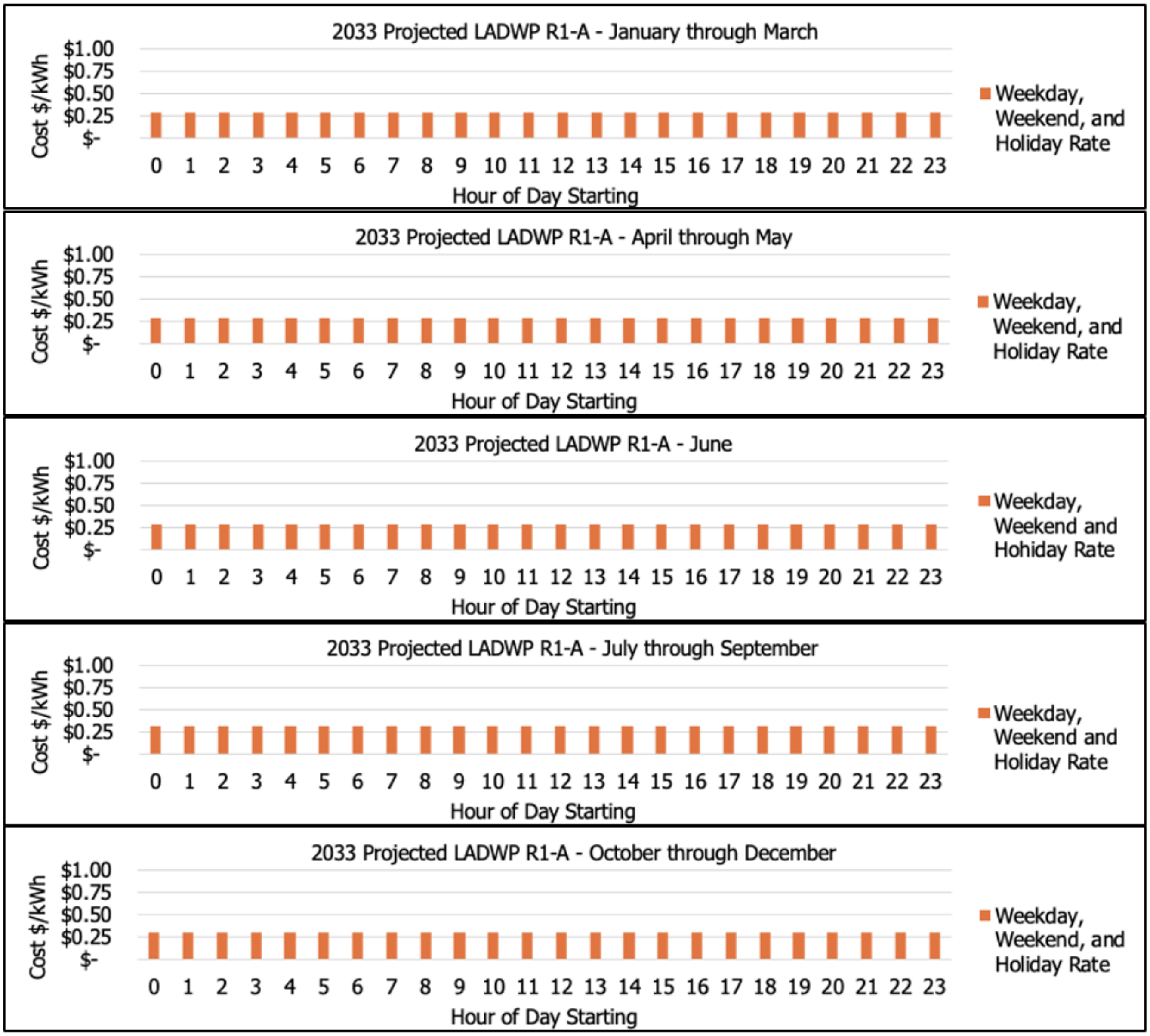
Source: California Energy Commission

Table A-6: LADWP Electricity Rates 2033

Season	Rate ($2022)
Winter	0.29
April /May	0.29
June	0.29
Summer	0.31
Winter	0.31

Source: California Energy Commission

Figure A-5: LADWP Fixed Electricity Rates In $2022



Source: California Energy Commission

Table A-7: PG&E Electricity Rates 2024

Season	Peak Hours	Peak Rate ($2022)	Off-Peak Hours	Off-Peak Rate ($2022)
Winter Oct. 1 – May 31	4 pm – 9 pm	0.34	9 pm – 4 pm	0.31
Summer Jun. 1 – Sept.30	4 pm – 9 pm	0.44	9 pm – 4 pm	0.36

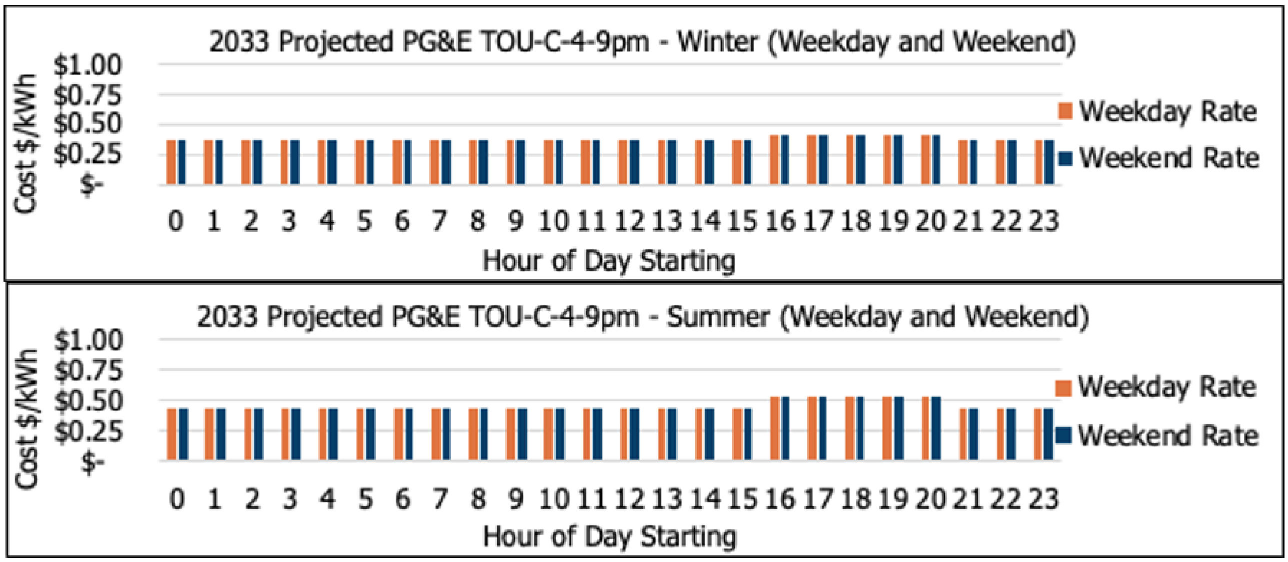
Source: California Energy Commission

Table A-8: PG&E Electricity Rates 2033

Season	Peak Hours	Peak Rate ($2022)	Off-Peak Hours	Off-Peak Rate ($2022)
Winter Oct. 1 – May 31	4 pm – 9 pm	0.41	9 pm – 4 pm	0.38
Summer Jun. 1 – Sept. 30	4 pm – 9 pm	0.54	9 pm – 4 pm	0.43

Source: California Energy Commission

Figure A-6: PG&E TOU Electricity Rates In $2022



Source: California Energy Commission

Table A-9: SCE Electricity Rates 2024

Season	Peak Hours	Peak Rate ($2022)	Mid-Peak Hours	Mid-Peak Rate ($2022)	Off-Peak Hours	Off-Peak Rate ($2022)
Winter Oct. 1 – May 31	4 pm – 9 pm	0.43	9 pm – 8 am	0.31	8 am – 4 pm	0.28
Summer Jun. 1 – Sept.30	4 pm – 9 pm	0.49 (0.39*)	–	–	9 pm – 4 pm	0.29

*Weekends and holidays

Source: California Energy Commission

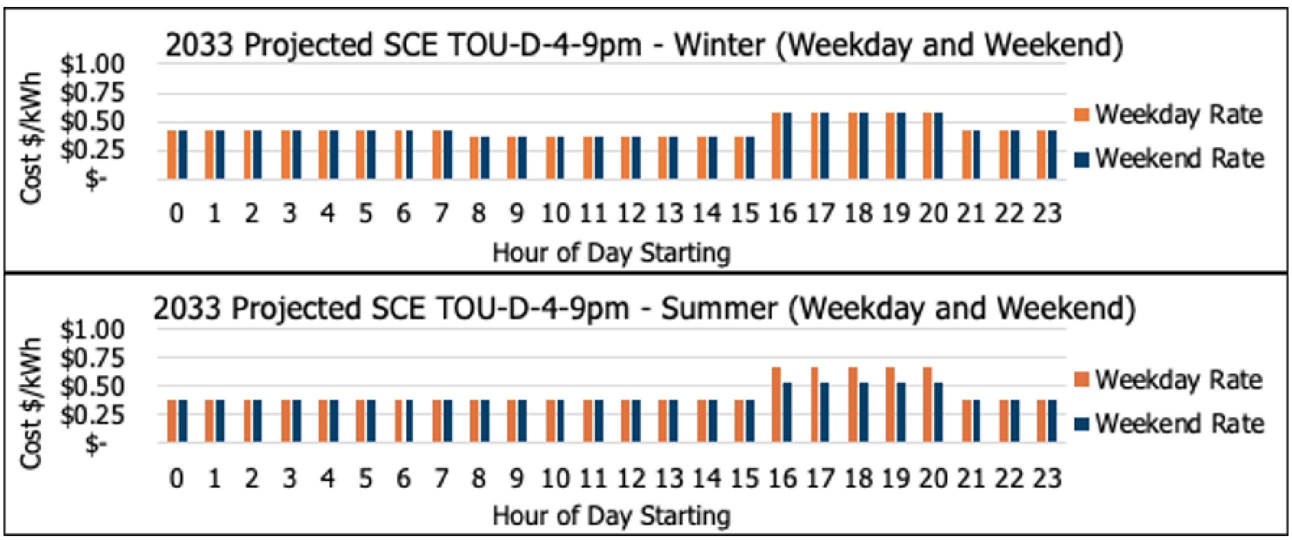
Table A-10: SCE Electricity Rates 2033

Season	Peak Hours	Peak Rate ($2022)	Mid-Peak Hours	Mid-Peak Rate ($2022)	Off-Peak Hours	Off-Peak Rate ($2022)
Winter Oct. 1 – May 31	4 pm – 9 pm	0.58	9 pm – 8 am	0.42	8 am – 4 pm	0.37
Summer Jun. 1 – Sept.30	4 pm – 9 pm	0.67 (0.58*)	–	–	9 pm – 4 pm	0.39

*Weekends and holidays

Source: California Energy Commission

Figure A-7: SCE TOU Electricity Rates In $2022



Source: California Energy Commission

Table A-11: SDG&E Electricity Rates Weekdays 2024

Season	Peak Hours	Peak Rate ($2022)	Mid-Peak Hours	Mid-Peak Rate ($2022)	Off-Peak Hours	Off-Peak Rate ($2022)
Winter 1 Nov. 1 – Feb.28 & May 1 – May 31	4 pm – 9 pm	0.48	6 am – 4 pm & 9 pm – 12 am (2 pm – 4 pm & 9 pm – 12 am*)	0.41	12 am – 6 am (12 am – 6 am*)	0.39
Winter 2 Mar. 1 – Apr. 30	4 pm – 9 pm	0.48	6 am – 10 am & 2 pm – 4 pm & 9 pm – 12 am (2 pm – 4 pm & 9 pm – 12 am*)	0.41	12 am – 6 am & 10 am – 2 pm (12 am – 2 pm*)	0.39
Summer Jun. 1 – Oct.31	4 pm – 9 pm	0.62	6 am – 4 pm & 9 pm – 12 am (2 pm – 4 pm & 9 pm – 12 am*)	0.39	12 am – 6 am (12 am – 2 pm*)	0.27

*Weekends and holidays

Source: California Energy Commission

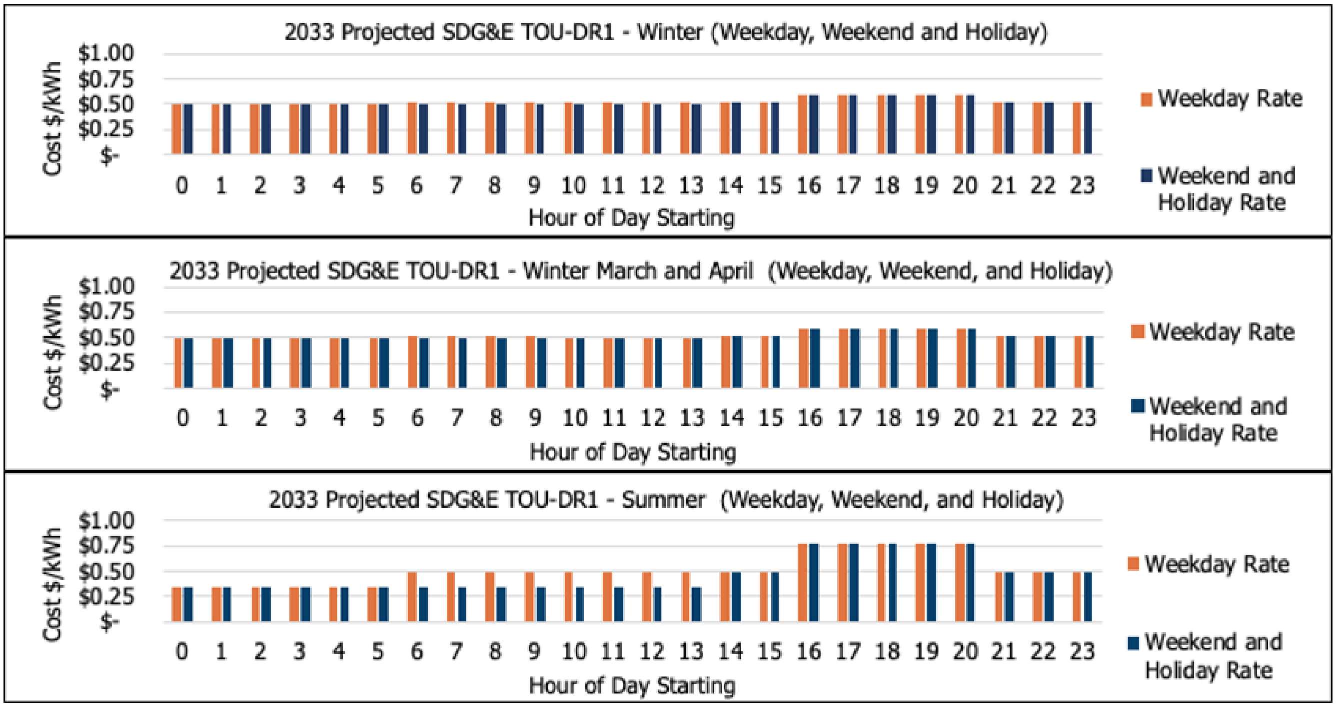
Table A-12: SDG&E Electricity Rates Weekdays 2033

Season	Peak Hours	Peak Rate ($2022)	Mid-Peak Hours	Mid-Peak Rate ($2022)	Off-Peak Hours	Off-Peak Rate ($2022)
Winter 1 Nov. 1 – Feb.28 & May 1 – May 31	4 pm – 9 pm	0.59	6 am – 4 pm & 9 pm – 12 am (2 pm – 4 pm & 9 pm – 12 am*)	0.51	12 am – 6 am (12 am – 2 pm*)	0.49
Winter 2 Mar. 1 – Apr. 30	4 pm – 9 pm	0.59	6 am – 10 am & 2 pm – 4 pm & 9 pm – 12 am (2 pm – 4 pm & 9 pm – 12 am*)	0.51	12 am – 6 am & 10 am – 2 pm (12 am – 2 pm*)	0.49
Summer Jun. 1 – Oct.31	4 pm – 9 pm	0.77	6 am – 4 pm & 9 pm – 12 am (2 pm – 4 pm & 9 pm – 12 am*)	0.48	12 am – 6 am (12 am – 2 pm*)	0.34

*Weekends and holidays

Source: California Energy Commission

Figure A-8: SDG&E TOU Electricity Rates In $2022



Source: California Energy Commission

Table A-13: SMUD Electricity Rates 2024

Season	Peak Hours	Peak Rate ($2022)	Mid-Peak Hours	Mid-Peak Rate ($2022)	Off-Peak Hours	Off-Peak Rate ($2022)
Winter Oct. 1 – May 31	5 pm – 8 pm	0.16	–	–	8 pm – 5 pm	0.12
Summer Jun. 1– Sept. 30	5 pm – 8 pm	0.34	12 pm – 5 pm & 8 pm – 12 am	0.19	12 am – 12 pm	0.14

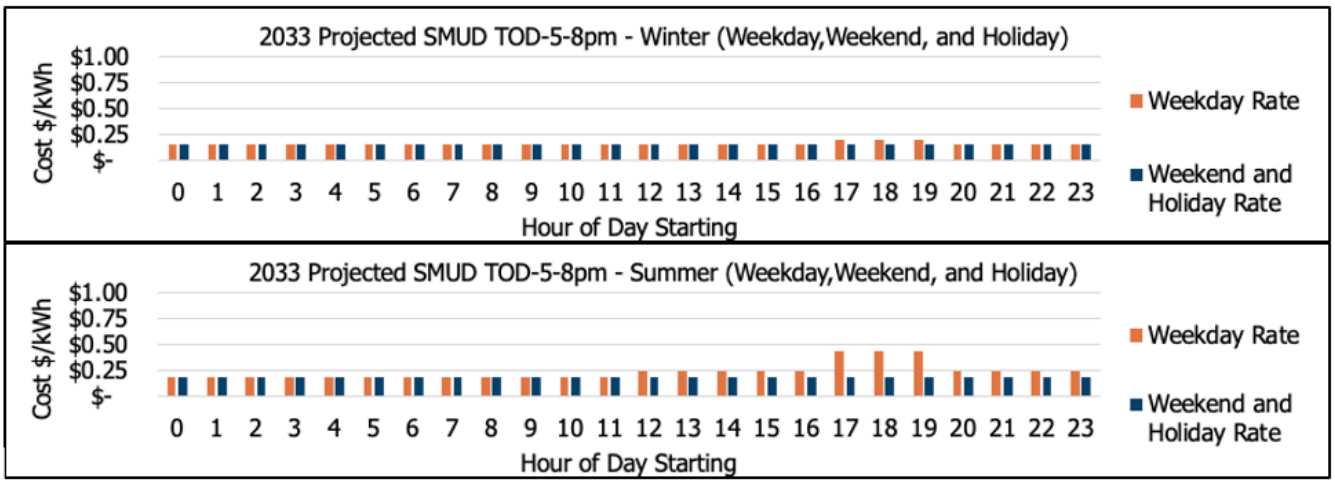
Source: California Energy Commission

Table A-14: SMUD Electricity Rates 2033

Season	Peak Hours	Peak Rate ($2022)	Mid-Peak Hours	Mid-Peak Rate ($2022)	Off-Peak Hours	Off-Peak Rate ($2022)
Winter Oct. 1 – May 31	5 pm – 8 pm	0.21	–	–	8 pm – 5 pm	0.15
Summer Jun. 1 – Sept. 30	5 pm – 8 pm	0.44	12 pm – 5 pm & 8 pm – 12 am	0.25	12 am – 12 pm	0.18

Source: California Energy Commission

Figure A-9: SMUD TOD Electricity Rates In $2022



Source: California Energy Commission

Marginal GHG Emission Rates

The hourly GHG emissions values are based on marginal hourly GHG emissions values for a middle demand, middle price, middle additional achievable energy efficiency scenario provided by staff in the CEC Energy Assessment Division (EAD). These values shown in **Figure A-10** are example CO_2e figures from the energy supply forecast in the 2021 Integrated Energy Policy Report (IEPR).[113]

113 CEC. 2021. "IEPR Session 2-Comissioner Workshop on Data Inputs and Assumptions for 2021 IEPR Modeling and Forecasting Activities." Available at https://efiling.energy.ca.gov/getdocument.aspx?tn=239170.

Figure A-10: Default Schedule Aligned with Low GHG Emissions (MTCO2e/MWh)

Hours	Winter			Spring			Summer			Fall		
Outside Default Schedule 12 am to 8:59 am	0.37	0.35	0.34	0.26	0.14	0.12	0.15	0.32	0.35	0.36	0.37	0.35
	0.37	0.36	0.34	0.25	0.16	0.13	0.17	0.32	0.37	0.37	0.37	0.36
	0.38	0.36	0.34	0.26	0.16	0.15	0.19	0.33	0.38	0.38	0.38	0.36
	0.38	0.36	0.34	0.26	0.17	0.16	0.21	0.33	0.38	0.38	0.38	0.36
	0.37	0.36	0.34	0.25	0.17	0.16	0.21	0.33	0.37	0.37	0.37	0.36
	0.37	0.35	0.34	0.24	0.14	0.14	0.20	0.33	0.37	0.36	0.36	0.35
	0.35	0.33	0.32	0.24	0.16	0.12	0.13	0.30	0.35	0.36	0.35	0.34
	0.34	0.32	0.28	0.12	0.05	0.04	0.04	0.12	0.15	0.27	0.28	0.31
	0.22	0.20	0.10	0.04	0.03	0.03	0.03	0.05	0.06	0.07	0.07	0.10
Default Schedule 9am to 3pm	0.08	0.08	0.05	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05
	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.05
	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.06	0.05	0.05
	0.08	0.07	0.04	0.03	0.03	0.03	0.04	0.06	0.07	0.08	0.06	0.06
Outside Default Schedule 3:01pm to 12 am	0.29	0.23	0.06	0.04	0.04	0.04	0.04	0.09	0.12	0.21	0.20	0.23
	0.34	0.33	0.28	0.14	0.05	0.05	0.05	0.11	0.18	0.27	0.30	0.32
	0.32	0.31	0.30	0.20	0.09	0.08	0.08	0.16	0.23	0.28	0.30	0.31
	0.31	0.30	0.28	0.19	0.13	0.09	0.13	0.24	0.30	0.31	0.29	0.30
	0.31	0.29	0.26	0.18	0.13	0.13	0.18	0.28	0.31	0.31	0.29	0.30
	0.32	0.30	0.27	0.17	0.13	0.12	0.18	0.29	0.31	0.32	0.31	0.31
	0.33	0.31	0.29	0.18	0.11	0.09	0.15	0.28	0.32	0.33	0.33	0.32
	0.34	0.33	0.31	0.21	0.11	0.09	0.14	0.30	0.33	0.35	0.35	0.34
	0.36	0.34	0.32	0.23	0.13	0.12	0.14	0.32	0.34	0.36	0.36	0.35
Move Electric Energy Use to times of peak solar production and lowest emissions (green fill)												

Source: California Energy Commission

The CEC's EAD staff used a PLEXOS[114] simulation to calculate the CO_2e emissions for in state generation and imported power. The CO_2e emissions for California's generation are calculated using projected fuel use (1000 MMBTUs) from PLEXOS for the middle case scenario and the U.S. EPA fuel conversion factors. The CO_2e emissions for California's imported power are calculated assuming a fuel mix of imported power (MWh). GHGs from imports to California are calculated based off an emission intensity factor dependent on the type of import, including specified fossil fuel, specified GHG free, or unspecified. Pacific Northwest imports get 20% of the unspecified CO_2e emissions rate of 0.428 $mTCO_2$/MWh through 2023, 30% for 2024 through 2026, and 50% starting in the year 2027.

Consumer Preferences

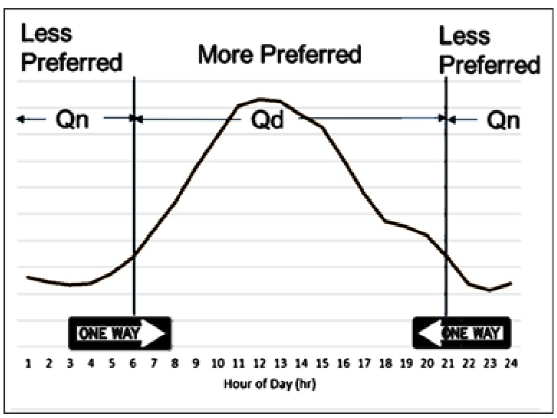
Consumers make decisions based upon their preferences. Consumers may have preferences to save money, minimize impact to the environment, or run pool equipment that minimizes any

114 Energy Exemplar. 2022. "PLEXOS Unified Energy Market Simulation Platform." Available at https://www.energyexemplar.com/plexos.

inconvenience. Consumers may also choose to run pool equipment based upon their previous experience. Stakeholders have commented that consumers are often not aware of the operation of their pool equipment and would likely accept shifts to the operation schedule without perceiving an inconvenience.[115]

Staff applied principles of microeconomics and consumer behavior to evaluate how consumers may choose to shift load due to TOU electric rates, marginal GHG emission rates, and combined TOU electric rates and marginal GHG emission rates.[116] Staff also considered a constant pool equipment schedule centered at noon as another alternative. Since there are few if any inconveniences to shifting pool equipment load during the day, staff assumed consumers would shift load to maximize their benefits. Staff evaluated scenarios where consumers are assumed to maximize their benefits per the four strategies. Since the HELM and other load profile data show such a strong consumer preference for pumping during the day, staff limited shifting load from day to night because such shifts may not be acceptable due to noise or effectiveness of chlorination. **Figure A-11** shows how consumer preference constrains shifting load from day to night.

Figure A-11: Preference for Pool Operations During Day



Name	Pumping Period (24 hr time)	Pumping Task(s)	Consumer Preference
Night Pumping (Qn)	21:00-06:00	Filtering	Low (noisy, chlorination not as effective, no filtering during swimming)
Day Pumping (Qd)	06:00-21:00	Filtering, chlorination, heating, sweeping, heating	High (noise not an issue, chlorination effective, filtering while swimming

Source: California Energy Commission

Load Shift Analysis

Staff created a model to study the impacts of load shifting based on TOU electric rates, load shifting based on marginal GHG emission rates, load shifting based on combined TOU electric and marginal GHG emission rates, and load shifting based on a default operation schedule. The model sets a baseline assuming no regulation and scenarios assuming different regulatory

115 Meeting with pool control manufacturers on February 11, 2022.

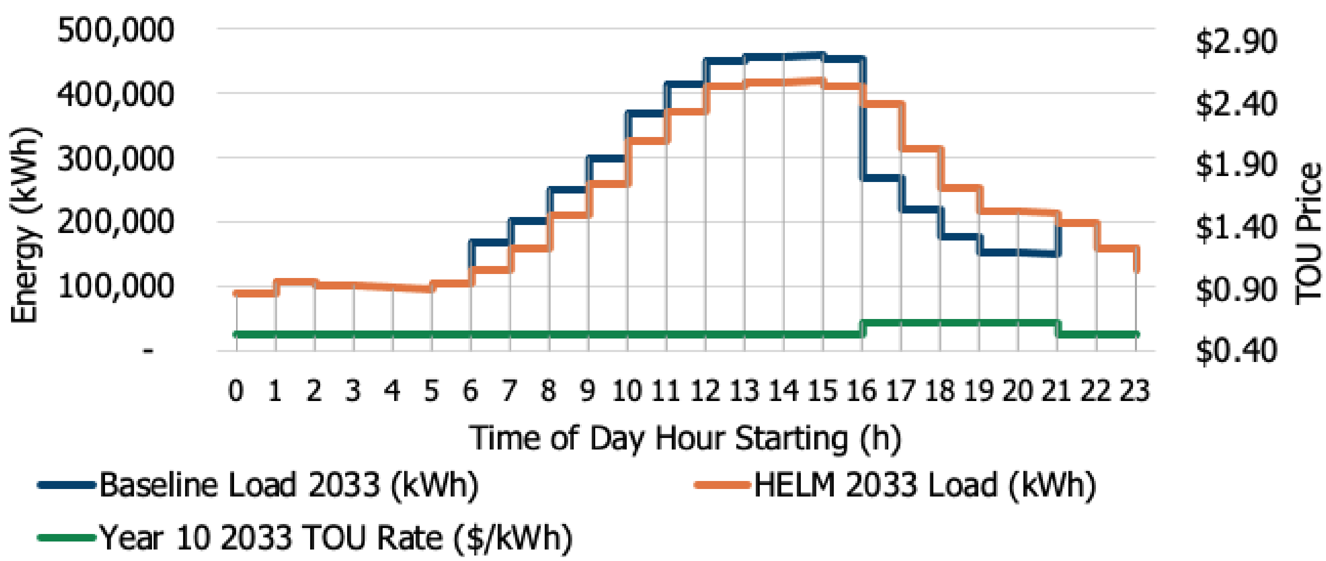
116 Neenan, Bernard and Jiyong Eom. Electric Power Research Institute. 2008. "Price Elasticity of Demand for Electricity: A Primer and Synthesis." Available at https://www.epri.com/research/products/1016264.

approaches. The analysis calculates the impacts 1 year and 10 years after the effective date, assumed for this analysis to be January 1, 2024.[117]

Analysis Baseline

Staff generated a baseline scenario assuming 70% of consumers schedule pool equipment load per the HELM load shape while 30% shift their load to maximize electric bill savings per the TOU electric rate. Staff assumed to account for shifts in load shape due to the introduction of TOU electric rates that were not widely available when the HELM load shape was created. **Figure A-12** provides a comparison of the HELM load shape and the baseline scenario load shape for PG&E utility territory. Staff created similar baselines for the four other LSE of the analysis. Staff created a 1-year and 10-year baseline to account for changes in compliance rate, marginal GHG emission rate and TOU electric rate between these times.

Figure A-12: Comparison HELM Load Shape Data and Baseline Load Shape



Source: California Energy Commission

Example equation for **Figure A-12**:

Baseline Load (year, LSE, day, hour) = HELM load (year, LSE, day, hour) x Baseline compliance rate (year 2022)

166,291 (kW) (2033, PG&E, day 1, hour 9) = 237,559 (kW) x 70%

Where:

HELM load (2033, PG&E, day 1, hour 9) = 237,559 (kW)

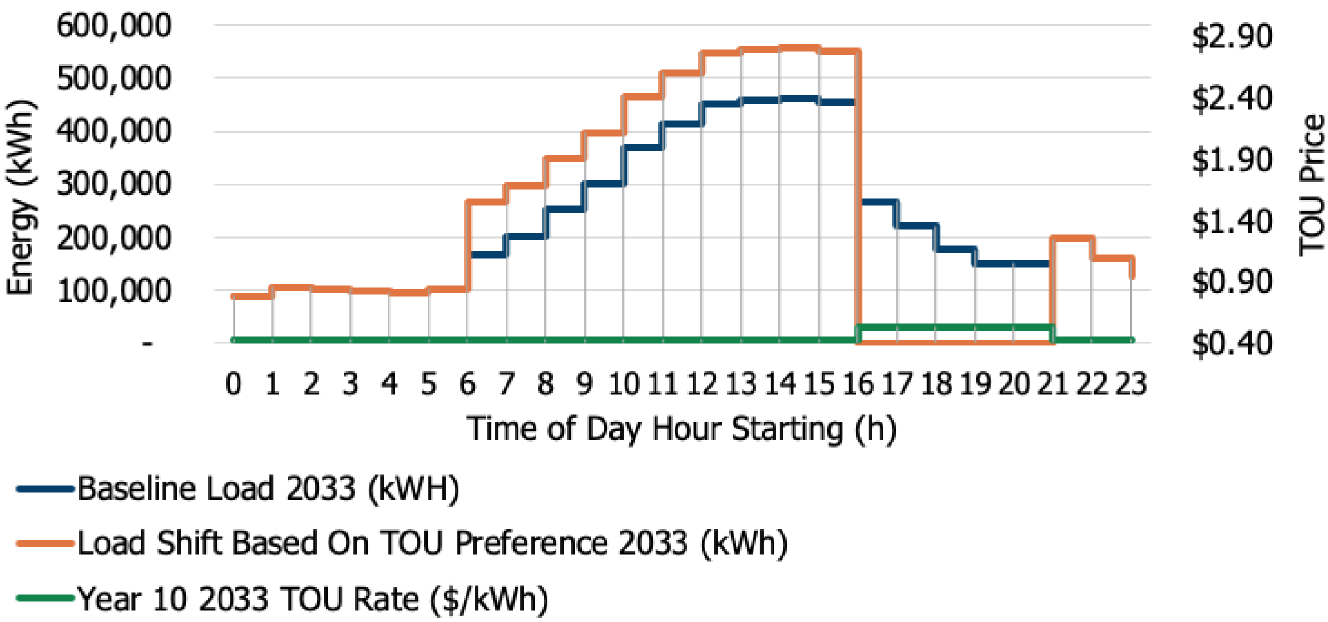
Baseline compliance rate = 70% (assumes 30% are already shifting based on a TOU rate)

117 Analysis assumes a 1-year effective date after the anticipated adoption on January 1, 2023.

Load Shift Based on TOU Electric Rate

Staff shifted load based upon the TOU electric rate to maximize consumer utility bill savings. Staff first ranked the TOU electric rate for each hour and then compared it to the rates available between 6:00 a.m. and 9 p.m. If a rate during the day was better than the rate at night, then the load during the night was shifted to the hours with the best rates during the day. Similarly, any hour during the day that had a higher rate than the lowest available during the day had its load shifted to the lower priced hour. The available shiftable load was evenly distributed among the hours with the lowest rate available during the day. **Figure A-13** illustrates the shifting based on TOU electric rates.

Figure A-13: Load Shifting Based on TOU Electric Rates



Source: California Energy Commission

Load shifting based on TOU rates yields reductions in load when the cost of electricity is high. Because TOU rates change only several times per day, they typically provide a signal to consumers of when not to use electricity. The rates do not provide a strong indication of where to put the load from the peak rate time. Therefore, shifting based on TOU rates results in strong consumer savings but lower GHG savings because the consumer lacks information on where to place the load shifted from the higher TOU rate period. **Table A-15** shows the resulting utility bill savings and the GHG emissions avoided for each utility for the Alternate 1 Load Shifting based on TOU electric rates. For LADWP the values are zero because of their fixed price tiered rate structure.

Table A-15: Load Shifting Based on TOU Electric Rates Results

Utility	Utility Bill Savings during year 2024 ($2022)	GHG Emissions Avoided during 2024 (metric tons CO_2e)	Utility Bill Savings during year 2033 ($2022)	GHG Emissions Avoided during 2033 (metric tons CO_2e)
SMUD	240,000	(160)	3,600,000	(650)
SCE	8,000,000	6,100	120,000,000	78,000
LADWP	0	0	0	0
PGE	1,400,000	670	17,000,000	14,000
SDGE	1,800,000	340	23,000,000	5,300
Total	11,400,000	7,000	160,000,000	97,000

Source: California Energy Commission

For each LSE, staff multiplied the hourly utility rate by the difference in the hourly baseline and shifted energy consumption to calculate the customer utility bill change.

Example equations for **Table A-15**, **Table A-16, Table A-17,** and **Table A-18** to calculate change in customer utility bill for the staff proposal from load shifting for each hour of an entire year for a single LSE:

LSE utility bill (year, LSE, day, hour) ($) = (Proposal load (year, LSE, day, hour) – Baseline Load (year, LSE, day, hour)) x Utility Rate (year, LSE, day, hour)

$55,474 (2033, SDG&E hour 9, day 1) = (208,847 kW – 95,634 kW) x $0.49 ($/kWh)

Where:

Proposal load (2033, SDG&E, day 1, hour 9) (kW) =208,847 kW

Baseline Load (2033, SDG&E, day 1, hour 9) (kW) = 95,634 kW

Utility Rate (2033, SDG&E, day 1, hour 9) ($/kWh) = $0.49

Staff totaled the utility bill savings for every hour of each day, for the entire year for each LSE. Only the first three days and the last day are shown below to simplify the example for a single LSE:

Utility Bill Savings (during a year) = Utility Bill Savings (year, LSE, day 1, hour 1) + Utility Bill Savings (year, LSE, day 1, hour 2) + Utility Bill Savings (year, LSE, day 1, hour 3) + … + Utility Bill Savings (year, LSE, day 365, hour 24)

$20,583,466 (2033, SDG&E) = $16,206.00 (2033, SDG&E, day 1, hour 1) + $17,468.20 (2033, SDG&E, day 1, hour 2) + $16,282.97 (2033, SDG&E, day 1, hour 3) + … + $11,355.57(2033, SDG&E, day 365, hour 24)

Where:

Utility Bill Savings (2033, SDG&E, day 1, hour 1) = $16,206.00

Utility Bill Savings (2033, SDG&E, day 1, hour 2) = $17,468.20

Utility Bill Savings (2033, SDG&E, day 1, hour 3) = $16,282.97

Utility Bill Savings (2033, SDG&E, day 365, hour 24) = $11,355.57

For each LSE, staff multiplied the hourly marginal GHG emission rate by the difference in the pool controls hourly baseline load and the pool controls hourly proposal load. This calculation uses the hourly energy change to determine the associated GHG emissions.

Example equations for **Table A-15**, **Table A-16**, **Table A-17,** and **Table A-18** to calculate GHG emissions avoided from the staff proposal because the electrical load was shifted in time for a single LSE:

GHG Emissions Avoided (year, LSE, day, hour) = (Proposal load (year, LSE, day, hour) – Baseline Load (year, LSE, day, hour)) x GHG emission rate (year, day, hour)

4.6 (metric tons CO_2e) (2033, SDG&E hour 9, day 1) = (208,847 kW – 95,634 kW) x 0.000041 (metric tons CO_2e per kWh)

Where:

Proposal load (2033, SDG&E, day 1, hour 9) = 208,847 kW

Baseline Load (2033, SDG&E, day 1, hour 9) = 95,634 kW

GHG emission rate (2033, SDG&E, day 1, hour 9) = 0.000041 (metric tons CO_2e per kWh)

Staff totaled the GHG Emissions Avoided for every hour of each day, for the entire year for each LSE. Only the first three days and the last day are shown below to simplify the example for a single LSE:

GHG Emissions Avoided $_{\text{(during a year)}}$ = GHG Emissions Avoided $_{\text{(year, LSE, day 1, hour 1)}}$ + GHG Emissions Avoided $_{\text{(year, LSE, day 1, hour 2)}}$ + GHG Emissions Avoided $_{\text{(year, LSE, day 1, hour 3)}}$ + … + GHG Emissions Avoided $_{\text{LSE hour 24, day 365}}$

39,017 (metric tons CO_2e) $_{\text{(2033, SDG\&E)}}$ = 9.6817446 $_{\text{(2033, SDG\&E, day 1, hour 1)}}$ + 10.7574590 $_{\text{(2033, SDG\&E, day 1, hour 2)}}$ + 10.2274379 $_{\text{(2033, SDG\&E, day 1, hour 3)}}$ + … + 6.3443149 $_{\text{(2033, SDG\&E, day 365, hour 24)}}$

Where:

GHG Emissions Avoided $_{\text{(2033, SDG\&E, day 1, hour 1)}}$ = 9.6817446 (metric tons CO_2e)

GHG Emissions Avoided $_{\text{(2033, SDG\&E, day 1, hour 2)}}$ = 10.7574590 (metric tons CO_2e)

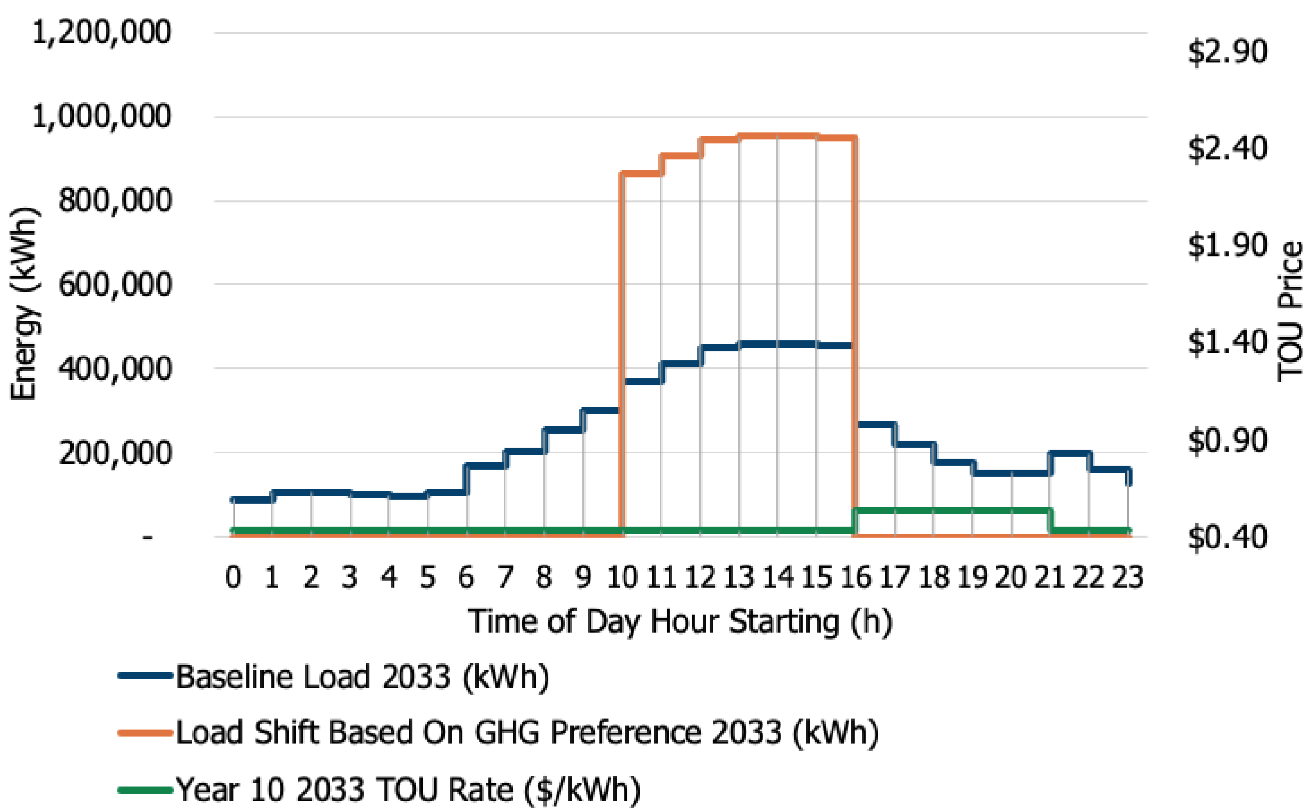
GHG Emissions Avoided $_{\text{(2033, SDG\&E, day 1, hour 3)}}$ = 10.2274379 (metric tons CO_2e)

GHG Emissions Avoided $_{\text{(2033, SDG\&E, day 365, hour 24)}}$ = 6.3443149 (metric tons CO_2e)

Load Shift Based on Marginal GHG Emission Rates

Staff pursued a similar ranking method for shifting based on marginal GHG emission rates. One difference was that the load was shifted into the best six hours by emission ranking. Load from all other hours was evenly distributed into the six lowest hours for GHG emissions. **Figure A-14** illustrates the shifting based on GHG marginal emission rates.

Figure A-14: Load Shifting Based on Marginal GHG Emission Rates



Source: California Energy Commission

Shifting load based on the lowest 6 hours of GHG marginal emissions yields the greatest GHG emission reductions. This strategy has an advantage over TOU rates in that the GHG signal is present on all days and weeks where TOU rates are often flat large parts of the day and for the entire day on weekends and holidays. The ever-present GHG signal ensures GHG savings every day of the year. Consumer bill savings are low because shifting based on GHG rates provides the consumer with no information on the rate. **Table A-16** shows the resulting utility bill savings and the GHG emissions avoided for each utility for the Alternate two Load Shifting based on Marginal GHG Emissions rates. For LADWP the utility bill savings values are zero because of LADWP's fixed price tiered rate structure. However, there are significant GHG emissions avoided for this proposal attributable to shifting based on Marginal GHG emissions rates for the Alternate two proposal.

Table A-16: Load Shifting Based on Marginal GHG Emissions Rates Results

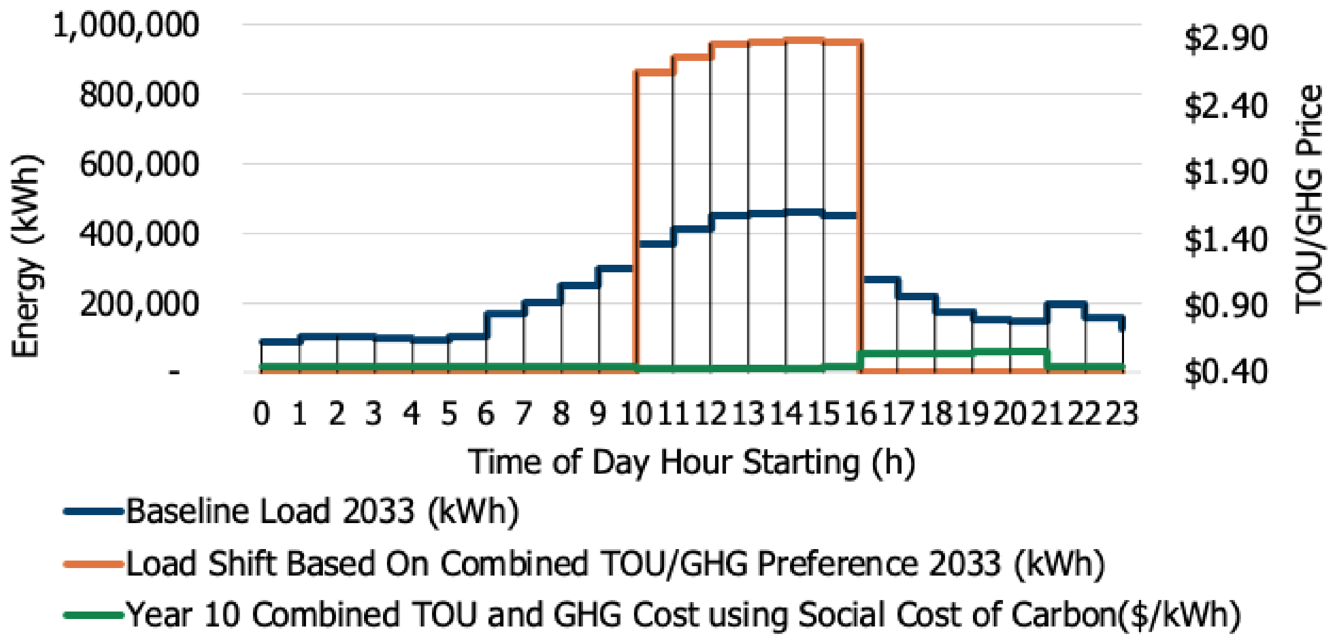
Utility	Utility Bill Savings during year 2024 ($2022)	GHG Emissions Avoided during 2024 (metric tons CO_2e)	Utility Bill Savings during year 2033 ($2022)	GHG Emissions Avoided during 2033 (metric tons CO_2e)
SMUD	(170,000)	1,600	510,000	18,000
SCE	2,500,000	17,000	93,000,000	180,000
LADWP	0	4,900	0	51,000
PGE	110,000	12,000	14,000,000	120,000
SDGE	(11,000)	4,200	11,000,000	41,000
Total	2,400,000	40,000	119,000,000	418,000

Source: California Energy Commission

Load Shift Based on Combined Marginal GHG Emission Rate and TOU Electric Rate

Staff applied the same method to shift load as per the TOU electric rate strategy. Staff created a combined marginal GHG emission rate and TOU electric rate signal by converting the GHG emission rate into a cost per kWh consumed. **Figure A-15** illustrates the shifting based on marginal GHG emission rates and TOU electric rates.

Figure A-15: Load Shifting Based on Combined Marginal Emission Rates and TOU Electric Rates



Source: California Energy Commission

Shifting based on a combined TOU and marginal GHG emission rate yields a result that is between shifting based on TOU or GHG emission rates alone. The addition of the Social Cost of Carbon to the TOU rate provides a small cost differential to assist the consumer or pool control to decide where to shift load from and where to put it. The addition of Social Cost of Carbon makes long periods of flat TOU pricing curved allowing for optimization of where to put shifted load. **Figure A-19** shows the source for the Social Cost of Carbon values and the text following the figure further describes the Social Cost of Carbon data source and assumptions. **Table A-17** shows the resulting utility bill savings and the GHG emissions avoided for each utility for the Alternate three Load Shifting based on TOU and Marginal GHG Emissions rates. For LADWP the utility bill savings values are zero because of their fixed price tiered rate structure. However, there are significant GHG emissions avoided for this proposal because of the shifting based on Marginal GHG emissions rates for the Alternate three proposal.

Table A-17: Load Shifting Based on Combined GHG and TOU Electric Rates Results

Utility	Utility Bill Savings during year 2024 ($2022)	GHG Emissions Avoided during 2024 (metric tons CO_2e)	Utility Bill Savings during year 2033 ($2022)	GHG Emissions Avoided during 2033 (metric tons CO_2e)
SMUD	240,000	1,000	3,600,000	13,000
SCE	8,000,000	16,000	120,000,000	180,000
LADWP	0	4,800	0	50,000
PGE	1,400,000	11,000	17,000,000	120,000
SDGE	1,800,000	2,800	23,000,000	29,000
Total	11,000,000	35,000	160,000,000	390,000

Source: California Energy Commission

The equation below shows how staff calculated the TOU electric rate and GHG emission rate are using the Social Cost of Carbon.

Equation showing calculation to determine the combined rate for a single LSE:

Combined rate $_{(year, LSE, day, hour)}$ = TOU rate $_{(year, LSE, day, hour)}$ + Marginal Emission rate $_{(year, day, hour)}$ x Social Cost of Carbon $_{(year)}$

0.49 $_{(2033, SDG\&E, day 1, hour 9)}$ ($/kWh) = 0.488771 $_{(2033, SDG\&E, day 1, hour 9)}$ ($/kWh) + 0.000041 $_{(2033, SDG\&E, day 1, hour 9)}$ (metric ton CO_2e /kWh) x 68.00 $_{(2033)}$ ($/metric ton CO_2e)

Where:

TOU rate $_{(2033, SDG\&E, day 1, hour 9)}$ = 0.488771 ($/kW)

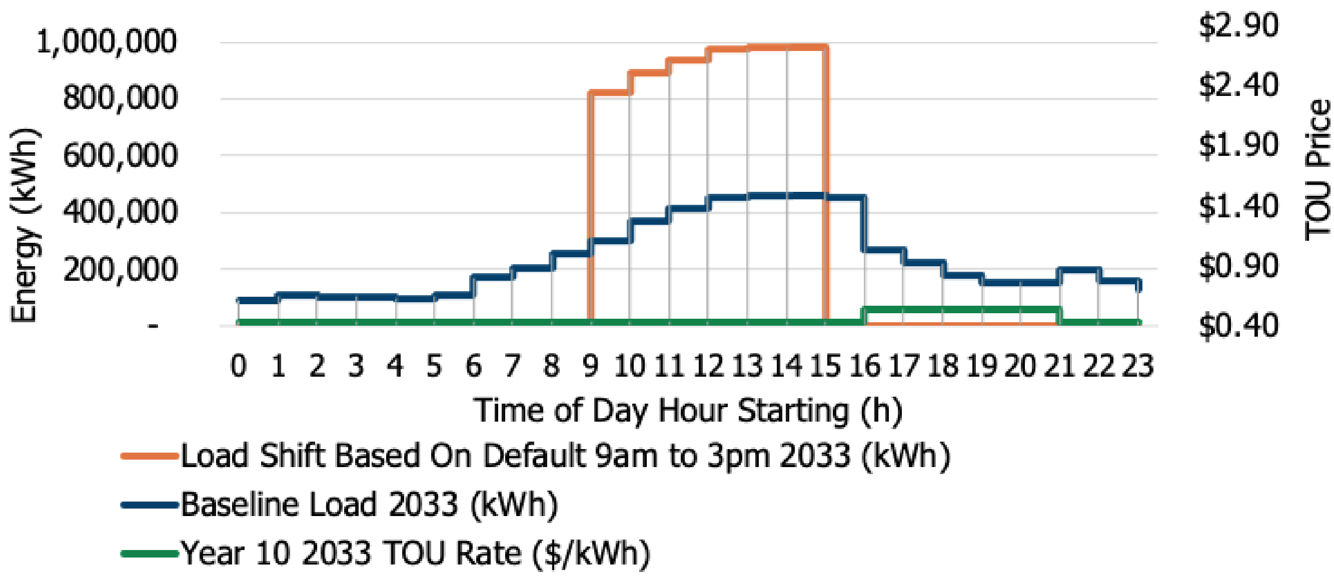
Marginal GHG emission rate $_{(2033, SDG\&E, day 1, hour 9)}$ = 0.000041 (metric tons CO_2e per kWh)

Social Cost of Carbon $_{(2033)}$ = $68.00

Load Shift to Default Schedule

Staff calculated the load shifted by the default schedule by adding up the load in all hours outside of the 9 a.m. to 3 p.m. schedule and then evenly distributing the load over the 9 a.m. to 3 p.m. time period. **Figure A-16** illustrates the shifting due to a default schedule.

Figure A-16: Load Shifting based on Default Schedule



Source: California Energy Commission

Staff devised the default schedule strategy by looking at the consistently low emissions for most days of the year between the hours of 9 AM and 3 PM PST. The strategy returns nearly the same GHG emission reductions as shifting based on a GHG rate. It returns higher consumer savings because lower TOU rates are found during the middle of the day on average. Shifting based on GHG rates alone sometimes causes the electric load to be placed in the peak TOU rate time to achieve only small gains in GHG savings over the middle of the day. These times can be found during the spring when load is light and stormy weather conditions cause a flatter GHG emissions profile during the day. **Table A-18** shows the resulting utility bill savings and the GHG emissions avoided for each utility for the staff proposal, Load Shifting based on Default Schedule. For LADWP the utility bill savings values are zero because of LADWP's fixed price tiered rate structure. However, there are significant GHG emissions avoided for this proposal because of the shifting based on Marginal GHG emissions rates for the staff proposal.

Table A-18: Load Shifting Based on Default Schedule Results

Utility	Utility Bill Savings during year 2024 ($2022)	GHG Emissions Avoided during 2024 (metric tons CO_2e)	Utility Bill Savings during year 2033 ($2022)	GHG Emissions Avoided during 2033 (metric tons CO_2e)
SMUD	88,000	1,400	1,300,000	17,000
SCE	8,000,000	14,000	120,000,000	170,000
LADWP	0	4,100	0	49,000
PGE	1,400,000	10,000	17,000,000	120,000
SDGE	1,300,000	3,500	16,000,000	40,000
Total	11,000,000	33,000	150,000,000	394,000

Source: California Energy Commission

Shifting Off Peak Analysis

The electricity grid's gross peak load occurs in late afternoon when consumers' demand for energy increases. But during high heat events, solar production is often declining when temperatures are still high, which means that the critical time for the grid can occur after sunset.[118]

The California ISO performed analysis and modeling to determine the probability of various capacity shortfall events occurring. CAISO simulated the Minimum Unloaded Capacity Margins (MUCM) of 2,000 scenarios. Simply put, the grid operator is required to maintain additional capacity that can be brought online for a short period of time to providing the grid a buffer. The amount of buffer is required to be greater than 6 percent.

Figure A-17 shows the distribution of the hour when each MUCM less than or equal to 6 percent occurred in comparison to the hours of solar generation during the 2021 summer peak day for sensitivity case.[119] **Figure A-17** shows the top 4 hours most likely requiring additional reserves are during hour 20, hour 19, hour 21 and hour 18.

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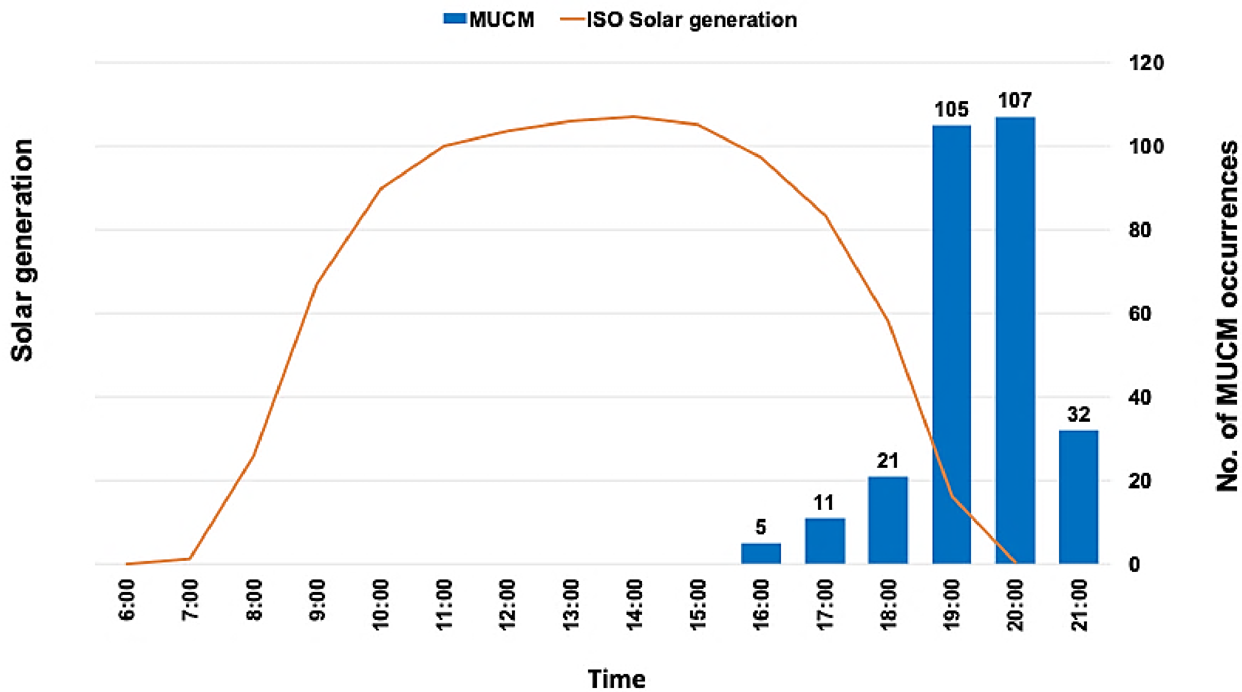
118 California ISO. 2022. "Gross & Net Load Peaks." Available at: http://www.caiso.com/documents/gross-and-net-load-peak-fact-sheet.pdf.

119 California ISO. 2022. "Summer Loads and Resources Assesment." Available at: http://www.caiso.com/Documents/2021-Summer-Loads-and-Resources-Assessment.pdf.

Figure A-17: CAISO Sensitivity Case MUCM Hour of Occurrence When 6 Percent or Less

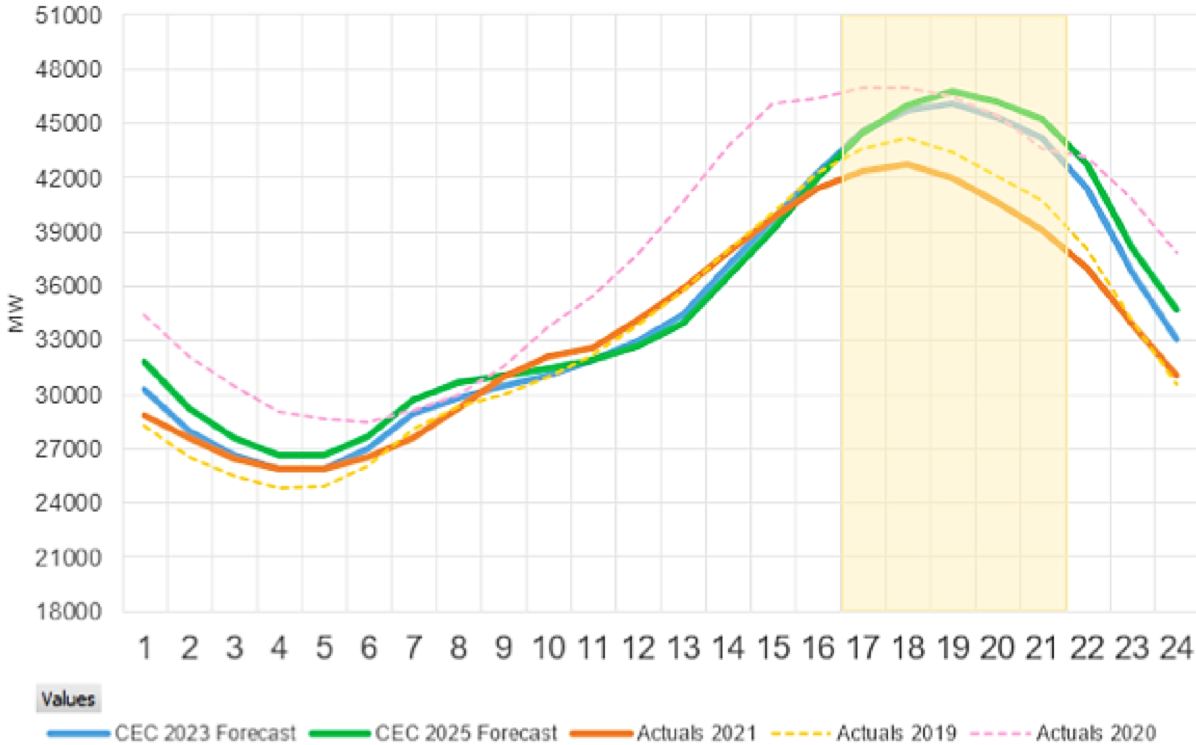


Source: California ISO

Figure A-18 highlights the hours of greatest reliability need for the California Grid into the near future.[120] **Figure A-18** also shows the current peaks and predicts a future higher peak for the top 4 hours most likely requiring additional reserves are during hour 20, hour 19, hour 21 and hour 18.

120 California ISO. 2022. "Draft 2023 Flexible Capacity Needs and Availability Assessment Hours Technical Study." Available at: http://www.caiso.com/InitiativeDocuments/Presentation-2023FlexibilityCapacityNeedsAssessment-Apr142022.pdf#search=hours%20of%20reliability.

Figure A-18: Expected CAISO Sumer Season Grid Load Shape Evolution



Source: California CEC, California ISO

Staff evaluated the proposals to determine the quantity of permanent load shifting away from the critical hours of the day for the year 2024 and the year 2033. Critical hours are typically the late afternoon and early evening during late summer and early fall. Staff evaluated the top 4 hours most likely requiring additional reserves, hour 18, hour 19, hour 20 and hour 21. The electrical load change from the baseline due to the proposal is the permanent load shift. The future load shape for pool controls will be permanently changed because of the standard.

Example equations using information from **Figure A-17** and **Figure A-18** to calculate the permanent load shifting for each proposal for **Table 7-4** and **Table 9-4** for a single LSE:

Permanent Load Shift $_{\text{(year, LSE, day, hour)}}$ = Proposal load $_{\text{(year, LSE, day, hour)}}$ – Baseline Load $_{\text{(year, LSE, day, hour)}}$

-58,868 kW= 0 $_{\text{(2033, SDG\&E, day 230, hour 18)}}$ kW - 58,868 $_{\text{(2033, SDG\&E, day 230, hour 18)}}$ kW

Where:

Proposal Load $_{\text{(2033, SDG\&E, day 230, hour 18)}}$ = 0 kW

Baseline Load $_{\text{(2033, SDG\&E, day 230, hour 18)}}$ = 58,868 kW

Staff totaled the permanent load shift for every hour of the evaluation for each LSE. Only the first three days and the last day are shown for the full year 2033 permanent load shift below to simplify the example for a single LSE:

Permanent Load Shift (for a LSE during a year) = Permanent Load Shift (year, LSE, day 1, hour 18) + Permanent Load Shift (year, LSE, day 1, hour 19) + Permanent Load Shift (year, LSE, day 1, hour 20) + Permanent Load Shift (year, LSE, day 1, hour 21) +... + Permanent Load Shift (year, LSE, day 365, hour 21)

61,869,323 (2033, SDG&E) kW = 31,457 (2033, SDG&E, day 1, hour 18) + 26,633 (2033, SDG&E, day 1, hour 19) +25,178 (2033, SDG&E, day 1, hour 20) +23,104 (2033, SDG&E, day 1, hour 21) + ... + 27,233 (2033, SDG&E, day 365, hour 21)

Where:

Permanent Load Shift (2033, SDG&E, day 1, hour 18) = 31,457 kW

Permanent Load Shift (2033, SDG&E, day 1, hour 19) = 26,633 kW

Permanent Load Shift (2033, SDG&E, day 1, hour 20) = 25,178 kW

Permanent Load Shift (2033, SDG&E, day 1, hour 21) = 23,104 kW

Permanent Load Shift (2033, SDG&E, day 365, hour 21) = 27,233 kW

Staff totaled the Permanent Load Shift for evaluation periods for the LSEs.

Permanent Load Shift (during a year) = Permanent Load Shift (year, SDG&E) + Permanent Load Shift (year, PG&E) + Permanent Load Shift (year, SCE) + Permanent Load Shift (year, LADWP) Permanent Load Shift (year, SMUD)

682,416,839 (2033) kWh = 61,869,323 (2033, SDG&E) + 188,262,699 (2033, PG&E) + 304,414,193 (2033, SCE) + 98,946,961 (2033, LADWP) + 28,923,663 (2033, SMUD)

Where:

Permanent Load Shift (2033, SDG&E) = 61,869,323 kWh

Permanent Load Shift (2033, PG&E) = 188,262,699 kWh

Permanent Load Shift (2033, SCE) = 304,414,193 kWh

Permanent Load Shift (2033, LADWP) = 98,946,961 kWh

Permanent Load Shift (2033, SMUD) = 28,923,663 kWh

Converting units from kWh to GWh, divide by 1,000,000 and rounding to three significant digits:

682 GWh (2033) = 682,416,839 / 1,000,000

Cost-Effectiveness Analysis

Incremental Costs

Staff estimated incremental costs of pool controls that meet the proposal by gathering retail price data on outdoor smart switches designed to control pool pumps and pool heaters. Staff analyzed the data to estimate the cost difference to consumers with the addition of the connectivity and scheduling features. Staff studied the typical components required to manufacture a compliant IOT device. Staff reviewed retail pool equipment product features and size of the electric load to determine the incremental cost of meeting the proposed standard. Staff chose to study the incremental cost of a pool equipment switch and a simplified pool control to make an easier comparison between the costs of the compliant and noncompliant equipment. **Table A-19** presents an abridged summary of the staff research. Staff estimate the incremental cost to add connectivity and a default control is $70.

Table A-19: Retail Cost of a Heavy-Duty Pool Equipment Switch (In $2022)

Pool Equipment Switch Type	Compliant / Non-compliant	Price Range
Mechanical	Non-compliant	$60-$120
Electronic with no WIFI	Non-compliant	$130-$150
Electronic with WIFI	Compliant	$130-$170

Source: California Energy Commission

Example equation for incremental cost:

Incremental Cost = Cost of compliant product – cost of non-compliant product

$70 = $130-$60

Where:

Cost of compliant product = $130

Cost of non-compliant product = $60

Avoided Costs of Greenhouse Gas Emissions

Staff determined a value for the avoided GHG emissions due to the proposals. Staff multiplied the total annual GHG emissions reduction due to the proposal by the Social Cost of Carbon. The emissions factors for quantity of hourly avoided GHG emissions are due to shift in timing of electricity consumption are based upon analysis conducted for the 2021 IEPR forecast on California electricity supply.[121]

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121 CEC. 2021. "IEPR Session 2-Comissioner Workshop on Data Inputs and Assumptions for 2021 IEPR Modeling and Forecasting Activities." Available at https://efiling.energy.ca.gov/getdocument.aspx?tn=239170.

On January 20, 2021, President Biden issued E.O. 13990 which re-established the Interagency Working Group (IWG) on the Social Cost of Greenhouse Gases. The task of the IWG is to ensure that the estimates agencies use when monetizing the value of changes in greenhouse gas emissions resulting from regulation continues to reflect the best available science and methodologies. **Figure A-19** shows the Technical Support Document (TSD), which provides the following interim estimates of the Social Cost of Carbon.

Figure A-19: Social Cost of Carbon, 2020-2050 (In $2020 per $MTCO_2$)

Emissions Year	Discount Rate and Statistic: 5% Average	3% Average	2.5% Average	3% 95th Percentile
2020	14	51	76	152
2025	17	56	83	169
2030	19	62	89	187
2035	22	67	96	206
2040	25	73	103	225
2045	28	79	110	242
2050	32	85	116	260

Source: White House Interagency Working Group

Staff selected the 3% average rates closest to the first year of the FDAS regulation and the tenth year of the FDAS regulation. Staff used the value of $56 for the year 2025 to calculate year one values. The value is $61 when adjusted to 2022 dollars using the CPI Inflation Calculator. The year ten value used is $62 based upon year 2030 is $68 when adjusted to 2022 dollars using the CPI Inflation Calculator.

Example equation used for **Table 9-3** to determine the value of the avoided GHGs using the SCC:

Value of Avoided GHGs $_{(year)}$ = Total Yearly GHGs Avoided$_{(year)}$ x SCC $_{(year)}$

\$26,776,209 $_{(2033)}$ = 393,767$_{(2033)}$ (metric tons CO_2e) x \$68$_{(2030 \text{ value for year } 2033)}$

Where:

SCC_{2024} = \$61.00 (using SCC TSD 2025 value)[122]

122 White House. 2021. "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide." Available at https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

SCC_{2033} = $68.00 (using SCC TSD 2030 value)[123]

Staff totaled the avoided GHGs for the LSEs for the entire year to determine the Total Yearly GHG's Avoided using the example equation:

Total yearly GHGs Avoided (metric tons CO_2e_{year}) = GHGs Avoided $_{(PG\&E\ over\ a\ year)}$ + GHGs Avoided $_{(SCE\ over\ a\ year)}$ + GHGs Avoided $_{(SDG\&E\ over\ a\ year)}$ + GHGs Avoided $_{(LADWP\ over\ a\ year)}$ + GHGs Avoided $_{(SMUD\ over\ a\ year)}$

393,767.78 $_{(2033)}$ (metric tons CO_2e) = 39,019.36 $_{(2033,\ SDG\&E)}$ (metric tons CO_2e) + 116,337.08 $_{(2033,\ PG\&E)}$ (metric tons CO_2e) + 172,702.55 $_{(2033,\ SCE)}$ (metric tons CO_2e) + 48,717.74 $_{(2033,\ LADWP)}$ (metric tons CO_2e) + 16,991.05 $_{(2033,\ SMUD)}$ (metric tons CO_2e)

Where:

GHGs Avoided $_{(2033,\ SDG\&E)}$ = 39,019.36 (metric tons CO_2e)

GHGs Avoided $_{(2033,\ PG\&E)}$ = 116,337.08 (metric tons CO_2e)

GHGs Avoided $_{(2033,\ SCE)}$ = 172,702.55 (metric tons CO_2e)

GHGs Avoided $_{(2033,\ LADWP)}$ = 48,717.74 (metric tons CO_2e)

GHGs Avoided $_{(2033,\ SMUD)}$ = 16,991.05 (metric tons CO_2e)

Cost-Effectiveness Calculation

To calculate the cost and benefit to consumers of appliances with flexible demand capability, staff determined the annual utility bill savings from shifted loads for five LSEs. For each of the five LSEs, staff multiplied the hourly utility rate by the difference in the hourly baseline and shifted energy consumption to calculate the customer utility bill change. Staff calculated the first year, 2024 for each 8,784 hours and the tenth year, 2033 for each of the 8,760 hours for five LSEs. Staff evaluated four proposals using the hourly calculations for the year 2024 and the year 2033. Staff used linear interpolation to determine the data points between the first year and the tenth year. **Table A-20** shows the estimated utility customer bill benefit for the staff proposal for each year from 2024 to 2033. **Table A-21** shows the statewide estimated customer incremental purchase cost for the staff proposal for each year from 2024 to 2033.

Table A-20: Staff Proposal Annual Benefit for 2024-2033 (in millions $2022)

Year	1	2	3	4	5	6	7	8	9	10	Total
Benefits	$11M	$26M	$42M	$57M	$73M	$88M	$104M	$119M	$135M	$150M	$805M

Source: California Energy Commission

123 White House. 2021. "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide." Available at https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

Table A-21: Staff Proposal Annual Cost for 2024-2033 (in millions $2022)

Year	1	2	3	4	5	6	7	8	9	10	Total
Costs	$8M	$8M	$8M	$8M	$8M	$8M	$8M	$8M	$8M	$8M	$80M

Source: California Energy Commission

Example equation for **Table A-21** to calculate the estimated customer incremental purchase cost for the staff proposal:

Incremental Cost to CA pool customer = Incremental Cost x Compliant Installed Devices $_{\text{(year)}}$

$7,767,410 = $70 x 110,963 units

Where:

Incremental Cost = $70

Compliant Installed Devices $_{\text{(2024)}}$ = 110,963 units

Example equations for **Table 7-2**, **Table 7-3,** and **Table A-20** to calculate change in customer utility bill for the staff proposal from load shifting during each hour of an entire year for a single LSE:

LSE utility bill $_{\text{(year, LSE, day, hour)}}$ ($) = (Proposal load $_{\text{(year, LSE, day, hour)}}$ – Baseline Load $_{\text{(year, LSE, day, hour)}}$) x Utility Rate $_{\text{(year, LSE, day, hour)}}$

$55,474 $_{\text{(2033, SDG\&E hour 9, day 1)}}$ = (208,847 kW – 95,634 kW) x $0.49 ($/kWh)

Where:

Proposal load $_{\text{(2033, SDG\&E, day 1, hour 9)}}$ (kW) =208,847 kW

Baseline Load $_{\text{(2033, SDG\&E, day 1, hour 9)}}$ (kW) = 95,634 kW

Utility Rate $_{\text{(2033, SDG\&E, day 1, hour 9)}}$ ($/kWh) = $0.49

Staff totaled the utility bill savings for every hour of every day, for the entire year for five LSEs. Only the first three days and the last day are shown below for a single LSE to simplify the example.

Utility Bill Savings $_{\text{(during a year)}}$ = Utility Bill Savings $_{\text{(year, LSE, day 1, hour 1)}}$ + Utility Bill Savings $_{\text{(year, LSE, day 1, hour 2)}}$ + Utility Bill Savings $_{\text{(year, LSE, day 1, hour 3)}}$ + … + Utility Bill Savings $_{\text{(year, LSE, day 365, hour 24)}}$.

$20,583,466 $_{\text{(2033, SDG\&E)}}$ = $16,206.00 $_{\text{(2033, SDG\&E, day 1, hour 1)}}$ + $17,468.20 $_{\text{(2033, SDG\&E, day 1, hour 2)}}$ + $16,282.97 $_{\text{(2033, SDG\&E, day 1, hour 3)}}$ + … + $11,355.57 $_{\text{(2033, SDG\&E, day 365, hour 24)}}$

Where:

Utility Bill Savings $_{\text{(2033, SDG\&E, day 1, hour 1)}}$ = $16,206.00

Utility Bill Savings $_{(2033,\ SDG\&E,\ day\ 1,\ hour\ 2)}$ = $17,468.20

Utility Bill Savings $_{(2033,\ SDG\&E,\ day\ 1,\ hour\ 3)}$ = $16,282.97

Utility Bill Savings $_{(2033,\ SDG\&E,\ day\ 365,\ hour\ 24)}$ = $11,355.57

Example equation for totaling the utility bill savings for the LSEs for the entire year:

Utility Bill Savings $_{(during\ a\ year)}$ = Utility Bill Savings $_{(year,\ SDG\&E)}$ + Utility Bill Savings $_{(year,\ PG\&E)}$ + Utility Bill Savings $_{(year,\ SCE)}$ + Utility Bill Savings $_{(year,\ LADWP)}$ Utility Bill Savings $_{(year,\ SMUD)}$

$154,960,825.06 $_{(2033)}$ = $20,583,465.59 $_{(2033,\ SDG\&E)}$ + $16,653,972.44 $_{(2033,\ PG\&E)}$ + $116,481,136.73 $_{(2033,\ SCE)}$ + $0.00 $_{(2033,\ LADWP)}$ + $1,305,250.30 $_{(2033,\ SMUD)}$

Where:

Utility Bill Savings $_{(2033,\ SDG\&E)}$ = $20,583,465.59

Utility Bill Savings $_{(2033,\ PG\&E)}$ = $16,653,972.44

Utility Bill Savings $_{(2033,\ SCE)}$ = $116,481,136.73

Utility Bill Savings $_{(2033,\ LADWP)}$ = $0.00

Utility Bill Savings $_{(2033,\ SMUD)}$ = $1,305,250.30

Staff estimates the number of appliances in the five LSE by using the compliance factor and the total stock of the appliance per LSE. statewide. **Table A-1** shows the pool controls per utility. **Table A-3** shows the baseline compliance factors, at year 1 the staff assumed a 10% compliance factor for the staff proposal and at full stock, staff assume 100% will be compliant.

Example equation for determining the number of compliant pool controls in each LSE per year:

Total Compliant Pool Controls $_{(year,\ LSE)}$ = Compliance factor$_{(year)}$ x Total appliance stock$_{(year,\ LSE)}$

35,478 units $_{(2024,\ PG\&E)}$ = 10% x 354,782 units

Where:

Compliance factor$_{(2024)}$ = 10%

Total appliance stock$_{(2024,\ PG\&E)}$ = 354,782 units

Staff calculates the benefit to consumers per pool control for the five LSEs by dividing the annual utility bill savings for each load serving entity by the total appliance stock per LSE from **Table A-1**. For example, examining consumers in PG&E Territory for the year 2024, the utility bill annual benefit per appliance is:

Benefit per pool control by LSE ($/unit) = Annual Savings $_{(Year,\ LSE)}$ / Total Units $_{(Year,\ LSE)}$

$38.05= $1,350,077.10/ 35,478 (units)

Where:

Annual Savings $_{(PG\&E,\ 2024)}$ = $1,350,077.10

Total Compliant Pool Controls $_{(PG\&E,\ 2024)}$ = 35,478 (units)

Table A-22 shows the staff proposal savings per pool control by load serving entity for the year 2024. For LADWP the benefit per pool control value is zero because of LADWP's fixed price tiered rate structure.

Table A-22: Savings per appliance by Load Serving Entity for year 2024

LSE	Benefit per Pool Control
PG&E	$38.05
SCE	$169.67
LADWP	$0.00
SDG&E	$124.12
SMUD	$12.71

Source: California Energy Commission

Staff calculated a statewide percentage weight of pool controls from the data in **Table A-1**. **Table A-23** shows the statewide pool controls per LSE with percentage weigth for the year 2024.

Table A-23: Statewide Pool Controls per LSE with percentage weight for year 2024

LSE	Pool Controls Per LSE (2024)	Percentage Weight Pool Controls Per LSE
SMUD	69,442	6%
SCE	470,023	42%
LADWP	111,003	10%
PGE	354,782	32%
SDGE	104,383	9%
Total	1,109,634	100%

Source: California Energy Commission

Staff calculated the aggregated statewide savings per pool control for the proposal during the year 2024 using a weighted average from data in **Table A-23** using the following sample equation:

Weighted average per pool control = ((Net benefit per pool control$_{(PG\&E)}$ x % of Pool Control $_{(PG\&E)}$) + (Net benefit per pool control$_{(SCE)}$ x % of Pool Control $_{(SCE)}$) + (Net benefit per pool control$_{(LADWP)}$ x % of Pool Control $_{(LADWP)}$) + (Net benefit per pool control$_{(SDG\&E)}$ x % of Pool Control $_{(SDG\&E)}$) + (Net benefit per pool control$_{(SMUD)}$ x % of Pool Control $_{(SMUD)}$))/(% of Pool Control $_{(PG\&E)}$ + % of Pool Control $_{(SCE)}$ + % of Pool Control $_{(LADWP)}$ + % of Pool Control $_{(SDG\&E)}$ +% of Pool Control $_{(SMUD)}$)

$96.33 = (($38.05 * 0.32) + ($169.67*0.42) + ($0.00 * .10) + ($124.12 * 0.09) + ($12.71 * 0.06))/ (0.32+0.42+0.10+0.09+0.06)

Where:

Net benefit per pool control$_{(2024, PG\&E)}$ = $38.05

Percentage of Pool Controls$_{(PG\&E)}$ = 32%

Net benefit per pool control$_{(2024, SCE)}$ = $169.67

Percentage of Pool Controls$_{(SCE)}$ = 42%

Net benefit per pool control$_{(2024, LADWP)}$ = $0.00

Percentage of Pool Controls$_{(LADWP)}$ = 10%

Net benefit per pool control$_{(2024, SDG\&E)}$ = $124.12

Percentage of Pool Controls$_{(SDG\&E)}$ = 9%

Net benefit per pool control$_{(2024, SMUD)}$ = $12.71

Percentage of Pool Controls$_{(SMUD)}$ = 6%

Staff used linear interpolation to calculate the data points between the first year and the tenth year. This is a method of using linear polynomials to construct new data points with the range of a discrete set of known data points used for **Table A-24** and **Table A-25**. Staff also used linear interpolation to calculate the cumulative values for **Table 9-1** and **Table 9-2**.

Example equation for filling in gaps in data tables with known end points.

$(y - y_0) / (x - x_0) = (y_1 – y_0) / (x_1 - x_0)$

Where:

y= the table data gap we are solving for (year 2025 - 2032)

x= the table data gap years we want to solve for (year 2025 - 2032)

y_0= the initial table data value (year 2024 table data)

y_1= the final table data value (year 2033 table data)

x_0= the starting point data year (year 2024, x_0=0)

x_1= the starting point data year (year 2033, x_1=9)

Rearranging the equation to solve for "y" for the year 2025 in **Table A-24**:

$y= y_0 + (x - x_0) * ((y_1-y_0)/(x_1-x_0))$

$103.56 = $99.81+ (1 – 0) * (($133.63-$99.81) / (9-0))

Where:

$X_0= 0$

$X_1 = 9$

$x= 1$

$y_0=$ $99.81

$y_1=$ $133.63

As shown below in **Table A-24**, staff assume an incremental cost of $70 for the connectivity requirement for appliances to calculate the lifecycle benefit.

Table A-24: Calculation of Annual Benefit (In $2022)

Year	1	2	3	4	5	6	7	8	9	10	Total
Savings	$97	$100	$104	$108	$111	$115	$119	$122	$126	$129	$1131

Source: California Energy Commission

Estimate of incremental cost of connectivity = $70

Savings-to-Investment Ratio = 1,131/70 = 16.1

Lifecycle benefit = NPV total benefit – NPV total cost

$1,061 = $1,131 - $70

Staff account for the time value of money by discounting the utility bill savings from **Table A-24** to estimate the Net Present Value (NPV) over the lifetime of the appliance as follows in the example equation for **Table A-25**:

Benefit over appliance lifetime ($/unit) = $(SBApp_t / (1+r)^t)_{year\ 0} + \ldots + (SBApp_t / (1+r)^t)_{year\ t}$

$1,017.45 = (($99.81 / $(1+0.03)^0$) + (($103.56 / $(1+0.03)^1$) + … + (($133.63 / $(1+0.03)^9$)

Where:

$SBApp_t$ = Statewide Benefit per appliance in a single period time (t) in ($)

r = discount rate of 3%

t = discounting time of the appliance (first year starts with 0, not discounted)

As shown below in **Table A-25**, staff assume an incremental cost of $70 for the connectivity requirement for appliances to calculate the lifecycle benefit.[124]

Table A-25: Net Present Value Calculation of Annual Impacts

Year	1	2	3	4	5	6	7	8	9	10	Total
Savings	$97	$97	$98	$98	$99	$99	$99	$99	$100	$100	$986

Source: California Energy Commission

Estimate of incremental cost of connectivity = $70

Savings-to-Investment Ratio = $986/$70 = 14.09

Lifecycle benefit = NPV total benefit – NPV total cost

$916 =$986 - $70

Impacts to Employment, Income, and Output

Staff estimate macroeconomic impacts of the proposed regulations using the 2022 updated Regional Input-Output Modeling System (RIMS II) multipliers of the Bureau of Economic Analysis (BEA).[125] These RIMS II multipliers are based upon 2020 regional data and BEA's 2012 benchmark Input-Output Accounts. California region Type II total multipliers were used to estimate impacts to jobs, earned income, and final demand output or gross state product due to changes in consumer spending as a result of annual utility bill savings, minus the higher incremental cost of pool controls. Estimates of impacts are based upon increased spending of utility bill savings on discretionary goods and services and reduced revenues going into the electric power sector of the California economy in 2033 at full stock turnover of pool controls.

2033 Increase in disposable household income: $150,000,000 - $8,000,000 = $142 million

2033 Decrease in electricity sector revenues: $150 million

Employment multiplier for discretionary spending (average of NAICS 713900, 722110-722A00, 812100) = 24.3029 jobs per million

Employment multiplier for electricity sector (NAICS 2211A0) = 4.7041 jobs per million

Increase in jobs = 24.3029 x $142.33 million = 3,459 jobs

Decrease in jobs = 4.7041 x -$150.4 million = -707 jobs

2033 Net increase in jobs = 3,459 - 707 = 2,752 jobs

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124 Based on initial research by staff of retail stores and interviews with pool pump manufacturers.

125 U.S. Department of Commerce. 2022. "Bureau of Economic Analysis RIMS II Multipliers." Available at https://www.bea.gov/help/glossary/rims-ii-multipliers.

Statewide earned income multiplier for discretionary spending (average of NAICS 713900, 722110-722A00, 812100) = 0.7855 per dollar

2033 Increase in statewide earned income = 0.7855 x $142M = $111,807,000

Statewide earned income multiplier for electricity sector (NAICS 2211A0) = 0.3485 per dollar

2033 Decrease in statewide earned income = 0.3485 x -$150M = -$52,434,166

2033 Net increase in statewide earned income = $111.8M - $52.4M = $59.4 million

Final demand output multiplier for discretionary spending (average of NAICS 713900, 722110-722A00, 812100) = 2.1632 per dollar

2033 Increase in final demand output = 2.1632 x $142M = $307,908,000

Final demand output multiplier for electricity sector (NAICS 2211A0) = 1.6468 per dollar

2033 Decrease in final demand output = 1.6468 x -$150M = -$247,772,000

2033 Net decrease in final demand output = $307.9M - $247.8M = $60.1 million

Note: Reduced demand for electricity output is a positive outcome for the California economy given the increasing demand for electricity expected to result from electrification of California’s buildings and transportation sectors.