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Title 20 Dishwasher CASE Report RFI Response Commercial Food Service

Additional submitted attachment is included below.

Commercial Dishwashers

Codes and Standards Enhancement (CASE) Initiative
For PY 2023: Title 20 Standards Development

Analysis of Standards Proposal for
Commercial Dishwashers
CEC Docket Number 23-AAER-01

DRAFT February 13, 2024

Prepared for:

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1 Executive Summary

1.1 CASE Team Proposal Objective

The Codes and Standards Enhancement (CASE) Team presents recommendations to support the California Energy Commission's (CEC) efforts to update California's Appliance Efficiency Regulations (Title 20). Three California Investor-Owned Utilities (IOUs), Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison sponsored this effort, herein referred to as the CASE Team. The program's goal is to prepare and submit proposals that would result in cost-effective improvements to the energy and water efficiency of appliances sold in California. The CASE Report presents a technical and cost-effectiveness analysis for commercial dishwasher appliance standards.

The CEC will evaluate proposals submitted by the CASE Team and other stakeholders. The CEC may revise or reject proposals. See the CEC's Appliance Efficiency Regulations – Title 20 website for information about the rulemaking schedule and how to participate in the process. https://www.energy.ca.gov/rules-and-regulations/appliance-efficiency-regulations-title-20

Sections 2 through 10 of this report cover the proposed appliance standards for commercial dishwashers and the supporting analysis. Section 1111 responds to the questions in the Request for Information docketed by the CEC on November 14, 2023.[1]

1.2 Commercial Dishwasher Types

Commercial dishwashers clean non-disposable dishes and utensils in restaurants, schools, or hospitals. Manufacturers design commercial dishwashers to handle many more loads of dishes per day than a residential dishwasher. Therefore, commercial dishwashers have design features for higher cleaning capacities and shorter wash cycles.

Commercial dishwashers are classified into two types based on rack design: stationary or conveyor. Stationary rack machines keep the dishes stationary while undergoing sequential wash and rinse sprays. Conveyor machines use conveyors to move dishes through the wash and rinse sprays. Among conveyor machines, flight-type models are larger, allowing wares to be placed directly on the conveyor belt with pegs.

Another important commercial dishwasher classification is low or high rinse water temperature. Some dual-rinse dishwashers may rinse at high or low temperatures. High-temperature rinse dishwashers rely on water temperature for sanitation, while low-temperature dishwashers use chemicals for sanitation.

[1] https://efiling.energy.ca.gov/GetDocument.aspx?tn=253089&DocumentContentId=88297

Figure 1: Undercounter Stationary Rack Dishwasher(Left) and Conveyor Dishwasher(Right)

1.3 CASE Team Proposed Standards

The CASE Team proposes performance standards for all commercial dishwashers, including stationary rack and conveyor product classes. The proposed standards address water use for all product classes and idle energy for most product classes. These standards include definitions for multiple product classes representing diverse commercial dishwashing applications. They also outline test procedures based on industry-developed procedures modified to suit specific product classes.

Specifically, the CASE Team proposes the scope and definitions aligned with the U.S. Environmental Protection Agency (US EPA) ENERGY STAR® Commercial Dishwasher Specification V3.0 to provide a well understood and consensus-based description. The CASE Team proposes adopting the most recent ASTM test procedures, aligning them with the ENERGY STAR Specification, and ensuring performance levels are consistent with the ENERGY STAR Commercial Dishwasher Specification V2.0 to harmonize standards adopted by other states.

The proposal would require specific products to undergo industry-accepted test procedures and certify their performance. This approach would empower consumers to make informed purchasing decisions and pave the way for potential future performance standards within those product categories. The following products would not be subject to standards but instead a test and list requirement:

- Rack washers that cannot accommodate a standard 20x20-inch rack
- Carousel glasswashers
- Conveyor washers that cannot accommodate a standard 20x20-inch rack and the height of 15 dishes per ASTM F1920, specifically conveyor glasswashers and conveyor sheet pan washers
- Dual compartment dishwashers designed to wash two different types of wares simultaneously (rack of plates and rack of glasses, or rack of pots and pans and rack of glasses)
- Roll in rack washers

Commercial dishwashers within the proposal's scope would be required to comply with existing CEC certification and marking requirements. Although the requirements are similar, participation in the ENERGY STAR program is not mandatory for compliance with the proposal.

The proposed effective date is March 1, 2026, allowing time for pre-rulemaking and rulemaking activities and for the 1-year period between adoption and effective dates required by California statute.

1.4 Market Analysis

The CASE Team studied commercial dishwashers available on the California market and engaged in discussions with commercial dishwasher manufacturers and industry trade associations. The Team presents the results to show that the proposed standards are technically feasible.

The ENERGY STAR qualified product list demonstrates that commercial dishwasher models from various manufacturers exist and comply with the proposed standards. According to the US EPA, approximately 63% of all commercial dishwashers sold in the United States comply with the ENERGY STAR V2.0 standards. Additionally, over half of manufacturers create products capable of meeting this standard.

The CASE Team concludes that the proposed standards would not cause any loss of consumer utility.

California statute limits the CASE Team proposal to appliances sold or offered for sale in California. Leased commercial dishwashers would be outside the proposal's scope.

Industry analysts report that California food service establishments purchase about half of the dishwashers. Chemical sales companies lease the other half of the dishwashers. These companies supply the machines, the required ware washing chemicals, and regular maintenance under a leasing contract. The ratio of owned to leased machines depends upon the machine type. Most door-type machines are leased, especially those operating at low temperatures. Food service establishments own most conveyor-type machines and almost all flight-type machines. Leasing companies based in Oregon and Nevada have state standards that align with ENERGY STAR V2.0. Therefore, the CASE Team concludes that adherence to the proposed standards would be high despite the limited scope of dishwashers sold or offered for sale.

1.5 Per Unit Energy Savings

The CASE Team relied on information from well vetted sources such as the Food Service Technology Center, US EPA, and US DOE, to assign values for the duty cycle, rack size, and wash time. The booster heater within the commercial dishwasher heats some water; however, the building water heater heats the majority. The building water heater performance is presumed to align with DOE appliance standards. The performance of the building water heater is assumed to be equal to appliance standards set by the US DOE. The CASE Team assumes the primary fuel source for most water heaters is gas. The report attributes the savings in natural gas to the reduced use of hot water by commercial dishwashers.

The CASE Team estimated energy and water use for models that reflect current market performance with no standards and models that would be minimally compliant with proposed standards. Savings are achieved through reduced water usage, idle energy consumption, and wash energy consumption. The table below presents the per unit energy savings by product class of commercial dishwashers.

Table 1: Annual Per Unit Water and Energy Savings

Product Class	Per unit savings - electricity (kWh/yr-unit)	Per unit savings - natural gas (therm/yr-unit)	Per unit savings - water (gal/yr-unit)
Undercounter – High Temp	3,915	74	7,300
Undercounter – Low Temp	1,305	92	9,125
Stationary Single-Tank Door – High Temp	4,404	111	10,950
Stationary Single-Tank Door – Low Temp	2,202	92	9,125
Pot, Pan, and Utensil	4,185	148	14,600
Single-Tank Conveyor – High Temp	18,542	739	73,000
Single-Tank Conveyor – Low Temp	17,228	886	87,600
Multiple-Tank Conveyor – High Temp	28,607	1,108	109,500
Multiple-Tank Conveyor – Low Temp	27,101	1,329	131,400
Single-Tank Flight-Type	24,200	4,789	505,525
Multiple-Tank Flight-Type	32,266	5,317	561,188

1.6 Cost Effectiveness

The commercial dishwasher consumer must recognize the proposal's cost effectiveness. The CASE Team compared the proposal's benefits and costs to calculate its effectiveness. The consumer would benefit from lower utility bills due to lower electricity, gas, and water. The present value of benefits shown in Table 2 were estimated through multiplying per unit energy and water savings by the present value of energy and water prices. The CASE team estimated the incremental cost of the more efficient commercial dishwasher. The costs and benefits were compared in terms of net present value using a 3% discount rate. The lifecycle benefit ratio must exceed one to be cost effective to the consumer. The proposal is cost effective for all commercial dishwasher product classes.

Table 2: Per Unit Lifetime Economic Impacts for Products Purchased in the First Year

Product Class	Design Life (years)	Present Value of Benefits (2024 $)	Present Value of Incremental Costs (2024 $)	Net Present Value (2024 $)	Simple Payback Period (years)	Lifecycle Benefit-Cost Ratio
Undercounter – High Temp	12	12,899.39	1,189.82	11,709.57	0.89	10.84
Undercounter – Low Temp	12	5,840.37	419.75	5,420.62	0.69	13.91
Stationary Single-Tank Door – High Temp	15	18,430.08	3,852.14	14,577.93	2.41	4.78
Stationary Single-Tank Door – Low Temp	15	10,983.86	-	10,983.86	-	Infinite
Pot, Pan, and Utensil	15	18,732.68	7,774.00	10,958.68	4.78	2.41
Single-Tank Conveyor – High Temp	20	109,667.69	8,087.08	101,580.61	1.05	13.56
Single-Tank Conveyor – Low Temp	20	109,705.15	7,742.00	101,963.15	1.00	14.17
Multiple-Tank Conveyor – High Temp	20	167,962.58	23,424.25	144,538.33	1.99	7.17
Multiple-Tank Conveyor – Low Temp	20	170,047.66	21,770.17	148,277.49	1.82	7.81
Single-Tank Flight-type	20	295,309.58	20,000.00	275,309.58	0.95	14.77
Multiple-Tank Flight-type	20	351,376.34	65,000.00	286,376.34	2.61	5.41

1.7 Statewide Impacts

The CASE Team estimates statewide shipments of approximately 10,000 commercial dishwashers per year. Using US EPA data, the CASE team calculated shipments by commercial dishwasher product class. The Team determined California commercial dishwasher stock by multiplying the dishwasher shipments by the design life. The estimated stock is 137,000 dishwashers.

The CASE Team estimated statewide savings by multiplying the stock by the per unit savings by the estimated non-compliance rate of 35%. The CASE Team estimates that the first year (2026) of the enacted proposed standards would yield an annual savings of 52 million gallons of water, 0.5 million therms of gas, and 12-gigawatt hours (GWh) reduction from direct and embedded electricity use. The CASE Team projects annual savings of 851.7 million gallons of water, 8.4 million therms of gas, and a 179.5 GWh reduction from direct electricity use after complete stock turnover. Although the full stock turnover of all dishwasher types will not occur until 2046, the utility bill savings were adjusted to 2024-dollar values to allow a comparison with other California initiatives.

Table 3: Estimated California Statewide Savings in the Stock Turnover Year

	Electricity (GWh/yr)	Natural Gas (million therms/yr)	Water (million gallons/yr)	GHG Emissions (MT CO2e/yr)	Utility Bill Savings (million 2024 $/yr)
Statewide Savings	**179.5**	**8.4**	**851.7**	**66,777.8**	**30.4**

Embedded energy savings (energy savings from reduced water use) were calculated using the indoor energy factor of 5,440 kWh/million gallons of water. With water savings of 851 million gallons at full stock turnover, the embedded energy savings will be 4.6 GWh/yr.

The incremental capital costs in the first full-year of implementation are $4.6 million, and utility bill savings in the first year are $1.6 million.

2 Introduction

Restaurants, hotels, cafeterias, and other establishments that serve large quantities of food use commercial dishwashers. Dishwashers can consume substantial amounts of water and energy. Dishwasher energy usage is twofold: direct, in the form of electricity consumed by the machine, and indirect, in the form of energy used by the water heater. Some commercial dishwashers consume additional energy by using a booster heater to raise the hot water temperature to the level required for proper sanitation.

California does not regulate the energy use of commercial dishwashers. However, the California Health and Safety Code has sanitation requirements for these products, and the California Plumbing Code has requirements regarding water discharge temperatures to the sanitary sewer.[2] Over the past decade, commercial dishwasher water and energy consumption have drastically reduced with the development and promotion of more efficient products. Electronic controls allow a more precise detergent dosage, thereby reducing water usage. New heat recovery technologies have also entered the market, enhancing water heating efficiency. As of 2022, the Environmental Protection Agency (EPA) ENERGY STAR® estimates that 47% of the commercial dishwashers sold in the United States meet the current V3.0 criteria. The 2022 California Green Building Code[3] references the older ENERGY STAR Version 2.0 (V2.0) for the maximum dishwasher water consumption. These voluntary performance requirements have driven a considerable share of the market to more efficient models that comply with the proposed standards and have resulted in the availability of a wide variety of efficient products across product classes. However, many less efficient products remain on the market. Adopting mandatory water and energy efficiency criteria through Title 20 codes and standards development will help further reduce commercial dishwasher water and energy waste.

The CASE Team proposes a comprehensive approach to attaining water and energy savings by installing and using more efficient commercial dishwashers. This approach involves three equally important components:

- **Appliance Standards**: In Title 20, establish energy and water performance standards for commercial dishwashers based on ENERGY STAR V2.0 and alignment with multiple other state standards for this product category. The proposed standards will cover most commercial dishwasher product categories, including undercounter, conveyer, flight, and tank-type products.
- **Building Codes**: In Title 24, exploration of provisions to address requirements for heat recovery, which may increase the machine's energy use but decrease the total energy use necessary to heat and clean dishes. The proposed standard covers heat recovery units and various products would be available under the proposed performance levels. However, Title 24 may provide an opportunity for optimizing these systems and realizing the full benefits of heat recovery for commercial dishwashing. Building codes can provide unique solutions or methods to reduce water consumption.

[2] "Cal. Code Regs. Tit. 17, § 30856 - Sanitizing Requirements for Dishwashing Machines," LII / Legal Information Institute, n.d., https://www.law.cornell.edu/regulations/california/17-CCR-30856;
Cal. Plumbing Code §810.1 High Temperature Discharge "2022 California Plumbing Code," iapmo.org, n.d., https://epubs.iapmo.org/2022/CPC/.

[3] UpCodes, "Appendix A5: Nonresidential Voluntary Measures, California Green Building Code 2022 | UPCodeS," https://up.codes/viewer/california/ca-green-code-2022/chapter/A5/nonresidential-voluntary-measures#A5.303.3.

- **Market Education**: The commercial dishwasher market has a sizeable lease and refurbishment component, which may fall outside the scope of the proposed performance standards. Market education can help lessees understand the benefits of more efficient equipment and help accelerate the transformation of the entire market to more efficient technologies.

This report provides supporting analysis for the first component of the comprehensive approach for the Title 20 code change proposal, which focuses on performance standards for all commercial dishwasher types within the scope of the ENERGY STAR program, generally setting standards at the ENERGY STAR Version 2.0 levels, rather than the current Version 3.0 levels. This proposal would require certain products to test to industry-accepted procedures and list their performance, allowing consumers to make informed purchasing decisions and enabling potential future performance standards for those product categories.

3 Product and Technology Description[4]

Commercial dishwashers in nonresidential settings such as restaurants, schools, and hospitals clean and sanitize non-disposable dishes, glassware, utensils, and other kitchenware using hot water, detergent, rinse, and sanitizing chemicals. Unlike their residential counterparts, commercial dishwashers manage dozens of loads per day, each taking only one to three minutes per load or operating continuously.

Based on the sanitation method, dishwashers may be classified as high or low-temperature machines. Low-temperature dishwashers are also commonly known as "chemical sanitizing." All dishwashers maintain a wash cycle of 120° to 140° F. However, the water temperature used in the rinse cycle differentiates high and low-temperature machines. Low-temperature machines use hot water and chemicals to sanitize during the rinse cycle.

In contrast, high-temperature machines use a booster heater to heat the rinse water above 180° F required for sanitation without chemicals. Low-temperature machines depend on the building's water heater to provide hot water, with some offering booster heaters as an added feature if the building's water heater cannot provide a consistent 140° to 160° F. While most booster heaters operate on electricity, options for external gas booster heaters are also available. Most facilities favor high-temperature dishwashers for their superior cleaning capability and absence of chemical odors or residues on glassware; however, some locations cannot accommodate these machines due to insufficient electrical amperage for the booster heater.[5] Different sanitation methods may be more effective for specific applications. For example, high-temperature sanitation cycles are often better at removing charred food from pots and pans. On the other hand, some products can be effectively cleaned at lower temperatures, eliminating the need for the additional booster heater hardware required for high-temperature sanitation.

Some dual rinse or dual sanitizing dishwashers operate as high- or low-temperature machines. These products are tested to the appropriate procedures for both a high and a low-temperature machine and have rated performance in both modes. Customers typically pre-select features like a booster heater or a chemical rinse supply specific to high- or low-temperature operation. After installation, the user may operate the machine at either a low or high temperature, but it typically functions in one mode.[6] To qualify for ENERGY STAR certification, a dual sanitizing machine must meet the low and high-temperature efficiency requirements. The machine would have separate water consumption and idle energy listings for each temperature configuration. The CASE Team recommends for this proposal that dual sanitizing machines meet both the high and low-temperature requirements for certification, as the operational mode—high or low-temperature—would depend on consumer choice.

Most dishwashing machines fall into two categories based on rack design: stationary rack or conveyor types. Stationary rack machines keep the dishes stationary while undergoing sequential wash and rinse sprays. Conveyor machines use conveyors to move dishes through the wash and rinse sprays. Among conveyor machines, flight-type models are larger, allowing wares to be placed directly on the conveyor

[4] All unlabeled images in this section are from the Hobart Corporation "Commercial Dishwashers | Dishmachines | Hobart Dishwashers," https://www.hobartcorp.com/products/commercial-dishwashers. All other images are labeled with their source.
[5] Discussions with manufacturers and resources, such as: Derek Hodges, "Commercial Dishwashers Low Temp vs. High Temp," KaTom Restaurant Supply, Inc., n.d., https://www.katom.com/learning-center/comparing-high-temp-low-temp-commercial-dishwashers.html.
[6] For example, a dual sanitizing product can be modified from a low-temperature to a high-temperature machine through the addition of an external booster heater, such as"Installation, Operation and Care of CLeN-SERIES DISHWASHERS," Hobart, 2023, https://www.hobartcorp.com/sites/default/files/webdam-assets/CLeN%20Dishwasher%20Instruction%20Man%20Eng%20Frn%20Spn%20F47607%20%2811-21%29.pdf.

belt with pegs. However, to simplify product testing, racks of dishes are often used. Some commercial establishments such as bars, restaurants, and hotels may prefer specialized glasswashing machines with or without racks due to the higher glassware volume.

Certain commercial dishwashers are designed exclusively for maritime use and have additional components or features to ensure effective operations for those applications. These products are therefore designed for mobile applications and fall outside the scope of Title 20. The CASE team believes that due to the specifications for these niche products they do not represent a likely alternative to products covered by the scope of the proposed standards.

3.1 Stationary Rack Machines

The following dishwasher types fall under stationary rack machines, with specifications defined in ASTM F0857, and use the applicable test method prescribed in ASTM F1696:

- Undercounter High-Temperature
- Undercounter Low-Temperature
- Stationary Single-Tank Door High-Temperature
- Stationary Single-Tank Door Low-Temperature
    - Fill-and-Dump machines are a subtype of door-type, low-temp machines covered by the ASTM F0953 specifications.
- Pot, Pan, and Utensil Washers (always High-Temperature)
    - These machines are covered by the ASTM F1114, F1202, or F1203 specifications, depending on the washing spray arm geometry.

Stationary rack commercial dishwashers keep dishes in place during the wash and rinse sprays. One of the most common examples is the undercounter dishwasher, specifically designed to fit beneath food preparation workstations. These machines generally operate on a two-minute wash cycle. They are commonly used in food service establishments like coffee shops and bars, particularly those without a dedicated dishwasher operator and with a daily requirement of fewer than 50 racks.

Figure 2: Undercounter Stationary Rack

Undercounter models are stationary rack machines designed to be placed under commercial kitchen workspaces (<38 inches high) and have a large front door for loading and unloading racks. Undercounter

machines operate at either low or high temperatures and are frequently used in bars and small restaurants.

Another standard product is the single tank, upright door-type commercial dishwasher. These products accommodate standardized dishwashing racks and automatically turn on by inserting the racks and closing the door. Most small to medium-sized restaurants that wash 100 to 300 racks per day use door-type dishwashers, making them a popular choice for establishments with reusable wares. These facilities typically have a part-time employee dedicated to operating the dishwasher by loading and unloading dishes from the racks, as cycle times are commonly 2-3 minutes for undercounter dishwashers and 1-1.5 minutes for stationary rack products.[7]

Many available models can wash two racks simultaneously for facilities that need higher throughput (over 200 racks per hour), but without the electrical capacity to install a conveyor dishwasher. Manufacturers of door-type washers also offer a tall version of their standard machine with an enlarged washing cavity to accommodate items like upright sheet pans. Despite the larger size, the energy and water usage components are the same as in standard models. High-temperature upright dishwashers usually have a 10-gallon wash tank maintained at 155° F using a resistance heating element.

Figure 3: Single Tank, Door-Type Stationary Rack

Door-type models or hood-types are designed for standard 20-inch by 20-inch dish racks. The racks are loaded and unloaded through an oversized door. The door is closed to initiate the wash cycle. These machines are available in low- and high-temperature variants and are commonly used in various establishments such as restaurants, schools, hospitals, and catering businesses.

Sub-type: **Pot, Pan, and Utensil**. These single-tank door machines are designed to clean larger pots, pans, and utensils.

Common sub-type: **Fill-and-Dump**. Fill-and-dump machines are predominantly low-temperature, single-tank door machines that dump their wash tanks after each wash mode. The fresh rinse water is reused once for the following wash cycle. Fill-and-dump machines are the most basic and least expensive option for food service facility operators. For example, fill-and-dump machines use cam timers instead of the more costly programmable logic board for setting cycle times. For reference, most other machine types hold wash water in a holding tank and reuse it for multiple washes, with make-up water added from rinse water to maintain a full wash tank. While some undercounter fill-and-dump machines exist, these products are primarily single-tank, door-type dishwashers. Because these machines are typically low-temperature, chemical sanitizing products, they are sometimes called chemical dump machines.

[7] Per industry feedback and specification sheets.

Fill-and-dump machines, a subcategory of an upright door-type machine, are designed to automatically dump the wash water into an adjoining tank or drain at the end of a wash cycle. The water used to fill the rinse tank becomes the wash water for the next wash cycle. Fill-and-dump machines are predominantly low-temperature, quite common, and characterized by their simplicity. These machines do not feature a tank heater, have a tank capacity of 1 to 2 gallons, and rely on the wash pump as the main mechanical component. Operators select low-temperature fill-and-dump machines over high-temperature single-rack washers because they do not have adequate panel amperage (60A minimum) to accommodate a high-temperature dishwasher.

Pots, pans, and utensil dishwashers clean and sanitize hard-to-clean items with baked-on food. These machines have larger door openings that can accommodate vertically placed sheet pans. With high-temperature settings, they offer selectable wash cycles ranging from 3 to 10 minutes. They are classified by the wash rack area, which is larger than a standard dish rack. Typically found in large facilities, they often work with a conveyor dishwasher dedicated to washing plates.

3.2 Conveyor Machines

The following dishwasher types are conveyor machines, with specifications defined in ASTM F0859, and use the applicable test method prescribed in ASTM F1920:

- Single Tank Conveyor High Temp
- Single Tank Conveyor Low Temp
- Multiple Tank Conveyor High Temp
- Multiple Tank Conveyor Low Temp
- Single Tank Flight-Type (always High Temp)
- Multiple Tank Flight-Type (always High Temp)

Large facilities such as full-service restaurants, hotels, college cafeterias, hospitals, and prisons that need to wash over 300 racks of dishes per day use these types of machines. The single-tank 44-inch conveyor machine is on the lower throughput end of conveyor machines, and multiple-tank flight-type machines with conveyors exceeding 100 inches in length are some of the highest throughput machines. These facilities need multiple full-time staff to operate the machines, with at least one person loading the conveyor belt and another unloading.

Conveyor machines are commercial dishwashers that use a conveyor belt to move plates, glasses, and utensils through a series of wash and rinse sprays within the machine. The three major types of conveyor products include single-tank rack, multiple-tank rack, and flight-type. In the case of single-tank dishwashers, a rack of dishes is loaded onto the conveyor and proceeds through a washing section followed by a sanitizing rinse. The 20- to 30-gallon tank below the wash section uses a heater to maintain a temperature between 150° to 160° F, and wash water is pumped and sprayed onto the rack from above and below.

In multiple-tank machines, the dish racks have an additional pre-rinse section before the wash section, followed by a sanitizing rinse. These products have separate tanks with separate pumps and heating elements for pre-rinsing and washing water, and some have separate rinse tanks. Multiple-tank machines clean 400 to 600 racks per day and are used in higher volume applications than single-tank machines and applications where the throughput does not require flight-type machines (over 600 racks per day equivalent).

Figure 4: Single or Multiple-Tank Conveyor

Conveyor designs are used for high-volume applications, such as larger restaurants, hotels, universities, or schools. Racks are loaded into the machine from the end or side and are carried back and forth through the wash and rinse sprays via a conveyor. Conveyor machines come in varying sizes. Single-tank machines include a tank for wash water followed by a sanitizing rinse. Multiple-tank machines are larger and have one or more tanks for wash water and rinse water. Conveyor machines can have low or high temperatures, but most are high.

Finally, flight-type conveyors do not utilize racks at all. Instead, dishes are loaded directly onto the conveyor and cycle through multiple tanks (or sections) for washing, rinsing, and sanitizing. Conveyor machines use hot water sanitizing and require an external booster heater. All flight-type machines are hot-water sanitizing and have multiple tanks. Booster heaters are either integrated into the high-temperature dishwasher or sold separately, depending on the dishwasher configuration and price.

Figure 5: Single or Multiple-Tank Flight-Type Conveyor

Flight-type designs are used for high-volume applications, such as large hotels or casinos with banquet facilities. Wares are placed directly on a continuous conveyor, passing through the machine like a moving sidewalk. The wash and rinse operation matches the conveyor-type machine described above, also known as rackless conveyors. Flight-type machines are sold as individual product lines but are often modified based on the needs of each facility. The factory builds these units in modules that are installed and connected onsite.

3.3 Glasswashing Machines

Glasswashing machines are specifically designed for businesses with high-volume glassware use, such as in a bar, and differ from other types of dishwashers, including undercounters and conveyors. Glasswashers are specialized dishwashers that can only wash glasses, not plates or silverware, unlike rack under-counter machines, which are more versatile. Therefore, many facilities that use glasswashers also have additional dishwashers to clean other dishes. These products are broken into four categories: stationary rack glasswashers, carousel glasswashers, conveyer glasswashers, and batch rotary glasswashers.

First, stationary rack glasswashing machines that can accommodate a standard 20x20-inch dishrack are in the scope of ENERGY STAR V2.0 and fall within Undercounter Dishwashers. These products are essentially the same as other undercounter dishwashers and are subject to the same test procedure as those products without modification. Consequently, these products would be subject to the proposed standards.

Figure 6: Example of a stationary-rack glasswasher

Figure 7: Stationary-rack glasswasher washing cavity open

Picture source: https://www.katom.com/099-DELTA5.html

Next, carousel glasswashing machines are distinct and not directly comparable to other commercial dishwashers. These products have a similar footprint as undercounter stationary rack machines; however, they do not use racks, so glasses are placed directly on the carousel. The carousel rotates continuously, pushing the glasses through a wash and a rinse section before they exit. This carousel process has similarities to conveyor dishwashers, although with a considerably different form factor. It may be possible to test these products using existing industry test procedures (ASTM F1920 section 10.8), which may need to be revised to enable the testing of these rackless products. The industry test procedure for door-type dishwashers (ASTM F1696 section 6.18) has already defined a standardized glass. It could be used as an example to make the necessary revisions for the ASTM F1920 to apply to glasswashing. The performance of carousel glasswashers is not fully understood due to the lack of a directly applicable test procedure. Therefore, additional test data is necessary to know how they compare to other conveyor products. These products are the most popular glasswashing dishwashers but are not included in the ENERGY STAR program and are proposed to be tested and listed.

Figure 8: Carousel Glasswashers

Picture Source: https://cmadishmachines.com/product/model-gw-100/

Carousel machines provide fast undercounter glasswashing for use in bars and locations with high glasswashing needs. These products can clean over 1200 glasses per hour and, like flight-type machines, do not rely on racks but provide continual cleaning through a circular carousel design, making these products significantly smaller than other flight-type machines.

Third, conveyor glasswashers are similar to standard rack conveyor dishwashers but smaller, and similar to flight-type machines in that these products do not use racks. The glasses are placed directly on the conveyor and come out washed from the other end. These products may require minimal test procedure revisions (from plates to glasses) to characterize performance.

Figure 9: Conveyor Glasswashing machines

Picture Source: https://www.centralrestaurant.com/media/pdf/396-031.pdf

These rackless machines operate similarly to larger flight-type dishwashers in that individual glasses are placed on a conveyor which carries them through a series of wash and rinse cycles. Glasswashing conveyor products are smaller than other conveyor types and are a relatively small subset of all glasswashers.

Finally, batch rotary glasswashers operate similarly to other undercounter batch rack dishwashers. Glasses are placed in the open compartment, which rotates into the washing cavity when the cycle is

engaged. Clean glasses move out of the washing cavity for unloading. While these products may use racks, they may differ from those used in standard test procedures. Thus, a slight alteration to existing test procedures may be necessary to determine energy performance. These machines have 18-24-inch diameter rotating designs, so each wash batch of glasses will be half the area of an 18 or 24-inch diameter circle.

Figure 10: Example of a batch glasswashing rack

Perlick PKBR24

Picture Source: https://www.katom.com/199-PKBR24.html

Figure 11: Example of a batch glasswashing rack

ADS ASQ II

Picture Source: https://www.americandish.com/wp-content/uploads/2022/11/ASQ-II-Brochure.pdf

3.4 Heat Recovery Technology

Heat recovery is a feature in many high-temperature commercial dishwasher product classes. Heat recovery is not a distinct performance feature or product class but a technology option to improve overall dishwashing energy efficiency by addressing hot water input energy and direct dishwasher energy use. Heat recovery dishwashers utilize exhaust steam or hot drain water to preheat the incoming cold water. Heat recovery machines must be hot water sanitizing and supplied with cold water for the heat transfer to occur. The heat recovery heat exchanger raises incoming cold water from 50-60˚F to 100-120˚F without water heating energy. The dishwasher's booster heater raises the water temperature from 100-120˚F to 185˚F to attain the required 180˚F sanitizing temperature. Traditional non-heat recovery machines draw hot water from the water heater. High-temperature machines use an internal booster heater to raise the incoming water temperature from 140˚F to 185˚F. Heat recovery dishwashers consume more energy from the booster heater than traditional machines because the water temperature, after heat recovery, is colder (100-120˚F) than the temperature supplied by a water heater (140˚F). However, heat recovery machines use significantly less energy at the water heater level

as they only use hot water to fill their wash tanks and not during rinse cycles as the rinse water is heated with heat recovery and the booster heater.

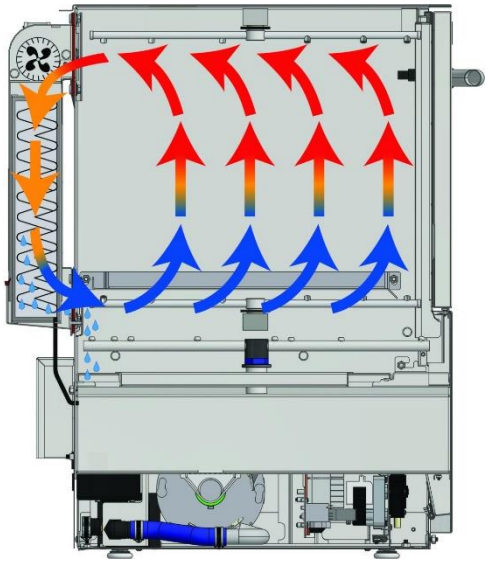

Figure 12: Undercounter Dishwasher Heat Recovery System Side View with Heat Exchanger on the Back of the Washing Cavity

Picture Source: https://resources.centralrestaurant.com/vent-vs-ventless-dishwashers/

3.5 Undercounter and Door-Type Heat Recovery

Undercounter and upright door-type heat recovery machines use steam from the previous rinse cycle to preheat water for the next cycle. The heat recovery cycle usually adds 30 seconds to the total wash time per rack as the heat recovery coil condenses steam. Heat recovery machines emit far less steam into the dish space than traditional machines, significantly improving kitchen comfort. In some jurisdictions, heat recovery machines are not required to have an exhaust hood and can reduce the HVAC load of the building.[8]

[8] San Francisco: UpCodes, "Chapter 5: Exhaust Systems, San Francisco Mechanical Code 2019 | UPCodes," 2019, https://up.codes/viewer/san_francisco/ca-mechanical-code-2019/chapter/5/exhaust-systems#519.1 and Los Angeles: UpCodes, "Chapter 5: Exhaust Systems, Los Angeles Mechanical Code | UPCodes," 2016, https://up.codes/viewer/los_angeles/ca-mechanical-code-2016/chapter/5/exhaust-systems#5.

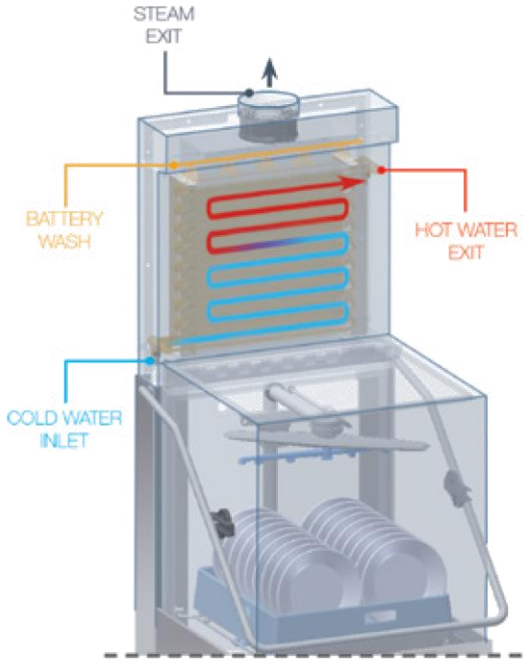

Figure 13: Door type dishwasher vapor exhaust heat recovery diagram, Front view

Picture Source: https://kitchensetup.com.au/product/dihr-hood-type-dish-washer-with-heat-recovery-system/

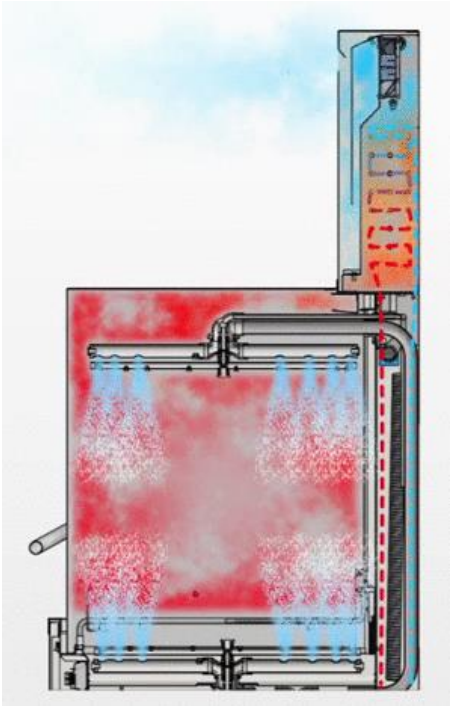

Figure 14: Door-type dishwasher vapor exhaust heat recovery diagram, Side view

Picture Source: https://www.southernhospitality.co.nz/news/dishwasher-heat-recovery-systems-are-not-created-equal/

3.6 Conveyor Heat Recovery

The size of conveyor dishwashers allows for several heat recovery technologies. One approach involves using drain-water heat recovery to capture the heat from rinse water. This water is continuously replenished to the rinse tank, which then overflows down the drain. Other machines use an exhaust coil on the exit end, which takes the hot-steam exhaust to preheat incoming water to the booster heater or utilizes a heat pump to condense and chill this steam. The heat generated through the process heats the tank heater and releases cool air into the room. Conveyor heat recovery machines have the same washing total rack wash time as non-heat recovery units.

Figure 15: Flight-type machine heat recovery system at the exit of the machine.

Picture Source: https://cdn.meiko-global.com/fileadmin/editor_upload/meiko.us/Downloads/M-iQ_Flight_type/Product_Brochure_M-iQ_Flight_Type.pdf

Figure 16: Heat Pump Exhaust Heat Recovery Machine Diagram

Picture Source: https://www.hobartcorp.com/products/commercial-dishwashers/conveyor-type/clen-ventless-conveyor-type

Heat recovery machines are engineered based on high-efficiency models; therefore, they exhibit water consumption patterns similar to those efficient machines. The idle energy rate is generally unaffected by heat recovery functionality. Heat pump heat recovery results in lower energy use as the water tank heater is the primary source of idle energy, typically provided by electric resistance heating elements for electrically powered products. Heat pumps use less energy than electric resistance heating elements. Like their high-temperature counterparts, heat recovery dishwashers use booster heaters, pumps, and fans, potentially leading to an incremental increase in energy usage. However, these increases are offset by the energy-efficient water-heating process, which involves heating cold inlet water using energy reclaimed from other operations during the wash cycles.

Figure 17: Drain Water Heat Recovery Machine Diagram

Source: https://www.hobartcorp.com/products/commercial-dishwashers/conveyor-type/clen-advansys-conveyor-type

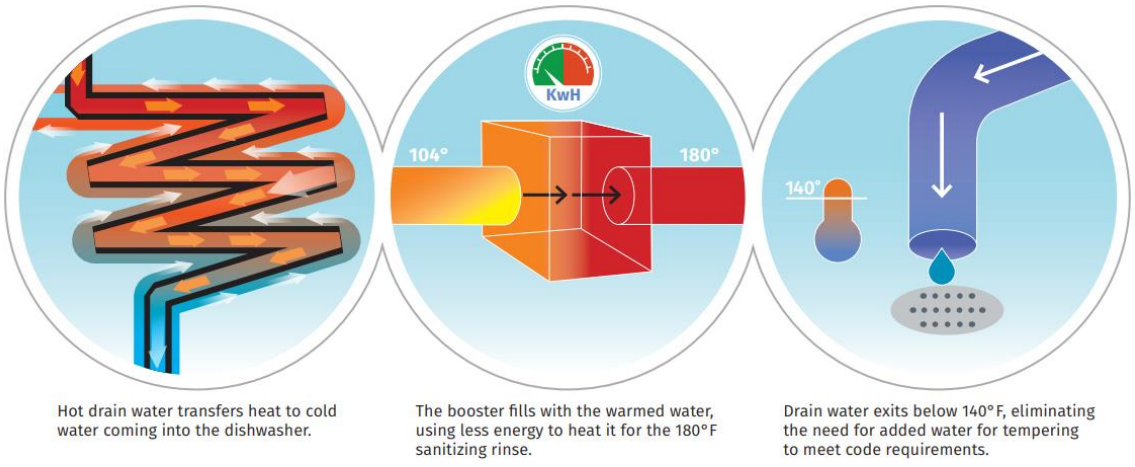

Figure 18: Drain Water Heat Recovery System Diagram

Picture Source: https://www.hobartcorp.com/sites/default/files/webdam-assets/DWER%20Sell%20Sheet%20F40647%20%2802-21%29.pdf

In commercial kitchen applications, heat recovery dishwashers could facilitate using heat pump water heaters by using less hot water. Traditionally, dishwashers, the primary consumers of hot water demand

in commercial kitchens require high Btu gas heaters to accommodate tank fills and consecutive washing cycles. However, heat recovery dishwashers can significantly reduce this hot water demand, allowing for a smaller-capacity heat pump water heater. Heat pump water heaters are used infrequently in commercial kitchen applications due to their lack of cost-effectiveness at capacities required to meet the hot water demand for dishwashing.

3.7 Heat Recovery for Drain Tempering

A notable advantage of drain heat recovery for conveyor dishwashers is its potential to act as a drain-tempering device. The California Plumbing Code limits the temperature of water discharged into the plumbing or drainage system to 140˚ F or below.[9] Consequently, many dishwashers incorporate a drain tempering device using treated cold water to reduce drain water temperature to comply with the code requirement. However, these tempering devices require a substantial volume of cold water that eventually goes down the drain, resulting in significant water wastage. By lowering the temperature of the discharge water, drain heat recovery reduces or eliminates the need for additional cold-water cooling before discharge, thereby conserving water.

[9] 810.1 High Temperature Discharge, CBSC 2022

4 Proposed Standards

4.1 Proposal Description

As noted in the Introduction, the CASE Team proposes a comprehensive approach to achieving water and energy savings by proposing standards for more efficient commercial dishwashers. This report provides supporting analysis for the Title 20 code change proposal, focusing on stricter performance standards for all commercial dishwasher types within the scope of the ENERGY STAR program, as described in Sections 3.1 and 3.2 of this report, with further elaboration in this section. The team proposes certain glasswashing products, which have low-market shares and limited testing data, be required to test and list to industry-accepted procedures with slight modifications to determine their energy performance (expressed as water consumption and idle energy). These products would then have an advertised performance, allowing consumers to make informed purchasing decisions and enabling potential future performance standards for these product categories.

4.2 Proposed Changes to Title 20 Code Language

4.2.1 Scope and Proposed Definitions

The CASE Team proposes that the scope aligns with ENERGY STAR V3.0 for products subject to standards and that additional products that meet the "commercial dishwasher" definition, but are not explicitly included in the scope of ENERGY STAR V3.0, be subject to a test and list requirement. Aligning with ENERGY STAR V3.0 allows the CEC to ensure product availability and adequate test procedures to assess a standard. Gathering data on products outside the scope of ENERGY STAR would enhance consumer choice and provide CEC data for future assessment of standards.

To develop comparable performance data, slight revisions to the ASTM test procedures may be necessary for glasswashing products with similar designs to standard undercounter or conveyor dishwashers. These revisions can be as simple as converting the number of racks tested with a comparable number of individual glasses for glasswashing products that do not use racks. However, certain glasswashing products, such as carousel glasswashers, are not directly comparable to standard commercial dishwashers and cannot be easily tested using existing procedures. These products are currently considered outside the scope of the proposed standards as energy performance is not well understood.

The CASE Team recommends aligning with the ENERGY STAR V3.0 definitions where possible. This alignment enables the CEC to benefit from definitions the industry has vetted over sixteen years of market engagement. It also allows for improving and refining the V2.0 definitions without substantially changing the scope of coverage. Specifically, the CASE Team proposes the following new definitions be added to Title 20 to define the scope of coverage and differentiate covered products from other product types:

- Commercial Dishwasher. The team recommends aligning the definition with the ENERGY STAR V3.0 "Dishwashing Machine" definition to ensure product availability based on substantial test data. Products that fall outside the scope of ENERGY STAR would be defined to incorporate test and list requirements to help consumers understand the product's performance.
- Definitions for machine types, including "Stationary Rack Machine" and the subcategories "Undercounter" and "Single Tank, Door Type," with further subcategories under "Single Tank,

Door Type" for "Pot, Pan, and Utensil" and "Fill and Dump." The team proposes these definitions align with ENERGY STAR V3.0 to maintain a consistent scope of included and excluded products.

- Definitions for conveyor machines, including "Conveyor Machine" and the subcategories "Single-Tank Conveyor," "Multiple-tank Conveyor," and "Flight-type Conveyor" to define the scope and coverage for standards for these product categories.
- Definitions for glasswashing machines, including "Glasswashing," "Rotary Batch Glasswashing," "Conveyor Glasswashing," and "Carousel Glasswashing." Including these definitions would clarify the applicable product standards and identify products subject to test and list requirements, helping consumers understand product performance and gather important data.
- Definitions for sanitation methods, including "High-Temperature Sanitizing," "Low-Temperature (Chemical) Sanitizing," "Chemical Fill-and-Dump Machine," and "Dual-Sanitizing Machine" to align with ENERGY STAR V3.0.
- Definitions of products that would be excluded from both standards and test and list requirements but would otherwise meet the definition of a commercial dishwasher, including "Gas or Steam Heated Conveyor" and "Laboratory Dishwasher."

The ENERGY STAR standard does not include nor exclude the following dishwasher types:

- Rack washers that cannot accommodate a standard 20x20-inch rack
- Carousel glasswashers
- Conveyor washers that cannot accommodate a standard 20x20-inch rack and the height of 15 dishes per ASTM F1920, specifically conveyor glasswashers and conveyor sheet pan washers
- Dual compartment dishwashers designed to wash two different types of wares simultaneously (rack of plates and rack of glasses, or rack of pots and pans and rack of glasses)
- Roll in rack washers

The team proposes excluding these dishwashers from the proposed scope of Title 20 standards but would instead be subject to a test and list requirement only.

4.2.2 Proposed Test Procedure

Over the past decade, the ASTM committee of major dishwasher manufacturers and test labs has actively developed and refined the dishwasher test procedure. They created test methods for stationary racks and conveyor dishwashers, finalizing the latest test method in 2020. However, products that used previous versions for ENERGY STAR V2.0 certification meet the exact same standard requirements and are therefore compliant. The table below shows the categories each test method covers. The team recommends allowing certification based on testing using any of the test method versions from 2007 or later.

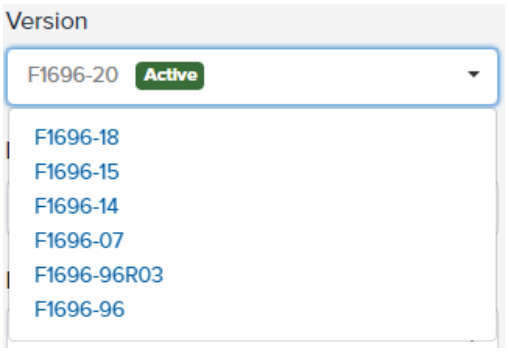

Figure 19: Door Type Dishwasher ASTM method

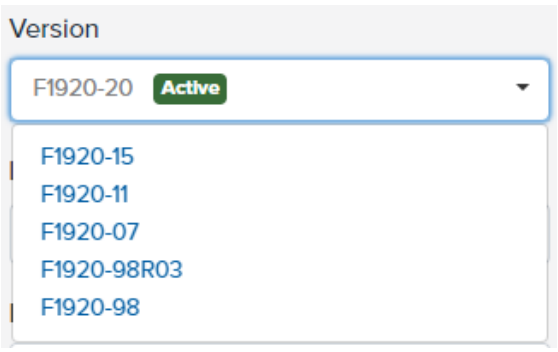

Figure 20: Conveyor Dishwasher ASTM method

Table 4: Test Methods for ENERGY STAR Certification

Dishwasher Category	Test Method Reference
Under-counter; stationary single tank door; pot-pan-utensil	ASTM F1696-20, *Standard Test Method for Energy Performance of Stationary-Rack, Door-Type Commercial Dishwashing Machines*
Single tank conveyor; multiple tank conveyor; single tank flight; multiple tank flight	ASTM F1920-20, *Standard Test Method for Energy Performance of Rack Conveyor Commercial Dishwashing Machines*

The test methods mimic real-world dishwasher operation to account for the dishwasher's water and energy use. Lab testing and the evaluation of commercial food service incentive programs have established the representativeness of these test methods. The washing test involves racks of dishes under heavy-load operation (back-to-back washing) and quantifying water and energy consumption per rack washed. If applicable, the Idle Test, used to quantify idle energy consumption, keeps the machine in ready-to-wash mode while maintaining ready-to-wash and rinse tank temperatures.

For the proposed standards, manufacturers must test stationary rack machines to ASTM F1696 Section 10.5 for water consumption and Section 10.8 for the idle rate. As the ENERGY STAR V2.0 requirements do not include specifications for machine-washing energy (this metric was added in V3.0), there are no proposed standards. Consequently, the Section 10.7 test is not necessary. Because the testing for Section 10.7 is relatively expensive and time-consuming, the team does not recommend a test and list requirement for this metric.

For the proposed standards, manufacturers must test conveyor machines to ASTM F1920 Section 10.7 for water consumption and Sections 10.9 and 10.10 for the idle rate. As per the above statement, Section 10.8 washing-energy test is not required due to the absence of any proposed standards for washing energy in the V2.0 machine. Section 10.8 wash-energy testing is time and labor intensive; therefore, the CASE Team does not recommend a test and list requirement.

Meeting the requirements for all three metrics (i.e., washing-water consumption, washing energy, and idle energy) qualify dishwashers for ENERGY STAR V3.0. Many products have undergone these procedures and are well known and understood within the industry. The ENERGY STAR V2.0 criteria only required water consumption and idle energy testing in alignment with the proposed standards.

For most product categories, the testing method does not require modification. However, as previously noted, some sections would not be used. Slight alterations are necessary for glasswashing machines, as the test procedures cannot incorporate racks in the testing process due to the size and design of these

products. The proposed changes to the test procedure would replace the rack requirements with a quantity of glasses that match a rack's capacity. The ASTM committee has not changed the test procedure for these products. Carousel glasswashers represent a small portion of the market, and the most active ASTM manufacturers do not produce this product, making this product category not a priority for the committee. Individual models must be tested because different components within a model line, such as tank volumes and heater power, affect the machine's energy and water use. Additional products subject to proposed test and list requirements do not require modification to the current test procedures. The CASE Team is not currently recommending standards for those products, as outlined in Section 4.2.1, due to the absence of performance data. These test and list requirements would provide the data necessary for consumer choice and potential amendment standards in the future.

4.2.3 Proposed Standard Level

The CASE Team proposes performance standards for chemical (low-temperature) and high-temperature sanitizing products. The proposed standards align with the previous version of ENERGY STAR (V2.0) and standards adopted in other states. These standards cover stationary rack and conveyor products and most glasswashing products except for carousel glasswashers, which will have a test and list requirement due to the lack of current performance data for that product category. The proposed requirements are limited to idle energy and hot water consumption.

While washing energy consumption can be tested according to ASTM F1696 for door-type dishwashers and ASTM F1920 for conveyor machines, performance data is currently available only for products meeting the current ENERGY STAR V3.0 criteria, and the current availability of products meeting these performance levels. Although products tested for wash energy comply with the ENERGY STAR V3.0 criteria, more data is needed to set a wash-energy performance level below this threshold. As more products reach the ENERGY STAR V3.0 performance level and test data are collected, the increased product availability could pave the way for revised standards.

Only water consumption requirements apply for flight-type dishwashers, idle energy rate for flight-type is test and list only for ENERGY STAR V2.0. In alignment with V2.0 criteria, the team proposes a test and list requirement for the idle energy rate of flight-type products. The proposed performance standards are as follows:

Table 5: ENERGY STAR V2.0 Requirements for Commercial Dishwashers

Machine Type	Idle Energy Rate (kW)	Water Consumption
Undercounter High-Temp	≤ .50 kW	≤ 0.86 GPR
Undercounter Low-Temp	≤ .50 kW	≤ 1.19 GPR
Stationary Single-Tank Door High-Temp	≤ 0.70 kW	≤ 0.89 GPR
Stationary Single-Tank Door Low-Temp	≤ 0.60 kW	≤ 1.18 GPR
Pot, Pan, and Utensil	≤ 1.2 kW	≤ .58 GPSF
Single-Tank Conveyor	≤ 1.5 kW	≤ .7 GPR
Multiple-Tank Conveyor High-Temp	≤ 2.25 kW	≤ .54 GPR
Multiple-Tank Conveyor Low-Temp	≤ 2.0 kW	≤ .54 GPR
Single-Tank Flight-Type	Test and list only	GPH ≤ 2.975x + 55
Multiple-Tank Flight-Type	Test and list only	GPH ≤ 4.96x + 17

Notes:
* Idle results should be measured with the door closed and represent the total idle energy consumed by the machine, including all tank heater(s) and controls. Booster heater (internal and external) energy consumption should not be part of this measurement unless it cannot be separately monitored per the ENERGY STAR Test Method referenced in Section 4.
** GPR = gallons per rack; GPSF = gallons per square foot of rack; GPH = gallons per hour; x = sf of conveyer belt (i.e. W*L)/min (max conveyor speed)

Source: https://www.energystar.gov/sites/default/files/specs//private/ENERGY%20STAR_CD_V2.0_Final%20Specification.pdf

4.2.4 Proposed Certification Requirements

The following items would be listing in the CEC Modernized Appliance Efficiency Database System (MAEDbS) for commercial dishwashers:

Table 6: Proposed Certification Requirements

Field	Source and Explanation	Example Values and Units
Brand Name	This is the company name	Kleen Dishmachines
Basic Model Number	This is usually name of the model series which may encompass multiple electrical configurations	CH44 series
Individual Model Number	This is usually an alphanumeric distinct model designation	CH44B3HR
Machine Type	Machine types are based on ENERGY STAR categories	undercounter door, rotary glasswasher, conveyor glasswasher, upright door-type, double rack door-type, pot, pan, utensil, rack conveyor, dual-tank rack conveyor, single-tank flight-type, multiple tank flight-type, carousel
Sanitization Method	Chemical sanitizing machines are low temperature with rinse temperatures around 140F, hot water sanitizing machines are high temperature with rinse temperatures above 180F. Dual temperature machines can be configured either way.	Low Temp, High Temp, Dual Sanitizing
Idle Energy Rate Low Temp	For low temp machines: For door type machines: ASTM F1696 Section 10.8 For conveyor machines: ASTM F1920 Section 10.9	kW
Idle Energy Rate High Temp	For high temp machines:	kW

Field	Source and Explanation	Example Values and Units
	For door type machines: ASTM F1696 Section 10.8 For conveyor machines: ASTM F1920 Section 10.9	
Inseparable Booster Heater	High temperature machines with integrated booster heaters may not be able to separate booster heater energy, this means that the booster heater energy is **already included** in the "Idle Energy Rate High Temp"	Yes or no
Booster heater Idle Energy Rate	High temperature machines with integrated booster heaters may not be able to separate booster heater energy, this means that the booster heater energy is **not included** in the "Idle Energy Rate High Temp" and is shown separately in this field For door type machines: ASTM F1696 Section 10.8.2 For conveyor machines: ASTM F1920 Section 10.10	kW
Water Consumption GPR	For dishwashers using racks. Water consumption is measured per cycle. For door type machines: ASTM F1696 Section 10.5 For conveyor machines: ASTM F1920 Section 10.8	Gallons per Rack
Water Consumption GPH	For dishwashers that do not use racks. Water consumption is measured per hour with continuous rinse. ASTM F1920 Section 10.7	Gallons per Hour
Water Consumption GPSF	For pot and pan utensil washers only. Water consumption is measured per cycle. The wash area is not standardized, so the width and depth of the washing cavity is measured. ASTM F1696 Section 10.5	Gallons per Square Foot

Field	Source and Explanation	Example Values and Units
(Optional) Washing Energy Consumption Low Temp	For low temperature machines: ENERGY STAR V3 reporting requirement, energy consumed by the machine which includes tank heat, pump and control energy. For door type machines: ASTM F1696 Section 10.7 For conveyor machines: ASTM F1920 Section 10.8	kWh/rack
(Optional) Washing Energy Consumption High Temp	For high temperature machines: ENERGY STAR V3 reporting requirement, energy consumed by the machine which includes tank heat, booster heat, pump and control energy. For door type machines: ASTM F1696 Section 10.7 For conveyor machines: ASTM F1920 Section 10.8	kWh/rack
Has Heat Recovery	Whether a machine has heat recovery features, vapor condensation without water preheat is not heat recovery	True or false
Heat Recovery Features	Type of heat recovery	Only if Has Heat Recovery is true: Exhaust Heat Exchanger or Supplemental Heat pump or Drainwater Heat Exchanger
(Optional) Claimed hot Water Energy Offset	If a machine has heat recovery, it should claim the hot water energy offset	True or false
(Optional) Hot Water Energy Offset	This is the energy that a heat recovery machine (fed with cold water) would be saving over a non-heat recovery machine that is fed with 140F water.	kWh/rack
Racks Per Hour	For machines that use racks, this is the production capacity. Per ASTM F1920 flight-type conveyor machines are tested with racks also.	Racks per Hour

Field	Source and Explanation	Example Values and Units
Pot Pan Utensil Wash Area	For pot pan and utensil wash machines, this is the area of the washing compartment (width multiplied by depth)	Square Feet
Has Energy Saver Mode	If a machine has an automatic idle setback mode which lowers component energy use after a period of inactivity	True or False
Energy Saver Mode Idle Rate	For door type machines: ASTM F1696 Section 10.9 For conveyor machines: ASTM F1920 Section 10.9.1.5	kW
Glasses per hour (Optional field not required by SASD or ENERGY STAR)	For rotating and conveyor glasswashers that do not use racks, this is the production capacity using standardized glasses defined in ASTM F1696 Section 6.18	Glasses per Hour

These fields align with the State Appliance Standards Database (SASD) and ENERGY STAR V3.0. Manufacturers report to SASD to comply with state appliance standards for Massachusetts, New Jersey, New York, and Rhode Island. Several of these categories are marked as optional reporting requirements; this will allow manufacturers who have this data and choose to report it in order to maintain consistency across ENERGY STAR and SASD to do so. These optional fields are not required for compliance with the proposed standards. Some optional fields are required for ENERGY STAR V3.0 qualifications, however since we are proposing the V2.0 threshold, models certified to that version will not have data for the optional fields. We encourage CEC to use the same fields in the same order to simplify compliance. We are proposing one optional field for glasswashers and have placed it at the end intentionally to maintain consistency between forms.

4.2.5 Proposed Marking and Labeling Requirements

Mark all appliances permanently, legibly, and conspicuously in an accessible place for each unit: the manufacturer name, brand name, or trademark; the model number; and the date of manufacture. The CASE team does not propose additional marking or labeling requirements for commercial dishwashers.

5 Market Analysis

5.1 Product Efficiency Opportunities

Commercial dishwashers effectively clean thousands of dishes per hour with short cycle times under five minutes. Consumers expect their dishes to be clean after a cycle. Therefore, appliances must balance delivering spotless dishes, maintaining water and energy efficiency, and meeting sanitization standards. If a cycle fails to clean the dishes adequately, consumers may need to run another cycle, increasing water and energy consumption. Currently, most stationary rack high-temperature dishwashers use less than a gallon of water per rack, and some use less than half a gallon per rack, approaching the limits of cleanability and food safety. Once the water consumption falls below 0.75 gallons per rack, the opportunities for further water savings become limited. Although there are additional prospects for energy performance savings, particularly during the wash cycle, the most substantial potential for savings lies in minimizing water heater usage through heat recovery and similar strategies.

Various technologies and approaches produce improved water and energy efficiency at the machine. Water and energy-saving options and features on commercial dishwashers include:

- Reuse of wash and rinse water;
- Multi-step rinse;
- Vapor recovery for water reuse;
- Modifications to spray nozzles to limit and optimize the use of water during the washing and rinsing process;
- Implementation of sensors that control the operation of wash and rinse sprays, ensuring they function only when racks are present in conveyor-type machines;
- Automatic soil removal during the wash cycle (eliminating the need to pre-rinse wares);
- Exhaust-air heat recovery (vapor-heat recovery);
- Double-wall insulation for wash tanks;
- Insulation for booster heaters;
- Thermal layered curtains for conveyor-type machines;
- Drain water energy recovery; and
- Advanced water filtration systems, including the delime cycle (addressing scaling issue).

Efficiency enhancements in products are the result of manufacturers integrating a variety of technologies and components. Improved efficiency results from a series of strategic design choices, not simply incorporating one or two technologies.

Low-temperature dishwashers, while energy-efficient in their operation, shift the energy demand to the water heating system. This system, however, is frequently not optimized for efficiency in a commercial dishwashing context. The proposed standards capture available energy and water savings opportunities; however, commercial hot water systems often exhibit inefficiencies, including extensive piping runs, inadequate insulation, and continuous recirculation. While the Title 20 standards play a crucial role in enhancing the efficiency of commercial dishwashers, more substantial energy savings may be attainable for low-temperature dishwashers through the holistic approach offered by Title 24 requirements.

Most recent advancements in dishwasher technology have focused on high-temperature dishwashers that use heat recovery. This approach confines energy consumption to the machine, thereby alleviating the burden on the water heating system. These recovery systems recover waste heat from the sanitization process and it us to preheat incoming cold water. Heat pumps in larger heat recovery machines increase tank heating efficiency, outperforming traditional resistance heating methods.

Stationary rack dishwashers are more water-efficient than conveyor products. The stationary rack design enables manufacturers to enhance operational efficiency due to the minimal variation from one cycle to another, with each cycle completed before the next one begins. Alternatively, conveyor dishwashers continuously process large quantities of racks. Therefore, these conveyor dishwashers operate at maximum efficiency when fed back-to-back racks of fully loaded dishes, requiring one person to load the conveyor and another to unload it. In the field, racks are frequently filled with a few items or irregularly sized objects, such as pots and pans. They may be operated by single user feeding and retrieving racks, especially in short-staffed commercial food service environments. In traditional commercial dishwasher designs, feeding a single rack into the machine leads to significant water waste because the pumps and rinse nozzles do not shut off immediately after the wash cycle completes. Irregular items like pots and pans fed into the conveyor may transfer water from one tank to another, causing the tanks to top off during the wash process and leading to inefficient operation. Current test procedures accurately reflect average product performance; however, consumer behavior significantly impacts operational efficiency. Ultimately, energy savings depend on two factors: product efficiency, captured through test procedures, and operating efficiency, influenced by consumer behavior and choices. Modern conveyors and flight-type dishwashers attempt to address some aspects of operational efficiency by using sensor and curtain technologies that prevent water waste by detecting and anticipating the dish load and turning off pumps and nozzles as appropriate.

Establishing energy and water performance standards across the range of commercial dishwashers will leverage these technological advances and provide significant water and energy savings in California.

5.2 Technical Feasibility

5.2.1 Future Market Adoption of Qualifying Products

The CASE Team reviewed the ENERGY STAR qualified product lists for V2.0 of the specification, the current qualified product list for V3.0, and the SASD to assess the availability of products meeting the proposed standards, i.e., qualifying products. Section 8.2 presents the results of that analysis.

Furthermore, when ENERGY STAR adopted the V2.0 criteria in 2013, EPA assessed the market to ensure adequate production of qualified products from various manufacturers at that time. EPA seeks to establish recognition criteria that are not dependent on proprietary technology. It determined that the proposed levels were well-represented in the market and offer consumers a robust selection of qualifying products. EPA analyzed the proposed standards across capacities and other performance features and determined that the V2.0 levels represented good coverage across the available features and product classes.[10] When ENERGY STAR adopted the V3.0 criteria, it was estimated that V2.0 qualifying products represented 63% of all dishwasher sales, demonstrating widespread consumer acceptance of products at the proposed level. Furthermore, more than half of the manufacturers of commercial dishwashers (19) have developed products that meet the V2.0 standards.[11]

[10] https://www.energystar.gov/sites/default/files/specs//private/Commercial_Dishwasher_Plots_Draft_2.pdf
[11] ENERGY STAR® Unit Shipment and Market Penetration Report Calendar Year 2020 Summary https://www.energystar.gov/sites/default/files/asset/document/2020%20USD%20Summary%20Report_Lighting%20%20EVSE%20Update.pdf

5.2.2 Consumer Utility and Acceptance

This section discusses consumer utility and acceptance of commercial dishwashers meeting the proposed standards level.

As previously noted, consumers have widely adopted products meeting the proposed specification level, with most dishwashers sold meeting the criteria. More efficient products are offered with additional premium capabilities, including improved controls, electronic chemical dosing, troubleshooting capabilities, anti-clogging technologies to support continual operation, and sensors that can adjust performance based on loads. Products with higher efficiency have additional premium capabilities, including enhanced controls, electronic chemical dosing, troubleshooting capabilities, anti-clogging technologies to support continuous operation, and sensors that adjust performance based on the load. While industry test methods do not evaluate these features the CASE Team believes that they do not typically influence the product's energy and water efficiency. All commercial dishwashers, both meeting the proposed standards and others, provide fast and effective dish cleaning. The throughput and cleaning efficacy for efficient and less efficient products are generally the same. Because cleanability and speed are the primary motivations for consumer purchasing, all products meeting the proposed standards provide robust performance in those areas and are comparable to less efficient products. All commercial dishwashers in the US must pass the NSF 3 test for food safety.

As noted in Section 3.4, heat recovery technologies offer additional consumer benefits, and most heat recovery products meet the proposed standards levels. All dishwashers operate at relatively high temperatures, and high-temperature sanitizing machines operate with water above 180˚F. At the end of a cycle, the excess heat generated by the dishwasher is released or "rejected" into the dish room or commercial kitchen. These spaces are typically already hot and humid, with inadequate HVAC capacity to provide comfortable cooling for staff. Heat recovery products help to reduce loads, improve occupant comfort, and lessen HVAC loads in well-designed commercial kitchens. Furthermore, heat recovery dishwashers may help kitchens meet recent OSHA requirements for indoor heat illness prevention[12].

The standards apply to a variety of dishwashers designed to meet commercial dishwashing needs, ranging from smaller undercounter models to larger flight-type units. These products cater to a diverse range of applications, from small-scale operations like coffee shops to large-capacity settings such as university dining halls and prisons. Certain application-specific products, such as dishwashing machines designed for laboratory use, are excluded from the scope of the proposed standards.

Manufacturers reported no concerns regarding consumer utility or acceptance of products meeting the proposed performance standards. Most consumers are unaware of the efficiency level of the dishwasher and mostly notice the additional features and functionality offered by products currently on the market that meet the proposed standards.

5.2.3 Commercial Dishwasher Market Structure

The market structure for commercial dishwasher sales aligns with the general market structure for commercial food service equipment and has been in place across many equipment types for decades.

Below are the stakeholders within the commercial food service market:

- **Equipment Manufacturers:** Commercial food service equipment manufacturers design, fabricate, and assemble equipment. Manufacturers are rarely involved in manufacturer-direct

[12]State of California Department of Industrial Relations (DIR), "Heat Illness Prevention in Indoor Places of Employment," Cal.gov, December 2023, https://www.dir.ca.gov/oshsb/Indoor-Heat.html.

sales; they utilize equipment representatives such as manufacturing representatives and vendor/dealers to distribute product, work with customers, and/or facilitate sales.

- **Manufacturer Representatives:** Manufacturers of commercial food service equipment design, fabricate, and assemble equipment. Manufacturers are rarely involved in manufacturer-direct sales. They rely on equipment representatives such as manufacturing representatives and vendors or dealers to distribute products, work with customers, and facilitate sales.
- **Equipment Vendors/Dealers:** Vendors are brick-and-mortar stores or online retailers that sell equipment directly to consumers. Consumers can work with dealers to make equipment selections stocked in the store or special orders. Larger vendors have a design-build component where sales staff take client requirements and specify products for new kitchens and extensive remodels. These vendors often participate in contract-bid activities where staff propose a suite of kitchen equipment based on customer specifications and bid on the project against other vendors for the equipment sales contract. These online and brick-and-mortar dealers will likely sell smaller stationary-rack machines, although some dealers have design consultants, as described below.
- **Buying Groups:** Buying groups are a coalition of equipment vendors or dealers eligible to participate due to their high-volume sales. These groups negotiate with manufacturers to secure the best possible prices for their members. A buying group can be advantageous for equipment vendors, as it often leads to lower prices and access to additional rebates or promotions on specific equipment. However, one potential drawback is that it may restrict the variety of brands available to customers.
- **Designers and Consultants:** Designers and consultants do not generally have a brick-and-mortar sales floor or offer online sales. However, they often have showrooms where they can meet with customers to design custom kitchens from scratch or existing specifications. Consultants and designers specialize in complete kitchens or extensive remodels and, therefore, are generally involved in the sales of large flight and conveyor dishwashers since these are significant systems. The consultant's design-build and contract-bid activities are similar to those of vendors.
- **Installers:** A general contractor, a plumber, and an electrician commonly install equipment.

5.2.4 Commercial Dishwasher Market

Leading commercial dishwasher manufacturers that sell machines in the U.S. include Hobart Corporation (ITW group), Champion Industries (Ali group), CMA Dishmachines (Ali group), Jackson WWS, LLC, Meiko USA, Electrolux Professional, Insinger Machine Company, MVP Group Corp., Stero, American Dish Service (Ali group), and Moyer Diebel Ltd (Ali group) with another 10 to 20 smaller manufacturers in the market. National Association of Food Equipment Manufacturers (NAFEM) is the organization that represents manufacturers in the industry.

Industry analysts report that food service establishments in California purchase about half of the dishwashers through the market structure described above. Chemical sales companies lease the other half of the dishwashers in California. These companies supply the machines, the required ware washing chemicals, and regular maintenance under a leasing contract.[13]

Commercial food service establishments, especially smaller ones like restaurants, typically opt to lease dishwashers. In contrast, larger institutional facilities usually prefer to purchase. The ratio of owned to

[13]Koeller and Company and H.W.(Bill) Hoffman & Associates, LLC, "A Report on Potential Best Management Practices - Commercial Dishwashers," June 2010, https://p2infohouse.org/ref/53/52002.pdf.

leased machines fluctuates depending on the type of machine. In California, most door-type machines, especially those operating at low temperatures, are leased. Food Service establishments own most conveyor-type machines and almost all flight-type machines. The distribution of leased versus owned units for under-counter machines is not definitively known. However, based on analyses from the DOE and industry interviews, it's estimated that about two-thirds are purchased, and one-third are leased.[14]

Ecolab and Auto-Chlor System are the largest providers in the dishwasher leasing market. Chemical sales companies such as Ecolab purchase machines from manufacturers or contract with manufacturers to build machines to the requested specifications. Auto-Chlor System's manufacturing facility leases products directly to end users.

When a food service facility contracts with a leasing company for a dishwasher, it may receive a brand-new or refurbished unit. In some instances, although refurbished units offer the benefit of embodied energy savings, refurbished units with aftermarket modifications and parts may be less efficient than new units. Industry stakeholders indicated that the market and use of refurbished machines are areas with great water inefficiency. Few incentives push leasing companies or consumers towards using or requesting more efficient machines. This structure can create a split incentive because the leasing company pays any incremental costs for purchasing more efficient equipment while the lessee receives the financial savings of reduced water and energy bills.

Historically, smaller facility owners, particularly price-sensitive consumers, prefer leasing dishwashing machines. This approach requires less upfront capital, making it an attractive option, especially when launching a new restaurant. Given the high failure rate of new restaurants, many operators are hesitant to invest in more efficient but costly equipment. According to the CASE Team's understanding of the leasing market, most companies that lease commercial dishwashers to restaurants are in the state. Consequently, the products sold to these companies are subject to Title 20 standards, although the stock turnover may be slower compared to products that a facility uses regularly. The team anticipates that the proposed standards would address these leased machines as older models are phased out and replaced with newer ones. Leasing companies based in Oregon and Nevada have state standards that align with ENERGY STAR V2.0. The recommendation in Section 4.1 aims to address the refurbished and leased market; however, implementing that approach falls outside the scope of this report.

Given the variety of commercial dishwashers in each product class that meet the proposed standards, the CASE Team anticipates the continued market adoption of these models in the standards and the non-standards case**.**

The CASE Team does not anticipate the standards proposal would significantly impact the existing manufacturer structure or supply, particularly since more than half of all sales already meet the criteria. If the proposed standards are adopted, providing at least one year between the adoption and effective date would allow manufacturers and supply chains sufficient time to adjust their operations to comply with the changes.

Undercounter and upright door-type machines account for most dishwasher sales by numbers; however, rack conveyor and flight-type machines account for most dishwasher sales by cost.[15] The largest dishwasher manufacturers, including Hobart, Jackson, Champion, Meiko, CMA, ADS, Stereo, Insinger, Electrolux, and Fagor, are NAFEM members. NAFEM data does not separate low- and high-

[14]Navigant Consulting, Inc. et al., "Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances (2015 Update)," June 2016, https://www.energy.gov/sites/prod/files/2016/06/f32/DOE-BTO%20Comml%20Appl%20Report%20-%20Full%20Report_0.pdf.

[15] https://www.nafem.org/2023/02/15/the-2022-nafem-size-and-shape-study-is-available-to-all/

temp machines. For Title 20 purposes, most glasswashers that use standardized 20”x20” racks are categorized as undercounter machines.

6 Per Unit Water and Energy Savings

6.1 Key Assumptions

Over the past nineteen years, the close study of dishwashers contributed to developing ENERGY STAR recognition criteria and implementing energy-efficiency programs. Studies have included extensive field testing by organizations such as the Food Service Technology Center (FSTC),[16] vetted by industry, and subject to program evaluation. These studies have demonstrated that commercial dishwashers are high-use products. Many commercial food service establishments operate 365 days a year, and large banquets or other facilities may experience the most use on holidays or other days when most businesses are closed. The largest facilities, such as hotels, casinos, or prisons, operate similarly to industrial facilities with near-constant cooking and cleaning operations.

The key assumptions reflect the heavy usage of commercial dishwashers. The CASE Team used findings and calculators from the Food Service Technology Center (FSTC) to determine appropriate inputs for the number of operational days, racks, and hours for different types of dishwashers. The rack size is based on industry-standard dimensions. The average wash time specified underscores the high-speed, and effective performance of commercial dishwashers.

The other key assumptions are related to energy use. First, the CASE Team determined by reviewing industry literature that booster heaters are primarily electrically powered. Natural gas is the predominant water heater fuel type in commercial applications across California. Presumed efficiencies for natural gas and electric water heat are based on U.S. Department of Energy (DOE) minimum-performance standards and market adoption as established through FSTC and EPA studies. Water temperature rise is based on the average temperature of operation minus average inlet water temperatures, as determined by EPA. The nationwide averages used for inlet water temperature are appropriate for approximating California's diversity of climate zones. Finally, the CASE Team relied on standardized metrics for water density and specific heat and approved methodologies for embedded electricity and load factors.

6.2 Methodology

6.2.1 Per Unit Water and Energy Savings Methodology

This section describes the CASE Team's methodology and approach for estimating water, energy, and environmental impacts. The team calculated the effect of the proposed standards by conducting a comparative analysis of products meeting these standards and those that do not. Baseline and efficient dishwashers are compared within the same product category. Customers have the ability to choose between less expensive, more energy, and water-intensive dishwashers and more expensive water and energy efficient dishwashers of the same utility and production capacity.

The difference in energy-efficient and baseline dishwashers is primarily defined by these assumptions:

- **Water usage** in gallons per rack (for stationary rack and rack conveyor machines), per hour (for flight-type dishwashers), or per square foot per cycle (for pot, pan, utensil washers).
- **Idle energy** in kilowatts (kW). As the machine is ready to wash but not actively washing, including washing tank energy (except for fill-and-dump machines, which do not have a tank

[16] "The Foodservice Energy Efficiency Experts," Frontier Energy, December 26, 2001, https://fishnick.com/.

heater) and booster heater energy for high-temperature machines. Idle energy is measured for at least 3 hours of inactivity and normalized per hour. Therefore, it is expressed in kilowatt-hours per hour (kWh/h), simplifying to (kW) to follow industry convention.

- **Washing energy** in kWh/rack or kW (for flight-type dishwashers). The energy used by the wash pump and the energy required to reheat the wash tank water as it cools down due to cold dishes. ENERGY STAR V2.0 does not propose a specific threshold for washing energy. However, washing energy data has been collected for over ten years to inform the development of ENERGY STAR V3.0. This test data[17] was incorporated in the savings methodology.

Usage assumptions estimate the annual water and energy usage of typical operation for baseline and energy-efficient dishwashers. These assumptions include:

- **Racks washed per day** using universal 20"x20"-inch racks filled with 20 plates or 36 glasses (for under-counter machines) and defined by the corresponding ASTM test method. Flight-type dishwasher usage is determined by how many hours the machine spent rinsing wares (flight-type machines do not use racks).
- **Hours on per day** define the hours the machine is on and ready to wash, but not necessarily actively washing wares.
- **Days operating per year** assumed to be 365-day operation.[18]
- **Domestic water heating energy** at the water heater involves supplying 140˚F water to non-heat recovery machines for tank fills, top-offs, and rinse water use. This energy also includes hot water piping and recirculation losses, typical for dish rooms. Gas water heating, a common practice in California's food service operations, is assumed.[19]

Annual energy usage calculations involve applying the usage assumptions to the baseline or energy-efficient machine's water and energy consumption characteristics. Daily dishwasher energy and water consumption consist of:

- **Morning and afternoon tank fill** is the machine wash tank volume filled with domestic hot water above 140˚F. The wash tank is assumed to be drained after the lunch and dinner rush to dispose of the debris accumulated after washing. Flight-type machines also include tank top-off, which is required when wares transfer water from one tank to another.
- **Washing energy and water consumption** are multiplied by the number of racks washed per day or hours in rinse operation for flight-type machines.

6.2.2 Universal Assumptions

Racks washed per day is the same for low temp and high temp dishwashers. These assumptions differ per dishwasher type as customers purchase different dishwasher types for their washing capacity needs:

- Undercounter: 50 racks per day
- Door-type: 100 racks per day
- Pot, pan, utensil washer: 50 racks per day

[17] "Dishmachine Performance Reports," California Energy Wise, 2023, https://caenergywise.com/report-library/dishmachines/.
[18] Koeller and Company and H.W.(Bill) Hoffman & Associates, LLC, "A Report on Potential Best Management Practices - Commercial Dishwashers," 11.
[19] California Energy Commission, "2006 California Commercial End-Use Survey (CEUS)," Ca.gov, 2006, 24, https://www.energy.ca.gov/data-reports/surveys/california-commercial-end-use-survey/2006-california-commercial-end-use-survey.

- Single-tank rack conveyor: 400 racks per day
- Multiple-tank rack conveyor: 600 racks per day
- Single-tank flight-type and Multiple-tank flight-type: 8 hours of washing per day as these do not use racks

The racks washed per-day assumptions were taken from the Foodservice Technology Center field monitoring data and documented in the latest California Electronic Technical Reference Manual (eTRM).[20] The following operation hours (on time) per day are assumed for each dishwasher:

- Undercounter, Door-Type and Pot and Pan dishwashers: 12 hours per day
- Single and multiple-tank rack conveyor dishwashers: 14 hours per day
- Single and multiple-tank flight-type dishwashers: 18 hours per day.

The operating hours differ from the washing hours as these products spend long periods of the day in idle mode. Longer operating times are assumed for larger high-capacity dishwashers, which are used in large facilities with longer operation hours.[21]

Domestic water heating energy is assumed to be 0.0101 therms per gallon for all dishwashers except for flight-type dishwashers. For flight-type dishwashers the location is typically closer to the water heater; therefore, water heating is assumed to have 0.0095 therms per gallon use per field data.[22] Domestic water heating energy calculation assumes a 60˚F to 140˚F rise and 65% water heating efficiency, per Section 11 of ASTM F1696 and F1920, which includes piping and recirculation losses.

6.3 Energy Efficiency Impacts

6.3.1 Per Unit Water and Energy Use Impacts

Annual per unit water and energy impacts are presented in the tables below. Non-qualifying products do not meet the proposed standards, and qualifying products meet the proposed standards. The methodology used to calculate these estimates is presented above in Section 8.2.

As shown in Table 7 below, the CASE Team estimates that a baseline dishwasher would use from 22,265 gallons of water per year to 788,400 gallons per year, depending on the machine type. A non-qualifying product would also use between 255 therms to 7,469 therms per year of natural gas to heat water and between 2,610 kWh to 182,500 kWh per year of electricity for water heating, depending on the machine type.

[20] "eTRM," https://www.caetrm.com/measure/SWFS018/05/.
[21] Frontier Energy, Inc. and Food Service Technology Center, "Sizing Dishroom Ventilation," 2019, 8 https://caenergywise.com/design-guides/CKV-Dishroom-Sizing-Design-Guide.pdf.
[22] Frontier Energy, Inc., "Flight-Type Dishmachine Replacement—Field Evaluation Report," 2018, 17 https://www.meiko.us/fileadmin/editor_upload/meiko.us/Images/FEM_2019/SR_Marriott_Dishmachine_Replacement_1-29-2019.pdf.

Table 7: Annual Per Unit Water and Energy Use for Baseline

Product Class	Baseline per-unit consumption - electricity (kWh/yr-unit)	Baseline per-unit consumption - natural gas (therms/yr-unit)	Baseline per-unit consumption - water (gal/yr-unit)
Undercounter - HT	10,047	225	22,265
Undercounter - LT	2,610	299	29,565
Stationary Single-Tank Door - HT	17,240	480	47,450
Stationary Single-Tank Door - LT	4,404	535	52,925
Pot, Pan, and Utensil	15,598	517	51,100
Single-Tank Conveyor - HT	75,774	1,699	167,900
Single-Tank Conveyor - LT	51,684	1,994	197,100
Multiple-Tank Conveyor - HT	119,948	2,659	262,800
Multiple-Tank Conveyor - LT	81,304	3,102	306,600
Single-Tank Flight-Type	136,875	6,639	700,800
Multiple-Tank Flight-Type	182,500	7,469	788,400

Table 8 summarizes the measure case per unit of energy use. The CASE Team estimates a qualifying dishwasher would use between 14,965 and 227,213 gallons per year, depending on the machine type. A qualifying product would also use between 151 and 2,153 therms of natural gas per year to heat water and 1,305 and 150,234 kWh of electricity per year for water heating, depending on the machine type.

Table 8: Annual Per Unit Water and Energy Use for Measure Case

Product Class	Measure case per unit consumption - electricity (kWh/yr-unit)	Measure case per unit consumption - natural gas (therms/yr-unit)	Measure case per unit consumption - water (gal/yr-unit)
Undercounter - HT	6,132	151	14,965
Undercounter - LT	1,305	207	20,440
Stationary Single-Tank Door - HT	12,836	369	36,500
Stationary Single-Tank Door - LT	2,202	443	43,800
Pot, Pan, and Utensil	11,412	369	36,500
Single-Tank Conveyor - HT	57,232	960	94,900
Single-Tank Conveyor - LT	34,456	1,108	109,500
Multiple-Tank Conveyor - HT	91,341	1,551	153,300
Multiple-Tank Conveyor - LT	54,203	1,772	175,200
Single-Tank Flight-Type	112,676	1,850	195,275
Multiple-Tank Flight-Type	150,234	2,153	227,213

Table 9 summarizes the annual per unit water and energy savings. The CASE Team estimates a qualifying dishwasher would save between 7,300 and 561,188 gallons of water per year, depending on the machine type. A qualifying product would save between 74 and 5,317 therms of natural gas per year to heat water and between 1,305 kWh and 32,266 kWh per year on booster heating and tank heater idling, depending on the machine type.

Table 9: Annual Per Unit Water and Energy Savings

Product Class	Per unit savings - electricity (kWh/yr-unit)	Per unit savings - natural gas (therm/yr-unit)	Per unit savings - water (gal/yr-unit)
Undercounter - HT	3,915	74	7,300
Undercounter - LT	1,305	92	9,125
Stationary Single-Tank Door - HT	4,404	111	10,950
Stationary Single-Tank Door - LT	2,202	92	9,125
Pot, Pan, and Utensil	4,185	148	14,600
Single-Tank Conveyor - HT	18,542	739	73,000
Single-Tank Conveyor - LT	17,228	886	87,600
Multiple-Tank Conveyor - HT	28,607	1,108	109,500
Multiple-Tank Conveyor - LT	27,101	1,329	131,400
Single-Tank Flight-Type	24,200	4,789	505,525
Multiple-Tank Flight-Type	32,266	5,317	561,188

6.3.2 Efficiency Measures

See Section 5.1 for a discussion on water and energy-saving options and features on commercial dishwashers.

Industry stakeholders have indicated, particularly with conveyor and flight machines, that proper commissioning of new units at installation and regular machine maintenance are two areas to gain significant water savings from the existing stock of operating dishwashers. Title 20 standards requirements cannot effectively capture these operational efficiencies but can be a part of the Title 24 building code requirement for design of new buildings. The CASE team also recommends market education components of part of compliance improvement.

7 Cost Effectiveness

This section describes the methodology the CASE Team used to analyze the economic impacts of the proposed standards.

7.1 Incremental Cost

The CASE Team obtained price data from four major online retailers to determine incremental costs for purchasing commercial food service equipment.

- Webstaurant Store
- KaTom
- Culinary Depot
- Cuda Kitchen

Average prices were obtained for qualifying and non-qualifying models by machine category. The average price of the least expensive models was used for baseline cost data. Maintenance and repair costs are not included, as these costs were assumed to be the same for the base and measure case. The incremental cost between the baseline equipment and equipment compliant with the proposed measure ranges from $-708.04 to $65,000.00 depending on equipment class. For low temperature Stationary Single-Tank Door type dishwashers the average cost of measure case equipment is lower than the baseline equipment; therefore, the incremental equipment cost is negative for this product class only.

Table 10: Per unit Costs

Product Class	Baseline Equipment Cost (2024 $)	Measure Case Equipment Cost (2024 $)	Incremental Equipment Cost (2024 $)
Undercounter - HT	4,774.14	5,963.97	1,189.82
Undercounter - LT	5,739.25	6,159.00	419.75
Stationary Single-Tank Door - HT	8,254.43	12,106.57	3,852.14
Stationary Single-Tank Door - LT	5,823.67	5,115.63	-708.04
Pot, Pan, and Utensil	14,930.00	22,704.00	7,774.00
Single-Tank Conveyor - HT	18,800.67	26,887.75	8,087.08
Single-Tank Conveyor - LT	17,216.50	24,958.50	7,742.00
Multiple-Tank Conveyor - HT	28,739.75	52,164.00	23,424.25
Multiple-Tank Conveyor - LT	23,712.33	45,482.50	21,770.17
Single-Tank Flight-Type	60,000.00	80,000.00	20,000.00
Multiple-Tank Flight-Type	86,000.00	151,000.00	65,000.00

7.2 Design Life

The lifetime of undercounter machines is assumed to be 12 years based the eTRM. Stationary machines, including single-tank doors, as well as pot, pan, and utensil machines are assumed to have a 15-year

lifetime, according to the eTRM. Conveyor and flight machines are believed to have a 20-year lifetime.[23] The CASE Team assumes that flight-type and conveyor products have longer operational lifetimes as they are more likely to be repaired due to their expense and customization than door-type products, which are more likely to be replaced if the product fails.[24]

The baseline of non-complying equipment and measure case share the same effective useful lifetime.

Table 11: Effective Useful Lifetime by Equipment Class

Equipment Class	Effective Useful Life of Equipment (years)
Undercounter - HT	12
Undercounter - LT	12
Stationary Single-Tank Door - HT	15
Stationary Single-Tank Door - LT	15
Pot, Pan, and Utensil	15
Single-Tank Conveyor - HT	20
Single-Tank Conveyor - LT	20
Multiple-Tank Conveyor - HT	20
Multiple-Tank Conveyor - LT	20
Single-Tank Flight-Type	20
Multiple-Tank Flight-Type	20

7.3 Economic Impacts

7.1.1 Life Cycle Cost and Net Benefit

Table 12 contains per unit lifecycle costs and benefits of the proposed standards. The proposed standards are cost effective, as indicated by the benefit-cost ratio greater than 1.0 for each equipment class, ranging from 2.41 for pot, pan, and utensil machines to infinity for stationary single-tank door with low temperature machines. The infinite benefit-cost ratio for stationary single-tank door with low temperature is due to negative incremental cost (see Table 10).

The incremental cost of the proposed standards ranges from $-708.04 to $65,000.00 depending on the machine category (equipment class). No additional costs, such as added maintenance or installation costs, were included in the analysis. See Section 7.1 for a further cost breakdown. The CASE Team will continue to work with stakeholders to understand maintenance and installation costs.

The electricity and natural gas prices were estimated based on the latest available data, which was derived from the U.S. Energy Information Administration (EIA)[25][26], on average electricity and natural gas prices paid by California consumers. The annual escalation rates were estimated using price forecasts. The electricity price forecast was derived from the California Energy Demand Forecast published by CEC

[23] Energy Solutions Commercial Foodservice Calculator based on energy efficiency programs – not publicly available.
[24] Koeller and Company and H.W.(Bill) Hoffman & Associates, LLC, "A Report on Potential Best Management Practices - Commercial Dishwashers," 11 at 16, https://p2infohouse.org/ref/53/52002.pdf.
[25] U.S. Energy Information Administration (EIA), Electric Power Monthly, 2023. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a
[26] U.S. Energy Information Administration (EIA), California Price of Natural Gas Sold to Commercial Consumers. https://www.eia.gov/dnav/ng/hist/n3020ca3m.htm

in 2022[27] and the natural gas price forecast was derived from the California Public Utility Commission's 2021 report "Utility Costs and Affordability of the Grid of the Future: An Evaluation of Electric Costs, Rates and Equity Issues"[28]. Further, electricity and natural gas prices were escalated based on the annual escalation rates. Finally, the price of water was assumed to be $6.13 per thousand gallon and remain constant over time.[29]

The CASE Team estimates total lifecycle benefits per unit compliant with the proposed standards range from $5,840.37 to $351,376.34, depending on the equipment class, as shown in Table 12. The proposed standards are cost effective, as indicated by the benefit-cost ratio ranging from 2.41 to infinity.

Table 12: Per Unit Lifetime Economic Impacts for Products Purchased in the First Year

Product Class	Design Life (years)	Present Value of Benefits (2024 $)	Present Value of Incremental Costs (2024 $)	Net Present Value (2024 $)	Simple Payback Period (years)	Lifecycle Benefit-Cost Ratio
Undercounter - HT	12	12,899.39	1,189.82	11,709.57	0.89	10.84
Undercounter - LT	12	5,840.37	419.75	5,420.62	0.69	13.91
Stationary Single-Tank Door - HT	15	18,430.08	3,852.14	14,577.93	2.41	4.78
Stationary Single-Tank Door - LT	15	10,983.86	-	10,983.86	-	Infinite
Pot, Pan, and Utensil	15	18,732.68	7,774.00	10,958.68	4.78	2.41
Single-Tank Conveyor - HT	20	109,667.69	8,087.08	101,580.61	1.05	13.56
Single-Tank Conveyor - LT	20	109,705.15	7,742.00	101,963.15	1.00	14.17
Multiple-Tank Conveyor - HT	20	167,962.58	23,424.25	144,538.33	1.99	7.17
Multiple-Tank Conveyor - LT	20	170,047.66	21,770.17	148,277.49	1.82	7.81
Single-Tank Flight-type	20	295,309.58	20,000.00	275,309.58	0.95	14.77
Multiple-Tank Flight-type	20	351,376.34	65,000.00	286,376.34	2.61	5.41

[27] California Energy Commission, "California Energy Demand Update, 2022–2035". https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2022-integrated-energy-policy-report-update-2

[28] California Public Utility Commission, "Utility Costs and Affordability of the Grid of the Future: An Evaluation of Electric Costs, Rates and Equity Issues," 2021, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf

[29] California Energy Commission, Staff Report - Staff Analysis of Proposed Efficiency Standards for Landscape Irrigation Controllers. https://efiling.energy.ca.gov/GetDocument.aspx?tn=253050&DocumentContentId=88249

8 Statewide Impacts

8.1 Annual Sales and Stock Turnover

The CASE Team developed savings based on annual shipments and stock turnover. The total estimated California commercial dishwasher shipments multiplied by the category breakdown percentages in Table 13 were used to determine the number of units shipped for each product category. Given the unpredictable sales growth in the food service industry due to the pandemic[30], the CASE team projected a market growth rate of 0% for commercial dishwashers.

The CASE Team proposes ENERGY STAR V2.0 as the Title 20 threshold for commercial dishwashers. ENERGY STAR estimated for 2021 the unit shipment for commercial dishwashers was 48,000 units shipped in the United States.[31] That unit shipment number dropped in 2022,[32] potentially reflecting the impacts of the COVID-19 pandemic, which had significant effects on the commercial food service industry. The Team estimates that California restaurants accounted for 12.1%[33] of the nation's total restaurant count and used this factor to translate national to statewide savings. Table 13 shows a breakdown of shipments by equipment class.[34]

[30] Joseph M. Carbonara, "2024 Foodservice Industry Forecast: Back to the Future," Foodservice Equipment & Supplies, December 1, 2023, https://fesmag.com/research/industry-forecast/21638-back-to-the-future. https://fesmag.com/research/industry-forecast/21638-back-to-the-future, and Luke Labree, "National Restaurant Association, Restaurant Industry 2030 Report," Dennis Food Service, October 6, 2020, https://dennisfoodservice.com/restaurant-industry-2030-report/#:~:text=Restaurant%20industry%20sales%20are%20expected,8.5%25%20between%202018%20and%202030.

[31] U.S. Environmental Protection Agency (EPA), "ENERGY STAR® Unit Shipment and Market Penetration Report Calendar Year 2021 Summary," 2019, https://www.energystar.gov/sites/default/files/asset/document/2021%20Unit%20Shipment%20Data%20Summary%20Report_0.pdf..

[32] U.S. Environmental Protection Agency (EPA), "ENERGY STAR® Unit Shipment and Market Penetration Report Calendar Year 2022 Summary," 2022, https://www.energystar.gov/sites/default/files/2022%20Unit%20Shipment%20Data%20Summary%20Report.pdf?itid=lk_inline_enhanced-template

[33] https://restaurant.org/research-and-media/research/industry-statistics/state-statistics/

[34] This breakdown was included with the 2015 draft CASE report materials siting conversations with EPA as the source. The CASE team is working to verify the validity of this data.

Table 13: Shipments in California Based on Equipment Class

Equipment Class	Percent of Shipments	CA Shipments (2024)
Undercounter - HT	27.9%	2,785
Undercounter - LT	18.8%	1,873
Stationary Single-Tank Door - HT	11.1%	1,103
Stationary Single-Tank Door - LT	38.0%	3,789
Pot, Pan, and Utensil	0.8%	80
Single-Tank Conveyor - HT	2.0%	197
Single-Tank Conveyor - LT	0.3%	26
Multiple-Tank Conveyor - HT	0.3%	33
Multiple-Tank Conveyor - LT	0.0%	0
Single-Tank Flight-Type	0.2%	20
Multiple-Tank Flight-Type	0.6%	58
Total	**100%**	**9,965**

8.2 Market Share of Qualifying Products

8.2.1 Current Market Share

The CASE team gathered two estimates for market penetration of commercial dishwasher sales that are compliant to the proposed ENERGY STAR V2.0 standard levels.

According to interviews with an industry expert, the market penetration of ENERGY STAR-certified machines varies by type and temperature. For low-temperature machines, undercounter models have a lower market penetration, representing less than 50% of sales. However, for other types, such as undercounter glasswashing, single-tank door, and single-tank rack conveyor machines, the market penetration of ENERGY STAR-certified models is significantly higher, ranging from approximately 60% to over 80%. In the case of high-temperature machines, ENERGY STAR's market penetration exceeds 60% for all types except flight-type machines. ENERGY STAR-certified flight-type machines account for 35% and 40% of total U.S. shipments.

ENERGY STAR offers unit shipment reports based on data provided by commercial dishwasher manufacturers. The latest report from 2021 indicates a compliance rate of 65% for the proposed ENERGY STAR V2.0 standard. [35] The CASE Team used this estimate over others because it originated from a published source.

The CASE Team reviewed the ENERGY STAR-Qualified Products List (QPL) for certified V2.0 models. The Team's analysis indicated that qualified commercial dishwashers meeting the proposed standards are available on the market, as shown in Table 14.

[35] U.S. Environmental Protection Agency (EPA), "ENERGY STAR® Unit Shipment and Market Penetration Report Calendar Year 2021 Summary." https://www.energystar.gov/sites/default/files/asset/document/2021%20Unit%20Shipment%20Data%20Summary%20Report_0.pdf.

Table 14: Commercial Dishwasher Models and Brands Meeting Proposed Standards Before V3.0 Publication, per 2021 ENERGY STAR V2.0 Qualified Products List

Equipment Class	Number of Models Meeting Proposed Standards*
Undercounter - HT	52
Undercounter - LT	20
Stationary Single-Tank Door - HT	124
Stationary Single-Tank Door - LT	87
Pot, Pan, and Utensil	8
Single-Tank Conveyor - HT	36
Single-Tank Conveyor - LT	12
Multiple-Tank Conveyor - HT	28
Multiple-Tank Conveyor - LT	9
Single-Tank Flight-Type	3
Multiple-Tank Flight-Type	15

* Dual sanitize products are included in counts for both low and high temperature categories since these machines can operate in either manner.

Source: CASE Team analysis of data from ENERGY STAR 2021

ENERGY STAR added Flight-type machines to the ENERGY STAR V2.0 program in 2013. ENERGY STAR V3.0 went into effect in September 2021. Considering the smaller market for these machines and their high cost, they represent a low volume of total ENERGY STAR-certified sales. Table 15 shows the number of models available on the market in 2023 meeting ENERGY STAR V3.0 standard levels, which are not proposed for Title 20. This chart demonstrates that certain categories such as Single-Tank Flight-type and low-temperature undercounter products have seen an increase in the number of available models despite more stringent criteria as manufacturers continue to develop more efficient products.

Table 15: Commercial Dishwasher Models and Brands Meeting Proposed Standards, per 2023 ENERGY STAR V3.0 Qualified Products List

Equipment Class	Number of Brands Meeting Proposed Standards*
Undercounter - HT	33
Undercounter - LT	23
Stationary Single-Tank Door - HT	70
Stationary Single-Tank Door - LT	58
Pot, Pan, and Utensil	21
Single-Tank Conveyor - HT	47
Single-Tank Conveyor - LT	6
Multiple-Tank Conveyor - HT	15
Multiple-Tank Conveyor - LT	3
Single-Tank Flight-Type	4
Multiple-Tank Flight-Type	10

* Dual sanitize products are included in counts for both low and high temperature categories since these machines can operate in either manner.

Source: CASE Team analysis of data from ENERGY STAR 2023

Some of the largest commercial dishwasher manufacturers, Jackson, Stero, and Champion-Moyer Diebel offer many ENERGIES STAR-certified models.[36] Ten smaller ENERGY STAR-Qualified brands offer multiple ENERGY STAR-certified models (ENERGY STAR 2022).

8.2.2 Future Market Adoption of Qualifying Products

Commercial dishwashers meeting the proposed standards are widely available on the market. However, leasing undercounter and single-tank door-type machines may hinder the adoption of more efficient units. The commercial dishwashers offered by the two largest leasing companies qualify for V2.0 ENERGY STAR certification;[37] however, less efficient units remain in circulation. Without necessary and progressive regulations, chemical sales companies are not incentivized to sell, lease, or stock higher efficiency dishwashers for use in commercial kitchens because they do not pay the utility bill.

Refurbished equipment on the leasing market presents another potential obstacle to the market adoption of qualifying products. Industry stakeholders indicated that chemical sales companies often provide refurbished equipment to those needing a commercial dishwasher but are either unable or unwilling to make a purchase. A refurbished dishwasher is preowned and has undergone repairs and, in some cases, modifications from original manufacturer specifications. If the proposed standards decrease the availability of lower-cost, ENERGY STAR-compliant equipment, leasing companies may offer less efficient, refurbished equipment. However, given the small size of the refurbishment market, its impact on the statewide savings outlined in this report would be negligible.

The CASE Team foresees no significant obstacles for chemical sales companies or food service operators in acquiring new equipment that complies with the proposed standards. Trends in ENERGY STAR market penetration suggest that the market has historically adapted quickly to the latest standards. The Team is confident that a broad range of models from many manufacturers will satisfy the proposed standards.

8.3 Statewide Water and Energy Savings – Methodology

The CASE Team calculated the statewide savings estimate using the per-unit water and energy savings and the statewide stock and shipments forecast. Section 5 of the report describes expected shipments per year.

The CASE Team reviewed 11 machine categories: low and high-temperature under-counter, stationary single-tank door, single-tank conveyor, multiple-tank conveyor, as well as high-temperature PPU, single-tank flight, and multiple-tank flight machines, and divided them into three specific groups based on their expected lifetime, as shown in Section 7.2.

The CASE Team ran a model to estimate statewide water and energy savings separately for each group and then aggregated the results to arrive at the statewide totals. The ENERGY STAR unit shipment data appropriate for each equipment class was also incorporated into the model to scale each group's water and energy use from unit to statewide level. A shipment-weighted average for unit water and energy use for relevant machine categories was used for each group.

The estimates presented in this report represent the savings attained by implementing the ENERGY STAR V2.0 standards. As previously noted, these water and energy savings estimates pertain only to nonresidential buildings.

[36] "United States Commercial Dishwasher Market 2024-2032 | Size, Share, Growth," MarkWide Research, n.d., https://markwideresearch.com/united-states-commercial-dishwasher-market/.

[37] "Single Rack Dishmachines," Ecolab, n.d., https://www.ecolab.com/offerings/single-rack-dishmachines. https://www.ecolab.com/offerings/single-rack-dishmachines and "Door Type," Auto-Chlor System, n.d., https://www.autochlor.com/dishmachines/door-type/.

Furthermore, the cost and energy analyses presented in this report include energy and cost savings from buildings with natural gas water heaters, a dominant fuel type throughout the state. Reported natural gas energy-saving estimates only occur in buildings with natural gas water heating.

The CASE Team assumed when calculating statewide impacts that 65% of commercial dishwashers sold each year would meet the proposed standards, even if not adopted into Title 20.[38]

8.4 Statewide Water and Energy Savings – Non-Standards and Standards Case

Table 16 and Table 17 present the first-year statewide annual water and energy use associated with commercial dishwashers if the proposed changes are not adopted, i.e., Non-Standards Case, and if the proposed standards are adopted, i.e., Standards Case, respectively.

Table 16: Estimated First-Year California Statewide Energy and Water Use for Non-Standard Case (Baseline)

Product Class	Electricity (GWh/yr)	Natural Gas (million therms/yr)	Water (million gallons/yr)
Under Counter - HT	20.97	0.50	48.96
Under Counter - LT	3.31	0.45	44.41
Stationary Single Tank Door - HT	15.92	0.45	44.66
Stationary Single Tank Door - LT	11.30	1.81	178.68
Pot, Pan, and Utensil	1.04	0.03	3.34
Single Tank Conveyor - HT	12.61	0.24	23.84
Single Tank Conveyor - LT	1.04	0.04	3.61
Multiple Tank Conveyor - HT	3.33	0.06	6.31
Multiple Tank Conveyor - LT	0.02	0.01×10^{-1}	0.05
Single Tank Flight-Type	2.47	0.07	7.59
Multiple Tank Flight-Type	9.35	0.23	24.53
TOTAL	81.36	3.88	385.98

Table 17: Estimated First-Year California Statewide Energy and Water Use for Standard Case

Product Class	Electricity (GWh/yr)	Natural Gas (million therms/yr)	Water (million gallons/yr)
Under Counter - HT	17.14	0.42	41.82
Under Counter - LT	2.45	0.39	38.41
Stationary Single Tank Door - HT	14.21	0.41	40.41
Stationary Single Tank Door - LT	8.37	1.68	166.54
Pot, Pan, and Utensil	0.92	0.03	2.93

[38] U.S. Environmental Protection Agency (EPA), "ENERGY STAR® Unit Shipment and Market Penetration Report Calendar Year 2021 Summary," https://www.energystar.gov/sites/default/files/asset/document/2021%20Unit%20Shipment%20Data%20Summary%20Report_0.pdf.

Product Class	Electricity (GWh/yr)	Natural Gas (million therms/yr)	Water (million gallons/yr)
Single Tank Conveyor - HT	11.33	0.19	18.78
Single Tank Conveyor - LT	0.89	0.03	2.82
Multiple Tank Conveyor - HT	3.01	0.05	5.04
Multiple Tank Conveyor - LT	0.01	0.04×10^{-2}	0.04
Single Tank Flight-Type	2.30	0.04	3.98
Multiple Tank	8.70	0.12	13.16
TOTAL	69.32	3.37	333.94

As shown in Table 18, the proposed standard would have a total first-year statewide savings of 12.04 GWh of electricity, 0.52 million therms of natural gas, 52.04 million gallons of water, $1.56 million in utility bills, and 4,189.66 MT CO2e of GHG emissions reduction.

Table 18: Estimated First-Year California Statewide Savings

Product Class	Electricity (GWh/yr)	Natural Gas (million therms/yr)	Water (million gallons/yr)	GHG Emissions (MT CO2e/yr)	Utility Bill Savings (million 2024 $/yr)
Undercounter - HT	3.83	0.07	7.14	779.10	0.43
Undercounter - LT	0.86	0.06	6.00	441.98	0.13
Stationary Single-Tank Door - HT	1.71	0.04	4.24	411.71	0.20
Stationary Single-Tank Door - LT	2.93	0.12	12.14	1002.04	0.38
Pot, Pan, and Utensil	0.12	0.04×10^{-1}	0.41	35.57	0.01
Single-Tank Conveyor - HT	1.28	0.05	5.06	423.03	0.16
Single-Tank Conveyor - LT	0.16	0.01	0.79	61.94	0.02
Multiple-Tank Conveyor - HT	0.33	0.01	1.26	106.32	0.04
Multiple-Tank Conveyor - LT	0.02×10^{-1}	0.01×10^{-2}	0.01	0.89	0.03×10^{-2}
Single-Tank Flight-Type	0.17	0.03	3.61	220.91	0.04
Multiple-Tank Flight-Type	0.65	0.11	11.38	706.16	0.14
TOTAL	12.04	0.52	52.04	4189.66	1.56

Table 19 summarizes the estimated statewide savings in the stock turnover year, which varies by equipment class based on effective useful lifetime. The Statewide CASE Team estimates these savings to be 179.53 GWh of electricity, 8.42 million therms of natural gas, 851.70 million gallons of water, $30.44 million in utility bill, and 66,777.82 MT CO2e of GHG emissions reduction.

Table 19: Estimated California Statewide Savings in the Stock Turnover Year

Product Class	Year of Stock Turnover	Electricity (GWh/yr)	Natural Gas (million therms/yr)	Water (million gallons/yr)	GHG Emissions (MT CO2e/yr)	Utility Bill Savings (million 2024 $/yr)
Undercounter - HT	2038	45.95	0.87	85.68	9,349.21	5.86
Undercounter - LT	2038	10.30	0.73	72.01	5,303.76	1.87
Stationary Single-Tank Door - HT	2041	25.60	0.64	63.65	6,175.71	3.55
Stationary Single-Tank Door - LT	2041	43.96	1.84	182.15	15,030.66	6.96
Pot, Pan, and Utensil	2041	1.77	0.06	6.16	533.57	0.27
Single-Tank Conveyor - HT	2046	25.69	1.02	101.13	8,460.56	4.32
Single-Tank Conveyor - LT	2046	3.10	0.16	15.78	1,238.86	0.57
Multiple-Tank Conveyor - HT	2046	6.59	0.26	25.22	2,126.44	1.10
Multiple-Tank Conveyor - LT	2046	0.05	0.02×10^{-1}	0.22	17.72	0.01
Single-Tank Flight-Type	2046	3.46	0.68	72.18	4,418.16	1.37
Multiple-Tank Flight-Type	2046	13.08	2.16	227.51	14,123.18	4.56
TOTAL		179.53	8.42	851.70	66,777.82	30.44

Embedded energy savings, energy savings from the reduced use of water, were calculated using the indoor energy factor of 5,440 kWh/million gallons of water. With water savings of 851 million gallons at full stock turnover, the embedded energy savings will be 4.6 GWh/yr. See appendix A for more details on embedded energy savings.

8.5 Impact on California's Economy

Consumers most impacted by the proposed standards are owners and operators of commercial kitchens, including commercial food service establishments, such as restaurants, bars, and coffee shops, and institutional kitchens, such as hospitals, schools, and prisons. As noted in Section 8.1.1, California has 76,750 commercial food service facilities and 20,110 institutional facilities. Most of these restaurants are classified as small businesses, employing fewer than 50 people. This category includes numerous chain restaurants and establishments owned by larger firms.[39] In California, 58% of restaurants are minority owned, and 32% are majority owned by women.[40] Furthermore, the CASE Team believes at least 147 commercial food service dealers sell commercial dishwashers based on participation in utility rebate programs. The largest impact on owners and operators will likely be increased upfront costs of purchasing a new commercial dishwasher. As previously mentioned, these owners and operators will experience considerable lifecycle cost benefits and quick returns on their investment.

The impact on manufacturers and distributors will vary based on the products they produce, stock, and sell. Several manufacturers produce compliant products, accounting for 65% of current sales. Manufacturers and distributors that sell compliant products would experience relatively small impacts.

[39] "National Statistics," National Restaurant Association, n.d., https://restaurant.org/research-and-media/research/industry-statistics/national-statistics/.

[40] National Restaurant Association, "Restaurant Owner Demographics," March 2022, https://restaurant.org/research-and-media/u-s-restaurant-owner-demographics/.

However, all parties must update their stock and comply with the standards, which could lead to increased administrative costs. The increased incremental costs of compliant products would result in larger profit margins for these manufacturers and distributors, offsetting these compliance costs. The CASE Team believes that CMA Dishmachines is the only California-based manufacturer of commercial dishwashers and they produce a variety of products across multiple categories that comply with the proposed standards.

Manufacturers who primarily produce non-compliant products, along with the distributors who stock and sell these models, are more likely to experience the adverse effects of the standards. These manufacturers may need to redirect their distribution toward compliant product lines, innovate new compliant products, or consider withdrawing from the California market. As noted, the proposed standards offer consumers choices from multiple manufacturers. Furthermore, manufacturers have had over a decade to align their products with the V2.0 ENERGY STAR specification. Distributors and other market players who mainly deal in non-compliant products might need to switch suppliers or modify their current practices. However, the increased incremental costs would likely benefit these distributors, counterbalancing any potential expenses incurred due to these changes.

The CASE Team considered only consumers' direct water and energy savings when calculating lifecycle benefits. This analysis does not incorporate savings related to reduced HVAC loads, water tempering from heat recovery products, or other ancillary benefits from more efficient equipment. The Team predicts that the lifecycle benefits for first-year sales would equal or exceed $543 million and that cumulative lifecycle savings would reach $YY million once the stock turns over in 2050, as summarized in Table 19. These estimates are based on custom energy-saving calculations and the volume of water savings multiplied by the volumetric water/sewer rates forecasted from 2025 to 2049. Please refer to Appendix A for the forecasted water and sewer rates and Section 7.3 for forecasted energy prices.

The first-year statewide utility bill savings were estimated by multiplying the statewide electricity, fuel, and water savings in the standard's first effective year with the corresponding energy and water prices for that year. Similarly, the statewide savings for the stock turnover year were calculated by multiplying the year's fuel and water savings with the year's electricity, fuel, and water prices.

As shown in Table 20, the incremental capital costs in the first year range from $-0.94 to $1.49 million. Utility bill savings in the first year range from $\$0.03 \times 10^{-2}$ to $0.43 million.

Table 20: Statewide Economic Impacts Occurring in the First Year

Product Class	Incremental Capital Costs (million 2024 $)	Utility Bill Savings (million 2024 $)
Undercounter - HT	1.16	0.43
Undercounter - LT	0.28	0.13
Stationary Single-Tank Door - HT	1.49	0.20
Stationary Single-Tank Door - LT	-0.94	0.38
Pot, Pan, and Utensil	0.22	0.01
Single-Tank Conveyor - HT	0.56	0.16
Single-Tank Conveyor - LT	0.07	0.02
Multiple-Tank Conveyor - HT	0.27	0.04
Multiple-Tank Conveyor - LT	0.02×10^{-1}	0.03×10^{-2}
Single-Tank Flight-Type	0.14	0.04
Multiple-Tank Flight-Type	1.32	0.14
TOTAL	4.57	1.56

Table 21 presents the statewide lifetime economic impacts for products purchased in the first year, as opposed to per unit. The total present value of benefits, realized by the end of the effective useful lifetime for each equipment class, is projected to be$167.17 million in the effective year (2024), with costs amounting to $15.75 million. The net present value, which is the difference between present value of benefits and present value of incremental cost, is estimated as $151.41 million.

Table 21: Statewide Lifetime Economic Impacts for Products Purchased in the First Year

Product Class	Present Value of Benefits (million 2024 $)	Present Value of Incremental Costs (million 2024 $)	Net Present Value (million 2024 $)
Undercounter - HT	36.05	3.33	32.72
Undercounter - LT	10.97	0.79	10.19
Stationary Single-Tank Door - HT	20.41	4.27	16.14
Stationary Single-Tank Door - LT	41.76	0.00	41.76
Pot, Pan, and Utensil	1.51	0.62	0.88
Single-Tank Conveyor - HT	21.70	1.60	20.10
Single-Tank Conveyor - LT	2.82	0.20	2.62
Multiple-Tank Conveyor - HT	5.53	0.77	4.76
Multiple-Tank Conveyor - LT	0.04	0.01	0.04
Single-Tank Flight-Type	6.02	0.41	5.62
Multiple-Tank Flight-Type	20.35	3.76	16.59
TOTAL	167.17	15.75	151.41

8.6 Environmental and Societal Impacts

More efficient commercial dishwashers save owners and operators significant energy and water. The process of building and operating a utility infrastructure and water and wastewater systems incurs mostly fixed costs. Therefore, the overall utility and water agency costs should remain relatively constant, even if using more efficient commercial dishwashers decreases electric system demands and the volume of water treated and distributed daily. Based on the rules of supply and demand, significant reductions in energy or municipal water demand could increase water and energy rates. However, the magnitude of this proposal's energy and water savings would unlikely lead directly to increased utility or water rates. This proposal would likely have little impact on the electric grid or wastewater conveyance and treatment system infrastructure.

Reducing the hot water demand would support commercial kitchen electrification by improving options for transitioning to electric heat pump water heaters for domestic hot water supply. Similarly, because domestic hot water in commercial service is provided mainly by gas water heaters, reducing this demand would lower the emission of criteria pollutants. Moreover, the proposal is estimated to decrease greenhouse gas emissions, as demonstrated in Table 22.

Table 22: Statewide GHG Emission Savings

Product Class	First Year GHG Emissions (MT CO2e/yr)	GHG Emissions in Stock Turnover Year (MT CO2e/yr)
Undercounter - HT	779.1	9,349.2
Undercounter - LT	442.0	5,303.8
Stationary Single-Tank Door - HT	411.7	6,175.7
Stationary Single-Tank Door - LT	1002.0	15,030.7
Pot, Pan, and Utensil	35.6	533.6
Single-Tank Conveyor - HT	423.0	8,460.6
Single-Tank Conveyor - LT	61.9	1,238.9
Multiple-Tank Conveyor - HT	106.3	2,126.4
Multiple-Tank Conveyor - LT	0.9	17.7
Single-Tank Flight-Type	220.9	4,418.2
Multiple-Tank Flight-Type	706.2	14,123.2
TOTAL	**4189.7**	**66,777.8**

Any appliance that uses less energy and water will reduce heat in the dish room. For commercial operators, more efficient commercial dishwashers may minimize heat in the dish room as more efficient products are often better insulated, resulting in less waste heat to the environment. Heat recovery machines significantly reduce the heat in the operational space. No significant noise or other differences in operating impact exist between compliant and non-compliant dishwashers.

The proposed standards would not significantly change the materials used in the dishwasher, their quantity, or the manufacturing process. Low-temperature machines using chlorine as a sanitizing chemical may require less water to reach the proper dilution ratio. This reduction in chemical use would positively impact wastewater treatment facilities that rely on biological water treatment, which can be disturbed by high chlorine concentrations in wastewater.

The proposed standards are not expected to have any significant societal impacts. This proposal should not affect aesthetics, biological resources, geology, hydrology, recreation, agricultural or cultural resources, land use, transportation, housing, mineral resources, public services, or tribal cultural resources.

9 Implementation Plan

The CASE Team does not foresee any unusual steps to implement the proposal. The Team anticipates Energy Code Ace would actively reach and engage manufacturers to facilitate an understanding of the compliance process and support the certification of products. Furthermore, the MAEDbS system would work with SASD and ENERGY STAR to streamline processes that simplify multi-jurisdictional compliance for manufacturers, reduce the regulatory load, and increase compliance through industry collaboration. Manufacturers expressed a desire for this coordination through interviews in the development of this report. The Team also encourages the decision-makers to pursue the other two components of the comprehensive approach detailed in Section 2.

10 Other Legislative and Regulatory Considerations

10.1 Federal Legislative and Regulatory Background

Commercial dishwashers are currently not regulated by DOE; furthermore, DOE lacks the authority to regulate these products under the current law.[41] The proposed standards for commercial dishwashers are similar to the voluntary requirements set forth by EPA for the ENERGY STAR program.

10.2 California Legislative and Regulatory Background

Commercial dishwashers do not have Title 20 requirements. In 2015, the California Building Standards Commission (CBSC) updated the voluntary commercial dishwasher standards for water usage in CALGreen to align with the ENERGY STAR Product Specification for Commercial Dishwashers V2.0. These standards went into effect in 2017, 18 months after adoption. Table 23 contains the CALGreen standards.

Table 23: CALGreen Commercial Dishwasher Voluntary Standards

Type	High-Temperature Maximum Gallons Per Rack (unless otherwise noted)	Low-Temperature Maximum Gallons Per Rack (unless otherwise noted)
Single-Tank Conveyor	0.70 (2.6 L)	≤ 0.79 (3 L)
Multiple-Tank Conveyor	≤ 0.54 (2 L)	≤ 0.54 (2 L)
Stationary Single Door	≤ 0.89 (3.4 LL)	≤ 1.18 (4.5 L)
Undercounter	≤ 0.86 (3.3 L)	≤ 1.19 (4.5 L)
Pot, Pan, and Utensil	≤ 0.58 GPSF	≤ 0.58 GPSF
Single-Tank Flight-Type	GPH ≤ 2.975x + 55.00	GPH ≤ 2.975x + 55.00
Multiple-Tank Flight-Type	GPH ≤ 4.96x + 17.00	GPH ≤ 4.96x + 17.00

Note: GPSF = gallons per square foot of rack; GPH = gallons per hour; X = square feet of conveyor belt/minute (max conveyor speed sf/min as tested and certified to NSF/ANSI Standard 3)

Source: Table A5.303.3 of CALGreen

California Title 24, Part 6 section 140.9(b) contains specific prescriptive requirements for commercial kitchens, but these sections address ventilation, not dishwasher performance.

Additionally, the California Plumbing Code has various requirements for installing and using commercial dishwashers. Section 810.1 High-Temperature Discharge limits the temperature of water discharged under pressure into the plumbing or drainage system from exceeding 140˚F (California Plumbing Code, 2022). For some dishwashers, compliance with this requirement requires a tempering device, which

[41] 42 U.S. Code § 6311(2) "Title 42 - The Public Health and Welfare," GovInfo, n.d., https://www.govinfo.gov/content/pkg/USCODE-2009-title42/pdf/USCODE-2009-title42-chap77-subchapIII-partA-1-sec6311.pdf.

adds cold water to high-temperature discharge to lower the temperature below 140˚F before entering the sanitary sewer system. This practice is associated with increased water consumption, which the recommended water use test method for dishwashers does not measure, nor is it included in the analysis present in this report. Nevertheless, the proposed standards would likely reduce the amount of tempering water due to reduced hot water use. Overall, the proposed standards presented in this report do not conflict with the California Plumbing Code.

The California Retail Food Code has established minimum performance requirements for mechanical machines used in retail food service. These standards encompass various aspects of the dishwashing process, including sanitizing chemicals, rinse water specifications, dishwasher loading procedures, minimum hot water requirements, and others to ensure adequate sanitation of the wares.[42] The proposed standards in this report do not conflict with the California Retail Food Code.

The CASE Team identified regulations in the Los Angeles municipal code governing commercial dishwasher water consumption. These requirements, established in the Water Conservation Ordinance effective December 30, 2016, are detailed in Chapter IX, Article 9, Division 5, Sec. 99.05.303 of the City of Los Angeles Municipal Code 2023. The ordinance states that all installed dishwashers must be ENERGY STAR certified. It further indicates that the maximum water use of high-efficiency commercial dishwashers shall be in accordance with the values provided in consumption standards specified in the ordinance. Table 24 summarizes these consumption standards.

Table 24: Maximum Water Use for Commercial Dishwashers Specified in the City of Los Angeles Municipal Code

Machine Type	High-Temperature Water Consumption*	Chemical (Low-Temperature) Water Consumption*
Conveyor	0.70 GPR	0.62 GPR
Door	0.95 GPR	1.16 GPR
Undercounter	0.90 GPR	0.98 GPR

* GPR = gallons per rack

Note: All installed dishwashers shall be ENERGY STAR® rated

Source: City of Los Angeles 2023

The City of Los Angeles ordinance does not establish a water use standard for pot, pan, utensil or flight-type machines. The ordinance also does not distinguish conveyor machines by the number of single or multiple-tank-type tanks.

The water consumption standards set by the City of Los Angeles ordinance are more stringent than those proposed by the CASE Team for low-temperature, undercounter, and door-type machines. For low-temperature conveyor machines, the ordinance is stricter than the proposed requirement for single-tank conveyors but not as rigorous as multiple-tank conveyors. The maximum water usage allowed by the ordinance for all three types of high-temperature machines is greater and, thus, less stringent than the proposed standards. The CASE Team identified the Los Angeles municipal ordinance as the only one governing commercial dishwasher water or energy use.

[42] Cal. Health & Safety Code, section 114094 et seq. California Department of Health, "California Retail Food Code," Calif, January 1, 2018, https://www.cdph.ca.gov/Programs/CEH/DFDCS/CDPH%20Document%20Library/FDB/FoodSafetyProgram/RetailFood/CRFC.pdf.

10.2.1 Utility and Other Incentive Programs

California IOUs offer $150 to $750 incentives for door-type and undercounter commercial dishwashers, meeting the current ENERGY STAR requirements via the California Energy Wise point-of-sale commercial food service rebate program.

ENERGY STAR's website provides a listing of 50 utilities outside of California that offer rebates for commercial dishwashers;[43] the CASE Team has not independently verified this information. The CASE Team has also not identified other municipal or regional water districts or utilities that offer rebates for commercial dishwashers in California.

10.3 Other State Standards

Commercial dishwashers are part of the Model Bill developed by the Appliance Standards Awareness Project (ASAP). More than ten states have adopted standards for these products and generally aligned them with the ENERGY STAR V2.0 criteria for all product categories. Vermont first adopted these standards in 2018, with several additional states following. However, manufacturers and market actors may not be aware of these existing standards. Several states, including New York and Massachusetts, use the SASD to determine compliance. The proposed standards align with those in other states and provide consistency across the industry.

10.4 Voluntary Standards

Several government and non-government entities have made substantial progress in establishing model building codes and voluntary standards that address dishwasher efficiency. Key industry stakeholders participated in rigorous public vetting processes to develop many of these existing codes and standards. Many of the water efficiency requirements in these model codes and standards align with either Version 1.1 or 2.0 of the ENERGY STAR Specification for Commercial Dishwashers. CASE Team evaluated some of the model building codes and voluntary standards that are listed below:

2021 International Association of Plumbing and Mechanical Officials Green Plumbing and Mechanical Code Supplement for use with all Codes (IAPMO GPMCS) and 2024 IAPMO GPMCS Proposed Changes for Public Comment: Developed by the International Association of Plumbing and Mechanical Officials through a public vetting process. The public process is vetting the 2024 proposed changes with the anticipated release of the final standards in the fall. More information is available at www.iapmo.org.

International Green Construction Code 2021 (IgCC): Developed by the International Code Council through a public vetting process. More information is available at http://www.iccsafe.org/CS/IGCC/Pages/default.aspx.

Leadership in Energy and Environmental Design (LEED) Building Design and Construction Rating System, Version 4.1: Developed by the U.S. Green Building Council through public vetting. More information is available at: http://www.usgbc.org/leed.

ENERGY STAR: EPA developed a process that relies on market, engineering, and pollution savings analyses and includes input from other EPA programs and industry and non-industry stakeholders. More information is available at: http://www.energystar.gov.

[43] "Product Rebate Finder," n.d., https://www.energystar.gov/rebate-finder or "Commercial Dishwashers," ENERGY STAR, n.d., https://www.energystar.gov/products/commercial_dishwashers.

ENERGY STAR is the most influential of the model codes and voluntary standards mentioned above, with most model codes establishing efficiency requirements in alignment with ENERGY STAR. In 2005, the EPA initiated the development of an ENERGY STAR product specification for commercial dishwashers, with version 1.1 becoming effective in October 2007. The requirements included four machine type categories: undercounter, stationary single-tank door, single-tank conveyor, and multiple-tank conveyor with idle energy rate and water consumption requirements for low- and high-temperature machine types.

In 2010, EPA announced its intent to update the Version 1.1 requirements, citing the rapidly growing market share of ENERGY STAR-certified products, greater than 80% market penetration in 2008, and the need to update the specification to ensure that ENERGY STAR continues to represent the top performers in terms of energy efficiency.[44] The version 2.0 specification development process, similar to the development of version 1.1, included significant industry feedback. Based on industry input, most categories' idle energy rate and water consumption requirements became more stringent. In the release announcement, ENERGY STAR highlighted that new version 2.0 certified products are, on average, 30-55% more energy efficient and 30-60% more water efficient than standard models.[45] The version 2.0 specification added three additional equipment categories: PPU, single-tank, flight-type, and multiple-tank flight-type. Version 2.0 efficiency requirements became effective on February 1, 2013, as shown in Table 5.

In 2017, the EPA again announced its intent to update the requirements for commercial dishwashers. The most significant addition to the 3.0 specification was incorporating washing energy performance criteria based on the most recent ASTM test procedures, as discussed in Section 4.2.2. The proposed standard directly incorporates the updated revised definitions, enhancing clarity about the coverage scope. Version 3.0 of the ENERGY STAR specification was published in 2021 and is currently in effect. As with previous ENERGY STAR revisions, the V3.0 process included multiple rounds of stakeholder engagement and refinement. Table 25 and Table 26 display current specification levels.

Table 25: ENERGY STAR Requirements for Commercial Dishwashers – Low Temperature

Machine Type	Low Temperature Efficiency Requirements		
	Idle Energy Rate*	Washing Energy	Water Consumption**
Under Counter	≤ 0.25 kW	≤ 0.15 kWh/rack	≤ 1.19 GPR
Stationary Single Tank Door	≤ 0.30 kW	≤ 0.15 kWh/rack	≤ 1.18 GPR
Single Tank Conveyor	≤ 0.85 kW	≤ 0.16 kWh/rack	≤ 0.79 GPR
Multiple Tank Conveyor	≤ 1.00 kW	≤ 0.22 kWh/rack	≤ 0.54 GPR

[44] Memo to Announce ENERGY STAR Commercial Dishwasher Specification Revision https://www.energystar.gov/sites/default/files/specs//private/EPA_Memo_V2_0_Launch.pdf

[45] Commercial Dishwashers Final Version 2.0 Cover Memo https://www.energystar.gov/sites/default/files/specs//private/CD_Final_V2.0_Spec_Memo.pdf

Table 26: ENERGY STAR Requirements for Commercial Dishwashers – High Temperature

Machine Type	High Temperature Efficiency Requirements		
	Idle Energy Rate*	**Washing Energy**	**Water Consumption****
Under Counter	≤ 0.30 kW	≤ 0.35 kWh/rack	≤ 0.86 GPR
Stationary Single Tank Door	≤ 0.55 kW	≤ 0.35 kWh/rack	≤ 0.89 GPR
Pot, Pan, and Utensil (PPU)	≤ 0.90 kW	≤ 0.55 + 0.05 x SF_{rack} †	≤ 0.58 GPSF
Single Tank Conveyor	≤ 1.20 kW	≤ 0.36 kWh/rack	≤ 0.70 GPR
Multiple Tank Conveyor	≤ 1.85 kW	≤ 0.36 kWh/rack	≤ 0.54 GPR
Single Tank Flight-Type	Reported	Reported	GPH ≤ 2.975**x** + 55.00
Multiple Tank Flight-Type	Reported	Reported	GPH ≤ 4.96**x** + 17.00

***** Idle results should be measured with the **door closed** and represent the total idle energy consumed by the machine, including all tank heater(s) and controls. The most energy-consumptive configuration in the product family shall be selected to test the idle energy rate. Booster heater (internal or external) energy consumption shall be measured and reported separately, if possible, per ASTM F1696-20 and ASTM F1920-20 Sections 10.8 and 10.9, respectively. However, if booster energy cannot be measured separately, it will be included in the idle energy rate measurements.

****** GPR = gallons per rack; GPSF = gallons per square foot of rack; GPH = gallons per hour; **x** = maximum conveyor speed (feet/min as verified through NSF 3 certification) x conveyor belt width (feet).

† PPU Washing Energy is still in format kWh/rack when evaluated; SF_{rack} is Square Feet of rack area, as in PPU water consumption metric.

Source:
https://www.energystar.gov/sites/default/files/Commercial%20Dishwashers%20Version%203.0%20Specification%20%28Rev.%20-%20September%202021%29.pdf?_gl=1*v1dlcb*_ga*MTYyNTg1MDQ0OS4xNjk1NjUwNjU2*_ga_S0KJTVVLQ6*MTcwMjkzMjQ1MS4xNy4xLjE3MDI5MzI2MzkuMC4wLjA.

11 Response to Request for Information

This section presents in question-and-answer format the 18 questions reprinted without modifications from the Request for Information that the CEC docketed on November 14, 2023, to Docket 23-AAER-01.[46] The answers are from the CASE Team and only address commercial dishwashers, the technology specific to this report. The team will cover other food service technologies in separate CASE reports.

1. Based on Table 27 (Table 1 in the RFI/RFP), are there additional classifications that should be considered in scope or out-of-scope? Based on what factors?

Table 27: Commercial Food Service Equipment Scope from CEC

Commercial Food Service Equipment Appliance	Classifications
Commercial Steam Cookers	• Natural Gas • Electric
Commercial Dishwashers	• Electric
Commercial Convection Ovens	• Natural Gas • Electric
Commercial Fryers	• Natural Gas • Electric

Source: California Energy Commission

For commercial dishwashers, electric is the only applicable classification. However, the hot water used for dishwashers is primarily provided by gas-fired water heaters, as noted in Sections 6.2 (Methodology) and 8.2 (Market Share of Qualifying Products) of the report.

2. What definitions are useful to describe Steam Cookers, Dishwashers, Ovens, and Fryers? Are there distinct characteristics within Steam Cookers, Dishwashers, Ovens, and Fryers that would allow multiple uses?

For information on commercial dishwashers, the Case Team directs readers to Section 4.2 (Proposed Changes to T20 Code Language) and, more specifically, Section 4.2.1 (Scope and Proposed Definitions) of this report. This section contains a set of revised definitions that the team found beneficial during the report's development and in formulating responses to the RFI.

3. Steam Cookers, Dishwashers, Ovens, and Fryers are found in commercial and institutional settings such as hospitals, schools, etc., are there other unique settings that staff should investigate?

Laboratories are a unique institutional setting identified by the CASE Team as requiring further investigation. Current standards do not cover dishwashers purchased and used in laboratories, and they are not eligible for ENERGY STAR product certifications. For additional information on laboratory dishwashers, the Case Team directs readers to Section 5.1.2 (Consumer Utility and Acceptance) of this report.

[46] https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=23-AAER-01

4. Are there other efficient technologies available on the market for Steam Cookers, Dishwashers, Ovens, and Fryers? Are there new or upcoming technological developments for Steam Cookers, Dishwashers, Ovens, and Fryers?

The CASE Team knows of several upcoming or iterative technological developments for dishwashers. One example is refrigerant-based heat pump heat recovery, which continues to be developed and refined for conveyor-based machines. Ongoing advancements in heat recovery technology could expand the use of heat pump water heaters in California's commercial kitchens, as dishwashers significantly increase the demand for hot water in these settings, traditionally necessitating high Btu gas heaters to meet the requirements of continuous tank fills and consecutive washing cycles. Dishwashers equipped with heat recovery technology could substantially reduce the demand for hot water using smaller-capacity heat-pump water heaters. Despite their ability to conserve water in a commercial kitchen setting, heat pump water heaters are rare due to their inability to keep pace with the high operational cycles typical of such environments.

The CASE Team would like to highlight that newer dishwashers include water tank solids skimming improvements, reducing the need for frequent emptying of the main tank, e.g., rack dishwashing machines. The team would refer readers to Section 3.4 (Heat Recovery Technology, particularly Section 3.4.2 (Conveyor Heat Recovery) to review research around existing and potential developments within the dishwasher marketplace.

5. Are there alternatives for Steam Cookers, Dishwashers, Ovens, and Fryers used by the food service industry that would achieve the same functions of those appliances? For example, are air fryers a viable efficient alternative to Fryers that use oil?

The CASE Team is not proposing any alternatives for commercial dishwashers the food service industry could use to attain the same functionality and potential water and energy savings as the products already available on the market.

6. The ENERGY STAR program provides a voluntary way to certify the efficiency of very efficient options on the listed appliances of Table 1 (Table 27 above), are there other approaches available that CEC should be aware of? Please include references to publicly available sources.

The CASE Team discussed and referenced additional state and voluntary dishwasher standards in Section 10 (Other Legislative and Regulatory Considerations) of this report, including the ENERGY STAR QPL and the SASD. Additional voluntary model building codes and standards that the CEC should be aware of while considering the proposed standards are:

- ENERGY STAR
- The 2021 International Association of Plumbing and Mechanical Officials Green Plumbing and Mechanical Code Supplement for use with all Codes (IAPMO GPMCS)
- The International Green Construction Code 2021 (IgCC)
- Leadership in Energy and Environmental Design (LEED) Building Design and Construction Rating System, Version 4.1

The CASE Team refers CEC staff and report readers to Sections 10.3 (Other State Standards) and 10.4 (Other Voluntary Standards) for a more in-depth examination of these voluntary and state-mandated standards when considering proposed changes to existing standards for the commercial food service equipment within the scope of the RFI.

7. What inspections or test methods should CEC staff use to verify compliance with each efficiency requirement?

The CASE Team believes that the existing test methods for most commercial dishwasher products do not require any modifications. The current approach uses the ASTM testing method, the foundation of ENERGY STAR certification. However, in Section 3.3 (Glasswashing Machines), the team noted that glasswashing machines require minor modifications to the ASTM testing method. These adjustments are needed to accommodate products not designed to use racks, primarily due to size. The team proposes that these specific machines adjust the current testing method to use the number of glasses equivalent to those that fit on a rack. Readers can review the proposed testing method in Section 4.2.2 (Proposed Test Procedure) for more information.

8. Is there current research or advancement by industry to improve the efficiency of the appliances listed in Table 1?

The CASE team is not aware of research to improve the efficiency of commercial dishwashers.

9. What is the market share of each identified classification of each appliance listed in Table 1? Based on Table 1, are there additional examples that should be considered in scope or out-of-scope? Based on what factors?

This question is not applicable as only electric commercial dishwasher categories are available for consumers to purchase and install.

10. What percent of the listed appliances in Table 1 are leased or sold in California?

11. Please provide an estimate of the current installed stock in California for each of the appliances listed in Table 1. What sources of information are available to estimate current and projected stock in California?

Section 8 addresses questions 10 and 11.

12. What is the retail cost per unit or differential within each appliance category for Steam Cookers, Dishwashers, Ovens, and Fryers?

The CASE Team refers readers of this report to Section 7 (Cost Effectiveness) to understand the CASE Team's methodology for determining the retail cost per unit for commercial dishwashers.

13. What is the installation cost per unit? What is the replacement cost per unit?

The CASE Team determined its methodology for determining the installation cost per unit by obtaining price data from four major online retailers for purchasing commercial food service equipment. Those online retailers are:

- Webstaurant Store
- KaTom
- Culinary Depot
- Cuda Kitchen

The CASE Team, however, is actively collaborating with industry stakeholders to gain a deeper understanding of the installation and maintenance costs associated with these machines.

The CASE Team refers readers to review Section 7.1 (Incremental Cost) for additional and more in-depth information on the installation costs for commercial dishwashers.

14. What is the average lifetime of each appliance listed in Table 1? What assumptions for product lifetime should staff consider for the listed appliances, and why? How do product lifetimes vary per product type within each appliance listed in Table 1? Please provide published sources of information.

The CASE Team estimates that the average lifetime of an electric commercial dishwasher is X years. To determine this average lifetime, the team used the following assumptions about certain appliances to

determine its estimation methodology. The lifespan of undercounter and PPU machines is assumed to be ten years, while stationary single tank doors are presumed to have a 15-year lifetime. Conveyor and flight machines are estimated to have an average lifespan of 20 years. For further details on how the team determined the average lifetime of dishwashing machines, readers should see Section 8.2 (Statewide Energy and Water Savings – Methodology) of this report.

15. What is the average run time for each of the appliances listed in Table 1? Do they vary by product type?

Some have run times of only one to three minutes per load, while others operate continuously. Section 3 discusses the different technologies in detail.

16. Do manufacturers provide a broad product offering for the listed appliances?

Yes. Each of the five major commercial dishwasher manufacturers offers multiple ENERGY STAR-certified models. The CASE Team can also point to at least ten smaller manufacturers offering multiple ENERGY STAR-certified models to potential customers. The CASE Team refers readers to Section 5.1.5 (Commercial Dishwasher Market) for a list of major manufacturers within the dishwashing market that offer ENERGY STAR-certified models. Readers can refer to Section 8.1.3 (Current Market Share) for an in-depth review of the CASE Team's research on the prevailing market share of ENERGY STAR-qualified appliances.

17. How many small businesses are involved in the manufacturing, sale, or installation of the listed appliances in California? How might small businesses be affected by any changes to the listed appliances?

The CASE Team refers readers to Section 8.4 (Impact on California's Economy) for the potential impacts of the proposed standards on smaller businesses.

18. What are the potential impacts and benefits the proposed standards may have for consumers (i.e., users of these appliances)?

More efficient commercial dishwashers would increase water and energy savings for facility owners and operators. However, the overall utility and water agency costs remain relatively constant for facilities where commercial dishwashers are most used, even if using more efficient commercial dishwashers decreases electric system demands and the volume of water treated and distributed daily. The CASE Team anticipates that the proposed standards will not have substantial societal impacts on consumers. The team recommends that readers review the entirety of Section 8 (Statewide Impacts) for a more in-depth review of the potential effects and benefits of the proposed standards.

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Appendix A: Embedded Electricity Usage Methodology

The Statewide CASE Team assumed the following embedded electricity in water values: 5,440 kWh/million gallons of water for indoor and 3,280 kWh/million gallons for outdoor water use. Embedded electricity for indoor water use includes water extraction, conveyance, treatment to potable quality, water distribution, wastewater collection, and wastewater treatment. Embedded electricity for outdoor water use consists of all energy uses upstream of the customer. It does not include wastewater collection or wastewater treatment. The embedded electricity values do not have on-site energy consumption associated with water use, e.g., the energy required for water heating or on-site pumping.

These embedded electricity values were derived from research conducted for CPUC Rulemaking 13-12-011. The CPUC study aimed to quantify the embedded electricity savings associated with IOU incentive programs that result in water savings. The findings represent the CPUC's most up-to-date research on embedded energy in water throughout California. This study resulted in the Water-Energy (W-E) Calculator 1.0, updated to Version 2.0 (SBW Consulting, Inc. 2022) in February 2022. The CPUC analysis was limited to evaluating the embedded electricity in water and did not include embedded natural gas in water use. For this reason, this CASE Report does not include estimates of embedded natural gas savings associated with water reductions.

For the code change proposal presented in this report, the CASE Team used embedded electricity value for indoor water use only.

Appendix B: Dishwasher Energy Use Assumptions

Below are water and energy use assumptions used for baseline and energy-efficient dishwashers. Energy-efficient water consumption and idle-rate assumptions were obtained from an average of ENERGY STAR V2.0 qualified products[47]. Baseline water consumption assumptions and idle rate were taken from an average of products not qualifying for ENERGY STAR V2.0. Dishwasher data was collected from the ENERGY STAR database for most dishwasher types, flight-type dishwasher data was acquired from field studies[48].

Table 28: Water Consumption Assumptions

Type	Baseline	EE	units
Undercounter - HT	1.10	0.70	gal/rack
Undercounter - LT	1.50	1.00	gal/rack
Stationary Single-Tank Door - HT	1.10	0.80	gal/rack
Stationary Single-Tank Door - LT	1.25	1.00	gal/rack
Pot, Pan, and Utensil - HT	2.00	1.20	gal/rack
Single-Tank Conveyor - HT	1.00	0.50	gal/rack
Single-Tank Conveyor - LT	1.20	0.60	gal/rack
Multiple-Tank Conveyor - HT	1.00	0.50	gal/rack
Multiple-Tank Conveyor - LT	1.20	0.60	gal/rack
Single-Tank Flight-Type - HT	4.00	1.00	gal/min
Multiple-Tank Flight-Type - HT	4.00	1.00	gal/min

Table 29: Idle Energy Assumptions

Type	Baseline	EE	units
Undercounter - HT	0.70	0.40	kW
Undercounter - LT	0.20	0.10	kW
Stationary Single-Tank Door - HT	0.70	0.50	kW
Stationary Single-Tank Door - LT	0.20	0.10	kW
Pot, Pan, and Utensil - HT	1.20	0.80	kW
Single-Tank Conveyor - HT	2.30	1.40	kW

[47] Archived Historical product list: "Commercial Dishwashers for Partners," ENERGY STAR, n.d., https://www.energystar.gov/products/commercial_dishwashers/partners.
[48] "Conveyor Dishwasher Performance Field Evaluation Report," Food Service Technology Center, December 2015, https://www.bewaterwise.com/assets/2013icp-fishernickel.pdf.

Type	Baseline	EE	units
Single-Tank Conveyor - LT	1.80	1.20	kW
Multiple-Tank Conveyor - HT	2.88	1.75	kW
Multiple-Tank Conveyor - LT	2.25	1.50	kW
Single-Tank Flight-Type - HT	7.50	3.75	kW
Multiple-Tank Flight-Type - HT	10.00	5.00	kW

Washing energy use was incorporated as a criterion in the ENERGY STAR version 3 standards. The current ENERGY STAR database includes energy-usage listings (in Wh/rack) for qualified models. Baseline energy use data was obtained from lab test reports published on the California Energy Wise website[49]. Flight-type machine data was gathered from field studies[50].

Table 30: Washing Energy Use Assumptions

Type	Baseline	EE	units
Undercounter - HT	400	250	Wh/rack
Undercounter - LT	100	50	Wh/rack
Stationary Single-Tank Door - HT	400	300	Wh/rack
Stationary Single-Tank Door - LT	100	50	Wh/rack
Pot, Pan, and Utensil - HT	667	500	Wh/rack
Single-Tank Conveyor - HT	450	350	Wh/rack
Single-Tank Conveyor - LT	300	200	Wh/rack
Multiple-Tank Conveyor - HT	495	385	Wh/rack
Multiple-Tank Conveyor - LT	330	220	Wh/rack
Single-Tank Flight-Type - HT	37.5	33.9	kW
Multiple-Tank Flight-Type - HT	50.0	45.2	kW

[49] "Dishmachine Performance Reports." https://caenergywise.com/report-library/dishmachines/.
[50] Frontier Energy, Inc., "Flight-Type Dishmachine Replacement—Field Evaluation Report." https://www.meiko.us/fileadmin/editor_upload/meiko.us/Images/FEM_2019/SR_Marriott_Dishmachine_Replacement_1-29-2019.pdf.

Appendix C: Electricity and Natural Gas Price Forecasts

Table 31 shows the electricity and natural gas prices from 2022 to 2050. The electricity and natural gas prices were estimated based on the latest available data, which was derived from the U.S. Energy Information Administration (EIA)[5152], on average electricity and natural gas prices paid by California consumers. The annual escalation rates were estimated using price forecasts. The electricity price forecast was derived from the California Energy Demand Forecast published by CEC in 2022[53] and the natural gas price forecast was derived from the California Public Utility Commission's 2021 report "Utility Costs and Affordability of the Grid of the Future: An Evaluation of Electric Costs, Rates and Equity Issues"[54]. Further, electricity and natural gas prices were escalated based on the annual escalation rates.

Table 31: Electricity and Natural Gas Price Forecasts

Year	Electricity (Cents per kWh)	Natural Gas (dollar per million Btu)
2022	19.74	11.24
2023	19.21	11.78
2024	19.01	12.35
2025	19.43	12.94
2026	19.51	13.56
2027	19.68	14.21
2028	19.96	14.89
2029	20.15	15.61
2030	20.22	16.36
2031	20.2	17.14
2032	20.31	17.96
2033	20.46	18.83
2034	20.61	19.73
2035	20.81	20.68
2036	20.9	21.67
2037	20.98	22.71
2038	21.07	23.8
2039	21.16	24.94
2040	21.24	26.14

[51] U.S. Energy Information Administration (EIA), Electric Power Monthly, 2023. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a

[52] U.S. Energy Information Administration (EIA), California Price of Natural Gas Sold to Commercial Consumers. https://www.eia.gov/dnav/ng/hist/n3020ca3m.htm

[53] California Energy Commission, "California Energy Demand Update, 2022–2035". https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2022-integrated-energy-policy-report-update-2

[54] California Public Utility Commission, "Utility Costs and Affordability of the Grid of the Future: An Evaluation of Electric Costs, Rates and Equity Issues," 2021, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf

Year	Electricity (Cents per kWh)	Natural Gas (dollar per million Btu)
2041	21.33	27.39
2042	21.42	28.71
2043	21.51	30.09
2044	21.59	31.53
2045	21.68	33.04
2046	21.77	34.63
2047	21.86	36.29
2048	21.95	38.03
2049	22.04	39.86
2050	22.13	41.77