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Food Service T20 CASE Report RFI Response Commercial Ovens

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Commercial Ovens

Codes and Standards Enhancement (CASE) Initiative

For PY 2024: Title 20 Standards Development

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

November 21, 2024

Prepared for:

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Acknowledgments

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1. Executive Summary

1.1 CASE Team Proposal Objective

The Codes and Standards Enhancement (CASE) Team, herein referred to as the 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. The program prepares and submits proposals for cost-effective enhancements to improve the energy and water efficiency of appliances sold in California. The CASE Report provides a technical and cost-effective analysis of commercial convection, combination, and rack oven appliance standards.

The CEC will evaluate proposals submitted by the CASE Team and other stakeholders. They may choose to revise or reject these proposals. For more information about the rulemaking schedule and how to participate in the process, see the CEC's Appliance Efficiency Regulations – Title 20 website.

Sections 2 through 10 of this report cover the proposed appliance standards for commercial convection, combination, and rack ovens, along with the supporting analysis. Section 11 responds to the questions in the Request for Information docketed by the CEC on November 14, 2023, and a second Request for Information docketed by the CEC on September 4, 2024.

1.2 Commercial Oven Types

The scope of the proposed appliance standards includes three types of commercial ovens: commercial convection, combination, and rack ovens. Convection ovens bake foods by circulating hot air within the cooking cavity. The heating elements or burners at the bottom of the cooking cavity generate heat by burning natural gas or through electric resistance. Most commercial convection ovens come in two sizes (full-size and half-size) and use two fuel sources (electric and gas). "Bakery depth" ovens fall under the CASE Report's proposed efficiency standards. These ovens have the same pan capacity as a full-size oven type but feature a deeper cavity. Convection oven sizes are defined by their ability to hold specific sheet pan sizes. Full-size convection ovens can accommodate a full-size sheet pan (18" x 26"x 1"), whereas half-size convection ovens can accommodate half-size sheet pans (13"x 18"x 1"). Half-size convection ovens are popular with quick-service restaurant chains for small breakfast items, such as biscuits and bacon. These ovens are predominantly electric, gas half-size ovens are out of scope due to the lack of popularity and available data. The proposed efficiency standards in this CASE Report cover the full-size convection ovens that fit three to six full-size pans and half-size electric convection ovens.

Combination ovens (combi ovens) are designed to bake foods using a combination of convection heating and steam. These ovens come in three sizes: fewer than 15 pans, 15 to 28 pans, and more than 28 pans. They use two fuel sources: electric and gas. Commercial combi oven size is determined by its capacity to accommodate a "hotel pan" (known in Europe as a "gastronorm pan") measuring 12.7" x 20.8" x 2.5. The proposed efficiency standards in this CASE Report cover combi ovens with a capacity ranging from three to 40 pans.

This CASE Report explores the efficiency standards for gas rack ovens. Rack ovens can be powered by gas or electricity and can fit 15 or 30 standard sheet pans. Rack ovens come in two sizes: single rack (15 pans) and double rack (30 pans). Although mini-rack ovens exist in the market, they cannot

accommodate a standard sheet pan and are not included in the scope of the proposed efficiency standards.

1.3 CASE Team Proposed Standards

The CASE Team proposes a set of performance standards for commercial convection, combi, and rack ovens, collectively referred to as "commercial ovens." Specifically, the CASE Team suggests aligning the scope and definition for commercial ovens with the United States (U.S.) Environmental Protection Agency (EPA) ENERGY STAR® Commercial Ovens Specification V2.2 for convection ovens and V3.0 for combi and rack ovens. This alignment ensures a well-understood and consensus-based description.

The CASE Team proposes adopting the most recent American Society for Testing and Materials (ASTM) test procedure, aligning with the ENERGY STAR Specification. This adoption ensures performance levels consistent with ENERGY STAR Commercial Ovens Specification V2.2 and V3.0, harmonizing Title 20 standards with those of other states. Section 1.2 briefly describes the ovens within this proposal's scope. The proposed standards address cooking efficiency and idle energy across all relevant product classes. Moreover, the test procedures are grounded in industry-developed methods.

Commercial ovens within the proposal's scope must comply with existing CEC certification and marking requirements. Although the requirements are similar, participation in the ENERGY STAR program is not mandatory. The proposed effective date is March 1, 2026, providing ample time for pre-rulemaking and rulemaking activities and meeting the California statute's one-year requirement between adoption and effective dates.

1.4 Market Analysis

The CASE Team studied commercial ovens in the California marketplace, engaging with manufacturers and industry representatives. The CASE Team's market analysis demonstrates that the proposed standards are technically feasible.

The CASE Team reviewed the V2.2 and V3.0 ENERGY STAR certified products list and the State Appliance Standards Database (SASD) to assess the availability of compliant products from various manufacturers that comply with the proposed standards. ENERGY STAR estimates that V2.2 and V3.0 qualifying products represent 53% of the convection, combi, and rack commercial oven market (Energy Star, 2022). The CASE Team concludes that the proposed standards would not reduce consumer utility.

1.5 Per Unit Energy Savings

The CASE Team used data from the California Electronic Technical Reference Manual (Convection Oven, Commercial eTRM, n.d.) to develop the appropriate inputs for the different types of convection ovens, including the number of operational days, operational hours per day, cooking efficiency, pounds of food cooked per day, and American Society for Testing and Materials (ASTM) energy to food ratio.[1] Assumptions for preheating time, energy use, idle energy rate, and cooking efficiency vary from baseline to energy-efficiency models. The analysis compared baseline units to compliant units.

Table 1 below presents the per unit energy savings by product class of commercial ovens.

[1] The ASTM energy to food ratio is the amount of energy it takes to raise 1 pound of standard food product 1°F.

Table 1 Annual Per Unit Energy Savings

Product Class	Electricity (kWh/yr-unit)	Peak demand (kW/unit)	Natural gas (therms/yr-unit)	Water (gallon/yr-unit)
Full-Size Convection Oven - gas	0	0	154	0
Full-Size Convection Oven - electric	1,258	0.179	0	0
Half-Size Convection Oven - electric	616	0.088	0	0
Combi Oven fewer than 15 Pans - electric	2,629	0.374	0	4,967
Combi Oven (Fewer than 15 Pans) - gas	0	0	199	10,298
Combi Oven 15-28 Pans - electric	5,011	1.000	0	10,655
Combi Oven (15-28 Pans) - gas	0	0	186	19,717
Combi Oven (More than 28 Pans) - electric	7,924	1.130	-	29,643
Combi Oven (More than 28 Pans) - gas	0	0	214	24,889
Single-Rack Oven - gas	1,039	0.148	323	0
Double-Rack Oven - gas	1,740	0.247	361	0

1.6 Cost Effectiveness

The CASE Team calculated the effectiveness and potential consumer impact by comparing the benefits and costs of the proposed standards. All ovens in the study were assumed to have a 12-year useful life. The proposed standards are cost effective for ovens with electric or gas heat sources, with total life cycle benefits exceeding life cycle costs. An “infinite” life cycle benefit-cost ratio indicates that the proposed compliant options have an incremental cost of zero or below the baseline options.

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)	Life Cycle Benefit-Cost Ratio
Full-Size Convection Oven - gas	12	2,603	1,000	1,603	3.65	2.60
Full-Size Convection Oven - electric	12	3,604	1,000	2,604	2.68	3.60
Half-Size Convection Oven - electric	12	1,765	1,000	765	5.46	1.77
Combi Oven fewer than 15 Pan - electric	12	8,405	0	8,405	0	Infinite
Combi Oven (Fewer than 15 Pans) - gas	12	6,806	0	6,806	0	Infinite
Combi Oven (15-28 Pan) - electric	12	18,541	0	18,541	0	Infinite
Combi Oven (15-28 Pan) - gas	12	8,934	0	8,934	0	Infinite
Combi Oven (28+ Pan) - electric*	12	-	-	-	-	-
Combi Oven (28+ Pan) - gas	12	14,099	0	14,099	0	Infinite
Single-Rack Oven - gas	12	8,438	6,813	1,625	7.71	1.24
Double-Rack Oven - gas	12	11,088	3,093	7,995	2.67	3.58

*Current sales projections for combi ovens of this size show a market preference only for the gas option.

1.7 Statewide Impacts

The CASE Team determined the number of units shipped for each product category using ENERGY STAR shipment data and National American Association of Food Manufacturers (NAFEM) data, adjusted for California's population. The CASE Team estimates over 11,900 commercial oven shipments to California annually. Convection ovens account for over 75% of shipments, with over 9,000 units installed yearly. Of these, approximately 90% are gas convection ovens and 10% are electric (NAFEM 2002). Combi ovens account for approximately 20% of the 11,900 and the balance goes to rack ovens.

Commercial ovens meeting the proposed standards are widely available, with ENERGY STAR-compliant ovens comprising 53% of the current market. The proposed standards do not pose any significant barriers to manufacturing compliant equipment.

Implementing these standards would result in a first-year statewide savings of 1.73 gigawatt hours (GWh) of electricity, 0.25 megawatts (MW) of onsite electricity demand, 0.77 million therms of natural gas, and 6.61 million gallons of water. After a complete stock turnover by 2038, California would

annually save an estimated 20.78 GWh of electricity, 2.96 MW of onsite electricity demand, 9.26 million therms of natural gas, and 79.38 million gallons of water, with savings varying by product class.

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

Product Class	Year of Stock Turnover	Electricity (GWh/yr)	On-site Electricity Demand (MW)	Natural Gas (million therms/yr)	Water (million gallons/yr)	Utility Bill Savings (million 2024 $/yr)
Full-Size Convection Oven - gas	2038	0	0	7.88	0	10.1
Full-Size Convection Oven - electric	2038	7.33	1.04	0.00	0	1.22
Half-Size Convection Oven - electric	2038	0.898	0.128	0	0	0.149
Combi Oven (Fewer than 15 Pans) - electric	2038	6.90	0.980	0	13.0	0.552
Combi Oven (Fewer than 15 Pans) - gas	2038	0	0	0.427	22.1	0.288
Combi Oven (15-28 Pan) - electric	2038	2.99	0.425	0.00	6.36	0.240
Combi Oven (15-28 Pan) - gas	2038	0	0	0.206	21.9	0.156
Combi Oven (28+ Pan) - electric*	2038	-	-	-	-	-
Combi Oven (28+ Pan) - gas	2038	0	0	0.137	16.0	0.106
Single-Rack Oven - gas	2038	0.355	0.051	0.110	0	0.112
Double-Rack Oven - gas	2038	2.38	0.338	0.494	0	0.573
TOTAL		**20.8**	**2.96**	**9.26**	**79.4**	**13.5**

*Current sales projections for combi ovens of this size show a market preference only for the gas option.

2. Introduction

Restaurants, hotels, cafeterias, and other settings use commercial ovens to prepare large quantities of food. Over the past decade, developing and promoting more efficient gas burner designs have reduced energy consumption. Improved insulation materials, sensors, control systems, and airflow management have decreased the energy required to reach the desired temperatures. As of 2022, 53% of commercial ovens sold in the U.S. meet the ENERGY STAR V2.2 criteria.

The CASE Team proposes an approach to reducing electricity and natural gas use by installing more energy-efficient commercial convection, combi, and rack ovens:

- **Appliance Standards**: In Title 20, establish idle rate power or fuel consumption standards and cooking energy efficiency standards based on ENERGY STAR V2.2 for commercial convection ovens and V3.0 for combi and rack ovens.

This report provides supporting analysis for the proposed Title 20 code change approach. It focuses on energy-efficiency standards for commercial convection, combi, and rack ovens within the scope of the ENERGY STAR program.

3. Product and Technology Description

Commercial kitchens use various oven types: convection, combi, standard, conveyor, slow cook-and-hold, deck, hearth, microwave, rack, range, rapid cook, rotisserie, and reel-type ovens. ENERGY STAR specifications cover only the most popular types: convection, combi, and rack ovens. This analysis focuses on these ovens and briefly describes the others.

Commercial convection ovens are the most popular type due to their versatile size and relatively low purchase cost. Essential in professional kitchens, they can cook almost any dish.

Combi ovens cost three to five times more than a similar-sized convection oven, leading most restaurant operators to opt for convection ovens.[2] Combi ovens cook using convection steam or a combination of convection and steam, and are gaining popularity due to their versatility and programmability. However, larger facilities may have a combi and convection oven, as more complicated dishes require temperature monitoring or steam.

Rack ovens are used in bakeries to cook large volumes of bread or baked goods, while convection ovens cook smaller items, such as cookies, cupcakes, or brownies.

3.1 Convection Oven

Commercial convection ovens typically accommodate five to six full-size sheet pans (18” x 26”) and can cook close to 100 pounds of russet potatoes per hour, which are used as the reference food in the test procedure. In most commercial kitchens, ranges with integrated ovens are commonly used. These ranges feature a stovetop unit and an oven below, primarily used to finish cooking items that began on the stovetop. Commercial kitchens use standalone convection ovens for most applications.

All commercial convection ovens have either electric heating elements or gas burners underneath the cooking cavity, along with a forced convection fan located at the back or to the right of the cooking cavity. Some convection ovens offer a steam injection feature where a small amount of water is introduced into the cooking cavity to keep the food from drying out or for baked items that require moisture to rise. The most common cooking temperatures in commercial convection ovens range from 325˚F to 375˚F, although thermostats usually range from 200˚F to 450˚F.

Most commercial convection ovens feature double-swing doors with dual-pane glass for easy access. Two convection ovens can be stacked to maximize kitchen space in large hotels or schools that may use four to eight ovens per kitchen. Commercial convection ovens are available in standard or bakery-depth sizes. Bakery-depth convection ovens can accommodate a sheet pan (18 x 26”) in any orientation because their cavity is eight inches deeper than standard ovens.

[2] Combi ovens cost around $20,000, whereas convection ovens of a similar size cost around $5,000.

Figure 1 Full-Size Convection Oven

Source: (Webstaurant Store, n.d.)

Figure 2 Half-Size Convection Oven

Source: (Webstaurant Store, n.d.)

3.1.1 Gas Convection Oven

Gas convection ovens have two to five burners beneath the cooking cavity, with input power ranging from 40 to 100 thousand British thermal units per hour (kBtu/h) for a five to six-pan convection oven. These ovens mix combustion byproducts into the cooking cavity (directly fired) or separate the gas flue from the cooking cavity (indirectly fired). All gas convection ovens have electronic ignition and are thermostatic. Most gas convection ovens are full-size and fit five to six pans. Although half-size convection ovens exist, only a few models are currently on the market, and no data on half size efficiency is available.

3.1.2 Electric Convection Oven

Electric convection ovens have heating elements beneath the cooking cavity, with input power ranging from 2 to 15 kilowatts (kW). They come in two sizes. The most popular can fit five to six full-size sheet pans. Half-size electric convection ovens, designed for half-size sheet pans, are popular with quick-service restaurant chains for preparing smaller breakfast items, such as biscuits and bacon.

3.2 Combi Oven

Most combi ovens use a different pan size from convection ovens. Combi oven capacity is measured using hotel pans, known in Europe as gastronorm pan (GN 1/1), which measures 12.7” x 20.8” x 2.5” (530 x 325mm). The number of hotel pans a combi can accommodate determines its size. Half-size combi ovens can fit one pan per level placed front to back, while full-size ovens can fit two pans placed horizontally per level.

The scope of this proposal is limited to three to 40-pan combi ovens and excludes mini-combi ovens that accommodate two-thirds-size pans. Combi ovens with a capacity of more than 28 pans are classified as 40-pan models, matching the capacity of a full-size rolling rack. These combi ovens, along with 20-pan half-size rolling rack combi ovens, include a rolling rack or trolley specific to the model. The rack rolls into the cooking cavity, and the door seals around its base to prevent moisture and heat loss.

Figure 3 Five-Pan Combi Oven (Half-size)

Source: (5 pan combi oven, 2024)

Figure 4 Ten-Pan Combi Oven (Full-size)

Source: (10 pan combi oven, 2024)

Figure 5 Ten-Pan Combi Oven (Half-size)

Source: (Rational Combi Ovens, 2024)

Figure 6 Twenty-Pan Combi Oven (Full-size)

Source: (Rational Combi Ovens, 2024)

Figure 7 Twenty-Pan Roll-In Rack Combi Oven (Half-size)

Source: (20 Pan Rack Roll In Combi, 2024)

Figure 8 Forty-Pan Roll-In Rack Combi Oven (Full-size)

Source: (40 Pan Rack Roll-In Combi Oven, n.d.)

Humidity is generated in the cooking cavity by spraying water onto the heat exchanger or creating steam in a separate atmospheric boiler (steam generator), which is then injected into the cooking cavity. The operator can control the humidity level from 0 to 100%. Most combi ovens do not have a direct way of measuring humidity, so the amount of steam delivered at a given setting varies from model to model. A combi oven can generally cook a full load of red potatoes at 212°F and 100% humidity without losing weight, indicating that enough steam is generated to offset the moisture lost. Combi ovens can operate at temperatures ranging from 150°F to 500°F; however, most recipes range from 325°F to 375°F, and steaming is done at 212°F.

Many combi ovens feature sophisticated touchscreen controls with menu programming. Manufacturers also offer basic models (estimated to comprise less than 10% of the market) that allow only temperature and humidity settings without programmability. Advanced combi ovens include integrated temperature probes for cooking various proteins and offer features, such as multi-menu programming for simultaneous cooking, multi-temperature and humidity programming, online menu integration and updates, delta T cooking, smoking, artificial intelligence (AI) recognition, and menu selection of cooked products.

Another popular feature of combi ovens is their self-cleaning capability, which allows them to run a cleaning cycle at the end of each day. Self-cleaning combi ovens typically use several water nozzles inside the cooking cavity and solid detergent placed in a separate compartment or liquid detergent pumped from a chemical container.

Combi ovens usually have two water connections: one for filtered water and another for unfiltered. Filtered water is used for cooking, whereas unfiltered water is used for condensate cooling to keep the drain water below 140°F. Water quality (total dissolved solids, hardness, and chloride level) affects combi oven longevity, so manufacturers often recommend installing an in-line reverse osmosis (RO) system and a water softener. An RO system has associated water use (membrane flush cycles) not factored into combi oven water consumption reported here.

3.2.3 Gas Combi Oven

Gas combi ovens use a power burner connected to a heat exchanger to heat the cooking cavity. Input rates range from 60 kBtu/h for a small combi to 300 kBtu/h for a roll-in combi. A convection fan evenly distributes the heat from the heat exchanger throughout the cavity. The burner and heat exchanger are usually located on the right side of the oven behind the control panel.

3.2.4 Electric Combi Oven

Electric ovens use a heating element instead of a power burner. The heating element is usually inside the cooking cavity, near the convection fan. Electric combis are offered in 208V or 240V single-phase or three-phase configurations for small to medium-sized units and 480V three-phase configurations for larger roll-in rack models.

All gas combi ovens must be vented outside using a Type I hood. Some smaller electric combi ovens are sold in ventless configurations. Ventless electric combi ovens have an integrated hood and an exhaust fan with a filtration system. These ovens often include a catalyst that breaks down effluent particles. The catalyst is usually actively heated and consumes a significant amount of energy.

3.3 Gas Rack Oven

Gas rack ovens use a power burner connected to a heat exchanger inside the cooking cavity. The heat exchanger sometimes includes steel balls to provide a large thermal mass. Convection fans evenly distribute air from the heat exchanger throughout the cavity. Rack ovens come in single and double-rack configurations, with double-rack ovens being more popular due to their higher capacity. A double-rack oven is slightly larger externally but can hold twice as many pans as a single-rack oven. A single rack accommodates 15 standard sheet pans (26 x 18 x 1”), while a double rack accommodates 30 standard sheet pans, two per level.

These racks are rolled into the oven, where a lift mechanism raises the rack 1-2 inches off the oven floor and rotates it throughout the cook cycle to ensure even cooking, as the heat exchanger is the hottest part of the oven. Mini-rack ovens cannot accommodate a standard 15-pan rack. They can use non-standardized 10-pan roll in racks or non-roll-in racks that accommodate 6-8 pans. Mini-rack ovens are excluded from this scope.

Figure 9 Single-Rack Oven

Source: (Single Rack Oven (Electric), n.d.)

Figure 10 Double-Rack Oven

Source: (Rotating Rack Oven, n.d.)

Rack ovens are shipped in several pieces (two body pieces, a hood, and a door) to reduce the shipping burden and assembled onsite to ensure the oven parts fit through standard-sized doors. It usually takes a technician one day to assemble an oven, start it up, and calibrate the burner for optimal combustion. Rack ovens feature an integrated hood above the door that vents the effluent outside or into the kitchen exhaust ductwork. The hood often has a separate exhaust motor. The gas oven flue is vented

separately from the exhaust hood or ducted together. Most rack ovens with 200 to 400 kBtu/h capacities are supplied with 1-inch diameter gas piping.

Water is essential for some baking recipes, and almost all rack ovens offer water injection capabilities. Water is briefly sprayed onto the heat exchanger and then vaporizes. The duration of the injections can be programmed and usually lasts less than a few minutes during the cooking cycle. Since not all recipes require water, rack ovens are assumed to use an insignificant amount.

Rack ovens usually operate between 325°F and 400°F and often have simple controls. However, some models offer more sophisticated touchscreen controls with recipe programming, automatic setbacks, and troubleshooting capabilities.

3.4 Items Explicitly Not within the Scope of This Proposal:

The proposal aligns with the scope of the ENERGY STAR voluntary ovens certification program. The following ovens are not within the scope of this report but may be considered for future appliance efficiency standards:

- **Rapid Cook Ovens**: Small cavity ovens that use a combination of convection heat and microwaves, or air impingement ovens, in which the airflow is from the top and bottom of the cooking cavity.
- **Conveyor Ovens**: Ovens in which the product is placed on a conveyor belt and moves through the cavity, which is open on either end.
- **Deck Ovens**: Ovens in which the bottom of the cooking cavity is a heated deck, and the product is usually placed directly on the deck instead of suspended on pans.
- **Slow Cook Ovens**: Ovens incapable of operating above 350˚F.
- **Retherm Ovens**: Ovens designed to re-thermalize or safely reheat prepackaged food to a safe temperature without cooking the product.
- **Holding Cabinets**: Cabinets used to keep products heated to a food-safe temperature without cooking them. Note that CEC has efficiency standards for hot food holding cabinets.
- **Rotisserie Ovens**: Ovens intended for products that revolve or rotate in a cooking cavity instead of being cooked in standardized size pans.
- **Range Ovens**: Ovens located beneath the range top (or cooktop), usually not intended for high-capacity cooking.
- **Full-Size Convection Ovens**: Ovens that can accommodate fewer than three full-size sheet pans.
- **Half-Size Convection Ovens**: Ovens that can accommodate fewer than three half-size sheet pans.
- **Half-Size Gas Convection Ovens**
- **Quarter-Size Convection Ovens**: Ovens used for reheating and finishing.
- **Convection Ovens**: Ovens that can accommodate more than six full-size sheet pans per cavity (loaded with potatoes per ASTM method).
- **Combi Ovens:**

- Ovens that cannot accommodate standard size 12.7 x 20.8 x 2.5-inch steam pans (often referred to as 2/3 size or mini combis)
- Ovens that cannot accommodate at least three steam pans.
- Ovens that can accommodate more than 40 steam pans.

- **Rack Ovens:**
  - Ovens that cannot accommodate a standard size roll-in rack with 15 sheet pans (often referred to as mini-rack ovens).
  - Ovens that can accommodate more than two racks (more than 30 sheet pans).

4. Proposed Standards

4.1 Proposal Description

As noted in the introduction, the CASE Team proposes a comprehensive approach to achieving energy savings by setting standards for more efficient convection, combi, and rack ovens. This report provides supporting analysis for the Title 20 code change proposal, focusing on improved performance standards for commercial ovens within the scope of the ENERGY STAR program. These standards are detailed in Sections 3.1 through 3.3 of this report, with further elaboration in this section.

4.2 Proposed Changes to Title 20 Code Language

4.2.1 Scope and Proposed Definitions

The CASE Team proposes definitions substantially similar to those in the ENERGY STAR V2.2 Commercial Ovens specification, as the industry has vetted these definitions over sixteen years of engagement with the EPA. However, the scope is limited to commercial convection, combi, and rack ovens. Therefore, the CASE Team proposes adding the following new scope and definitions to Title 20:

- **Add to and modify the definition for commercial convection ovens in section 1602**: A convection oven is a general-purpose oven that is not a consumer product and cooks food by forcing hot, dry air over the surface of the food product. The rapidly moving hot air strips away the layer of cooler air next to the food, enabling the food to absorb the heat energy. Convection ovens do not include ovens that can heat the cooking cavity with saturated or superheated steam.
    - **Half-Size Convection Oven**: A convection oven that can accommodate a standard half-size sheet pans measuring 18 x 13 x 1-inch.
    - **Full-Size Convection Oven**: A convection oven that can accommodate a standard full-size sheet pans measuring 18 x 26 x 1-inch.
    - The proposed standards apply only to convection ovens that can accommodate between three pans and no more than six pans.
- **Add a new definition for commercial combination ovens in section 1602**:
  Combination Oven: A device that combines the function of hot air convection (oven mode), steam heating (steam mode), and a combination of both (combination mode), which includes high- and low-temperature steaming, baking, roasting, rethermalizing, and proofing of various food products. The term combination oven generally describes this type of self-contained equipment, also known as a combination oven/steamer, combi, or combo.
    - **Half-Size Combination Oven**: A combination oven that can accommodate a single 12.7 x 20.8 x 2.5-inch steam table pan per rack position, loaded from front-to-back or lengthwise.
    - **Full-Size Combination Oven**: A combination oven that can accommodate two 12.7 x 20.8 x 2.5-inch steam table pans per rack position, loaded from front-to-back or lengthwise.

    - **2/3-Size Combination Oven**: A combination oven that can accommodate a single 13.8 x 12.7 x 2.5-inch steam table pan per rack position, loaded from front-to-back or lengthwise. It may also be referred to as a mini-size combination oven.
    - Only combination ovens that can accommodate three or more and 40 or fewer 12.7 x 20.8 x 2.5-inch (standard size) steam pans are included in the scope of these proposed standards. 2/3-Size or mini-size combi ovens are out of scope. However, an oven referred to as a mini-size combi oven in its literature that can accommodate at least three standard-size steam pans is within the scope of the proposal.

- **Add a new definition for commercial rack ovens in section 1602**:
  Rack Oven: A high-capacity oven that can produce internal steam, equipped with a motor-driven mechanism for rotating multiple pans inserted into one or more removable or fixed pan racks within the oven cavity.
    - **Mini-Rack Oven**: A stand-mounted rack oven designed with a load-in-place rack that cannot be removed. Mini-rack ovens can accommodate up to 10 standard full-size sheet pans measuring 18 x 26 x 1-inch.
    - **Single-Rack Oven**: A floor-model rack oven that can accommodate one removable single rack of standard sheet pans measuring 18 x 26 x 1-inch.
    - **Double-Rack Oven**: A floor-model rack oven that can accommodate two removable single racks of standard sheet pans measuring 18 x 26 x 1-inch or one removable double-width rack.
    - **Quadruple-Rack Oven**: A floor-model rack oven that can accommodate four removable single racks of standard sheet pans measuring 18 x 26 x 1-inch or two removable double-width racks.
    - These proposed standards include only rack ovens that can accommodate a standard-size roll-in rack with 15 sheet pans and rack ovens that can accommodate two racks (more than 30 sheet pans). Mini-rack ovens accommodating fewer than 15 sheet pans are out of scope.
- **Add a definition for Cooking-Energy Efficiency**: The ratio of energy absorbed by the food product to the total energy supplied to the oven during cooking.
- **Add a definition for Idle Energy Rate**: The rate of oven energy consumption while maintaining or holding at a stabilized operating condition or temperature. Also called standby energy rate.

Manufacturer literature and labeling for commercial convection ovens typically do not indicate pan size capacity. As a result, some smaller commercial convection ovens may or may not be in scope. The CASE Team recommends including a rebuttable presumption that a commercial convection oven with an internal cavity height of at least 14 inches is in scope; if the CEC determines this is an appropriate approach it may make sense to include the cavity height in the definition. This presumption will help the CEC verify whether a product should comply with the proposed standards or is out of scope and does not need to comply.

Manufacturers may rebut this presumption by providing the CEC with a picture of the pan's size capacity measurements to show whether the product meets the three-pan size threshold for the standards to apply. Manufacturer literature often includes the internal cavity, which can be measured on the physical unit. Therefore, this rebuttable presumption will provide a simple verification tool to determine if a product complies with the standards.

4.2.2 Proposed Test Procedure

The CASE Team proposes adopting the most recent ASTM test procedures, aligning with the ENERGY STAR Specification for convection, combi, and rack ovens. Adopting this test procedure ensures that performance levels are consistent with the ENERGY STAR Commercial Ovens Specification V2.2 and V3.0 and harmonizes Title 20 standards with those adopted by other states.

Convection Ovens

The ASTM committee, consisting of leading oven manufacturers and test labs, has developed and refined the test procedure for convection ovens since 1999. The latest test method was finalized in 2013 and reapproved in 2019. Convection ovens are tested with room temperature russet potatoes cooked at 350°F until they reach 205°F. The requirements for cooking energy efficiency, idle energy rate, and production capacity must be tested according to ASTM F1496-13 (2019) Standard Test Method for Performance of Convection Ovens. Adopting ASTM F1496-13 (2019) as the test procedure for convection ovens aligns the Title 20 test procedure with the test procedure adopted by ENERGY STAR.

Section 3.3 of this document states that ovens with fewer than three and more than six pans are excluded from the scope of the proposal. Most convection ovens fall within this pan capacity. No single-cavity convection ovens on the market can accommodate more than six pans. Only mini-rack ovens, which are out of scope, have a higher capacity. Customers needing more than six pans capacity will buy a double-stack five-pan convection oven. Although rare, ovens that cannot accommodate three pans have lower cooking efficiencies due to the food product volume to cavity surface area ratio and are unlikely to meet the proposed energy efficiency criteria. Furthermore, limited test data exists on convection ovens that accommodate fewer than three or more than six pans, making it difficult to propose a meaningful energy efficiency and idle rate threshold. ENERGY STAR does not have pan capacity thresholds because it is a voluntary standard, and ovens that meet ENERGY STAR criteria fall between three and six pans.

The ASTM F1496-13 test method includes a measurement for pan capacity that can determine whether a product is within the standard's scope. Section 3.1.9 of the ASTM F1496-13 requires vertical pan spacing of at least 2.75 inches when measuring pan capacity. Per the ASTM test method, convection ovens marketed as three-pan ovens may lack sufficient spacing, which leads to testing with less than three pans and puts them out of scope of this proposal. CEC has a test procedure for commercial convection ovens and this proposal would update the test procedure to the new version.

Combi Ovens

The ASTM committee, consisting of leading oven manufacturers and test labs, has developed and refined the test procedure for combi ovens since 2010. The latest test method was finalized in 2020. Combi ovens are tested in convection mode with room temperature russet potatoes cooked at 350°F in dry mode until they reach 205°F. Combi ovens are also tested in steam mode with room temperature red potatoes cooked at 212°F in maximum humidity mode until they reach 195°F. The requirements for cooking energy efficiency, idle energy rate, and production capacity in both convection and steam modes must be tested according to ASTM F2861-20 Standard Test Method for Enhanced Performance of Combination Oven in Various Modes. Adopting ASTM F2861-20 as the test procedure for combi ovens aligns the Title 20 test procedure with that adopted by ENERGY STAR.

Rack Ovens

The ASTM committee, consisting of leading oven manufacturers and test labs, has developed and refined the test procedure for rack ovens since 2001. The latest test method was finalized in 2018 and reapproved in 2023. Rack ovens are tested with frozen apple pies cooked at 400°F until they reach

185°F. The requirements for cooking energy efficiency, idle energy rate, and production capacity must be tested according to ASTM F2093-18 (2023) Standard Test Method for Performance of Rack Ovens. Adopting ASTM F2093-18 (2023) as the test procedure for rack ovens aligns Title 20 with that adopted by ENERGY STAR.

4.2.3 Proposed Standard Level

The CASE Team proposes performance standards for Idle Rate and Cooking Energy Efficiency that align with ENERGY STAR V2.2 Commercial Ovens for commercial convection ovens. As shown below, the minimum performance standards vary based on fuel source and size.

Table 4 Proposed Convection Oven Performance Standards

Gas

Oven Capacity	Idle Rate, BTU/hr	Cooking Energy Efficiency, %
Full Size	≤ 12,000	≥ 46

Electric

Oven Capacity	Idle Rate, kW	Cooking Energy Efficiency, %
Half Size	≤ 1.00	≥ 71
Full Size	≤ 1.60	≥ 71

The energy efficiency requirements for combi ovens are shown for ENERGY STAR V2.2 below for comparison purposes. The "P" in the idle rate formula is the pan capacity of the combi oven.

Table 5 Combi Oven Performance Standards (V2.2)

Gas

Operation	Idle Rate, BTU/hr	Cooking Energy Efficiency, %
Steam Mode	≤ 200x*P*+6,511	≥ 41
Convection Mode	≤ 150x*P* +5,425	≥ 56

Electric

Operation	Idle Rate, kW	Cooking Energy Efficiency, %
Steam Mode	≤ 0.133x*P* +0.6400	≥ 55
Convection Mode	≤ 0.080x*P* +0.4989	≥ 76

The energy-efficiency requirements for combi ovens were revised in 2022. The criteria for gas combi oven idle and efficiency remained unchanged. However, the requirements for electric idle and efficiency became more stringent, with the idle efficiency increasing from 56 to 57 in convection mode and from 76 to 78 in steam mode. Additionally, specific criteria were developed for electric combis with fewer than five pans, including mini combis. Cooking water consumption thresholds were introduced, and idle water consumption reporting became mandatory. The CASE Team proposes performance standards for idle rate and cooking energy efficiency that align with *ENERGY STAR V3.0 Combination Oven*. The

qualification criteria for ENERGY STAR V3.0 and the proposed performance standard for Title 20 are shown below:

Table 6 Proposed Combi Oven Performance Standards (V3.0)

Gas 3-40 Pan

Operation	Idle Rate, BTU/hr	Cooking Energy Efficiency, %
Steam Mode	≤ 200x*P*+6,511	≥ 41
Convection Mode	≤ 140x*P* +3,800	≥ 57

Electric 5-40 Pan

Operation	Idle Rate, kW	Cooking Energy Efficiency, %
Steam Mode	≤ 0.133x*P* +0.64	≥ 55
Convection Mode	≤ 0.083x*P* +0.35	≥ 78

Electric 3-4 Pan

Operation	Idle Rate, kW	Cooking Energy Efficiency, %
Steam Mode	≤ 0.60x*P*	≥ 51
Convection Mode	≤ 0.05x*P* +0.55	≥ 70

Water Consumption Rate: All Combi Ovens

Operation	During Idle Periods (gal/hr/pan)	During Cooking Periods (gal/pan)
Steam Mode	Reporting Requirement	less than 0.5 gal/pan
Convection Mode	Reporting Requirement	less than 0.4 gal/pan

Additional Idle Calculation Guidance: Compliance with the convection and combination oven idle rate requirements shall be based only on gas energy for certifying gas models. Electric energy consumed by auxiliary components shall not be considered when calculating the gas oven idle rates. It is noted that convection fan energy is not reported for gas convection ovens in the ENERGY STAR database. However, the electric energy consumption measured during idle tests shall be reported separately.

Rack oven energy-efficiency requirements remain unchanged between ENERGY STAR V2.2 and V3.0. The CASE Team proposes performance standards for rack ovens focused on idle rate and cooking energy efficiency to align with ENERGY STAR V2.2 and V3.0, as shown below.

Table 7 Proposed Rack Oven Performance Standards

Oven Rack Capacity	Total Idle Energy Rate (including electric energy converted into Btu/h), Btu/h	Cooking Energy Efficiency, %
Single	≤ 25,000	≥ 48
Double	≤ 30,000	≥ 52

Water Consumption Rate: All Rack Ovens with Steam Injection Mode

Mode	Steam Injection (gal/min)
Steam Injection Mode	Reporting Requirement

Additional Total Idle Calculation Guidance: Compliance with the rack oven total idle rate requirements shall be based on gas and electric energy for certifying gas models. Electric energy consumed by auxiliary components shall be converted to Btu/h and added to the gas idle rate expressed in Btu/h when calculating the total idle rates of the gas rack oven. The electric energy consumption measured during idle tests shall also be reported as expressed in kW.

4.2.4 Proposed Reporting Requirements

Below are the proposed reporting requirements for convection ovens for the CEC database to align with the existing State Appliance Standards Database (SASD):

Table 8 Reporting Requirements

Field	**Source and Explanation**	**Example Values and Units**
Brand Name	This is the company name	Superbake Ovens
Model Number	This is usually an alphanumeric distinct model designation	EBD5
Convection Oven size	Oven size refers to the width of the oven and the ability to accommodate either full-size (26”x18”) or half-size (13”x18”) sheet pans. This size does not refer to the pan capacity.	Full or Half
Combi Oven Pan Capacity	Steam pan capacity (12.7 x 20.8 x 2.5”)	3-40
Rack Oven Size	Whether the rack oven is a single rack (15 sheet pan capacity) or double rack (30 sheet pan capacity)	Single or Double
Primary Fuel Source	NA	Gas or Electric
Electric Input Rate	Not required for gas ovens	kW
Gas Input Rate	For gas ovens only	Btu/h
Ready To Cook Convection Idle Energy Rate Gas	Convection Ovens: ASTM F1496 Section 10.5 Combi Ovens: ASTM F2861 Section 10.4.6 Rack Ovens: ASTM F2093 Section 11.7	Btu/h

Field	Source and Explanation	Example Values and Units
Ready To Cook Convection Idle Energy Rate Electric	Convection Ovens: ASTM F1496 Section 10.5 Combi Ovens: ASTM F2861 Section 10.4.6 Rack Ovens: ASTM F2093 Section 11.7	W
Ready To Cook Steam Idle Energy Rate Gas	Applicable to combi ovens only: ASTM F2861 Section 10.4.7	Btu/h
Ready To Cook Steam Idle Energy Rate Electric	Applicable to combi ovens only: ASTM F2861 Section 10.4.7	W
Convection Cooking Efficiency	Convection Ovens: ASTM F1496 Section 10.6 Heavy Load Russet Potatoes Combi Ovens: ASTM F2861 Section 11.9.2 Russet Potatoes Rack Ovens: ASTM F2093 Section 11.11 Frozen Apple Pies	%
Steam Cooking Efficiency	Applicable to combi ovens only: tested with red potatoes ASTM F2861 Section 11.8.2	%
(Optional) Door Type	Full-size convection ovens have two doors. They are usually glass. However, some models have one solid glass door, some models have two solid doors. Almost all half-size convection ovens have a single glass door	Glass or Glass Solid or Solid
(Optional) Additional Door Type	This field is in addition to the door-type field and is only filled if the individual model number encompasses multiple-door configurations. Results are typically shown for glass doors, representing the worst-case scenario due to higher energy loss and idle rates than solid doors.	Glass or Glass Solid or Solid
Number of Cooking Cavities*	For convection ovens only: A 6-pan oven can be either a single cavity or two cavities with 3 pans.	1 or 2
Pan Capacity per Cavity	For convection ovens: sheet pans: A 6-pan oven can be either a single cavity or two cavities with 3 pans. For combi ovens: 3-40 pans: steam pans For rack ovens: sheet pans: either 15 (single rack) or 30 (double rack)	3,4,5,6
Convection Baking Production Capacity	Convection Ovens: ASTM F1496 Section 10.6 Heavy Load Russet Potatoes Combi Ovens: ASTM F2861 Section 11.9.4 Rack Ovens: ASTM F2093 Section 11.11.4	Lb/h

Field	Source and Explanation	Example Values and Units
Steam Baking Production Capacity	Applicable to combi ovens only: ASTM F2861 Section 11.8.4	Lb/h
Water Consumption in Idle	Applicable to combi ovens only: ASTM F2861 Section 10.4.8	Gal/pan/h
Water Consumption in Cooking	Applicable to combi ovens only: ASTM F2861 Section 10.6.16	Gal/pan
Water Injection	Applicable to rack ovens only: ASTM F2093 Section 11.10 average of five 10-second steam injections at 15-minute intervals	Gal

*Not in SASD

4.2.5 Proposed Marking and Labeling Requirements

All appliances must be permanently marked with the manufacturer's name, brand name or trademark, model number, and manufacturing date, clearly and prominently displayed in an easily accessible location on the unit.

The CASE team does not propose any additional marking requirements. However, manufacturers of products that are *outside* the scope of the regulations may voluntarily choose to mark their products with the pan size capacity to rebut the presumption that their products are within the regulation. We believe such voluntary marking would be an acceptable way to rebut the presumption without providing pictures or other pan-size-capacity documentation to the CEC.

5. Market Analysis

Convection ovens, excluding microwaves, are the most popular type used in restaurants due to their low cost and high production capacity. Other popular ovens include combi ovens, which offer steam cooking capabilities and advanced recipe programming but are two to four times more expensive than convection ovens of similar capacity. Bakeries use rack ovens to cook products by rotating the rack near the heat source and forcing hot air onto the food.

Other ovens include conveyor pizza, deck pizza, rapid-cook (high-speed), and cook-and-hold ovens, which are less popular than convection ovens. California offers a rebate program for gas conveyor pizza and electric deck ovens. According to NAFEM market data (2022 NAFEM report, "Size and Shape of the Industry,", 2022), the breakdown of oven sales in 2022 is as follows.

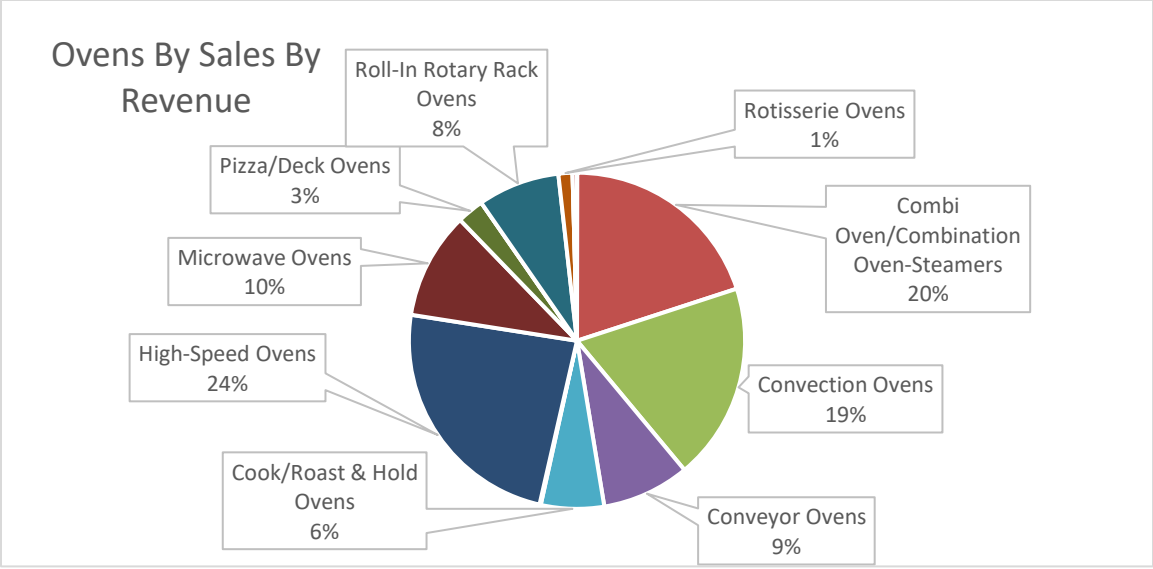

Figure 11 Breakdown of Sales by Revenue, per Oven Types

Assuming representative product costs, the following shows the number of ovens sold by oven type. Microwave ovens dominate the market with a 76% share, followed by convection ovens at 13%, combination ovens at 3%, and rack ovens at 1%.

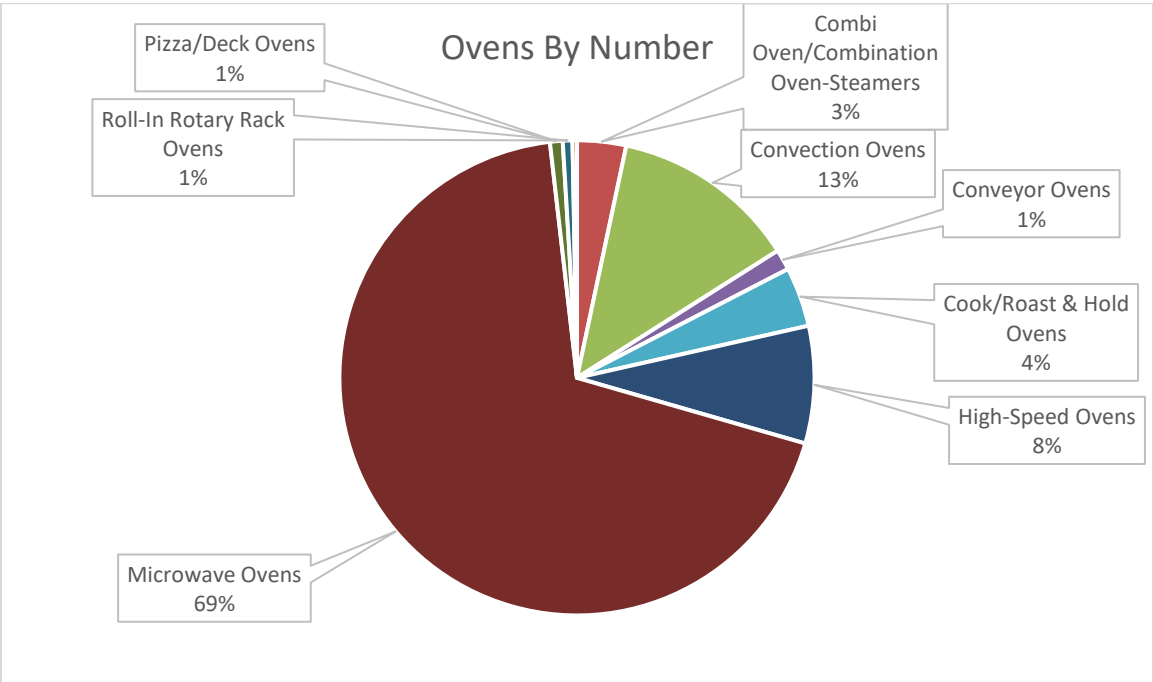

Figure 12 Breakdown of Sales by Oven Types

The graph below shows that convection ovens account for 76% of the sales when considering only ENERGY STAR-eligible oven categories.

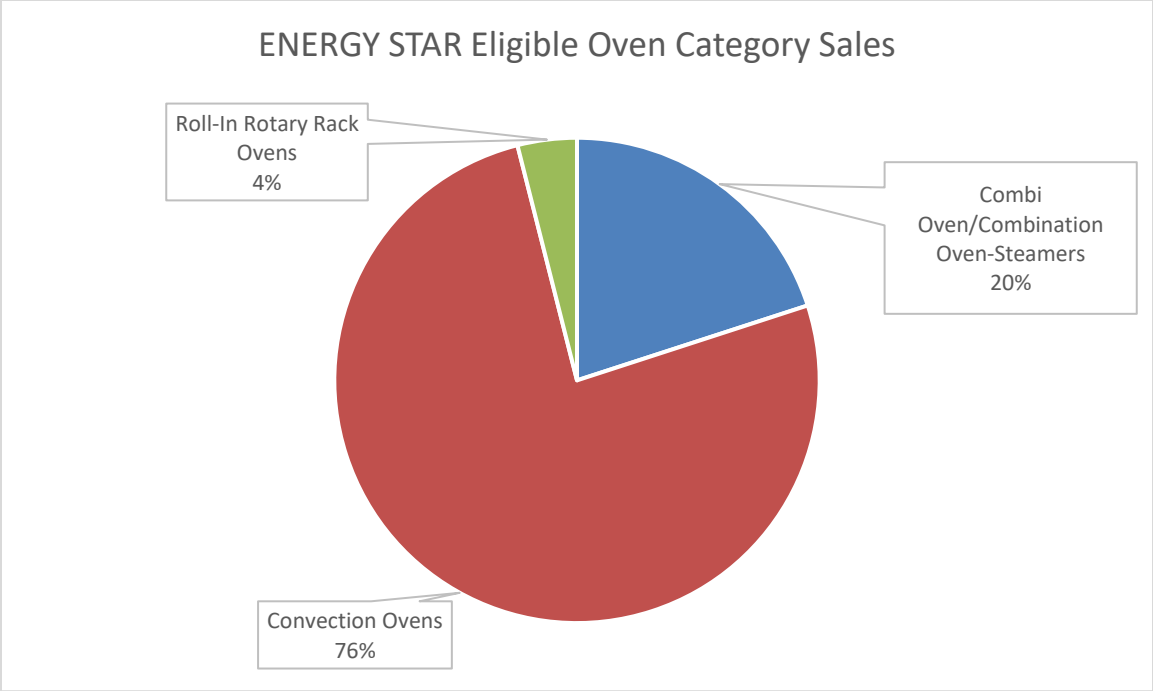

Figure 13 Breakdown of Energy Star-Compliant Ovens Sales Data

Mini-combi ovens (fewer than five pan of 2/3 size pan) are expected to have an insignificant market share. Four mini combi ovens are available in the U.S. Three of the four (Rational XS, Blodgett BLCT-6E, Convotherm Mini) are already ENERGY STAR-certified. The fourth model (Vulcan MINI-JET) lacks energy test data. Additionally, two more mini-combi oven models (Electrolux Multislim and Eloma Joker) are unavailable in the U.S.

A list of the most popular combi oven models currently available in the U.S. market was compiled based on product availability from major foodservice online retailers (Webstaurant, Katom, Chef's Deal Restaurant Supply) and evaluated qualification for ENERGY STAR. Only a handful of models qualified for V2.2 but not V3.0, as Appendix C shows.

Rack ovens account for 4% of the oven categories sold, with an estimated 2,100 rack ovens sold annually in the U.S. Almost all rack ovens are gas fueled. Efficient gas models offer efficient electric components that can contribute to electric energy savings. Estimated figures show that 80% of these ovens are double rack, while the remaining 20% are single rack. Mini-rack ovens are expected to have an insignificant market share, with only three models currently on the market (Baxter OV310, Revent ONE39, and Blodgett XR8). The qualification criteria for rack ovens are the same between ENERGY STAR V2.2 and V3.0.

Table 9 Most Popular Rack Ovens on the U.S. Market

Brand	Model	ESTAR
Doyon	SRO1G	no
Doyon	SOR2G	yes
LBC	LRO-1G5	yes
LBC	LRO-2G5	yes
LBC	LMO-MAX-G	no
Revent	726U-G	yes

Brand	Model	ESTAR
Revent	724U-G	yes
Revent	One26-G	yes
Baxter	OV500G1EE-NG	no
Baxter	OV500G2EE-NG	yes

5.1 Product Efficiency Opportunities

Several technologies can improve the energy efficiency of convection ovens. Energy-efficient models feature insulation, more robust door seals, and smaller gaps. Gas convection ovens benefit from more efficient burners and gas flue routing. Pilotless ignition reduces natural gas consumption. Energy use is further minimized with more efficient convection fans. Additionally, digital controls often offer tighter temperature bands, ensuring more consistent temperature control and higher cooking efficiency.

Cooking energy efficiency and idle rate are the key performance characteristics of convection ovens. The graphs below show the range of idle rates and efficiencies from models that meet the proposed performance criteria. This data comes from either the ENERGY STAR listings or the SASD for compliant products, or the CA eTRM for baseline products.

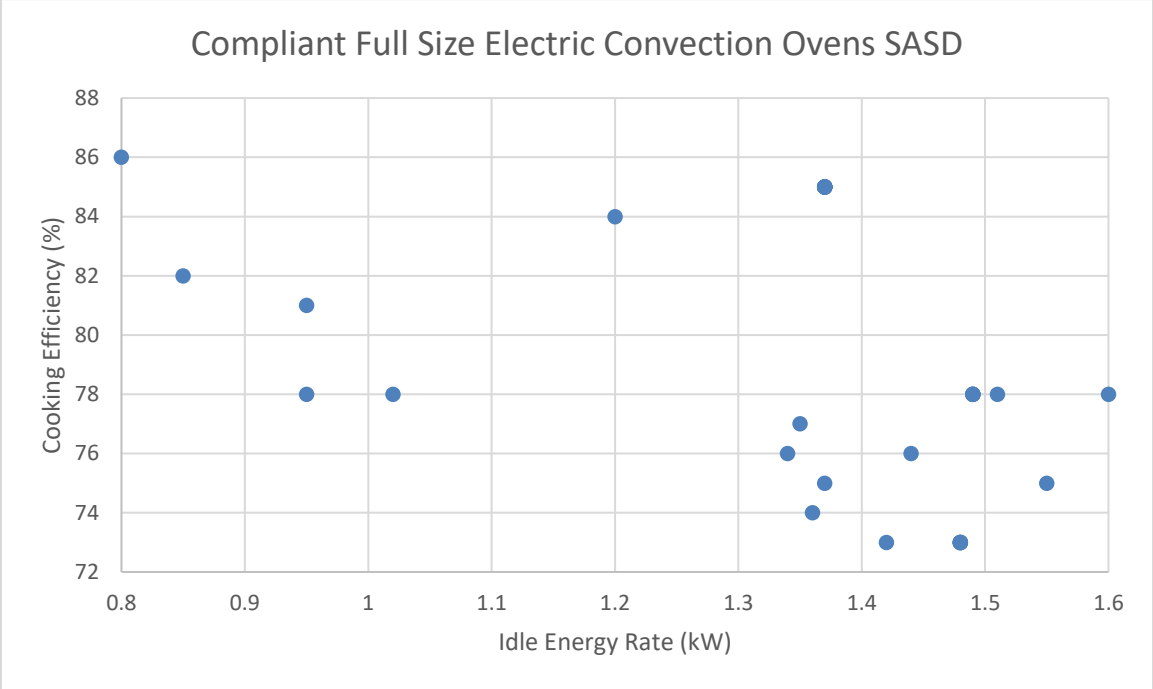

Figure 14 Idle Energy Rate vs. Cooking Efficiency for Compliant Full-size Electric Ovens

The top left corner shows more efficient models, and the bottom right corner shows less efficient ovens.

Source: (Northeast Energy Efficiency Partnerships, n.d.)

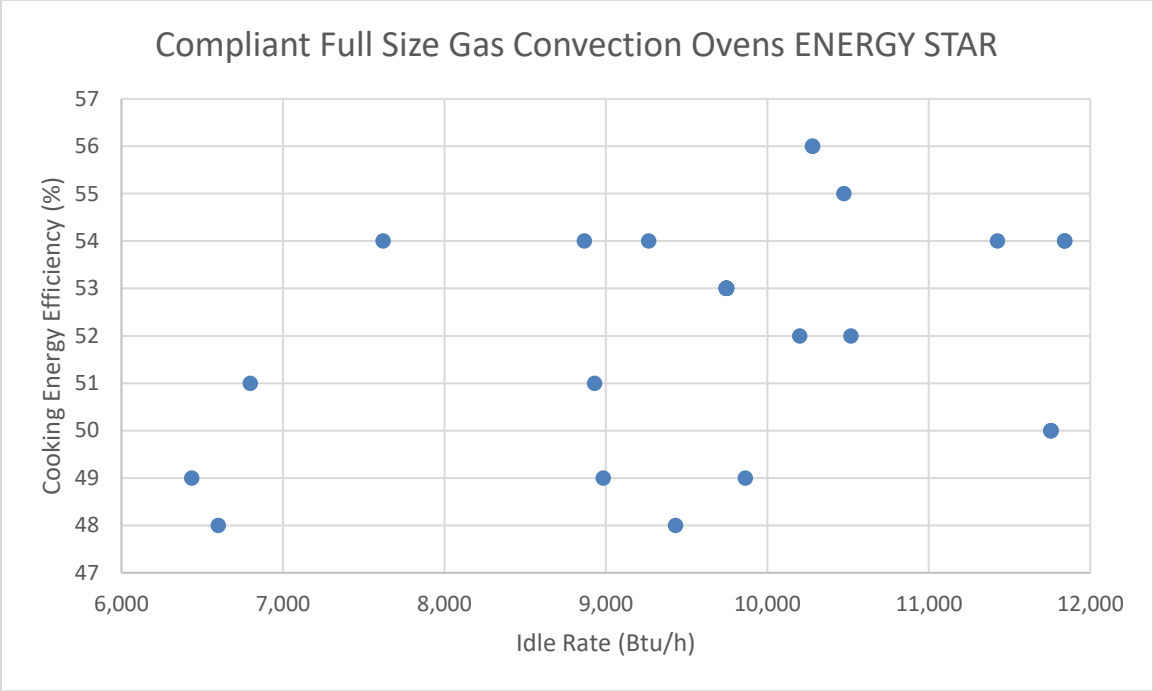

Figure 15 Idle Energy Rate vs. Cooking Efficiency for Compliant Gas Ovens

Source: (Energy Star, n.d.)

The graphs above show energy performance varies significantly among different models on the market.[3] Test data from the eTRM (Convection Oven, Commercial eTRM, n.d.) reveals an even wider range of energy performance for baseline ovens that do not meet the proposed criteria. Electric convection oven energy efficiency ranges from 60% to 86%, while gas oven energy efficiency ranges from 26% to 56%.

[3] The SASD database was used to show range of performance of electric full-size ovens because it is more extensive than the archived ENERGY STAR V2 product list and includes newer models. The ENERGY STAR V2 archived product list was used to show a range of performance for gas convection ovens because the SASD did not show the gas idle rate at the time.

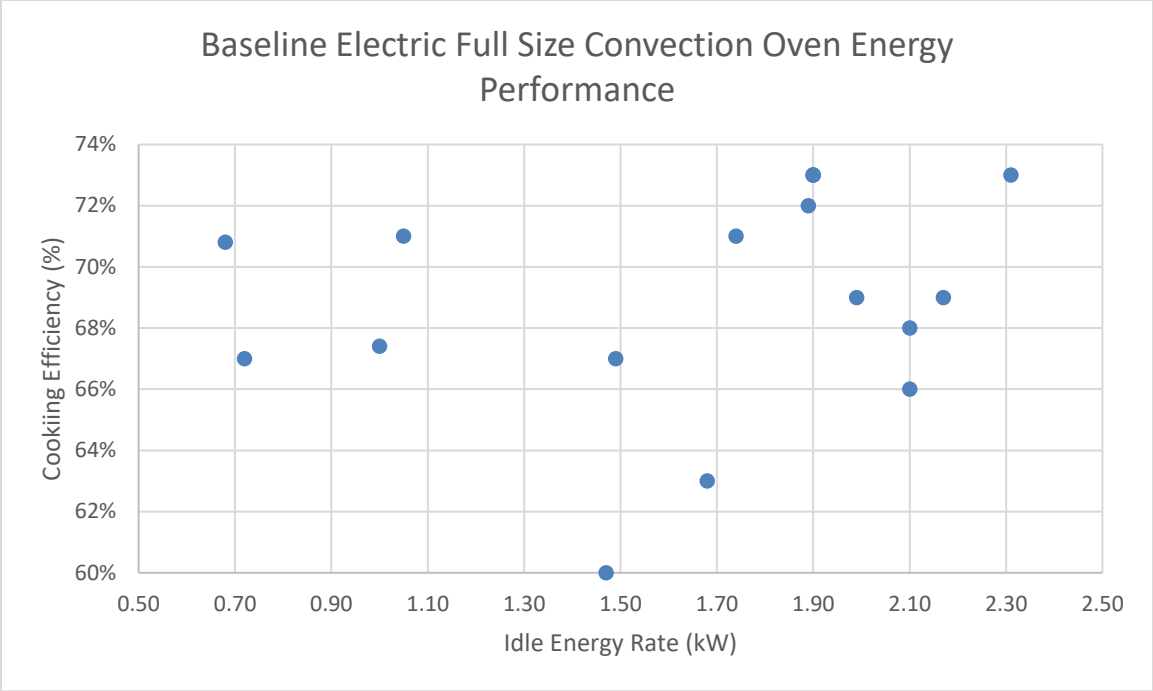

Figure 16 Idle Energy Rate vs. Cooking Efficiency for Baseline Electric Convection Ovens

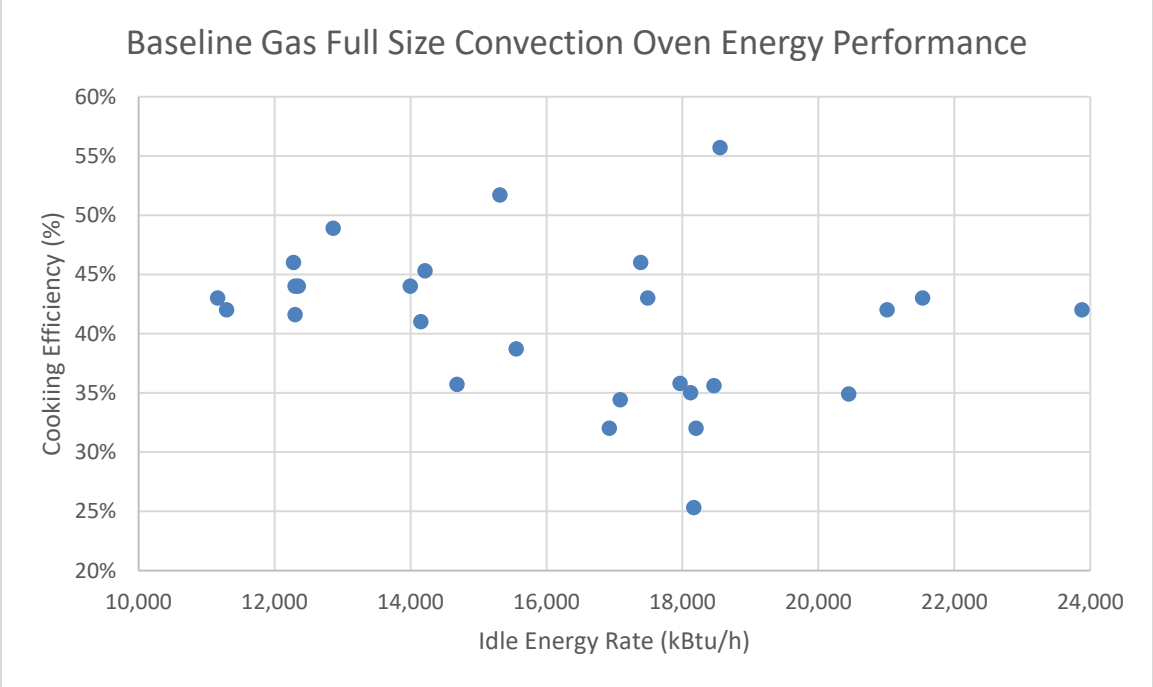

Figure 17 Idle Energy Rate vs. Cooking Efficiency for Baseline Gas Convection Ovens

Combi oven energy efficiency improvement opportunities are similar to convection ovens with the addition of water injection strategies in steam mode. The efficiency ranges of V3.0 ENERGY STAR-qualified combi ovens are presented below. Very limited data is available on efficiency ranges of baseline combi ovens.

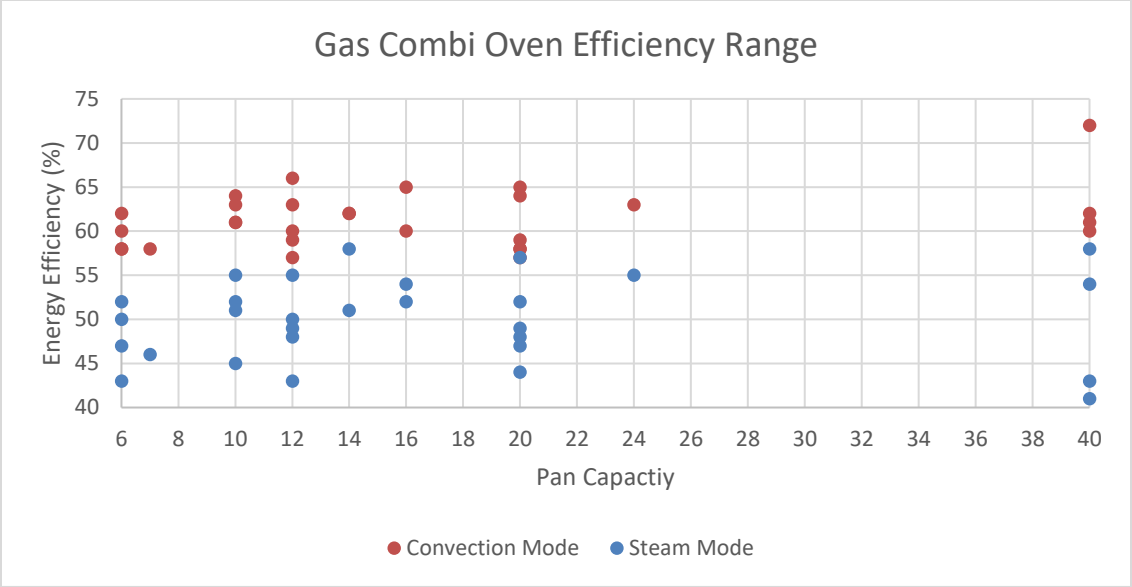

Figure 18 Gas Combi Oven Efficiency Range

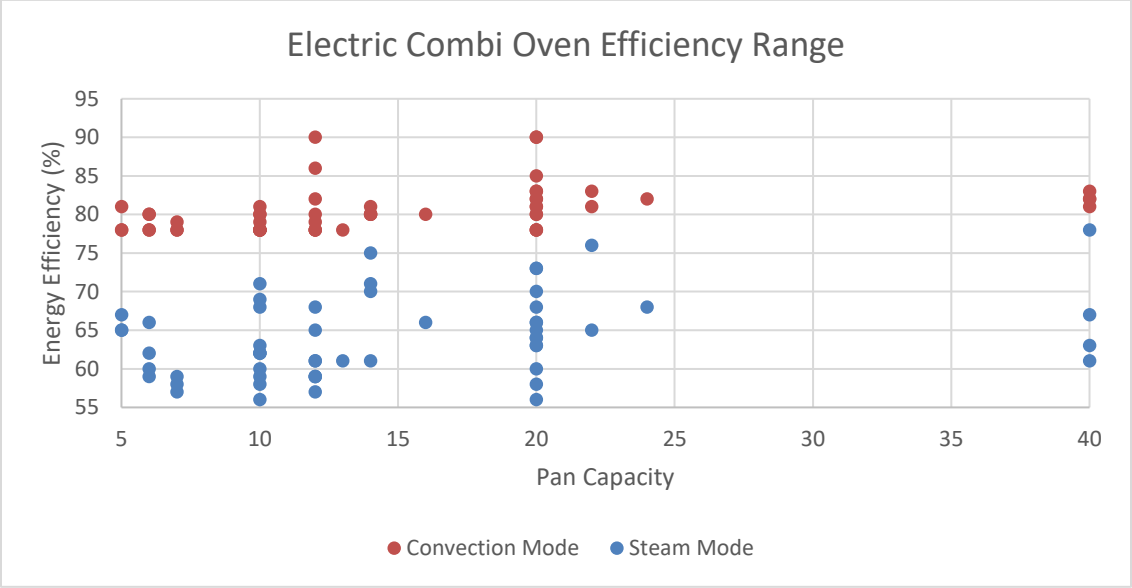

Figure 19 Electric Combi Oven Efficiency Range

Efficiency range in steam mode is wider than in convection mode, presenting an opportunity to reduce combi oven energy consumption while maintaining high humidity. This variability is also evident in the steam idle rates shown in the following two graphs.

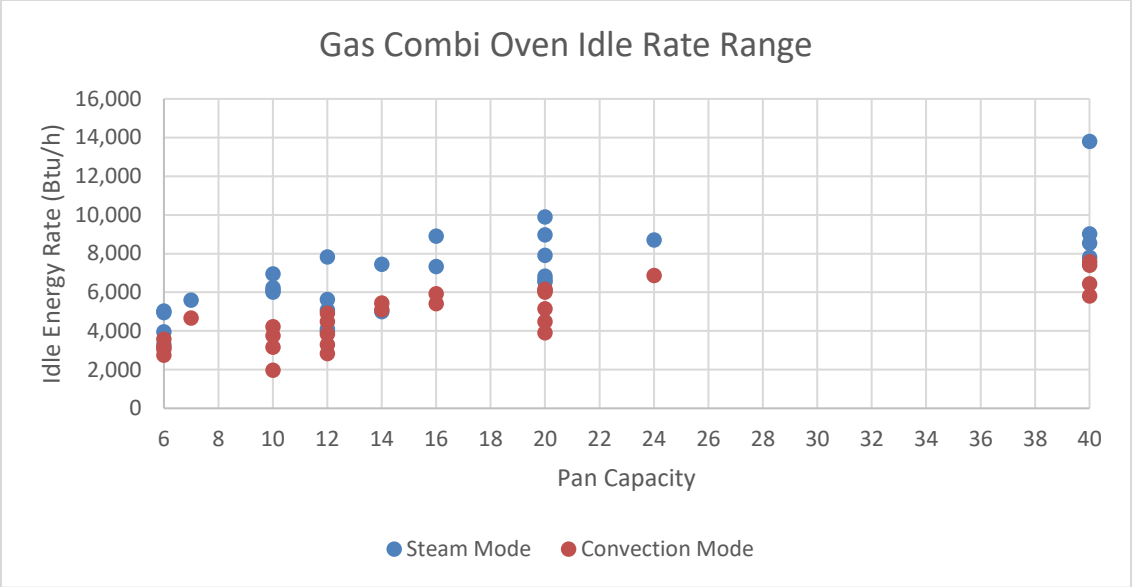

Figure 20 Gas Combi Oven Idle Range

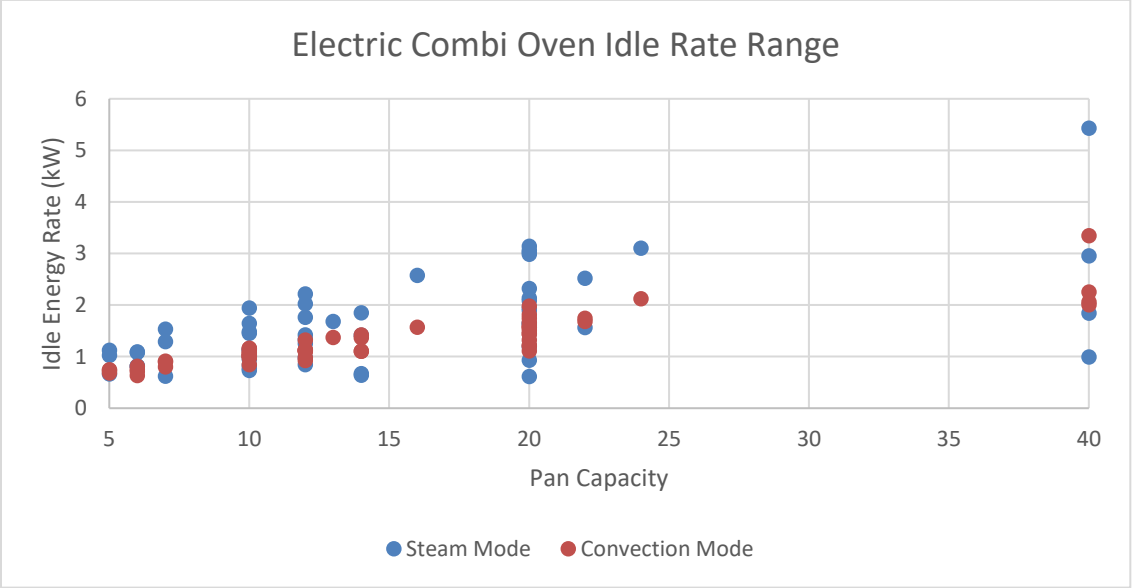

Figure 21 Electric Combi Oven Idle Range

Although few rack oven models are available, the market indicates potential for energy efficiency improvement. The energy efficiency of rack oven models varies from 49% to 61% for single-rack ovens and 55% to 71% for double-rack ovens. The combined idle energy rate varies widely, from 14 kBtu/h to 25 kBtu/h for single-rack ovens and 20 kBtu/h to 26 kBtu/h for double-rack ovens. This idle rate, which includes electric idle energy to run the fan motors), ranges from 0.3 kW to 1 kW, depending on the oven model.

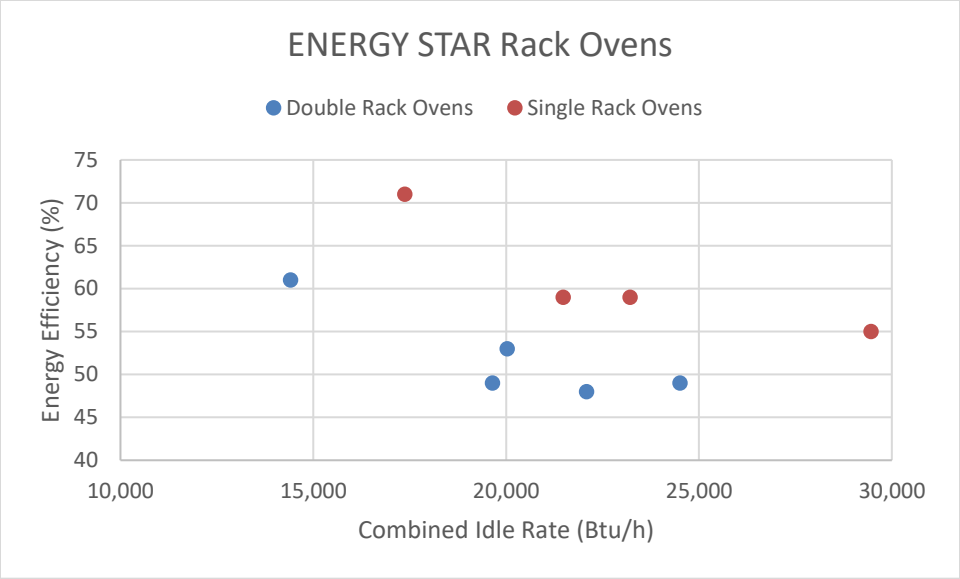

Figure 22 Idle Energy Rate vs. Cooking Efficiency for ENERGY STAR Rack Ovens

5.2 Technical Feasibility

Convection ovens, combi ovens, and rack ovens are a well-accepted and established product categories and energy-efficient ovens do not present any technical feasibility issues.

5.2.1 Future Market Adoption of Qualifying Products

In 2022, ENERGY STAR estimated that 53% of commercial ovens meet the ENERGY STAR V2.2 product criteria, which became effective in 2015 (Energy Star, 2022). Since ENERGY STAR V3 took effect in 2023, market penetration for the new specification is not yet available. Note that our estimates were based on 2022 shipment data, and the 2023 data, which became available prior to finalizing this report, did not change. ENERGY STAR did not break down the percentage of ENERGY STAR-qualified ovens by fuel or oven type. Section 8.1 includes a more detailed market breakdown and assumptions. Below is a summary of energy-efficient models currently on the market. The tables below show the number of ENERGY STAR-qualified convection oven models.

Table 10 Number of ENERGY STAR V3 Qualified Convection Oven Models in 2024

Fuel	Type	Avg efficiency (%)	Avg idle rate (W or Btu/h)	Number of models	Number of manufacturers
Electric	Full Size	79.6	1,125	14	5
Electric	Half Size	76.0	824	13	6
Gas	Full Size	52.4	7,816	14	6

ENERGY STAR V3 established a more stringent idle rate and efficiency thresholds for full-size ovens compared to ENERGY STAR V2.2. The efficiency threshold for gas ovens increased from 46% to 49%, and

the idle rate threshold reduced from 12,000 Btu/h to 9,000 Btu/h. The efficiency threshold for electric ovens rose from 71% to 76%, and the idle rate threshold decreased from 1.6 kW to 1.4 kW.

Table 11 Number of ENERGY STAR V2.2 Qualified Convection Oven Models in 2022

Fuel	Type	Avg efficiency (%)	Avg idle rate (W or Btu/h)	Number of models	Number of manufacturers
Electric	Full Size	79.0	1,403	28	7
Electric	Half Size	75.6	813	13	6
Gas	Full Size	52.8	9,553	31	9

Similar analysis was conducted for combi ovens:

Table 12 Number of ENERGY STAR V3 Qualified Combi Oven Models in 2024

Fuel	Type	Avg convection efficiency (%)	Avg steam efficiency (%)	Avg convection idle rate (W or Btu/h)	Avg steam idle rate (W or Btu/h)	Number of distinct models	Number of manufacturers
Electric	5-16 pan	79.5	62.8	1.01	1.21	34	8
Electric	16-24 pan	82.1	65.8	1.57	2.13	18	9
Electric	24+ pan	82.0	67.3	2.41	2.80	4	4
Gas	5-16 pan	60.9	49.7	3,764	5,449	16	4
Gas	16-24 pan	61.0	50.9	5,556	7,970	9	5
Gas	24+ pan	63.8	49.0	6,804	9,798	4	3

The difference between ENERGY STAR V2.2 and V3 lies in the more stringent idle rate and efficiency threshold for electric combi ovens. The efficiency threshold increased from 56% to 57% for convection mode and from 76% to 78% in steam mode, while the idle rate threshold was reduced proportionally to the pan capacity. This change impacted only a few combi ovens, as most comply with V2.2 and meet V3 criteria. The number of distinct models and manufacturers varied between 2022 (pre-V3.0) and 2024, primarily due to the lower popularity of certain combi ovens in the U.S. market.

Table 13 Number of ENERGY STAR V2.2 Qualified Combi Oven Models in 2022

Fuel	Type	Avg convection efficiency (%)	Avg steam efficiency (%)	Avg convection idle rate (W or Btu/h)	Avg steam idle rate (W or Btu/h)	Number of distinct models	Number of manufacturers
Electric	5-16 pan	79.5	62.6	1.04	1.32	44	12
Electric	16-24 pan	80.7	64.7	1.68	2.23	15	8
Electric	24+ pan	na	na	na	na	0	0
Gas	5-16 pan	59.8	49.1	4,533	5,718	24	6
Gas	16-24 pan	60.7	50.5	6,451	7,247	16	6

Fuel	Type	Avg convection efficiency (%)	Avg steam efficiency (%)	Avg convection idle rate (W or Btu/h)	Avg steam idle rate (W or Btu/h)	Number of distinct models	Number of manufacturers
Gas	24+ pan	61.4	52.8	9,527	10,002	8	6

Only a handful of manufacturers produce rack ovens, and most of the new models from Revent, Baxter, and LBC qualify for ENERGY STAR. Below is the summary of ENERGY STAR-qualified rack oven models. The efficiency and idle rate criteria did not change from V2.2 to V3.0 of ENERGY STAR.

Table 14 Number of ENERGY STAR V3 Qualified Rack Oven Models in 2024

Fuel	Type	Avg efficiency (%)	Avg idle gas rate (Btu/h)	Avg electric idle rate (kW)	Number of models	Number of manufacturers
Gas	Single rack	52.0	19,723	0.61	5	3
Gas	Double Rack	60.0	22,893	0.56	5	3

5.2.2 Consumer Utility and Acceptance

All compliant ovens within the scope of this proposal function the same as baseline ovens, with no usability setbacks. Convection ovens come in standard and bakery depth. Bakery-depth ovens have cooking cavities eight inches deeper than standard convection ovens, accommodating sheet pans placed lengthwise. This design allows for better air circulation and even heat distribution, which is beneficial for certain bakery situations. However, deeper cooking cavities with more heated volume lead to increased idle energy compared to standard-depth ovens.

Most manufacturers offer standard and bakery depth options within a model range. Bakery-depth ovens have unique model numbers, distinguishing them from standard-depth ovens. For major U.S. manufacturers, bakery-depth ovens have a cost premium of less than 10% over comparable standard-depth models. Only one gas and one electric bakery-depth convection oven are on the ENERGY STAR V3-qualified product list. One other model in both gas and electric configurations would qualify for ENERGY STAR V2.2 but not V3. Therefore, two electric and two gas bakery-depth models would meet the proposed energy efficiency criteria.

No usability difference exists in terms of pan capacity and production capacity between ENERGY STAR and non-ENERGY STAR combi or rack ovens.

5.2.3 Manufacturer Structure and Supply Chain Timelines

Blodgett, Vulcan, Garland, and Southbend are the most prominent U.S. convection oven manufacturers. Other notable U.S. convection-oven brands include Imperial, Montague, American Range, Lang, Doyon, Baker's Pride, and Duke. These ovens cost from $5,000 to $10,000 per cooking cavity. Moffat and Cadco specialize in smaller ovens manufactured outside of the U.S. All mentioned manufacturers sell electric and gas convection ovens (except Cadco) and offer ENERGY STAR-qualified models. The most affordable non-ENERGY STAR-qualified convection-oven brands priced between $2,000 to $5,000 include Cooking

Performance Group, Main Street Equipment, Black Diamond, MoTak, Falcon Foodservice, Migali, Kratos, and Empura.

Rational, Alto Shaam, and Unox are the largest combi oven brands in the U.S. Less popular brands include Convotherm, Blodgett, Atosa, and Electrolux. Rational is a globally recognized brand expected to account for more than 50% of California oven sales. Most combi ovens are built in Europe (Rational, Convotherm, Unox, and Electrolux) and then imported into the U.S. by manufacturers (Blodgett and Vulcan), comprising a small percentage of their sales. Rational, Convotherm, and Unox exclusively produce combi ovens. Alto Shaam, a well-known brand favored by restaurants, focuses on supermarket equipment with a product range that includes combi, rotisserie, and cook-and-hold ovens.

Combi ovens are two to four times more expensive than convection ovens, with the median model priced around $20,000 and roll-in 40-pan combis exceeding $40,000. The price difference between gas and electric combi ovens is minimal. Some manufacturers offer boilerless or spritzer steam generation options for a similar price. Most customers choose their combi oven based on the simplicity of recipe programming and everyday operation. Manufacturer representatives for combi ovens often arrange equipment demos for prospective clients to showcase the cooking flexibility.

Revent, Baxter, LBC, and Doyon dominate the rack oven market, accounting for 90% or more of U.S. sales. Rack ovens are often sold directly from manufacturers to buyers, bypassing dealers or distributors. These ovens are primarily sold to supermarket chains, with the remainder sold to bakeries, large restaurants, hotels, college cafeterias, and hospitals. Single-rack ovens cost approximately $30,000, while double-rack ovens cost around $40,000. Double-rack ovens offer twice the production capacity for only a one-third price increase, making them more popular with buyers.

Rack ovens enter the secondary market when supermarkets decommission them or a bakery goes out of business. Independent bakeries typically purchase these used ovens. Conversations with manufacturers suggest that the used market may represent 10% to 30% of rack oven sales.

The market structure for commercial oven sales aligns with the general market structure for commercial foodservice equipment and has remained consistent across various equipment types for decades.

Below are the stakeholders within the commercial foodservice market:

- **Equipment Manufacturers:** Commercial foodservice equipment manufacturers design, fabricate, and assemble equipment. Manufacturers are rarely involved in direct customer sales, except for rack ovens sold to supermarkets and combi ovens sold to large restaurant chains. Instead, they rely on equipment representatives, vendors and dealers to distribute products, work with customers, and facilitate sales.
- **Manufacturer Representatives:** Commercial foodservice equipment manufacturers design, fabricate, and assemble equipment. They rarely handle direct sales but rely on equipment representatives, vendors, or dealers to distribute products, work with customers, and facilitate sales.
- **Equipment Vendors and Dealers:** Vendors are brick-and-mortar stores or online retailers that sell equipment directly to consumers. Consumers can work with dealers to choose in-stock or special-order equipment. 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, proposing kitchen equipment based on

customer specifications and bidding on the project against other vendors for the equipment sales contract.

- **Buying Groups:** Buying groups consist of various equipment vendors and dealers who sell a high volume of equipment to qualify for participation. The buying group negotiates with the manufacturers on behalf of its members to secure the best prices for offered brands. Participating in a buying group generally benefits vendors by allowing them to obtain lower prices and additional rebates or promotions on specific equipment. However, it limits the number of brands available to customers.
- **Designers and Consultants:** Designers and consultants typically do not operate brick-and-mortar sales floors or engage in online sales. Instead, they utilize showrooms to collaborate with customers to design custom kitchens from scratch or based on existing specifications. Consultants and designers specialize in complete kitchen designs or extensive remodels. Their design-build and contract-bid activities are similar to those of vendors.
- **Installers:** A general contractor, plumber, and electrician install equipment.

Some restaurant operators purchase equipment from large online retailers, such as Webstaurant Store, Wasserstrom, or Katom. However, these retailers are less popular and do not provide the support local equipment vendors and dealers offer. Online retailers offer search tools that help consumers to identify more efficient products. Additionally, many online sales include information regarding compliance with other state standards that align with the proposed standards. Therefore, online retailers will not require significant changes to incorporate California standards into their sales processes. Table 15 below shows the breakdown of foodservice equipment sales by channel.

Table 15 Operators Foodservice Equipment and Supplies Purchases by Channel

Channel	Market Share
Traditional Equipment and Service Dealers	52.9%
Broadline distributors	11.0%
Online-only suppliers	10.2%
Direct from manufacturer	8.8%
Buying groups	7.1%
Specialty distributors	6.0%
Cash and carry	3.3%
Club store	0.5%
Catalog houses	0.2%

Source: (Foodservice Equipment & Supplies, 2020)

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

6. Per-Unit Water and Energy Savings

6.1 Key Assumptions

6.1.1 Convection Ovens

Convection oven energy is compared between baseline and compliant units using the following static operating assumptions from the convection oven eTRM (Convection Oven, Commercial eTRM, n.d.):

- 13.1 hours of operation per day
- 270.3 days per year
- 133 lbs. of food cooked per day for full size ovens and 67 lbs. for half size ovens
- ASTM energy to food ratio: 250 Btu/lb

The following assumptions differ from baseline to compliant convection ovens.

- Preheat time and energy
- Idle energy rate
    - 16,210 Btu/h vs. 12,000 Btu/h for gas
    - 2.0 kW vs. 1.6 kW for electric full-size ovens
    - 1.16 kW vs. 1.0 kW for electric half-size ovens
- Cooking efficiency
    - 40.8% vs. 46.0% for gas
    - 70.7% vs. 71.0% for electric full-size ovens
    - 66.6% vs. 71.0% for electric half-size ovens

All the above assumptions were averaged for models that do not qualify for ENERGY STAR V2.2 using it as a baseline. The benchmark for energy-efficient models was the ENERGY STAR V2.2 threshold. The idle energy rate significantly impacts annual energy consumption. The CASE Team analyzed eTRM lab data to exclude any models from baseline assumptions that meet ENERGY STAR V2.2 and have incomparable pan capacities.

6.1.2 Combi Ovens

Combi ovens operate under similar operating assumptions as convection ovens because both are mainly used in restaurants or schools. The amount of food cooked in combi ovens is higher than in convection ovens because of their larger cooking cavities. The amount of food cooked in a medium-sized combi is comparable to a double-stacked convection oven. Energy and water consumption for combi ovens are compared between baseline and compliant units using the following static operating assumptions from the combi oven eTRM (CA eTRM, 2024):

- 13.1 hours of operation per day
- 270.3 days per year

- 200 / 250 / 400 lbs. of food cooked per day for fewer than 15 / 15 to 28 / greater than 28 pan combi ovens
- ASTM energy to food: 250 Btu/lb in convection mode and 105 Btu/lb in steam mode
- Percentage of time spent in steam mode: 50% (and 50% in convection mode)

The following assumptions differ between baseline and efficient combi ovens. Efficient combi oven assumptions are averaged for all models that qualify for ENERGY STAR V3.0 within a given size category. Inefficient combi oven assumptions are derived from an average or a representative model that does not qualify for ENERGY STAR V2.2. Since combi ovens have four sets of qualification criteria (efficiency and idle in two modes), failing any of these criteria disqualifies an oven from ENERGY STAR certification. In some cases, one of the parameters for inefficient ovens can be the same or more efficient than for efficient ovens (e.g., 15-28 pan gas convection efficiency, 28+ pan gas steam mode efficiency).

- Preheat time and energy
- Idle energy rate
- Cooking efficiency

Appendix B shows idle energy rate and cooking efficiency assumptions for combi ovens.

6.1.3 Rack Ovens

Rack ovens are used primarily in supermarkets and bakeries, whose operation assumptions differ from those of convection and combi ovens. Rack ovens are typically not found in schools where there are fewer operational days per year due to holidays and breaks. Primarily found in production settings, rack ovens maximize loading, resulting in a significantly higher volume of food cooked than convection or combi ovens. Energy and water consumption for rack ovens are compared between baseline and compliant units using the following static operating assumptions from the rack oven eTRM (CA eTRM, 2024):

- 11.3 hours of operation per day
- 335 days per year
- 600 lbs. of food cooked per day for single-rack ovens
- 1200 lbs. of food cooked per day for double-rack ovens
- ASTM energy-to-food ratio: 235 Btu/lb (to bring frozen apple pies to 185°F)

The following assumptions vary between baseline and efficient rack ovens. Assumptions for units meeting the proposed standard are based on an average of models qualifying for ENERGY STAR V2.2 or V3.0. Assumptions for the baseline units are based on models that do not qualify.

- Preheat Time and Energy
- Idle Energy Rate
    - 25,745 Btu/h (and 0.87 kW) vs. 19,698 Btu/h (and 0.60 kW) for single-rack ovens
    - 29,855 Btu/h (and 1.43 kW) vs. 23,128 Btu/h (and 0.98 kW) for double-rack ovens
- Cooking Efficiency
    - 44.5% vs. 50.3% for single-rack ovens

- 53.3% vs. 58.3% for double-rack ovens

6.2 Methodology

Annual oven consumption is calculated by adding daily energy consumption for the following activities:

- Preheat
- Cooking
- Idle mode

Cooking energy is calculated by multiplying the amount of food cooked per day by the theoretical ASTM energy-to-food ratio and dividing by the cooking energy efficiency. Although combi ovens spend some time in "combination mode" with partial humidity, it is assumed they spend half the time in steam mode and half in convection mode, which means half of the idle time is in steam mode, and half of the food cooked is in steam mode. A more detailed calculation methodology can be found in the eTRM.

6.3 Per-Unit Water and Energy Saving Results

6.3.1 Convection Ovens

Convection ovens do not use water, so energy savings have been calculated for compliant products versus baseline products for full-size gas and electric and half-size electric convection ovens. Table 16, 17, and Table 18 present data that compares the annual per-unit energy for different convection oven types under baseline and compliant case scenarios and the resulting savings.

Table 16 Annual Convection Oven Per-Unit Energy Use for Baseline Case

Product Class	Base case per-unit consumption - electricity (kWh/yr-unit)	Base case per-unit consumption - peak demand (kW/unit)	Base case per-unit consumption - natural gas (therms/yr-unit)
Full-Size Oven - gas	-	-	758
Full-Size Oven - electric	10,356	1.47	-
Half-Size Oven - electric	5,769	0.82	-

Table 17 Annual Convection Oven Per-Unit Energy Use for Compliant Case

Product Class	Compliant case per-unit consumption - electricity (kWh/yr-unit)	Compliant case per-unit consumption - peak demand (kW/unit)	Compliant case per-unit consumption - natural gas (therms/yr-unit)
Full-Size Oven - gas	-	-	604
Full-Size Oven - electric	9,098	1.29	-
Half-Size Oven - electric	5,153	0.73	-

As mentioned above, Table 18 summarizes the per-unit energy savings. The compliant gas model is estimated to save 154 therms of natural gas per unit per year, and the compliant electric models are estimated to save between 565 kWh and 1,258 kWh of electricity per unit per year.

Table 18 Annual Convection Oven Per-Unit Energy Savings

Product Class	Per-unit savings - electricity (kWh/yr-unit)	Per-unit savings - peak demand (kW/unit)	Per-unit savings - natural gas (therm/yr-unit)
Full-Size Oven - gas	0	0	154
Full-Size Oven - electric	1,258	0.18	0
Half-Size Oven - electric	616	0.09	0

6.3.2 Combi Ovens

Energy and water savings were calculated for compliant products vs. baseline products, for gas and electric combi ovens in three different size categories. Table 19, Table 20, andTable 21 present data that compare the annual per-unit energy and water consumption for different oven types under baseline and compliant case scenarios, and the resulting savings.

Table 19 Annual Combi Oven Per-Unit Energy Use for Baseline Case

Product Class	Per-unit consumption - electricity (kWh/yr-unit)	Per-unit consumption - peak demand (kW/unit)	Per-unit consumption - natural gas (therms/yr-unit)
Electric (fewer than 15 pan)	10,118	1.44	0
Electric (15-28 pan)	16,063	2.28	0
Electric (28+pan)	24,536	3.49	0
Gas (fewer than 15 pan)	0	0	509
Gas (15-28 pan)	0	0	613
Gas (28+pan)	0	0	815

Table 20 Annual Combi Oven Per-Unit Energy Use for Compliant Case

Product Class	Per-unit consumption - electricity (kWh/yr-unit)	Per-unit consumption - peak demand (kW/unit)	Per-unit consumption - natural gas (therms/yr-unit)
Electric (fewer than 15 pan)	7,489	1.06	0
Electric (15-28 pan)	11,052	1.57	0
Electric (28+pan)	16,612	2.36	0
Gas (fewer than 15 pan)	0	0	310
Gas (15-28 pan)	0	0	427
Gas (28+pan)	0	0	601

Table 21 summarizes the per-unit energy savings. The compliant gas models are estimated to save between 186 and 214 therms of natural gas per unit per year, and the compliant electric models are estimated to save between 2,629 and 7,924 kWh of electricity per unit per year.

Table 21 Annual Combi Oven Per-Unit Energy Savings

Product Class	Per-unit savings - electricity (kWh/yr-unit)	Per-unit savings - peak demand (kW/unit)	Per-unit savings - natural gas (therm/yr-unit)
Electric (fewer than 15 pan)	2,629	0.37	0
Electric (15-28 pan)	5,011	0.71	0
Electric (28+pan)	7,924	1.13	0
Gas (fewer than 15 pan)	0	0	199
Gas (15-28 pan)	0	0	186
Gas (28+pan)	0	0	214

Combi ovens use water anytime in steam mode or when partial humidity is generated, and they use more water when cooking than idling in steam mode. Water usage and savings are presented below:

Table 22 Annual Combi Oven Per-Unit Water Savings

Product Class	Base case per-unit consumption - (gal/yr-unit)	Compliant case per-unit consumption - (gal/yr-unit)	Annual Water Savings (gal/yr-unit)
Electric (fewer than 15 pan)	7,464	2,497	4,967
Electric (15-28 pan)	14,007	3,352	10,655
Electric (28+pan)	31,915	2,272*	29,643
Gas (fewer than 15 pan)	12,198	1,900	10,298
Gas (15-28 pan)	22,872	3,155	19,717
Gas (28+pan)	30,142	5,253	24,889

*Although 28+ pan-efficient electric combi ovens use more water during cooking, they use less idle water than smaller size units.

6.3.3 Rack Ovens

Gas rack oven energy savings components include gas and electric energy, but no water savings for rack ovens.

Table 23 Annual Rack Oven Per-Unit Energy Savings

Product Class	Base case per-unit consumption - (therm/yr-unit)	Compliant case per-unit consumption - (therm/yr-unit)	Annual Gas Energy Savings (therm/yr-unit)
Single Rack	1,835	1,512	323
Double Rack	2,715	2,354	361
Product Class	**Base case per-unit consumption - (kWh/yr-unit)**	**Compliant case per-unit consumption - (kWh/yr-unit)**	**Annual Electric Energy Savings (kWh/yr-unit)**
Single Rack	3,304	2,265	1,039
Double Rack	5,433	3,693	1,740

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

Convection oven analysis was conducted in December 2023 using data from major online food service equipment retailers. Retail pricing data was gathered from the following websites:

- Webstaurant Store (Webstaurant Store, n.d.)
- Katom (KaTom Restaurant Supply, Inc., n.d.)
- JES restaurant equipment (JES Restaurant Equipment, n.d.)

The CASE Team decided to align with the incremental measure cost (IMC) used by ENERGY STAR in its calculator,[4] which is $1000. The CASE Team believes this assumption is conservative because a web search found two units by the same manufacturer with an IMC of less than $1000.[5]

Table 24 and Table 25 show the per-unit costs for baseline and compliant cases for convection ovens, respectively. Table 26 presents the per-unit incremental cost, which is the difference between per-unit baseline and per-unit compliant costs. The incremental lifetime maintenance and repair costs are zero because the costs would be the same for the baseline and compliant scenario.

Table 24 Baseline Convection Oven Per-Unit Costs

Product Class	Equipment Cost (2024 $)	Installation Cost (2024 $)	Total Cost (PV 2024 $)
Full-Size Oven - gas	5,511	200	5,711
Full-Size Oven - electric	4,758	200	4,958
Half-Size Oven - electric	7,824	200	8,024

[4] https://statics.teams.cdn.office.net/evergreen-assets/safelinks/1/atp-safelinks.html

[5] Blodgett non-ESTAR model: https://www.webstaurantstore.com/blodgett-zephaire-100-g-single-deck-natural-gas-full-size-standard-depth-convection-oven-with-draft-diverter-50-000-btu/195ZEP100G1N.html and their ESTAR model: https://www.webstaurantstore.com/blodgett-zephaire-100-g-es-natural-gas-single-deck-full-size-convection-oven-with-draft-diverter-45-000-btu/195ZEP1GES1N.html Southbend ENERGY STAR model: https://www.katom.com/348-BES17SC2401.html and their non-ESTAR model: https://www.katom.com/348-PCE75SSD2401.html

Table 25 Compliant Convection Oven Per-Unit Costs

Product Class	Equipment Cost (2024 $)	Installation Cost (2024 $)	Total Cost (PV 2024 $)
Full-Size Oven - gas	6,511	200	6,711
Full-Size Oven - electric	5,758	200	5,958
Half-Size Oven - electric	8,824	200	9,024

Table 26 Incremental Convection Oven Per-Unit Costs

Product Class	Incremental Equipment Cost (2024 $)	Incremental Installation Cost (2024 $)	Incremental Total Cost (PV 2024 $)
Full-Size Oven - gas	1,000	0	1,000
Full-Size Oven - electric	1,000	0	1,000
Half-Size Oven - electric	1,000	0	1,000

The average cost of ENERGY STAR-compliant combi ovens is lower than that of non-ENERGY STAR baseline combi ovens. Major combi oven manufacturers, whose equipment lines are mostly ENERGY STAR certified, sell these at a lower cost. Conversely, non-ENERGY STAR-certified combi ovens typically come from manufacturers that do not specialize in combi ovens and often produce convection ovens. These ovens have a higher markup. Installation, maintenance, and repair costs are assumed to be the same for compliant and baseline combi ovens.

Table 27 Baseline Combi Oven Per-Unit Costs

Product Class	Equipment Cost (2024 $)	Installation Cost (2024 $)	Total Cost (PV 2024 $)
fewer than 15 Pan - electric	15,446	400	15,846
fewer than 15 Pan - gas	21,945	400	22,345
15-28 Pan - electric	26,678	600	27,278
15-28 Pan - gas	32,634	600	33,234
28+ Pan – electric*	48,651	1,000	49,651
28+ Pan - gas	54,712	1,000	55,712

Table 28 Compliant Combi Oven Per-Unit Costs

Product Class	Equipment Cost (2024 $)	Installation Cost (2024 $)	Total Cost (PV 2024 $)
fewer than 15 Pan - electric	14,868	400	15,268
fewer than 15 Pan - gas	19,112	400	19,512
15-28 Pan - electric	23,129	600	23,729
15-28 Pan - gas	28,012	600	28,612
28+ Pan – electric*	39,652	1,000	40,652
28+ Pan - gas	45,704	1,000	46,704

Table 29 Incremental Combi Oven Per-Unit Costs

Product Class	Incremental Equipment Cost (2024 $)	Incremental Installation Cost (2024 $)	Incremental Total Cost (PV 2024 $)
fewer than 15 Pan - electric	(578)	0	0
fewer than 15 Pan - gas	(2,833)	0	0
15-28 Pan - electric	(3,549)	0	0
15-28 Pan - gas	(4,622)	0	0
28+ Pan – electric*	(8,999)	0	0
28+ Pan - gas	(9,008)	0	0

The average cost of ENERGY STAR-compliant rack ovens is higher than that of non-ENERGY STAR baseline rack ovens. Installation, maintenance, and repair costs are assumed to be the same for compliant and baseline rack ovens.

Table 30 Baseline Rack Oven Per-Unit Costs

Product Class	Equipment Cost (2024 $)	Installation Cost (2024 $)	Total Cost (PV 2024 $)
Single Rack Oven - gas	34,434	2,000	36,434
Double Rack Oven - gas	41,271	3,000	44,271

Table 31 Compliant Rack Oven Per-Unit Costs

Product Class	Equipment Cost (2024 $)	Installation Cost (2024 $)	Total Cost (PV 2024 $)
Single Rack Oven - gas	41,247	2,000	43,247
Double Rack Oven - gas	44,364	3,000	47,364

Table 32 Incremental Rack Oven Per-Unit Costs

Product Class	Incremental Equipment Cost (2024 $)	Incremental Installation Cost (2024 $)	Incremental Total Cost (PV 2024 $)
Single Rack Oven - gas	6,813	0	6,813
Double Rack Oven - gas	3,093	0	3,093

7.2 Design Life

Convection, combi, and rack oven design life is assumed to be 12 years per the eTRM.

7.3 Lifecycle Cost and Net Benefit

Table 33 presents the per-unit lifecycle costs and benefits of the proposed standards. These standards are cost effective, with lifecycle benefits exceeding lifecycle costs for each product class. The minimum cost-effectiveness ratio is 1.62 for half-size electric ovens.

The electricity and natural gas prices were estimated using the latest U.S. Energy Information Administration (EIA) data to reflect California consumer's average price (U.S. Energy Information Administration, n.d.). The annual escalation rates were estimated using price forecasts. The electricity price forecast was derived from the CEC's 2022 California Energy Demand Forecast (California Energy Commission, n.d.). The natural gas price forecast was derived from "U.S. Energy Information Administration." Electricity and gas prices were increased (U.S. Energy Information Administration, s.f.) per the annual escalation rates.

Table 33 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
Full-Size Convection Oven - gas	12	2,603	1,000	1,603	3.65	2.60
Full-Size Convection Oven - electric	12	3,604	1,000	2,604	2.68	3.60
Half-Size Convection Oven - electric	12	1,765	1,000	765	5.46	1.77
Combi Oven fewer than 15 Pan - electric	12	8,405	0	8,405	0	Infinite
Combi Oven fewer than 15 Pan - gas	12	6,806	0	6,806	0	Infinite
Combi Oven 15-28 Pan - electric	12	18,541	0	18,541	0	Infinite
Combi Oven 15-28 Pan - gas	12	8,934	0	8,934	0	Infinite
Combi Oven 28+ Pan - electric*	12	-	-	-	-	-
Combi Oven 28+ Pan - gas	12	14,099	0	14,099	0	Infinite
Single-Rack Oven - gas	12	8,438	6,813	1,625	7.71	1.24
Double-Rack Oven - gas	12	11,088	3,093	7,995	2.67	3.58

*Current sales projections for combi ovens of this size indicate a strong market preference for the gas option.

8. Statewide Impacts

8.1 Annual Sales and Stock Turnover

8.1.1 Total Inventory based on CEC Data.

California is estimated to have 142,452 ovens, including convection, combi, and rack ovens. The current inventory was calculated by multiplying annual shipments (Energy Star, 2022) by the assumed 12-year lifespan. For details on the estimation of annual shipments, see Section 8.1.2.

According to NAFEM (2022 NAFEM report, "Size and Shape of the Industry,", 2022) convection ovens constitute 76% of sales across the three oven categories, while combi ovens account for 20%, and rack ovens make up 4%. This percentage translates to approximately 108,264 convection ovens, 28,488 combi ovens, and 5,700 rack ovens in California, totaling 142,452 ovens. Combi ovens are used in facilities similar to those with convection ovens but are less common in quick-service restaurants. Rack ovens are predominantly located in supermarkets, bakeries, and large institutional cafeterias.

8.1.2 Annual Shipments based on ENERGY STAR data

According to California rebate analysis in section 5.1, 87% of convection ovens sold are gas, while the remaining 13% are assumed to be electric. Based on ENERGY STAR shipment data from 2022, an estimated 52,000 ovens are sold annually in the U.S., with 76% being convection ovens, as indicated by NAFEM data in section 5.1 (Energy Star, 2022). When normalizing this figure to California's population, approximately 4,200 ENERGY STAR-qualified convection ovens are sold yearly—3,700 gas and 400 full-size electric. The market for electric half-size convection is minimal,[6] with around 100 units sold annually. An estimated 9,000 convection ovens are sold each year in California, with fewer than half considered ENERGY STAR eligible. California has approximately 108,000 convection ovens, assuming an oven lifespan of 12 years and stable shipments over the next 30 years.

California rebate data shows that 45% of combi ovens with fewer than 15 pans are gas, while 55% are electric. For combi ovens with capacities ranging from 15 to 28 pan, 65% are gas, and 35% are electric. Nearly all 40-pan combi ovens, the only popular pan capacity above 28 pans, are gas due to the high amperage requirement for electric versions. The most commonly sold combi oven sizes are 12-pan and 20-pan models. Roll-in 40-pan combi ovens are rare and typically purchased by large institutional dining facilities, such as hospitals, college cafeterias, and catering services. According to California rebate data, combi ovens with fewer than 15 pans account for 67% of the units sold, those with capacities between 15 and 28 pans account for 24%, and ovens with a capacity greater than 28 pans represent only 9% or less of the units sold.

Approximately 80% of the rack ovens sold are double racks, while single racks make up only 20%. The minimal cost and footprint difference contribute to higher double-rack oven sales.

[6] Large chain quick-service restaurants (QSRs) typically purchase half-size convection ovens, which account for an estimated 12% of electric oven sales.

ENERGY STAR estimates indicate that of the 98,000 sold annually in the U.S., approximately 52,000 are compliant, reflecting a 53% compliance rate across three oven categories. This figure includes around 20,000 combi ovens (75% compliant, 25% non-compliant) and 4,000 rack ovens (70% compliant, 30% non-compliant). Adjusting for California's 12.1% share of restaurant sales, the annual sales figures for combi and rack ovens can be normalized accordingly:

Table 34 Annual California Combi Oven Sales Estimates

Combi Oven	Gas	Electric
Fewer than 15 pans	716	875
15 to 28 pans	370	199
Greater than 28 pans	214	0

Table 35 Annual California Rack Oven Sales Estimates

Rack Oven	Gas
Single Rack	95
Double Rack	380

Table 36 Annual California Convection Oven Sales Estimates

Convection Oven	Gas	Electric
Half Size	NA	225
Full Size	7,898	899

8.2 Market Share of Qualifying Products

8.2.1 Current Market Share

ENERGY STAR estimated that 53% of eligible ovens met the V2.2 standard in 2021 and 2022 before the activation of V3. Eligible ovens include convection, combi, and rack ovens. Most combi (Flow Foodservice + Design, 2022) and rack ovens (Qualified Combination Ovens, n.d.) are already ENERGY STAR V2.2 certified. Assuming 70% of combi and rack ovens are ENERGY STAR-certified and convection ovens account for 76% of the sales (see Section 5.1), the market penetration of ENERGY STAR convection ovens is 48%.[7]

ENERGY STAR market penetration of combi ovens is estimated to be 75%, as shown in Appendix C. ENERGY STAR market penetration of rack ovens is estimated to be 70%, as shown in Section 5.

[7] The CASE Team's analysis revealed that seven of the 10 most popular rack oven models meet the proposed criteria, and 35 out of 50 most popular combi oven models meet the proposed criteria.

8.2.2 Future Market Adoption of Qualifying Products

Commercial convection ovens that meet the proposed standards are readily available. During the pandemic, the used market for commercial convection ovens grew because several restaurants with relatively new equipment went out of business. However, the supply of used ovens is slowly shrinking as the effects of the pandemic and supply chain constraints diminish in the marketplace. A refurbished convection oven has typically undergone repairs and may have modifications from the original manufacturer's specifications. Given the small size of the refurbished market based on conversations with manufacturers and a review of products available online, its impact on the statewide savings outlined in this report would be negligible. The CASE Team is confident that a broad range of models from many manufacturers would meet the proposed standards and anticipates no significant obstacles for consumers in obtaining such models.

An abundance of compliant combi ovens from top manufacturers is available, while the market for used ovens remains minimal. According to manufacturer insights, restaurants seldom purchase used combi ovens from second-hand resellers and online auction sites due to potential reliability issues. New combi ovens come with warranty and technical support from manufacturers. Additionally, manufacturer representatives often develop customized recipe programming during the sales process. Combi oven longevity is highly susceptible to water quality, which can damage the boiler or corrode if the water has high chloride content. As a result, customers view buying a used combi oven as a significant risk because of unknown previous water maintenance practices.

Few manufacturers produce rack ovens, but most offer energy-efficient (compliant) products. Supermarkets and large commercial production bakeries primarily purchase these ovens. These businesses have operating budgets different from those of restaurants, which typically include capital for equipment replacement. Smaller bakeries often purchase refurbished rack ovens, with the market for used rack ovens accounting for an estimated 10% to 30% of sales based on conversations with rack oven manufacturers. Rack ovens are challenging and costly to install, and a used oven further complicates the process, often requiring disassembly and posing a risk of potential failure. Manufacturers design these large appliances to be highly serviceable, making replacement easy.

Without standards, the CASE Team expects the market penetration of ENERGY STAR-certified convection ovens to remain around 46%. This level of market penetration demonstrates the proposal's technical feasibility, as many certified products are already available. We expect statewide energy savings to grow significantly by adopting efficiency standards, as this would increase market penetration of ENERGY STAR convection ovens from 46% to 100%. The market share for energy-efficient combination and rack ovens is 75% and 70%, respectively. We expect the market of efficient products to grow to 90% in the absence of standards due to the proliferation of ENERGY STAR-qualified products as manufacturers update their offerings, suggesting many compliant products would be available to meet potential proposed standards. However, because market penetration for these products is already high, the statewide savings from standards are expected to be relatively small.

8.3 Statewide Energy Savings – Methodology

The CASE Team calculated statewide savings estimates using the per-unit energy savings while factoring in the statewide stock and shipments forecast. Section 8.1 describes the total expected shipments per year. As convection ovens do not use water, no expected water savings are associated with this measure.

The CASE Team reviewed three types of commercial convection ovens: full-size electric, full-size gas, and half-size electric, and aggregated these categories to determine the statewide total. We used ENERGY STAR unit shipment data for commercial convection ovens and applied it to the three types of ovens using the CEC-500-06-028 Report (Fisher-Nickel, Inc., 2014) and the California rebate data. Section 8.1 presents the market distribution of these three types and utilizes a shipment-weighted average to calculate unit energy use for the relevant categories.

The estimates presented here represent the savings achieved through implementing the ENERGY STAR V2.2 standards. These energy savings estimates pertain only to non-residential buildings. The CASE Team assumed when calculating statewide impacts that 46% of commercial convection ovens sold each year would meet the proposed standards, even if not adopted into Title 20 (Energy Star, 2022).

8.4 Statewide Energy Use – Baseline and Compliant Case

Table 37 and Table 38 provide estimates of first-year statewide energy use for baseline and compliant cases.

As shown in Table 39, the proposed standard would have a first-year statewide savings of 1.74 GWh of electricity and 0.77 million therms of natural gas.

Table 37 Estimated First-Year California Statewide Energy Use for Baseline Cases

Product Class	Electricity (GWh/yr)	On-site Electricity Demand (MW)	Natural Gas (million therms/yr)	Water (million gallons/yr)
Full-size Convection Oven - gas	0	0	5.43	0
Full-size Convection Oven - electric	8.79	1.25	0	0
Half-size Convection Oven - electric	1.23	0.175	0	0
Combi Oven (fewer than 15 Pan) - electric	7.13	1.01	0	3.27
Combi Oven (fewer than 15 Pan) - gas	0	0	0.258	3.20
Combi Oven (15-28 Pan) - electric	2.45	0.348	0	1.20
Combi Oven (15-28 Pan) - gas	0	0	0.175	2.99
Combi Oven (28+ Pan) – electric*	-	-	-	-
Combi Oven (28+ Pan) - gas	0	0	0.140	2.46
Single-Rack Oven - gas	0.245	0.035	0.153	0
Double-Rack Oven - gas	1.60	0.228	0.936	0
Total	**21.4**	**3.05**	**7.09**	**13.1**

*Current sales projections for combi ovens of this size show a market preference only for the gas option.

Table 38 Estimated First-Year California Statewide Energy Use for Compliant Cases

Product Class	Electricity (GWh/yr)	On-site Electricity Demand (MW)	Natural Gas (million therms/yr)	Water (million gallons/yr)
Full-size Convection Oven - gas	0	0	4.77	0
Full-size Convection Oven - electric	8.18	1.16	0	0

Product Class	Electricity (GWh/yr)	On-site Electricity Demand (MW)	Natural Gas (million therms/yr)	Water (million gallons/yr)
Half-size Convection Oven - electric	1.16	0.165	0	0
Combi Oven (fewer than 15 Pan) - electric	6.55	0.931	0	2.18
Combi Oven (fewer than 15 Pan) - gas	0	0	0.222	1.36
Combi Oven (15-28 Pan) - electric	2.20	0.313	0	0.667
Combi Oven (15-28 Pan) - gas	0	0	0.158	1.17
Combi Oven (28+ Pan) – electric*	-	-	-	-
Combi Oven (28+ Pan) - gas	0.000	0	0.129	1.12
Single-Rack Oven - gas	0.215	0.031	0.144	0
Double-Rack Oven - gas	1.40	0.199	0.894	0.
Total	**19.7**	**2.80**	**6.32**	**6.50**

*Current sales projections for combi ovens of this size show a market preference only for the gas option.

Table 39 Estimated First-Year California Statewide Savings

Product Class	Electricity (GWh/yr)	On-site Electricity Demand (MW)	Natural Gas (million therms/yr)	Water (million gallons/yr)	Utility Bill Savings (million 2024 $/yr)
Full-size Convection Oven - gas	0	0	0.657	0	0.481
Full-size Convection Oven - electric	0.610	0.087	0	0	0.094
Half-size Convection Oven - electric	0.075	0.011	0	0	0.012
Combi Oven (fewer than 15 Pan) - electric	0.575	0.082	0	1.09	0.043
Combi Oven (fewer than 15 Pan) - gas	0	0	0.036	1.843	0.015
Combi Oven (15-28 Pan) - electric	0.249	0.035	0	0.530	0.019
Combi Oven (15-28 Pan) - gas	0	0	0.017	1.82	0.009
Combi Oven (28+ Pan) – electric*	-	-	-	-	-
Combi Oven (28+ Pan) - gas	0	0	0.011	1.33	0.006

Product Class	Electricity (GWh/yr)	On-site Electricity Demand (MW)	Natural Gas (million therms/yr)	Water (million gallons/yr)	Utility Bill Savings (million 2024 $/yr)
Single-Rack Oven - gas	0.030	0.004	0.009	0	0.006
Double-Rack Oven - gas	0.198	0.028	0.0412	0	0.034
TOTAL	**1.74**	**0.247**	**0.771**	**6.62**	**0.717**

*Current sales projections for combi ovens of this size show a market preference only for the gas option.

Table 40 summarizes the estimated statewide savings in the stock turnover year. The CASE Team estimates these savings to be 20.9 GWh of electricity and 9.26 million therms of natural gas.

Table 40 Estimated California Statewide Savings in the Year of Stock Turnover

Product Class	Year of Stock Turnover	Electricity (GWh/yr)	On-site Electricity Demand (MW)	Natural Gas (million therms/yr)	Water (million gallons/yr)	Utility Bill Savings (million 2024 $/yr)
Full-size Convection Oven - gas	2038	0	0	7.88	0	10.1
Full-size Convection Oven - electric	2038	7.33	1.04	0	0	1.22
Half-size Convection Oven - electric	2038	0.898	0.128	0	0	0.149
Combi Oven (fewer than 15 Pan) - electric	2038	6.90	0.980	0	13.0	0.552
Combi Oven (fewer than 15 Pan) - gas	2038	0	0	0.427	22.1	0.288
Combi Oven (15-28 Pan) - electric	2038	2.99	0.425	0	6.36	0.240
Combi Oven 15-28 Pan - gas	2038	0	0	0.206	21.9	0.156
Combi Oven (28+ Pan) – electric*	2038	-	-	-	-	-
Combi Oven (28+ Pan) - gas	2038	0	0	0.137	16.0	0.106
Single-Rack Oven - gas	2038	0.36	0.051	0.110	0	0.112
Double-Rack Oven - gas	2038	2.38	0.338	0.494	0	0.573
TOTAL		**20.9**	**2.96**	**9.26**	**79.4**	**13.5**

*Current sales projections for combi ovens of this size show a market preference only for the gas option.

8.5 Impact on California's Economy

The proposed standards will primarily impact owners and operators of commercial kitchens, including commercial food service establishments (restaurants and hotels) and institutional kitchens (hospitals, schools, and prisons). As noted in Section 8.1, California has 76,750 restaurants and 20,110 institutional food service facilities. Most restaurants are small businesses, employing fewer than 50 people, although this number includes many chain restaurants and those owned by larger firms (National Restaurant Association, n.d.). In California, 58% of restaurants are minority-owned, and 32% are majority-owned by women (National Restaurant Association, 2022). The most significant impact on owners and operators will likely be the increased upfront costs of purchasing a new compliant commercial convection, combi, or rack oven. However, these owners and operators will benefit from reduced utility bills, exceeding any increased upfront costs.

At least 100 commercial food service dealers in the state sell commercial convection ovens, not including online retailers (Participating Dealer List for Instant Rebates, 2022). Depending on the products they currently make, stock, and sell, manufacturers, retailers, and distributors would be impacted differently. Several manufacturers already make compliant products, with compliant convection ovens representing 48% of current sales, compliant combi ovens at 75%, and compliant rack ovens representing 70%. Therefore, the impact on manufacturers and distributors selling these products would be relatively small. However, all parties must update stock and comply with the standards, increasing administrative costs.

The standards would likely adversely impact manufacturers that predominately make non-compliant products and the distributors that stock and sell these models.[8] These manufacturers would shift distribution toward compliant product lines, develop new compliant products, or exit the California market. As noted, the proposed standards provide significant consumer choice from various manufacturers. For over two decades, these manufacturers have designed products that align with the ENERGY STAR V2.2 and V3.0 for gas combi and rack ovens specifications. Distributors and other market actors who predominantly sell non-compliant products may have to change suppliers, product lines, or stock-keeping practices to ensure compliant stock is available or ready to order.

The CASE Team focused solely on the direct energy savings for consumers when calculating lifecycle benefits. This analysis does not anticipate any savings from changes in HVAC loads, as kitchen hoods would maintain a consistent HVAC load in a commercial kitchen regardless of the oven's efficiency.

To estimate the first-year statewide utility bill savings, the CASE Team multiplied the statewide electricity and fuel savings in the standard's first effective year by the corresponding energy prices. Similarly, the team calculated the statewide savings for the stock turnover year by multiplying the year's fuel savings by the year's electricity and fuel prices. The cost of the water saved in the first year is also included.

As shown in Table 41, statewide incremental capital costs in the first year range from $0.51 million to $4.26 million, depending on the product class. Statewide utility bill savings in the first year range from $0.00 million to $0.48 million, depending on the product class, with $0.7 million as the total utility bill savings across all product classes.

[8] Examples include Imperial, Royal, American Range, Montague

Table 41 Statewide Economic Impacts Occurring in the First Year

Product Class	Incremental Capital Costs (million 2024 $)	Utility Bill Savings (million 2024 $)
Full-size Convection Oven - gas	4.26	0.481
Full-size Convection Oven - electric	0.485	0.094
Half-size Convection Oven - electric	0.122	0.012
Combi Oven (fewer than 15 Pan) - electric	(0.126)	0.043
Combi Oven (fewer than 15 Pan) - gas	(0.507)	0.015
Combi Oven (15-28 Pan) - electric	(0.177)	0.019
Combi Oven (15-28 Pan) - gas	(0.428)	0.009
Combi Oven (28+ Pan) – electric*	-	-
Combi Oven (28+ Pan) - gas	(0.482)	0.006
Single-Rack Oven - gas	0.194	0.006
Double-Rack Oven - gas	0.353	0.034
TOTAL	**3.70**	**0.717**

* Current sales projections for combi ovens of this size show a market preference only for the gas option.

Table 42 presents the statewide lifetime economic impacts for products purchased in the first year, as opposed to per unit. The total value of benefits, realized by the end of the effective useful lifetime for convection ovens in each product class, is projected to be worth $20.13 million in the effective year (2024), with costs amounting to $5.42 million, resulting in a net present value of $14.71 million.

Table 42 Statewide Lifetime economic impacts for Products Purchased in the First Year

Product Class	Design Life (years)	Present Value of Benefits (MM 2024 $)	Present Value of Incremental Costs (MM 2024 $)	Net Present Value (MM 2024 $)
Full-size Convection Oven - gas	12	11.1	4.27	6.84
Full-size Convection Oven - electric	12	1.75	0.485	1.26
Half-size Convection Oven - electric	12	0.214	0.122	0.093
Combi Oven (fewer than 15 Pan) - electric	12	1.84	0	1.84
Combi Oven (fewer than 15 Pan) - gas	12	1.22	0	1.23
Combi Oven (15-28 Pan) - electric	12	0.922	0	0.922
Combi Oven (15-28 Pan) - gas	12	0.826	0	0.826

Product Class	Design Life (years)	Present Value of Benefits (MM 2024 $)	Present Value of Incremental Costs (MM 2024 $)	Net Present Value (MM 2024 $)
Combi Oven (28+ Pan) – electric*	12	-	-	-
Combi Oven (28+ Pan) - gas	12	0.754	0	0.754
Single-Rack Oven - gas	12	0.240	0.194	0.046
Double-Rack Oven - gas	12	1.26	0.353	0.911
Total		**20.1**	**5.42**	**14.7**

*Current sales projections for combi ovens of this size show a market preference only for the gas option.

8.6 Environmental and Societal Impacts

More efficient commercial convection ovens offer significant energy savings for owners and operators. Most costs associated with building and operating a utility infrastructure are fixed. Therefore, the overall utility and water agency costs remain relatively consistent, even if daily use of electricity or gas decreases with more efficient convection ovens. Although unlikely, significant energy use reductions could increase utility rates, resulting in more offsetting costs.

The proposed standards will not change the types of materials used in commercial convection ovens or the number of materials used, nor will they make noteworthy modifications to the manufacturing process. Additionally, these standards are not expected to have any significant societal impacts. This proposal will not impact aesthetics, biological resources, geology, hydrology, recreation, agriculture, cultural resources, land use, transportation, housing, mineral resources, public services, or tribal cultural resources.

9. Implementation Plan

The CASE Team foresees a straightforward implementation process for the proposal. We anticipate active outreach and engagement from Energy Code Ace to help manufacturers understand the compliance process and support product certification. Furthermore, the Modernized Appliance Efficiency Database System (MAEDbS) can work with SASD and ENERGY STAR to facilitate multi-jurisdictional compliance, reduce regulatory burdens, and enhance industry collaboration. Section 4.2.4 describes the reporting requirements for MAEDbs. Manufacturers have expressed a desire for this coordination in interviews conducted during the report's development. The Team also encourages decision-makers to pursue the other components outlined in Section 2 of the comprehensive approach.

10. Other Legislative and Regulatory Considerations

10.1 Federal Legislative and Regulatory Background

The DOE does not regulate convection, combi, and rack ovens. Moreover, DOE lacks the authority to regulate these products under current law (Cornell Law School, n.d.). The proposed standards for convection ovens are similar to the V2.2 voluntary requirements set forth by the EPA for the ENERGY STAR program. However, these proposed standards are less stringent than the newly effective V3.0 ENERGY STAR requirements.

10.2 California Legislative and Regulatory Background

Title 20 contains test-and-list requirements for commercial convection ovens but lacks efficiency standards. Initially adopted in 2002, these requirements remain unchanged, with only a fraction of manufacturers reporting to MAEDbS. Section 1604(r) requires using the ASTM 1469-99 test method, which the 2013 test method has since superseded. CEC collects data on the energy input and idle energy consumption rates for commercial convection ovens.

California Title 20 does not include test-and-list requirements for combi or rack ovens.

California Title 24, Part 6 Section 140.9(b) specifies prescriptive requirements for commercial kitchens, focusing on ventilation rather than oven performance. The CASE Team found no direct references to convection, combi, and rack ovens in a California municipal code.

10.2.1 Utility and Other Incentive Programs

The CA IOUs offer incentives of $600 per cavity for gas convection ovens, $450-$600 for electric convection ovens, and $450 for half-size models. These incentives are part of the California Energy Wise point-of-sale commercial food service rebate program that meets current ENERGY STAR requirements.

According to ENERGY STAR's website, 50 utilities outside of California offer rebates for convection ovens (Energy Star, n.d.). However, the CASE Team has not independently verified this information. We have also not identified other utilities offering rebates specifically for California convection ovens.

The CA IOUs offer incentives of $700 per cavity for combi ovens with fewer than 15 pans, $1,000 per cavity for 15 to 28 pans, and $1,200 per cavity incentives for ovens with more than 28 pans regardless of whether they are gas or electric. These incentives are part of the California Energy Wise point-of-sale commercial food service rebate program for ovens that meet current ENERGY STAR requirements.

The CA IOUs offer $2,000 incentives for single or double-rack ovens that meet or exceed 50% cooking energy efficiency through the California Energy Wise point-of-sale commercial food service rebate program. The rebate criteria differ from ENERGY STAR's requirements, including idle energy. The 50% cooking efficiency threshold falls between ENERGY STAR's threshold of 48% for single-rack and 52% for double-rack ovens.

10.3 Other State Standards

Convection, combi, and rack ovens are part of the Model Bill developed by the Appliance Standards Awareness Project (ASAP). Ten states have adopted standards for these products that generally align with the ENERGY STAR V2.2 criteria for ovens. The first standards for these products were adopted by New Jersey in 2021, with other states quickly following suit. However, many states lack a significant compliance and enforcement mechanism. Therefore, many 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 Model Codes and Voluntary Standards

Both government and non-government organizations have made substantial progress in creating model building codes and voluntary standards. Government and non-government organizations developed these codes and standards through a comprehensive process involving public review and industry stakeholder participation to enhance the efficiency of convection ovens. The CASE Team evaluated several model building codes and voluntary standards, which are listed below:

Leadership in Energy and Environmental Design (LEED) Commercial Interiors, Version 4.0: Developed by the U.S. Green Building Council through public vetting. Although energy-efficient convection, combi, and rack ovens are not a prerequisite for LEED, having ENERGY STAR-rated commercial food service equipment can earn up to two LEED points: one point for 70% of appliances and two points for 90% of all meeting ENERGY STAR criteria (US Green Building Council, n.d.). LEED is currently reviewing Version 5 criteria. More information is available at: http://www.usgbc.org/leed.

ENERGY STAR: Developed by the EPA through a process involving market, engineering, and pollution savings analyses, along with input from other EPA programs and industry and non-industry stakeholders. More information is available at http://www.energystar.gov.

ENERGY STAR is regarded as the most influential model code and voluntary standard. Most model codes align their efficiency requirements with ENERGY STAR. The current recognition criteria were established in 2009 and developed with input from the industry. Proposed levels are in effect for the following equipment categories.

Table 43 Equipment Categories with Proposed ENERGY STAR Levels

ENERGY STAR Version	Release Date	Latest Impacted Equipment Type
1.0	2009	Electric Convection Ovens
2.0	2013	Gas Convection Ovens
2.2	2015	Rack Ovens; Gas Combi Ovens
3.0	2023	Electric Combi Ovens

Commercial Energy Codes (ASHRAE 90.1-2022 and 2024 International Energy Conservation Code (IECC): The latest version of national model commercial energy codes adopted by states outside of California includes sections that require commercial buildings that follow the prescriptive pathway to

achieve energy credits from a list of options (Chapter 11 in ASHRAE 90.1-2022 and Section C406 in the 2024 IECC). Choosing more efficient ovens that meet ENERGY STAR V2.2 criteria is one option in these codes, enabling buildings to earn energy credits.

11. Response to Request for Information

This section includes the 18 questions reprinted without modifications from the Request for Information (RFI) docketed by the CEC on November 14, 2023, to Docket 23-AAER-01 (California Energy Commission, 2023). The CEC issued a second RFI on September 4, 2024, specifically requesting information on commercial ovens, which is included after the initial RFI. The CASE Team answers the questions and addresses both RFIs, focusing solely on commercial convection ovens, the technology specific to this report. Additional CASE Reports provide detailed discussions on various food service technologies, covered separately.

Below is the CASE Team's response to the November 14, 2023, request for information on ovens.

1. Based on Table 1, are there additional classifications that should be considered in scope or out-of-scope? Based on what factors?

For commercial convection ovens, the CASE Team suggests adding oven sizes to the list of classifications. Electric ovens are available in full and half-size options. Both gas and electric full-sized options include a variant known as "bakery depth ovens." The primary difference between half and full-size ovens is the sheet pan capacity. No functional efficiency difference exists between bakery depth ovens and standard depth full-size gas or electric ovens.

The scope excludes mini combi ovens and mini rack ovens for the following reasons:

- Limited market size
- Limited baseline data available to estimate savings
- High probability that ovens on the market are already efficient
- Low energy usage compared to standard-size ovens that accommodate standard pan or rack sizes

Section 3.4 lists other commercial oven types that were explicitly excluded.

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?

The CASE Team proposes sources for several definitions for the CEC's review, including ENERGY STAR definitions for "Commercial Convection, Combination and Rack Ovens," "Cooking-Energy Efficiency," and "Idle Energy Rate."

The CASE Team refers readers to Section 4.2.1 for specific details on these definitions.

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?

Supermarkets primarily purchase rack ovens, while commercial bakeries are also a significant market. Similar markets buy convection and combi ovens, with combi ovens becoming increasingly common in school settings.

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 is unaware of other available efficient technologies in the convection, combi, and rack oven 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?

Rapid cook ovens use hot air and microwaves to accelerate cooking and can function similarly to convection ovens. These ovens have much smaller cooking cavities and faster cook times, making them ideal for cook-to-order scenarios. In contrast, convection ovens are better suited for large-batch cooking production capacity.

Conveyor ovens pull food through a cooking cavity on a conveyor belt and can offer the same functions as convection ovens. Widely used by national pizza chains, these ovens can also cook items like wings and sub sandwiches. Staff must constantly monitor them because food can fall off the belt. They have a larger footprint and are more expensive than convection ovens. Additionally, they use more energy as they are open to ambient air on both sides of the belt.

Deck ovens operate at higher temperatures (450°F and above) than convection ovens (350°F and above) and cook the food mainly through conduction from the bottom of the cooking cavity. They are typically used to cook pizzas but can also roast different foods. The cooking profile of deck ovens differs from that of convection ovens.

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

The CASE Team investigated alternative certification approaches for convection, combi, and rack ovens beyond the ENERGY STAR program but did not find a widely accepted alternative. Section 10.4 provides more detail about voluntary standards from LEED that utilize ENERGY STAR certifications.

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

The CASE Team suggests that the CEC staff adopt ASTM Standard F1496-13 (2019) as the testing component for convection ovens in California. This well-established standard accurately determines the commercial convection oven's energy efficiency and production capability. The test procedure uses russet potatoes as a test medium and outlines how to measure an oven's idle energy rate and cooking energy efficiency. ENERGY STAR references the F1496-13 (2019) for its V2.2 procedure. The CASE Team anticipates ENERGY STAR will update its specifications to the most recent ASTM version within one to two years. For more information on the ASTM Standard F1496-13 (2019) test procedure, see Section 4.2.2.

A comparable testing method can be applied to combi ovens using ASTM F2861-20, which entails baking red potatoes in steam mode and russet potatoes in convection mode. Rack ovens are tested per ASTM F2093-18 using frozen apple pies. This method outlines measuring an oven's idle energy rate and cooking energy efficiency.

One challenge the CEC may face is determining whether a commercial convection oven falls within the scope of the standards, using only its manufacturer literature. The CASE Team's proposal applies to

convection ovens with a pan size capacity of at least three and no more than six. The ASTM 1469-13 test procedure evaluates the capacity of pan sizes, but manufacturer literature and appliance markings typically do not disclose this information. Without specific details from the manufacturer regarding the pan size capacity, it is challenging to determine whether an oven meets the exemption criteria of having fewer than three or more than six pans. Testing is required to confirm if the oven complies with these standards.

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

Based on the CASE Team's research, after optimizing the cooking efficiency and idle energy rate, the most effective way to improve convection oven efficiency is to improve insulation, door seals, and convection fans. Digital controls can also offer enhanced cooking efficiency and a more consistent cooking temperature. The CASE Team refers readers to Section 5.1 for additional information on this potential efficiency opportunity for convection ovens.

Combi and rack ovens are higher-tech appliances than convection ovens and undergo redesign cycles every 5-7 years. Manufacturers of those two product types strive (and usually succeed) to exceed the current ENERGY STAR standard for the new designs.

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?

The CASE Team's analysis of California restaurant data revealed 121,000 commercial convection ovens in use in 2009. Independent restaurants comprised nearly half of the convection oven counts, followed by institutional food services and then by schools. Using ENERGY STAR's shipment data from 2022 and normalizing to California's population, the CASE Team estimates approximately 4,600 compliant convection ovens are sold annually in California.

Combi ovens are estimated to account for 20% of annual sales in three oven categories, while rack ovens make up 4% and convection ovens 76%.

For additional information, the CASE Team refers readers to Section 8.1.

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

Due to insufficient data on convection oven leasing services, the CASE Team estimates that all commercial convection, combi, and rack ovens are sold. Convection ovens are affordable enough not to require leasing. Combi ovens are typically not leased due to the risk of damage from improper water chemistry. Rack ovens are expensive and challenging to move and install, making leasing financially impractical.

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?

The CASE Team estimates California uses approximately 108,200 commercial convection ovens, 94,800 gas ovens, 10,800 electric ovens, and 2,700 half-size electric ovens. Nationally, annual figures are 8,000 gas ovens, 900 electric ovens, and 200 half-size electric ovens.

The CASE Team has identified approximately 28,500 combi ovens and 5,700 rack ovens installed in California. Smaller combi ovens are mainly electric, mid-size combi ovens are primarily gas, and large roll-in rack combi ovens are almost exclusively gas. The proposal focuses solely on gas rack ovens, as the

electric rack oven market is minimal due to high amperage requirements for double rack ovens, which are the most popular type.

Section 8.1 explains the CASE Team's methodology for determining this estimation.

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

The CASE Team collected price data from the following sites:

- Webstaurant Store
- Katom
- JES Restaurant Equipment

We averaged pricing for the market's least expensive gas and electric convection ovens to determine baseline costs and the least costly compliant ovens to determine the incremental costs. We determined the incremental cost between baseline and compliant convection ovens to be $1,000 for the three types of ovens within the scope of this report. For a more in-depth explanation of the CASE Team's research and analysis, see Section 7.1.

The average price of ENERGY STAR-certified combi ovens is lower than non-ENERGY STAR models. Major manufacturers offer competitively priced, energy-efficient combi ovens, making most of the market ENERGY STAR certified.

Leading rack oven manufacturers mainly sell energy-efficient, competitively priced combi ovens to supermarkets, which negotiate lower prices than retail. The CASE Team averaged rack oven prices for units that met ENERGY STAR and compared them to those that did not.

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

The CASE Team lacks data on the replacement costs for commercial convection ovens. We assume that the incremental installation cost for inefficient and efficient convection ovens is the same, ranging from $300 to $500 per oven cavity. These costs vary depending on the accessibility of the oven location and whether the electrical cord or gas hose needs replacement.

Combi ovens are more expensive to install than convection ovens, requiring water filtration and water and drain connection. Their adaptability and versatility, excluding water filters, can potentially double the cost of convection oven installations.

Rack ovens are costly due to the need for on-site assembly, ductwork installation to route flue and exhaust gases, and other factors. Installation costs for rack ovens can range from $1,000 to over $5,000, depending on the facility layout.

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.

Convection ovens typically last around 12 years. These relatively simple appliances allow food service technicians to replace most parts easily. Commonly replaced parts include the thermostat, thermocouple, ignition module (for gas models), and convection oven fan. Metal gaskets need replacement every three to five years. Well-maintained brands like l Blodgett, Montague, or Vulcan can last over 20 years. Less expensive brands may require replacement sooner than 10 years if repair costs exceed half the price of a new oven. A convection oven's lifespan depends on proper treatment from staff and the facility's maintenance practices.

Combi ovens can have a lifespan similar to convection ovens if adequately maintained. Improper water chemistry can destroy an oven cavity and boiler within a few years. California's water is known for poor water quality and high hardness. Installing a water softener and a reverse osmosis system costs between $1,000 to $5,000, but it can serve multiple appliances, such as steamer and coffee and ice machines.

Rack ovens have similar lifetimes to convection and combi ovens. Major supermarket chains have equipment replacement cycles every 8 to 12 years, including racks, combi ovens, and fryers. Commercial bakeries typically have between 4 to 12 rack ovens. This redundancy allows for the intensive use of each oven. However, a rack oven can last up to 20 years with proper maintenance and regular component replacement, even with heavy use.

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

Convection ovens, like other food service equipment, are preheated at the beginning of the first shift and operate until the kitchen closes. Operating hours vary based on restaurant type and the number of meal periods. On average, convection ovens operate 13 hours per day. Hotel kitchens serving breakfast, lunch, and dinner may run their ovens for 18 hours daily, sometimes 24 hours if offering room service. School districts typically use convection ovens for breakfast and lunch only, resulting in fewer operating hours.

Combi ovens, used in the same environment as convection ovens, typically have similar operating hours. More school districts are purchasing combi ovens for their rethermalizing abilities. Rack ovens are primarily used in supermarkets from 6 a.m. to 2 p.m. daily. Commercial bakeries may have much longer operating hours, but the ovens may not operate seven days a week. Schools do not use rack ovens, which makes the average operating days higher than convection and combi ovens.

Refer to section 6.1 for key operating assumptions, including hours and days of operation.

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

Five-pan full-size convection ovens are the mainstay of American commercial kitchens, with almost every major U.S. food service manufacturer offering a model. Leading manufacturers like Blodgett, Vulcan, Imperial, Garland, and Southbend provide ENERGY STAR-certified models and non-certified models. Blodgett and Vulcan offer standard, bakery depth, and half-size ENERGY STAR-certified models. Moffat has lower-cost, smaller convection ovens that are also ENERGY STAR certified.

Rational, the largest manufacturer of combi ovens, offers a complete line of ENERGY STAR-certified products. Alto Shaam and Unox's most popular models are ENERGY STAR certified. Conversely, several combi ovens by Vulcan, Blodgett, and Henny Penny are not ENERGY STAR qualified, but these models are less popular. A wide range of ENERGY STAR combi oven sizes are available at competitive costs.

Revent, Baxter, LBC, and Doyon are the leading rack oven manufacturers. Most Revent, Baxter, and LBC product lines are ENERGY STAR qualified. Due to limited data on Doyon ovens, the CASE Team assumes its models do not qualify for ENERGY STAR.

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?

California's leading convection oven manufacturers include Imperial, American Range, Montague, and Royal Range. Although the CASE Team conducted no in-depth market analysis, these manufacturers employ less than 1,000 people each, fitting the U.S. Small Business Administration's definition of small businesses. California has numerous small businesses specializing in food service equipment and selling convection ovens. These firms are typically small, employing less than 50 people each (SoCal Gas, n.d.).

Most combi ovens are produced in Europe and imported into the U.S. However, combi ovens by Alto Shaam and Vulcan are made domestically. California has no combi oven manufacturers.

Baxter, a part of Vulcan/ITW, produces its rack ovens in Washington State. Other popular rack ovens are made abroad, such as, Revent in Sweden and Doyon in Canada. LBC, a California company, sources most of its oven components from Taiwan.

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

According to the CASE Team's research methodology, the proposed standard would result in first-year statewide savings of 1.73 GWh of electricity, 0.77 million therms of natural gas, and 6 million gallons of water. More efficient commercial convection, combi, and rack ovens save owners and operators significant energy and gas.

Refer to Section 8.4 for the complete list of the potential impacts and benefits of the proposed standards for consumers and businesses using convection ovens.

Below are the responses to the September 4, 2024, request for information on ovens.

1. Are there other types of commercial ovens, beyond the scope of the ENERGY STAR specification, that the CEC should consider for efficiency standards? Please elaborate.

We do not recommend commercial ovens beyond the scope of the ENERGY STAR specification. Convection, combi, and rack ovens have the largest share of the market and the most lab test data supporting energy-efficient standards. The recently updated ENERGY STAR standards still apply to these ovens, eliminating the need to set energy efficiency or idle rate thresholds beyond the current standard. See section 3.4 for details on excluded oven products. Question 2 contains reasons for excluding additional oven types.

2. Are there any types of commercial ovens that the CEC should consider for test-and-list requirements? Please elaborate.

Due to the small market share and limited information on efficiency opportunities, the CASE Team does not recommend test-and-list requirements for the ovens listed below. ASTM test standards exist for ovens beyond convection, combi, and rack ovens listed below. These standards apply to both gas and electric versions.

Although the test-and-list burden is relatively low for mass-produced models to test-and-list only the idle rate, energy-efficiency testing adds significant cost. Depending on the size of the oven, a full-efficiency test may cost between $10,000 and $20,000. Costs depend on the type and size of oven and can vary depending on how many units can be tested back-to-back, as test setup and instrumentation is one of the biggest drivers of test price.

- **Conveyor Ovens** (ASTM F1817-17)

- Almost all large conveyor ovens are gas, with only a few manufacturers: Middleby, XLT, and Lincoln. Major pizza chains such as Domino's, Papa John's, Pizza Hut, and Little Caesars already use efficient appliances. The market for conveyor pizza ovens in most independent restaurants is limited, as most prefer deck ovens. These ovens are complicated to set up for testing. Information on baseline ovens is limited, making the purchased models unclear. As large pizza chains upgrade their ovens, the used market may be significant, with older models sold to independent restaurants.
- Small electric conveyor ovens are gaining popularity and could compete with conveyor toasters and rapid cook ovens. However, their open cavity design and lack of data make them relatively inefficient. It is uncertain whether some models are more efficient than others. As electric heating elements are similar across models, the only energy-saving feature is the temperature setback mode, which may not be feasible for all operations requiring rapid heat-up times.

- **Rapid Cook Ovens** (ASTM F2238-20)
  - Electric only. The market for sandwich shops and bakeries is comparatively large. Most rapid-cook ovens are energy efficient because they use microwaves for cooking. They operate at high temperatures (450°F to 500°F) to activate a catalyst required for ventless operation, which is a key selling feature. These ovens have no rebates due to the small energy differences between models.
- **Deck Ovens 450°F to 600°F** (ASTM F1965-17)
  - Most deck ovens in California are gas, and minimal data is available on their energy efficiency. ASTM pizza cooking test is relatively complicated and inconsistent compared to conveyor ovens. Most deck ovens have similar burner designs and are well insulated to limit heat in the kitchen. They are typically designed to operate between 400°F to 550°F and have efficient doors compared to 700°F + Neapolitan or Igloo-style pizza ovens rarely have doors. No energy consumption data exists on 700°F + ovens, partly because many of the models are custom built.
- **Range Ovens** (modified ASTM F1496-13)
  - Mostly gas. Nearly every restaurant has a range. Convection ovens are preferred for cooking, making it unclear how often kitchens use range ovens. Range ovens are sometimes used for pan storage or to finish dishes cooked on the range top, particularly if the restaurant does not have a salamander. Many manufacturers produce range ovens, making them low cost and inefficient, which can impose a financial burden on operators to upgrade to a range oven with technology comparable to a standard convection oven.
- **Rotisserie Ovens** (ASTM F1787-98)
  - Mostly gas. Rotisserie ovens come in two types: open design and revolving closed-cavity design. Open designs are inefficient compared to the more efficient closed cavity design. Grocery stores primarily use rotisserie ovens but have mostly transitioned to a closed cavity design or combi ovens have replaced them for cooking chickens. Although closed-cavity models have limited energy-efficiency opportunities, data on open-cavity

rotisserie ovens may prove helpful. It is unclear if kitchens turn off rotisserie ovens after cooking or set them to idle all day, which could significantly impact energy savings.

- **Mini-Rack Ovens** (ASTM F2093-18)
    - Gas or electric. Only a few rack oven manufacturers exist, but nearly all offer eight-pan mini- rack ovens. Most of these rack oven manufacturers offer ENERGY STAR full-single and double-rack ovens and integrate similar designs into their mini rack ovens, so the savings between these options may be limited.
- **Mini-Combi Ovens (ASTM F2861-20)**
    - Almost all electric. Only a few mini-combi ovens on the market have a 2/3-size pan or a full-pan capacity of fewer than five pans. All mini-combi ovens are electric. Although mini combi ovens are a part of the ENERGY STAR program, most models are already certified. The difference in energy consumption from model to model is relatively small, and they use less energy than standard-size (5-40 pan) combi ovens covered by this proposal.

3. Should the CEC consider aligning any proposed appliance efficiency regulations on commercial ovens with ENERGY STAR v2.2, ENERGY STAR v3.0, or some other stringency level? Please elaborate and provide as much supporting information as available.

The CASE Team recommends aligning with ENERGY STAR V2.2 for convection ovens and V3.0 for combi and rack ovens. Selecting V3.0 for convection ovens will significantly decrease the number of available ovens on the market from 31 full-size gas and 28 full-size electric to 14 full-size gas and 14 full-size electric. Only two gas and two electric bakery depth ovens would qualify for ENERGY STAR V2.2. Only one gas and one electric bakery depth oven model would be eligible for ENERGY STAR V3.0.

Convection oven manufacturers often also make fryers, griddles, and ranges, which are currently unregulated and do not adhere to the latest version of the ENERGY STAR code in other states. Most combi-oven manufacturers specialize in making only combi ovens. All rack oven manufacturers focus solely on producing rack ovens. Setting V2.2 standards for convection ovens and V3.0 for combi and rack ovens would avoid confusion. However, if the last ENERGY STAR version is not selected, it may cause uncertainty for combi oven manufacturers, as they would need to revert to older ENERGY STAR lists.

4. In addition to the rebate programs offered through the IOUs, are there additional rebate programs that the CEC should be aware of?

There are a couple programs in the state offering rebates on the proposed measures. SoCalGas' Business Rebates program is a downstream program that mirrors the gas foodservice offerings of the California Instant Rebates program. Additionally, LADWP offers a downstream program for electric equipment. Both programs can be accessed at https://caenergywise.com/business-rebates/

5. What impact have these rebate programs had on the market of commercial ovens? Please elaborate.

The California statewide foodservice rebate program and the previous individual IOU programs have played a significant role in expanding the awareness, availability, and selection of high efficiency commercial ovens. Most commercial foodservice dealers in the state participate in the California Instant Rebates mid-stream program so end users have been introduced to high efficiency equipment through the rebate, marketing materials at the dealers and program outreach through webinar, advertising and

direct outreach. Dealers have adapted their stocking to include a higher percentage of qualified convection ovens to take advantage of rebates for their customers. The 2021 evaluation on the California Instant Rebates program found 88% of distributors reported that the Foodservice program influenced the efficiency level that their company recommends to end users. Additionally, the evaluation found 92% of dealers rated the program a 4 or 5 in a 1-5 rating system with 5 being "extremely influential" when asked how the Foodservice program influenced the selection of high-efficiency equipment their company typically sells. Finally, manufacturers have made efforts to improve the efficiency of their products to meet the qualification requirements so their customers can take advantage of utility rebates as evidenced by their engagement with the utility foodservice labs and engineering teams.

6. What impact will appliance efficiency standards on commercial ovens have on existing and future rebate programs in California? Please elaborate.

State standards would require an update to the deemed savings in the eTRM measure package which would reduce the savings for the convection ovens by 30% for gas and full-size electric units, and reduce half sized electric units by 80%, which would eliminate them from the program. The rebates for the full-sized units would be reduced by at least 30% to compensate for the lost in savings. The rebates for convection ovens are already relatively low comparative to the equipment cost and further reduction to an estimated $400 would reduce qualified purchases of models meeting v3.0 by 20-35%. The state standards for combi and rack ovens would remove rebates for these products entirely.

Convection, combi, and rack ovens currently make up 17% of the natural gas savings and 25% of the program's electric savings. The state standards would remove about 13% of the gas savings from the program and almost 25% of the electric savings. Additionally, fryers, steamers and dishwashers would make up 74% of gas savings and 6% of electric savings in the program. In total, savings for the program would be reduced by nearly 90% for gas and 30% for electric if the standards were implemented for all six products.

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Appendix A: Embedded Electricity Usage Methodology

The 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 includes all energy uses upstream of the customer. It does not include wastewater collection or treatment. The embedded electricity values do not include on-site energy consumption associated with water use (e.g., the energy required for water heating or on-site pumping).

The CASE Team derived the embedded electricity values from research conducted for CPUC Rulemaking 13-12-011. The CPUC study aimed to quantify the embedded electricity savings associated with CA 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.

Convection and rack ovens do not contribute to water savings; however, water savings are associated with combi ovens. The table below shows annual energy savings linked to water savings for each combi oven type based on indoor water use.

Table 44 Annual Combi Oven Energy Savings Associated with Water Savings

Product Class	Annual Water Savings (gal/yr-unit)	Annual Energy Savings Associated with Water Savings (kWh/yr-unit)	Number of Units Sold Per Year in CA	Number of Inefficient Units Sold Per Year in CA	Annual Energy Savings Associated with Water Savings (kWh/yr)
Electric fewer than 15 pan	4,968	27.0	875	219	5,912
Electric 15-28 pan	10,655	58.0	199	50	2,884
Electric 28+pan	29,643	161.3	0	0	0
Gas fewer than 15 pan	10,298	56.0	716	179	10,028
Gas 15-28 pan	19,717	107.3	370	93	9,922
Gas 28+pan	24,888	135.4	214	54	7,243

Appendix B: Convection and Combi Oven Energy Use Assumptions

Section 6.2 describes the methodology for calculating energy savings. The table below shows each subcategory's key assumptions for baseline and compliant convection ovens, including preheat time, preheat energy, idle energy rate, and cooking efficiency. Compliant convection ovens have lower idle rates and higher cooking efficiency than baseline ovens. Each baseline value is an average of available lab test data points for ovens that do not meet the idle and energy efficiency criteria. The efficiency threshold is the assumed value for idle energy rate and cooking efficiency for compliant convection ovens.

Table 45: Energy Assumptions for Baseline and Compliant Convection Ovens

Fuel	Efficiency	Preheat time (min)	Preheat energy (kWh or Btu)	Idle energy rate (kW or Btu/h)	Cooking efficiency (%)	Production capacity (lb/h)
Electric	Baseline – Full Size	8.5	1.53	2.00	70.7%	89.4
Electric	Compliant – Full Size	8.5	1.53	1.60	71.0%	89.4
Electric	Baseline – Half Size	9.4	1.16	1.16	66.6%	42.8
Electric	Compliant – Half Size	9.4	1.00	1.00	71.0%	42.8
Gas	Baseline – Full Size	11.5	14,028	16,210	40.8%	88
Gas	Compliant – Full Size	11.5	14,028	12,000	46.0%	88

The table below shows each subcategory's key assumptions for baseline and compliant combi ovens, including idle energy rate and cooking efficiency in convection and steam modes. Compliant convection ovens have lower idle rates and higher cooking efficiency than baseline ovens. Each baseline value is an average of available lab test data points for ovens that do not meet the idle and energy efficiency criteria. The efficiency threshold is the assumed value for idle energy rate and cooking efficiency for compliant convection ovens.

Table 46: Idle Rate Assumptions for Baseline and Compliant Combi Ovens

Pan Capacity	Fewer than 15 Pan	Fewer than 15 Pan	15-28 Pan	15-28 Pan	28+ Pan	28+ Pan
Case	**Baseline**	**Compliant**	**Baseline**	**Compliant**	**Baseline**	**Compliant**
Electric Convection Mode	1.09 kW	1.01 kW	2.11 kW	1.57 kW	3.73 kW	2.41 kW
Electric Steam Mode	2.87 kW	1.21 kW	4.60 kW*	2.13 kW	6.00 kW**	2.80 kW
Gas Convection Mode	6,697 Btu/h	3,764 Btu/h	7,626 Btu/h	5,556 Btu/h	12,866 Btu/h	6,804 Btu/h

Pan Capacity	Fewer than 15 Pan	Fewer than 15 Pan	15-28 Pan	15-28 Pan	28+ Pan	28+ Pan
Case	**Baseline**	**Compliant**	**Baseline**	**Compliant**	**Baseline**	**Compliant**
Gas Steam Mode	14,015 Btu/h	5,449 Btu/h	17,482 Btu/h	7,970 Btu/h	17,014 Btu/h	9,798 Btu/h

*Based on the tests, the least efficient 10 full-size sheet pan combi ovens currently on the market have cavity volumes comparable to 15-28 pan steam combi ovens.

**Based on the ENERGY STAR threshold, whether the 8.8 kW steam idle rate 40-pan combi oven is still on the market is unclear. The least efficient 40-pan ENERGY STAR combi has a steam idle rate of 5.43 kW.

Table 47: Efficiency Assumptions for Baseline and Compliant Combi Ovens

Pan Capacity	Fewer than 15 Pan	Fewer than 15 Pan	15-28 Pan	15-28 Pan	28+ Pan	28+ Pan
Case	**Baseline**	**Compliant**	**Baseline**	**Compliant**	**Baseline**	**Compliant**
Electric Convection Mode	74%	80%	77%	82%	76%	82%
Electric Steam Mode	55%	63%	58%	66%	61%	67%
Gas Convection Mode	54%	61%	61%	61%	60%	64%
Gas Steam Mode	44%	50%	45%	51%	53%*	49%*

*The average efficiency of the four ENERGY STAR models is 49% (with individual rates of 41%, 43%, 54%, and 58%). In comparison, one non-ENERGY STAR model has an efficiency rate of 53% and does not qualify based on steam and convection idle energy rates.

Appendix C: Combi Oven Market Share

For electric combi ovens, 78% of the models qualified for ENERGY STAR V2.2 and 75% for V3.0. Based on web research from major online restaurant equipment stores like Webstaurant, Ckitchen, and Katom, only a handful of models qualified for V2.2 but not V3.0.

Table 48 Most Popular Electric Combi Ovens on the US market

Brand	Model	ESTAR V2.2	ESTAR V3.0
Atosa	AEC-1021E	1	1
Atosa	AEC-0621E	1	1
Alto-Shaam	7-20E Pro	1	1
Axis	AX-CL10M	0	0
Axis	AX-CL06D	0	0
Blodgett	BLCT-61E	0	0
Convotherm	C4ED12.20EB	0	0
Convotherm	C4ED12.20ES	0	0
Convotherm	C4ET10.20EB	1	1
Convotherm	C4ET10.20ES	1	1
Convotherm	C4ED6.20ES	1	1
Convotherm	C4ED6.20EB	1	1
Convotherm	C4ED6.10EB	0	0
Convotherm	C4ED6.10ES	0	0
Electrolux	Skyline Pro Boilerless 61 Electric (219930)	0	0
Henny Penny	FPE 615	1	0
Rational	iCombi Pro 10 full electric	3	3
Rational	iCombi Pro 6 full electric	3	3
Rational	iCombi Pro 20 full electric	3	3
Rational	iCombi Pro 10 half electric	3	3
Rational	iCombi Pro 6 half electric	3	3
Rational	iCombi Pro 20 half electric	3	3
Unox	XAVC-0511-EPR	1	1
Unox	XAVC-0513-EPLM	1	1
Unox	XAVC-1011-EPLM	1	1
Unox	XAVC-10FS-EPLM	1	1
Vulcan	ABC7E	0	0
Vulcan	TCM-102E	1	1

*Market weighting: 0 non-ESTAR; 1 ESTAR; 3 high market percentage ESTAR model

Gas combi ovens have a 74% qualification rate for ENERGY STAR V2.2 and V3.0, as the specifications for both versions are identical.

Table 49 Most Popular Gas Combi Ovens on the U.S. market

Brand	Model	ESTAR V2.2 or V3.0
Alto-Shaam	20-20G	1
Alto-Shaam	7-20G Pro	1
Alto-Shaam	6-10G Pro	0
BKI	CLBKI-62G	0
BKI	CLBKI-102G	0
Convotherm	C4ET10.20GS	0
Convotherm	C4ET10.20GB	0
Convotherm	C4ED6.20GS	1
Convotherm	C4ED6.20GB	1
Convotherm	C4ED6.10GB	0
Convotherm	C4ED6.10GS	0
Electrolux	Skyline Pro Boilerless 61 Gas (219680)	1
Electrolux	Skyline Pro Boilerless 62 Gas (219681)	1
Electrolux	Skyline Pro Boilerless 102 Gas (219683) ECOG102K3	1
Rational	iCombi Pro 10 full gas	3
Rational	iCombi Pro 6 full gas	3
Rational	iCombi Pro 20 full gas	3
Rational	iCombi Pro 10 half gas	3
Rational	iCombi Pro 6 half gas	3
Rational	iCombi Pro 20 half gas	3
Unox	XAVC-10FS-GPRM	1
Vulcan	ABC7G	0
Vulcan	TCM-102G	0

*Market weighting: 0 non-ESTAR; 1 ESTAR; 3 high market percentage ESTAR model

Appendix D: Electricity and Natural Gas Price Forecasts

Table 50 shows the electricity and natural gas prices from 2022 to 2050. The CASE Team used the latest U.S. Energy Information Administration (EIA) data to estimate these prices, reflecting average electricity and natural gas costs paid by California consumers.[9,10] We calculated annual escalation rates using price forecasts from the California Energy Demand Forecast published by CEC in 2022[11] and 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."[12] We adjusted prices annually according to these escalation rates.

Table 50: 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

[9] 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

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

[11] 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

[12] 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