SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Preliminary Draft Staff Report

Proposed Amended Rule 1146.2 – Emissions of Oxides of Nitrogen (NOx) from Large Water Heaters, Small Boilers and Process Heaters

January 2024

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South Coast AQMD Rule 1146.2 – Emissions of Oxides of Nitrogen from Large Water Heaters, Small Boilers and Process Heaters (Rule 1146.2), regulates oxides of nitrogen (NOx) emissions from natural gas-fired large water heaters, small boilers, and process heaters that have a rated heat input capacity of less than or equal to two million British thermal units (Btu) per hour. This rule does not regulate residential gas-fired tank type water heaters rated at less than 75,000 Btu/hr heat input, which are regulated under Rule 1121 – Control of Nitrogen Oxides from Residential-Type, Natural Gas-Fired Water Heaters (Rule 1121); however, residential instantaneous (tankless) water heaters are regulated by Rule 1146.2 due to the higher Btu ratings of those type of units. The provisions of Rule 1146.2 are applicable to manufacturers, distributors, retailers, installers, refurbishers, and operators.

Rule 1146.2 was initially adopted in January 1998. A Best Available Retrofit Control Technology (BARCT) assessment was conducted for the 2006 amendment where the NOx emission limits were lowered from 30 parts per million by volume (ppmv) to 20 ppmv, except for pool heaters, which remained at 55 ppmv. The rule was last amended in 2018 to remove the exemption for facilities in the REgional CLean Air Incentives Market (RECLAIM) and to require applicable new installations in RECLAIM facilities to meet the 20 ppmv NOx emission limits.

Proposed Amended Rule 1146.2 – Emissions of Oxides of Nitrogen from Large Water Heaters, Small Boilers and Process Heaters (PAR 1146.2), seeks further NOx emission reductions and implements the 2022 Air Quality Management Plan (AQMP) Control Measure C-CMB-01-Emission Reductions from Replacement with Zero Emission or Low NOx Appliances – Commercial Water Heating (Control Measure C-CMB-01).

For PAR 1146.2, staff conducted a comprehensive BARCT assessment which included an analysis of the technical feasibility and cost-effectiveness of zero-emission NOx technologies. PAR 1146.2 proposes to divide the applicable large water heaters, small boilers, and process heaters into six categories and require zero-emission (0 ppmv) limits for new installations based on future effective dates depending on the commercial availability of zero-emission technologies. The zero-emission compliance dates are further differentiated for units installed in new or existing buildings. The future effective dates will allow time for the technology to mature, with longer timelines provided for the technologies that are not widely commercially available at this time. PAR 1146.2 also proposes zero-emission limits for existing units that will reach the end of unit age after the zero-emission compliance dates, with an exemption for units used for residential and multifamily structures. In addition, PAR 1146.2 clarifies and updates rule language, restructures the rule, and removes obsolete language.

PAR 1146.2 will affect approximately 773,000 units in the South Coast AQMD. Staff estimates that upon full implementation, PAR 1146.2 will reduce NOx emissions by 8.0 tons per day (tpd). The public process for PAR 1146.2 consisted of five working group meetings, a public workshop, and multiple meetings with industry stakeholders and technology vendors to obtain feedback.

CHAPTER 1: BACKGROUND

INTRODUCTION

Rule 1146.2 limits NOx and carbon monoxide (CO) emissions from natural gas-fired large water heaters, small boilers, and process heaters that have a rated heat input capacity less than or equal to two million Btu per hour (MMBtu/hr). The rule was initially adopted in January 1998, and beginning on January 1, 2000, the provisions of the rule were applicable to manufacturers, distributors, retailers, refurbishers, installers, and operators of new units. Beginning July 1, 2002, the provisions of the rule were also applicable to operators of existing Type 2 units.

In Rule 1146.2, units are split into two categories based on rated heat input capacity: Type 1 units for units rated at less than or equal to 400,000 Btu/hr and Type 2 units for units rated at greater than 400,000 Btu/hr and less than or equal to 2,000,000 Btu/hr. Rule 1146.2 does not regulate residential gas-fired tank type water heaters rated less than 75,000 Btu/hr heat input, which are regulated under South Coast AQMD Rule 1121. However, residential instantaneous (tankless) water heaters are regulated by Rule 1146.2 due to the higher Btu ratings of those type of units. Units used in recreational vehicles are exempt from the requirements of Rule 1146.2 as they are smaller units that are typically operated with electricity or propane.

REGULATORY BACKGROUND

Rule 1146.2 was initially adopted in 1998 and has been amended three times: in 2005, 2006, and 2018. The table below summarizes the current NOx and CO emission limits required in Rule 1146.2.

Table 1-1. Current Rule 1146.2 NOx and CO Emission Limits

Equipment Category	NOx Emission Limit*	CO Emission Limit*
Type 1 Units, excluding Pool Heaters	14 ng/J or 20 ppmv	N/A**
Type 1 Pool Heaters	40 ng/J or 55 ppmv	N/A**
Type 2 Units	14 ng/J or 20 ppmv	400 ppmv

* Nanograms per Joule (ng/J) of NOx (calculated as NO_2) of heat output or the specified ppmv of NOx or CO at three percent oxygen (O_2) correction, on a dry basis

** Type 1 units are not subject to a CO limit by Rule 1146.2, but may be subject to CO limits by other South Coast AQMD rules.

South Coast AQMD developed the Rule 1146.2 Certification Program in 1998 which requires manufacturers to submit documentation for new unit models, including source test reports, to South Coast AQMD to demonstrate compliance with Rule 1146.2 emission limits.

Rule 1146.2, as adopted in January 1998, required new Type 2 water heaters or boilers to meet an emission limit of 30 ppmv of NOx or 0.037 pound NOx per million Btu of heat input and 400 ppmv of CO. New Type 1 units were required to meet a NOx emission limit of 55 ppmv of NOx or 40 ng/J of heat output. Compliance dates for the emission limits were based on the date of unit manufacture. Following rule adoption, staff prepared three implementation studies as required by the rule. A working group comprised of manufacturers, end-users, utilities, and other interested parties was convened to provide input and guidance to staff during each of the three implementation studies. The purpose of the third and final implementation study, Phase III Implementation Study, was to evaluate the requirement for retrofit of units greater than 400,000 Btu/hr and less than or equal to 1,000,000 Btu/hr (smaller Type 2 units). The findings of the Phase III Implementation Study were presented at the July 2004 Governing Board meeting. The Phase III Implementation Study recommended modifying retrofit requirements and evaluating whether lower NOx emission limits were feasible for new equipment.

Based on the findings of the Phase III Implementation Study, Rule 1146.2 was amended on January 7, 2005, to require existing in-use equipment to comply with the emission limit once the unit reached 15 years of unit age, and to address technical and cost issues for the retrofit of existing units. The rule was amended to require smaller Type 2 units up to 1,000,000 Btu/hr manufactured prior to January 1, 2000 with unit age over 15 years to be retrofitted to meet 30 ppmv NOx limit and 400 ppmv CO limit; and require larger Type 2 units up to 2,000,000 Btu/hr manufactured on and after 1992 with unit age over 15 years to be retrofitted to meet 30 ppmv NOx limit and 400 ppmv CO limit. Lower emission limits for new equipment were not considered for the January 7, 2005, rule amendment because additional time was needed to evaluate low NOx technologies and their cost-effectiveness.

Rule 1146.2 was amended again in May 2006 to establish lower NOx emission limits for new equipment. Staff noted that the technology to reduce NOx emissions was available, that many of the new Rule 1146.2 boilers and heaters sold met the proposed 20 ppmv limit, and that the proposed rule allowed manufacturers four to six years to design equipment which would meet the proposed limit. New manufactured units rated greater than 400,000 Btu/hr were required to meet a NOx emission limit of 20 ppmv effective January 1, 2010, and new manufactured units rated less than or equal to 400,000 Btu/hr, with the exception for pool heaters, had to meet a 20 ppmv (less than 14 ng/J heat output) NOx limit effective January 1, 2012. The NOx limit for pool heaters rated less than or equal to 400,000 Btu/hr remained at 55 ppmv (or 40 ng/J heat output) because it was deemed not cost-effective for this category to meet a 20 ppmv NOx limit at the time of the rulemaking, primarily due to the small number of hours these units operate each year.

Rule 1146.2 was amended in 2018 along with Rule 1146 – Emissions of Oxides of Nitrogen from Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters, and Rule 1146.1 – Emissions of Oxides of Nitrogen from Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters. The 2018 rule amendments were to create landing rules in anticipation of the sunset of the RECLAIM program when facilities would be transitioned to a command-and-control regulatory structure. The amendment for Rule 1146.2 extended the applicability to the RECLAIM facilities and required the RECLAIM facilities to meet applicable NOx emission limits by December 31, 2023, for new installations. The 2018 amendment also committed staff to conduct a BARCT technology assessment by January 2022 to determine if a more stringent BARCT requirement should be applied to existing Type 2 units operated in RECLAIM facilities. About 80 RECLAIM facilities have been identified to operate one or more Rule 1146.2 units.

A technology assessment for Rule 1146.2 was completed by January 1, 2022, determining that the NOx emission limits should be lowered in order to satisfy BARCT requirements. Staff evaluated water heaters and boilers rated less than or equal to 2,000,000 Btu/hr in both non-RECLAIM and RECLAIM facilities and reviewed certification test reports submitted in recent years to understand the actual emission levels of certified models and the potential for achieving NOx emission reductions. Staff reviewed 137 source tests conducted since 2017 for units required to be certified at 20 ppmv for NOx emissions and found that 39 units (28 percent of units) had NOx concentrations less than 12 ppmv and 21 units (15 percent of units) had NOx concentrations less than 10 ppmv. As part of the 2021 technology assessment, staff met with stakeholders seeking their input and conducted a working group meeting on December 16, 2021. Staff recommended a future rule amendment and BARCT assessment to evaluate the potential for further NOx emission reductions.

2022 AIR QUALITY MANAGEMENT PLAN

The 2022 Air Quality Management Plan (AQMP) adopted on December 2, 2022, set forth a path for improving air quality and meeting federal air pollution standards by striving for zero-emission technologies across all sectors. The 2022 AQMP included Control Measure C-CMB-01, which seeks further NOx emission reductions from commercial building water heating sources subject to Rule 1146.2. Control Measure C-CMB-01 proposed an emission reduction of NOx by 70 to 75 percent by 2037. The control strategy focused on a combination of long-term regulation and short-term incentives with a focus on replacing existing water heaters with new zero-emission units. The incentive approach would achieve additional emission reduction, encouraging use and further technology development of zero-emission water heating for existing buildings. PAR 1146.2 will implement the 2022 AQMP Control Measure C-CMB-01.

AFFECTED INDUSTRIES

Rule 1146.2 is applicable to manufacturers, distributors, refurbishers, retailers, resellers, installers, and operators of natural gas-fired large water heaters, small boilers, and process heaters less than or equal to 2 MMBtu/hr. The table below shows the North American Industry Classification System (NAICS) for the industries affected by Rule 1146.2. Staff estimated a total of 773,000 units in the South Coast AQMD are regulated by PAR 1146.2.

Table 1-2. NAICS Codes

Industry that Typically Uses the Equipment	NAICS Codes
Oil and gas extraction	211
Electric power generation, transmission, and distribution	2211
Natural gas distribution	2212
Water, sewage, and other systems	2213
Clay product and refractory manufacturing	3271
Steel product manufacturing from purchased steel	3312
Alumina and aluminum production and processing	3313
Nonferrous metal (except aluminum) production and processing	3314
Forging and stamping	3321
Boiler, tank, and shipping container manufacturing	3324
Coating, engraving, heat treating, and allied activities	3328
Other fabricated metal product manufacturing	3329
Communications equipment manufacturing	3342
Semiconductor and other electronic component manufacturing	3344
Aerospace product and parts manufacturing	3364
Other miscellaneous manufacturing	3399
Animal food manufacturing	3111
Dairy product manufacturing	3115
Animal slaughtering and processing	3116
Bakeries and tortilla manufacturing	3118
Other food manufacturing	3119
Beverage manufacturing	3121
Textile mills and textile product mills	313, 314
Pulp, paper, and paperboard mills	3221
Converted paper product manufacturing	3222
Petroleum and coal products manufacturing	324
Basic chemical manufacturing	3251
Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	3252
Pharmaceutical and medicine manufacturing	3254
Plastics product manufacturing	3261
Retail trade	44-45
Pipeline transportation	486
Monetary authorities, credit intermediation, and related activities	521, 522
Real estate	531
Computer systems design and related services	5415
Office administrative services; Facilities support services	5611, 5612
Amusement, gambling, and recreation industries	713
Accommodation	721
Dry-cleaning and laundry services	8123

PUBLIC PROCESS

PAR 1146.2 was developed through a public process that began in the second quarter of 2023 and included a series of working group meetings, individual stakeholder meetings, and site visits to affected facilities. South Coast AQMD staff held five working group meetings on April 26, 2023, June 7, 2023, August 30, 2023, October 19, 2023, and December 13, 2023. The working group is composed of representatives from manufacturers, trade organizations, permit stakeholders, businesses, environmental groups, public agencies, consultants, and other interested parties. The purpose of the working group meetings was to present and discuss staff's BARCT assessment and the development of the proposed amendments and NOx limits for PAR 1146.2. Staff presented initial preliminary draft rule language at the working group meeting on December 13, 2023. A public workshop is scheduled for February 7, 2024. The table below summarizes the working group meetings held throughout the development of PAR 1146.2 and provides a summary of the key topics discussed at each of the working group meetings.

Table 1-3. Summary of Working Group Meetings

Date	Meeting Title	Highlights
April 26, 2023	Working Group Meeting #1	• Rule Development Process • Rule 1146.2 background • Rule approach • Unit types and NOx emissions • BARCT analysis overview • Initiated BARCT Assessment
June 7, 2023	Working Group Meeting #2	• Follow-up to stakeholder comments from Working Group Meeting #1 • Discussion on alignment with rules and strategies of other agencies • Discussion on cost and electric grid infrastructure
August 30, 2023	Working Group Meeting #3	• Follow-up to stakeholder comments from Working Group Meeting #2 • Discussion on manufacturer survey • Federal, state, and utility incentives for commercial appliances • Discussion on technologies and other regulatory requirements • Continuation of the BARCT Assessment

Date	Meeting Title	Highlights
		• Presented cost-effectiveness methods, assumptions, and initial results
October 19, 2023	Working Group Meeting #4	• Follow-up to stakeholder comments from Working Group Meeting #3 • Continued BARCT Assessment • Further discussion on applications • Further discussion on and updates to cost-effectiveness • Key rule proposal for BARCT limits for categories
December 13, 2023	Working Group Meeting #5	• Follow-up to stakeholder comments from Working Group Meeting #4 • Updates to baseline emissions and cost-effectiveness • Rule language key revisions overview
January 19, 2024		Release Preliminary Draft Rule and Staff Report
February 7, 2024		Public Workshop

In addition, staff held numerous individual meetings with stakeholders who may be impacted by this rulemaking and conducted multiple site visits to various stakeholders.

CHAPTER 2: BARCT ASSESSMENT

INTRODUCTION OF BARCT ASSESSMENT

EQUIPMENT CATEGORIES AND PROCESSES

BARCT ASSESSMENT

COST-EFFECTIVENESS AND INCREMENTAL COST-EFFECTIVENESS

ADDITIONAL BENEFITS AND CHALLENGES

INTRODUCTION OF BARCT ASSESSMENT

The purpose of a BARCT assessment is to assess available pollution controls to establish emission limits for specific equipment categories consistent with state law. Under Health and Safety Code Section 40406, BARCT is defined as:

> "an emission limitation that is based on the maximum degree of reduction achievable, taking into account environmental, energy, and economic impacts by each class or category of source."

The BARCT assessment follows a framework through the rule development process and includes public participation. The figure below illustrates the overall BARCT assessment approach.

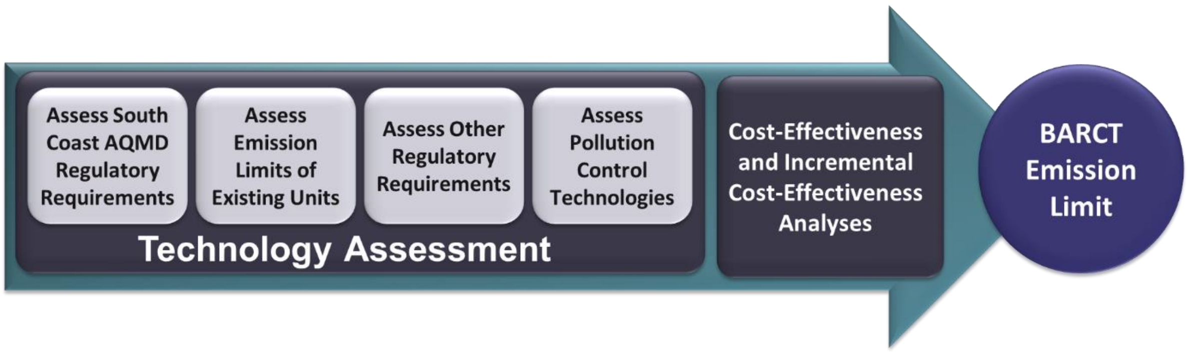

Figure 2-1. BARCT Assessment Approach

For PAR 1146.2, staff conducted a thorough technology assessment to evaluate the NOx control technologies that will achieve the BARCT level for equipment subject to PAR 1146.2. The technology assessment consists of four steps including the assessment of South Coast AQMD requirements, a complete assessment of emission limits of existing units, review of other regulatory requirements, and assessment of available pollution control technologies. Cost-effectiveness was estimated for each control technology which staff has referenced for the proposed BARCT emission limit.

EQUIPMENT CATEGORIES

One of the first steps in the BARCT assessment is to establish the category of equipment. Staff collaborated with the stakeholders to establish the categories by accounting for the type of equipment and other unique features of the units. Compared with the current Rule 1146.2, PAR 1146.2 defines Type 1 and Type 2 units by the same heat input capacities, except that additional categories are defined for Type 1 and Type 2 units for different implementation schedules. Staff categorized the equipment subject to PAR 1146.2 as presented in Table 2-1:

Table 2-1. PAR 1146.2 Equipment Categories

Equipment Category	Description
Type 1 Unit	Units with rated heat input capacity less than or equal to 400,000 Btu per hour as defined in the rule. For zero-emission limit requirements, Type 1 high temperature units, Type 1 pool heaters, and tankless water heaters are divided out for different implementation dates.
Type 2 Unit	Units with rated heat input capacity greater than 400,000 Btu per hour and up to and including 2,000,000 Btu per hour as defined in the rule. For zero-emission limit requirements, Type 2 high temperature units and tankless water heaters are divided out for different implementation dates.
Type 1 Pool Heater	Units with rated heat input capacity less than or equal to 400,000 Btu per hour that are used for pool heating. Note that pool heaters in the Type 2 size range are covered under the Type 2 water heater category.
Type 1 High Temperature Unit	Referring to Type 1 units that are high temperature units, which are units used to produce steam or to heat water above 190 degrees Fahrenheit.
Type 2 High Temperature Unit	Referring to Type 2 units that are high temperature units.
Instantaneous (Tankless) Water Heater	Units sized at or under 2,000,000 Btu/hr that heat water only when water flows through a heat exchanger. There is no storage tank for this kind of unit.

BARCT ASSESSMENT

Assessment of South Coast AQMD Regulatory Requirements

Staff reviewed existing South Coast AQMD NOx regulations for large commercial water heaters, boilers, process heaters, and similar equipment. The following table summarizes the current South Coast AQMD NOx rules that staff evaluated as part of the BARCT technology assessment. Staff presented the assessment of South Coast AQMD regulatory requirements in Working Group Meeting #1 on April 26, 2023.

Rules 1146, 1146.1, and 1121

Rule 1146 establishes emission limits for boilers, steam generators, and process heaters fueled by gaseous fuels, which are segregated into three different groups based on heat input capacity:

- Group I (greater than or equal to 75,000,000 Btu/hr, excluding thermal fluid heaters and units operated at schools and universities),
- Group II (greater than or equal to 20,000,000 Btu/hr and less than 75,000,000 Btu/hr, excluding units burning digester and landfill gases and thermal fluid heaters and units operated at schools and universities) and
- Group III (greater than or equal to 5,000,000 Btu/hr and less than 20,000,000 Btu/hr, excluding units burning digester and landfill gases and atmospheric units and thermal fluid heaters).

By the 2008 amendment, Rule 1146 Group I units were required to meet a lower NOx emission limit of 5 ppmv. Group II and III are subject to the 9 ppmv NOx limit.

Rule 1146.1 establishes emission limits for small industrial, institutional, and commercial boilers, steam generators, and process heaters with rated heat input greater than 2,000,000 Btu/hr and less than 5,000,000 Btu/hr. Most of the Rule 1146.1 units are subject to the 9 ppmv NOx limit.

Both Rules 1146 and 1146.1 include a limit of 12 ppmv NOx for atmospheric units and a limit of 30 ppmv for thermal fluid heaters. All units subject to Rule 1146 and 1146.1 fired by landfill gases were required to meet NOx emissions limits of 25 ppmv by January 1, 2015, and units fueled by digester gas were required to meet 15 ppmv by January 1, 2015.

Rule 1121 establishes NOx emissions limits for natural gas-fired water heaters with heat input rates less than 75,000 Btu/hr which are mostly tank type water heaters used in residential buildings. Rule 1121 requires a NOx emission limit of 10 ng/J (15 ppmv) with an exemption for water heaters in recreational vehicles.

Table 2-2. South Coast AQMD Regulatory Requirements

Regulation/Rule Title	Relevant Unit/Equipment Size	Current NOx Emission Limits in ng/J or ppmv at 3% O_2, dry
Rule 1146 – Emissions of Oxides of Nitrogen from Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters	Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters (greater than or equal to 5,000,000 Btu/hr rated heat input capacity)	• 9 ppmv for units burning gaseous fuels 5,000,000 Btu/hr to 75,000,000 Btu/hr; • 5 ppmv for units burning natural gas greater than or equal to 75,000,000 Btu/hr; • 30 ppmv for thermal fluid heaters burning gaseous fuels; • 40 ppmv for nongaseous fuels; • 12 ppmv for atmospheric units; • 15 ppmv for units burning digester gas; • 25 ppmv for units burning landfill gas
Rule 1146.1 – Emissions of Oxides of Nitrogen from Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters	Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters (greater than 2,000,000 Btu/hr and less than 5,000,000 Btu/hr rated heat input capacity)	• 9 ppmv for units greater than 2,000,000 Btu/hr and less than 5,000,000 Btu/hr burning natural gas; • 12 ppmv for atmospheric units; • 15 ppmv for units burning digester gas; • 25 ppmv for units burning landfill gas

Regulation/Rule Title	Relevant Unit/Equipment Size	Current NOx Emission Limits in ng/J or ppmv at 3% O_2, dry
Rule 1146.2 – Emissions of Oxides of Nitrogen (NOx) from Large Water Heaters, Small Boilers and Process Heaters	Large Water Heaters, Small Boilers and Process Heaters (less than or equal to 2,000,000 Btu/hr rated heat input capacity, excluding tank type water heaters subject to Rule 1121)	14 ng/J; 20 ppmv (except for Type 1 pool heaters which are at 40 ng/J or 55 ppmv)
Rule 1121 – Control of Nitrogen Oxides from Residential-Type, Natural Gas-Fired Water Heaters	Residential-Type, Natural Gas-Fired Water Heaters (less than 75,000 Btu/hr rated heat input capacity)	10 ng/J; 15 ppmv (except for water heaters used in recreational vehicles)

Assess Limits of Existing Units

The next step of the BARCT assessment is to evaluate the emission of existing units operating within the South Coast AQMD. For this step, staff evaluated current South Coast AQMD NOx regulations for other similar combustion equipment to assess potential technology transfer. Staff reviewed 137 source tests conducted since 2017, as shown in the figure below. For Type 1 and Type 2 units required to be certified at 20 ppmv for NOx emissions, staff found that 39 units (28 percent of units) had tested under 12 ppmv and 21 units (15 percent of units) had tested under 10 ppmv. Reviewing certification tests conducted since 2017 indicated that 33 percent of certified pool heaters tested under 12 ppmv, with some testing at 3.3 ppmv.

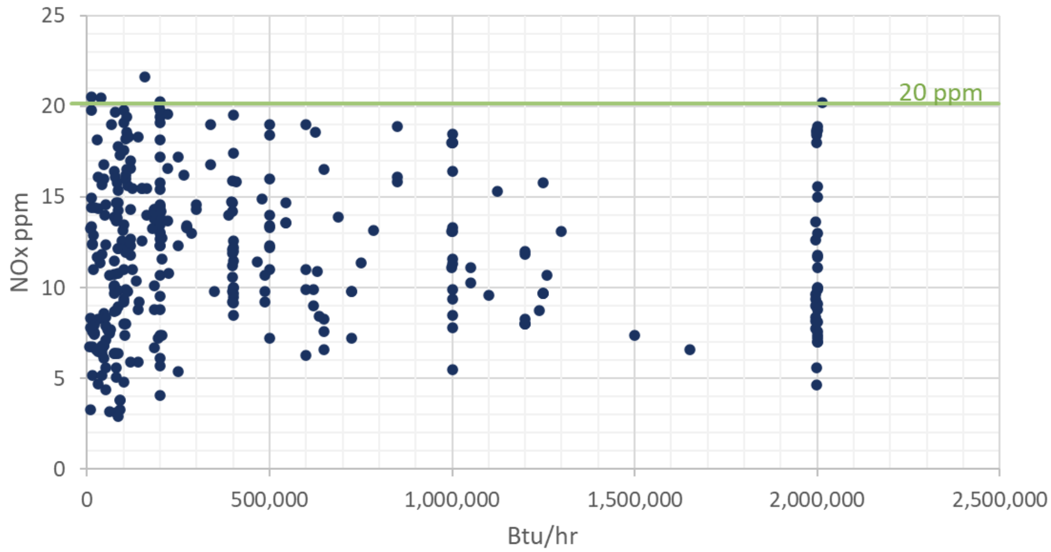

Figure 2-1. Source Test Data: NOx ppmv at 3 percent Oxygen from Certifications

Assess Other Regulatory Requirements

Other Regulatory Requirements

The next step of the assessment is to identify other agencies that regulate the same or similar equipment and compare the regulatory requirements and emissions limits. The purpose of this step is to evaluate if there are applicable emissions limits lower than the current South Coast AQMD limits that should be considered. The table below includes the list of regulations by other agencies which staff reviewed for applicable emissions limits. The specific emission limits and their impact on the BARCT assessment included for each category are discussed later for each of the equipment categories.

With regards to zero-emission standards for building appliances, other agencies are considering or have already adopted similar rules, and a South Coast AQMD rule cannot be less stringent than a state-wide rule. The California Air Resources Board (CARB) has commenced its rulemaking process for potential state-wide standards to "develop and propose zero-emission standards for space and water heaters sold in California" with potential implementation in 2030 as committed in the 2022 State Strategy for the State Implementation Plan.[1] CARB held its first public workshop on May 10, 2023.[2] The California Energy Commission's (CEC) 2022 Building Energy Efficiency Standards (Energy Code) apply to newly constructed buildings and additions and alterations to existing buildings. The 2022 Energy Code encourages efficient electric heat pumps, establishes electric-ready requirements for new homes, expands solar photovoltaic and battery storage standards, and more.[3] Buildings whose permit applications are applied for on or after January 1, 2023, must comply with the 2022 Energy Code. There are mandatory requirements for electric ready and heat pump ready multifamily buildings, and the Energy Code discourages use of electric

[1] California Air Resources Board, 2022 State SIP Strategy, p. 30, https://ww2.arb.ca.gov/sites/default/files/2022-08/2022_State_SIP_Strategy.pdf

[2] California Air Resources Board, Zero-Emission Appliances Meetings & Workshops, https://ww2.arb.ca.gov/our-work/programs/building-decarbonization/zero-emission-appliance-standards/meetings-workshops

[3] California Energy Commission, 2022 Building Energy Efficiency Standards, https://www.energy.ca.gov/sites/default/files/2022-12/CEC-400-2022-010_CMF.pdf

resistance heating when an alternative method of heating is available. The Energy Code is contained in Title 24, Part 6 of the California Code of Regulations and is updated every three years.

Bay Area Air Quality Management District (BAAQMD) adopted Rule 9-6 – Nitrogen Oxides Emissions from Natural Gas-Fired Boilers and Water Heaters in March 2023 with zero-emission limits for 2031 implementation. The BAAQMD analysis found that zero-NOx 240-volt heat pump water heaters are widely commercially available at sizes equivalent to existing natural gas systems on market for commercial spaces; technology development and field testing is still needed to bring compliant appliances of larger water heaters and boilers up to 2 MMBtu/hr to market; and BAAQMD staff expects that the availability of zero-NOx units will increase, and costs will decrease over time. BAAQMD committed to an Implementation Working Group and reporting back to their Board on technology developments and availability. Staff presented the assessment of other regulatory requirements in Working Group Meetings #1 and #2, detailed in the tables below.

Table 2-3. Other Regulatory Requirements

Regulatory Entity	Regulation/Rule	Relevant Emission Limits
San Joaquin Valley Air Pollution Control District (Valley Air District)[4]	Rule 4308 – Boilers, Steam Generators, Process Heaters (units with a total rated heat input capacity of greater than or equal to 75,000 Btu/hr and less than 2,000,000 Btu/hr) – Exempts units installed in manufactured homes, units installed in recreational vehicles, and hot water pressure washers	20 ppmv (except for pool heaters greater than or equal to 75,000 Btu/hr and less than or equal to 400,000 Btu/hr, which are at 55 ppmv)
Bay Area Air Quality Management District (BAAQMD)[5]	Rule 9-6 – Nitrogen Oxides Emissions from Natural Gas-Fired Boilers and Water Heaters (units with total rated heat input capacity of 75,000 – 2,000,000 Btu/hr) adopted in March 2023	Zero-emission limits with implementation in 2031 – Exempts units installed in manufactured homes (40 ng/J limit), units installed in recreational vehicles, and pool/spa heaters with less than 400,000 Btu/hr rated heat input capacity used exclusively to heat swimming pools, hot tubs, or spas

[4] San Joaquin Valley Air Pollution Control District, Rule 4308, https://ww2.valleyair.org/media/o5pdu0oe/rule-4308.pdf

[5] Bay Area Air Quality Management District, Rule 9-6, https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-4-nitrogen-oxides-from-fan-type-residential-central-furnaces/2021-amendments/documents/20230315_rg0906-pdf.pdf?rev=436fcdb037324b0b8f0c981d869e684d&sc_lang=en

Regulatory Entity	Regulation/Rule	Relevant Emission Limits
California Air Resources Board (CARB)[6]	2022 State Strategy for the State Implementation Plan (adopted September 22, 2022) proposed measures for residential and commercial buildings; Anticipating Board consideration for rule adoption in 2025	Proposed zero-emission limits (GHG, NOx) for new equipment and appliances sold for use in both residential and commercial buildings, with implementation in 2030

On the local level, over 60 cities and counties across California are considering policies to support zero-emission appliances for new construction.

Assess Pollution Control Technologies

Assessment of Pollution Control Technologies

The next step is to research the commercially available emission control technologies and seek information on any emerging emission control technologies. As part of this assessment, staff met with multiple manufacturers. South Coast AQMD Rule 1146.2 is technology and fuel neutral and is focused on achieving NOx emission reductions.

Staff assessed different pollution control technologies as part of the BARCT assessment. Staff presented and discussed the pollution control technology assessment in working group meetings. The objective is to identify and evaluate control technologies, approaches, and potential emission reductions.

Emerging Technology and Zero-Emission Technology

Zero-emission technologies such as heat pumps and electric resistance technologies were explored as part of the BARCT assessment. Staff conducted internet searches, met with stakeholders, and sent a survey to manufacturers to gather more information on emerging and zero-emission technology.

Manufacturer Survey

On May 10, 2023, staff sent a survey to space and water heating manufacturers to gather information on zero-emission technologies, after sending an initial draft survey to stakeholders for feedback on April 28, 2023. The survey covered types of zero-emission technology; applications for installation in residential or commercial buildings; available models; energy efficiency ranges; current annual sales in the South Coast AQMD region; incremental manufacturing cost for the technology; concerns for the technology; and focus of current and future development.[7] Staff received eight responses to the manufacturer survey and presented the aggregate and anonymized responses in the working group meeting on August 30, 2023. Manufacturers who responded to the survey reported that they provided air source and water source heat pump water heater units and hybrid heating, cooling, and water heating, including split system units with heating capacity

[6] California Air Resources Board, 2022 State SIP Strategy, p. 30, https://ww2.arb.ca.gov/sites/default/files/2022-08/2022_State_SIP_Strategy.pdf

[7] South Coast AQMD, Proposed Amended Rule 1146.2, Manufacturer Survey, http://www.aqmd.gov/docs/default-source/rule-book/Proposed-Rules/rule-1146-1146.1-and-1146.2/manufacturer-survey---may-10.xlsx?sfvrsn=6

between 60,000 to 250,000 Btu/hr; variable speed; ducted or ductless; indoor or outdoor; and modular units (that can dynamically adjust their capacity) up to 2.2 MMBtu/hr. Manufacturers also reported integrated units with up to 2 MMBtu/hr output. Manufacturers reported plans for future heat pump water heater development, including: reduce necessary storage tank capacity; improve capacity and efficiency at lower ambient temperatures; improve efficiency through variable speed compressor and pump control; increase outlet water temperature; utilize alternate refrigerants that allow lower ambient and higher output temperature operation; expand integrated and split-system all-electric heat pumps (air-to-water) to units with larger heating capacities; expand water source in addition to air source technology; and expand efforts in modular design and commercial hydronic heating heat pumps.

Manufacturers who responded to the survey also reported that they provided electric resistance elements for boilers; electric resistance single-stage compressor and fan for pool heating; and all-electric air-to-water heat pumps for pool heating. Manufacturers who responded to the survey reported that they provide electric resistance storage water heater products up to 900 kW input (approximately 3 MMBtu/hr) and electric resistance tankless water heater products up to 150 kW (approximately 500,000 Btu/hr).

Based on the feedback from manufacturers, staff understands that there is a range of heat pump and electric resistance units available to replace gas units subject to this rule. However, manufacturers will continue development to improve and expand zero-emission products.

Heat Pump Technology

Common zero-emission water heating technology includes heat pumps. Heat pumps operate like a refrigerator or air conditioning unit by moving heat from one place (such as air, water, or ground) to another. This technology can be over three times more efficient than conventional appliances and can be used for water heating and space heating and cooling. For pool heating, heat pump pool heaters are an option and are often more efficient than electric resistance pool heating.

An integrated heat pump with a water tank packaged as a single unit, as shown in the image below, can be sized for commercial applications and can include rooftop units for one or multiple zones. Another type of heat pump is a split heat pump water heater with a water tank that can be located as far as fifty feet apart, as shown in the image below. The compressor when located outdoors takes in heat from outdoor air rather than indoor air.

Figure 2-2. Examples of Integrated Heat Pump (Left) and Split System Heat Pump (Right)

Some stakeholders have expressed concerns over how well heat pumps will operate in colder climates, such as the high-altitude locations within the South Coast AQMD. There are heat pump products available in the market that can operate at low temperatures, and the Northwest Energy Efficiency Alliance's Qualified Products List includes heat pump water heater products that are energy efficient in cold climates and products that can produce hot water via heat pump at negative 25 degrees Fahrenheit. Cold climate heat pumps can pull heat from the air even at below-zero temperatures and are utilized in colder climates in the U.S. and abroad. Maine has one of highest per capita heat-pump adoption rates, outpacing Scandinavian countries, with rebates incentivizing installation of approximately 116,000 heat pumps in a state that has fewer than 600,000 occupied housing units. Heat pump technology is also being adopted in states such as Vermont and Alaska, and according to the International Energy Agency, 60 percent of Norway's buildings are fitted with a heat pump.

One concern is whether sufficiently high-water temperatures needed to meet certain commercial applications could be achieved by using a heat pump water heater. One common practice is to use a booster heater, which can be electric, to increase water temperature up to 180 degrees Fahrenheit. This would satisfy the domestical water temperature requirements for dietary, laundry, and dishwashing. There are also products existing and emerging in the market that can meet the high-water temperature demand. For example, an internet search of examples of units sold or installed in U.S. or Southern California with focus on high water temperatures found products providing water temperature between 160 and 248 degrees Fahrenheit, with waste heat recycling systems capable of achieving up to 248 degrees Fahrenheit. This is a type of technology where a heat pump extracts wasted heat from a heat source (chilled water, cooling tower water, or any consistent waste heat) and raises the temperature to a useful level. The heat pump allows reuse of low-temperature heat (less than 140 degrees Fahrenheit). Through the refrigeration cycle of the heat pump, hot water temperature can be increased up to 248 degrees Fahrenheit.[8] Applications of waste heat include sterilization; hot and chilled water for hotels, hospitals, schools, and universities; boiling processes for food manufacturing; and other industry processes. Waste heat application is opted for only when there is an existing source that provides waste heat. It is not intended for installation of a large combustion unit with the purpose of serving waste heat for a zero-emission unit such as a heat pump. The energy efficiency of these products varied, with Coefficient of Performance (COP) between 4.3 and 6.0, or between 4.3 to 6 times more efficient than electric resistance units. For many commercial processes, heat pumps are a viable technology.

Staff recognizes that for steam, heat pump technology may not be viable in the market yet, and for certain industrial processes, heat pump technology is not as mature and electric resistance options are more expensive to operate due to the energy demand. As part of the BARCT assessment, including discussions with manufacturers, staff determined that a temperature threshold was necessary to provide more time for the zero-emission technology market to mature for high temperature applications. As discussed above, zero-emission technologies for providing water temperature up to 180 degrees Fahrenheit are available. Further discussion in a later section indicates that California plumbing code hot water temperature requirements are also up to 180 degrees Fahrenheit. Therefore, staff suggested a temperature threshold of 190 degrees Fahrenheit in the working group meetings for special consideration on high temperature applications. PAR 1146.2 provides a definition for high temperature units used to produce steam or heat water above 190 degrees Fahrenheit, and the compliance schedule for zero-emission limits differentiates high temperature units with further implementation dates. Staff intends to conduct a technology assessment prior to the proposed implementation dates for high temperature units to gather information on changes in technology development and availability.

Zero-emission technology for commercial and industrial applications is continuing to develop, with New Belgium Brewing in Colorado partnering with AtmosZero on a pilot study to replace their gas boiler with industrial electric heat pump technology in 2024.[9] The facility is currently operating at 329 degrees Fahrenheit. An air source heat pump water heater can be used to generate steam (greater than 212 degrees Fahrenheit), operate in sub-zero temperatures, with potential applications including breweries, dairies, plastics, pharmaceuticals, food, paper, and more. The pilot study hopes to result in an off-the-shelf product at a comparable price to a combustion unit. The current unit is larger than the size range for 1146.2 units, with some potential for further technology development for smaller units. The International Energy Agency's Technology Collaboration Programme on Heat Pumping Technologies expects high-temperature heat pump technologies to become more commercially available and implemented in coming years.[10]

Electric Resistance Technology

Another common zero-emission water heating technology is electric resistance water heating with storage. Generally, this consists of an insulated steel tank with two electric resistance elements that heat the water. These units are available in a large range of sizes for the commercial market. For a

[8] Armstrong International Inc., https://armstronginternational.com/products-landing/heat-pump-packages/
[9] The Colorado Sun, New Belgium Brewing prepares for industrial heat pump that could cut its greenhouse gas emissions, https://coloradosun.com/2023/09/11/new-belgium-greenhouse-gases-atmoszero-heat-pump/
[10] Annex 58, Task 1: Technologies, https://heatpumpingtechnologies.org/annex58/task1/

commercial electric boiler, no air intake or exhaust venting is required. There are also tankless/mini-tank (point-of-use) electric water heaters which provide hot water at the consumption point and only heat water when necessary. For pool heating, electric resistance swimming pool heaters are a more efficient option than gas-fired pool heaters.

There are also commercial hybrid electric water heaters which utilize heat pump heating and electric resistance heating. These units pull heat from the surrounding air to heat water and use less energy than a standard electric water heater. A commercial heat pump boiler would consist of an all-electric heat pump with an optional built-in backup electric boiler for very cold days.

Solar Water Heating Technology

Solar water heating is another option, where solar thermal hot water systems range in size from conventional-sized systems to large industrial applications and consist of flat plate collectors, a controller, pump, storage. There are also swimming pool solar heaters which consist of solar collectors, filters, pumps, and control valves. They can be standalone units, with collectors mounted on roofs or anywhere near the pool.

Fuel Cell Technology

Fuel cells have a broad range of applications from multi-megawatt systems to small units and continue to expand with emerging technologies.[11] Cost and durability are still critical challenges, and studies have indicated price ranges between $4,000 to $20,000 per kW. Natural gas fuel cells produce some NOx emissions. Staff recognizes the applications of zero-emission fuel cells and that this is an emerging technology. Over 100,000 fuel cells have been deployed in Europe and over 300,000 units in Japan primarily for residential applications.[12] Fuel cell adoption in California currently is limited.

COST-EFFECTIVENESS AND INCREMENTAL COST-EFFECTIVENESS

Initial BARCT Emission Limit and Other Considerations

After completing the technology assessment, staff recommends an initial BARCT NOx emission limit established using information gathered from the technology assessment. All provided emission concentration values (i.e., initial and final) in this report refer to concentration in terms of parts per million by volume (ppmv) based on a dry basis. Additionally, staff evaluates other considerations that could affect the emission limits that represent BARCT, including limits for those units operating close to the BARCT NOx limits. Heat pump technologies are still the main technologies that can achieve in the nearer-term the NOx concentration limits proposed in PAR 1146.2. Summary of the BARCT assessment and staff's recommendations based on feasibility is shown below.

Method for Cost-Effectiveness and Incremental Cost Effectiveness Analysis

The South Coast AQMD routinely conducts cost-effectiveness analyses regarding proposed rules and regulations that result in the reduction of criteria pollutants (NOx, SOx, VOC, PM, and CO). The analysis is used as a measure of relative effectiveness of a proposal. It is generally used to compare and rank rules, control measures, or alternative means of emissions control relating to the cost of purchasing, installing, and operating control equipment to achieve the projected emission

[11] U.S. Department of Energy, Multi-Year Research, Development, and Demonstration Plan, https://www.energy.gov/sites/default/files/2017/05/f34/fcto_myrdd_fuel_cells.pdf

[12] PACE, Fuel Cell micro-Cogeneration reaches another milestone in Japan, https://pace-energy.eu/fuel-cell-micro-cogeneration-reaches-another-milestone-in-japan/

reductions. The major components of the cost-effectiveness analysis are capital costs, emission reductions, discount rate, and equipment useful age. The cost-effectiveness for PAR 1146.2 was completed using the discounted cash flow method, explained below:

Discounted Cash Flow (DCF)

The DCF method converts all costs, including initial capital investments and costs expected in the present and all future years of unit useful age, to present value. Conceptually, it is as if calculating the number of funds that would be needed at the beginning of the initial year to finance the initial capital investments and to set aside to pay off the annual costs as they occur in the future. The fund that is set aside is assumed to be invested and generates a rate of return at the discount rate chosen. The final cost-effective measure is derived by dividing the present value of total costs by the total emissions reduced over the unit useful age. The equation below is used for calculating cost-effectiveness with DCF. The equation was presented in the 2022 AQMP Socioeconomic Report Appendix 2-B (p. 2-B-3):

$$Cost - effectiveness = \frac{Initial\ Capital\ Investments\ +\ (Annual\ O\&M\ Costs\ \times\ PVF)}{Annual\ Emission\ Reductions\ \times\ Years\ of\ Equipment\ Life}$$

Where O&M = Operation and Maintenance; and
PVF = Present Value Factor.

Equation 2-1. Discounted Cash Flow Cost Effectiveness Equation

And the PVF is calculated as follows:

$$PVF = \frac{(1+r)^N - 1}{r * (1+r)^{(N-1)}}$$

Where r = real interest rate (discount rate); and
N = years of equipment life.

Equation 2-2. PVF Equation

Finally, Health and Safety Code Section 40920.6 (a)(3) states that an incremental cost-effectiveness assessment should be performed on identified potential control options that meet air quality objectives. To determine the incremental cost-effectiveness under this paragraph, South Coast AQMD calculates the difference in the dollar costs divided by the difference in the emission reduction potentials between each progressively more stringent potential control option as compared to the next less expensive control option. Once the BARCT assessment is complete and NOx limits are established, staff considers incrementally more stringent options to demonstrate that the NOx limit represents the "maximum degree of reduction achievable by each class or category." The equation for incremental cost-effectiveness is below:

$$I\text{-}CE\left(\$/_{tons\ NOx\ reduced}\right) = \frac{Incremental\ Difference\ in\ Cost\ (Present\ Worth\ Value)}{Incremental\ Difference\ in\ Emission\ Reductions\ (Lifetime\ Reductions)}$$

Where I-CE = Incremental Cost-Effectiveness

Equation 2-3. Incremental Cost Effectiveness Equation

For PAR 1146.2, staff did not identify multiple control options that would meet the air quality objectives. The 2022 AQMP's objective is to transition to zero-emission technologies wherever feasible and staff identified technically feasible zero-emission control options for each category of equipment subject to Rule 1146.2; therefore, staff did not conduct an incremental cost-effectiveness assessment.

Summary of Cost-Effectiveness Analysis and Incremental Cost-Effectiveness Analysis

In order to determine cost-effectiveness for the proposed BARCT limits, cost information and estimates for the control equipment were obtained. Staff met with multiple manufacturers and stakeholders to gather cost data and estimates for various types of units. In addition, staff also sent out a survey to the facilities to gather equipment data and cost information for recent NOx control projects. After cost information was obtained, a bottom-up approach evaluated each unit category subject to PAR 1146.2 and cost-effectiveness analysis was conducted on a per equipment basis. Baseline emissions for each equipment were calculated using the assumption methodology outlined in Chapter 4.

Natural Gas-Fired Unit Efficiency

A major manufacturer recommended utilizing 95 percent efficiency for gas-fired units in cost effectiveness calculations. Currently products in the market range from 80 to 95 percent, with older units being less efficient. Some products in the market can reach a 95 percent efficiency, and manufacturers suggested that future U.S. Department of Energy (U.S. DOE) or CEC standards may be raised to require 95 percent efficiency. As not all units currently achieve 95 percent efficiency, this assumption likely results in an overestimate of the cost to switch to zero-emission technologies; however, the cost-effectiveness assessment is for future available technologies, so staff agreed to use the 95 percent efficiency assumption. Utilizing a lower percentage efficiency for natural gas-fired units would result in better cost-effectiveness estimates.

Capacity Factors

The capacity factor is the proportion of time the unit is expected to operate. Consistent with the rule development process for the Rule 1146.2 amendments in 2006, the analysis assumed the capacity factor for Type 1 and Type 2 natural gas-fired water heaters and boilers to be 21.5 percent, meaning the unit is estimated to operate 21.5 percent of time at maximum heat input capacity. This assumption was taken from a manufacturer survey conducted during the previous Rule 1146.2 rule development.

The analysis assumed a 7.16 percent capacity factor for Type 1 pool heaters that are gas-fired. This assumption was taken from the 2004 implementation study for Rule 1146.2. The PAR 1146.2 analysis for heat pump pool heaters assumed a 14.32 percent capacity factor, double of 7.16 percent, since heat pump pool heaters are expected to operate for longer times than gas-fired pool heaters.

Tankless on-demand units operate at high heat for less time than tank-type units operate. The Energy Star's estimated annual usage for the natural gas-fired tankless water heater example is 178 therms or 17.8 MMBtu/hr. The analysis divided 17.8 MMBtu/hr by 8,760 hours in a year and by the size of the unit to estimate the capacity factor for a tankless unit: 17.8 MMBtu/hr ÷ 8,760 hours ÷ 150,000 Btu = 0.0135, or 1.35 percent.

Incremental Installation, Maintenance, and Labor Cost

The analysis considered negligible incremental installation, maintenance, and labor costs, since the requirement for zero-emission units is at the end of natural gas-fired unit age, when similar costs will be required for installing another natural gas-fired unit. As heat pump installations become more standard, the installation costs are anticipated to be comparable to the installation costs for conventional units.

Electrical Panel Upgrade Cost

In some instances, the transition to zero-emission units will require the electrical panel to be upgraded, which will add costs for the owner or operator of the units. For the cost-effectiveness analysis, the analysis relied on the panel upgrade cost estimate of $5,000 from the 2022 AQMP and considered a useful age of 30 years for the panel. However, the cost of an electrical panel upgrade was adjusted to account for this longer useful age of the electrical panel versus the unit. For panel upgrade cost in the PAR 1146.2 cost-effectiveness calculation, $2,500 was utilized for pool heaters (considering the 15-year useful unit age) and $4,200 was utilized for other categories (considering the 25-year useful unit age). For some categories involving residential units, the panel cost was split between residential appliances. Electrical panel upgrades will not be required for all instances where conventional units are replaced with zero-emission units, so staff assessed the cost-effectiveness with and without the estimated cost of the upgrades.

Type 1 Water Heaters

For storage water heaters, U.S. DOE estimates a unit useful age of 10 to 15 years.[13] For the 2022 AQMP Control Measure C-CMB-01 development, the analysis assumed 15 years of unit age for commercial water heaters.[14] For this reason, the analysis for Type 1 water heaters assumes a 15-year unit age and four percent discount rate and thus a PVF of 11.118, as calculated per Equation 2-2, and the estimated cost of an electrical panel upgrade of $2,500.

Type 2 Water Heaters

Meetings and site visits with manufacturers during the rulemaking process indicated useful unit age of over 25 years for gas-fired water heaters. For Type 2 water heaters, the analysis assumes a 25-year unit age and four percent discount rate thus a PVF of 15.622, as calculated per Equation 2-2, and the estimated cost an electrical panel upgrade of $4,200.

Type 1 Pool Heaters

According to U.S. DOE, heat pump swimming pool heaters work efficiently as long as the outside temperature remains above the range of 45 to 50 degrees Fahrenheit. The cooler the outside air that a heat pump draws in, the less efficient it is. However, as outdoor pools are more frequently

[13] U.S. Department of Energy, Tankless or Demand-Type Water Heaters, https://www.energy.gov/energysaver/tankless-or-demand-type-water-heaters

[14] South Coast AQMD, 2022 AQMP, https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/final-2022-aqmp/appendix-iv-a.pdf?sfvrsn=18

used during warm and mild weather, this reduced efficiency is generally not an issue. Heat pump pool heaters may cost more than natural gas-fired pool heaters, but they typically have much lower annual operating costs due to their higher efficiencies. With proper maintenance, heat pump pool heaters typically last longer than gas pool heaters. U.S. DOE estimates that with proper installation and maintenance, heat pump pool heaters can last 10 or more years.[15] For Type 1 pool heaters, the analysis assumes a 15-year unit useful age and four percent discount rate and thus a PVF of 11.118, as calculated per Equation 2-2, and the estimated cost for an electrical panel upgrade of $2,500. If splitting the panel cost between pool heating and other residential appliances, the panel cost is $2,500 ÷ 2 = $1,250. The analysis also utilizes the residential utility rate forecast for Type 1 pool heaters.

Type 1 and Type 2 Boilers

Meetings and site visits with manufacturers during the rulemaking process indicated useful unit age of over 25 years for gas-fired boilers. For Type 1 and Type 2 boilers, the analysis assumes a 25-year unit age and four percent discount rate and thus a PVF of 15.622, as calculated per Equation 2-2, and the estimated cost for an electrical panel upgrade of $4,200.

Instantaneous (Tankless) Water Heaters

U.S. DOE estimates a useful unit age of more than 20 years for instantaneous (tankless) water heaters.[16] For tankless water heaters, the analysis assumes a 25-year unit age and four percent discount rate and thus a PVF of 15.622, as calculated per Equation 2-2, and the estimated cost of an electrical panel upgrade of $4,200. If splitting the panel cost between pool heating and other residential appliances, the panel cost is $4,200 ÷ 2 = $2,100.

Estimating Fuel Switching Cost

The analysis considered the cost impacts of transitions from conventional combustion heating that use natural gas to zero-emission technologies that use electricity as part of the cost-effectiveness assessment. For this assessment, the analysis relied upon the fuel price estimates which are based on a combination of CEC's Integrated Energy Policy Report and Energy Information Administration (EIA) national level forecasts. The current CEC forecast extends to 2035. Electricity forecasts are based on the Los Angeles Department of Water and Power (LADWP) and Southern California Edison (SCE) planning areas. Natural gas forecasts are only based on Southern California Gas company forecasts, as Southern California Gas company is the primary gas utility in the region. Forecasted prices will not match observed electric and natural gas prices in any given year and may differ materially. Current prices are affected by demand and supply shocks, geopolitical factors, and other considerations which are all unforecastable. However, the CEC forecasts are created through a rigorous modeling process and reflect the best available expectation for future prices in the region. CEC forecasts are released every two years.

The analysis utilizes the residential utility rate forecast for Type 1 pool heaters and tankless water heaters, and commercial utility rate forecast for other units.

[15] U.S. Department of Energy, Heat Pump Swimming Pool Heaters, https://www.energy.gov/energysaver/heat-pump-swimming-pool-heaters

[16] U.S. Department of Energy, Tankless or Demand-Type Water Heaters, https://www.energy.gov/energysaver/tankless-or-demand-type-water-heaters

Since the forecasted prices for LADWP and SCE differ, staff calculated a weighted average price based on the population served by each utility as follows:

- LADWP: 4 million ÷ 17.2 million (Population served by LADWP ÷ regional population) = 0.23
- SCE: 13.2 million ÷ 17.2 million = 0.77

To estimate the fuel switching cost by category for replacement of natural gas-fired units with zero-emission technology, the analysis:

1. Estimated the daily electricity demand (in kWh) of the electric unit which will be replacing the existing natural gas fired unit;
2. Estimated the daily natural gas demand (in therms) of the existing natural gas fired unit;
3. Multiplied the daily demand for each fuel type by the number of operating days in a year to estimate the annual energy demand of each unit;
4. Multiplied the annual energy demand in each year and for each fuel type by the forecasted price of each fuel in that year to estimate the annual fuel cost for each unit;
5. Netted the difference between the total electricity cost and total natural gas cost to estimate incremental fuel switching cost in each year.

The list of steps explains the process to estimate switching costs of a single unit. The analysis also utilized a bottom-up calculation with individual units that fill similar roles from different categories. The daily electricity and natural gas demand values were estimated by the following approaches, where applicable.

Energy Input Estimate Method

With this method, the fuel switching costs for electric replacement units were estimated based on electric input values (kWh) provided by the unit manufacturer.

Energy Input Calculation Method

For situations where the energy input was not provided by an unit manufacturer, an alternate, more conservative method than the Energy Input Estimate Method was relied upon to calculate fuel switching cost, which is referred to here as the "Energy Input Calculation Method." There are certain factors that this alternate method does not take into account. For example, while the Energy Input Calculation Method assumes the same amount of energy output for the gas unit and electric replacement unit via hot water, the oversizing of heat pumps replacing gas-fired units and cycling losses may not be represented. To calculate daily kWh input:

$$\text{Gas Unit Rating in Btu/hr} \times 24 \text{ hours} \times \text{Gas Unit Capacity Factor} \div 3{,}412.14 \text{ Btu/kWh} \times 0.95 \text{ Gas Unit Efficiency} \div \text{COP Heat Pump Efficiency}$$

Equation 2-4. Energy Input Calculation Method Equation

Note that 1 kWh = 3,412.14 Btu.

Cost and Cost-Effectiveness

Cost-Effectiveness Screening Threshold

The 2022 AQMP established a cost-effectiveness screening threshold of $325,000 per ton of NOx reduced based on 2021 dollars. The 2022 AQMP stated that this screening threshold will be adjusted based on the annual California Consumer Price Index (CPI). PAR 1146.2 currently considers a $349,000 per ton of NOx reduced cost-effectiveness screening threshold using 2022 dollars. The 2022 AQMP threshold is neither considered a starting point for control costs, nor an absolute cap.

Type 1 Water Heater

The analysis considered the potential replacement of a 76,000 Btu/hr natural gas-fired Type 1 water heater with a zero-emission heat pump water heater. The capital cost for a natural gas-fired unit is estimated at $7,000, which was derived from the Rule 1146.2 May 2006 final staff report which estimated the cost for a unit with a heat rating ranging from 100,000 to 300,000 Btu/hr and adjusted to present value by the CPI Inflation Calculator. A manufacturer provided the capital cost of $11,000 for a zero-emission indoor packaged commercial heat pump unit with a COP of 4.2. The annual energy input of 5,841 kWh was provided by the manufacturer for the unit. The unit water use is 350 gallons per day.[17]

By applying the Energy Input Estimate Method, the calculation for kWh of daily energy input is 5,841 kWh ÷ 365 days = 16 kWh daily input. Fuel switching cost savings are $5,000. In terms of cost-effectiveness, without a panel upgrade, there are cost savings of $54,000 per ton of NOx reduced; with a panel upgrade, the cost is $44,000 per ton of NOx reduced.

For contrast, by applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 76,000 Btu/hr × 24 hours × 0.215 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh ÷ 4.2 heat pump COP = 26 kWh daily input. Fuel switching cost is $2,000. In terms of cost-effectiveness, without a panel upgrade, there is a cost of $235,000 per ton of NOx reduced; with a panel upgrade, the cost is $332,000 per ton of NOx reduced.

Type 2 Water Heater

Type 2 Water Heater Scenario 1: Replacement with Six Integrated Heat Pumps

The analysis considered the potential replacement of a 500,000 Btu/hr natural gas-fired Type 2 water heater with six 76,000 Btu/hr zero-emission integrated heat pump water heaters. The capital cost for a natural gas-fired commercial tank type high efficiency unit is estimated at $14,000, which was derived from the Rule 1146.2 May 2006 final staff report which estimated the cost for a unit with a heat rating ranging from 400,000 to 500,000 Btu/hr and adjusted to present value by the CPI Inflation Calculator. The analysis also considered a case presented by an installer where two 500,000 Btu/hr units were replaced with seven integrated heat pumps. In this case, the second 500,000 Btu/hr unit and the seventh heat pump were for redundancy purposes, so the analysis considered the replacement of one 500,000 Btu/hr natural gas-fired unit with six zero-emission heat pumps. A manufacturer provided the capital cost of $11,000 for one zero-emission indoor packaged commercial integrated heat pump unit with a COP of 4.2; the capital cost for the six zero-emission heat pumps is $66,000, which is the cost of the individual heat pump multiplied by six. The annual energy input of 5,841 kWh was provided by the manufacturer for one unit.

By applying the Energy Input Estimate Method, the calculation for kWh of daily energy input is 5,841 kWh ÷ 365 days × 6 units = 96 kWh daily input. Fuel switching cost savings are $59,000. In terms of cost-effectiveness, without a panel upgrade, the cost savings will be $26,000 per ton of NOx reduced; with a panel upgrade, the cost savings will be $11,000 per ton of NOx reduced.

[17] AO Smith, https://assets.hotwater.com/damroot/Original/10003/AOSZE55000.pdf

By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 500,000 Btu/hr × 24 hours × 0.215 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh ÷ 4.2 heat pump COP = 171.03 kWh daily input. Fuel switching cost is $19,000. In terms of cost-effectiveness, without a panel upgrade, the cost is $251,000 per ton of NOx reduced; with a panel upgrade, the cost is $266,000 per ton of NOx reduced.

Type 2 Water Heater Scenario 2: Replacement with Two Split Heat Pumps

A major manufacturer recommended a different replacement case for Type 2 water heaters and recommended replacing one 500,000 Btu/hr natural gas-fired unit with two large split heat pumps with a COP of 4.38 paired with a 400-gallon tank for an anticipated capital cost of $70,000.[18] Capital cost for the natural gas-fired commercial tank type high efficiency unit is estimated at $14,000, taken from the Rule 1146.2 May 2006 staff report estimated cost for the 400,000-500,000 Btu/hr unit range and adjusted to present value by the CPI Inflation Calculator.

The energy input (kWh) for this scenario was not provided by the manufacturer, so the analysis did not apply the Energy Input Estimate Method. By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 500,000 Btu/hr × 24 hours × 0.215 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh ÷ 4.38 heat pump COP = 164 kWh daily input. Fuel switching cost is $12,000. In terms of cost-effectiveness, without a panel upgrade, the cost is $239,000 per ton of NOx reduced; with a panel upgrade, the cost is $254,000 per ton of NOx reduced.

Scenario 2 provides a cost-effectiveness value estimate less than the 2022 AQMP cost-effectiveness screening threshold of $349,000 per ton of NOx reduced. Scenario 2 has a slightly higher capital cost of $4,000 greater than Scenario 1.

Type 1 Pool Heater

The analysis considered the potential replacement of a 125,000 Btu/hr natural gas-fired pool heater with a 90,000 Btu/hr zero-emission heat pump pool heater. As of December 2023, an internet search for a 125,000 Btu/hr natural gas-fired unit indicated that the capital cost is $1,800.[19] The table below presents other natural gas water heater cost examples obtained via an internet search. For example, as of December 2023, an internet search for a 90,000 Btu/hr zero-emission heat pump indicated that the capital cost is $4,100.[20] The heat pump has a COP of 5.7.

[18] Lochinvar, https://www.lochinvar.com/products/commercial-heat-pump-water-heaters/veritus-air-source-commercial-heat-pump-water-heater/

[19] In the Swim, https://intheswim.com/p/ec-462024-mastertemp-low-nox-125k-btu-natural-gas-pool-spa-heater-with-cord---limited-warranty/387225.html

[20] In the Swim, https://intheswim.com/p/w3hp21004t-heatpro-90k-btu-230v-titanium-digital-electric-pool-heat-pump/340101.html

Table 2-4. Natural gas water heater cost examples from internet search

Heat Output Btu/hr	Price ($)	Heat Output Btu/hr	Price ($)	Heat Output Btu/hr	Price ($)
105,000	2,000	206,000	2,000	300,000	4,000
125,000	2,000	240,000	3,000	333,000	4,000
156,000	2,000	264,000	3,000	360,000	4,000
180,000	3,000	266,000	3,000	404,000	4,000

By applying the Energy Input Estimate Method, the calculation for kWh of daily energy input is 4.9 kW input × 24 hours/day × 0.1432 capacity factor = 16.84 kWh daily input. The analysis utilized the 0.1432 capacity factor for the Energy Input Estimate Method to represent the heat pump runtime, which is expected to be greater than that of a natural gas-fired unit. Fuel switching cost savings are $6,000. In terms of cost-effectiveness, without a panel upgrade, the cost savings are $106,000 per ton of NOx reduced; with a panel upgrade, the cost savings are $43,000 per ton of NOx reduced. When splitting the panel cost between residential appliances, with half of the panel cost for pool heating, the cost-effectiveness estimate is cost savings of $75,000 per ton of NOx reduced.

By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 125,000 Btu/hr × 24 hours × 0.0716 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh ÷ 5.7 heat pump COP = 10.49 kWh daily input. The analysis utilized the 0.0716 capacity factor for the Energy Input Calculation Method to represent the natural gas-fired unit runtime, taken from the previous Rule 1146.2 rule development assumption. Fuel switching cost savings are $1,000. In terms of cost-effectiveness, without a panel upgrade, the cost is $26,000 per ton of NOx reduced; with a panel upgrade, the cost is $89,000 per ton of NOx reduced. When splitting the panel cost between residential appliances, with half of the panel cost for pool heating, the cost-effectiveness estimate is $57,000 per ton of NOx reduced.

Type 1 Boiler

Type 1 Boiler Scenario 1: Replacement with Heat Pump Unit

The analysis considered the potential replacement of a 399,000 Btu/hr natural gas-fired Type 1 boiler with a 365,000 Btu/hr heat pump. A manufacturer provided a capital cost of $24,000 for a 399,000 Btu/hr natural gas-fired Type 1 boiler. A manufacturer provided a capital cost to consumer of $185,000 for a 365,000 Btu/hr heat pump using waste heat with a COP of 6.3.[21]

The energy input (kWh) for this scenario was not provided by the manufacturer, so the analysis did not apply the Energy Input Estimate Method. By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 399,000 Btu/hr × 24 hours × 0.215 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh ÷ 6.3 heat pump COP = 90.99 kWh daily input. Fuel switching cost savings are $32,000. In terms of cost-effectiveness,

[21] Armstrong International, Inc., https://armstronginternational.com/products/armstrongcombitherm-heat-pumps/

without a panel upgrade, the cost is $570,000 per ton of NOx reduced; with a panel upgrade, there is a cost of $589,000 per ton of NOx reduced.

Type 1 Boiler Scenario 2: Replacement with Electric Resistance Unit

The analysis considered replacement of a 399,000 Btu/hr natural gas-fired Type 1 boiler with a 358,000 Btu/hr electric boiler. A manufacturer provided a capital cost of $24,000 for a 399,000 Btu/hr natural gas-fired Type 1 boiler. As of December 2023, an internet search for a 358,000 Btu/hr electric resistance boiler indicated that the capital cost is $25,000.[22] The analysis also assumed a 100 percent efficiency for electric resistance units.

The energy input (kWh) for this scenario was not provided by the manufacturer, so the analysis did not apply the Energy Input Estimate Method. By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 399,000 Btu/hr × 24 hours × 0.215 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh = 573.22 kWh daily input. Fuel switching cost is $471,000. In terms of cost-effectiveness, without a panel upgrade, the cost is $2,092,000 per ton of NOx reduced; with a panel upgrade, the cost is $2,111,000 per ton of NOx reduced.

Type 2 Boiler

Type 2 Boiler Scenario 1: Replacement of 1 MMBtu Unit with Heat Pump

The analysis considered the potential replacement of a 1,000,000 Btu/hr natural gas-fired Type 2 boiler with a 1,709,000 Btu/hr heat pump. A manufacturer provided a capital cost of $32,500 for a 1,000,000 Btu/hr natural gas-fired Type 2 boiler. A manufacturer provided a capital cost to consumer of $280,000 for a 1,709,000 Btu/hr heat pump using waste heat with a COP of 5.9.

The energy input (kWh) for this scenario was not provided by the manufacturer, so the analysis did not apply the Energy Input Estimate Method. By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 1,000,000 Btu/hr × 24 hours × 0.215 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh ÷ 5.9 heat pump COP = 243.5 kWh daily input. Fuel switching cost savings are $65,000. In terms of cost-effectiveness, without a panel upgrade, there is a cost of $323,000 per ton of NOx reduced; with a panel upgrade, the cost is $330,000 per ton of NOx reduced.

Type 2 Boiler Scenario 2: Replacement of 1 MMBtu Unit t with Electric Resistance

The analysis considered replacement of a 1,000,000 Btu/hr natural gas-fired Type 2 boiler with a 1,000,000 Btu/hr electric boiler. A manufacturer provided a capital cost of $32,500 for a 1,000,000 Btu/hr natural gas-fired Type 2 boiler. As of December 2023, an internet search for a 1,000,000 Btu/hr electric resistance boiler indicated that the capital cost is $34,000.[23]

The energy input (kWh) for this scenario was not provided by the manufacturer, so the analysis did not apply the Energy Input Estimate Method. By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 1,000,000 Btu/hr × 24 hours × 0.215 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh = 1,436.64 kWh daily input. Fuel switching cost is $1,180,000. In terms of cost-effectiveness, without a panel upgrade,

[22] ecomfort, https://www.ecomfort.com/Electro-Industries-EB-NB-105-208/p18338.html
[23] ecomfort, https://www.ecomfort.com/Electro-Industries-EB-NB-300-480/p18335.html

there is a cost of $2,090,000 per ton of NOx reduced; with a panel upgrade, there is a cost of $2,097,000 per ton of NOx reduced.

Type 2 Boiler Scenario 3: Replacement of 2 MMBtu Unit with Heat Pump

The analysis considered the replacement of a 2,000,000 Btu/hr natural gas-fired Type 2 boiler with a 2,286,000 Btu/hr heat pump. A manufacturer provided a capital cost of $43,500 for a 2,000,000 Btu/hr natural gas-fired Type 2 boiler. A manufacturer provided a capital cost to consumer of $462,000 for a 2,286,000 Btu/hr heat pump using waste heat with a COP of 6.1.

The energy input (kWh) for this scenario was not provided by the manufacturer, so the analysis did not apply the Energy Input Estimate Method. By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 2,000,000 Btu/hr × 24 hours × 0.215 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh ÷ 6.1 heat pump COP = 471.03 kWh daily input. Fuel switching cost savings are $147,000. In terms of cost-effectiveness, without a panel upgrade, there is a cost of $240,000 per ton of NOx reduced; with a panel upgrade, there is a cost of $244,000 per ton of NOx reduced.

Instantaneous (Tankless) Water Heater

Tankless Water Heater Scenario 1: Replacement with Electric Resistance Tank Type Unit

The analysis assumed that a 150,000 Btu/hr natural gas-fired tankless water heater could be replaced with a 75-gallon electric resistance tank type unit. The analysis also assumed that the installation cost would be approximately 25 percent of project cost. Drawing from an E3 study, the natural gas-fired unit capital cost is $3,700 × 0.75 = $2,775 for a 150,000 Btu/hr tankless water heater.[24] As of December 2023, an internet search for a 75-gallon electric resistance tank type unit indicated that the capital cost is $2,100.[25]

The energy input (kWh) for this scenario was not provided by the manufacturer, so the analysis did not apply the Energy Input Estimate Method. By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 150,000 Btu/hr × 24 hours × 0.0135 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh= 13.53 kWh daily input. Fuel switching cost is $14,000. In terms of cost-effectiveness, without a panel upgrade, there is a cost of $2,580,000 per ton of NOx reduced; with a panel upgrade, there is a cost of $3,369,000 per ton of NOx reduced. When splitting the panel cost between residential appliances, with half of the panel cost for pool heating, the cost-effectiveness estimate is cost of $2,974,000 per ton of NOx reduced.

Tankless Water Heater Scenario 2: Replacement with Electric Resistance Tankless Unit

The analysis assumed that a 150,000 Btu/hr natural gas-fired tankless water heater could be replaced by an electric resistance tankless unit. The analysis assumed that installation cost is approximately 25 percent of project cost. Drawing from the E3 study, the natural gas-fired unit

[24] E3, Residential Building Electrification in California, https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

[25] The Home Depot, https://www.homedepot.com/p/Rheem-Marathon-Eclipse-Light-Duty-75-gal-Commercial-277-Volt-12kW-Field-Convertible-Non-Metallic-Electric-Water-Heater-MELD75-TB-277-Volt-12-kW/305422236

capital cost is $3,700 × 0.75 = $2,775 for a 150,000 Btu/hr tankless water heater. As of December 2023, an internet search for an electric resistance tankless unit indicated that the higher end capital cost is $2,300.[26]

The energy input (kWh) for this scenario was not provided by the manufacturer, so the analysis didnot apply the Energy Input Estimate Method. By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 150,000 Btu/hr × 24 hours × 0.0135 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh= 13.53 kWh daily input. Fuel switching cost is $14,000. In terms of cost-effectiveness, without a panel upgrade, there is a cost of $2,617,000 per ton of NOx reduced; with a panel upgrade, there is a cost of $3,407,000 per ton of NOx reduced. When splitting the panel cost between residential appliances, with half of the panel cost for pool heating, the cost-effectiveness estimate is cost of $3,012,000 per ton of NOx reduced.

Tankless Water Heater Scenario 3: Replacement with Heat Pump Tank Type Unit

The analysis assumed that a 150,000 Btu/hr natural gas-fired tankless water heater could be replaced with a residential 65-gallon storage volume heat pump with a COP of 3.0. The analysis also assumed that the installation cost is approximately 25 percent of project cost. Drawing from an E3 study, the natural gas-fired unit capital cost is $3,700 × 0.75 = $2,775 for a 150,000 Btu/hr tankless water heater. Energy Star by U.S. EPA provided information on a 64-gallon storage volume heat pump with a Uniform Energy Factor of 3.64, which has a capital cost of around $2,000 from internet search.[27] Energy Star provides 178 therms per year for tankless and 1,233 kwh for an equivalent heat pump.

By applying the Energy Input Estimate Method, the calculation for kWh of daily energy input is 1,233 kWh ÷ 365 days = 3.4 kWh daily input. Fuel switching cost is $1,000. In terms of cost-effectiveness, without a panel upgrade, the cost is $33,000 per ton of NOx reduced; with a panel upgrade, the cost is $823,000 per ton of NOx reduced.

When splitting the panel cost between residential appliances, with half of the panel cost for pool heating, the cost-effectiveness estimate is cost of $428,000. When considering available residential incentives including the TECH Clean California single-family heat pump water heater $3,100 rebate and the Inflation Reduction Act (IRA) maximum up to $2,000 tax credit, for a total of $5,100 in incentives, splitting the panel cost between residential appliances results in cost-effectiveness of $530,000 cost savings.

By applying the Energy Input Calculation Method, the calculation for kWh of daily energy input is 150,000 Btu/hr × 24 hours × 0.0135 capacity factor × 0.95 natural gas-fired unit efficiency ÷ 3412.14 Btu/kWh ÷ 3.0 heat pump COP = 4.51 kWh daily input. Fuel switching cost is $2,000. In terms of cost-effectiveness, without a panel upgrade, there is a cost of $310,000 per ton of NOx reduced; with a panel upgrade, there is a cost of $1,100,000 per ton of NOx reduced.

When splitting the panel cost between residential appliances, with half of the panel cost for pool heating, the cost-effectiveness estimate is cost of $705,000 per ton of NOx reduced. When

[26] Carbon Switch, Tankless Water Heater Buyer's Guide, https://carbonswitch.com/tankless-water-heater-buyers-guide/

[27] Energy Star, https://www.energystar.gov/productfinder/product/certified-water-heaters/details/2408601

considering available residential incentives including the TECH Clean California single-family heat pump water heater $3,100 rebate and the IRA maximum up to $2,000 tax credit, for a total of $5,100 in incentives, splitting the panel cost between residential appliances results in cost-effectiveness of $253,000 per ton of NOx reduced cost savings.

By applying the Energy Input Calculation Method for gas-fired tankless units replaced by heat pumps, there is a higher energy input (kWh) and higher fuel switching cost which may result from oversizing. The energy input (kWh) may be overestimated.

Summary of Cost-Effectiveness

The following table summarizes the cost-effectiveness estimates for each category.

Table 2-5. Cost-Effectiveness for PAR 1146.2 Categories

Category	Replace with	Cost-Effectiveness ($,Ton), No Panel Upgrade		Cost-Effectiveness ($,Ton), With Panel Upgrade	
		Energy Input Estimate Method	Energy Input Calculation Method	Energy Input Estimate Method	Energy Input Calculation Method
Type 1 Water Heater	Heat Pump	(54,000)	235,000	44,000	332,000
Type 2 Water Heater	Six Heat Pumps (Integrated)	(26,000)	251,000	(11,000)	266,000
	Two Heat Pumps (Split)	-	239,000	-	254,000
Type 1 Pool Heater	Heat Pump	(106,000)	26,000	(43,000)	89,000
	Heat Pump and Split Panel Cost	-	-	(75,000)	57,000
Type 1 Boiler	Heat Pump	-	571,000	-	589,000
	Electric Resistance	-	2,092,000	-	2,111,000
Type 2 Boiler (1 MMBtu)	Heat Pump	-	323,000	-	330,000
	Electric Resistance	-	2,090,000	-	2,097,000
Type 2 Boiler (2 MMBtu)	Heat Pump	-	240,000	-	244,000

Category	Replace with	Cost-Effectiveness ($,Ton), No Panel Upgrade		Cost-Effectiveness ($,Ton), With Panel Upgrade	
		Energy Input Estimate Method	Energy Input Calculation Method	Energy Input Estimate Method	Energy Input Calculation Method
Instantaneous (Tankless) Water Heater	Heat Pump	33,000	310,000	823,000	1,100,000
	Heat Pump and Split Panel Cost	-	-	428,000	705,000
	Heat Pump and Split Panel Cost and Incentives of $5,100	-	-	(530,000)	(253,000)
	Electric Resistance Tank Type	-	2,580,000	-	3,369,000
	Electric Resistance Tank Type and Split Panel Cost	-	-	-	2,974,000
	Electric Resistance Tankless	-	2,617,000	-	3,407,000
	Electric Resistance Tankless and Split Panel Cost	-	-	-	3,012,000

The cost-effectiveness values for most categories in PAR 1146.2 were less than the $349,000 per ton of NOx screening threshold; thus, zero-emission (0 ppmv) technologies are considered cost-effective. While some cost-effectiveness values are greater than the 2022 AQMP screening threshold of $349,000 per ton of NOx reduced, future effective compliance dates will allow for market growth in the next 10 years. Market growth for emerging technologies typically includes a price decrease. Currently, the market supply is limited and some of the zero-emission units staff evaluated require preplanning and adjustment prior to installation, which will involve a considerably higher cost. Once more units are commercialized and sold as off-the-shelf units, staff expects costs to drop. Staff is proposing to conduct a technology assessment prior to the implementation of the zero-emission units that had a high cost-effectiveness and will reassess costs at that time.

Proposed BARCT Emission Limit

Health and Safety Code Section Sections 40920.6(a)(1) and 40920.6(a)(2) require that prior to adopting rules to meet the requirement of BARCT, one or more potential control options which achieve the emission reduction objectives of the rule must be identified and the cost-effectiveness assessment of the potential control option(s) must be conducted. The final proposed BARCT emission limit for each class and category is the emission limit that achieves the maximum degree of emission reductions and is determined to be cost-effective. The following table summarizes the proposed NOx limits that represent BARCT and the applicable CO limits for each class and category. The zero-emission technologies staff evaluated operate on electricity and have zero CO emissions in addition to zero NOx emissions; hence, staff is proposing zero emission limits for both pollutants.

Table 2-6. Proposed BARCT NOx and CO Emission Limits, Compliance Schedule, and Unit Useful Age

Equipment Category	NOx and CO Emission Limits (ppmv)	Building Type	Compliance Date	Useful Age (years)
Type 1 Unit*	0	New	January 1, 2025	15
		Existing	January 1, 2029	
Instantaneous (Tankless) Water Heater	0	New	January 1, 2025	25
		Existing	January 1, 2029	
Type 1 Pool Heater	0	New	January 1, 2027	15
		Existing	January 1, 2031	
Type 2 Unit**	0	New	January 1, 2027	25
		Existing	January 1, 2031	
Type 1 High Temperature Unit	0	New	January 1, 2029	25
		Existing	January 1, 2033	
Type 2 High Temperature Unit	0	New	January 1, 2029	25
		Existing	January 1, 2033	

* Referring to a Type 1 unit that is not a high temperature unit, Type 1 pool heater, or tankless water heater.

** Referring to a Type 2 unit that is not a high temperature unit.

Future implementation dates will allow for an increase in supply of zero-emission technology in the market. Manufacturers are already producing heat pumps and may adjust business operations based on policy direction and market conditions. There is expectation for the supply chain to adjust to changing market conditions. Furthermore, staff is proposing to require the zero-emissions technologies at end-of-unit-age, with unit expected age potentially 15 to 25 years depending on the type of unit; therefore, staff does not expect a sudden peak in demand. PAR 1146.2 proposes longer timeframes for end-of-unit-age replacements in existing buildings versus installations in new buildings and also proposes zero-emission limits for retrofits and burner modification after the proposed compliance dates.

Some of the proposed emission limits for some of the equipment categories subject to PAR 1146.2 are considered technology-forcing, meaning the emission limits are based on a technology that is not widely commercially available at the time of amending the rule. When South Coast AQMD adopts rules with technology-forcing emission limits, the limits are given a future implementation date to allow time for the technology to develop. BARCT limits evolve over time as the technology improves or new pollution control technologies emerge; setting future effective emission limits is an approach that has been used and upheld in other rules. For example, South Coast AQMD adopted VOC limits in Rule 1113 – Architectural coatings in 2002 with a future effective date of July 1, 2006, based on emerging technology (e.g., reformulated coatings). The technology to meet the lower VOC limits was commercially available at the time of rule development but had performance issues that had yet to be overcome. The American Coatings Association sued the South Coast AQMD for adopting technology-forcing BARCT limits, but the South Coast AQMD prevailed in the Supreme Court of California, which upheld the ability to adopt technology-forcing BARCT limits. Furthermore, staff will include a requirement to conduct a technology assessment prior to the zero-emission compliance dates.

Staff proposes to conduct a technology assessment, which will be included as part of the Governing Board resolution adopting PAR 1146.2. The technology assessment would assess any change in capital cost or technology development for certain high temperature applications; assess any change in cost-effectiveness for certain categories; and monitor market supply and growing opportunities for contractor training. Staff will also reassess the fuel switching costs. Utility rates tend to fluctuate over time and are difficult to predict, so an evaluation of utility rates would be appropriate. The technology assessment will evaluate the status of zero-emission technology for all equipment categories and address any equity issues.

ADDITIONAL BENEFITS AND CHALLENGES

Electric Grid Infrastructure

In 2021, renewable generation accounted for 33.6 percent of the total California Power Mix, not including solar photovoltaic systems installed on residential and commercial buildings that are less than one megawatt (MW) as they are typically considered distributed generation and not required to report to CEC.[28] The California Power Mix is the percentage of specified fuel types derived from the California Energy Mix, and the California Energy Mix is the total in-state electric generation plus energy imports. There is expected to be more renewables adoption by states in the future, and California Senate Bill 100 called for a Renewables Portfolio Standard of 60 percent by 2030. Electricity imports account for approximately 30 percent of total system electric generation, with other states pursuing Renewable Portfolio Standards and state energy goals.

The CEC, California Public Utilities Commission (CPUC), and CARB are working to coordinate across efforts, identify issues not covered by ongoing efforts, and assess needed actions to better align the energy system with the state's climate targets. Related initiatives include the CPUC's proceeding to support decarbonizing buildings in California (R.19-01-011), which eliminated gas line extension subsidies for new gas hookups to homes and commercial buildings effective July 1, 2023.[29] In February 2023, the CPUC ordered load serving entities to procure an additional 4,000 MW of Net Qualifying Capacity for 2026 and 2027, in addition to the mid-term reliability procurement requirements ordered in 2021 (11,500 MW, enough to power approximately 2.5 million homes). The CPUC also approved four energy storage contracts totaling 372 MW for SCE and recommended an electric resource portfolio for use in the California Independent System Operator's (CAISO) 2023-24 Transmission Planning Process. The recommended portfolio includes over 85 gigawatts (GW) of new resources by 2035, including 54,000 MW of renewable resources; over 28,000 MW of batteries; 2,000 MW of long-duration storage; and 1,100 MW of demand response. The CEC adopts an Integrated Energy Policy Report (IEPR) every two years and an update every other year. The 2022 IEPR has recognized the proposed zero-emission

[28] California Energy Commission, 2021 Total System Electric Generation, https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation

[29] California Public Utilities Commission, Press Release, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M496/K979/496979465.PDF

requirements for residential and commercial buildings in California and included recommendations and updates to the energy demand forecast.[30] Under Assembly Bill 3232, the CEC must assess the feasibility of reducing greenhouse gas emissions in residential and commercial buildings 40 percent below 1990 levels by January 1, 2030. Statewide electricity consumption was over 280,000 GWh in 2021 and is forecasted to be 358,738 GWh in 2035. The 2022 Planning Scenario peak forecast for CAISO, which manages roughly 80 percent of California's load, reaches 55,117 MW by 2035. CAISO is planning $11 billion in transmission capacity projects over the next 20 years, which covers 80 percent of the entire state service area. The 20-Year Transmission Outlook document from May 2022 considers transmission needs to meet load and renewable energy growth aligned with state policy. The plan describes $11 billion in upgrades to the existing CAISO transmission footprint.[31] In addition, solar photovoltaic generation continues to increase as shown in the figure below.[32] Between 2022 and 2035, behind-the-meter photovoltaic generation is expected to grow on average by about 6 percent, reaching annual photovoltaic generation of 55,740 GWh by 2035.

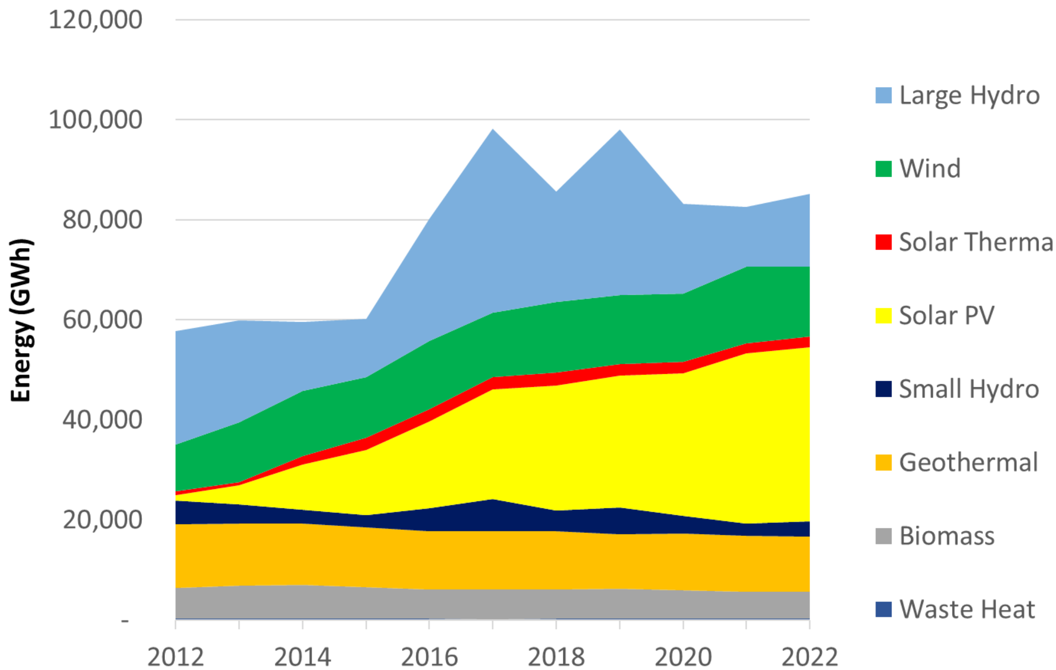

Figure 2-3. In-State Electric Generation – Select Fuel Types, Sourced from CEC Quarterly Fuels and Energy Reporting Regulations

According to SCE's 2021 Sustainability Report, SCE is expected to invest over $5 billion annually in the electric grid, with approximately 3,400 MW of energy storage installed or contracted. In 2021, SCE procured 530 MW of energy storage through three new contracts from third parties and in the same year, entered into an engineering, procurement, and construction agreement to construct approximately 535 MW of utility-owned storage. SCE also expected increases in

[30] California Energy Commission, 2022 Integrated Energy Policy Report Update, https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2022-integrated-energy-policy-report-update

[31] California ISO, 20-Year Transmission Outlook, http://www.caiso.com/InitiativeDocuments/20-YearTransmissionOutlook-May2022.pdf

[32] California Energy Commission, 2022 Electric Generation and Capacity, https://www.energy.ca.gov/media/3757

Distributed Energy Resources such as solar.[33] In the Pathway to 2045 document, SCE expected a 60 percent increase in electricity load and 40 percent increase in peak load by 2045, with building electrification responsible for 15 percent of load by 2045. SCE noted that the grid will still be summer peaking due to air conditioning.[34]

Staff recognizes the importance of electric grid reliability for electric units, but also for natural gas units, which often require electricity to operate. In 2021, the CPUC created new programs and modified existing programs to reduce energy demand and increase energy supply during critical hours of the day.[35] Per Senate Bill 350, the CPUC developed an integrated resource planning process to ensure that California's electric sector meets its greenhouse gas reduction goals while maintaining reliability at the lowest possible costs.[36] Staff recognizes that there are externalities for both electric and natural gas production and distribution. Staff also recognizes the need for regulation of emissions from electricity generation. South Coast AQMD Rule 1135 – Emissions of Oxides of Nitrogen from Electricity Generating Facilities, is a rule that aims to lower emissions from electricity generation.[37] Regarding the natural gas system, natural gas leaks into the atmosphere from natural gas wells, storage tanks, pipelines, and processing plants. In 2020, methane emissions from natural gas and petroleum systems and from abandoned oil and natural gas wells were source of approximately 33 percent of U.S. methane emissions and approximately four percent of U.S. greenhouse gas emissions. In the South Coast AQMD region, there have been examples of large leaks such as Aliso Canyon, where 109,000 metric tons of methane emissions were released between October 2015 and February 2016. For this rulemaking, staff did not conduct lifecycle analyses related to the BARCT assessment for either the electricity or natural gas systems.

Hot Water Requirements for Health Facilities and Use in Hospitals

The 2022 California Plumbing Code includes sections on Water Supply and Distribution; Domestic Hot-Water Distribution Systems for Health Facilities and Clinics. For laundry, 160 degrees Fahrenheit hot water is acceptable, or 140 degrees Fahrenheit hot water if the laundry also passes through a tumbler dryer at 180 degrees Fahrenheit. Hot water between 158 to 176 degrees Fahrenheit is used to reprocess cloths and mop heads.[38] For dishwashing equipment, 180 degrees Fahrenheit is acceptable, and 125 to 180 degrees Fahrenheit booster heaters are acceptable as a second piece of equipment for dishwashing. There is a redundancy requirement for dishwashing and minimum patient services such as handwashing and bathing. The California Plumbing Code hot water use temperature requirements for health facilities and clinics are displayed in the following table.

[33] SCE, Sustainability Report, https://www.edison.com/sustainability/sustainability-report

[34] SCE, Pathway 2045, https://www.edison.com/our-perspective/pathway-2045

[35] California Public Utilities Commission, CPUC Ensures Electricity Reliability During Extreme Weather for Summers 2022 and 2023, https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-ensures-electricity-reliability-during-extreme-weather-for-summers-2022-and-2023

[36] California Public Utilities Commission, CPUC Approves Long Term Plans To Meet Electricity Reliability and Climate Goals, https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-approves-long-term-plans-to-meet-electricity-reliability-and-climate-goals

[37] South Coast AQMD, Rule 1135, http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1135.pdf?sfvrsn=4

[38] CDC, Best Practices for Environmental Cleaning in Healthcare Facilities, https://www.cdc.gov/hai/pdfs/resource-limited/environmental-cleaning-RLS-H.pdf

Table 2-7. California Plumbing Code Hot Water Temperature Requirements (Degrees Fahrenheit)

Clinical	Dietary	Laundry	Dishwashing
105-120	120	160	180

Staff visited a hospital in Los Angeles with sixteen natural gas-fired units below 2 MMBtu/hr, spread between two buildings. The units included four for domestic hot water and 12 for space heating, with the highest water temperature output at 180 degrees Fahrenheit. This also included redundant units, and units are often oversized. Hospital steam for sterilization is usually generated by larger boilers permitted under Rule 1146. The hospital is considering replacement with heat pumps for domestic hot water Type 1 units. One challenge is that it may take five to seven years for California Department of Health Care Access and Information (HCAI) project approval to replace a boiler.

Staff also contacted the all-electric UCI Medical Center, which is anticipated to be operational in 2025 with the Acute Care Center and Central Utility Plant operational in 2024.[39] Future plans include fuel cells and battery storage. The heat pump COP is 3, or 300 percent more efficient than a conventional unit. The team noted lower maintenance costs of $338,000 for all-electric distributed steam compared to $1,751,000 for gas-fired, and $737,000 annual operational cost savings. There was an estimated 3.8 years simple payback. In addition to zero-emission space and water heating, electric appliances were installed in the kitchen. The team working on the UCI project mentioned that they obtained HCAI approval for the initial phase in about one year. The experience they shared is to have early planning and good communication and to implement the project by phases.

Hot Water Requirements and Use in Restaurants

Requirements for restaurant hot water are included in the California Retail Food Code.[40], [41], [42] Hot water generation and distribution systems must be sufficient to meet the peak hot water demands throughout the food facility. In sizing the water heater, the peak hourly demands for all sinks, dishwashing machines, etc., are added together to determine the minimum required recovery rate. A minimum of 120 degrees Fahrenheit should be supplied from the faucet and a minimum of 100 degrees Fahrenheit for handwashing.

Restaurant dishwashers use a majority of the hot water and require 180 degrees Fahrenheit. Restaurants can use electric "booster heaters" to achieve the required temperature. Restaurants may also choose to utilize a distributed generation water system to save on water use and cost. A distributed generation water system consists of the primary heat pump water heater serving key points such as kitchen sinks and point-of-use electric heaters serving most others.

[39] Building Design+Construction, UC Irvine takes sustainability to new level with all-electric medical center, https://www.bdcnetwork.com/uc-irvine-takes-sustainability-new-level-all-electric-medical-center

[40] California Legislative Information, Health and Safety Code, https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=113953

[41] California Legislative Information, Health and Safety Code, https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=114192

[42] California Legislative Information, Health and Safety Code, https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=114195

Staff visited a facility with a restaurant which utilized 500,000 Btu to 2 MMBtu sized units. Electric booster heaters were used for dishwashing to increase the temperature from 120 to 170 degrees Fahrenheit, as shown in the image below. For restaurant sanitation, 120 degrees Fahrenheit used. There was no need for hot water at a temperature above 180 degrees Fahrenheit.

Figure 2-4. Examples of Dishwashing Unit (Left) and Electric Booster Heater (Right)

Zero-Emission Co-Benefits

South Coast Air Basin has been classified as "extreme" nonattainment for the 2015 ozone standard. Ozone is formed when NOx and VOC react in the presence of sunlight. While both NOx and VOC contribute to ozone, the key to attaining the ozone standard in the Basin is to reduce NOx.[43] While PAR 1146.2 is focused on zero-NOx standards, air quality co-benefits of zero-emission standards include reducing other emissions such as greenhouse gas (GHG) and particulate matter (PM) emissions. CARB's current rulemaking for potential statewide zero-emission appliance standards would be focused on zero-GHG and zero-NOx, while also quantifying the air quality co-benefits of reducing criteria pollutants such as smog-forming NOx, CO, and toxic air contaminant emissions.[44] The PAR 1146.2 zero-emission standard will also be considered as a control strategy for the South Coast AQMD to attain the 2012 annual PM 2.5 national ambient air quality standard by 2030.

Incentives

There are some federal and state incentives for zero-emission commercial appliances. Section 179D of the Internal Revenue Code allows deductions for energy-efficient commercial buildings, including new or existing buildings.[45] The Inflation Reduction Act extended and expanded these

[43] South Coast AQMD, 2022 AQMP, https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/final-2022-aqmp/final-2022-aqmp.pdf?sfvrsn=16

[44] California Air Resources Board, Zero-emission Appliances, https://ww2.arb.ca.gov/our-work/programs/building-decarbonization/zero-emission-appliance-standards/faq

[45] U.S. Department of Energy, 179D Commercial Buildings Energy-Efficiency Tax Deduction, https://www.energy.gov/eere/buildings/179d-commercial-buildings-energy-efficiency-tax-deduction

tax deductions.[46] TECH Clean California launched more state-wide incentives for multifamily and commercial water heating in 2023.[47] Other state programs can provide incentives such as for new all-electric multifamily pool heating.[48] There are also utility incentives for appliances in commercial buildings, including SCE's Willdan Commercial Energy Efficiency Program, which incentivizes replacement of an existing electric resistance or gas-fired water heater with a packaged heat pump water heater.[49] San Diego Gas and Electric's Comprehensive Energy Management Solutions Program provided heat pump water heater rebates in 2023.[50]

[46] IRS, Inflation Reduction Act of 2022, https://www.irs.gov/inflation-reduction-act-of-2022
[47] TECH Clean California, Incentives, https://techcleanca.com/incentives/multifamily-information/
[48] California Energy Commission, California Electric Homes Program, https://caelectrichomes.com/
[49] Willdan Commercial Energy Efficiency Program, https://willdanefficiency.com/commercial/
[50] Comprehensive Energy Management Solutions, http://www.savingwithcems.com/

CHAPTER 3: SUMMARY OF PROPOSALS

INTRODUCTION

PROPOSED AMENDED RULE STRUCTURE

PROPOSED AMENDED RULE 1146.2

INTRODUCTION

The main objective of PAR 1146.2 is to propose NOx limits that represent BARCT for the applicable equipment. PAR 1146.2 also deletes outdated rule language and reorganizes the rule structure to be consistent with recently amended or adopted rules. The proposed revised rule structure and key provisions are discussed below.

PROPOSED AMENDED RULE STRUCTURE

(a) Purpose
(b) Applicability
(c) Definitions
(d) Requirements
(e) Unit Age
(f) Certification
(g) Demonstrations of Compliance with Emission Limits
(h) Identification and Verification of Compliant Units
(i) Exemptions

PROPOSED AMENDED RULE 1146.2

The proposed amended rule separates the purpose and applicability to be consistent with recently adopted and amended rules.

The table below shows the emission limits for new units in the current Rule 1146.2 and proposed revisions in PAR 1146.2.

Table 3-1. Summary of Emission Limits for New Units in Rule 1146.2 and New Revisions in PAR 1146.2

Rule 1146.2 Current Section	Unit Type	Compliance Date	Emission Limit	PAR 1146.2 Revision*
Rule 1146.2 (c)(1)	Type 2	2000	30 ppmv NOx; 400 ppmv CO	Obsolete; section removed
Rule 1146.2 (c)(2)	Type 1	2001	40 ng/J NOx (55 ppmv NOx)	Obsolete (except for pool heaters); section removed
Rule 1146.2 (c)(2)	Type 1 Pool Heaters	2001	40 ng/J NOx (55 ppmv NOx)	Current limits; now included in PAR 1146.2 (d)(1) and Table 1
Rule 1146.2 (c)(7)	Type 2	2010	14 ng/J NOx (20 ppmv NOx)	
Rule 1146.2 (c)(8)	Type 1 (excluding Pool Heaters)	2012	14 ng/J NOx (20 ppmv NOx)	

* PAR 1146.2 zero-emission requirements for new units installed in new and existing buildings are included in PAR 1146.2 (d)(2).

The table below shows the phase-out/retrofit requirements in the current rule and proposed revisions in PAR 1146.2. Phase-out/retrofit was required in Rule 1146.2 for unregulated old units to phase into the emission limits.

Table 3-2. Summary of Phase-out/Retrofit Requirements in Rule 1146.2 and New Revisions in PAR 1146.2

Rule 1146.2 Current Section	Unit Type and Age	Compliance Date	Emission Limit	PAR 1146.2 Revision*
Rule 1146.2 (c)(3)-(c)(5)	Type 2; Manufactured prior to 2000	2002-2006	30 ppmv NOx	Obsolete; section removed
Rule 1146.2 (c)(11)	Type 2; Manufactured and purchased prior to 2010 and sold/installed by December 31, 2010	Until Dec 31, 2010	30 ppmv NOx	Should have met the limits; now included in PAR 1146.2 (d)(6) as a compliance tool if a non-compliant unit is found
Rule 1146.2 (c)(12)	Type 1; Manufactured and purchased prior to 2012 and sold/installed by December 31, 2012	Until Dec 31, 2012	40 ng/J NOx (55 ppmv NOx)	Should have met the limits; now included in PAR 1146.2 (d)(7) as a compliance tool if a non-compliant unit is found

* Additionally, PAR 1146.2 will require units reaching their useful age after PAR 1146.2 Table 2 zero-emission compliance dates of their applicable categories to phase into zero-emission requirement as specified in PAR 1146.2 (d)(3).

PAR 1146.2 Purpose [Subdivision(a)]

The purpose of this rule is to reduce NOx emissions from water heaters, boilers, and process heaters as defined in this rule.

PAR 1146.2 Applicability [Subdivision(b)]

The provisions of this rule are applicable to manufacturers, distributors, retailers, resellers, installers, owners, and operators of units that have a rated heat input capacity less than or equal to 2,000,000 Btu per hour. Refurbishers were also subject to Rule 1146.2 but have been removed from PAR 1146.2 applicability to avoid redundancy. A refurbisher can be a manufacturer, reseller, or installer; therefore, removing this term does not change the applicability. The provisions of this rule are not applicable to manufacturers, distributors, retailers, Resellers, installers, owners, and operators of units subject to the limits in South Coast AQMD Rule 1121 – Control of Nitrogen Oxides from Residential Type, Natural Gas-fired Water Heaters.

PAR 1146.2 Definitions [Subdivision(c)]

The following are key new definitions for Proposed Amended Rule 1146.2. For all definitions, refer to the preliminary draft of PAR 1146.2 released with the staff report.

EXISTING BUILDING in paragraph (c)(3), which means:

> *"a building that is not a New Building as defined in this rule"*

HIGH TEMPERATURE UNIT in paragraph (c)(7), which means:

> *"any Unit as defined in this rule that is used to produce steam or to heat water above 190 degrees Fahrenheit"*

MULTIFAMILY STRUCTURE in paragraph (c)(10), which means:

> *"any structure which is used exclusively as a dwelling for more than four families, and where equipment is used by the owner or occupant of such a dwelling"*

NEW BUILDING in paragraph (c)(11), which means:

> *"a building that has never been used or occupied for any purpose, or a building with a major alteration which changes the occupancy classification of a building"*

STANDARD CONDITIONS in paragraph (c)(21), which is:

> *"as defined by Rule 102 – Definition of Terms"*

PAR 1146.2 Requirements [Subdivision(d)]

Paragraph (d)(1) – Current Rule 1146.2 Emission Limit

The provisions that were originally included in paragraphs (c)(2), (c)(7), and (c)(8) in Rule 1146.2 have been moved to paragraph (d)(1) in PAR 1146.2 to display current emission limits. Paragraph (d)(1) provides that no person shall manufacture, supply, sell, offer for sale, or install, for use within the South Coast AQMD, any unit subject to this rule, unless the unit is certified pursuant to subdivision (f) not to exceed the applicable NOx and CO emission limits specified in Table 1, prior to the compliance dates specified in Table 2.

Table 3-3. PAR 1146.2 Table 1 (NOx and CO Emission Limits)

Equipment Category	NOx Emission Limit*	CO Emission Limit*
Type 1 Units, excluding Pool Heaters	14 ng/J or 20 ppmv	N/A**
Type 1 Pool Heaters	40 ng/J or 55 ppmv	N/A**
Type 2 Units	14 ng/J or 20 ppmv	400 ppmv

* Ng/J of NOx (calculated as NO_2) of heat output or the specified ppmv of NOx or CO at three percent oxygen (O_2) correction, on a dry basis.

** Type 1 units are not subject to a CO limit by Rule 1146.2 but may be subject to CO limits by other South Coast AQMD rules.

Paragraph (d)(2) – PAR 1146.2 BARCT Emission Limit for New Installations

PAR 1146.2 establishes updated BARCT NOx and CO emission limits for applicable equipment as shown in the table below. This paragraph provides that no person shall manufacture, supply, sell, offer for sale, or install, for use in the South Coast AQMD, any unit subject to this rule, unless such unit does not exceed the applicable NOx and CO emission limit and compliance date set forth in Table 2.

Table 3-4. PAR 1146.2 Table 2 (NOx and CO Emission Limits, Compliance Schedule, and Unit Useful Age)

Equipment Category	NOx and CO Emission Limits (ppmv)	Building Type	Compliance Date	Useful Age (years)
Type 1 Unit*	0	New	January 1, 2025	15
		Existing	January 1, 2029	
Instantaneous Water Heater	0	New	January 1, 2025	25
		Existing	January 1, 2029	
Type 1 Pool Heater	0	New	January 1, 2027	15
		Existing	January 1, 2031	
Type 2 Unit**	0	New	January 1, 2027	25
		Existing	January 1, 2031	
Type 1 High Temperature Unit	0	New	January 1, 2029	25
		Existing	January 1, 2033	
Type 2 High Temperature Unit	0	New	January 1, 2029	25
		Existing	January 1, 2033	

* Referring to a Type 1 unit that is not a high temperature unit, Type 1 pool heater, or instantaneous (tankless) water heater.

** Referring to a Type 2 unit that is not a high temperature unit.

Paragraph (d)(3) – Zero-Emission for Existing Units after Their Useful Age

PAR 1146.2 requires units reaching their useful age after the Table 2 zero-emission compliance dates of their applicable categories to phase into the zero-emission requirement. On and after the compliance dates in Table 2, an owner or operator of a unit shall not operate a unit which does not meet the applicable emission limit in Table 2 once the unit age that is determined pursuant to subdivision (e) reaches its useful age in Table 2. Units installed or used for residential or multifamily structures are exempted from this requirement pursuant to paragraph (i)(3).

Paragraph (d)(4) – Emission Demonstration at Unit Modification

Paragraph (d)(4) of PAR 1146.2 provides guidance for an owner or operator to demonstrate that a modified unit meets the NOx and CO emission limits in subdivision (d).

Paragraph (d)(5) – Emission Limits at Burner Modification or Replacement

Paragraph (d)(5) specifies the applicable emission limit when an owner or operator modifies or replaces a burner. If the modification or replacement occurs prior to the applicable compliance dates in Table 2 or before the unit reaches its useful age, the emission limit in Table 1 will apply. If the modification or replacement occurs on and after the applicable compliance dates and when the unit has reached its useful age in Table 2, the emission limit in Table 2 will apply. This provision addresses stranded assets by allowing a unit that has not reached the end of its useful age but requires a burner replacement after the Table 2 limits have gone into effect, to be retrofit to continue operation. Once the unit reaches the end of its useful age, it will have to meet the Table 2 emission limits.

Paragraph (d)(6) – Type 2 Unit Manufactured Prior to January 1, 2010

The provision that was originally included in paragraph (c)(11) in Rule 1146.2 has been moved to paragraph (d)(6) in PAR 1146.2. These units should already comply with the limits, and this provision is included in PAR 1146.2 (d)(6) as a compliance tool if a non-compliant unit is found. Paragraph (d)(6) provides that an owner or operator shall not operate any Type 2 unit manufactured prior to January 1, 2010, in the South Coast AQMD which does not meet the emission limit of 30 ppmv (corrected at 3 percent O_2 correction, on a dry basis) or 0.037 pound NOx per million Btu of heat input and no more than 400 ppmv of carbon monoxide (at 3 percent O_2, dry).

Paragraph (d)(7) – Type 1 Unit Manufactured Prior to January 1, 2012

The provision that was originally included in paragraph (c)(12) in Rule 1146.2 has been moved to paragraph (d)(7) in PAR 1146.2. These units should already comply with the limits, and this provision is included in PAR 1146.2 (d)(7) as a compliance tool if a non-compliant unit is found. An owner or operator shall not operate any Type 1 unit manufactured prior to January 1, 2012, in the South Coast AQMD which does not meet the emission limit of 55 ppmv (corrected at 3 percent O_2 correction, on a dry basis).

Paragraph (d)(8) – Record of Maintenance Activity

The owner or operator of a unit shall maintain on-site a copy of the manufacturer’s and/or distributor's written instructions and retain a record of the maintenance activity for a period of not less than three years.

Paragraph (d)(9) – RECLAIM and Formal RECLAIM Pre-2010 Type 2 and Pre-2012 Type 1 Units

The provision addresses Type 2 units manufactured prior to January 1, 2010, and Type 1 units manufactured prior to January 1, 2012, in RECLAIM and formal RECLAIM facilities, which are not subject to any emission limit in current Rule 1146.2. On the other hand, comparable units in non-RECLAIM facilities are either subject to the emission limit specified in paragraph (d)(6) or (d)(7), or have been replaced with a unit meeting the 20 ppm NOx emission limit. PAR 1146.2 will require those units in RECLAIM and formal RECLAIM facilities to phase into the same emission limits as for non-RECLAIM facilities in one year after rule adoption. At the time of implementation, the owner or operator cannot operate a Type 2 unit with NOx emissions higher than 30 ppmv or a Type 1 unit with NOx emissions higher than 55 ppmv. The owner or operator can modify or replace the burner of the unit when the emission limit specified in paragraph (d)(5) applies, which is either 20 ppmv or zero-emission for NOx depending on the time of modification or replacement.

PAR 1146.2 Unit Age [Subdivision(e)]

Subdivision (e) provides guidance for an owner or operator of a unit to determine unit age.

Paragraph (e)(1) – Unit Age Determination

Paragraph (e)(1) provides guidance for an owner or operator of a unit to determine unit age. Unit age shall be based on the original date of manufacture determined by an invoice from purchase of unit provided by the manufacturer; the original unit manufacturer’s identification or rating plate permanently affixed to the unit; or any other method of determining unit age that can be substantiated through written information as approved by the Executive Officer. The unit shall be deemed at the end of its useful age as of January 1, 2024, for any unit where the unit age cannot be determined pursuant to subparagraph (e)(1)(A).

PAR 1146.2 Certification [Subdivision(f)]

Subdivision (f) provides guidance to manufacturers regarding unit certification. Subdivision (f) in PAR 1146.2 was originally subdivision (d) in Rule 1146.2.

Paragraph (f)(1) – Independent Testing Laboratory

The manufacturer shall obtain confirmation from an independent testing laboratory prior to applying for certification for a natural gas unit that each unit model or retrofit kit complies with the applicable requirements of subdivision (d). This confirmation shall be based upon emission source tests of a randomly selected unit of each model, and the protocol shall be adhered to during the confirmation testing of all units subject to this rule.

Paragraph (f)(2) – Applying for Unit Certification

When applying for unit(s) certification, the manufacturer shall submit to the Executive Officer the following: a statement that the model is in compliance with subdivision (d), signed and dated, attesting to the accuracy of all statements; general information including name and address of manufacturer, brand name, and model number as it appears on the unit rating plate; a description of each unit being certified; and a source test report verifying compliance with the emission limits in subdivision (d) for each model to be certified. The source test report shall be prepared by the confirming independent testing laboratory and shall contain all the elements identified in the protocol for each unit tested.

Paragraph (f)(3) – Timeline

When applying for unit certification, the manufacturer shall submit the items identified in paragraph (f)(2) no more than ninety (90) days after the date of the source test identified in subparagraph (f)(2)(D).

Paragraph (f)(4) – Unit Certification

The Executive Officer shall certify a unit model which complies with the provisions of subdivision (d) and of paragraphs (f)(1), (f)(2), and (f)(3).

PAR 1146.2 Demonstrations of Compliance With Emission Limits [Subdivision(g)]

Paragraph (g)(1) – Source Test Report

The owner or operator that elects to demonstrate compliance pursuant to subparagraph (d)(4)(B) shall maintain a copy of the South Coast AQMD approved source test report on-site and make it available to the Executive Officer upon request. The source test report shall, at a minimum, include: the emissions limit of the unit in ppmv or ng/J of NOx or ppmv of CO of heat output; the South Coast AQMD approved protocol used to conduct the source test; and the model and serial numbers of the unit(s).

Paragraph (g)(2) – Demonstrate Compliance for Exemption in Paragraph (i)(2)

The owner or operator of a unit that elects to comply with the exemption in paragraph (i)(2), shall demonstrate compliance by a calculation based on the annual fuel consumption recorded by an in-line fuel meter or the annual operating hours recorded by a timer and using one of the following methods: annual therm usage recorded by fuel meter and corrected to standard pressure; amount of fuel (i.e., in thousand cubic feet of gas corrected to standard pressure) converted to therms using the higher heating value of the fuel; or annual therm usage calculated by multiplying the number of hours fuel is burned by the rated heat input capacity of the unit converted to therms. The owner or operator can also use the monthly fuel billing statements or any other equivalent methodology to quantify the fuel usage that is approved by the Executive Officer. The fuel meter or time meter is required to be non-resettable and calibrated according to the manufacturer's recommendation.

PAR 1146.2 Identification and Verification of Compliant Units [Subdivision(h)]

Subdivision (h) outlines the procedure and requirements for identification and verification of compliant units. Subdivision (h) in PAR 1146.2 was originally subdivision (f) in Rule 1146.2.

Paragraph (h)(1) – Newly Manufactured Units

The manufacturer shall display the model number of the unit complying with subdivision (d) on the shipping carton and permanent rating plate. The manufacturer shall also display the certification status on the shipping carton and on the unit.

Paragraph (h)(2) – Certified Retrofit Kits

The manufacturer shall display the model number of the retrofit kit and manufacturer and model of applicable units on the shipping carton and in a plainly visible portion of the retrofit kit.

Paragraph (h)(3) – Rated Heat Input Capacity Documentation

The owner or operator of a unit shall maintain on-site a copy of all documents identifying the unit's rated heat input capacity including the manufacturer's or distributor's manual or invoice; maintain documentation of the rated heat input capacity for a modified unit, signed by the licensed person modifying the unit, including a description of all unit modifications, the dates the unit was modified, and calculation of rated heat input capacity.

PAR 1146.2 Exemptions [Subdivision(i)]

Subdivision (i) has been updated to clarify exemptions and phase in new emission limits. Subdivision (i) in PAR 1146.2 was originally subdivision (h) in Rule 1146.2.

Paragraph (i)(1) – Units in Recreational Vehicles and Units Subject to Rule 1121

The provisions of this rule shall not apply to units used in recreational vehicles or units subject to the limits in South Coast AQMD Rule 1121 – Control of Nitrogen Oxides from Residential Type, Natural Gas-fired Water Heaters.

Paragraph (i)(2) – Low Use Exemption

Until the effective dates in Table 2, the NOx and CO emission limits in the rule shall not apply to units with a rated heat input capacity greater than 400,000 Btu per hour, but less than or equal to 2,000,000 Btu per hour, that are demonstrated to use less than 9,000 therms during every calendar year.

Paragraph (i)(3) – Residential or Multifamily Structures

The provisions of paragraphs (d)(3), (d)(4), (d)(5), (d)(6), (d)(7), and (d)(8) shall not apply to units installed or used for residential or multifamily structures.

CHAPTER 4: IMPACT ASSESSMENT

INTRODUCTION

EMISSIONS INVENTORY AND EMISSION REDUCTIONS

COST-EFFECTIVENESS AND INCREMENTAL COST-EFFECTIVENESS

SOCIOECONOMIC ASSESSMENT

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) ANALYSIS

DRAFT FINDINGS UNDER HEALTH AND SAFETY CODE

COMPARATIVE ANALYSIS

INTRODUCTION

PAR 1146.2 is expected to impact 773,000 units located in the South Coast AQMD region.

EMISSIONS INVENTORY AND EMISSION REDUCTIONS

The total NOx inventory for the RECLAIM and non-RECLAIM units affected by PAR 1146.2 is estimated to be 8.0 tpd. For context, the 2022 AQMP indicated a total of 351 tpd of NOx emitted from all sources in the region in 2018, the base-year of the emissions inventory and modeling analysis in the plan. Appliances used in residential and commercial buildings emit about 22.1 tpd of NOx, which is about 54 percent of 2037 NOx emissions from all stationary and area sources that South Coast AQMD regulates, shown in the figure below. Those appliances are primarily space and water heaters, cooking devices, and some other appliances combusting natural gas.

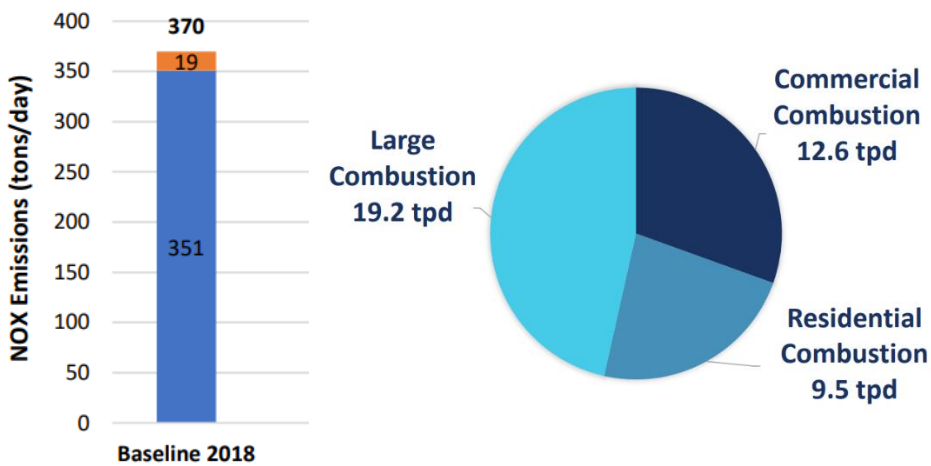

Figure 4-1. Emissions from the South Coast Air Basin in Blue and Coachella Valley in Orange (Left) and NOx Emissions from Stationary and Area Sources (Right)

Baseline Emissions

PAR 1146.2 will impact 773,000 units, the applicable large water heaters, small boilers, and process heaters. To estimate baseline emissions, staff evaluated the following information:

- Estimated universe by category and categories' percentage of universe
- Unit size (MMBtu/hr) of the gas unit being replaced in each category
- Baseline Emission Factor (lb/MMBtu)
- Capacity Factor (or Usage Factor)
- Unit Useful Age (years)

The following table was presented in Working Group Meeting #5:

Table 4-1. Baseline Emission Estimates

Equipment Category	Estimated Universe	Baseline Emissions Estimate (tpd)
Type 1 Water Heaters	60,000	0.50
Type 1 Boilers		0.19
Type 2 Water Heaters and Boilers		1.39
Type 1 Pool Heaters	413,000	5.66
Instantaneous (Tankless) Water Heaters	300,000	0.28
Total	**773,000**	**8.02**

Staff estimated the Type 1 pool heater universe and updated the baseline emission estimate in Working Group Meeting #5. According to the 2019 Residential Appliance Saturation Study (RASS), seven percent of homes in the SoCalGas region have spas with gas heaters. There are approximately 5.9 million homes in the region from the U.S. Census' 2021 American Housing Survey. Staff estimated 413,000 Type 1 pool heaters in the region and baseline emissions of 5.66 tpd for this category as 5.9 million homes × 0.07 = 413,000.

Analysis during the 2006 rule amendment estimated around 40,000 Type 1 units and 22,000 Type 2 units in the South Coast AQMD based on data provided by SoCalGas. For PAR 1146.2, staff updated the Type 1 and Type 2 water heater and boiler categories' percentages of universe based on Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certifications data.

In recent years, adoption of residential tankless units has increased with state and federal energy efficiency regulations. Staff estimated the tankless universe to be approximately 300,000 tankless water heaters in the South Coast AQMD region using the 2019 California Residential Appliance Saturation Study (RASS) from the CEC and the Residential Energy Consumption Survey (RECS) from the U.S. Energy Information Administration.[51][52]

The baseline emission was estimated per unit by category as: Lifetime NOx Baseline Emission (tons) = Unit Size (MMBtu/hr) × Baseline Emission Factor (lb/MMBtu) × Capacity Factor (or usage factor) × Annual Hours × Unit Useful Age (years) ÷ 2,000 pounds per ton.

For Type 1 water heaters, Type 1 boilers, Type 1 pool heaters, and tankless units, 0.238 MMBtu/hr was the Type 1 mid-range unit size utilized in the calculation. For Type 2 water heaters and Type 2 boilers, 1.2 MMBtu/hr was the Type 2 mid-range unit size utilized in the calculation.

[51] California Energy Commission, 2019 California Residential Appliance Saturation Study, https://www.energy.ca.gov/publications/2021/2019-california-residential-appliance-saturation-study-rass

[52] U.S. Energy Information Administration, 2020 Residential Energy Consumption Survey Data, https://www.eia.gov/consumption/residential/data/2020/

The baseline emission factor (pounds per MMBtu) taken from previous Rule 1146.2 rulemaking was 0.067 pound of NOx per MMBtu for 20 ppmv at 3% oxygen for Type 1 pool heaters and 0.024 pound of NOx per MMBtu for 20 ppmv at 3% oxygen for other categories.

The analysis also assumed 100 percent emission reduction for zero-emission units. The estimated emission reduction is 8.0 tpd at full implementation. For context, the 2022 AQMP indicated a total of 351 tpd of NOx emitted in 2018, the base-year of the emissions inventory and modeling analysis in the plan.

COST-EFFECTIVENESS

Health and Safety Code Section 40920.6 requires a cost-effectiveness analysis when establishing BARCT requirements. The cost-effectiveness of a control technology is measured in terms of the control cost in dollars per ton of air pollutant reduced is measured in terms of the control cost in dollars per ton of air pollutant reduced for each class and category of equipment. The costs for the control technology include purchasing, installation, operating, and maintaining the control technology.

As detailed in chapter two, the South Coast AQMD typically relies on the DCF method which converts all costs, including initial capital investments and costs expected in the present and all future years of unit useful age, to a present value. The DCF calculation is detailed in Chapter 2.

The table below summarizes the cost-effectiveness estimates for each category.

Table 4-2. Cost-Effectiveness for PAR 1146.2 Categories

Category	Replace with	Cost-Effectiveness ($,Ton), No Panel Upgrade		Cost-Effectiveness ($,Ton), With Panel Upgrade	
		Energy Input Estimate Method	Energy Input Calculation Method	Energy Input Estimate Method	Energy Input Calculation Method
Type 1 Water Heater	Heat Pump	(54,000)	235,000	44,000	332,000
Type 2 Water Heater	Six Heat Pumps (Integrated)	(26,000)	251,000	(11,000)	266,000
	Two Heat Pumps (Split)	-	239,000	-	254,000
Type 1 Pool Heater	Heat Pump	(106,000)	26,000	(43,000)	89,000
	Heat Pump and Split Panel Cost	-	-	(75,000)	57,000
Type 1 Boiler	Heat Pump	-	571,000	-	589,000
	Electric Resistance	-	2,092,000	-	2,111,000
	Heat Pump	-	323,000	-	330,000

Category	Replace with	Cost-Effectiveness ($,Ton), No Panel Upgrade		Cost-Effectiveness ($,Ton), With Panel Upgrade	
		Energy Input Estimate Method	Energy Input Calculation Method	Energy Input Estimate Method	Energy Input Calculation Method
Type 2 Boiler (1 MMBtu)	Electric Resistance	-	2,090,000	-	2,097,000
Type 2 Boiler (2 MMBtu)	Heat Pump	-	240,000	-	244,000
Instantaneous (Tankless) Water Heater	Heat Pump	33,000	310,000	823,000	1,100,000
	Heat Pump and Split Panel Cost	-	-	428,000	705,000
	Heat Pump and Split Panel Cost and Incentives of $5,100	-	-	(530,000)	(253,000)
	Electric Resistance Tank Type	-	2,580,000	-	3,369,000
	Electric Resistance Tank Type and Split Panel Cost	-	-	-	2,974,000
	Electric Resistance Tankless	-	2,617,000	-	3,407,000
	Electric Resistance Tankless and Split Panel Cost	-	-	-	3,012,000

The proposed BARCT emission limits will take effect at the end of the presumed useful age of the equipment that is currently being used; therefore, the majority if the cost impacts are at the natural turnover of the equipment. The facilities will incur some cost to upgrade the equipment, but some of the cost will already be incurred due to end-of-useful-age replacement.

SOCIOECONOMIC IMPACT ASSESSMENT

A socioeconomic impact assessment will be conducted and, if applicable, released for public review and comments at least 30 days prior to the South Coast AQMD Governing Board Hearing for PAR 1146.2, which is anticipated to be heard on April 5, 2024 (subject to change).

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) ANALYSIS

Pursuant to the California Environmental Quality Act (CEQA) and South Coast AQMD's certified regulatory program (Public Resources Code Section 21080.5, CEQA Guidelines Section 15251(l) and South Coast AQMD Rule 110), the South Coast AQMD, as lead agency, is reviewing the proposed project (PAR 1146.2) to determine if it will result in any potential adverse environmental impacts. Appropriate CEQA documentation will be prepared based on the analysis.

DRAFT FINDINGS UNDER HEALTH AND SAFETY CODE SECTION 40727

Requirements to Make Findings

Health and Safety Code Section 40727 requires that prior to adopting, amending, or repealing a rule or regulation, the South Coast AQMD Governing Board shall make findings of necessity, authority, clarity, consistency, non-duplication, and reference based on relevant information presented at the public hearing, and in the staff report.

Necessity

Proposed Amended Rule 1146.2 is needed to establish BARCT requirements and achieve emission reductions proposed by 2022 AQMP Control Measure C-CMB-01 in order to meet the National Ambient Air Quality Standards for ozone.

Authority

The South Coast AQMD Governing Board has authority to adopt amendments to Rule 1146.2 pursuant to the California Health and Safety Code Sections 39002, 40000, 40001, 40440, 40702, 40725 through 40728, and 41508.

Clarity

Proposed Rule 1146.2 is written or displayed so that its meaning can be easily understood by the persons directly affected by it.

Consistency

Proposed Rule 1146.2 is in harmony with and not in conflict with or contradictory to, existing statutes, court decisions, or state or federal regulations.

Non-Duplication

Proposed Rule 1146.2 will not impose the same requirements as any existing state or federal regulations. The proposed amended rule is necessary and proper to execute the powers and duties granted to, and imposed upon, the South Coast AQMD.

Reference

In amending Rule 1146.2, the following statutes which the South Coast AQMD hereby implements, interprets or makes specific are referenced: Health and Safety Code Sections 39002, 40000, 40001, 40440, 40702, 40725 through 40728, and 41508.

COMPARATIVE ANALYSIS

Under Health and Safety Code Section 40727.2, the South Coast AQMD is required to perform a comparative analysis when adopting, amending, or repealing a rule or regulation. The comparative analysis is relative to existing federal requirements, existing or proposed South Coast AQMD rules and air pollution control requirements and guidelines which are applicable to combustion equipment subject to PAR 1146.2. A comparative analysis will be prepared and released in the Draft Staff Report at least 30 days prior to the South Coast AQMD Governing Board Hearing on PAR 1146.2, which is anticipated to be considered for approval on April 5, 2024 (subject to change).