Codes and Standards Enhancement (CASE) Initiative

2028 California Energy Code

Process Boilers

Amy Droitcour, Emma Conroy, Eva Hidalgo,
Joe Vukovich (2050 Partners), Shafi Amoni (Cascade Energy),
Ryan Swanson (Enesfere), Lily Baldewicz (CAI Energy Consulting)

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Draft CASE Report

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Authors: Amy Droitcour, Emma Conroy, Eva Hidalgo, Joe Vukovich (2050 Partners), Shafi Amoni (Cascade Energy), Ryan Swanson (Enesfere), Lily Baldewicz (CAI Energy Consulting)

Project Support: Kyle Dunn, Martin Vu (RMS Energy Consulting), Fawn Brooks (2050 Partners), Gina Rodda (Gabel Energy Consulting)

Prime Contractor: 2050 Partners

Project Management: California Statewide Utility Codes and Standards Team: Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas & Electric Company

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Draft Report – Request for Comments

The Statewide Codes and Standards Enhancement (CASE) Team welcomes feedback on the proposed code changes and the supporting analyses presented in this draft report. To strengthen the review process, commenters are encouraged to include relevant data and justifications where applicable.

The Statewide CASE Team will consider all comments as it refines the proposals and analyses. The Final CASE Report is scheduled for submission to the California Energy Commission (CEC) in Spring 2026.

For this report, the Statewide CASE Team is requesting input on the following:

1. *Stack economizer first and maintenance costs and dimensions for boilers with different input capacities,*
2. *Current market share of stack economizers and automatic blowdown in process boilers above 10 MMBtu/h input capacities, and*
3. *The prevalence of stack temperatures below 340°F, blowdown heat recovery, and makeup water treated by RO systems in process boilers above 10 MMBtu/h input capacities.*

Email comments and suggestions to info@title24stakeholders.com and emmaconroy@2050partners.com*. Comments will either remain confidential or anonymized if shared publicly.*

Acronyms

Table 1 presents a list of acronyms used in this report. Title24stakeholders.com also maintains a glossary of terms.

Table 1: List of Acronyms

Acronym	Definition
ACM	Alternative Calculation Method
ADA	Americans with Disabilities Act
AHJ	Authority Having Jurisdiction
APCD	Air Pollution Control District
AQMD	Air Quality Management District
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ATT	Acceptance Test Technician
BCR	Benefit-to-cost Ratio
BEA	Bureau of Economic Analysis
BEM	Building Energy Modeling
Btu	British Thermal Units
CALGreen	California Green Building Standards Code
Cal/OSHA	California Division of Occupational Safety and Health
CARB	California Air Resources Board
CASE	Codes and Standards Enhancement
CBSC	California Building Standards Commission
CBECC	California Building Energy Code Compliance Software
CBECC-Res	California Building Energy Code Compliance for Residential Buildings Software
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CBO	Community-Based Organization
CO_2e	Carbon Dioxide Equivalent
CPUC	California Public Utilities Commission
CSE	California Simulation Engine
CTF	Conduction Transfer Functions
CZ	Climate Zone
DAC	Disadvantaged Community
DGS	California Department of General Services

DOAS	Dedicated Outdoor Air System
DOE	Department of Energy
DOSH	Division of Occupational Safety and Health
ECC	Energy Code Compliance
EIR	Environmental Impact Report
EPIC	Electric Program Investment Charge
ESJ	Environmental and Social Justice
EUL	Effective Useful Life
FGR	Flue Gas Recirculation
FRED	Federal Reserve Economic Data
FSOR	Final Statement of Reasons
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWh	Gigawatt-Hour
HVAC	Heating, Ventilation, and Air Conditioning
IAC	Industrial Assessment Center
IDF	Input Data File
IECC	International Energy Conservation Code
IOU	Investor-Owned Utility
IPGR	Industrial Product Growth Rate
ISOR	Initial Statement of Reasons
kBtu/yr	Thousand British Thermal Units Per Year
Kg/s	Kilograms per Second
kWh	Kilowatt-Hour
kWh/year	Kilowatt-Hour Per Year
LED	Light Emitting Diode
LMI	Low- and Moderate-Income
LPD	Lighting Power Density
LSC	Long-term System Cost
MeasureSET	CASE Measure Savings Estimation Template
MG	Million Gallons of Water
MMBtu	Million British Thermal Units
MMBtu/h	Million British Thermal Units Per Hour
NAICS	North American Industry Classification System
NOx	Nitrogen Oxides
NPDI	Net Private Domestic Investment
NR	Nonresidential

NRCA	Nonresidential Certificate of Acceptance
NRCC	Nonresidential Certificate of Compliance
NRCI	Nonresidential Certificate of Installation
OEM	Original Equipment Manufacturer
PEP	Public Engagement Plan
ppmv	Parts Per Million by Volume
psig	Pounds Per Square Inch Gauge
PV	Present Value
RO	Reverse Osmosis
SCR	Selective Catalytic Reduction
SDD	Standards Data Dictionary
SOC	Standard Occupational Classification
SPMS	Saturation Pressure Measurement Sensors
SRIA	Standardized Regulatory Impact Assessment
TDS	Total Dissolved Solids
UL	Underwriters Laboratories
W	Watt

1. Introduction

This is a draft report. The Statewide Codes and Standards Enhancement (CASE) Team encourages readers to provide comments on the proposed code changes and supporting analyses. The CEC will evaluate proposals that the Statewide CASE Team and other stakeholders submit and may revise or reject proposals. More information about the rulemaking schedule and how to participate in the process can be found on CEC's 2028 code cycle website. Suggested revisions will be considered when refining proposals and analyses. The final CASE Report will be submitted to the CEC in May 2026.

Email comments and suggestions to info@title24stakeholders.com *and* emmaconroy@2050partners.com*. Comments will not be attributed to their authors unless these are publicly docketed or with permission of the contributor.*

1.1 Report Context

This proposal describes specific energy efficiency code changes (referred to as "measures") aimed at reducing wasteful, uneconomic, inefficient, or unnecessary consumption of energy in California. These measures are submitted to the California Energy Commission (CEC) for consideration and potential inclusion in California's Energy Code (Title 24, Part 6), which sets statewide energy efficiency requirements for newly constructed buildings and for additions and alterations to existing buildings. Measures may also be considered for inclusion in CALGreen (Title 24, Part 11) as voluntary energy efficiency standards, which would take effect only if adopted by a local jurisdiction seeking to exceed the minimum requirements of the Energy Code. Measures submitted to the CEC will be reviewed, may be modified, and may be incorporated into a broader regulatory package proposed and adopted by the CEC. To be included in the Energy Code, proposed measures must be both cost effective and technically feasible.

1.2 Proposal Sponsors

Three California Investor-Owned Utilities (IOUs) — Pacific Gas & Electric Company, San Diego Gas & Electric, and Southern California Edison sponsored this effort as a group. Where the term, "Statewide CASE Team" is used in this report, it refers the authors of the CASE report and the Codes & Standards programs of the supporting California Investor-Owned Utilities.

1.2.1 Stakeholder Engagement to Inform Proposal

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with or gathered feedback from many industry stakeholders including manufacturers, sales representatives, maintenance and installation providers, an economic research and consulting firm, an industrial energy benchmarking and consulting firm, the California Air Resources Board (CARB) and others involved in the code compliance process. The proposal incorporates feedback received during a public stakeholder workshop that the Statewide CASE Team held on September 23, 2025. Materials from the workshops are available at title24stakeholders.com (Amoni, et al., Process Boiler #1: Non-Condensing Stack Economizer Requirement 2025 Amoni, et al., Process Boiler #2: Conductivity-Based Blowdown & Deaerator Settings 2025).

The Statewide CASE Team engaged with multiple boiler manufacturers and representatives to learn more about current industry trends and practices across all the proposed measures. The Statewide CASE Team formally interviewed five boiler representatives from three organizations and received feedback from three additional representatives via email. Topics covered in the interviews included boiler lifespan and efficiency and current industry practices related to blowdown, deaerator pressure, and stack economizers. Insights from these interviews were used to inform estimates for the current market share, incremental costs, and barriers to adoption of the proposed measures. The Statewide CASE Team shared specific details of the proposed measures, including planned measure exceptions and requirement thresholds, and received feedback from interviewees that was incorporated into the proposed code language.

See Appendix E for details on the Statewide CASE Team’s stakeholder engagement.

2. Stack Economizer

2.1 Stack Economizer – Measure Description

2.1.1 Proposed Code Change

A process boiler is a type of boiler with a capacity (rated maximum input) of 300,000 Btu per hour (Btu/h) or more that serves loads other than space conditioning and service water heating related to human occupancy. A boiler stack economizer is a heat exchanger that recovers heat from boiler flue gas and transfers it to boiler feedwater or a combination of boiler feedwater and make-up water.

This proposed code change would require boiler stack (non-condensing) economizers on process boilers with capacities at or above 10 million British Thermal Units per hour (MMBtu/h). The requirement would apply to all new process boilers, including replacement boilers and boilers in additions to existing facilities, with the following exceptions:

- Boilers with stack temperatures below 340°F at their lowest firing rate without an economizer.
- Boiler systems designed to burn biomass[1] from facility processes or biomass produced from waste material produced at the facility, such as woody biomass, digester gas, landfill gas, and animal fat.
- Boilers employing stack heat recovery, such as a heat exchanger that serves an industrial heat pump or process drying application.
- Indoor replacement boilers at existing facilities with roof clearances (distance between the boiler outlet connection to the stack and the ceiling) less than 88 inches for boilers with an input capacity at or below 25 MMBtu/h; and less than 116 inches for boilers with an input capacity above 25 MMBtu/h.

The Statewide CASE Team is considering an additional exception for low-use boilers. Boilers used in oilfield production and municipal power generation are often not in buildings and therefore not expected to be within the scope of Title 24, Part 6. Table 2 summarizes the scope of the proposed code change.

[1] Has a dedicated line to the burner for biomass as specified. This does not include utility-supplied fuel that includes biomass.

Table 2: Scope of Proposed Code Change.

A ☒ indicates the proposed code change is relevant.

Building Type(s)	Construction Type(s)	Type of Change
☐ Single Family	☒ New Construction	☒ Mandatory
☐ Multifamily	☒ Additions	☐ Prescriptive
☒ Nonresidential (excluding Occupancy R uses)	☒ Alterations	☐ Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	• Part 6, Section 100.1(b) and Section 120.6(d) •	• NRCC-PRC-E • NRCI-PRC-E	• N/A

Third Party Verification	Updates to Compliance Software
☒ No changes to third party verification	☒ No updates
☐ Update existing verification requirements	☐ Update existing feature
☐ Add new verification requirements	☐ Add new feature

2.1.2 Benefits of Proposed Change

Most steam boilers lose 20 percent or more of their input fuel energy in the form of heat of the combustion exhaust (Rahman 2011). A stack economizer can recover a significant fraction of this waste heat, reducing load and thermal stress on the boiler, lowering fuel consumption, and extending boiler useful life. The use of a stack economizer is typically the highest-impact action that sites can take to reduce their boiler natural gas usage, saving two to four percent of fuel energy by preheating boiler feedwater. A 2012 Department of Energy (DOE) steam tip sheet estimated that an economizer can reduce fuel requirements by five to ten percent and pay for itself in less than two years (Office of Industrial Technologies, Energy Efficiency and Renewable Energy, US Department of Energy 1999).

This proposed code change can also achieve benefits that include job creation in the manufacturing and installation of stack economizers, as well as improved local air quality due to a reduction in burned fuel, which is typically natural gas. Many industrial facilities are located near Low- and Moderate-Income (LMI) housing, which disproportionately experiences lower air quality. This proposal would also reduce photochemical smog in these communities.

2.1.3 Background Information

A boiler stack economizer is an air-to-water heat exchanger consisting of tubes placed in the boiler exhaust stream. Boiler feedwater is run through the tubes and the hot boiler flue gas then pre-heats the boiler feedwater. Since the water enters the boiler at a higher temperature, the boiler requires much less fuel to heat the water to the desired temperature and pressure, increasing overall efficiency.

The use of boiler stack economizers has been listed in DOE literature as a best practice since at least 1999 (Office of Industrial Technologies, Energy Efficiency and Renewable Energy, US Department of Energy 1999). Despite its cost-effectiveness, building owners and operators too often fail to implement the practice because of its initial cost and the general lack of awareness of the energy benefits. That said, boiler system vendors and contractors are familiar with this technology, and they ensure it is widely available. Further, stack economizers can be installed in various configurations, making them feasible in most facilities.

Title 24, Part 6 first adopted requirements for process boilers in 2013. To the knowledge of the Statewide CASE Team, boiler stack economizer requirements have not been proposed in previous code cycles. Multiple utilities in the United States offer incentives for boiler stack economizers, including SoCalGas in California (SoCalGas 2025 Consumers Energy 2025).

2.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 2.6 of this report for detailed revisions to code language.

2.1.4.1 Energy Code Change Summary

SECTION 100.1(b) – DEFINITIONS AND RULES OF CONSTRUCTION

Subsection 100.1(b): The proposed measure would add new definitions for 1) boiler stack economizer, 2) mesh burner, 3) selective catalytic reduction (SCR) system, and 4) biomass.

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

Subsection 120.6(d)4: The proposed measure would add a non-condensing stack economizer requirement for newly installed process boilers with an input capacity greater than 10 MMBtu/h (10,000,000 Btu/h), with exceptions for boilers with stack temperatures below 340°F at their lowest firing rate without an economizer, boilers that burn biomass, boilers employing other methods of stack heat recovery, and indoor replacement boilers with low roof clearance. This requirement would cost-effectively increase the stringency of the Energy Code, thereby minimizing the energy use of covered processes, which in turn improves the state's economic and environmental health.

2.1.4.2 Reference Appendices Change Summary

The proposed measure will not modify the reference appendices because there is no functional testing required for compliance verification.

2.1.4.3 Compliance Manuals Change Summary

The proposed changes would include updates to Section 10.9.2 of the Nonresidential Compliance Manual, which outlines mandatory requirements for process boilers. A new section, 10.9.2.5, would be created to explain the stack economizer requirement and verification.

2.1.4.4 Alternative Calculation Method Reference Manual Change Summary

The proposed measure will not modify Alternative Calculation Method (ACM) Reference Manuals because the proposed measure requires no associated software updates.

2.1.4.5 Compliance Forms Change Summary

The existing Process System Certificate of Compliance form (NRCC-PRC-E, Section I: Process Boilers) and Process System Certificate of Installation form (NRCI-PRC-E, Process Boilers) would both need new input fields added to ensure that qualified boilers meet the stack economizer requirement. The Certificate of Compliance form would also demonstrate verification of any applicable exceptions.

2.1.5 Measure Context

2.1.5.1 Comparable Model Codes or Standards

Review found no relevant and comparable model codes or standards for context.

2.1.5.2 Interactions with Other Regulations

Review found no known existing federal, state, or local regulatory requirements that address process boiler stack economizers. Current Title 24, Part 6 requirements for process boilers cover combustion air positive shut-off, combustion air fans, and stack-gas oxygen concentrations. The proposed non-condensing stack economizer requirement discussed in this document would have no impact on these existing requirements.

Review finds no anticipated conflicts between these proposed requirements and the other proposed submeasure for process boilers, discussed in Section 3, which would require conductivity-based blowdown and steam supply line pressure regulator setpoints at or below 5 pounds per square inch of gauge pressure (psig).

2.2 Stack Economizer – Compliance and Enforcement

2.2.1 Compliance Considerations

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced. The Statewide CASE Team believes that compliance and enforcement of the proposed measure is feasible and would not add significant compliance or enforcement burden to those responsible for ensuring compliance with building code.

To ensure compliance with the proposed stack economizer requirement, confirmation steps would need to be taken during permit application (plans review), installation, and inspection by the AHJ or building department. New fields in the Process Systems Certificate of Compliance Form NRCC-PRC-E and the Process System Certificate of Installation form NRCI-PRC-E would need to be completed.

Designers. Designers would need to be aware that requirements for process boilers in section 120.6(d) have been expanded so they can design compliant process boiler systems. They would need to fill out an updated NRCC-PRC-E form and to submit design documents indicating a compliant design. If a site is planning to pursue an exemption for the use of biomass, the fuel line needs to be depicted and labeled in the construction documents. To qualify for the heat recovery exemption, the designer would need to ensure that the stack heat recovery equipment is included in the construction documents. For replacement boilers at existing facilities, the NRCC-PRC-E form may be completed by the plant engineering department or another party and must include the existing roof clearance at the boiler (distance between the boiler outlet connection to the stack and the ceiling).

Authorities Having Jurisdiction (AHJ) Plan Checkers. During the permit application phase, AHJ plan checkers would review the submitted NRCC-PRC-E form and design documents to confirm that the design either includes a stack economizer in the design or qualifies for a claimed exception via stack temperature, use of biomass, alternative methods of heat recovery, or low roof clearance.

Installation contractors. Installation contractors would be required to correctly install stack economizers in accordance with design and manufacturing specifications, which their normal operating procedures already require. The installation contractors will document the installation in the NRCI-PRC-E form unless done by another party. When the installation contractor fills in the Certificate of Installation form, they would need to include the model and serial number for the stack economizer in addition to information on the process boiler that is already required.

Field technicians. Field technicians are typically the installers or technicians configuring the boiler system controls and are not a certified Acceptance Testing Technician (ATT). Field technicians may complete the stack economizer fields in the process boilers section of the NRCI-PRC-E form if not done by the installation contractors. For sites claiming no exemption, compliance verification includes confirmation of stack economizer installation and verification that the stack economizer is not bypassed. Field technicians would need to understand these different code and testing requirements for exempt and non-exempt sites. Sites seeking to reduce compliance burdens can have the commissioning technicians that tune the equipment prior to AQMD-required stack testing also confirm installation of stack economizer and stack temperature at low firing rates.

AHJ Building Inspectors. The AHJ building inspector would need to verify the installation of the stack economizer in the NRCI-PRC-E form in addition to the other process boiler inspection items already required for a new boiler installation.

Review finds that all definitions added for new proposed code language do not conflict with any existing definitions in other parts of Title 24.

2.2.2 Impact on Market Actors

Table 3 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements.

Table 3: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Developers [a]	Be aware that stack economizers are required, and plan for additional costs.	Additional training likely unnecessary.
Design Professionals[b]	Be aware of new requirements, code triggers, and exceptions when designing process boiler systems. Include correctly-sized stack economizers in all process boilers system designs where required and include relevant specifications in design documents. Complete new fields of NRCC-PRC-E Process Boilers section in addition to existing fields.	Industrial boiler equipment design firms should be provided training on the energy code including compliance requirements and compliance documentation.
Construction Team[c]	Install stack economizer as specified in the approved design documents, consistent with standard practice.	Stack economizer/boiler system installer should be provided training on the energy code

	Complete a new field in the process boilers section of NRCI-PRC-E.	updates and supporting documentation, compliance requirements, and compliance documentation.
Building Departments[d]	Plan Reviewers will have an additional requirement to check when reviewing NRCC form and design documents. Building inspectors will have to confirm completion of an NRCI form and verify compliant installation of a stack economizer in addition to existing process boilers requirements.	Provide education and training to local building department plans examiners to familiarize them with new code language.
Verification Testers[e]	If verification testing is performed by installing technician, see Construction Team. If field technicians are needed for verification testing, they would be required to fill out the new field in the process boilers section of the NRCI-PRC-E.	Boiler field technicians should be provided training on the energy code updates, compliance requirements, and compliance documentation.
Building Owners, Managers, and Occupants	Higher upfront cost and reduced energy bills. Need to maintain stack economizer when maintaining boiler. May need to complete the NRCC-PRC-E form for replacement boilers at existing facilities.	Outreach to owners and operations personnel could improve understanding of the benefits of stack economizers and address concerns. Additional training could reinforce the importance of water quality maintenance and stack economizer maintenance.
Manufacturers and Distributors	Additional sales of stack economizers.	Additional training likely unnecessary.

a. Developers plan the project, manage finances, and manage risks from start to finish.
b. Design professionals include architects, interior designers, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.
d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians, and sustainability department staff.
e. Verification testers include commissioning agents, Energy Code Compliance Raters, and Acceptance Test Technicians.

The 2028 CASE Methodology Report presents a quantitative assessment of how changes to the California building code impact builders, building designers, and energy consultants. The analysis in the methodology report is not specific to the code changes presented in this report. This section provides a qualitative description of how this specific code change affects various market actors and additional quantitative analyses of its potential impacts on building industry subsectors.

Builders. The proposed change would likely affect commercial and industrial builders; however, it would likely not impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers in the commercial and industrial building industries equally; instead, it would primarily affect specific subsectors within the industries. Table 4 shows the commercial and industrial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Table 4 lists the industrial and commercial subsectors that would be impacted by the proposed code change.

Table 4: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2022 (Estimated)

Construction Subsector	Establishments	Employment	Annual Payroll (Billions $)
Industrial Building Construction	TBD	TBD	TBD
Nonresidential Structural Steel Contractors	363	13,110	1.1
Nonresidential Plumbing & HVAC Contractors	2,346	55,572	5.5
Other Nonresidential Equipment Contractors	556	9,594	1.0
Nonresidential Site Preparation Contractors	1,159	18,322	1.6
All Other Nonresidential Trade Contractors	940	18,027	1.6

a. Source: (State of California n.d.)

Facility owners. Facility owners would have to cover the upfront costs of the stack economizer equipment and installation and the ongoing maintenance costs, but they would also save money from reduced fuel costs due to decreased energy consumption. Overall, for California building owners, the proposed code changes would result in lower energy bills. The Statewide CASE Team estimates that, on average, the proposed change to Title 24, Part 6 would increase new boiler and installation costs by about $1,612 to $5,667 per MMBtu/h of boiler capacity and would increase maintenance costs by $1,417 to $4,983 per MMBtu/h of boiler capacity over 30 years, depending on the individual boiler's capacity. However, the measure would ultimately result in a savings of $36,862 to $57,168 per MMBtu/h of boiler capacity in energy cost savings over 30 years, roughly equivalent to a $102 to $159 per month reduction in energy costs per MMBtu/h of boiler capacity. Overall, the Statewide CASE Team expects the 2028 Title 24, Part 6 updates would save facility owners about $1,128 to $1,551 per year per MMBtu/h of boiler capacity relative to facilities that remain minimally compliant with the 2025 Title 24, Part 6 requirements.

Manufacturers. As discussed in Section 2.3.1.1, multiple manufacturers and installers of stack economizers are based in California, and these businesses would sell and install additional stack economizers. Refer to Section 2.3.4 for more information on the resultant impact to California jobs.

2.2.3 Compliance Software Updates

Review finds no compliance software updates required for this measure proposal.

2.2.4 Cost of Enforcement

The Statewide CASE Team acknowledges that changes to the code will impact enforcement costs. This report is an evaluation of specific measures, and the collective impact of all proposed changes for the 2028 Title 24, Part 6 may represent an increase in training and/or workload for enforcement personnel.

Costs of enforcement would include costs to deliver training to enforcement officials to enable them to adequately enforce the proposed measure.

The incremental enforcement requirement additions are small, as Title 24, Part 6 already includes requirements for process boilers that mandate plan reviews and inspections when new process boilers are installed. This proposal adds verification of operational requirements for the certificate of installation, which is performed by a field technician and not enforcement officials. Plans examiners would also need to check for one new requirement, and building inspectors would need to check completion of a new acceptance testing form and would need to verify installation of one additional requirement.

The Statewide CASE Team will work with the Compliance Improvement Team to estimate the total cost of enforcement.

2.3 Stack Economizer – Market and Economic Analysis

2.3.1 Market Structure and Availability

2.3.1.1 Current Market Structure and Availability

The stack economizer market is composed of manufacturers, designers and engineers, suppliers and distributors, installers and contractors, and field technicians.

Manufacturers provide base designs for stack economizers integrated with boilers or sold separately.

Designers and engineers work with manufacturers to select a correctly sized base stack economizer design and customize selections for specific site needs.

Suppliers and distributors provide parts and facilitate sales and logistics. They maintain inventory of standard models and spare parts, manage the procurement process, and handle delivery to the facility.

Installers and contractors install the physical equipment and work with field technicians to commission boiler systems and tune the boiler operating setpoints so its performance meets design specifications, site requirements, and any regulatory requirements. Field technicians also fill out related forms as required.

The market for stack economizers is mature, with multiple manufacturers and suppliers providing designers and contractors many options for purchasing. Table 5 lists manufacturers, installers, and vendors that the Statewide CASE Team has identified as major market actors.

Table 5: Major Stack Economizer Manufacturers, Installers, and Vendors

Company	Market Actor Type	Product Offering	Headquartered in California?
Cain Industries	Manufacturer	Stack economizers and integrated boiler and stack economizers	No
California Boiler	Manufacturer	Stack economizers and integrated boiler and stack economizers	Yes
Cleaver-Brooks	Manufacturer	Stack economizers and integrated boiler and stack economizers	No
Enervex Venting Design Solutions	Vendor	Stack economizers	No
Parker Boiler	Manufacturer, Installer	Stack economizers and integrated boiler and stack economizers	Yes
R.F. MacDonald	Vendor	Stack economizers and integrated boiler and stack economizers	Yes

Boiler system manufacturers and vendors are familiar with stack economizer technology. Current market adoption rates are limited by a combination of initial capital cost and customer concerns about complexity. When purchasing a new boiler (or a replacement), many industrial buyers focus on minimizing the initial capital expenditure and fail to perform long-term cost analyses. Even when energy savings have relatively quick payback periods, industry still often prioritizes first costs (Energy Efficiency Movement 2025). Some sites and their managers may be concerned about maintenance requirements for stack economizers or potential maintenance of additional components required to route feedwater through the stack economizer. Further, many system owners and operators may lack a deep understanding of the true fuel-saving potential and efficiency gains that stack economizers offer.

Site managers who have larger boilers will more commonly include a stack economizer in their design strategy due to fuel savings scaling with boiler capacity. In an interview with the Statewide CASE Team, for example, one boiler vendor stated that economizers are economically justified for any boiler rated for several hundred horsepower or more. More proactive outreach to owners and operations personnel could improve understanding of the benefits of stack economizers and address their concerns in a way that would effectively increase adoption rates.

Table 6 details estimated current market adoption of stack economizers on newly installed boilers in California separated by boiler capacity. These market adoption estimates were informed by stakeholder interviewees and a statewide boiler inventory of local AQMD boiler permits (Swanson Staller 2025). Larger boilers generally experience higher adoption rates due to greater opportunity for fuel savings that further improve cost effectiveness of the stack economizer. The Statewide CASE Team anticipates that current market adoption will not change significantly without adoption of this measure, likely only experiencing slow increases.

Table 6: Estimated Current Stack Economizer Market Adoption in California

Boiler Capacity	Estimated Stack Economizer Market Adoption
10-15[2] MMBtu/h	25%
15-25 MMBtu/h	30%
25-50 MMBtu/h	40%
50-100 MMBtu/h	45%
100-200 MMBtu/h	50%
200+ MMBtu/h	90%

One boiler manufacturer representative noted that adoption rates may be increasing as the fraction of newly sold boilers with integrated stack economizers is higher than they currently see in the field. The Statewide CASE Team plans to reach out to additional stakeholders to gather more information about market adoption.

[2] All boiler capacity bins use an inclusive lower bound. For example, the 10-15 MMBtu/h bin means 10 ≤ boiler capacity < 15.

2.3.1.2 Market Challenges and Solutions

See Section 2.2 for a description of workforce trainings that may be needed to ensure effective design, installation, and commissioning.

Research finds a well-established market for stack economizers. The Statewide CASE Team surveyed manufacturer websites to confirm the availability of stack economizers in the current market from several manufacturers. Additionally, dozens of vendors and suppliers have decades of experience procuring and installing stack economizers. The Statewide CASE Team plans to confirm product reliability, producer stability, and stack economizer field performance through additional stakeholder outreach.

The Statewide CASE Team identified potential market adoption barriers to be 1) boiler system first cost and 2) boiler fuel type. The incorporation of stack economizers in boiler design increases the first cost of a boiler system. In stakeholder interviews with boiler manufacturers and vendors, interviewees described that industrial sites look for payback periods as low as 18 months to justify an investment, so even measures with a three-year payback can be passed over on just a cost basis. Many system owners and operators are also unaware of the energy savings benefits associated with stack economizers and extended boiler lifetime due to reduced thermal load, both of which justify the added cost to a boiler system for a stack economizer. The Statewide CASE Team recognizes that suppliers typically understand these benefits and expects these stakeholders will assist with the education of facility owners and the promotion of regulation compliance. The Statewide CASE Team also identified that facilities that burn wood processing byproducts or other biomass would experience increased maintenance costs from stack economizers due to the external fouling and residue these fuels deposit on the outside of economizer tubes. As such, the Statewide CASE Team has included an exemption for these types of facilities.

2.3.2 Design and Construction Practices

2.3.2.1 Current Design and Construction Practices

Manufacturers provide two main types of stack economizers: condensing and non-condensing. Condensing economizers are more efficient because they condense water vapors in flue gas and capture both latent and sensible heat of combustion (Waldron 2021).They are also more expensive, as the condensed water vapor is often acidic and requires economizers to be made of expensive, corrosion-resistant alloys (Waldron 2021). Additional equipment is also required to manage the accumulation of the condensed water vapors.

Non-condensing economizers only recover sensible heat and do not condense any liquids in the flue gas and therefore manufacturers typically use carbon steel for both the tubes and fins (Jouhara, et al 2018). While non-condensing economizers are not as efficient as condensing economizers, this proposed code change would require only non-condensing economizers to ensure measure cost-effectiveness for all types of facilities, including smaller facilities and seasonal producers.

The design and selection of a non-condensing stack economizer is driven by efficiency goals, feedwater conditions, and corrosion prevention. The most common design for maximizing heat transfer surface in a compact space is a finned-tube heat exchanger, also known as gilled-tube, but shell-and-tube heat exchangers are also used (Moynihan Barringer 2017). Shell-and-tube heat exchangers typically utilize a rectangular or cylindrical casing installed directly into the exhaust stack ducting. The cylindrical economizer is more compact and can thus be used on smaller boilers. The rectangular stack economizer can also be installed in a horizontal or vertical orientation, depending on space constraints, and is used for larger boilers. Typically, the compact design of the cylindrical economizer requires the tubes to be welded in, whereas the rectangular economizer has replaceable tubes that can be more easily maintained (Nationwide Boiler Incorporated 2019). Non-condensing economizers do not require expensive corrosion-resistant materials like condensing economizers, so they must be sized and controlled to ensure that the flue gas temperature remains above the acid dew point, which is typically around 250°F for natural gas fuels, to prevent acidic condensation (Reddy, Naidu Rangaiah 2013). The economizer heats the boiler feedwater and is designed for pressurized operation to raise the water temperature toward the saturation point without flashing to steam.

A stack economizer should be sized for the maximum feedwater flow rate and designed to handle the system's pressure. Installation must ensure that the water pressure at the economizer outlet sufficiently prevents the water from flashing to steam within the tubes, which can cause flow instability and thermal stress. Best practices for installation include locating the economizer directly above the boiler's stack outlet when possible. Stack economizer designs usually include bypass valves to enable isolation of the economizer for emergencies, such as a tube leak, or for general maintenance (Cain Industries n.d.). Stack economizer data sheets include rated boiler capacities and full economizer dimensions.

The proposed requirement would not impact construction best practices, as respective market actors are accustomed to the technology and its various installations and applications. The biggest impact of the proposed requirement is on space requirements. In new construction, larger overall boiler house footprints or increased stack height clearances may be required. For replacement boilers in existing facilities, limited space in the boiler room may require custom and smaller-footprint designs or the use of cylindrical economizers that fit into the stack. The added pressure drop for the flue gas may necessitate a larger forced-draft or induced-draft fan to overcome the resistance of the economizer.

While most process boilers burn natural gas, some facilities may choose to use alternative fuel sources. Other facilities may use wood processing byproducts or other biomass as their primary fuel source. The ash generated when burning many of these fuels builds up on the flue gas-side of the stack economizer tubes and requires additional, frequent maintenance to address and maintain heat transfer. The Statewide CASE Team also proposes an exemption for biomass due to the decreased cost effectiveness because of additional maintenance costs and reduced energy savings in these facilities. Refineries typically burn natural gas or process fuel gas, which can contain a mixture of process fuel byproducts. The Statewide CASE Team will continue to evaluate how this measure would apply to sites using multiple or mixed fuel sources and how the proposed code language can best address variable fuel compositions.

2.3.2.2 Health and Safety Considerations

The proposed code change does not impact any existing regulations pertaining to health and safety. Compliance with this code change would reduce local photochemical smog and improve air quality by reducing boiler fuel consumption and emissions.

2.3.2.3 Design and Construction Challenges and Solutions

See Table 3 in Section 2.2.2 for a description of workforce trainings that could support effective design, installation, and commissioning.

The Statewide CASE Team has identified two main design and construction challenges: 1) stack economizer tube fouling and 2) facility space constraints.

Non-condensing stack economizers are typically low maintenance as they have no moving parts. However, poor water quality management causes stack economizer fouling through the same mechanisms as boiler tube fouling, where scale deposits occur when solids that were dissolved in the water react to form a continuous layer of material on the waterside of the heat exchange tubes. Scale typically has a thermal conductivity an order of magnitude less than the corresponding value for bare steel, so even thin layers of scale reduce heat transfer (US Department of Energy 2012). Proper water quality management practices would minimize stack economizer and boiler degradation, maintain boiler efficiency, minimize unplanned downtime, and avoid the cost of boiler and economizer full tube replacements. Although stack economizers degrade at a slower rate than boilers, fouling rates can be significant and facilities managers need to address them during planned maintenance outages for boilers. Facilities occasionally neglect stack economizer maintenance due to a lack of planning or an overall desire to reduce maintenance cost and downtime. In such cases, the operator would likely bypass the stack economizer and render it inactive. This practice leads to a reduction in boiler efficiency and an increase in fuel consumption, as recoverable heat is expelled through the stack. To address this challenge, facilities would need to plan effectively for stack economizer maintenance cost and downtime. Maintenance costs and downtime may be minimized by scheduling cleaning and retubing of the boiler and stack economizer simultaneously.

Additional conditions that increase the risk of stack economizer fouling and failure include boilers with low stack temperatures and boilers burning biomass. For this reason, the Statewide CASE Team included measure exceptions for boilers with stack temperatures below 340°F at their lowest firing rate without an economizer and boiler systems designed to burn biomass[3] from facility processes or biomass produced from waste material produced at the facility.

Facilities may also experience space constraints when required to install an economizer when replacing a boiler that previously did not have a stack economizer or when adding a boiler at an existing facility. As described in Section 2.3.2.1, manufacturers offer multiple economizer designs that can be installed in different orientations to address this challenge. Facilities can work with designers to determine the best solution for their space constraints while complying with the proposed requirement. In certain cases, facilities may not have the required amount of space for a stack economizer installation in the boiler room and would thus be required to install the stack economizer on the roof. Roof installations may require structural work to support the additional weight, which can significantly increase installation costs. To ensure measure cost-effectiveness, the Statewide CASE Team included an exception to the proposed measure requirement for boilers at sites that would likely require roof installation.

2.3.3 Energy Equity and Environmental Justice

The Statewide CASE Team evaluated the potential impact on environmental and social justice (ESJ) communities,[4] including impacts related to race, class, and gender.

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[3] Has a dedicated line to the burner for biomass as specified. This does not include utility-supplied fuel that includes biomass.

[4] The CPUC refers to ESJ communities as “low-income or communities of color that have been underrepresented in the policy setting or decision-making process, are subject to a disproportionate impact from one or more environmental hazards, and likely to experience disparate implementation of environmental regulations and socio-economic investments in their communities” (CPUC 2022). ESJ communities also include the CPUC definition for Disadvantaged Communities, which comprises “(1) Census tracts receiving the highest 25 percent of overall scores in CalEnviroScreen 4.0 (1,984 tracts); (2) Census tracts lacking overall scores in CalEnviroScreen 4.0 due to data gaps, but receiving the highest 5 percent of CalEnviroScreen 4.0 cumulative pollution burden scores (19 tracts); (3) Census tracts identified in the 2017 DAC designation as disadvantaged, regardless of their scores in CalEnviroScreen 4.0 (307 tracts); and (4) Lands under the control of federally recognized Tribes (OEHHA 2022).

The Statewide CASE Team identified potential impacts of the proposed code change via research and stakeholder input, though the gathered list of impacts should not yet be considered exhaustive. Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement. Stakeholders with further input should reach out to Emma Conroy (emmaconroy@2050partners.com) to share further details on how this proposal may impact ESJ communities or any other perspectives.

The use of stack economizers in boiler systems would reduce boiler fuel consumption and avoid the associated emissions from burning fuel. The value of improved air quality from the proposed code changes is amplified by the fact that many industrial facilities are more often located near Low- and Moderate-Income (LMI) housing, thus disproportionally exposing these residents to lower air quality. As a result, the Statewide CASE Team expects that ESJ communities would disproportionately benefit from these changes.

2.3.4 Impacts on Jobs and Businesses

This section will be completed for the Final CASE Report.

2.3.5 Economic and Fiscal Impacts

This section will be completed for the Final CASE Report.

2.4 Stack Economizer – Cost Effectiveness

2.4.1 Cost Effectiveness Methodology

The Statewide CASE Team collaborated with CEC staff to confirm that the cost-effectiveness methodology aligns with CEC guidelines, including cost-inclusion parameters. The 2028 CASE Methodology Report and Appendix A provide reproducibility details.

Per California Law (Public Resources Code 25000), a measure is considered cost effective if its Benefit-Cost Ratio (BCR) is 1.0 or greater, amortized over the economic life of the structure. The Statewide CASE Team calculates BCR by dividing total dollar benefits by total dollar costs over a 30-year analysis period.

Benefits are based on Long-term System Cost (LSC), which assigns an hourly dollar value to energy use. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are valued more than off-peak hours. These factors are not utility rates, forecasts, or bill estimates. The CEC develops and publishes LSC hourly conversion factors for each code cycle.

Evaluation of costs include both initial costs and ongoing maintenance costs assessed over the 30-year period. Benefits and costs are evaluated incrementally, relative to the most recently adopted Energy Code. The analysis excludes design costs and incremental code compliance verification costs.

2.4.2 Energy and Energy Cost Savings Results

The Statewide CASE Team completed an energy savings analysis for the proposed stack economizer requirement, calculating the difference in energy consumption between the baseline (a boiler without a stack economizer) and measure case, a boiler with a non-condensing stack economizer. Savings result from improved boiler combustion efficiency due to the economizer using recovered heat to increase the temperature of boiler feedwater, and were calculated using the following steps:

1. Calculate the measure case boiler combustion efficiency using the American Society of Mechanical Engineers (ASME) PTC-4 Indirect Method: Stack Loss Method.[5]
2. Calculate annual boiler load from baseline annual gas consumption and baseline boiler efficiency.
3. Given that the annual boiler load is the same for the baseline and measure cases, calculate the measure case annual boiler gas consumption from the annual boiler load and the measure case boiler efficiency.
4. Calculate the difference between the baseline and measure case gas consumption to arrive at the measure's energy savings.

Natural gas savings for this measure will increase as the boiler capacity and stack economizer size increase. This correlation occurs because more heat traveling through the boiler stack leads to more heat being recovered to offset feedwater heating energy. The longer the boiler is operated, the greater the savings. As such, boilers that operate infrequently throughout the year due to seasonal loads will experience lower savings. Due to this variance, the Statewide CASE Team calculated annual energy savings and cost-effectiveness for boilers with seasonal loads separately from boilers with more typical annual loads. Calculations for boilers operating annually assumed 6,500 operating hours per year at 40 percent load, while calculations for seasonal boilers assumed 2,400 operating hours per year (primarily July through October) at 80 percent load. The Statewide Case TEAM based these assumptions for operating hours and load factor on analysis of data from 128 California steam-using sites sourced from the national Industrial Assessment Center (IAC) database Swanson Staller

[5] An explanation of the ASME PTC-4 Indirect Method: Stack Loss Method can be found at: ww2.arb.ca.gov/sites/default/files/cap-and-trade/allowanceallocation/boiler_efficiency_calc.pdf

2025). Industrial boilers may operate more than 6,500 annual hours, making the collective prototypes a conservative representation of boiler operating hours.

The Statewide CASE Team estimates an 80° stack economizer temperature drop in the stack exhaust for boilers between 10 and 25 MMBtu/h and a 100°F for boilers at or above 25 MMBtu/h. The Statewide CASE Team believes that both the estimated temperature drop of 80°F for smaller process boilers and 100°F for larger process boilers are slightly conservative based on field experience.

The persistence of energy savings depends on occupant behavior. Energy savings will diminish gradually over time as the stack economizer fouls, and the fouling rate increases with poor water treatment practices. The Statewide CASE Team accounted for economizer retubing costs halfway through the stack economizer lifetime, which should eliminate the impact of previous fouling and maintain savings throughout the 15-year stack economizer lifetime. When the stack economizer fouls, boiler operators may elect to bypass the stack economizer rather than retubing it. If the stack economizer is bypassed, the energy savings would drop to zero at that time. However, the cost-effectiveness of the measure would not be impacted because a stack economizer replacement in year 16 is included in the cost-effectiveness analysis.

While a stack economizer has no dedicated pump or fan, use of a stack economizer would slightly increase the energy usage of the combustion fan, which would have to run slightly higher to overcome the pressure drop of the economizer. The measure energy and emissions impacts and cost effectiveness data will be updated to consider the increased electricity usage in the Final CASE Report. As feedwater pumps use valves to control the boiler feedwater level, the economizer would have a negligent impact on feedwater pump energy usage.

The Statewide CASE Team used these calculated savings to arrive at the savings per MMBtu/h of boiler capacity for each boiler size bin. As shown in Table 7, per-unit savings for the stack economizer measure for the first year are expected to be 68,542 to 84,452 thousand British Thermal Units (kBtu) per MMBtu/h of boiler capacity for boilers operated year-round and 50,100 to 61,800 kBtu per MMBtu/h of boiler capacity for boilers operated seasonally. No electricity savings are associated with this measure. The per-unit energy savings of this measure are not impacted by climate zone and remain the same for new construction, additions, and alterations. Although the first-year savings are independent of climate zone, the LSC factors vary by climate zone. Table 8: Total 30-Year LSC Savings (2029 PV$) Per MMBtu/h of Boiler Capacity – Stack Economizers presents total per-unit energy cost savings for newly added boilers in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$) for year-round and seasonal boilers in the various size bins by climate zone.

Table 7: First Year Natural Gas Savings (kBtu) Per MMBtu/h of Boiler Capacity –- Stack Economizers

Boiler Capacity	First Year Natural Gas Savings (kBtu)
Year-Round 10-15 MMBtu/h	68,542.15
Year-Round 15-25 MMBtu/h	68,542.15
Year-Round 25-50 MMBtu/h	84,451.94
Year-Round 50-100 MMBtu/h	84,451.94
Year-Round 100-200 MMBtu/h	84,451.94
Year-Round 200+ MMBtu/h	84,451.94
Seasonal 10-15 MMBtu/h	50,100.00
Seasonal 15-25 MMBtu/h	50,100.00
Seasonal 25-50 MMBtu/h	61,800.00
Seasonal 50-100 MMBtu/h	61,800.00
Seasonal 100-200 MMBtu/h	61,800.00
Seasonal 200+ MMBtu/h	61,800.00

Table 8: Total 30-Year LSC Savings (2029 PV$) Per MMBtu/h of Boiler Capacity – Stack Economizers

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Year-Round 10-15 MMBtu/h	56,820	56,820	56,820	56,820	56,820	57,509	57,339	57,509	57,509	57,509	56,820	56,820	56,820	57,509	57,509	57,509
Year-Round 15-25 MMBtu/h	56,820	56,820	56,820	56,820	56,820	57,509	57,339	57,509	57,509	57,509	56,820	56,820	56,820	57,509	57,509	57,509
Year-Round 25-50 MMBtu/h	70,009	70,009	70,009	70,009	70,009	70,857	70,649	70,857	70,857	70,857	70,009	70,009	70,009	70,857	70,857	70,857
Year-Round 50-100 MMBtu/h	70,009	70,009	70,009	70,009	70,009	70,857	70,649	70,857	70,857	70,857	70,009	70,009	70,009	70,857	70,857	70,857
Year-Round 100-200 MMBtu/h	70,009	70,009	70,009	70,009	70,009	70,857	70,649	70,857	70,857	70,857	70,009	70,009	70,009	70,857	70,857	70,857
Year-Round 200+ MMBtu/h	70,009	70,009	70,009	70,009	70,009	70,857	70,649	70,857	70,857	70,857	70,009	70,009	70,009	70,857	70,857	70,857
Seasonal 10-15 MMBtu/h	36,836	36,836	36,836	36,836	36,836	36,887	36,878	36,887	36,887	36,887	36,836	36,836	36,836	36,887	36,887	36,887
Seasonal 15-25 MMBtu/h	36,836	36,836	36,836	36,836	36,836	36,887	36,878	36,887	36,887	36,887	36,836	36,836	36,836	36,887	36,887	36,887
Seasonal 25-50 MMBtu/h	45,439	45,439	45,439	45,439	45,439	45,502	45,490	45,502	45,502	45,502	45,439	45,439	45,439	45,502	45,502	45,502
Seasonal 50-100 MMBtu/h	45,439	45,439	45,439	45,439	45,439	45,502	45,490	45,502	45,502	45,502	45,439	45,439	45,439	45,502	45,502	45,502
Seasonal 100-200 MMBtu/h	45,439	45,439	45,439	45,439	45,439	45,502	45,490	45,502	45,502	45,502	45,439	45,439	45,439	45,502	45,502	45,502
Seasonal 200+ MMBtu/h	45,439	45,439	45,439	45,439	45,439	45,502	45,490	45,502	45,502	45,502	45,439	45,439	45,439	45,502	45,502	45,502

2.4.3 Incremental First Cost

The Statewide CASE Team evaluated the incremental cost for stack economizers using a boiler without a stack economizer as a baseline. The incremental first cost for this measure includes the purchase of the stack economizer and the cost of its design, installation, and compliance verification. Stack economizer installation costs vary widely depending on where the stack economizer is installed. Indoor installations are much costlier than outdoor installations, with their specific cost and complexity depending on the unique dimensions of the indoor space. The proposed measure includes an exception for newly installed indoor replacement boilers at existing facilities without much space between boiler stack outlet and the ceiling, as the cost of stack economizer installations at these sites would likely be too high to ensure measure cost-effectiveness.

Given the high variance of installation costs, the Statewide CASE Team estimated total incremental first costs by boiler capacity without separating equipment and installation costs. The total incremental first costs were estimated based on anonymized data from four sites that completed work with Cascade Energy, which included stack economizer purchase and installation costs in 2024. In addition, one large boiler vendor provided an estimate for stack economizer equipment and installation costs in June 2025 and confirmed the cost estimations used in the Statewide CASE Team's initial payback calculations were reasonable in September 2025. The cost to the site of commissioning and performance acceptance testing is included in the stack economizer installation cost.

Costs of stack economizer equipment and installation increase with boiler capacity. Stack economizer incremental costs are not expected to change significantly over time. The Statewide CASE Team plans to use additional cost estimates from stakeholders to inform the incremental cost estimates used in this analysis. The incremental first costs for equipment and installation are shown in Table 9.

Table 9: Process Boiler Non-Condensing Stack Economizer Incremental First Costs by Boiler Capacity

Boiler Capacity	Stack Economizer Total First Cost
12 MMBtu/h	$68,000
19 MMBtu/h	$98,000
33 MMBtu/h	$150,000
71 MMBtu/h	$242,000
143 MMBtu/h	$443,000
739 MMBtu/h	$1,191,000

2.4.4 Incremental Maintenance and Replacement Costs

Incremental maintenance costs include the incremental cost of replacing the equipment or parts of the equipment, as well as periodic maintenance required to keep the equipment operating relative to current practices over the 30-year period of analysis. A description of the incremental maintenance and replacement costs and estimation of present value of maintenance and replacement costs are provided in the 2028 CASE Methodology Report.

The maintenance cost for stack economizers includes a full replacement in year 16 and a partial tube replacement in year 8 and year 24. The stack economizer lifetime of 15 years was obtained from the effective useful life (EUL) from California Electronic Technical Resource Manual guidance for Industrial Steam Boiler Economizers (California Electronic Technical Resource Manual 2024). The full replacement cost was estimated to be equivalent to the first cost. The partial tube replacement cost was estimated to be 20 percent of the cost of full replacement. A boiler vendor provided the frequency and cost of partial replacements. The Statewide CASE Team plans to conduct further stakeholder outreach to obtain additional input on maintenance cost and frequency. Because the practices for stack economizer tube replacement are similar to practices for boiler tube replacements, both would be conducted by the same technicians.

Failure to replace fouled or failed tubes would reduce boiler efficiency by requiring higher firing rates, and therefore higher gas consumption, to maintain the same steam output. This practice would thus adversely impact measure energy savings. Proper commissioning practices need to be used to ensure the stack economizer is placed back in service after maintenance, not left in bypass and failing to recover waste heat. Appropriate operational practices for water quality management would have a significant impact on energy savings between maintenance periods for stack economizer and boiler tubes.

2.4.5 Cost Effectiveness

As described in Section 2.4.3, to validate stack economizer costs, the Statewide CASE Team requested and received an estimate for the equipment and installation costs of a specific size of stack economizer from a large boiler vendor in June 2025. In addition, the vendor separately confirmed in September 2025 that the cost estimates used in preliminary stack economizer simple payback calculations were reasonable.

The Statewide CASE Team evaluated per-unit cost-effectiveness for both year-round operation and seasonal boilers at six boiler capacities to ensure cost-effectiveness of the proposed requirement for boilers with lower annual operating hours and throughout the size range covered by the proposed measure. Table 10 shows the boiler capacity bin ranges and the average capacity of the boilers within each bin, which was used to perform the cost-effectiveness calculations. Data on the capacity of installed boilers in California came from the statewide boiler inventory of local air district boiler permits developed as part of the Code Readiness program (Swanson Staller 2025) and described in more detail in Appendix C. Boilers not subject to Title 24 or the proposed measure were removed prior to determining the average capacity as described in more detail in Section 2.5.1.

Interviewees reiterated that the payback of boiler stack economizers varies significantly with boiler capacity, and installing stack economizers on small boilers likely will not be cost effective. In response to this information and after running initial cost-effectiveness calculations, the Statewide CASE Team raised the minimum boiler capacity for the proposed requirement from 5 MMBtu/h to 10 MMBtu/h.

Table 10: Process Boiler Capacity Bins

Boiler Capacity Bin	Average Boiler Capacity Used for Calculations
10-15 MMBtu/h	12 MMBtu/h
15-25 MMBtu/h	19 MMBtu/h
25-50 MMBtu/h	33 MMBtu/h
50-100 MMBtu/h	71 MMBtu/h
100-200 MMBtu/h	143 MMBtu/h
200+ MMBtu/h	739 MMBtu/h

The Statewide CASE Team also evaluated the proposed measure's cost-effectiveness when the boiler steam header pressure was set to 15 psig rather than 100 psig to account for sites with lower steam header pressures. With the lower pressure, savings decreased by 13.2 percent and the measure remained cost effective.

As neither costs nor savings differ between new construction, additions, and alterations, cost effectiveness was not evaluated by project type.

Results of the per-unit cost-effectiveness analyses are presented in Table 11 and Table 12. The proposed measure saves money over the 30-year period of analysis relative to the existing conditions and is cost effective for both annual and seasonal boilers in each capacity bin and climate zone.

In Table 11 below, all values are presented in 2029 present value dollars (2029 PV$). Benefits represent 30-year LSC savings and other savings, including incremental first-cost savings if the proposed first cost is less than the current first cost, incremental maintenance cost savings if the proposed maintenance costs are less than the current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at the end of the 30-year period of analysis. Costs represent the total incremental PV cost, including incremental equipment, replacement, and maintenance costs over the period of analysis. The analysis treats a negative incremental maintenance cost as a positive benefit. If total incremental costs are zero, the BCR is considered infinite. Costs and other savings are discounted at a real (inflation-adjusted) three percent rate. If there are no total incremental PV costs, the BCR is considered infinite. A BCR of "NA" indicates that there is no boiler capacity in that climate zone that would be impacted by the proposed requirement.

Table 11: 30-Year Cost-Effectiveness Summary Per MMBtu/h of Boiler Capacity –- Stack Economizers

Prototype	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
Year-Round Boiler 10-15 MMBtu/h	$57,168.41	$15,633.60	3.66
Year-Round Boiler 15-25 MMBtu/h	$57,163.52	$14,229.97	4.02
Year-Round Boiler 25-50 MMBtu/h	$70,367.68	$12,694.19	5.54
Year-Round Boiler 50-100 MMBtu/h	$70,057.84	$9,403.48	7.45
Year-Round Boiler 100-200 MMBtu/h	$70,213.58	$8,546.71	8.22
Year-Round Boiler 200+ MMBtu/h	$70,599.54	$4,445.10	15.88
Seasonal Boiler 10-15 MMBtu/h	$36,862.16	$15,633.60	2.36
Seasonal Boiler 15-25 MMBtu/h	$36,861.72	$14,229.97	2.59
Seasonal Boiler 25-50 MMBtu/h	$45,465.37	$12,694.19	3.58
Seasonal Boiler 50-100 MMBtu/h	$45,442.30	$9,403.48	4.83
Seasonal Boiler 100-200 MMBtu/h	$45,453.82	$8,546.71	5.32
Seasonal Boiler 200+ MMBtu/h	$45,482.44	$4,445.10	10.23

Table 12: Benefit-to-Cost Ratio – Stack Economizers

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Year-Round 10-15 MMBtu/h	3.63	3.63	3.63	3.63	3.63	3.68	3.67	3.68	3.68	3.68	3.63	3.63	3.63	3.68	3.68	3.68
Year-Round 15-25 MMBtu/h	N/A	3.99	3.99	3.99	3.99	4.04	4.03	4.04	4.04	4.04	3.99	3.99	3.99	4.04	4.04	4.04
Year-Round 25-50 MMBtu/h	5.52	5.52	5.52	5.52	5.52	5.58	5.57	5.58	5.58	5.58	5.52	5.52	5.52	5.58	5.58	5.58
Year-Round 50-100 MMBtu/h	N/A	7.45	7.45	7.45	7.45	7.54	7.51	7.54	7.54	7.54	7.45	7.45	7.45	7.54	7.54	7.54
Year-Round 100-200 MMBtu/h	N/A	8.19	8.19	8.19	N/A	8.29	N/A	8.29	8.29	8.29	8.19	8.19	8.19	8.29	8.29	8.29
Year-Round 200+ MMBtu/h	15.75	15.75	15.75	15.75	N/A	15.94	N/A	15.94	15.94	15.94	15.75	15.75	15.75	15.94	15.94	15.94
Seasonal 10-15 MMBtu/h	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36
Seasonal 15-25 MMBtu/h	N/A	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
Seasonal 25-50 MMBtu/h	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58
Seasonal 50-100 MMBtu/h	N/A	4.83	4.83	4.83	4.83	4.84	4.84	4.84	4.84	4.84	4.83	4.83	4.83	4.84	4.84	4.84
Seasonal 100-200 MMBtu/h	N/A	5.32	5.32	5.32	N/A	5.32	N/A	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32
Seasonal 200+ MMBtu/h	10.22	10.22	10.22	10.22	N/A	10.24	N/A	10.24	10.24	10.24	10.22	10.22	10.22	10.24	10.24	10.24

2.5 Stack Economizer – Statewide Impacts

2.5.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team took the following steps to determine statewide savings from the proposed stack economizer measure.

First, the Statewide CASE Team used a statewide boiler inventory of local AQMD boiler permits (Swanson Staller 2025) to estimate statewide boiler capacities and total quantity of installations by boiler capacity bins. More information on the data can be found in : Assumptions for Statewide Savings Estimates.

The Statewide CASE Team refined the statewide capacity for each capacity bin to account for Title 24, Part 6 purview and stack economizer exceptions, making the following changes:

- Removed boilers with input capacities under 10 MMBtu/h and any units that were indicated to be hot water boilers or hot water heaters in the permit data.
- Removed oilfield and utility boilers, which are not in buildings and not subject to Title 24, Part 6 requirements.
- Removed boilers in the lumber industry, which likely use biomass as fuel and qualify for an exception from the stack economizer requirement.
- Removed ten percent to account for boiler capacity operating with a stack temperature below 340°F, which qualify for an exception from the stack economizer requirement.
- Removed 20 percent of alteration capacity estimated to qualify for the roof clearance exception.
- Separated seasonal boilers from annual boilers by classifying boilers at major tomato and canned fruit and vegetable processers as seasonal boilers.

The statewide capacity after these changes represents the Existing Boilers Stock. Boilers at or above 10 MMBtu/h in the manufacturing, non-cannery food, education, refinery, and ‘all other’ sectors were included in the statewide capacity totals. The Statewide CASE Team may update inclusion of boilers from each industry according to ongoing conversations regarding Title 24, Part 6 and process load applicability in these sectors.

To estimate the capacity of new process boilers installed annually from new construction and additions, the Statewide CASE Team calculated two Industrial Product Growth Rates (IPGRs) for California, one for year-round boilers and one for seasonal boilers. See : Assumptions for Statewide Savings Estimates for details on how the

Statewide CASE Team calculated the IPGR. The annual new construction and additions forecast is equivalent to the Existing Boiler Stock multiplied by the IPGR.

To estimate the capacity of new process boilers installed annually from alterations or replacements, the Statewide CASE Team calculated the replacement rate for boilers and applied it to Existing Boilers Stock. Boiler lifetimes range widely, with most estimates in the 25- to 40- year range (Van Wortswinkel Nijs 2010). The boiler replacement rate is based on a 30-year boiler lifetime, which means that 3.3 percent of the Existing Boiler Stock is replaced each year. The alterations forecast is therefore equivalent to the Existing Boiler Stock multiplied by 3.3 percent.

The Statewide CASE Team then multiplied the per-unit measure savings by the annual new construction and additions forecast and by the alterations forecast to get first-year statewide savings, not accounting for natural market adoption. To estimate the share of new boilers that would have stack economizers installed without the requirement in place, the Statewide CASE Team leaned on input from boiler manufacturers and vendors during stakeholder interviews and an analysis of IAC audit data from 64 boilers at 32 steam-using industrial plants from 2010 to 2022. The Statewide CASE Team applied these market share percentages to the statewide savings for each boiler capacity bin to arrive at the final statewide savings estimate.

For more details on the methodology and context about estimating the statewide energy and energy cost savings, see the 2028 CASE Methodology Report.

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 13) and alterations (Table 14) by climate zone.

Table 15 presents first-year statewide savings from new construction, additions, and alterations.

Table 13: Statewide Energy and LSC Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (Million Btu/h of boiler capacity)	First-Year Electricity Savings (Gigawatthours, GWh)	First-Year Peak Electrical Demand Reduction (Megawatts, MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	1	-	-	0.00	-	$0.07
2	7	-	-	0.01	-	$0.43
3	47	-	-	0.04	-	$3.06
4	18	-	-	0.01	-	$1.18
5	5	-	-	0.00	-	$0.30
6	28	-	-	0.02	-	$1.75
7	11	-	-	0.01	-	$0.70
8	37	-	-	0.03	-	$2.34
9	48	-	-	0.04	-	$3.01
10	33	-	-	0.02	-	$2.07
11	10	-	-	0.01	-	$0.64
12	150	-	-	0.12	-	$9.96
13	170	-	-	0.14	-	$11.47
14	16	-	-	0.01	-	$1.06
15	8	-	-	0.01	-	$0.51
16	5	-	-	0.00	-	$0.30
Total	594	-	-	0.47	-	$38.86

Table 14: Statewide Energy and LSC Impacts – Alterations

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (Million Btu/h of boiler capacity)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	2	-	-	0.00	-	$0.15
2	14	-	-	0.01	-	$0.86
3	95	-	-	0.07	-	$6.10
4	37	-	-	0.03	-	$2.34
5	9	-	-	0.01	-	$0.56
6	53	-	-	0.04	-	$3.31
7	20	-	-	0.01	-	$1.25
8	71	-	-	0.05	-	$4.43
9	91	-	-	0.07	-	$5.71
10	62	-	-	0.05	-	$3.89
11	21	-	-	0.02	-	$1.31
12	310	-	-	0.25	-	$20.32
13	354	-	-	0.29	-	$23.46
14	34	-	-	0.03	-	$2.20
15	16	-	-	0.01	-	$1.00
16	10	-	-	0.01	-	$0.61
Total	1,199	-	-	0.94	-	$77.51

Table 15: Statewide Energy and LSC Impacts – New Construction, Additions, and Alterations

Construction Type	First -Year Natural Gas Savings (Million Therms)	30-Year Present Valued LSC Savings (Million 2029 PV$)
New Construction & Additions	0.5	39
Alterations	0.9	78
Total	**1.4**	**116**

2.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 16 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 27,368 metric tons of carbon dioxide equivalent (CO_2e) emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of California Building Energy Code Compliance Software (CBECC), as well as data from the CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

Table 16: First-Year Statewide GHG Emissions Impacts

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO_2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO_2e)	Total Reduced GHG Emissions (Metric Tons CO_2e)	Total Monetary Value of Reduced GHG Emissions ($)
New Construction & Additions	0	2,443.43	2,443.43	300,902.94
Alterations	0	4,903.58	4,903.58	603,863.32
Total	**0**	**7,347**	**7,347**	**904,766**

2.5.3 Statewide Water Use Impacts

The proposed code change will not result in water use impacts as the stack economizer recovers heat from the boiler stack and has no impact on water use in the boiler system.

2.5.4 Statewide Material Impacts

The proposed code change would require the addition of non-condensing stack economizers to newly installed process boiler systems. Non-condensing stack economizers are typically made of carbon steel (Jouhara, et al 2018). The proposed requirement would lead to an increase in the demand for steel at industrial sites. The Statewide CASE Team used vendor data sheets to estimate the mass of steel in stack economizers for boiler capacities up to 50 MMBtu/h and derived a linear regression equation to estimate the pounds of steel per unit of boiler capacity using a least squares approach (Cleaver-Brooks n.d.). This linear regression equation was used to estimate additional steel used per unit of boiler capacity, as shown in Table 17. For more information on the Statewide CASE Team's methodology and assumptions used to calculate embodied GHG emissions, see the 2028 CASE Methodology Report.

Table 17: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per MMBtu/h)	First-Year Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO_2e)
Mercury	No Change	0	0	0
Lead	No Change	0	0	0
Copper	No Change	0	0	0
Steel	Increase	173	310,749	-171
Plastic	No Change	0	0	0
TOTAL	**N/A**	**173**	**310,749**	**-171**

2.5.5 Environmental Impacts

Requiring the use of stack economizers will decrease the energy required to operate a boiler, which in turn reduces GHG emissions from the reduced need to produce that energy, typically by burning natural gas (Chen, Omotesho Johnson 2025). Direct benefits are fully discussed in Sections 2.5.1 and 2.5.2, above.

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of "specific economic, environmental, legal, social, and technological factors" (Cal. Code Regs., tit. 14, § 15021). The Statewide CASE Team did not determine this measure would result in significant direct or indirect adverse environmental impacts and therefore did not develop any mitigation measures.

The Statewide CASE Team has considered alternatives to the proposal and determined that there are no alternate proposals that would achieve the same impact of reduced energy consumption from process boilers.

2.5.6 Other Non-Energy Impacts

The use of a stack economizer for boiler feedwater preheating would reduce boiler fuel consumption and emissions, reducing photochemical smog and improving local air quality.

2.6 Stack Economizer – Proposed Code Language

2.6.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2025 documents should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions).

2.6.2 Administrative Code (Title 24, Part 1)

No changes are proposed to Title 24, Part 1.

2.6.3 Energy Code (Title 24, Part 6)

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

Section 100.1(b) – Definitions: Recommends new or revised definitions for the following terms:

- **BOILER STACK ECONOMIZER** (also known as a flue gas heat recovery unit) is a heat exchanger that recovers heat from boiler flue gas and transfers it to boiler feedwater or a combination of boiler feedwater and make-up water.
- **MESH BURNER** is a type of burner constructed from fine metal mesh. In this system, combustion air is premixed with fuel before entering the burner. The premixed air-fuel mixture is directed through a steel tube into the mesh burner, where it passes through the fine mesh and enters the combustion chamber. Combustion occurs at the mesh surface, which acts as a flame arrestor, stabilizing and maintaining the flame.
- **SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM** is a system used to reduce nitrogen oxide (NOx) emissions. In this system, aqueous ammonia is injected into the boiler stack, where it mixes with the combustion exhaust gases. This ammonia (NH_3) and exhaust gas mixture then passes through a catalyst. Within the catalyst, the ammonia reacts with the NOx to produce nitrogen (N_2) and water (H_2O). Urea can also be used as an alternative to ammonia; it is converted into ammonia in the hot stack before entering the catalyst.
- **BIOMASS** is non-fossilized and biodegradable organic material originating from plants, animals or micro-organisms, including products, by-products, residues and

waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes, including gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material.

SUBCHAPTER 3 – NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, HOTEL/MOTEL OCCUPANCIES, AND COVERED PROCESSES--MANDATORY REQUIREMENTS

SECTION 120.6 – MANDATORY REQUIRMENTS FOR COVERED PROCESSES

120.6(d) Mandatory requirements for process boilers.

1. Combustion air positive shut-off shall be provided on all newly installed process boilers as follows:

    A. All process boilers with an input capacity of 2.5 MMBtu/h (2,500,000 Btu/h) and above, in which the boiler is designed to operate with a nonpositive vent static pressure.

    B. All process boilers where one stack serves two or more boilers with a total combined input capacity per stack of 2.5 MMBtu/h (2,500,000 Btu/h).

2. Process boiler combustion air fans with motors 10 horsepower or larger shall meet one of the following for newly installed boilers:

    A. The fan motor shall be driven by a variable speed drive; or

    B. The fan motor shall include controls that limit the fan motor demand to no more than 30 percent of the total design wattage at 50 percent of design air volume.

3. Newly installed process boilers with an input capacity greater than 5 MMBtu/h (5,000,000 Btu/h) shall maintain stack-gas oxygen concentrations at less than or equal to 3.0 percent by volume on a dry basis over firing rates of 20 to 100 percent.

Combustion air volume shall be controlled with respect to measured flue gas oxygen concentration. Use of a common gas and combustion air control linkage or jack shaft is prohibited.

    Exception to Section 120.6(d)3: Boilers with steady state full-load combustion efficiency 90 percent or higher.

4. Stack economizer. Newly installed process boilers with an input capacity equal to or greater than 10 MMBtu/h (10,000,000 Btu/h) shall have a boiler stack economizer.

    Exception 1 to Section 120.6(d)4: Boilers where the stack temperature measured at their lowest firing rate is below 340°F as documented in manufacturer performance data.

Exception 2 to Section 120.6(d)4: Boiler systems designed to burn biomass[6] from facility processes or biomass produced from waste material produced at the facility, such as woody biomass, digester gas, landfill gas, and animal fat.

Exception 3 to Section 120.6(d)4: Boilers employing other methods of stack heat recovery, such as a heat exchanger serving a load other than boiler feedwater.

Exception 4 to Section 120.6(d)4: Indoor replacement boilers at existing facilities with roof clearance (distance between boiler stack outlet to the ceiling) less than 88 inches for boilers with an input capacity at or below 25 MMBtu/h and less than 116 inches for boilers with an input capacity above 25 MMBtu/h.

2.6.4 Reference Appendices

No changes are proposed to the Reference Appendices.

2.6.5 Compliance Manuals

The Statewide CASE Team will provide CEC with recommended revisions to compliance manuals after the 45-Day Language is published.

2.6.6 ACM Reference Manual

No changes are proposed to the ACM Reference Manual.

2.6.7 Compliance Forms

As discussed in Section 2.1.4.5, the NRCC-PRC-E and NRCI-PRC-E compliance forms would be updated or added to reflect the proposed change. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

NRCC-PRC-E

To section I PROCESS BOILER table:

- Add a selection in the dropdown for rated input capacity to include: ≥ 10MMBtu/h
- Add a column for Stack Economizer
    - To the corresponding section for the form in the Virtual Compliance Assistant, add:
    - Does this process boiler have a stack economizer connected to the stack that is not bypassed and has feedwater piping from the deaerator or

[6] Has a dedicated line to the burner for biomass as specified. This does not include utility-supplied fuel that includes biomass.

feedwater tank passing through the economizer before entering the boiler?

  - Question response dropdown options:
    - Yes
    - This doesn't apply because the process boiler has a rated capacity less than 10MMbtu/h.
    - This doesn't apply because the stack temperature is below 340°F.
    - This doesn't apply because there is an alternative heat exchanger connected to the stack that is operational and heating another process.
    - This doesn’t apply because the clearance needed for the stack economizer is lower than the clearances listed in the exceptions table.

NRCI-PRC-E

To the Process Boilers Table, add:

- Column for Stack Economizer
  - Verify maximum capacity is greater than or equal to 10 MMBtu/h (T/F)
  - Verify that an economizer (air-to-water heat exchanger) is connected to the stack. (P/F)
  - Ensure the feedwater piping from the deaerator or feedwater tank passes through the deaerator. (P/F)
  - Confirm the economizer is not bypassed. (P/F)
- Column for Stack Economizer Serial and Model #

3. Automatic Blowdown and Deaerator Pressure

3.1 Automatic Blowdown and Deaerator Pressure – Measure Description

3.1.1 Proposed Code Change

This proposal would add the following requirements for all newly installed process steam boiler systems with input capacities at or above 10 MMBtu/h:

1) The boilers have an automatic surface blowdown controller that is programmed to be controlled by conductivity, and
2) For systems that use the boiler steam header to pressurize the deaerator, the steam supply line pressure regulator serving the deaerator must be set at or under 5 psig and between (and inclusive of) 2 and 5 psig for boilers with tubes not rated for oxidizing conditions.

The requirements would apply to all sites with new process steam boilers, including replacement boilers and boilers in additions to existing facilities, with the following exceptions:

Exceptions for the automatic blowdown requirement:

- Boiler systems with returned condensate composing more than 90 percent of feedwater flow,
- Boilers with make-up water treated by a reverse osmosis system, and
- Boilers with a heat exchanger that recovers energy from the blowdown to heat make-up water or another process stream, with or without a flash tank (blowdown heat recovery).

Exception for the steam supply line pressure regulator requirement:

- Sites with swings in make-up water equal to or above 20 percent of feedwater flow.

This proposal would require updates to compliance document review and a verification of controls and the steam supply line pressure regulator setpoint by a field technician.

Boilers used in oilfield production and municipal power generation are not expected to be within the scope of Title 24, Part 6. Table 18 summarizes the scope of the proposed code change.

Table 18: Scope of Proposed Code Change

A ☒ indicates the proposed code change is relevant

Building Type(s)	Construction Type(s)	Type of Change
☐ Single Family	☒ New Construction	☒ Mandatory
☐ Multifamily	☒ Additions	☐ Prescriptive
☒ Nonresidential (excluding Occupancy R uses)	☒ Alterations	☐ Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	• Part 1, Section • Part 6, Sections 100.1 (b) and 120.6 (d) • Nonresidential Reference Appendix Section 7	NRCC-PRC NRCI-PRC NRCA-PRC-XX-F	• N/A

Third Party Verification	Updates to Compliance Software
☒ No changes to third party verification	☒ No updates
☐ Update existing verification requirements	☐ Update existing feature
☐ Add new verification requirements	☐ Add new feature

3.1.2 Benefits of Proposed Changes

Manual boiler blowdown typically discharges more hot water than is needed to remove suspended and dissolved solids from the boiler water, resulting in unnecessary water and chemical losses. Reducing blowdown saves energy because less cold make-up water enters the system, and therefore less energy is needed at the deaerator and at the boiler to maintain system temperatures. Automatic blowdown systems continuously monitor surface conductivity and control a blowdown valve according to the conductivity levels, avoiding excessive blowdown by eliminating the need for operators to make manual valve adjustments. Improved conductivity control using an automatic blowdown system can also extend boiler useful life and slow efficiency degradation of the boiler.

Deaerators may be operated at higher-than-necessary pressures. Over-pressurization leads to excess venting, while under-pressurization can lead to insufficient air removal that may result in oxygen pitting and corrosion on contact surfaces. Ensuring proper deaerator pressurization through the steam supply line regulator saves energy and has no additional cost for end users.

In addition to the energy benefits, these practices would reduce local photochemical smog and improve air quality. The value of improved air quality is amplified by the consideration that many industrial facilities are located near LMI housing, which typically gets disproportionately exposed to lower air quality.

3.1.3 Background Information

High boiler water conductivity indicates high mineral content, which leads to fouling of the boiler heat exchanger tubes, increased thermal stress, lower boiler efficiency, and ultimately accelerated system wear and tear. High dissolved solids concentrations can also lead to foaming and the carryover of boiler water into the steam, which can foul downstream components, trigger water hammer[7], and accelerate system wear and tear.

To limit the levels of suspended and dissolved solids in steam boilers, water is periodically or continuously discharged or blown down. This surface blowdown removes dissolved solids that accumulate near the surface of the boiler water. When boiler operators complete blowdown manually, they commonly do so on a set schedule, testing the conductivity level once per shift and performing surface blowdown based on their reading. As many site changes can affect feedwater conductivity values and therefore require a change in blowdown, maintaining correct conductivity levels manually is very difficult and often leads to excessive or insufficient blowdown. To ensure that dissolved solid concentrations stay below acceptable limits with periodic testing, operators may conservatively blow down more than needed to provide a safety factor. Given that any water blown down must ultimately be replaced, blowdown beyond what is necessary to remove dissolved solids ends up wasting water, chemical treatments, and energy required to replace it. Automatic surface blowdown systems avoid excessive blowdown by automatically monitoring and maintaining water conductivity within manufacturer-specified setpoints. These systems use a conductivity probe to continuously measure surface conductivity, an indicator of the level of dissolved solids in the water. When conductivity rises above the setpoint, the system modulates a control valve to discharge the minimum amount of water necessary to bring conductivity back into its acceptable range.

Automatic boiler blowdown control was patented in the early 1970s and has been in DOE tip sheets since 2001 (Office of Industrial Technologies, Energy Efficiency and Renewable Energy, US Department of Energy 2001). IAC audits often recommend the practice (McLaughlin, Choi Kissock 2022), addressing the standard IAC audit recommendation to "reduce excessive boiler blowdown" (Michael Muller 2019). The Statewide CASE Team estimates that 20 to 30 percent of existing steam boilers in California use automatic blowdown systems, with the prevalence of these systems increasing with boiler size. Without a code requirement, the Statewide CASE Team estimates that the current market share will remain relatively stable, as boiler operators

[7] Water hammer, or hydraulic shock, occurs when a sudden change in water flow direction or velocity creates a pressure surge within plumbing.

have already had ample time and opportunity to move to automatic blowdown systems if their preference was to do so. The market share may increase slowly as the benefits of automatic blowdown become more widely understood, but the rate of adoption would not be expected to increase substantially. Utility incentive programs for automatic blowdown exist in other states, such as Consumers Energy offering customers in Michigan a financial incentive for automatic boiler blowdown (Consumers Energy 2025).

Boiler systems with returned condensate comprising more than 90 percent of feedwater flow qualify for an exemption from the proposed automatic blowdown system requirement. Condensate is essentially pure, distilled water with almost no dissolved solids, so systems where feedwater is largely condensate need less frequent blowdown to maintain total dissolved solids below manufacturer recommendations. Because these systems would experience lower energy savings from automatic blowdown, an investment in an automatic blowdown system is unlikely to be cost-effective and so these systems qualify for an exception.

The reverse osmosis process removes over 90 percent of the dissolved solids and impurities from boiler make-up water. As such, boilers with make-up water treated by reverse osmosis also require less frequent blowdown to maintain total dissolved solids below manufacturer recommendations and would experience lower energy savings from automatic blowdown. Given that fact, automatic blowdown systems are unlikely to be cost effective for these boilers and so they also qualify for an exemption.

Boilers recovering heat from their blowdown water also qualify for an exception, as they would also achieve lower energy savings from switching from manual blowdown to an automatic blowdown system, reducing cost-effectiveness.

Deaerators are sold with all large steam boiler systems. A deaerator is a pressurized vessel that heats a boiler’s feedwater to temperatures that release the dissolved gases (mainly oxygen and carbon dioxide) from the water. Removing the dissolved gases from the feedwater protects the system from corrosion. As the pressurization of the deaerator increases, the saturation temperature of the pressurized water also increases, which means a higher deaerator pressure setpoint heats the feedwater to higher temperatures. Almost all dissolved gases are removed at a temperature of 212°F. A steam supply line pressure regulator controls the pressure (and therefore the temperature) of the steam delivered to the deaerator. Setting the steam supply line pressure regulator, and correspondingly the deaerator pressure, to 5 psig (equivalent to 227°F) provides a 15°F margin in case of fluctuations in cold make-up water that can swing the deaerator temperature lower. Setting the pressure higher than 5 psig leads to higher amounts of steam venting out without providing additional benefits, wasting energy and water. Facilities commonly use a 5 psig setpoint, but a small percentage of facilities instead set their steam supply line pressure regulator and deaerator to a higher pressure out of an abundance of caution. This over-pressurization leads to excess steam venting and wasted energy. On the other hand, while uncommon, under-pressurization can cause insufficient dissolved gas removal, which can lead to oxygen pitting and corrosion on contact surfaces.

In addition to steam from the steam supply line, some facilities may also direct condensate return to feed their deaerator. Boiler systems with high-pressure (above 5 psig) and high-temperature (above 227°F) condensate return may therefore operate with deaerator pressure higher than 5 psig due to the influx of high-pressure condensate. By implementing a setpoint requirement at the steam supply line pressure regulator instead of the deaerator itself, systems that use high-pressure condensate to feed the deaerator may still comply with the 5 psig setpoint requirement for their steam supply line pressure regulator and avoid energy losses from deregulating the returned condensate.

Discussions with industry stakeholders demonstrated that a steam supply line pressure regulator limit of 5 psig is impractical when large amounts of make-up water serve the boiler feedwater. In these cases, the steam supply line must be at a higher pressure to compensate for the reduced energy of the incoming boiler feedwater. To account for sites that may use make-up water to serve the boiler feedwater, the CASE Team added an exception for sites with swings in make-up water equal to or above 20 percent of feedwater flow. Qualification for this exception will be determined by the professional engineer during the design process.

Title 24, Part 6 first adopted requirements for process boilers in 2013. Based on research conducted by the Statewide CASE Team, neither automatic blowdown nor deaerator or steam supply line regulator pressure requirements have been proposed in previous code cycles.

3.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 3.6 of this report for detailed revisions to code language.

3.1.4.1 Energy Code Change Summary

SECTION 100.1(b) – DEFINITIONS AND RULES OF CONSTRUCTION

Subsection 100.1(b): The proposed measure would add new definitions for a boiler blowdown valve, automatic boiler blowdown controller, boiler deaerator, and blowdown heat recovery.

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

Subsection 120.6(d)x: The proposed regulations would add an automatic surface blowdown system requirement for newly installed process boilers with an input capacity greater than 10 MMBtu/h (10,000,000 Btu/h), with exceptions for boilers with condensate return above 90 percent, boilers with make-up water treated by a reverse osmosis (RO) system, and boilers employing blowdown heat recovery.

Subsection 120.6(d)y: The proposed regulations would add a requirement for all newly installed process boilers with an input capacity greater than 10 MMBtu/h (10,000,000 Btu/h) that use the boiler steam header to pressurize the deaerator that the steam supply line pressure regulator serving the deaerator must be set at or under 5 psig. For boilers with tubes that are not rated for oxidizing conditions, the proposal would require that the steam supply line pressure regulator setpoint be within 2 to 5 psig. There would be one exception for sites with large swings in make-up water as a percentage of feedwater flow.

3.1.4.2 Reference Appendices Change Summary

Appendix NA7 – Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes Process Boiler Acceptance Tests: The proposed changes would expand this appendix to include information on new process boiler acceptance tests that verify compliance with the proposed blowdown and deaerator pressure requirements.

3.1.4.3 Compliance Manuals Change Summary

Section 10.9.2 of the Nonresidential Compliance Manual, which outlines mandatory requirements for process boilers, would be updated. Two new sections, 10.9.2.x and 10.9.2.y, would be created to explain the automatic surface blowdown and deaerator pressure requirements and verification.

3.1.4.4 Alternative Calculation Method Reference Manual Change Summary

The proposed measure will not modify ACM Reference Manuals because no software updates are associated with the proposed measure.

3.1.4.5 Compliance Forms Change Summary

The existing process systems Certificate of Compliance form (NRCC-PRC-E, Section I: Process Boilers) and Process System Certificate of Installation form (NRCI-PRC-E, Process Boilers) would need additional input fields to ensure that qualified boilers planned and installed an automatic blowdown system or qualify for an exception. A new Nonresidential Certificates of Acceptance form (NRCA-PRC-XX-F) would need to be created to demonstrate compliance with new acceptance testing requirements for process boilers, including that automatic blowdown is programmed to be controlled by conductivity and that the steam supply line pressure regulator setpoint meets the specified threshold.

3.1.5 Measure Context

3.1.5.1 Comparable Model Codes or Standards

Boiler blowdown is referenced in Appendix L (Sustainable Practices) of Title 24, Part 5 (California's Plumbing Code). L 507.0 (Heat Recovery from Steam Boiler Blowdown) stipulates that where heat recovery can be used beneficially to heat boiler makeup water or for other purposes, boiler blowdown from steam boilers exceeding 15 psi and 3,400,000 MMBtu/h shall be directed to a heat recovery system that reduces the temperature of the blowdown discharge to below 140°F without using tempering water. Provisions in Appendix L are not mandatory. The proposed code change for Title 24, Part 6 would lessen the energy savings from the provision in Title 24, Part 5, Appendix L for individual boilers, but a boiler that met the proposed requirement for Title 24, Part 6 would save more energy overall than a boiler that employed blowdown heat recovery as described in Title 24, Part 5, Appendix L.

3.1.5.2 Interactions with Other Regulations

Review has found no known existing federal, state, or local regulatory requirements that require conductivity-based blowdown in process boilers. Current Title 24, Part 6 requirements for process boilers cover combustion air positive shut-off, combustion air fans, and stack-gas oxygen concentrations. The proposed requirements for automatic (conductivity-based) blowdown and the steam supply line pressure regulator setpoints would have no impact on these existing requirements. Review finds no anticipated conflicts between these proposed requirements and the proposed Title 24, Part 6 measure requiring stack economizers and updating allowable stack-gas oxygen concentrations.

3.2 Automatic Blowdown and Deaerator Pressure – Compliance and Enforcement

3.2.1 Compliance Considerations

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process ways to mitigate or reduce negative impacts on market actors who are involved in the process. The Statewide CASE Team believes that compliance and enforcement of the proposed measure is feasible and would not add significant compliance and enforcement burdens to those responsible for ensuring compliance with building code.

To ensure compliance with the proposed automatic blowdown and deaerator pressure requirements, verification steps would need to be taken during permit application (such as reviewing plans), installation (including acceptance testing by field technician), and inspection. New fields would need to be completed in the NRCC-PRC-E and NRCI-

PRC-E forms. A new form for Process Boilers, NRCA-PRC-XX-F, would also need to be completed to document new acceptance tests performed by field technicians.

Designers would need to be aware that requirements for process boilers in section 120.6(d) have been expanded so they can design compliant process boiler systems. They would need to fill out an updated NRCC-PRC-E form and submit design documents indicating a compliant design with an automatic surface blowdown control system or qualification for an exception to the requirement. If a site is planning to pursue an exemption based on boiler feedwater being more than 90 percent composed of returned condensate, the plans should indicate planned installation of condensate return infrastructure sized to meet more than 90 percent of the boiler feedwater volume. Designers would need to do a simple calculation using the design flow rates and loads in the plans to confirm qualification for the exception. At existing systems, conductivity logs could be used to verify the exception if plans are not available. If a site is planning to pursue an exemption based on RO treatment of make-up water, the plans should indicate planned installation of an RO system. If a site is planning to pursue an exemption based on the use of blowdown heat recovery, the plans should indicate planned installation of blowdown heat recovery equipment.

If a site is planning to pursue an exception for the supply line pressure regulator requirement based on the make-up water swings as a percentage of feedwater flow, the designers would need to indicate the recommended steam supply line pressure regulator pressure setpoint on the design documents.

During the permit application phase, AHJ plan checkers would review the submitted NRCC-PRC-E form and design documents to confirm that the design either includes an automatic surface blowdown system in the design or qualifies for a claimed exception.

Installation contractors would be required to correctly install automatic surface blowdown systems in accordance with design and manufacturing specifications, which is their normal operating procedure. When the installation contractor fills in the Certificate of Installation form, they would need to include the make and model of the automatic surface blowdown controller in addition to the information already required on the process boiler.

Field technicians, who are typically the installers or technicians configuring the boiler system controls, would be required to set the setpoints for automatic blowdown conductivity and the steam supply line pressure regulator serving the deaerator. They would also complete the automatic blowdown system and deaerator pressure acceptance tests and record results on the new NRCA-PRC-XX-F form. If no exemption is claimed, the acceptance test would include verification that the system is programmed to be controlled by conductivity. The acceptance test would also include verification that the steam supply line pressure regulator setpoint is at or under 5 psig and within (and inclusive of) 2 to 5 psig for boilers with tubes that are not rated for oxidizing conditions. Field technicians would need to understand these different code and testing requirements for exempt and non-exempt sites.

Sites seeking to reduce compliance burdens can require the commissioning technicians that tune the equipment prior to AQMD-required stack testing to also conduct verification testing of the automatic surface blowdown system and deaerator pressure.

The AHJ building inspector would need to verify the installation of the automatic blowdown system (including each of the valve, controller, and conductivity probe), RO system, or blowdown heat recovery equipment if the boiler is claiming an exception from the automatic blowdown system requirement. They would also verify completion of the NRCI-PRC-E and NRCA-PRC-XX-F form in addition to the other process boiler inspection items already required for a new boiler installation.

Definitions added for new proposed code language do not conflict with any existing definitions in other parts of Title 24.

3.2.2 Impact on Market Actors

Table 19 summarizes impacts on market actors and suggests outreach and education to support market actors as they prepare for the effective date of the requirements.

Table 19: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Developers[a]	Ensure that the field technician completes the acceptance test and fills in the NRCA form or perform the acceptance test and submit applicable forms to the inspector.	Additional training likely unnecessary.
Design Professionals[b]	Be aware of new requirements, code triggers, and exceptions when designing process boiler systems. Include automatic blowdown systems in all process boilers system designs where required and include relevant specifications in design documents. Complete new fields of NRCC-PRC-E Process Boilers section in addition to existing fields.	Industrial boiler and steam system design firms should be provided training on the energy code adoption and compliance documentation.
Construction Team[c]	Ensure that field technician performs acceptance testing per NA7.XX and completes new NRCA form. Install automatic blowdown system as specified in the approved design documents, consistent with standard practice. Complete a new field in the process boilers section of NRCI-PRC-E. Installing technicians will need to conduct acceptance testing in accordance with NA7 and complete a new NRCA-PRC-XX-F form.	Automatic blowdown system installer should be provided training on the energy code adoption, compliance requirements, acceptance testing, and documentation.
Building Departments[d]	Have plan reviewers complete an additional requirement check when reviewing NRCC form and design documents. Have building inspectors confirm completion of a new NRCA form and verify compliant installation of an automatic blowdown system in addition to existing process boilers requirements.	Provide education and training to local building department plans examiners to familiarize with new code language and new acceptance tests.

Verification Testers[e]	Because verification testing is performed by installing technician, see Construction Team.	N/A
Building Owners, Managers, and Occupants	Expect increased first cost, but with reduced energy bills and, in some cases, reduced maintenance needs.	Outreach to owners and operations personnel could improve understanding of the benefits of automatic blowdown and address concerns.
Manufacturers and Distributors	Expect additional sales of automatic blowdown systems.	Additional training likely unnecessary.

a. Developers plan the project, manage finances, and manage risks from start to finish.

b. Design professionals include architects, interior designers, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.

c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.

d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians and sustainability department staff.

e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

The 2028 CASE Methodology Report presents a quantitative assessment of how changes to the California building code impact builders, building designers, energy consultants, building owners, and occupants. The analysis in the methodology report is not specific to the particular code changes presented in this report. The following section provides a qualitative description of how this specific code change affects various market actors and additional quantitative analyses of its potential impacts on building industry subsectors.

Builders. The proposed change would likely affect commercial and industrial builders. However, the change would likely not impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers in the commercial and industrial building industries. Instead, the change would primarily affect specific subsectors within the industries. Table 20 shows the commercial and industrial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report. Builders will primarily feel the impact of needing to ensure that a new acceptance test is completed by field technician and a new NRCA form is completed and provided to the building inspector. No regulations previously required acceptance tests for process boilers, so this change represents a minor adjustment in their workflow. An installation or controls technician that the builder currently coordinates with can complete this test to minimize impacts. Industrial and commercial subsectors that would be impacted by the proposed code change are shown in Table 20.

Table 20: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2022 (Estimated)

Construction Subsector	Establishments	Employment	Annual Payroll (Billions $)
Industrial Building Construction	TBD	TBD	TBD
Other Nonresidential Equipment Contractors	556	9,594	1.0
All Other Nonresidential Trade Contractors	940	18,027	1.6

b. Source: (State of California n.d.)

Facility owners. Facility owners would need to cover the upfront cost of the automatic blowdown system, the costs of acceptance testing, and ongoing component replacements. However, they would also save money from reduced fuel costs from decreased natural gas consumption. For California facility owners, the proposed code changes would result in lower energy bills. The Statewide CASE Team estimates that, on average, the proposed automatic blowdown and deaerator pressure requirements in

Title 24, Part 6 would increase design and construction costs by $41 to $850 per MMBtu/h of boiler capacity and, over 30 years, would increase maintenance costs by $37 to $1,260 per MMBtu/h of boiler capacity, depending on the individual boiler's capacity. However, the measure would also result in a savings of $11,775 to $22,951 per MMBtu/h of boiler capacity in energy cost savings over 30 years, or $33 to $64 per month. Overall, the Statewide CASE Team expects the updated Title 24, Part 6 Standards to save facility owners about $390 to $695 per year relative to owners whose facilities are minimally compliant with the current Title 24, Part 6 requirements.

Manufacturers. As discussed in Section 3.3.1.1, at least two manufacturers of automatic blowdown systems are headquartered in California, along with several vendors. Refer to section 3.3.4 for more information on the projected impact on California jobs.

3.2.3 Compliance Software Updates

Review finds no expected compliance software updates to be required for this measure proposal.

3.2.4 Cost of Enforcement

The Statewide CASE Team acknowledges that changes to the code will impact enforcement costs. This report is an evaluation of specific measures, and the collective impact of all proposed changes for the 2028 Title 24, Part 6 may represent an increase in training and/or workload for enforcement personnel.

The CASE report team does not anticipate significant additional state costs as a result of this measure. AHJs would only have to confirm that plans include the use of an automatic blowdown control system or qualify for one of the exceptions.

The proposed code changes would not add entirely new reviews and inspections. Plan examiners and building inspectors would spend slightly more time on process boilers plans reviews and inspections to verify additional requirements, which would increase labor costs. This proposal adds acceptance testing for process boilers, which is performed by a field technician and not enforcement officials.

Costs of enforcement will include additional labor costs for plan examiners and building inspectors and costs to deliver training to enforcement officials to enable them to adequately enforce the proposed measure described in Section 3.2.2. Plans examiners are expected to spend less than 30 additional minutes on plans reviews and building inspectors are expected to spend up to 60 additional minutes on inspections.

The incremental enforcement requirements are small, given that Title 24, Part 6 already includes requirements for process boilers and thus plans reviews and inspections are already taking place when new process boilers are installed. This proposal adds acceptance testing for process boilers, which is performed by a field technician and not enforcement officials. Plans examiners will need to check for one additional requirement, and building inspectors will need to check completion of a new acceptance testing form and verify implementation of one additional system requirement.

The Statewide CASE Team will work with the CASE Compliance Improvement Team to estimate the total cost of enforcement.

3.3 Automatic Blowdown and Deaerator Pressure – Market and Economic Analysis

3.3.1 Market Structure and Availability

3.3.1.1 Current Market Structure and Availability

Automatic Blowdown

The automatic blowdown market includes boiler system designers, component manufacturers, original equipment manufacturer (OEM) suppliers, boiler manufacturers, manufacturer representatives, distributors, mechanical contractors, boiler technicians, and water treatment companies. Designers specify the boilers and automatic blowdown systems that meet project needs and comply with regulations. Component manufacturers and OEMs design, manufacture, and supply the system components, including conductivity probes, controllers, and modulating valves, which are often sold as packaged systems. Boiler manufacturers often provide the automatic blowdown systems as an optional accessory or a fully integrated package with a new boiler installation. Manufacturer representatives and distributors act as the local sales and distribution channel for the component manufacturers and specialized boiler accessory companies. Mechanical contractors handle the physical installation of the system, including piping, wiring, and integration with the boiler's main controls. Boiler technicians install and commission the automatic blowdown systems and, under the proposed change, would complete acceptance testing and fill out acceptance forms in most cases. Water treatment companies often advise clients on the correct blowdown setpoints based on their water quality and may recommend the control equipment.

The market for automatic blowdown systems is mature, with multiple manufacturers and suppliers providing designers and contractors many options for purchasing. Table 21 lists companies that the Statewide CASE Team has identified as major market actors.

Table 21 Major Automatic Blowdown System Component Manufacturers, Installers, and Vendors

Company	Market Actor Type	Product Offering	Headquartered in California
Electro-Chemical Devices	Manufacturer	Controller, probe	Yes
Lakewood Instruments	Manufacturer	Controller, probe, valve	No
Rite Boilers	Manufacturer	Controller, probe, valve	Yes
Spirax Sarco	Manufacturer	Controller, probe, valve	No
R. F. MacDonald	Vendor	Automatic blowdown systems	Yes
Nationwide Boiler Incorporated	Vendor	Automatic blowdown systems	Yes

Designers commonly include automatic blowdown systems in standard boiler system designs. The Statewide CASE Team believes that boiler system designers are familiar with these systems but would require minimal training on code updates to ensure designs meet the proposed code requirements.

Manufacturers and vendors have a comprehensive understanding of the benefits of automatic blowdown in boiler systems. During a stakeholder interview with the Statewide CASE Team, one boiler manufacturer noted that they recommend an automatic blowdown system for all steam systems over 3.3 MMBtu/h.

Table 22 includes the estimated current market adoption of automatic blowdown systems on newly installed boilers in California by boiler capacity. Market adoption estimations were based on estimates from stakeholder interviewees and a statewide boiler inventory of local AQMD boiler permits (Swanson Staller 2025). The prevalence of automatic blowdown systems is estimated to increase with boiler capacity as a result of improved cost-effectiveness with increasing boiler capacity. The Statewide CASE Team plans to reach out to additional stakeholders to gather more information about market adoption.

The Statewide CASE Team does not foresee this regulation having negative impacts on technology adoption.

Table 22: Estimated Current Automatic Blowdown Market Adoption in California

Boiler Capacity	Estimated Automatic Blowdown Market Adoption
10-15 MMBtu/h	25%
15-25 MMBtu/h	30%
25-50 MMBtu/h	35%
50-100 MMBtu/h	40%
100-200 MMBtu/h	45%
200+ MMBtu/h	75%

Deaerator Pressure

Deaerators and steam supply line pressure regulators are standard components of boiler systems. The proposed code change specifies a set pressure range for the steam supply line pressure regulator to avoid excess energy loss to high deaerator pressurization. This code change would not result in any changes to current market structure and product availability.

The Statewide CASE Team estimates that 20 percent of sites with process boilers in California set their steam supply line pressure regulators and deaerators above 5 psig based on anecdotal industry experience and conversations with facility operators.

3.3.1.2 Market Challenges and Solutions

See Section 2.2 for a description of workforce trainings that may be needed to ensure effective design, installation, and commissioning.

Automatic Blowdown

The market for automatic blowdown systems is well-established, with multiple vendors and suppliers with decades of experience designing and installing automatic blowdown systems. The Statewide CASE Team does not anticipate any market challenges related to product availability, given the current market availability.

Despite the clear fuel, chemical, and water savings provided by automatic blowdown systems, many industrial process facilities continue to use manual or fixed-rate blowdown due to a combination of factors. Primarily, these facilities focus on the increased upfront cost of automatic blowdown systems, as they require a specialized conductivity probe for each boiler, a dedicated controller, and a modulating (automated) blowdown valve, all of which represent a higher initial cost compared with a basic manual valve setup. Industrial facilities often operate with a high barrier for capital expenditure on auxiliary equipment, even if the payback period from operational savings is short (Energy Efficiency Movement 2025). Facility owners often prefer to save the immediate capital expense. The first cost of an automatic blowdown system has a payback period up to 4.6 years. The Statewide CASE Team recognizes most facilities consider the upper range of that payback period as being slightly longer than they typically consider for investments, which may dissuade facilities from purchasing automatic blowdown systems without a code requirement. Conducting market education and creating supporting guidelines would improve awareness of the benefits of automatic blowdown systems, helping facilities justify and accept longer payback periods.

Some facility owners and operators may not be fully aware of the measurable energy, water, and chemical savings that an optimized automatic blowdown system provides. In facilities with experienced, stable operators and a consistent boiler load, management may feel that a manual system they regularly monitor and adjust provides sufficiently for their needs so the additional cost and perceived complexity of adding automation are not worthwhile. Further, automatic systems introduce new electronic and mechanical components that require maintenance and calibration, which some facilities may prefer to avoid. The most common failure points in automatic blowdown systems are the blowdown valve and the conductivity probe. The Statewide CASE Team included the cost of regular blowdown valve and conductivity probe replacement in the measure costs. See Section 3.4.4 for a full description of maintenance costs.

Some facilities have highly variable steam demand. While an automatic system can handle variable loads, some operators may prefer to manually over-blowdown during peak usage rather than relying on the automated system's responsiveness. As described in section 3.2.2, owners and operators would benefit from education on the impact of automatic blowdown systems and personal outreach to address any concerns they may have with moving to an automatic blowdown system. To address a lack of awareness among different market actors, the Statewide CASE Team plans to include information on automatic blowdown system operation in the NonRes & Multifamily Compliance Manual and Non-Residential Appendices.

Deaerator Pressure

The deaerator market is well established, and deaerators and steam supply line pressure regulators are standard components of all boiler systems. The proposed code change would require facilities to set the steam supply line pressure regulator to a value between 2 and 5 psig, lower than pressures used today. The Statewide CASE Team identified operational risk minimization practices and existing manufacturer setpoint ranges as potential market challenges. Facilities may opt to set deaerator regulator pressures at higher setpoints to minimize the potential of oxygen carryover, increasing the boiling point and ensuring dissolved oxygen removal, but increasing steam and energy use. To address this challenge, the Statewide CASE Team plans to confirm proposed code language and required maximum pressures with experts and support the creation of guidelines and deaerator pressure training for boiler operators. Additionally, the Statewide CASE Team plans to include information on deaerators in the Compliance Manual and Non-Residential Appendix to support the proposed code deaerator pressures.

3.3.2 Design and Construction Practices

3.3.2.1 Current Design and Construction Practices

Automatic Blowdown

Automatic blowdown systems are common in boiler controls design. They have been listed as a best practice in DOE literature for over 20 years, including an Energy Steam Tip Sheet that discusses the advantages of an automatic blowdown system (DOE 2012). Additionally, patents for these systems date back to the (Gasper 1987)This regulation would not impact current design or construction best practices. These systems consist of three main components: a blowdown valve, valve controller, and conductivity probe. The conductivity probe measures the conductivity of hot boiler water. If the conductivity exceeds a predetermined max value, the controller will then open the blowdown valve, allowing blowdown water to pass through and restore conductivity back to the predetermined ranges.

The market features two types of automatic blowdown systems: continuous and timed. Continuous automatic blowdown systems are used for larger boiler systems and require a constant small stream of boiler water to be passed through the probe for monitoring. Timed automatic blowdown systems are used for smaller systems and send hot boiler water across the conductivity probe on a preset schedule (Yamatho 2017). Automatic blowdown systems require electricity to operate the controller and probe, and the blowdown valve is typically operated by pneumatic solenoid valve and would require instrument air or nitrogen. These automatic blowdown systems are common in boiler system design today and no impacts are expected to current design and construction best practices.

Deaerator Pressure

Removing dissolved gases from boiler water is crucial to boiler systems because dissolved gases, such as oxygen and carbon dioxide, cause aggressive corrosion and equipment failure (Lawley 2023).To address this issue, boiler systems are installed with atmospheric feedwater tanks or pressurized deaerator systems (Chem Aqua n.d.). Atmospheric feedwater systems are cheaper and operate at atmospheric pressure and lower temperature ranges (150 to 190°F). However, they remove less dissolved gases than pressurized deaerators and boiler systems with atmospheric feedwater systems often require additional chemical water treatment to reach desired levels of dissolved gases (Chem Aqua n.d.). Pressurized deaerators operate at higher pressures (2 to 15 psig), higher temperatures (227°F and above), and achieve higher levels of dissolved gas removal than atmospheric feedwater systems, providing increased protection from corrosion (Chem Aqua n.d.). Both atmospheric feedwater systems and pressurized deaerators preheat feedwater and prevent thermal shock to the boiler, extending boiler lifetime (Chem Aqua n.d.). This proposed measure only applies to boiler systems with pressurized deaerators.

Deaerators remove dissolved gases from feedwater by using steam to heat the feedwater to its saturation (that is, its boiling point), breaking the surface water tension through turbulent conditions and allowing sufficient time for the steam to scrub the gases out of the water (Waldron 2022). The steam and dissolved gases then exit through the deaerator vent (American Boilers Manufacturing Association 2011). The saturation temperature at which the feedwater boils is dependent on the pressure in the deaerator, which is set by the pressure regulator on the incoming steam supply line (Lawley 2023). The higher the pressure of the incoming steam, the more energy will be required to heat the water to a boil and the more steam will be vented through the top of the deaerator, resulting in additional energy losses.

In all deaerators, the pressure of the incoming steam supply line is crucial for achieving complete removal of dissolved oxygen and ensuring that excess energy is not required to heat feedwater to its saturation point because of excessively high incoming steam pressure. This proposed measure would require the steam supply line pressure regulator to be set at 2 to 5 psig to avoid under- and over- pressurization. Because steam supply line regulator setpoints do not impact the equipment itself, no impacts are expected to current design and construction best practices.

3.3.2.2 Health and Safety Considerations

The proposed code change does not impact any existing regulations pertaining to health and safety. If a facility typically conducts manual boiler blowdown, compliance with the proposed automatic blowdown requirement would reduce the amount of time boiler operators are exposed to hot, high-pressure equipment and boiler exhaust fumes. Review finds no health and safety considerations pertaining to the proposed steam supply line pressure regulator requirements. Additionally, both proposed submeasures would reduce local photochemical smog and improve air quality by decreasing boiler fuel consumption.

3.3.2.3 Design and Construction Challenges and Solutions

See Table 19 in Section 3.2.2 for a description of workforce trainings that could support effective design, installation, and commissioning.

The Statewide CASE Team identified automatic blowdown system component malfunction as a potential challenge. If the controller is not working correctly or the conductivity probe or blowdown valve has failed, a facility would need to fix or replace these components to maintain proper boiler water quality. To address this challenge, the Statewide CASE Team has included the cost of replacement for the system in the calculations of cost effectiveness.

The Statewide CASE Team does not anticipate any design and construction challenges for the proposed deaerator set pressure range. Adjustment of the set pressure is standard on deaerators today.

3.3.3 Energy Equity and Environmental Justice

The Statewide CASE Team evaluated the potential impact on ESJ communities, including impacts related to race, class, and gender.

The Statewide CASE Team identified potential impacts of the proposed code change via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement. Stakeholders can reach out to Emma Conroy (emmaconroy@2050partners.com) with input on how this proposal may impact ESJ communities or any other perspectives.

The proposed submeasures would have a positive impact on ESJ communities. Reduction of blowdown by using an automated system will lower boiler fuel consumption. Lowering the maximum set pressure range for deaerators would result in less steam venting, which would lower the amount of boiler fuel consumption. Both of these factors reducing fuel consumption will likewise reduce GHG emissions and improve local air quality. The value of improved air quality by complying with this code change is further amplified by the fact that many industrial facilities are located near LMI communities, which are disproportionately exposed to lower air quality.

3.3.4 Impacts on Jobs and Businesses

This section will be completed for the Final CASE Report.

3.3.5 Economic and Fiscal Impacts

This section will be completed for the Final CASE Report.

3.4 Automatic Blowdown and Deaerator Pressure – Cost Effectiveness

3.4.1 Cost Effectiveness Methodology

The Statewide CASE Team collaborated with CEC staff to confirm that the cost effectiveness methodology aligns with CEC guidelines, including cost inclusion parameters. The 2028 CASE Methodology Report and Appendix A provide reproducibility details.

Per California Law (Public Resources Code 25000), a measure is considered cost effective if its BCR is 1.0 or greater, amortized over the economic life of the structure. The Statewide CASE Team calculates BCR by dividing total dollar benefits by total dollar costs over a 30-year analysis period.

Benefits are based on LSC, which assigns an hourly dollar value to energy use. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are valued more than off-peak hours. These factors are not utility rates, forecasts, or bill estimates. Instead, the CEC develops and publishes LSC hourly conversion factors for each code cycle.

Costs include first costs and ongoing maintenance costs assessed over the 30-year period. Benefits and costs are evaluated incrementally, relative to the most recently adopted Energy Code. The analysis excludes design costs and incremental code compliance verification costs.

3.4.2 Energy and Energy Cost Savings Results

Analyses of per-unit energy savings were completed independently for the automatic blowdown and deaerator pressure requirements. Review finds no anticipated interactive effects between automatic blowdown and deaerator pressure setpoints.

Automatic Blowdown

For the automatic blowdown requirement, the baseline case is a boiler maintained with manual blowdown and the proposed case is a boiler with an automatic blowdown system. Savings result from the reduction in hot water removed from the boiler when conducting less blowdown, calculated by subtracting the boiler's annual energy lost to blowdown with automatic blowdown from the boiler's annual energy lost to blowdown with manual blowdown.

Natural gas savings increase as the boiler capacity increases because a larger total volume of water is blown down. The percentage of water savings scales based on the boiler capacity, so the greater the water savings the greater the energy saved from avoided make-up water heating.

The main driver of savings from automatic blowdown comes from the difference between the boiler water conductivity in the baseline and the proposed measure cases. A larger difference indicates more fluctuation in conductivity with manual blowdown and more excessive manual blowdown. The assumed difference of 500 μ℧ used for the calculation was chosen to be conservative because both sites used as a reference experienced a conductivity difference of over 1,000 μ℧.

The longer the boiler is operated, the greater the resultant savings. As such, boilers that operate infrequently throughout the year due to seasonal loads will experience lower savings. Due to this variance, the Statewide CASE Team calculated annual energy savings and cost effectiveness for boilers with seasonal loads separately from boilers with more typical annual loads. Calculations for boilers operating annually assumed 6,500 operating hours per year at 40 percent load, while calculations for seasonal boilers assumed 2,400 operating hours per year (primarily in July through October) at 80 percent load. The Statewide Case TEAM based these assumptions for operating hours and load factor on field data from 128 California steam-using sites sourced from the national IAC database (Swanson Staller 2025).

Savings from an automatic blowdown system should stay constant over the measured lifetime. Boiler operators could choose not to use an installed automatic blowdown system, which would decrease the energy savings from the measure.

Per-unit savings for the first year for the automatic blowdown measure are expected to be about 21,713 kBtu/yr per MMBtu/h boiler capacity for year-round boiler operation, and about 15,900 kBtu/yr per MMBtu/h boiler capacity for seasonal boiler operation, as shown in Table 23.There are no electric savings or demand reductions associated with this measure. The per-unit energy savings of this measure are not impacted by climate zone and are the same for new construction, additions, and alterations.

Table 24 presents total energy cost savings for the automatic blowdown measure per unit for newly added boilers in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$) for the boilers in each size bin.

Table 23: First Year Natural Gas Savings (kBtu) Per MMBtu/h of Boiler Capacity –- Automatic Blowdown

Boiler Capacity	First Year Natural Gas Savings (kBtu)
Year-Round 10-15 MMBtu/h	21,713
Year-Round 15-25 MMBtu/h	21,713
Year-Round 25-50 MMBtu/h	21,713
Year-Round 50-100 MMBtu/h	21,713
Year-Round 100-200 MMBtu/h	21,713
Year-Round 200+ MMBtu/h	21,713
Seasonal 10-15 MMBtu/h	15,900
Seasonal 15-25 MMBtu/h	15,900
Seasonal 25-50 MMBtu/h	15,900
Seasonal 50-100 MMBtu/h	15,900
Seasonal 100-200 MMBtu/h	15,900
Seasonal 200+ MMBtu/h	15,900

Table 24: Total 30-Year LSC Savings (2029 PV$) Per MMBtu/h of Boiler Capacity – Automatic Blowdown

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Year-Round 10-15 MMBtu/h	18,000	18,000	18,000	18,000	18,000	18,218	18,164	18,218	18,218	18,218	18,000	18,000	18,000	18,218	18,218	18,218
Year-Round 15-25 MMBtu/h	17,917	17,917	17,917	17,917	17,917	18,134	18,081	18,134	18,134	18,134	17,917	17,917	17,917	18,134	18,134	18,134
Year-Round 25-50 MMBtu/h	17,834	17,834	17,834	17,834	17,834	18,050	17,997	18,050	18,050	18,050	17,834	17,834	17,834	18,050	18,050	18,050
Year-Round 50-100 MMBtu/h	18,083	18,083	18,083	18,083	18,083	18,302	18,248	18,302	18,302	18,302	18,083	18,083	18,083	18,302	18,302	18,302
Year-Round 100-200 MMBtu/h	17,917	17,917	17,917	17,917	17,917	18,134	18,081	18,134	18,134	18,134	17,917	17,917	17,917	18,134	18,134	18,134
Year-Round 200+ MMBtu/h	17,834	17,834	17,834	17,834	17,834	18,050	17,997	18,050	18,050	18,050	17,834	17,834	17,834	18,050	18,050	18,050
Seasonal 10-15 MMBtu/h	11,691	11,691	11,691	11,691	11,691	11,707	11,704	11,707	11,707	11,707	11,691	11,691	11,691	11,707	11,707	11,707
Seasonal 15-25 MMBtu/h	11,691	11,691	11,691	11,691	11,691	11,707	11,704	11,707	11,707	11,707	11,691	11,691	11,691	11,707	11,707	11,707
Seasonal 25-50 MMBtu/h	11,691	11,691	11,691	11,691	11,691	11,707	11,704	11,707	11,707	11,707	11,691	11,691	11,691	11,707	11,707	11,707
Seasonal 50-100 MMBtu/h	11,691	11,691	11,691	11,691	11,691	11,707	11,704	11,707	11,707	11,707	11,691	11,691	11,691	11,707	11,707	11,707
Seasonal 100-200 MMBtu/h	11,691	11,691	11,691	11,691	11,691	11,707	11,704	11,707	11,707	11,707	11,691	11,691	11,691	11,707	11,707	11,707
Seasonal 200+ MMBtu/h	11,691	11,691	11,691	11,691	11,691	11,707	11,704	11,707	11,707	11,707	11,691	11,691	11,691	11,707	11,707	11,707

Deaerator Pressure

For the deaerator pressure requirement, the baseline case is a boiler with its steam supply line pressure regulator and deaerator set to 8 psig and the proposed case is a boiler with its steam supply line pressure regulator and deaerator set to 5 psig. Savings result from the decreased energy loss when less steam is vented due to over-pressurization of the deaerator.

To estimate the natural gas savings from improved deaerator control, the Statewide CASE Team calculated the mass flow of steam lost to over-pressurization in lbs/h when the deaerator setpoint is 8 psig. The Statewide CASE Team used a Cascade Energy tool to calculate the amount of steam vented and then calculated the therms required to make up for the volume of excess steam vented.

Natural gas savings are higher for the largest boiler size because the deaerator and vent valve are larger. The estimates are neither conservative nor ambitious, though they may be conservative for larger boilers. While the savings are modest, they are not offset by any costs. The savings due to deaerator pressure should stay constant over the measure lifetime. The savings would change if a boiler operator chose to change the steam supply line pressure regulator or deaerator pressure setpoints.

The longer the boiler is operated, the greater the savings. As such, boilers that operate infrequently throughout the year due to seasonal loads will experience lower savings. Due to this variance, the Statewide CASE Team calculated annual energy savings and cost-effectiveness for boilers with seasonal loads separately from boilers with more typical annual loads. Calculations for boilers operating annually assumed 6,500 operating hours per year at 40 percent load, while calculations for seasonal boilers assumed 2,400 operating hours per year (primarily July through October) at 80 percent load. The Statewide Case TEAM based these assumptions for operating hours and load factor on analysis of data from 128 California steam-using sites sourced from the national IAC database Swanson Staller 2025).

Per-unit savings for the first year for the deaerator pressure measure are expected to range from 300 to 5,804 kBtu/yr per MMBtu/h boiler capacity for year-round boiler operation and from 100 to 2,500 kBtu/yr per MMBtu/h boiler capacity for seasonal boiler operation, as shown in Table 25. No electric savings or demand reductions are assumed to be associated with this measure. The per-unit energy savings of this measure are not impacted by climate zone and remain consistent between new construction, additions, and alterations.

Table 26 presents total energy cost savings for the deaerator pressure measure per unit for newly added boilers in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$) for the boilers in each size bin.

Table 25: First Year Natural Gas Savings (kBtu) Per MMBtu/h of Boiler Capacity –- Deaerator Pressure

Boiler Capacity	First Year Natural Gas Savings (kBtu)
Year-Round 10-15 MMBtu/h	5,804
Year-Round 15-25 MMBtu/h	3,602
Year-Round 25-50 MMBtu/h	2,101
Year-Round 50-100 MMBtu/h	2,001
Year-Round 100-200 MMBtu/h	1,001
Year-Round 200+ MMBtu/h	300
Seasonal 10-15 MMBtu/h	2,500
Seasonal 15-25 MMBtu/h	1,500
Seasonal 25-50 MMBtu/h	900
Seasonal 50-100 MMBtu/h	800
Seasonal 100-200 MMBtu/h	400
Seasonal 200+ MMBtu/h	100

Table 26: Total 30-Year LSC Savings (2029 PV$) Per MMBtu/h of Boiler Capacity – Deaerator Pressure

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Year-Round 10-15 MMBtu/h	4,811	4,811	4,811	4,811	4,811	4,869	4,855	4,869	4,869	4,869	4,811	4,811	4,811	4,869	4,869	4,869
Year-Round 15-25 MMBtu/h	2,986	2,986	2,986	2,986	2,986	3,022	3,013	3,022	3,022	3,022	2,986	2,986	2,986	3,022	3,022	3,022
Year-Round 25-50 MMBtu/h	1,742	1,742	1,742	1,742	1,742	1,763	1,758	1,763	1,763	1,763	1,742	1,742	1,742	1,763	1,763	1,763
Year-Round 50-100 MMBtu/h	1,659	1,659	1,659	1,659	1,659	1,679	1,674	1,679	1,679	1,679	1,659	1,659	1,659	1,679	1,679	1,679
Year-Round 100-200 MMBtu/h	829	829	829	829	829	840	837	840	840	840	829	829	829	840	840	840
Year-Round 200+ MMBtu/h	249	249	249	249	249	252	251	252	252	252	249	249	249	252	252	252
Seasonal 10-15 MMBtu/h	1,838	1,838	1,838	1,838	1,838	1,841	1,840	1,841	1,841	1,841	1,838	1,838	1,838	1,841	1,841	1,841
Seasonal 15-25 MMBtu/h	1,103	1,103	1,103	1,103	1,103	1,104	1,104	1,104	1,104	1,104	1,103	1,103	1,103	1,104	1,104	1,104
Seasonal 25-50 MMBtu/h	662	662	662	662	662	663	662	663	663	663	662	662	662	663	663	663
Seasonal 50-100 MMBtu/h	588	588	588	588	588	589	589	589	589	589	588	588	588	589	589	589
Seasonal 100-200 MMBtu/h	294	294	294	294	294	295	294	295	295	295	294	294	294	295	295	295
Seasonal 200+ MMBtu/h	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74

3.4.3 Incremental First Cost

Automatic Blowdown

The baseline case to evaluate the incremental costs of an automatic blowdown system consists of the purchase and installation costs of a manual valve. The incremental first cost of an automatic blowdown system includes the hardware and installation costs of a controller, a valve with an actuator that can be controlled by the controller, and a conductivity probe. During stakeholder interviews, multiple boiler vendors quoted approximately $5,000 as the general cost of an automatic blowdown system. The Statewide CASE Team conservatively estimated the blowdown system installation costs to be roughly equivalent to the equipment costs, including system startup and commissioning (setting conductivity parameters), and completion of required acceptance testing. Overall, the Statewide CASE Team estimates the incremental first costs of an automatic blowdown system to be $10,000 for boilers rated 50 MMBtu/h and smaller, $15,000 for boilers from 50 to 100 MMBtu/h, $20,000 for boilers from 100 to 200 MMBtu/h, and $30,000 for boilers 200 MMBtu/h or larger. The Statewide CASE Team estimates acceptance testing costs to amount to one hour of field technician labor at $200 per hour.

The Statewide CASE Team does not expect the incremental first costs to vary significantly between new and replacement systems or change significantly over time. The Statewide CASE Team will continue to solicit stakeholder feedback on the estimated costs and will update assumptions accordingly in the Final CASE Report.

Deaerator Pressure

Adjusting the deaerator pressure setpoint has no associated equipment cost. The only incremental cost for the deaerator pressure requirement is the cost of the labor for the acceptance test performed by a field technician to confirm that the regulator pressure is set in accordance with the requirement. The Statewide CASE Team estimates acceptance testing costs to amount to about one hour of field technician labor at $200 per hour. The Statewide CASE Team expects that in most cases, the same field technician would verify settings for and fill out the NRCA-PRC-XX-F acceptance test form to verify compliance with both the automatic blowdown and deaerator pressure requirements.

3.4.4 Incremental Maintenance and Replacement Costs

Description of the incremental maintenance and replacement costs, as well as estimation of present value of maintenance and replacement costs, are provided in the 2028 CASE Methodology Report.

Automatic Blowdown

Incremental maintenance for automatic blowdown systems includes replacement of the blowdown valve and conductivity probe every three years. Full system replacement is anticipated every 15 years. Replacement costs for the valve ($1,000) and probe ($500) were assumed to be equivalent to the valve and probe first costs. These component replacements are much less expensive than the total system cost because most of the system cost comes from the controller, which requires replacement only every 15 years. The Statewide CASE Team estimated valve replacement in the baseline case to be negligible, given the extremely low first cost of the manual valve and lessened needs for replacement, as the automatic blowdown valves are actuated more frequently. The Statewide CASE Team assumed that facility operators would replace the valves and conductivity probes simultaneously.

Deaerator Pressure

The proposed deaerator pressure requirement only involves changing the setpoint on an existing piece of equipment and has no associated incremental maintenance costs.

3.4.5 Cost Effectiveness

As described in Section 3.4.3, the Statewide CASE Team used 2025 cost estimates from a boiler manufacturer and a boiler vendor to estimate the incremental costs of an automatic blowdown system.

The Statewide CASE Team evaluated per-unit cost effectiveness for both year-round operation and seasonal boilers at six different capacities to ensure cost effectiveness of the proposed requirement for boilers with lower annual operating hours and throughout the size range covered by the proposed measure.

Table 27 shows the boiler capacity bin ranges and the average capacity of the boilers within each bin, which was used to perform the calculations of cost effectiveness. Data on the capacity of installed boilers in California came from the statewide boiler inventory of local AQMD permits described in more detail in Appendix C. Boilers not subject to Title 24 or the proposed measure were removed prior to determining the average capacity as described in more detail in Section 3.5.1. As neither costs nor savings vary by climate zone or differ between new construction, additions, and alterations, cost effectiveness was not evaluated by either climate zone or project type.

Table 27. Process Boiler Capacity Bins

Boiler Capacity Bin	Average Boiler Capacity Used for Calculations
10-15 MMBtu/h	12 MMBtu/h
15-25 MMBtu/h	19 MMBtu/h
25-50 MMBtu/h	33 MMBtu/h
50-100 MMBtu/h	71 MMBtu/h
100-200 MMBtu/h	143 MMBtu/h
200+ MMBtu/h	739 MMBtu/h

The Statewide CASE Team also evaluated the proposed measure's cost effectiveness when the boiler steam header pressure was set to 15 psig rather than 100 psig to account for sites with lower steam header pressures. With the lower pressure, energy savings decreased by 28.6 percent and the measure remained cost effective.

Results of the per-unit cost-effectiveness analyses are presented in Table 28 and

Table 29 for year-round and seasonal boilers, respectively, for the automatic blowdown measure and in Table 31 and

Table 32 for year-round and seasonal boilers, respectively, for the deaerator pressure measure. Table 30 and Table 33 display the BCR values for each prototype by climate zone. The proposed measure saves money over the 30-year period of analysis relative to the existing conditions and is cost effective for both annual and seasonal boilers in each capacity bin.

In the tables below, all values are presented in 2029 present value dollars (2029 PV$). Benefits represent 30-year LSC savings and other savings, including incremental first-cost savings if the proposed first cost is less than the current first cost, incremental maintenance cost savings if the proposed maintenance costs are less than the current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at the end of the 30-year period of analysis. Costs represent the total incremental PV cost, including incremental equipment, replacement, and maintenance costs over the period of analysis. The analysis treats a negative incremental maintenance cost as a positive benefit. If total incremental costs are zero, the BCR is considered infinite. Costs and other savings are discounted at a real (inflation-adjusted) three percent rate. If there are no total incremental PV costs, the BCR is infinite. A BCR of "NA" indicates that there is no boiler capacity in that climate zone that would be impacted by the proposed requirement.

Table 28: 30-Year Automatic Blowdown Cost-Effectiveness Summary Per MMBtu/h – Year-Round Boilers

Prototype	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
Year-Round Boiler 10-15 MMBtu/h	$18,110.29	$3,352.67	5.40
Year-Round Boiler 15-25 MMBtu/h	$18,025.29	$2,117.47	8.51
Year-Round Boiler 25-50 MMBtu/h	$17,925.42	$1,234.11	14.52
Year-Round Boiler 50-100 MMBtu/h	$18,095.51	$724.84	24.96
Year-Round Boiler 100-200 MMBtu/h	$17,969.35	$438.43	40.99
Year-Round Boiler 200+ MMBtu/h	$17,984.48	$115.20	156.11

Table 29: 30-Year Automatic Blowdown Cost-Effectiveness Summary Per MMBtu/h – Seasonal Boilers

Prototype	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
Seasonal Boiler 10-15 MMBtu/h	$11,698.74	$3,352.34	3.49
Seasonal Boiler 15-25 MMBtu/h	$11,698.63	$2,117.47	5.52
Seasonal Boiler 25-50 MMBtu/h	$11,697.40	$1,234.11	9.48
Seasonal Boiler 50-100 MMBtu/h	$11,691.47	$724.84	16.13
Seasonal Boiler 100-200 MMBtu/h	$11,694.43	$438.43	26.67
Seasonal Boiler 200+ MMBtu/h	$11,701.79	$115.20	101.57

Table 30: Benefit-to-Cost Ratio – Automatic Blowdown

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Year-Round 10-15 MMBtu/h	5.37	5.37	5.37	5.37	5.37	5.43	5.42	5.43	5.43	5.43	5.37	5.37	5.37	5.43	5.43	5.43
Year-Round 15-25 MMBtu/h	N/A	8.46	8.46	8.46	8.46	8.56	8.54	8.56	8.56	8.56	8.46	8.46	8.46	8.56	8.56	8.56
Year-Round 25-50 MMBtu/h	14.45	14.45	14.45	14.45	14.45	14.63	14.58	14.63	14.63	14.63	14.45	14.45	14.45	14.63	14.63	14.63
Year-Round 50-100 MMBtu/h	N/A	24.95	24.95	24.95	24.95	25.25	25.18	25.25	25.25	25.25	24.95	24.95	24.95	25.25	25.25	25.25
Year-Round 100-200 MMBtu/h	N/A	40.87	40.87	40.87	N/A	41.36	N/A	41.36	41.36	41.36	40.87	40.87	40.87	41.36	41.36	41.36
Year-Round 200+ MMBtu/h	154.80	154.80	154.80	154.80	N/A	156.68	N/A	156.68	156.68	156.68	154.80	154.80	154.80	156.68	156.68	156.68
Seasonal 10-15 MMBtu/h	3.49	3.49	3.49	3.49	3.49	3.49	3.49	3.49	3.49	3.49	3.49	3.49	3.49	3.49	3.49	3.49
Seasonal 15-25 MMBtu/h	N/A	5.52	5.52	5.52	5.52	5.53	5.53	5.53	5.53	5.53	5.52	5.52	5.52	5.53	5.53	5.53
Seasonal 25-50 MMBtu/h	9.47	9.47	9.47	9.47	9.47	9.49	9.48	9.49	9.49	9.49	9.47	9.47	9.47	9.49	9.49	9.49
Seasonal 50-100 MMBtu/h	N/A	16.13	16.13	16.13	16.13	16.15	16.15	16.15	16.15	16.15	16.13	16.13	16.13	16.15	16.15	16.15
Seasonal 100-200 MMBtu/h	N/A	26.66	26.66	26.66	N/A	26.70	N/A	26.70	26.70	26.70	26.66	26.66	26.66	26.70	26.70	26.70
Seasonal 200+ MMBtu/h	101.48	101.48	101.48	101.48	N/A	101.62	N/A	101.62	101.62	101.62	101.48	101.48	101.48	101.62	101.62	101.62

Table 31: 30-Year Deaerator Pressure Cost-Effectiveness Summary Per MMBtu/h – Year-Round Boilers

Prototype	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
Year-Round Boiler 10-15 MMBtu/h	$4,840.54	$16.67	290.43
Year-Round Boiler 15-25 MMBtu/h	$3,004.21	$10.53	285.40
Year-Round Boiler 25-50 MMBtu/h	$1,750.85	$6.13	285.39
Year-Round Boiler 50-100 MMBtu/h	$1,660.14	$2.82	589.35
Year-Round Boiler 100-200 MMBtu/h	$831.91	$1.40	594.82
Year-Round Boiler 200+ MMBtu/h	$250.95	$0.27	927.50

Table 32: 30-Year Deaerator Pressure Cost-Effectiveness Summary Per MMBtu/h – Seasonal Boilers

Prototype	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
Seasonal Boiler 10-15 MMBtu/h	$1,839.43	$16.67	110.37
Seasonal Boiler 15-25 MMBtu/h	$1,103.64	$10.53	104.85
Seasonal Boiler 25-50 MMBtu/h	$662.12	$6.13	107.93
Seasonal Boiler 50-100 MMBtu/h	$588.25	$2.82	208.83
Seasonal Boiler 100-200 MMBtu/h	$294.20	$1.40	210.35
Seasonal Boiler 200+ MMBtu/h	$73.60	$0.27	272.01

Table 33: Benefit-to-Cost Ratio – Deaerator Pressure

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Year-Round 10-15 MMBtu/h	288.7	288.7	288.7	288.7	288.7	292.2	291.3	292.2	292.2	292.2	288.7	288.7	288.7	292.2	292.2	292.2
Year-Round 15-25 MMBtu/h	N/A	283.7	283.7	283.7	283.7	287.1	286.3	287.1	287.1	287.1	283.7	283.7	283.7	287.1	287.1	287.1
Year-Round 25-50 MMBtu/h	283.9	283.9	283.9	283.9	283.9	287.4	286.5	287.4	287.4	287.4	283.9	283.9	283.9	287.4	287.4	287.4
Year-Round 50-100 MMBtu/h	N/A	588.9	588.9	588.9	588.9	596.1	594.3	596.1	596.1	596.1	588.9	588.9	588.9	596.1	596.1	596.1
Year-Round 100-200 MMBtu/h	N/A	593.1	593.1	593.1	N/A	600.3	N/A	600.3	600.3	600.3	593.1	593.1	593.1	600.3	600.3	600.3
Year-Round 200+ MMBtu/h	919.7	919.7	919.7	919.7	N/A	930.9	N/A	930.9	930.9	930.9	919.7	919.7	919.7	930.9	930.9	930.9
Seasonal 10-15 MMBtu/h	110.3	110.3	110.3	110.3	110.3	110.4	110.4	110.4	110.4	110.4	110.3	110.3	110.3	110.4	110.4	110.4
Seasonal 15-25 MMBtu/h	N/A	104.8	104.8	104.8	104.8	104.9	104.9	104.9	104.9	104.9	104.8	104.8	104.8	104.9	104.9	104.9
Seasonal 25-50 MMBtu/h	107.9	107.9	107.9	107.9	107.9	108.0	108.0	108.0	108.0	108.0	107.9	107.9	107.9	108.0	108.0	108.0
Seasonal 50-100 MMBtu/h	N/A	208.8	208.8	208.8	208.8	209.1	209.0	209.1	209.1	209.1	208.8	208.8	208.8	209.1	209.1	209.1
Seasonal 100-200 MMBtu/h	N/A	210.3	210.3	210.3	N/A	210.6	N/A	210.6	210.6	210.6	210.3	210.3	210.3	210.6	210.6	210.6
Seasonal 200+ MMBtu/h	271.7	271.7	271.7	271.7	N/A	272.1	N/A	272.1	272.1	272.1	271.7	271.7	271.7	272.1	272.1	272.1

3.5 Automatic Blowdown and Deaerator Pressure – Statewide Impacts

3.5.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team took the following steps to determine statewide savings from the proposed automatic blowdown and deaerator pressure measure.

The Statewide CASE Team used a statewide boiler inventory with 9,000 equipment entries from local air quality management districts to estimate current installed boiler capacity and boiler counts in the state of California that was developed as part of a Code Readiness project (Swanson Staller 2025). The Statewide CASE Team split this inventory into bins by boiler capacity.

The Statewide CASE Team refined the statewide capacity for each capacity bin to account for Title 24, Part 6 purview and proposed exceptions, making the following changes:

- Removed boilers with input capacities under 10 MMBtu/h and any units that were indicated to be hot water boilers or hot water heaters in the permit data.
- Removed oilfield and utility boiler capacity, as oilfield boilers are not in buildings and are thus not subject to Title 24, Part 6 requirements.
- For the automatic blowdown measure only: Removed an additional percentage of boiler capacity to represent the total proportion of boilers estimated to qualify for a measure exception, including boiler systems with returned condensate comprising more than 90 percent of feedwater flow, boilers with make-up water treated by a reverse osmosis system, and boilers employing blowdown heat recovery. The Statewide CASE Team chose to aggregate estimates of boiler exception qualification because of overlapping applicability, where sites may qualify for the exception in more than one way. Table 34 includes the percentages of boiler capacity that were removed from the statewide capacity by boiler capacity bin. Larger boilers are more likely to qualify for these exceptions, which generally have shorter payback periods.
- For the deaerator pressure measure only: Removed 7.5 percent of boiler capacity to account for sites that serve the deaerator with high-pressure, high-temperature condensate and sites that may qualify for the exception. Sites with high-pressure, high temperature condensate may comply with the proposed requirement for the steam supply line pressure regulator setpoint to be 5 psig, but the deaerator will be operating at a higher pressure, and they will not realize direct energy savings from the proposed requirement. The Statewide CASE

Team is soliciting additional stakeholder input on the instance of sites that may serve the deaerator with high-pressure, high-temperature condensate.

- Separated seasonal boilers from annual boilers by classifying boilers at major tomato and canned fruit and vegetable processers as seasonal boilers.

Table 34. Boilers Qualifying for Blowdown Requirement Exception by Boiler Capacity

Boiler Capacity Bin	Estimated Percentage of Boilers Qualifying for Blowdown Requirement Exceptions
10-15 MMBtu/h	5%
15-25 MMBtu/h	7%
25-50 MMBtu/h	10%
50-100 MMBtu/h	25%
100-200 MMBtu/h	30%
200+ MMBtu/h	30%

Following these refinements, the statewide capacity represents the Existing Boilers Stock. Boilers at or above 10 MMBtu/h in the healthcare, education, non-cannery food, lumber, refinery, and ‘all other’ sectors were included in the statewide capacity totals. The Statewide CASE Team plans to update inclusion of boilers from each industry according to ongoing conversations regarding Title 24, Part 6 and process load applicability in these sectors.

To estimate the capacity of new process boilers installed annually in new construction and additions, the Statewide CASE Team calculated two IPGRs for California, one for year-round boilers and one for seasonal boilers. See Appendix C for details on how the Statewide CASE Team calculated the IPGRs. The annual new construction and additions forecast is equivalent to the Existing Boiler Stock multiplied by the IPGRs.

To estimate the capacity of new process boilers installed annually from alterations, which are typically boiler replacements, the Statewide CASE Team calculated the replacement rate for boilers and applied it to Existing Boilers Stock. Boiler lifetimes range widely, with most estimates in the 25- to 40- year range (Van Wortswinkel Nijs 2010). The boiler replacement rate is based on a 30-year boiler lifetime, which means that 3.3 percent of the Existing Boiler Stock is replaced each year. The annual alterations forecast is therefore calculated as the Existing Boiler Stock multiplied by 3.3 percent. See the 2028 CASE Methodology Report for details on how statewide savings are calculated.

The Statewide CASE Team then multiplied the per-unit measure savings (the sum of the automatic blowdown savings and the deaerator pressure savings) by the annual new construction and additions forecast and by the alterations forecast to get first-year statewide savings, not accounting for natural market adoption.

To estimate the share of new boilers that would have automatic blowdown systems installed without the requirement in place, the Statewide CASE Team leaned on input from boiler manufacturers and vendors during stakeholder interviews and an analysis of IAC audit data from 64 boilers in 32 steam-using industrial plants from 2010 to 2022 (Swanson Staller 2025). The estimated market adoption is outlined in Table 35.

Table 35: Estimated Current Automatic Blowdown Market Adoption in California

Boiler Capacity	Estimated Automatic Blowdown Market Adoption
10-15 MMBtu/h	25%
15-25 MMBtu/h	30%
25-50 MMBtu/h	35%
50-100 MMBtu/h	40%
100-200 MMBtu/h	45%
200+ MMBtu/h	75%

The Statewide CASE Team applied these market share percentages to the statewide savings for each boiler capacity bin to arrive at the final statewide savings estimate. Appendix C presents the assumptions on the percentage of the total construction forecast that the proposed measure would impact. For more details on the methodology and context about estimating the current market share rate, as well as statewide energy and energy cost savings, see the 2028 CASE Methodology Report.

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 36 and

Table 39) and alterations (Table 37 and Table 40) by climate zone for each submeasure. Table 38 presents first-year statewide savings from new construction, additions, and alterations for the automatic blowdown sub measure and Table 41 presents first-year statewide savings from new construction, additions, and alterations for the deaerator pressure submeasure.

Table 36: Statewide Energy and LSC Impacts Automatic Blowdown – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (MMBtu/h)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	1.65	-	-	0.000	-	$0.03
2	7.13	-	-	0.002	-	$0.13
3	48.27	-	-	0.010	-	$0.86
4	19.41	-	-	0.004	-	$0.34
5	5.06	-	-	0.001	-	$0.09
6	31.16	-	-	0.007	-	$0.56
7	11.77	-	-	0.003	-	$0.21
8	43.23	-	-	0.009	-	$0.78
9	54.81	-	-	0.012	-	$0.98
10	37.71	-	-	0.008	-	$0.68
11	13.39	-	-	0.003	-	$0.24
12	145.72	-	-	0.031	-	$2.60
13	162.27	-	-	0.035	-	$2.90
14	17.47	-	-	0.004	-	$0.31
15	9.07	-	-	0.002	-	$0.16
16	5.09	-	-	0.001	-	$0.09
Total	**613**	**-**	**-**	**0.132**	**-**	**$10.96**

Table 37: Statewide Energy and LSC Impacts Automatic Blowdown – Alterations

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (MMBtu/h)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	3.74	-	-	0.001	-	$0.06
2	15.49	-	-	0.003	-	$0.27
3	103.95	-	-	0.022	-	$1.81
4	42.04	-	-	0.009	-	$0.73
5	10.31	-	-	0.002	-	$0.18
6	66.25	-	-	0.014	-	$1.17
7	23.97	-	-	0.005	-	$0.43
8	93.04	-	-	0.020	-	$1.63
9	117.60	-	-	0.025	-	$2.07
10	80.55	-	-	0.017	-	$1.42
11	30.55	-	-	0.006	-	$0.52
12	313.19	-	-	0.066	-	$5.46
13	345.97	-	-	0.074	-	$6.06
14	39.39	-	-	0.008	-	$0.68
15	19.93	-	-	0.004	-	$0.35
16	11.23	-	-	0.002	-	$0.19
Total	1,317	-	-	0.279	-	$23.04

Table 38: Statewide Energy and LSC Impacts Automatic Blowdown – New Construction, Additions, and Alterations

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
New Construction & Additions	-	-	0.13	-	$10.96
Alterations	-	-	0.28	-	$23.04
Total	**-**	**-**	**0.41**	**-**	**$34.00**

Table 39: Statewide Energy and LSC Impacts Deaerator Pressure – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (MMBtu/h)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	1.37	-	-	0.0000	-	$0.0008
2	3.14	-	-	0.0001	-	$0.0052
3	20.63	-	-	0.0004	-	$0.0353
4	8.45	-	-	0.0002	-	$0.0141
5	1.56	-	-	0.0000	-	$0.0041
6	13.99	-	-	0.0003	-	$0.0236
7	3.51	-	-	0.0001	-	$0.0109
8	21.90	-	-	0.0004	-	$0.0322
9	26.80	-	-	0.0005	-	$0.0408
10	18.00	-	-	0.0003	-	$0.0291
11	10.23	-	-	0.0001	-	$0.0076
12	60.97	-	-	0.0012	-	$0.1012
13	67.01	-	-	0.0014	-	$0.1123
14	9.88	-	-	0.0001	-	$0.0107
15	4.90	-	-	0.0001	-	$0.0063
16	2.61	-	-	0.0000	-	$0.0033
Total	275	-	-	0.0053	-	$0.4377

Table 40: Statewide Energy and LSC Impacts Deaerator Pressure – Alterations

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (MMBtu/h)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	2.75	-	-	0.000	-	$0.00
2	6.33	-	-	0.000	-	$0.01
3	41.57	-	-	0.001	-	$0.07
4	17.03	-	-	0.000	-	$0.03
5	3.14	-	-	0.000	-	$0.01
6	28.19	-	-	0.001	-	$0.05
7	7.07	-	-	0.000	-	$0.02
8	44.13	-	-	0.001	-	$0.06
9	54.02	-	-	0.001	-	$0.08
10	36.27	-	-	0.001	-	$0.06
11	20.62	-	-	0.000	-	$0.02
12	122.88	-	-	0.002	-	$0.20
13	135.04	-	-	0.003	-	$0.23
14	19.91	-	-	0.000	-	$0.02
15	9.88	-	-	0.000	-	$0.01
16	5.25	-	-	0.000	-	$0.01
Total	554	-	-	0.011	-	$0.88

Table 41: Statewide Energy and LSC Impacts Deaerator Pressure – New Construction, Additions, and Alterations

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
New Construction & Additions	-	-	0.005	-	$0.438
Alterations	-	-	0.011	-	$0.882
Total	**-**	**-**	**0.016**	**-**	**$1.320**

3.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 42 and Table 43 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 2,267 metric tons of CO_2e emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

Table 42: First-Year Statewide GHG Emissions Impacts – Automatic Blowdown

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO_2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO_2e)	Total Reduced GHG Emissions (Metric Ton CO_2e)	Total Monetary Value of Reduced GHG Emissions ($)
New Construction & Additions	0.0	689	689	$84,807
Alterations	0.0	1,455	1,455	$179,234
Total	**0.0**	**2,144**	**2,144**	**$264,042**

Table 43: First Year Statewide GHG Emissions Impacts – Deaerator Pressure

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO_2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO_2e)	Total Reduced GHG Emissions (Metric Ton CO_2e)	Total Monetary Value of Reduced GHG Emissions ($)
New Construction & Additions	0.0	28	28	$3,388
Alterations	0.0	55	55	$6,827
Total	**0.0**	**83**	**83**	**$10,215**

3.5.3 Statewide Water Use Impacts

The Statewide CASE Team used boiler steam production, feedwater conductivity, and boiler water conductivity setpoint assumptions to calculate the blowdown flow rate in pounds per hour for each boiler capacity bin. The blowdown flow rate was converted to gallons per year and summed across boiler capacity bins to estimate the total annual water savings from the automatic blowdown measure in gallons per year. See Appendix C for more details on calculation assumptions.

Table 44 and Table 45 present the impact on water use. See the 2028 CASE Methodology Report for additional information on the embedded electricity savings estimates, which assume embedded energy factors of 5,440 kWh per million gallons of water for indoor use and 3,280 kWh per million gallons of water for outdoor water use (SBW Consulting, Inc. 2022).

To comply with Section 810.1 of the California Plumbing Code, which limits water discharged from the facility to the public sewer to below 140°F, water from boiler blowdown is commonly tempered with cold water to cool the blowdown. Initial analyses of water savings do not consider savings from reduced use of tempering water, making the water use impact a conservative estimation. If a heat recovery system is not used, the amount of cooling water often equals the amount of blowdown water.

Table 44: Impacts on Water Use and Embedded Electricity in Water – Automatic Blowdown

Impact	On-Site Indoor Water Savings (Gallons/Year)	On-site Outdoor Water Savings (Gallons/Year)	Embedded Electricity Savings (kWh/Year)
Average Per MMBtu/h Impacts	7,409.77	-	40.31
First-Year Statewide Impacts for New Construction and Additions	4,593,936	-	24,991.01
First-Year Statewide Impacts for Alterations	9,710,014	-	52,822.48
Total First-Year Statewide Impacts	**14,303,950**	**-**	**77,813.49**

Table 45: Impacts on Water Use and Embedded Electricity in Water – Deaerator Pressure

Impact	On-Site Indoor Water Savings (Gallons/Year)	On-site Outdoor Water Savings (Gallons/Year)	Embedded Electricity Savings (kWh/Year)
Average Per MMBtu/h Impacts	163.51	-	0.89
First-Year Statewide Impacts for New Construction and Additions	44,954	-	244.55
First-Year Statewide Impacts for Alterations	90,596	-	492.84
Total First-Year Statewide Impacts	**135,550**	**-**	**737.39**

3.5.4 Statewide Material Impacts

Automatic Blowdown

Automatic blowdown systems require the installation of a blowdown valve, controller, and conductivity probe. Material impacts from automatic blowdown systems are expected to be the same across different boiler sizes as component sizing does not increase significantly with boiler size. Because blowdown valves are required for both manual and automatic blowdown systems (representing the baseline and measure case), they will not have any incremental impact on material use.

Conductivity controller materials typically include plastic (casing and for the circuit board) and copper (on the circuit board and for the wires). Based on a datasheet from Myron L Company, a large manufacturer of water quality management instruments, a standard 750 Series II controller weighs 2.0 pounds (Myron L Company n.d.). The Statewide CASE Team assumed that 1.5 pounds are from the plastic casing and circuit board and 0.5 pounds are from the copper. Conductivity probes are typically made of stainless steel. After examining vendor datasheets that listed conductivity probe weights ranging from 0.5 pounds to 1.0 pound, the Statewide CASE Team used 1 pound as a conservative value for conductivity probe weight (Sensorex n.d.) (Cannon Water Technology Inc n.d.).

The materials for automatic blowdown are consistent across boiler capacity. Therefore, the Statewide CASE Team took the total qualifying statewide boiler capacity construction forecast for new construction, additions, and alterations and divided that total by the statewide average boiler capacity to estimate the construction forecast in number of boilers. That value was multiplied by the material impacts per boiler to calculate the first-year statewide impacts. For more information on the Statewide CASE Team's methodology and assumptions used to calculate embodied GHG emissions, see the 2028 CASE Methodology Report.

The materials impacts and embodied GHG emissions impacts from the increase in material use for automatic blowdown systems are summarized Table 46.

Table 46. First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds Per Boiler)	First-Year Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO_2e)
Mercury	No change	-	-	-
Lead	No change	-	-	-
Copper	Increase	0.02	30	-0.04
Steel	Increase	0.03	61	-0.03
Plastic	Increase	0.05	91	-0.08
TOTAL	**N/A**			**-0.15**

Deaerator Pressure

The deaerator pressure submeasure specifies operating setpoints and does not have any impacts on material use.

3.5.5 Environmental Impacts

Requiring the use of automatic blowdown systems avoids releasing more water than is necessary, as commonly occurs with manual blowdowns. This practice saves energy by reducing the need to heat make-up water. The higher the pressure setpoint the higher the boiling point of water, and thus an increased amount of energy is needed to boil the water. As such, unnecessarily high setpoints result in unnecessary consumption of energy, while lowering setpoints will save energy. These direct benefits are fully discussed in Sections 3.5.1, 3.5.2, and 3.5.3 above.

Automatic blowdown controls can reduce fouling and extend system lifetimes. It also reduces wastewater by avoiding purging more water than is necessary. Deaerator controls can also extend system lifetimes by reducing oxygen pitting and corrosion. Reducing fouling and corrosion will also reduce the need for water treatment chemicals intended to protect equipment from these impacts. Making equipment replacement more infrequent would reduce the embodied carbon emissions produced during the manufacture and transportation of the equipment.

The reduced energy consumption from these measures will also indirectly lead to improvements in local air quality. Combustion of natural gas produces NOx, a chemical precursor to ozone. Reducing the consumption of natural gas will therefore indirectly lead to reduced ozone (Chen, Omotesho Johnson 2025).

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of “specific economic, environmental, legal, social, and technological factors” (Cal. Code Regs., tit. 14, § 15021). The Statewide CASE Team did not determine this measure would result in significant direct or indirect adverse environmental impacts and therefore, did not develop any mitigation measures.

3.5.6 Other Non-Energy Impacts

Automatic Blowdown

Manual boiler blowdown is typically excessive, resulting in unnecessary water losses. Automatic blowdown systems reduce the use of water and the chemicals used to treat it. In addition to water and chemical savings, the reduction in fuel usage to heat fresh water to replace excess blowdown results in lower boiler NOx emissions. This would reduce local photochemical smog and improve air quality.

Deaerator Pressure

The lower deaerator pressure setpoints specified in this regulation require less boiler fire, leading to lower boiler emissions and improved local air quality.

3.6 Automatic Blowdown and Deaerator Pressure - Proposed Code Language

3.6.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2025 documents should be marked with dark blue <u>underlining</u> (new language) and ~~strikethroughs~~ (deletions).

3.6.2 Administrative Code (Title 24, Part 1)

No changes are proposed to Title 24, Part 1.

3.6.3 Energy Code (Title 24, Part 6)

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

Section 100.1(b) – Definitions: Recommends new or revised definitions for the following terms:

<u>**BOILER BLOWDOWN VALVE** is a valve used for discharging water from a boiler to maintain the desired concentration of solids and chemicals to deter scale buildup, corrosion and carryover of impurities in the boiler water.</u>

AUTOMATIC BOILER SURFACE BLOWDOWN CONTROLLER is an automated system that optimizes surface-blowdown rates by regulating the volume of water discharged from the boiler in relation to the concentration of dissolved solids present.

BOILER DEAERATOR is a system that is used for the removal of oxygen and other dissolved gases from the feedwater to steam generating boilers. Dissolved gases in boiler feedwater cause corrosion damage in steam systems by attaching to metallic components and forming oxides, or rust.

BLOWDOWN HEAT RECOVERY is a heat exchanger that recovers energy from the blowdown to heat make-up water or another process stream, with or without a flash tank.

SUBCHAPTER 3 – NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, HOTEL/MOTEL OCCUPANCIES, AND COVERED PROCESSES--MANDATORY REQUIREMENTS

SECTION 120.6 – MANDATORY REQUIRMENTS FOR COVERED PROCESSES

120.6 (d) Mandatory requirements for process boilers.

1. Combustion air positive shut-off shall be provided on all newly installed process boilers as follows:

   A. All process boilers with an input capacity of 2.5 MMBtu/h (2,500,000 Btu/h) and above, in which the boiler is designed to operate with a nonpositive vent static pressure.

   B. All process boilers where one stack serves two or more boilers with a total combined input capacity per stack of 2.5 MMBtu/h (2,500,000 Btu/h).

2. Process boiler combustion air fans with motors 10 horsepower or larger shall meet one of the following for newly installed boilers:

   A. The fan motor shall be driven by a variable speed drive; or.

   B. The fan motor shall include controls that limit the fan motor demand to no more than 30 percent of the total design wattage at 50 percent of design air volume.

3. Newly installed process boilers with an input capacity greater than 5 MMBtu/h (5,000,000 Btu/h) shall maintain stack-gas oxygen concentrations at less than or equal to 3.0 percent by volume on a dry basis over firing rates of 20 to 100 percent. Combustion air volume shall be controlled with respect to measured flue gas oxygen concentration. Use of a common gas and combustion air control linkage or jack shaft is prohibited.

Exception to Section 120.6(d)3: Boilers with steady state full-load combustion efficiency 90 percent or higher.

4. [Placeholder for Stack Economizer code]

5. Automatic Blowdown. Newly installed process steam boilers with an input capacity greater than or equal to 10 MMBtu/h (10,000,000 Btu/h) shall have an automatic boiler surface blowdown controller that is programmed to be controlled by conductivity.

Exception 1 to Section 120.6(d)5: Systems with returned condensate composing more than 90 percent of feedwater flow.

Exception 2 to Section 120.6(d)5: Boilers with make-up water treated by a reverse osmosis (RO) system.

Exception 3 to Section 120.6(d)5: Boilers employing blowdown heat recovery.

6. Deaerator Pressure Control. For systems that use the boiler steam header to pressurize the deaerator, the steam supply line pressure regulator serving the deaerator shall be set at or under 5 psig for all newly installed process steam boilers with an input capacity greater than or equal to 10 MMBtu/h (10,000,000 Btu/h). For boilers with tubes that are not rated for oxidizing conditions, the steam supply line pressure regulator setpoint shall be within 2 to 5 psig.

- **Exception 1 to Section 120.6(d)6**: Sites with swings in make-up water equal to or above 20 percent of feedwater flow.

3.6.4 Reference Appendices

Appendix NA7 – Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes.

NA7.21 Process Boiler Installation and Acceptance Tests

NA7.21.1 Process Boiler Automatic Blowdown

Acceptance tests for process boilers in accordance with Section 120.6(d)5.

NA7.21.1.1 Construction Inspection

Verify and document the planned installation of a boiler blowdown valve, valve controller, and conductivity probe (automatic blowdown system) prior to functional testing. If the boiler is pursuing an exception, verify and document the planned installation of the according heat recovery equipment, RO system, or adequate condensate return infrastructure.

NA7.21.1.2 Functional Testing

Additional acceptance testing, performed by field technician, shall be added to verify and document the following for newly installed process boilers with an input capacity equal to or greater than 10 MMBtu/h (10,000,000 Btu/h):

- automatic blowdown is programmed to be controlled by conductivity.
- blowdown heat recovery equipment, RO system, or condensate return equipment is operational if the boiler is pursuing the associated exception.

Step 1: Installation Verification

1. Confirm that an automatic blowdown controller is installed in the surface blowdown line.

Step 2: Setpoint Verification

2. Visually verify the current conductivity setpoint configured on the controller.

Step 3: Operational Cycle Observation

1. Observe the controller as it completes one full cycle: The controller should sample the boiler water conductivity and display a reading.
    a. Based on the reading:
        i. **If the conductivity is above the setpoint**: The controller should automatically open the blowdown valve to reduce TDS.
        ii. **If the conductivity is below the setpoint**: The blowdown valve should remain closed.

Step 4: Functional Test (if conductivity is below setpoint)

2. To verify system functionality even when blowdown is not triggered under current conditions:
    a. Temporarily lower the blowdown setpoint below the current conductivity value.
    b. Observe one full cycle and confirm that the blowdown valve opens as expected.
    c. **Restore the conductivity setpoint** to its original value after testing.

NA7.21.2 Process Boiler Deaerator Pressure

Acceptance tests for process boilers in accordance with Section 120.6(d)6.

NA7.21.2.1 Construction Inspection

None.

NA7.21.2.2 Functional Testing

Acceptance testing, performed by field technician, shall be added to verify and document the following for newly installed process boilers with an input capacity equal to or greater than 10 MMBtu/h (10,000,000 Btu/h): that deaerator pressure setpoint is at or under 5 psig and within 2 to 5 psig for boilers with tubes that are not rated for oxidizing conditions.

Step 1: Boiler Pressure Confirmation

1. Ensure the boiler is at its design condition operating pressure.

Step 2: DA Pressure Verification

2. Visually confirm that the pressure gauge on the deaerator reads between 2 psig and 5 psig.

Step 3: High Pressure Check (if deaerator pressure > 5 psig)

3. If the deaerator pressure is above 5 psig, verify the following:
    a. Condensate Return Pressure
        i. Confirm that the returning condensate enters the deaerator at a pressure greater than 5 psig, and that it matches the pressure measured inside the deaerator.
    b. Regulator Pressure Setpoint
        i. Ensure the deaerator steam supply line pressure regulator setpoint is below 5 psig.

3.6.5 Compliance Manuals

The Statewide CASE Team will provide CEC with recommended revisions to compliance manuals after the 45-Day Language is published.

3.6.6 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

3.6.7 Compliance Forms

As discussed in Section 2.1.4.5, the NRCC-PRC-E and NRCI-PRC-E forms and a new NRCA-PRC-XX-F compliance form would be updated or added to reflect the proposed change. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

NRCC-PRCC-E

To section I PROCESS BOILER table:

- Add a selection in the dropdown for rated input capacity to include: ≥ 10MMBtu/h
- Add a column for Automatic Blowdown

- To the corresponding section for the form in the Virtual Compliance Assistant, add:
  - Does this process boiler have an automatic surface blowdown controller that is that is programmed to be controlled by a conductivity setpoint?
    - Question response dropdown options:
      - Yes
      - This doesn't apply because the system has returned condensate composing more than 90 percent of feedwater flow.
      - This doesn't apply because this boiler has make-up water treated by a reverse osmosis (RO) system.
      - This doesn't apply because this process boiler employs blowdown heat recovery.

- Add column for Deaerator Pressure
  - To the corresponding section for the form in the Virtual Compliance Assistant, add:
    - Does this process boiler have the steam supply line pressure regulator serving the deaerator set at 5 psig or under, OR the steam supply line pressure regulator set at 2-5 psig if the boiler does not have tubes rated for oxidizing conditions?
      - Question response dropdown options:
        - Yes
        - This doesn't apply because the boiler steam header is not used to pressurize the deaerator.
        - This does not apply because the system has swings in make-up water equal to or above 20% of feedwater flow.

<u>NRCI-PRCC-E</u>

To the Process Boilers Table, add:

- Column for Automatic Blowdown
- Column for Automatic Blowdown Controller Make and Model #
- Column for Deaerator Pressure

NRCA-PRC-XX (Automatic Blowdown)-F

Create new NRCA-PRC form with the following:

- Construction Inspection Table
    - Verify maximum capacity is greater than or equal to 10MMBtu/h. (T/F)
    - Document automatic blowdown conductivity controller make and model.
- Functional Testing Table
    - Verify the current conductivity setpoint configured on the controller. (P/F)
    - Observe the controller as it completes one full cycle. Verify the following (No Entry):
        - If the conductivity is above the setpoint, the controller automatically opens the blowdown valve. If the conductivity is below the setpoint, the blowdown valve should remain closed. (P/F)
        - If the conductivity is below the setpoint, temporarily lower the blowdown setpoint below the current conductivity value. Observe the controller for one full cycle. Verify the following (No Entry):
            - Blowdown valve opens. (P/F)
            - Return system to original operating conditions. (P/F)

NRCA-PRC-XX (Deaerator)-F

Create a new NRCA-PRC form with the following:

- Construction Inspection Table
    - Verify maximum capacity is greater than or equal to 10MMBtu/h. (T/F)
    - Verify the deaerator is pressurized by a boiler steam header. (P/F)
- Functional Testing
    - Verify the boiler is at its design condition operating pressure. (No Entry)
    - Verify that the pressure gauge on the deaerator reads less than 5psig or 2-5psig for boilers with non-oxidizing tubes. (P/F)
    - If the deaerator is above 5psig, verify the following (No Entry):
        - Confirm that the returning condensate enters the deaerator at a pressure greater than 5psig and matches the pressure measured inside the deaerator. (P/F)
        - Ensure the deaerator steam supply line pressure regulator setpoint is below 5psig or 2-5psig for boilers with non-oxidizing tubes. (P/F)

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Appendix A: Assumptions for Cost-effectiveness Analysis

Key Assumptions for Energy Savings Analysis

Stack Economizers

For the stack economizer requirement, the baseline case is a boiler without a stack economizer, and the proposed case is a boiler with a non-condensing stack economizer.

Savings calculation assumptions for both the baseline and proposed cases include the following:

a. Boiler operation (year-round boilers): 6,500 hours per year, based on a survey of from 128 California steam-using sites sourced from the national IAC database Swanson Staller 2025).
b. Boiler operation (seasonal boilers): 2,400 hours per year, based on a survey of from 128 California steam-using sites sourced from the national IAC database Swanson Staller 2025).
c. Shell losses: 1.0 percent, based on industry standard rule of thumb.
d. Combustion air temperature: 75°F, based on outdoor air temperatures in California.
e. Stack oxygen content: 7.1 percent, based on field data from 10 sites that conducted fieldwork with Cascade Energy. See Boiler Field Data for full information.

Savings calculation assumptions and outputs for the baseline case include the following:

a. Annual boiler gas consumption: calculated at 40 percent load for year-round boilers and 80 percent load for seasonal boilers.
b. Stack exhaust temperature: 382°F at 40 percent boiler load and 100 psig, based on field data from 10 sites.
c. Combustion efficiency: 80.5 percent, based on field data from 10 sites.
d. Boiler efficiency: 79.5 percent, equivalent to the combustion efficiency minus shell losses.

Savings calculation assumptions and outputs for the proposed measure case include the following:

a. Combustion efficiency: 82.8 percent, calculated using the ASME PTC-4 Indirect Method: Stack Loss Method.
b. Boiler efficiency: 81.8 percent, calculated based on the combustion efficiency minus shell losses.
c. Stack exhaust temperature: 302°F, based on an 80°F temperature drop due to the stack economizer for boilers 10-25 MMBtuh/h and a 100°F temperature drop due to the stack economizer for boilers 25 MMBtuh/h or greater.
d. Stack economizer heat transfer effectiveness: 95.0 percent, accounting for heat loss to the atmosphere.

Stack economizers are standardized products, and the Statewide CASE Team assumes consistent performance across makes and models. The Statewide CASE Team applied the climate-zone-specific LSC hourly factors when calculating energy cost impacts.

Automatic Blowdown

For the automatic blowdown requirement, the baseline case is a boiler maintained with manual blowdown and the proposed case is a boiler with an automatic blowdown system.

Savings calculation assumptions for both the baseline and proposed cases include the following:

a. Boiler operation (year-round boilers): 6,500 hours per year, based on a survey of from 128 California steam-using sites sourced from the national IAC database Swanson Staller 2025).
b. Boiler operation (seasonal boilers): 2,400 hours per year, based on a survey of from 128 California steam-using sites sourced from the national IAC database Swanson Staller 2025).
c. Steam header pressure: 100 psig, informed by average industry steam header pressure.
d. Condensate conductivity: 20 μ℧, based on field data from two industrial sites from prior work with Cascade Energy.
e. Make-up water conductivity: 440 μ℧, based on field data from two industrial sites from prior work with Cascade Energy.
f. Feed water conductivity: 345 μ℧, based on field data from two industrial sites from prior work with Cascade Energy.
g. Feedwater enthalpy: 194.5 Btu/lb, from steam tables.
h. Steam enthalpy: 1,190.8 Btu/lb, from steam tables.
i. Enthalpy of boiler water: 309.2 Btu/lb, from steam tables at 100 psig.

j. Make-up water enthalpy: 33 Btu/lb, calculated based on make-up water temperature of 65°F.
k. Steam flow: 3,752 lbs/h, calculated for a 12 MMBtu/h boiler at 40 percent load.
l. Boiler water conductivity setpoint: 3,000 μ℧.

No unique assumptions apply to the baseline case. Savings calculation assumptions unique to the proposed case include the following:

a. Boiler water conductivity: 500 μ℧ less than in the baseline case.

Automatic blowdown systems are standardized products, and the Statewide CASE Team assumes consistent performance across makes and models. The Statewide CASE Team applied the climate-zone-specific LSC hourly factors when calculating energy cost impacts.

Deaerator Pressure

For the deaerator pressure requirement, the baseline case is a boiler with its steam supply line pressure regulator and deaerator set to 8 psig and the proposed case is a boiler with its steam supply line pressure regulator and deaerator set to 5 psig.

Savings calculation assumptions for both the baseline and proposed cases include the following:

a. Boiler operation (year-round boilers): 6,500 hours per year, based on a survey of from 128 California steam-using sites sourced from the national IAC database Swanson Staller 2025).
b. Boiler operation (seasonal boilers): 2,400 hours per year, based on a survey of from 128 California steam-using sites sourced from the national IAC database Swanson Staller 2025).
c. Valve flow coefficient (Cv): 1, from steam tables.
d. Pressure differential ratio factor: 0.72, calculated value.

Savings calculation assumptions unique to the baseline case include the following:

a. Deaerator pressure: 8 psig, based on industry experience and estimated to apply to about 20 percent of sites statewide.
b. Feedwater temperature: 234.6°F, based on a deaerator pressure of 8 psig.
c. Steam flow rate: 35 lbs/h, calculated value.

Savings calculation assumptions unique to the proposed case include the following:

a. Deaerator pressure: 5 psig, based on industry experience.
b. Feedwater temperature: 226°F, based on a deaerator pressure of 5 psig.
c. Steam flow rate: 27 lbs/h, calculated value.

Energy Savings Methodology

Prototype Development - Stack Economizer and Automatic Blowdown and Deaerator Pressure

The Statewide CASE Team analyzed energy savings and cost effectiveness in six boiler capacity ranges to account for savings and cost differences for boilers with different capacities. Table 47. Process Boiler Capacity Bins shows the boiler capacity bin ranges and the average capacity of the boilers within each bin, which was used to perform the calculations of cost effectiveness. The prototype is the average capacity boiler for each boiler capacity bin, as shown Table 47. Data on the capacity of installed boilers in California came from the statewide boiler inventory of local air district boiler permits developed as part of the Code Readiness program (Swanson Staller 2025).

Table 47. Process Boiler Capacity Bins

Boiler Capacity Bin	Average Boiler Capacity Used for Calculations
10-15 MMBtu/h	12 MMBtu/h
15-25 MMBtu/h	19 MMBtu/h
25-50 MMBtu/h	33 MMBtu/h
50-100 MMBtu/h	71 MMBtu/h
100-200 MMBtu/h	143 MMBtu/h
200+ MMBtu/h	739 MMBtu/h

For both measures, boilers that operate infrequently throughout the year due to seasonal loads will experience lower savings. Due to this variance, the Statewide CASE Team also developed prototypes and calculated annual energy savings and cost effectiveness for boilers with seasonal loads separately from the more typical annual loads. Calculations for boilers operating annually assumed 6,500 operating hours per year at 40 percent load, and calculations for seasonal boilers assumed 2,400 operating hours per year (primarily July through October) at 80 percent load. To calculate statewide capacity, seasonal boilers were all boilers in canneries. Boilers used in all other industries were assumed to be year-round boilers.

Review finds no anticipated differences between new process boilers that are installed during the new construction, addition, or alteration of a building, so the same prototypes were used for new construction, additions, and alterations.

Existing Title 24, Part 6 requirements already cover process boilers and apply to new construction, additions, and alterations, so the Standard Design (baseline case) is minimally compliant with the 2025 Title 24 requirements and informs the baseline combustion efficiency estimate used in savings calculations. These requirements include combustion air positive shut-off for all process boilers with an input capacity of

2.5 MMBtu/h and above, variable speed drive for process boiler combustion air fans with motors 10 horsepower and greater, and stack oxygen concentrations at less than or equal to 3.0 percent by volume on a dry basis over firing rates of 20 to 100 percent for process boilers with an input capacity greater than 5.0 MMBtu/h.

The 2028 CASE Methodology Report provides details on estimating energy savings per prototypical building and unit.

Energy Savings Calculations

Stack Economizers

The Proposed Design (measure case) was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Specifically, the proposed conditions assume installation of a non-condensing stack economizer on the boiler stack.

Savings result from improved boiler combustion efficiency due to the economizer using recovered heat to increase the temperature of boiler feedwater. Energy savings were calculated for a 12 MMBtu/h boiler using the following steps:

1. Calculate the measure case boiler combustion efficiency using the ASME PTC-4 Indirect Method: Stack Loss Method.[8]
2. Calculate annual boiler load from baseline annual gas consumption and baseline boiler efficiency, where:
    a. $\boldsymbol{Boiler\ Load} = \frac{\boldsymbol{Annual\ Gas\ Consumption_{Baseline}}}{\boldsymbol{Boiler\ Efficiency_{Baseline}}}$
3. The annual boiler load is the same for the baseline and measure cases. Calculate the measure case annual boiler gas consumption from the annual boiler load and the measure case boiler efficiency, where:
    a. $\boldsymbol{Annual\ Gas\ Consumption_{Post}} = \frac{\boldsymbol{Boiler\ Load}}{\boldsymbol{Boiler\ Efficiency_{Post}}}$
4. Calculate the difference between the baseline and measure case gas consumption to arrive at the measure's energy savings, where:
    a. $\boldsymbol{Savings} = \boldsymbol{Annual\ Gas\ Consumption_{Baseline}} - \boldsymbol{Annual\ Gas\ Consumption_{Post}}$

Automatic Blowdown

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Specifically, the proposed

[8] An explanation of the ASME PTC-4 Indirect Method: Stack Loss Method can be found at: ww2.arb.ca.gov/sites/default/files/cap-and-trade/allowanceallocation/boiler_efficiency_calc.pdf

conditions assume installation and use of an automatic blowdown system in place of manual blowdown.

Savings result from the reduction in hot water removed from the boiler when conducting less blowdown and were calculated by subtracting the boiler's annual energy lost to blowdown with automatic blowdown from the boiler's annual energy lost to blowdown with manual blowdown.

The annual energy lost to blowdown is equal to the average blowdown energy in Btu/h * (hours of operation / 100,000 / Boiler Efficiency), where

$$\boldsymbol{Blowdown\ Energy} \doteq \dot{\boldsymbol{m}}_{\boldsymbol{bdn}} * (\boldsymbol{H}_{\boldsymbol{bw}} - \boldsymbol{H}_{\boldsymbol{mw}})$$

$\dot{m}_{bdn}$ = *blowdown flow rate in (lbs/h)*

H_{bw} = ***Enthalpy of boiler water***

H_{mw} = *Enthalpy of make-up water*

$$\dot{m}_{bdn} = \frac{Steam\ flow}{(COC - 1)}$$

$$COC = \frac{C_b}{C_{fw}}$$

COC = *Cycles of Concentration*

C_b = *average conductivity of boiler water*

C_{fw} = *conductivity of feedwater*

Deaerator Pressure

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Specifically, the proposed conditions assume boiler operation with steam supply line regulator and deaerator setpoints at 5 psig instead of 8 psig. Savings result from the decreased energy loss when less steam is vented due to over-pressurization of the deaerator.

To estimate the natural gas savings from improved deaerator control, the Statewide CASE Team calculated the mass flow of steam lost to over-pressurization in lbs/h when the deaerator setpoint is 8 psig. The Statewide CASE Team used a Cascade Energy tool to calculate the amount of steam vented and then calculated the therms required to make up for the volume of excess steam vented, using the following equations:

$$\frac{(p_1 - p_2)}{p_1} < F_\gamma * x_T \rightarrow m_s = 63.3 * C_v * \left(1 - \frac{\frac{p_1 - p_2}{p_1}}{3 * F_\gamma * x_T}\right) * \sqrt{(p_1 - p_2) * \rho}$$

$$\frac{(p_1-p_2)}{p_1} \geq F_\gamma * x_T \rightarrow m_s = 0.66 * 63.3 * C_v * \sqrt{F_\gamma * x_T * p_1 * \rho}$$

p_1: Primary Pressure (psia)

p_2: Secondary Pressure (psia)

C_v: Valve Cv Value (Cv (US))

m_s: Steam Flow Rate (lb/h)

ρ: Density of steam (lb/ft^3)

F_γ: Specific heat ratio factor

x_T: Pressure differential ratio factor

Energy benefits for deaerators set inadvertently under 2 psig were not calculated, as such values typically only occur after installation and sites with deaerators set inadvertently under 2 psig are estimated to make up a very small percentage of newly installed boiler systems.

Boiler Field Data

Table 48, Table 49, and Table 50 include process boiler field data from 10 sites collected through Cascade Energy's work at the sites. These data were used to inform the assumptions for boiler stack oxygen content, stack exhaust temperature, and combustion efficiency that were used in the per-unit energy savings calculations.

Table 48. Boiler Field Data - Low Fire

Site Number	Stack Oxygen Concentration	Stack Temperature (°F)	NOx (ppmv)	Combustion Efficiency
1	7.0%	381	5.4	80.60%
2	4.8%	370	3.8	81.83%
3	7.8%	377	6.8	80.29%
4	8.3%	376	6.7	80.03%
5	8.0%	363	6.9	80.59%
6	8.1%	367	7.5	80.41%
7	8.0%	345	7.5	81.13%
8	7.7%	351	7.7	81.10%
9	[no data]	[no data]	[no data]	90.72%
10	6.7%	386	7	80.61%

Table 49. Boiler Field Data - Mid Fire

Site	Stack Oxygen Concentration	Stack Temperature (°F)	NOx (ppmv)	Combustion Efficiency
1	5.5%	399	7.5	80.81%
2	4.5%	374	4.5	81.84%
3	7.6%	410	6.4	79.44%
4	8.0%	421	6.4	78.86%
5	8.1%	375	6.28	80.17%
6	7.8%	380	7.5	80.20%
7	7.9%	365	7.7	80.59%
8	8.0%	360	7.1	80.68%
9	6.8%	392	26.1	80.39%
10	4.1%	427	6.4	80.70%

Table 50. Boiler Field Data - High Fire

Site	Stack Oxygen Concentration	Stack Temperature (°F)	NOx (ppmv)	Combustion Efficiency
1	7.5%	394	5.7	79.96%
2	4.5%	378	4.5	81.74%
3	7.4%	451	6.4	78.37%
4	7.8%	444	6.4	78.31%
5	8.1%	389	6.14	79.75%
6	7.7%	396	7.31	79.78%
7	7.8%	384	7.8	80.08%
8	7.8%	370	7.7	80.49%
9	5.2%	450	25.1	79.64%
10	3.5%	500	7.1	79.21%

Appendix B: Purpose and Necessity of Proposed Code Changes

Introduction

The section below provides the purpose and necessity of proposed changes to Title 24, Part 1; Title 24, Part 6; and the reference appendices, intending to provide the CEC with the information needed for the Initial Statement of Reasons.

See Sections 2.6 and 3.6 of this report for markup for updated code language.

Stack Economizer

Purpose and Necessity of Changes to Title 24, Part 1

No changes are proposed to Title 24, Part 1.

Purpose and Necessity of Changes to Title 24, Part 6

Section: 100.1

Purpose: The purpose of this change is to aid in the interpretation and implementation of new requirements for process boilers in Title 24, Part 6, Section 120.6(d) by adding several new definitions.

Necessity: This change adds definitions for Boiler Stack Economizer, Mesh Burner, Selective Catalytic Reduction (SCR) System, and Biomass. These definitions ensure clarity of the proposed process boiler requirements for the use of economizers.

Section: 120.6(d)3, 4

Purpose: The purpose of this change is to add a new requirement for boiler stack economizers. Requiring the use of stack economizers will result in energy savings by recovering energy from exhaust that is otherwise wasted.

Necessity: These changes intend to reduce the energy consumed by process boilers. These adjustments align with the mandated cost-effective building design standards outlined in the California Public Resources Code, specifically Sections 25213 and 25402.

Purpose and Necessity of Changes to the Reference Appendices

There are no required updates to the reference appendices as a result of this measure

Automatic Blowdown and Deaerator Pressure

Purpose and Necessity of Changes to Title 24, Part 1

No changes are proposed to Title 24, Part 1.

Purpose and Necessity of Changes to Title 24, Part 6

Section: 100.1

Purpose: The purpose of this change is to aid in the interpretation and implementation of proposed new requirements for process boilers in Title 24, Part 6, Section 120.6(d) by adding several new definitions.

Necessity: This change adds definitions for Boiler Blowdown Valve, Automatic Boiler Surface Blowdown Controller, Boiler Deaerator, and Blowdown Heat Recovery. These definitions provide necessary clarity for the proposed additions to Title 24, Part 6, Section 120.6(d) that require new process boilers to use automatic blowdown systems and comply with specified steam supply line pressure regulator setpoints.

Section: 120.6(d)4, 5

Purpose: The purpose of these changes is to require new process boilers to use automatic blowdown systems and to limit the pressure of steam supply line pressure regulators, which will result in energy savings.

Necessity: These changes are intended to reduce process boiler energy consumption. These adjustments align with the mandated cost-effective building design standards outlined in the California Public Resources Code, specifically Sections 25213 and 25402.

Purpose and Necessity of Changes to the Reference Appendices

Section: NA7

Purpose: The purpose of this change is to add process boiler acceptance testing to ensure compliance with automatic blowdown and deaerator pressure requirements.

Necessity: This change is necessary in order to implement and enforce the proposed requirements for process boilers.

Appendix C: Assumptions for Statewide Savings Estimates

Stack Economizer and Automatic Blowdown and Deaerator Pressure

The Statewide CASE Team took the following steps to determine statewide savings from the proposed stack economizer and automatic blowdown and deaerator pressure measures.

To estimate statewide boiler capacities and counts by boiler capacity bins, the Statewide CASE Team leveraged statewide boiler inventory data developed as part of a Code Readiness project. This inventory is a nearly complete statewide boiler inventory that has over 9,000 equipment entries from local air quality management districts, which were collected and preprocessed by the Code Readiness project team in 2023 and 2024 (Swanson Staller 2025).

The Statewide CASE Team refined the statewide capacity for each capacity bin to account for Title 24 purview and requirement exceptions, making the following changes:

- Removed boilers with input capacities under 10 MMBtu/h and any units that were indicated to be hot water boilers or hot water heaters in the permit data.
- Removed oilfield and utility boilers, which are not in buildings and not subject to Title 24, Part 6 requirements.
- For the stack economizer measure only: Removed boilers in the lumber industry, which typically use biomass as fuel and thus qualify for an exception from the stack economizer requirement.
- For the stack economizer measure only: Removed ten percent to account for boiler capacity operating with a stack temperature below 340°F, which qualifies for an exception from the stack economizer requirement.
- For the stack economizer measure only: Removed 20 percent of alteration capacity estimated to qualify for the roof clearance exception.
- For the automatic blowdown measure only: Removed an additional percentage of boiler capacity to represent the total proportion of boilers estimated to qualify for a measure exception, including boiler systems with returned condensate composing more than 90 percent of feedwater flow, boilers with make-up water treated by a reverse osmosis system, and boilers employing blowdown heat recovery. The Statewide CASE Team chose to aggregate estimates of boiler exception qualification because of overlapping applicability, where sites may qualify for the exception in more than one way. Table 32 includes the

percentages of boiler capacity that were removed from the statewide capacity by boiler capacity bin.

- For the deaerator pressure measure only: Removed 7.5 percent of boiler capacity to account for sites that serve the deaerator with high-pressure, high-temperature condensate and sites that may qualify for the exception. Sites with high-pressure, high temperature condensate may comply with the proposed requirement for the steam supply line pressure regulator setpoint to be 5 psig, but the deaerator will be operating at a higher pressure, and they will not realize direct energy savings from the proposed requirement. The Statewide CASE Team is seeking additional stakeholder input on the instance of sites that may serve the deaerator with high-pressure, high-temperature condensate.
- Separated seasonal boilers from annual boilers by classifying boilers at major tomato and canned fruit and vegetable processers as seasonal boilers.
  - The cannery capacity includes the capacity from major tomato and canned fruit and vegetable processers in the state. The Statewide CASE Team is not aware of other major facility types in California that would typically operate boilers seasonally.

The statewide capacity after these changes were made represents the Existing Boilers Stock. Boilers at or above 10 MMBtu/h in the healthcare, education, non-cannery food, refinery, and ‘all other’ sectors were included in the statewide capacity totals. The Statewide CASE Team plans to update inclusion of boilers from each industry according to ongoing conversations regarding Title 24 and process load applicability in these sectors.

To estimate the capacity of new process boilers installed annually from new construction and additions, the Statewide CASE Team calculated two IPGRs for California, one for annual boilers and one for seasonal boilers.

The Statewide CASE Team analyzed both national and state data to develop an IPGR for California. The IPGR from the 2022 Steam Trap Monitoring CASE Report was calculated using an average of the 10-year and 30-year compound annual growth rate (CAGR) of INDPRO, the national Federal Industrial Production Index (Johnson, Heinrichs Coakley 2020). However, the Statewide CASE Team determined that national trends would not provide an accurate representation of the California industrial production market. While California is the largest contributor to the U.S. manufacturing industry in terms of output and employment, it accounts for 14.5 percent of U.S. manufacturing output (Profozich 2022). A study performed by Beacon Economics for the California Manufacturing Network confirmed that California’s manufacturing sector has grown at a faster rate compared the that of the US (Economics n.d.).

To more accurately estimate California's IPGR, the Statewide CASE Team met with Beacon Economics to discuss the availability of California-specific data on industrial production growth and the differences between California's manufacturing sector and the U.S. manufacturing sector as a whole. Beacon Economics provided a 2025 study demonstrating that California's manufacturing growth was not only faster than the rest of the United States, but California's manufacturing is also more productive (Beacon Economics 2025). The Statewide CASE Team investigated California real Gross Domestic Product (GDP) data from the U.S. Bureau of Economic Analysis (BEA) and California Federal Reserve Bank of St. Louis' Federal Reserve Economic Data (FRED) for industries classified as manufacturing per 2017 NAICS U.S. Bureau of Economic Analysis 2025 FRED 2025).

The Statewide CASE Team calculated the average of the 7-year CAGR and 10-year CAGR from both sources through 2024. The California real GDP manufacturing growth rate from BEA and FRED was similar at 2.25 percent and 2.74 percent, respectively. The data from BEA provided a more conservative growth rate and were selected for California IPGR calculations.

To further tailor this data to the proposed Process Boilers measures, the Statewide CASE Team applied weights based on the proportion of boiler capacity in each of the main industry subsectors (i.e., food and beverage manufacturing, wood manufacturing, and total other manufacturing which is defined as all other manufacturing that was not food and beverage, wood, lumber, petroleum/refining, or other subsectors that burn byproduct waste), calculated from the statewide boiler inventory based on AQMD data to subsector-specific California real GDP BEA data. Boiler capacity from canneries was excluded from the weighted average for year-round boilers. The calculated weighted average IPGR for year-round boilers was 1.65 percent.

The growth rate for the seasonal facilities is best represented by the Food and Beverage Manufacturing IPGR of 0.46 percent, which was calculated from BEA real GDP data in 2017 chained dollars.

Statewide savings estimates were calculated using an IPGR of 1.65 percent for year-round boilers and 0.46 percent for seasonal boilers. The annual new construction and additions forecast is equivalent to the Existing Boiler Stock multiplied by the IPGR.

To estimate the capacity of new process boilers installed annually from alterations or replacements, the Statewide CASE Team calculated the replacement rate for boilers and applied it to Existing Boilers Stock. Boiler lifetimes range widely, with most estimates in the 25- to 40-year range (Van Wortswinkel Nijs 2010). The boiler replacement rate is based on a 30-year boiler lifetime, which means that 3.3 percent of the Existing Boiler Stock is replaced each year. The alterations forecast is therefore equivalent to the Existing Boiler Stock multiplied by 3.3 percent.

The Statewide CASE Team then multiplied the per-unit measure savings by the annual new construction and additions forecast and by the alterations forecast to get statewide savings, not accounting for natural market adoption.

The final statewide savings and cost estimates take the current market adoption rate into account by removing the market adoption estimation for each measure from the boiler capacity used for the statewide savings estimate. The Statewide CASE Team estimated a current market share rate for both proposed measures based on boiler capacity. The market share is likely slightly lower for the retrofit market than the new construction market. The current market share rates were estimated based on interviews with well-informed boiler manufacturers and vendors and data from an analysis of IAC audit data from 64 boilers in 32 steam-using industrial plants from 2010 to 2022. The current market adoption rates are shown in Table 51 and Table 52 for stack economizers and automatic blowdown, respectively.

The Statewide CASE Team estimated that 20 percent of current process boilers operate with steam supply line regulators and deaerator setpoints above 5 psig, based on anecdotal industry experience and conversations with facility operators. Therefore, the per-unit savings were applied to only 20 percent of statewide new boiler capacity to reach the statewide savings.

Table 51: Estimated Current Stack Economizer Market Adoption in California

Boiler Capacity Bin	Estimated Stack Economizer Market Adoption
10-15 MMBtu/h	25%
15-25 MMBtu/h	30%
25-50 MMBtu/h	40%
50-100 MMBtu/h	45%
100-200 MMBtu/h	50%
200+ MMBtu/h	90%

Table 52: Estimated Current Automatic Blowdown Market Adoption in California

Boiler Capacity	Estimated Automatic Blowdown Market Adoption
10-15 MMBtu/h	25%
15-25 MMBtu/h	30%
25-50 MMBtu/h	35%
50-100 MMBtu/h	40%
100-200 MMBtu/h	45%
200+ MMBtu/h	75%

The Statewide CASE Team applied these market share percentages to the statewide savings for each boiler capacity bin to arrive at the final statewide savings estimate.

The energy impacts of the proposed code change do not vary by climate zone. The measure is not climate-dependent because the impact of the outdoor air temperature on the boiler's and stack economizer's operation is minimal and does not materially impact estimated measure savings. Since savings do not vary by climate zone, the Statewide CASE Team used the statewide LSC hourly factors when calculating energy and LSC impacts.

Table 53: Percentage of Statewide Capacity Impacted by Proposed Code Change in 2029, by Boiler Capacity – Stack Economizer Table 54: Percentage of Statewide Capacity Impacted by Proposed Code Change in 2029, by Boiler Capacity – Automatic Blowdown and Table 55: Percentage of Statewide Capacity Impacted by Proposed Code Change in 2029, by Boiler Capacity – Deaerator Pressure show the percentages of statewide capacity of process boilers with input capacities over 10 MMBtu/h that would be impacted by the proposed code changes in 2029. These percentage capacities impacted remove the industries that are not impacted by Title 24, Part 6, the capacity expected to qualify for exceptions for each measure, and the estimated share of the potentially impacted capacity that is estimated to adopt the proposed requirement without a requirement. No differences are found for affected boiler capacity by climate zone.

Table 53: Percentage of Statewide Capacity Impacted by Proposed Code Change in 2029, by Boiler Capacity – Stack Economizer

Boiler Capacity Bin	New Construction Impacted (Percent Capacity)	Existing Boiler Capacity (Alterations) Impacted (Percent Capacity)
Year-Round Boiler 10-15 MMBtu/h	67%	2.23%
Year-Round Boiler 15-25 MMBtu/h	62%	2.05%
Year-Round Boiler 25-50 MMBtu/h	52%	1.72%
Year-Round Boiler 50-100 MMBtu/h	24%	0.80%
Year-Round Boiler 100-200 MMBtu/h	43%	1.45%
Year-Round Boiler 200+ MMBtu/h	2%	0.07%
Seasonal Boiler 10-15 MMBtu/h	68%	2.25%
Seasonal Boiler 15-25 MMBtu/h	63%	2.10%
Seasonal Boiler 25-50 MMBtu/h	54%	1.80%
Seasonal Boiler 50-100 MMBtu/h	50%	1.65%
Seasonal Boiler 100-200 MMBtu/h	45%	1.50%
Seasonal Boiler 200+ MMBtu/h	9%	0.30%

Table 54: Percentage of Statewide Capacity Impacted by Proposed Code Change in 2029, by Boiler Capacity – Automatic Blowdown

Boiler Capacity Bin	New Construction Impacted (Percent Capacity)	Existing Boiler Capacity (Alterations) Impacted (Percent Capacity)
Year-Round Boiler 10-15 MMBtu/h	71%	2.36%
Year-Round Boiler 15-25 MMBtu/h	64%	2.12%
Year-Round Boiler 25-50 MMBtu/h	57%	1.89%
Year-Round Boiler 50-100 MMBtu/h	22%	0.73%
Year-Round Boiler 100-200 MMBtu/h	39%	1.28%
Year-Round Boiler 200+ MMBtu/h	5%	0.17%
Seasonal Boiler 10-15 MMBtu/h	71%	2.37%
Seasonal Boiler 15-25 MMBtu/h	65%	2.17%
Seasonal Boiler 25-50 MMBtu/h	59%	1.95%
Seasonal Boiler 50-100 MMBtu/h	45%	1.50%
Seasonal Boiler 100-200 MMBtu/h	39%	1.28%
Seasonal Boiler 200+ MMBtu/h	18%	0.58%

Table 55: Percentage of Statewide Capacity Impacted by Proposed Code Change in 2029, by Boiler Capacity – Deaerator Pressure

Boiler Capacity Bin	New Construction Impacted (Percent Capacity)	Existing Boiler Capacity (Alterations) Impacted (Percent Capacity)
Year-Round Boiler 10-15 MMBtu/h	18%	0.61%
Year-Round Boiler 15-25 MMBtu/h	18%	0.60%
Year-Round Boiler 25-50 MMBtu/h	18%	0.60%
Year-Round Boiler 50-100 MMBtu/h	9%	0.30%
Year-Round Boiler 100-200 MMBtu/h	19%	0.62%
Year-Round Boiler 200+ MMBtu/h	5%	0.18%
Seasonal Boiler 10-15 MMBtu/h	19%	0.62%
Seasonal Boiler 15-25 MMBtu/h	19%	0.62%
Seasonal Boiler 25-50 MMBtu/h	19%	0.62%
Seasonal Boiler 50-100 MMBtu/h	19%	0.62%
Seasonal Boiler 100-200 MMBtu/h	19%	0.62%
Seasonal Boiler 200+ MMBtu/h	19%	0.62%

Table 56, Table 58, and Table 60 present the projected process boilers new construction that the proposed stack economizer, automatic blowdown, and deaerator code changes would respectively impact in 2029. Table 57, Table 59, and Table 61 show the projected existing statewide boiler stock that the proposed stack economizer, automatic blowdown, and deaerator code change would respectively affect through alterations in 2029. The Statewide CASE Team developed these estimates using the methods described in this section.

The 2028 CASE Methodology Report includes additional information about the methodology and assumptions used to calculate statewide energy impacts.

Table 56: Estimated New Process Boiler Capacity Impacted by Proposed Stack Economizer Code Change in 2029, by Climate Zone, Boiler Capacity and Year-Round vs. Seasonal Operation (Million Btu/h)

Boiler Capacity Bin	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Year-Round Boiler 10-15 MMBtu/h	0.13	1.55	8.88	4.08	1.12	6.97	4.61	9.76	12.12	9.39	1.96	14.97	10.65	1.72	1.50	0.63	90.05
Year-Round Boiler 15-25 MMBtu/h	0.00	1.28	7.53	3.41	1.34	7.55	2.56	10.76	13.21	9.22	1.53	16.75	16.64	2.88	2.30	1.03	98.01
Year-Round Boiler 25-50 MMBtu/h	0.59	1.40	8.35	4.15	1.77	7.97	2.86	8.15	11.99	7.39	1.67	21.67	17.91	2.77	1.12	1.11	100.85
Year-Round Boiler 50-100 MMBtu/h	0.00	0.79	12.68	2.22	0.57	1.18	1.17	1.89	2.16	1.95	0.82	68.88	102.44	2.22	0.89	0.40	200.26
Year-Round Boiler 100-200 MMBtu/h	0.00	1.36	7.58	3.54	0.00	1.97	0.00	2.79	3.68	2.09	1.38	22.45	18.50	4.59	1.29	1.03	72.23
Year-Round Boiler 200+ MMBtu/h	0.31	0.20	0.95	0.51	0.00	1.50	0.00	2.99	3.42	2.24	2.09	0.94	0.29	1.10	0.64	0.27	17.45
Seasonal Boiler 10-15 MMBtu/h	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.02	0.01	0.00	0.00	0.00	0.12
Seasonal Boiler 15-25 MMBtu/h	0.00	0.00	0.02	0.01	0.00	0.02	0.01	0.02	0.03	0.02	0.00	0.03	0.03	0.01	0.00	0.00	0.20
Seasonal Boiler 25-50 MMBtu/h	0.00	0.01	0.05	0.02	0.01	0.05	0.02	0.05	0.07	0.04	0.01	0.13	0.10	0.02	0.01	0.01	0.59
Seasonal Boiler 50-100 MMBtu/h	0.00	0.01	0.20	0.04	0.01	0.02	0.02	0.03	0.03	0.03	0.01	1.10	1.63	0.04	0.01	0.01	3.19
Seasonal Boiler 100-200 MMBtu/h	0.00	0.16	0.91	0.43	0.00	0.24	0.00	0.34	0.44	0.25	0.17	2.70	2.22	0.55	0.15	0.12	8.68
Seasonal Boiler 200+ MMBtu/h	0.04	0.02	0.12	0.06	0.00	0.19	0.00	0.38	0.43	0.28	0.26	0.12	0.04	0.14	0.08	0.03	2.19
TOTAL	**1.07**	**6.79**	**47.27**	**18.48**	**4.82**	**27.65**	**11.24**	**37.17**	**47.60**	**32.93**	**9.92**	**149.75**	**170.48**	**16.03**	**8.01**	**4.64**	**593.85**

Table 57: Estimated Existing Process Boiler Capacity Impacted by Proposed Stack Economizer Code Change in 2029 (Alterations), by Climate Zone and Boiler Capacity and Year-Round vs. Seasonal Operation (Million Btu/h)

Boiler Capacity Bin	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Year-Round Boiler 10-15 MMBtu/h	0.21	2.51	14.32	6.58	1.81	11.24	7.43	15.74	19.54	15.14	3.16	24.14	17.18	2.77	2.42	1.02	145.19
Year-Round Boiler 15-25 MMBtu/h	0.00	2.07	12.13	5.50	2.16	12.18	4.13	17.35	21.30	14.87	2.47	27.01	26.82	4.65	3.72	1.66	158.02
Year-Round Boiler 25-50 MMBtu/h	1.18	2.82	16.82	8.37	3.56	16.05	5.76	16.42	24.17	14.90	3.37	43.67	36.09	5.59	2.25	2.23	203.25
Year-Round Boiler 50-100 MMBtu/h	0.00	1.59	25.56	4.47	1.14	2.38	2.36	3.81	4.36	3.92	1.66	138.81	206.44	4.48	1.80	0.81	403.60
Year-Round Boiler 100-200 MMBtu/h	0.00	2.74	15.27	7.13	0.00	3.96	0.00	5.63	7.41	4.22	2.78	45.24	37.28	9.25	2.59	2.07	145.57
Year-Round Boiler 200+ MMBtu/h	0.63	0.40	1.91	1.03	0.00	3.01	0.00	6.03	6.89	4.52	4.22	1.90	0.59	2.21	1.29	0.54	35.17
Seasonal Boiler 10-15 MMBtu/h	0.00	0.01	0.07	0.03	0.01	0.06	0.04	0.08	0.10	0.07	0.02	0.12	0.08	0.01	0.01	0.01	0.71
Seasonal Boiler 15-25 MMBtu/h	0.00	0.02	0.09	0.04	0.02	0.09	0.03	0.13	0.16	0.11	0.02	0.20	0.20	0.03	0.03	0.01	1.18
Seasonal Boiler 25-50 MMBtu/h	0.02	0.06	0.35	0.17	0.07	0.34	0.12	0.34	0.51	0.31	0.07	0.91	0.75	0.12	0.05	0.05	4.25
Seasonal Boiler 50-100 MMBtu/h	0.00	0.09	1.47	0.26	0.07	0.14	0.14	0.22	0.25	0.22	0.09	7.96	11.83	0.26	0.10	0.05	23.13
Seasonal Boiler 100-200 MMBtu/h	0.00	1.19	6.60	3.08	0.00	1.71	0.00	2.43	3.20	1.82	1.20	19.55	16.11	4.00	1.12	0.89	62.92
Seasonal Boiler 200+ MMBtu/h	0.29	0.18	0.86	0.47	0.00	1.36	0.00	2.72	3.11	2.04	1.90	0.86	0.27	1.00	0.58	0.24	15.88
TOTAL	**2.33**	**13.66**	**95.46**	**37.14**	**8.84**	**52.51**	**20.00**	**70.90**	**90.99**	**62.16**	**20.97**	**310.36**	**353.66**	**34.35**	**15.96**	**9.59**	**1,198.88**

Table 58: Estimated New Process Boiler Capacity Impacted by Automatic Blowdown Code Change in 2029, by Climate Zone, Boiler Capacity, and Year-Round vs. Seasonal Operation (Million Btu/h)

Boiler Capacity Bin	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Year-Round Boiler 10-15 MMBtu/h	0.13	1.64	9.37	4.31	1.19	7.36	4.86	10.30	12.79	9.91	2.07	15.80	11.25	1.81	1.59	0.67	95.06
Year-Round Boiler 15-25 MMBtu/h	0.00	1.33	7.79	3.53	1.39	7.82	2.65	11.14	13.67	9.55	1.59	17.34	17.22	2.98	2.39	1.07	101.46
Year-Round Boiler 25-50 MMBtu/h	0.65	1.54	9.18	4.57	1.94	8.76	3.14	8.96	13.19	8.13	1.84	23.83	19.70	3.05	1.23	1.22	110.94
Year-Round Boiler 50-100 MMBtu/h	0.00	0.72	11.56	2.02	0.52	1.07	1.07	1.72	1.97	1.77	0.75	62.78	93.36	2.03	0.82	0.37	182.52
Year-Round Boiler 100-200 MMBtu/h	0.00	1.21	6.71	3.13	0.00	1.74	0.00	2.47	3.26	1.85	1.22	19.87	16.38	4.06	1.14	0.91	63.96
Year-Round Boiler 200+ MMBtu/h	0.79	0.49	2.38	1.28	0.00	3.74	0.00	7.49	8.56	5.62	5.24	2.36	0.74	2.74	1.60	0.67	43.69
Seasonal Boiler 10-15 MMBtu/h	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.02	0.02	0.00	0.00	0.00	0.13
Seasonal Boiler 15-25 MMBtu/h	0.00	0.00	0.02	0.01	0.00	0.02	0.01	0.02	0.03	0.02	0.00	0.04	0.04	0.01	0.00	0.00	0.21
Seasonal Boiler 25-50 MMBtu/h	0.00	0.01	0.05	0.03	0.01	0.05	0.02	0.05	0.08	0.05	0.01	0.14	0.11	0.02	0.01	0.01	0.64
Seasonal Boiler 50-100 MMBtu/h	0.00	0.01	0.18	0.03	0.01	0.02	0.02	0.03	0.03	0.03	0.01	1.00	1.48	0.03	0.01	0.01	2.90
Seasonal Boiler 100-200 MMBtu/h	0.00	0.14	0.78	0.36	0.00	0.20	0.00	0.29	0.38	0.22	0.14	2.31	1.90	0.47	0.13	0.11	7.43
Seasonal Boiler 200+ MMBtu/h	0.08	0.05	0.23	0.12	0.00	0.37	0.00	0.73	0.83	0.55	0.51	0.23	0.07	0.27	0.16	0.07	4.26
TOTAL	**1.65**	**7.13**	**48.27**	**19.41**	**5.06**	**31.16**	**11.77**	**43.23**	**54.81**	**37.71**	**13.39**	**145.72**	**162.27**	**17.47**	**9.07**	**5.09**	**613.20**

Table 59: Estimated Existing Process Boiler Capacity Impacted by Automatic Blowdown Code Change in 2029, by Climate Zone, Boiler Capacity, and Year-Round vs. Seasonal Operation (Million Btu/h)

Boiler Capacity Bin	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Year-Round Boiler 10-15 MMBtu/h	0.27	3.31	18.89	8.69	2.39	14.83	9.80	20.76	25.78	19.98	4.17	31.85	22.66	3.65	3.20	1.35	191.57
Year-Round Boiler 15-25 MMBtu/h	0.00	2.68	15.70	7.12	2.80	15.76	5.34	22.45	27.56	19.24	3.20	34.95	34.71	6.01	4.81	2.15	204.48
Year-Round Boiler 25-50 MMBtu/h	1.30	3.10	18.51	9.20	3.91	17.66	6.34	18.06	26.59	16.39	3.71	48.03	39.70	6.14	2.48	2.46	223.58
Year-Round Boiler 50-100 MMBtu/h	0.00	1.45	23.29	4.07	1.04	2.16	2.15	3.48	3.97	3.57	1.51	126.52	188.16	4.08	1.64	0.74	367.84
Year-Round Boiler 100-200 MMBtu/h	0.00	2.43	13.52	6.31	0.00	3.51	0.00	4.98	6.56	3.74	2.46	40.05	33.01	8.19	2.29	1.83	128.89
Year-Round Boiler 200+ MMBtu/h	1.59	0.99	4.79	2.58	0.00	7.55	0.00	15.09	17.25	11.32	10.56	4.76	1.48	5.53	3.22	1.34	88.06
Seasonal Boiler 10-15 MMBtu/h	0.00	0.02	0.09	0.04	0.01	0.07	0.05	0.10	0.13	0.10	0.02	0.16	0.11	0.02	0.02	0.01	0.94
Seasonal Boiler 15-25 MMBtu/h	0.00	0.02	0.12	0.05	0.02	0.12	0.04	0.17	0.21	0.14	0.02	0.26	0.26	0.04	0.04	0.02	1.53
Seasonal Boiler 25-50 MMBtu/h	0.03	0.06	0.38	0.19	0.08	0.36	0.13	0.37	0.55	0.34	0.08	0.99	0.82	0.13	0.05	0.05	4.60
Seasonal Boiler 50-100 MMBtu/h	0.00	0.08	1.33	0.23	0.06	0.12	0.12	0.20	0.23	0.20	0.09	7.23	10.76	0.23	0.09	0.04	21.03
Seasonal Boiler 100-200 MMBtu/h	0.00	1.01	5.65	2.64	0.00	1.47	0.00	2.08	2.74	1.56	1.03	16.73	13.79	3.42	0.96	0.77	53.83
Seasonal Boiler 200+ MMBtu/h	0.56	0.35	1.68	0.90	0.00	2.65	0.00	5.29	6.05	3.97	3.70	1.67	0.52	1.94	1.13	0.47	30.87
Total	**3.74**	**15.49**	**103.95**	**42.04**	**10.31**	**66.25**	**23.97**	**93.04**	**117.60**	**80.55**	**30.55**	**313.19**	**345.97**	**39.39**	**19.93**	**11.23**	**1,317.22**

Table 60: Estimated New Process Boiler Capacity Impacted by Proposed Deaerator Pressure Code Change in 2029, by Climate Zone, Boiler Capacity, and Year-Round vs. Seasonal Operation (Million Btu/h)

Boiler Capacity Bin	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Year-Round Boiler 10-15 MMBtu/h	0.03	0.43	2.43	1.12	0.31	1.91	1.26	2.68	3.32	2.57	0.54	4.10	2.92	0.47	0.41	0.17	24.68
Year-Round Boiler 15-25 MMBtu/h	0.00	0.38	2.21	1.00	0.39	2.22	0.75	3.17	3.89	2.71	0.45	4.93	4.89	0.85	0.68	0.30	28.83
Year-Round Boiler 25-50 MMBtu/h	0.20	0.49	2.90	1.44	0.61	2.77	0.99	2.83	4.17	2.57	0.58	7.54	6.23	0.96	0.39	0.39	35.08
Year-Round Boiler 50-100 MMBtu/h	0.00	0.30	4.75	0.83	0.21	0.44	0.44	0.71	0.81	0.73	0.31	25.81	38.38	0.83	0.34	0.15	75.04
Year-Round Boiler 100-200 MMBtu/h	0.00	0.58	3.22	1.51	0.00	0.84	0.00	1.19	1.56	0.89	0.59	9.55	7.87	1.95	0.55	0.44	30.73
Year-Round Boiler 200+ MMBtu/h	0.83	0.52	2.51	1.35	0.00	3.96	0.00	7.92	9.05	5.94	5.54	2.50	0.78	2.90	1.69	0.71	46.19
Seasonal Boiler 10-15 MMBtu/h	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.02	0.01	0.00	0.00	0.00	0.12
Seasonal Boiler 15-25 MMBtu/h	0.00	0.00	0.02	0.01	0.00	0.02	0.01	0.02	0.03	0.02	0.00	0.04	0.04	0.01	0.01	0.00	0.22
Seasonal Boiler 25-50 MMBtu/h	0.00	0.01	0.06	0.03	0.01	0.06	0.02	0.06	0.09	0.05	0.01	0.16	0.13	0.02	0.01	0.01	0.72
Seasonal Boiler 50-100 MMBtu/h	0.00	0.02	0.27	0.05	0.01	0.03	0.03	0.04	0.05	0.04	0.02	1.48	2.19	0.05	0.02	0.01	4.29
Seasonal Boiler 100-200 MMBtu/h	0.00	0.24	1.35	0.63	0.00	0.35	0.00	0.50	0.65	0.37	0.25	3.99	3.29	0.82	0.23	0.18	12.83
Seasonal Boiler 200+ MMBtu/h	0.29	0.18	0.88	0.47	0.00	1.39	0.00	2.78	3.17	2.08	1.94	0.87	0.27	1.02	0.59	0.25	16.19
TOTAL	**1.37**	**3.14**	**20.63**	**8.45**	**1.56**	**13.99**	**3.51**	**21.90**	**26.80**	**18.00**	**10.23**	**60.97**	**67.01**	**9.88**	**4.90**	**2.61**	**274.94**

Table 61: Estimated Existing Boiler Capacity Impacted by Proposed Deaerator Pressure Code Change in 2029, by Climate Zone, Boiler Capacity, and Year-Round vs. Seasonal Operation (Million Btu/h)

Boiler Capacity Bin	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Year-Round Boiler 10-15 MMBtu/h	0.07	0.86	4.91	2.26	0.62	3.85	2.54	5.39	6.69	5.19	1.08	8.27	5.88	0.95	0.83	0.35	49.74
Year-Round Boiler 15-25 MMBtu/h	0.00	0.76	4.46	2.02	0.79	4.48	1.52	6.38	7.83	5.47	0.91	9.93	9.86	1.71	1.37	0.61	58.11
Year-Round Boiler 25-50 MMBtu/h	0.41	0.98	5.85	2.91	1.24	5.58	2.00	5.71	8.41	5.18	1.17	15.19	12.55	1.94	0.78	0.78	70.70
Year-Round Boiler 50-100 MMBtu/h	0.00	0.59	9.58	1.67	0.43	0.89	0.88	1.43	1.63	1.47	0.62	52.01	77.35	1.68	0.68	0.30	151.22
Year-Round Boiler 100-200 MMBtu/h	0.00	1.17	6.50	3.03	0.00	1.69	0.00	2.39	3.15	1.80	1.18	19.25	15.86	3.93	1.10	0.88	61.94
Year-Round Boiler 200+ MMBtu/h	1.68	1.05	5.07	2.73	0.00	7.98	0.00	15.95	18.23	11.97	11.17	5.03	1.57	5.85	3.40	1.42	93.09
Seasonal Boiler 10-15 MMBtu/h	0.00	0.00	0.02	0.01	0.00	0.02	0.01	0.03	0.03	0.03	0.01	0.04	0.03	0.00	0.00	0.00	0.24
Seasonal Boiler 15-25 MMBtu/h	0.00	0.01	0.03	0.02	0.01	0.03	0.01	0.05	0.06	0.04	0.01	0.07	0.07	0.01	0.01	0.00	0.43
Seasonal Boiler 25-50 MMBtu/h	0.01	0.02	0.12	0.06	0.03	0.11	0.04	0.12	0.17	0.11	0.02	0.31	0.26	0.04	0.02	0.02	1.46
Seasonal Boiler 50-100 MMBtu/h	0.00	0.03	0.55	0.10	0.02	0.05	0.05	0.08	0.09	0.08	0.04	2.97	4.42	0.10	0.04	0.02	8.65
Seasonal Boiler 100-200 MMBtu/h	0.00	0.49	2.71	1.27	0.00	0.70	0.00	1.00	1.32	0.75	0.49	8.04	6.62	1.64	0.46	0.37	25.87
Seasonal Boiler 200+ MMBtu/h	0.59	0.37	1.78	0.96	0.00	2.80	0.00	5.59	6.39	4.19	3.91	1.76	0.55	2.05	1.19	0.50	32.63
TOTAL	**2.75**	**6.33**	**41.57**	**17.03**	**3.14**	**28.19**	**7.07**	**44.13**	**54.02**	**36.27**	**20.62**	**122.88**	**135.04**	**19.91**	**9.88**	**5.25**	**554.08**

Appendix D: Environmental Analysis

Stack Economizer

Potential Significant Environmental Effect of Proposal

The Statewide CASE Team has considered the environmental benefits and adverse impacts of its proposal, including but not limited to an evaluation of factors contained in the California Code of Regulations, Title 14, section 15064, and has determined that the proposal will not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

Requiring the use of stack economizers will decrease the energy required to operate a boiler, which in turn reduces GHG emissions from the reduced need to produce that energy, typically by burning natural gas. The direct environmental benefits of this proposal are demonstrated by the estimated energy reductions, as discussed in Sections 2.5.1 and 2.5.2.

Direct Adverse Environmental Impacts

The Statewide CASE Team has not identified direct adverse environmental impacts.

Indirect Environmental Impacts

Indirect Environmental Benefits

The Statewide CASE Team has not identified any indirect environmental benefits.

Indirect Adverse Environmental Impacts

The Statewide CASE Team has not identified any indirect adverse environmental impacts.

Mitigation Measures

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of “specific economic, environmental, legal, social, and technological factors” (Cal. Code Regs., tit. 14, § 15021). The Statewide CASE Team did not determine this measure would result in significant direct or indirect adverse environmental impacts and therefore did not develop any mitigation measures.

Reasonable Alternatives to Proposal

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternate proposals would achieve the same impact of reduced energy consumption from process boilers.

Water Use and Water Quality Impacts Methodology

The Statewide CASE Team has not identified any impacts to water quality or water use that would result from adopting the proposed changes.

Automatic Blowdown and Deaerator Pressure

Potential Significant Environmental Effect of Proposal

The Statewide CASE Team considered the environmental benefits and adverse impacts of its proposal, including but not limited to an evaluation of factors contained in the California Code of Regulations, Title 14, section 15064, and determined that the proposal will not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

Requiring the use of automatic blowdown systems avoids releasing more water than is necessary, as commonly occurs with manual blowdowns. This practice saves energy by reducing the need to heat make-up water.

Higher deaerator pressure setpoints lead to a higher boiling point of water, and thus an increased amount of energy is needed to boil the water. As such, unnecessarily high steam supply line header setpoints, which feed the deaerator, will result in unnecessary consumption of energy. The proposed code change would ensure that steam supply line header setpoints are not unnecessarily high.

The data demonstrating energy benefits are discussed in section 3.5.1. The data demonstrating GHG benefits are discussed in section 3.5.2. The data demonstrating water use benefits are discussed in section 3.5.3.

Direct Adverse Environmental Impacts

The Statewide CASE Team has not identified any direct adverse environmental impacts that would result from the proposed changes.

Indirect Environmental Impacts

Indirect Environmental Benefits

Automatic blowdown controls can reduce fouling and extend system lifetimes, while also reducing wastewater by avoiding purging more water than is necessary. Deaerator controls can also extend system lifetimes by reducing oxygen pitting and corrosion. Reducing fouling and corrosion will also reduce the need for water treatment chemicals intended to protect equipment from these impacts. Making equipment replacement more infrequent would reduce the embodied carbon emissions produced during the manufacture and transportation of the equipment.

The reduced energy consumption from these measures will also indirectly lead to improvements in local air quality. Combustion of natural gas produces NOx, a chemical precursor to ozone. Reducing the consumption of natural gas will therefore indirectly lead to reduced ozone (Environmental Defense Fund 2025).

Indirect Adverse Environmental Impacts

The Statewide CASE Team has not identified any indirect adverse environmental impacts.

Mitigation Measures

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of "specific economic, environmental, legal, social, and technological factors" (Cal. Code Regs., tit. 14, § 15021). The Statewide CASE Team did not determine this measure would result in significant direct or indirect adverse environmental impacts and therefore did not develop any mitigation measures.

Reasonable Alternatives to Proposal

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternate proposals would achieve the same impact of reduced boiler energy consumption.

Water Use and Water Quality Impacts Methodology

Reducing excessive blowdown and avoiding unnecessary steam venting due to deaerator over-pressurization will reduce water consumption by reducing the amount of water that needs to be replaced in the boiler system. The quantity of water saved will vary depending on a site's practices in the absence of the proposed requirements.

Appendix E: Summary of Stakeholder Engagement

Introduction to Stakeholder Engagement

Collaborating with stakeholders who may be affected by proposed code changes is a core component of the Statewide CASE Team's process. The Statewide CASE Team engages interested parties to identify and address issues related to the proposals, with the goal of submitting recommendations to the CEC in this Draft CASE Report that reflect broad support. Public stakeholders provide valuable feedback on draft analyses and help identify and address adoption challenges, including cost effectiveness, market and technical barriers, compliance and enforcement, and potential impacts on human health or the environment. Some stakeholders also provide data that the Statewide CASE Team uses to support analyses.

This appendix summarizes the stakeholder engagement conducted by the Statewide CASE Team during the development and refinement of the report's recommendations.

Stack Economizer and Automatic Blowdown and Deaerator Pressure

Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2025 code cycle. The goal of these meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To promote transparency in the development of code change proposals, the Statewide CASE Team uses stakeholder meetings to solicit feedback on the following:

- Proposed code changes,
- Draft code language,
- Draft assumptions and results of analyses,
- Data to support assumptions,
- Compliance and enforcement, and
- Technical and market feasibility.

The Statewide CASE Team hosted one stakeholder meeting for the proposed process boilers measures via webinar, as described in Table 62. Dates and links to event pages are listed and updated at Title24Stakeholders.com. Materials from each meeting, such as slide presentations, proposal summaries with code language, and meeting notes, are included in the bibliography section of this report. (CA Statewide Utility Codes and Standards Team 2025)

Table 62: Utility-Sponsored Stakeholder Meetings

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of Process Boiler Utility-Sponsored Stakeholder Meeting	Tuesday, September 23, 2025	Appendix A: Proposal description Appendix B: Market and technical considerations Appendix C: Energy savings methodology and cost assumptions Appendix D: Compliance verification
Second Round of Process Boiler Utility-Sponsored Stakeholder Meeting	Tuesday, February 17, 2026	Appendix E: Stack oxygen concentration public comments and proposed changes Appendix F: Stack economizer measure assumptions Appendix G: Blowdown measure assumptions Appendix H: Deaerator measure assumptions

The first round of utility-sponsored stakeholder meetings began in September 2025 and served as an early forum to promote transparency and gather stakeholder feedback on measures under consideration by the Statewide CASE Team.

The objectives of the first round of stakeholder meetings were to solicit input on the scope of the 2025 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers. Initial draft code language was posted on Title24Stakeholders.com for public stakeholder review.

The second round of utility-sponsored stakeholder meetings will be held on February 17, 2026 to provide updated details on proposed code changes. These meetings will introduce and solicit feedback on early results of energy savings, market adoption, and incremental cost analyses.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com. One email was sent to the full Title 24 Stakeholders listserv, which includes over 3,000 individuals. A second email targeted specific recipients based on their subscription preferences.

The Title 24 Stakeholders listserv is an opt-in service comprising participants from a diverse industries and trades, such as manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was announced on the Title 24 Stakeholders LinkedIn page and cross-promoted on the CEC LinkedIn page approximately two weeks in advance to engage individuals, organizations, and broader channels outside beyond the listserv. The Statewide CASE Team conducted extensive personal outreach to stakeholders identified in initial work plans who had not yet opted in to the listserv. Exported webinar meeting data captured attendance numbers, individual comments, and results from live attendee polls to help evaluate stakeholder participation and support.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders when developing this report, listed in Table 63. Most stakeholders preferred to be anonymous.

Table 63. Engaged Stakeholders

Organization Name	Market Role	Mentioned in CASE Report Sections
Anonymous Stakeholder 1	Boiler systems manufacturer	2.1.2 Benefits of Proposed Change 2.3.1.1 Current Market Structure and Availability 2.4.3 Incremental First Cost 2.4.5 Cost Effectiveness 2.5.1 Statewide Energy and Energy Costs Savings 3.1.1.1 Current Market Structure and Availability 3.4.3 Incremental First Cost 3.5.1 Statewide Energy Costs and Savings Appendix C: Assumptions for Statewide Savings Estimates
Anonymous Stakeholder 2	Boiler systems manufacturer	2.1.2 Benefits of Proposed Change 2.3.1.1 Current Market Structure and Availability 3.3.1.1 Current Market Share and Structure Availability 3.5.1 Statewide Energy Costs and Savings Appendix C: Assumptions for Statewide Savings
Anonymous Stakeholder 3	Boiler and stack economizer representative	2.3.1.1 Current Market Structure and Availability 3.1.1.1 Current Market Structure and Availability 3.5.1 Statewide Energy Costs and Savings Appendix C: Assumptions for Statewide Savings Estimates
Anonymous Stakeholder 4	Boiler servicer (maintenance and installation)	Did not inform specific assumptions.
Anonymous Stakeholder 5	Stack economizer and stack heat recovery equipment manufacturer	Did not inform specific assumptions.

Anonymous Stakeholder 6	Boiler servicer (maintenance and installation)	Did not inform specific assumptions.
Anonymous Stakeholder 7	Industrial energy benchmarking representative	Did not inform specific assumptions.
California Air Resources Board	Regulator	Did not inform specific assumptions.
Beacon Economics	Economic research and consulting firm	Appendix C: Assumptions for Statewide Savings Estimates

Engagement with ESJ communities

The Statewide CASE Team did not conduct stakeholder outreach specifically targeted towards ESJ communities for this proposed code change. The proposed measures would have no direct impact on residential communities in California, and the only indirect anticipated impact is decreased exposure to air pollution due to reduced natural gas combustion at nearby industrial facilities.

Mass Email Cold Outreach

The Statewide CASE Team leveraged a list of organizations and emails from the California Directory of Manufacturers to send cold outreach email to about 600 organizations believed to have process boilers. The email invited respondents to participate in a conversational interview about or otherwise provide feedback on the proposed measures. Many of the email addresses were outdated at the time of sending, and the Statewide CASE Team did not receive responses from any stakeholders who wished to contribute to the process.