Codes and Standards Enhancement (CASE) Initiative

2025 California Energy Code

Cooling Towers CASE Report

Number: 25-NR-HVAC-COOLINGTOWER-F
Nonresidential HVAC

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Energy 350

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Draft CASE Report

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Executive Summary

This is a draft report. The Statewide CASE Team encourages readers to provide comments on the proposed code changes and the analyses presented in this draft report. When possible, provide supporting data and justifications in addition to comments. Suggested revisions will be considered when refining proposals and analyses. The Final CASE Report will be submitted to the California Energy Commission in summer 2023. For this report, the Statewide CASE Team is requesting input on the following:

1. *Input on estimated costs.*
2. *Information on the baseline HVAC system type for buildings requiring greater than 300 tons of cooling capacity.*
3. *Data on high efficiency air-cooled chiller performance, i.e., rated efficiencies and performance curves.*
4. *Data on baseline cycles of concentration in California.*
5. *Information on the appropriateness of the Langelier Saturation Index (LSI) as the sole parameter for determining achievable cycles of concentration and/or the need for additional water quality control parameters.*
6. *Feedback on the cost and impacts of the proposed acceptance test for cooling tower blowdown controls and overflow alarms, as well as compliance rates with the current requirements.*

*Email comments and suggestions to Bryan Boyce (*bboyce@energy-solution.com) and info@title24stakeholders.com *by Tuesday, May 30. Comments will not be released for public review or will be anonymized if shared.*

Introduction

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support the California Energy Commission's (CEC's) efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. Three California Investor-Owned Utilities (IOUs) — Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities — Los Angeles Department of Water and Power, and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) — sponsored this effort. The program goal is to prepare and submit proposals that would result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposals presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the CEC, the state agency that has authority to adopt revisions to Title 24, Part 6. The CEC will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The CEC may revise or reject proposals. See the CEC's 2025 Title 24 website for information about the rulemaking schedule and how to participate in the process: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

The Statewide CASE Team gathered input from stakeholders to inform the proposal and associated analyses and justifications. Stakeholders also provided input on the code compliance and enforcement process. Stakeholder input comprised of two utility sponsored stakeholder meetings (October 25, 2022, and February 13, 2023) and 6 individual meetings with interested stakeholders. Additionally, the Statewide CASE Team engaged via email with stakeholders as follow up to the February 13th, 2023 stakeholder meeting. Engaged stakeholders included cooling tower manufacturers, chiller manufacturers, water efficiency experts, national laboratories, cooling tower water treatment experts, and design engineers. These stakeholders provided valuable input on cooling tower and chiller costs and efficiency as well as feedback on the feasibility and market effects of the proposal. The Statewide CASE Team looks forward to continued engagement with stakeholders as this Draft CASE Report is finalized.

See Appendix F for a summary of stakeholder engagement.

The goal of this CASE Report is to present a cost-effective code change proposal for cooling towers. The report contains pertinent information supporting the code change.

The following sections provide an overview of the three cooling tower measures considered in this CASE Report:

- **Cooling Tower Efficiency:** Updating the prescriptive minimum efficiency requirements in Sections 140.4(h)5 and 170.2(c)4Fv for axial, open-circuit cooling towers serving condenser water loops of 900 gallons per minute (gpm) or greater. This section currently requires cooling towers to meet ≥ 60 gpm/hp with an exception for Climate Zones 1 and 16, which are required to meet the mandatory minimum of 42.1 gpm/hp. The proposed requirement would add a table of climate-zone specific values determined by cost effectiveness, ranging from the current mandatory efficiency of 42.1 gpm/hp to 120 gpm/hp. The measure would increase the minimum requirement to 100 gpm/hp in Climate Zones 6, 7, 9, 11, and 12, and to 120 gpm/hp in Climate Zones 8, 10, and 15, and also eliminate an exception for Climate Zones 1 and 16, which is made redundant by the introduction of the table of requirements.

- **Air-Cooled Chiller Threshold:** Adding an exception to the prescriptive requirements in Sections 140.4(j) and 170.2(c)4H limiting air-cooled chillers to 300 tons of cooling capacity for air-cooled chillers that meet certain efficiency criteria. This measure would also add an exception for air-to-water heat pumps and heat recovery chillers; and
- **Blowdown Controls:** Strengthening the mandatory blow-down control requirements of 110.2(e) through improved compliance documentation and the addition of an acceptance test.

Proposal Description

Proposed Code Change

Cooling Tower Efficiency

This measure proposes an increase of the prescriptive requirement for efficiency of axial fan, open-circuit cooling towers in condenser water systems of 900 gallons per minute (gpm) or greater established in 140.4(h)5 and 170.2(c)4Fv. This measure would apply to nonresidential and multifamily new construction and new systems serving additions. This measure also impacts alterations, except where the equipment is being mounted to an existing building.

The current 2022 Title 24, Part 6 Standards' prescriptive minimum efficiency for axial fan cooling towers is 60 gallons per minute per horsepower (gpm/hp). The intent of this proposal is to update the prescriptive efficiency requirement from the statewide minimum of 60 gpm/hp (with the exception of Climate Zones 1 and 16, which are exempted) to climate zone specific values, increasing the requirement where cost effective. The code change would be implemented by introducing a table, shown in Table 1, that establishes climate zone specific minimum efficiencies based on cost effectiveness, ranging from the current mandatory efficiency of 42.1 gpm/hp for Climate Zones 1 and 16, to 120 gpm/hp for Climate Zones 8, 10, and 15. The proposed code change applies to cooling towers in condenser water systems serving condenser water loops of 900 gpm or greater. The proposed code change does not recommend modifications to the existing mandatory minimum efficiency requirements.

Table 1: Proposed Cooling Tower Efficiencies by Climate Zone

Equipment Type	Prescriptive Minimum Efficiency (gpm/hp)															
	Climate Zone															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Propeller or axial fan	42.1	60	60	60	60	100	100	120	100	120	100	100	60	60	120	42.1

Open-circuit cooling towers																	

Though not included in the Draft CASE Report, the Statewide CASE Team is also examining whether setting higher efficiency requirements for cooling towers that are part of chilled water systems with water-side economizers might be warranted. The CASE Team welcomes all stakeholder input and feedback pertaining to this system type.

The proposal recommends using the existing test procedure and rating conditions to evaluate cooling tower efficiency, which are listed in Title 24, Part 6, Table 110.2-F Performance Requirements for Heat Rejection Equipment. The test procedures identified are the Cooling Technology Institute's (CTI) standards, CTI ATC-105 and CTI STD-201 RS, which require cooling tower efficiency ratings under the standardized conditions of 95°F entering water temperature, 85°F leaving water temperature, and 75°F entering air wet-bulb temperature.

Replacement towers (alterations) are exempted if they are building-mounted but would have to meet the existing mandatory efficiency requirements in Section 110.2. Replacement towers (alterations) that do not meet the building-mounted exemption would be required to comply with the prescriptive efficiency requirements.

Air-Cooled Chiller Threshold

This measure proposes adding an exception to the prescriptive requirement in Title 24, Part 6 140.4(j) and 170.2(c)4H which currently limits air-cooled chillers to providing no more than 300 tons of cooling capacity. The exception would allow for air-cooled chillers in excess of this 300-ton capacity for high efficiency air-cooled chillers that meet certain efficiency requirements. This measure would apply to nonresidential and multifamily new construction and new systems serving additions. Alterations are not expected to be impacted due to the nature of design and selection of chiller type and supplementary equipment.

Projects are exempted from the current requirement at sites where the water quality fails to meet manufacturer's requirements for the use of water-cooled chillers, for chillers that are used to charge a thermal storage system with a design temperature of less than 40°F, and for systems serving healthcare facilities. These current exemptions would be maintained.

This measure also proposes adding an exception for heating-only air-to-water heat pumps and a limited exception for chillers using heat recovery. The current language arguably does not apply to heating-only air-to-water heat pumps as it specifically references chilled water plants, but the proposed exception would clarify this current ambiguity. The exception for chillers with heat recovery would allow for air-cooled chillers in excess of the 300-ton threshold where the difference in cooling capacity and recovered heat capacity is no more than 300 tons per plant.

The primary focus of the analysis of this measure is on the exception for high-efficiency chillers which has a more direct impact on both on-site and statewide energy use, and considerations for cost effectiveness must be examined.

Blowdown Controls

This measure would update the mandatory language in Section 110.2(e) which currently requires all open- and closed-circuit cooling towers 150 tons and larger to:

- Be equipped with either conductivity or flow-based controls that automate system bleed and chemical feed in order to maximize cycles of concentration and reduce cooling tower blowdown.
- Be equipped with a makeup water flow meter and overflow alarm that alerts to a makeup water valve failure.
- Have efficient drift eliminators installed.
- Document the maximum achievable cycles of concentration achievable given local water quality conditions and a Langelier Saturation Index (LSI) of 2.5 or less.

The proposed measure would revise Section 110.2(e) and associated cycles of concentration compliance document as follows:

- Require the use of conductivity-based controls (eliminate the option to use flow-based controls).
- Update the NRCC-MCH-E compliance document to require the designer to maximize cycles of concentration. While this is currently required by Section 110.2(e), the current NRCC-MCH-E form will pass any cycles of concentration that achieves an LSI of 2.5 or less.
- Add thresholds for silica and other recirculating water properties in line with ANSI/ASHRAE Standard 189.1-2020.
- Add an acceptance test to verify installation and programming of controls to achieve documented cycles of concentration and overflow alarms.

Section 110.2(e) currently applies to both new construction, additions, and alterations in both nonresidential and multifamily buildings, and this would remain the same with the proposed changes. Since this is a mandatory measure, it would not affect the compliance software.

Justification

Cooling towers in nonresidential and multifamily buildings represent a significant opportunity to reduce energy and water use in California. Cooling towers account for an estimated 20 to 40 percent of water demand in buildings that include water-cooled chillers (Tomberlin, Dean and Deru, Continuous Monitoring and Partial Water Softening for Cooling Tower Water Treatment 2020) (U.S. Department of Energy 2016). In recent years, water consumption has come to the forefront of concerns in the state of California. According to the State of California Water Year 2021 report, the water year ending September 30, 2021 was the second driest year on record based on statewide runoff, following 2020 which was the fifth driest year (California Department of Water Resources 2021). As such, methods for achieving water savings in California are of prime importance.

Title 24 Part 6 has included updated requirements for cooling towers previously in 2005, 2013, and 2019. The three measures under consideration in this CASE Report build upon and update these current requirements.

The air-cooled chiller threshold was originally set in 2005 and was based on the available efficiencies of air and water-cooled systems at the time. Water-cooled chillers are typically more energy efficient than air-cooled chillers, and at the time provided a cost-effective solution to achieving energy savings. Air-cooled chillers, however, provide a significant opportunity for water savings by eliminating the use of a cooling tower, the primary source of water losses in a water-cooled system resulting from losses to evaporation, blowdown, and drift. Additionally, since the threshold was adopted in 2005, air-cooled chillers have increased in efficiency, with the advancement of technologies such as oil free magnetic bearing centrifugal compressors. With these improvements, the energy penalty typically associated with air-cooled chillers can be reduced or potentially eliminated. Additionally, air-to-water heat pumps and heat recovery chillers, which were not considered in the 2005 analysis, are becoming an increasingly popular system type in all-electric construction and are currently limited in application by the 300-ton air-cooled chiller threshold.

In 2013, Title 24, Part 6 introduced requirements to limit blowdown water usage through controls aimed at maximizing achieved cycles of concentration. Blowdown and the consequent makeup water use represent a significant source of cooling tower water usage, providing the most significant opportunity for conservation according to the U.S. DOE Federal Energy Management Program (FEMP) (U.S. DOE Federal Energy Management Program n.d.). However, the benefits of the 2013 requirements have not been fully realized as the NRC-MCH-E form does not actually require the designer to maximize cycles of concentration and there is no mechanism in place to ensure that controls are programmed to achieve maximum cycles of concentration in the field. Furthermore, the allowance of flow-based controls permits sites to manage cycles of concentration without responding to actual water quality, increasing water use from towers that use flow-based controls. Stakeholders have also raised the need to be able to control based on other recirculating water parameters, such as silica.

A variety of technologies that were not considered in the original CASE Report (Statewide CASE Team 2013) have been developed to improve water quality in cooling towers since the previous CASE Report, increasing achievable cycles of concentration. These include electrolysis/ionization, ozonation, and water softening systems. These systems have demonstrated cost-effectiveness in retrofit applications and have the potential to increase cycles of concentration from typical values between two and five to cycles of concentration as high as 80 (U.S. Department of Energy 2020).[1] While these systems are not directly required by the proposed changes, they represent a further opportunity to maximize cycles of concentration and reduce blowdown.

In 2019, a prescriptive minimum efficiency of ≥80 gpm/hp was proposed for open-circuit cooling towers with axial fans. Due to the product efficiency at the time however, ultimately a prescriptive minimum efficiency of ≥60 gpm/hp was adopted for 2019 Title 24, Part 6. It has been six years since the research and analysis was performed to inform the 2019 proposal, and in the time since, cooling tower technology has advanced. The current proposal examines revising the prescriptive minimum efficiency to ≥ 100 to 120 gpm/hp based on cost effectiveness analysis in each climate zone.

Background Information

Cooling towers are used to reject heat from a condenser water system by evaporating water in an airstream. Energy used by cooling towers takes the form of energy used by the fan motor and the condenser water pumps. As a result, the metric for cooling tower efficiency consists of the gallons per minute (a metric of cooling capacity) as tested by the Cooling Technology Institute under standard conditions compared to the rated fan horsepower, in “gpm/hp.” The key technologies that result in improved cooling tower efficiencies are:

- Increased tower size to provide greater surface area of the water air interface for evaporation to occur and lower pressure drop in air stream.
- Optimized spray performance due to advances in computational and experimental research.
- Low pressure drop, high efficiency fans as characterized by induced draft axial fans.
- High efficiency motors.
- High efficiency propellers.

[1] Note that water savings typically diminish at around 7 to 10 cycles of concentration.

- High efficacy heat transfer membrane.

Cooling towers use water through evaporation, drift, and blowdown. Blowdown is the process of removing water from the cooling tower to eliminate the dissolved solids and chemicals that have accumulated during the cooling tower's operation. Removing these solids and chemicals reduces the potential for corrosion, scale, fouling, and biological growth which can reduce the lifetime and efficacy of both the cooling tower and chiller. Cycles of concentration refers to the ratio of dissolved solids or chemicals in the blowdown water compared to the makeup water; effectively how concentrated the cooling tower water is allowed to get before it is removed from the tower through blowdown. Conventional cooling water management involves the use of chemicals to manage corrosion, scale, fouling, and biological growth.

Scope of Code Change Proposal

Table 2 through Table 4 summarize the scope of the proposed changes and which sections of standards, Reference Appendices (including acceptance tests), Alternative Calculation Method (ACM) Reference Manuals, and compliance documents that would be modified as a result of the proposed change(s).

Table 2: Scope of Code Change Proposal – Cooling Tower Efficiency

Proposal Name	Cooling Tower Efficiency
Type of Requirement	Prescriptive
Applicable Climate Zones	6-12, 15
Modified Section(s) of Title 24, Part 6	140.4(h)5 and 170.2(c)4Fv
Modified Title 24, Part 6 Appendices	None
Would Compliance Software Be Modified	Yes, affects prescriptive baseline
Modified Compliance Document(s)	NRCC-MCH-E

Table 3: Scope of Code Change Proposal – Air-Cooled Chiller Threshold

Proposal Name	Air-Cooled Chiller Threshold
Type of Requirement	Prescriptive
Applicable Climate Zones	All
Modified Section(s) of Title 24, Part 6	140.4(j) and 170.2(c)4H
Modified Title 24, Part 6 Appendices	None
Would Compliance Software Be Modified	No
Modified Compliance Document(s)	None

Table 4: Scope of Code Change Proposal – Blowdown Controls

Proposal Name	Blowdown Controls
Type of Requirement	Mandatory
Applicable Climate Zones	All
Modified Section(s) of Title 24, Part 6	110.2(e)
Modified Title 24, Part 6 Appendices	Nonresidential Appendix 7 (newly proposed acceptance test)
Would Compliance Software Be Modified	No
Modified Compliance Document(s)	NRCC MCH-E

Market Analysis and Regulatory Assessment

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. Estimates of market size, incremental measure cost, and measure applicability were identified through research and outreach with stakeholders including utility program staff, CEC staff, and a wide range of industry actors.

Key market actors in the design, procurement, and operation of cooling towers include the building owner, design engineer, cooling tower manufacturers, chiller manufacturers, controls vendors, chemical and/or water treatment system vendor, distributor, HVAC contractor, and building inspector.

Cooling towers are produced by three major manufacturers: SPX Cooling Technologies Inc., Evapco Inc., and Baltimore Aircoil Company (BAC). The Cooling Technology Institute (CTI) establishes standards and certifies that equipment will perform in accordance with the published ratings. Based on data available from CTI's certification directory and directly from manufacturers' publicly available data, each of the three major manufacturers currently provides high-efficiency cooling towers that meet the requirements of the proposed code change (Cooling Technology Institute n.d.) . The data show that for cooling towers of 900 to 1,100 gpm approximately 44 percent of units available from SPX Cooling Technologies Inc., Evapco Inc., and BAC have an efficiency of 80 gpm/hp or higher, and 34 percent have an efficiency of 100 gpm/hp or higher, and 15 percent have an efficiency of 120 gpm/hp or higher. Data were collected from manufacturer engineering data documentation and software for product selection (SPX Cooling Technologies n.d., Evapco n.d., Baltimore Aircoil Company n.d.).

Chillers are produced by several major manufacturers, of which Trane, Carrier, Daikin, and York play a dominant role. Air-cooled chillers from these four manufacturers are offered in capacities ranging from 10 to 575 tons and full load efficiencies from 9.35 to 20.01 EER and 13.70 to 25.72 IPLV, with the highest efficiencies achieved by oil-free magnetic bearing centrifugal compressors followed by screw compressors. Air-cooled chiller efficiencies have improved since the 2005 Title 24, Part 6 code cycle when the 300-ton limitation was adopted, for which the Statewide CASE Team used an assumed efficiency of 2.8 COP or 9.55 EER. Water-cooled chillers from major manufacturers are available in capacities from 30 to 6,000 tons and rated full-load efficiencies from 0.49 to 0.75 kW/ton (16 to 24.5 EER), with most options significantly higher in energy efficiency and cooling capacity than air-cooled options. A review of data from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Directory of Certified Product Performance, on the number of available models from the major manufacturers (Carrier, Daikin, Trane, and York) at each capacity level showed that though water-cooled chillers are more readily available at larger capacities, sufficient air-cooled chiller models are available to exceed the existing 300-ton limitation. Additionally, engineering data from each of the major manufacturers shows at least one product line with units exceeding the proposed minimum efficiency (10.72 EER/20.1 IPLV) to qualify for an exception to the air-cooled chillers limitation.

Cooling tower controls are produced by a variety of manufacturers, including, for example, Advantage Controls, Chemtrol, Lakewood, and Walchem. The vast majority of controls available include conductivity controls.[2] The Statewide CASE Team determined the following barriers that currently inhibit the achievement of reduced cooling tower blowdown through conversations with building design engineers and cooling tower experts:

- The NRCC-MCH-E cycles of concentration compliance document does not actually require the designer to maximize cycles of concentration and instead will pass any value that results in an LSI of 2.5 or less. For example, a cycles of concentration of 1, which is equivalent to once-through-cooling, is permissible using the compliance document.
- The vast majority of designers do not specify the overflow alarm required by 2022 Title 24, Part 6 section 110.2(e).
- Stakeholders raised the need to be able to control other water quality parameters besides LSI and specifically raised the need to control for concentration of silica. Stakeholders also identified the requirements in ASHRAE/ANSI Standard 189.1-2020 which include criteria for silica and other water quality parameters.
- Cooling tower controls can fail or drift over time, reducing achieved cycles of concentration in the field. While this measure would not necessarily prevent this drift, adding an acceptance test confirms that controls are properly installed at time of building occupancy and to verify that overflow alarms are installed and functioning.

[2] The Statewide CASE Team was unable to identify a flow-only control that was capable of regulating blowdown.

The proposed changes to cooling tower requirements would likely affect commercial builders but would not impact firms that focus on construction and retrofit of industrial buildings, utility systems, public infrastructure, or other heavy construction. The effects on the residential and commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors.

Adoption of the code changes proposed would result in relatively modest economic impacts through the additional direct spending by those in the commercial building industry. The Statewide CASE Team does not anticipate that money saved by commercial building owners or other organizations affected by the proposed 2025 code cycle regulations would result in additional spending by those businesses.

Cost-Effectiveness

The proposed code changes were found to be cost-effective for all climate zones where it is proposed to be required. For the cooling tower efficiency measure, the benefit-to-cost (B/C) ratio over the 30-year period of analysis ranged between 1.02 and 1.64 depending on climate zone. For the air-cooled chiller threshold measure, the B/C ratio over the 30-year period of analysis ranged between 1.4 and 36.5 depending on climate zone. For the blowdown controls measure, the B/C ratio over the 30-year period of analysis ranged between 387 and 2,483 depending on climate zone. See more details in Sections 0, 3.4, and 4.4.[3]

California consumers and businesses would save more money on energy and water than they would spend to finance the efficiency measures. As a result, over time this proposal would leave more money available for discretionary and investment purposes once the initial cost is paid off.

See Sections 0, 3.4, and 4.4 for the methodology, assumptions, and results of the cost-effectiveness analysis.

Statewide Energy Impacts: Energy, Water, and Greenhouse Gas (GHG) Emissions, and Embodied Carbon Impacts

Table 3 presents the estimated impacts of the proposed code change that would be realized statewide during the first 12 months that proposed requirements are in effect.

First-year statewide energy impacts are represented by the following metrics: electricity savings in gigawatt-hours per year (GWh/yr), peak electrical demand reduction in megawatts (MW), natural gas savings in million therms per year (million therms/yr),

[3] The benefit-to-cost (B/C) ratio compares the benefits or cost savings to the costs over the 30-year period of analysis. Proposed code changes that have a B/C ratio of 1.0 or greater are cost effective. The larger the B/C ratio, the faster the measure pays for itself from energy cost savings.

source energy savings in millions of kilo British thermal units per year (million kBtu/yr), and lifecycle energy savings in millions of kilo British thermal units per year (million kBtu/yr). See Sections 2.5,3.5, and 4.5 for more details on the first-year statewide impacts. Sections 2.3.2, 3.3.2, and 4.3.2 contain details on the per-unit energy savings.

Avoided GHG emissions are measured in metric tons of carbon dioxide equivalent (metric tons CO2e). Assumptions used in developing the GHG savings are provided in Sections 2.5.2, 3.5.2, and 4.5.2 and Appendix C of this report. The monetary value of avoided GHG emissions is included in the Long-term Systemwide Cost (LSC) hourly factors provided by CEC and is thus included in the cost-effectiveness analysis.

The cooling tower efficiency measure would result in significant cost-effective electricity savings of 1.3 GWh in the first year. The air-cooled chiller measure as modeled in this Draft CASE Report would result in an energy penalty of -0.4 kWh per square foot in the first year but would eliminate cooling tower water usage for buildings that chose to use this compliance option, saving 3.5 gallons of water per square foot in the first year and result in a net cost savings. *The Statewide CASE Team is seeking additional information on the performance of high efficiency air-cooled chillers that may reduce or eliminate this energy penalty.* The Statewide CASE Team estimates that the introduction of this compliance pathway would save 17.8 million gallons of water in the first year but would result in an energy penalty of 2.1 GWh. The blowdown controls measure would also result in significant water savings – a total of 22.3 million gallons of water in the first year.

First-year statewide water savings are presented in 2.5.3, 3.5.3, and 4.5.3 along with the associated embedded electricity savings. Table 67 of Section 3.5.3 and Table 87 of Section 4.5.3 of this report to presents water quality impacts and the methodology used to derive water savings and water quality impacts. The methodology used to calculate embedded electricity in water is presented in Appendix B.

In addition to the emissions reductions noted in Table 3, the Statewide CASE Team calculated impacts on GHG emissions for these measures associated with embodied carbon. These measures increase GHG emissions by 19 metric tons CO2e due to embodied carbon impacts. This increase in GHG emissions is due to the energy penalty associated with the air-cooled chiller threshold measure. These measures do not have additional reductions from embodied carbon.

Table 5: Summary of Impacts for Cooling Tower Efficiency

Category	Metric	New Construction & Additions	Alterations
Cost-effectiveness	Benefit-Cost Ratio Range (varies by climate zone and building type)	0.12 – 1.6	0.12 – 1.6
Statewide Impacts During First Year	Electricity Savings (GWh)	0.29	1.03
	Peak Electrical Demand Reduction (MW)	0.01	0.02
	Natural Gas Savings (million therms)	0.00	0.00
	Source Energy Savings (million kBtu)	0.00	0.00
	LSC Electricity Savings (million 2026 PV$)	1.36	4.84
	LSC Gas Savings (million 2026 PV$)	0.00	0.00
	Total LSC Savings (million 2026 PV$)	1.36	4.84
	Avoided GHG Emissions (Metric Tons CO2e)	9.83	34.99
	Monetary Value of Avoided GHG Emissions ($2026)	1,211	4,309
	On-site Indoor Water Savings (gallons)	0.00	0.00
	On-site Outdoor Water Savings (gallons)	0.00	0.00
	Embedded Electricity Savings (kWh)	0.00	0.00
Per Square Foot Impacts During First Year	Electricity Savings (kWh)	0.0041	0.0159
	Peak Electrical Demand Reduction (W)	0.0001	0.0003
	Natural Gas Savings (kBtu)	0.0000	0.0000
	Source Energy Savings (kBtu)	0.0000	0.0000
	LSC Savings (2026 PV$)	0.1727	0.1735
	Avoided GHG Emissions (kg CO2e)	0.0012	0.0013
	On-site Indoor Water Savings (gallons)	0.00	0.00
	On-site Outdoor Water Savings (gallons)	0.00	0.00
	Embedded Electricity Savings (kWh)	0.00	0.00

Table 6: Summary of Impacts for Air-Cooled Chiller Threshold

Category	Metric	New Construction & Additions	Alterations
Cost-effectiveness	Benefit-Cost Ratio Range (varies by climate zone and building type)	1.35 – 3.54	
Statewide Impacts During First Year	Electricity Savings (GWh)	-2.11	
	Peak Electrical Demand Reduction (MW)	-0.02	
	Natural Gas Savings (million therms)	0.00	
	Source Energy Savings (million kBtu)	-0.03	
	LSC Electricity Savings (million 2026 PV$)	-9.41	
	LSC Gas Savings (million 2026 PV$)	-0.02	
	Total LSC Savings (million 2026 PV$)	-9.43	
	Avoided GHG Emissions (Metric Tons CO2e)	-63.99	
	Monetary Value of Avoided GHG Emissions ($2026)	-7,880	
	On-site Indoor Water Savings (gallons)	17,768,182	
	On-site Outdoor Water Savings (gallons)	0.00	
	Embedded Electricity Savings (kWh)	96,659	
Per Square Foot Impacts During First Year	Electricity Savings (kWh)	-0.4154	
	Peak Electrical Demand Reduction (W)	-0.0043	
	Natural Gas Savings (kBtu)	-0.0062	
	Source Energy Savings (kBtu)	-0.0056	
	LSC Savings (2026 PV$)	-1.85	
	Avoided GHG Emissions (kg CO2e)	-0.0126	
	On-site Indoor Water Savings (gallons)	3.5	
	On-site Outdoor Water Savings (gallons)	0.00	
	Embedded Electricity Savings (kWh)	0.02	

Table 7: Summary of Impacts for Blowdown Controls

Category	Metric	New Construction & Additions	Alterations
Cost-effectiveness	Benefit-Cost Ratio Range (varies by climate zone and building type)	0 – 2,701	388 – 2,701
Statewide Impacts During First Year	Electricity Savings (GWh)	0.00	0.00
	Peak Electrical Demand Reduction (MW)	0.00	0.00
	Natural Gas Savings (million therms)	0.00	0.00
	Source Energy Savings (million kBtu)	0.00	0.00
	LSC Electricity Savings (million 2026 PV$)	0.00	0.00
	LSC Gas Savings (million 2026 PV$)	0.00	0.00
	Total LSC Savings (million 2026 PV$)	0.00	0.00
	Avoided GHG Emissions (Metric Tons CO2e)	0.00	0.00
	Monetary Value of Avoided GHG Emissions ($2026)	0	0
	On-site Indoor Water Savings (gallons)	5,196,780	17,098,984
	On-site Outdoor Water Savings (gallons)	0.00	0.00
	Embedded Electricity Savings (kWh)	28,270	93,018
Per Square Foot Impacts During First Year	Electricity Savings (kWh)	0.0000	0.0000
	Peak Electrical Demand Reduction (W)	0.0000	0.0000
	Natural Gas Savings (kBtu)	0.0000	0.0000
	Source Energy Savings (kBtu)	0.0000	0.0000
	LSC Savings (2026 PV$)	0.0000	0.0000
	Avoided GHG Emissions (kg CO2e)	0.0000	0.0000
	On-site Indoor Water Savings (gallons)	0.5	-
	On-site Outdoor Water Savings (gallons)	0.00	0.00
	Embedded Electricity Savings (kWh)	0.00	0.00

Compliance and Enforcement

Overview of Compliance Process

The compliance process is described in Sections 2.1.5, 3.1.5, and 4.1.5 and in Appendix E including impacts that the proposed measure would have on market actors. The Statewide CASE Team worked with stakeholders to develop a recommended compliance and enforcement process and to identify the impacts this process would have on various market actors.

The key issues related to compliance and enforcement are summarized below:

- For the cooling tower efficiency measure, there would be minimum effects on compliance and enforcement. Since this is an incremental efficiency improvement, the process is expected to remain largely the same.
- The air-cooled chiller threshold measure would change the design phase, as decisions between air-cooled and water-cooled chillers would be expanded to a wider range of projects. The exceptions for heating-only air-to-water heat pumps and chillers with heat recovery would also clarify and expand the use cases for those systems.
- The blowdown measure would affect designers, who would be required to calculate the maximum cycles of concentration and develop a control strategy in combination with a water treatment vendor. It would also add an acceptance test which would affect the compliance process.

Field Verification and Acceptance Testing

The blowdown controls measure would add an acceptance test to verify that conductivity controls has been installed and are programmed not to allow blowdown until maximum cycles of concentration or other water quality parameter thresholds have been reached. The acceptance test would also verify that overflow alarms have been installed. The cooling tower efficiency and air-cooled chiller threshold measures would not be subject to acceptance tests. For further information, see Sections 2.1.5, 3.1.5, and 4.1.5 for additional information.

Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in disproportionately impacted populations (DIPs) and the role this history plays in the environmental justice issues that persist today. DIPs refers to the areas throughout California that most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes, as well as high incidence of asthma and heart disease. DIPs also incorporate race, class, and gender since these intersecting identity factors affect how people frame issues, interpret, and experience the world.[4] While the term disadvantaged communities (DACs) is often used in the energy industry and state agencies, the Statewide CASE Team chose to use

[4] Environmental disparities have been shown to be associated with unequal harmful environmental exposure correlated with race/ethnicity, gender, and socioeconomic status. For example, chronic diseases, such as respiratory diseases, cardiovascular disease, and cancer, associated with environmental exposure have been shown to occur in higher rates in the LGBTQ+ population than in the cisgender, heterosexual population (Goldsmith and Bell 2021). Socioeconomic inequities, climate, energy, and other inequities are inextricably linked and often mutually reinforcing.

terminology that is more acceptable to and less stigmatizing for those it seeks to describe (DC Fiscal Policy Institute 2017).

Including impacted communities in the decision-making process, ensuring that the benefits and burdens of the energy sector are evenly distributed, and grappling with the unjust legacies of the past all serve as critical steps to achieving energy equity. Code change proposals must be developed and adopted with intentional screening for unintended consequences, otherwise they risk perpetuating systemic injustices and oppression.

This proposal primarily affects large nonresidential buildings (buildings that have cooling towers). The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice, therefore reducing the impacts of disparities in DIPs. The Statewide CASE Team does not recommend further research or action at this time but is open to receiving feedback and data that may prove otherwise. Please reach out to Nancy Metayer (nmetayer@energy-solution.com) and Marissa Lerner (mlerner@energy-solution.com) for further engagement." Full details addressing energy equity and environmental justice can be found in Sections 2.6, 3.6, and 4.6 of this report.

1. Introduction

This is a draft report intended to allow for public review and comment before the Final Report is issued. The Statewide CASE Team encourages readers to provide comments on the proposed code changes and the analyses presented. When possible, include supporting data and justifications in addition to comments. The Statewide CASE Team will review all suggestions and consider them when revising and refining proposals and analyses. The Final CASE Report will be submitted to the California Energy Commission in summer 2023. For this report, the Statewide CASE Team is requesting input on the following:

1. *Cooling tower market trends*
2. *Equipment first-cost estimates*
3. *Statewide impact methodology*

Email comments and suggestions to Bryan Boyce (bboyce@energy-solution.com) and info@title24stakeholders.com by March 27, 2023. Comments will not be released for public review or will be anonymized if shared with stakeholders.

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (CEC's) efforts to update California's Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The three California Investor Owned Utilities (IOUs) — Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities — Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) — sponsored this effort. The program goal is to prepare and submit proposals that would result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposal presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

The CEC is the state agency that has authority to adopt revisions to Title 24, Part 6. One of the ways the Statewide CASE Team participates in the CEC's code development process is by submitting code change proposals to the CEC for consideration. CEC will evaluate proposals the Statewide CASE Team and other stakeholders submit and may revise or reject proposals. See the CECs 2025 Title 24 website for information about the rulemaking schedule and how to participate in the process.

The goal of this CASE Report is to present three code change proposals:

- Updating the prescriptive requirements in Sections 140.4(h)5 and 170.2(c)Fv to climate zone specific values, increasing the requirement where cost effective;
- Adding an exception to the prescriptive requirements in Sections 140.4(j) and 170.2(c)4H limiting air-cooled chillers to 300 tons of cooling capacity for air-cooled chillers that meet certain efficiency criteria;
- Strengthening the mandatory blow-down control requirements of 110.2(e) through improved compliance documentation and the addition of an acceptance test.

The report contains pertinent information supporting the proposed code changes.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders, including building officials, manufacturers, builders, Title 24 energy analysts, 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 October 25th, 2022, and February 13, 2023.

The following is a summary of the contents of this report:

Section 2 – Cooling Tower Efficiency

- Section 2.1 – Measure Description of this CASE Report provides a description of the measure and its background. This section also presents a detailed description of how this code change is accomplished in the various sections and documents that make up the Title 24, Part 6 Standards.
- Section 2.2 – Market Analysis includes a review of the current market structure. Section 2.2.2 describes the feasibility issues associated with the code change, including whether the proposed measure overlaps or conflicts with other portions of the building standards, such as fire, seismic, and other safety standards, and whether technical, compliance, or enforceability challenges exist.
- Section 2.3 – Energy Savings presents the per-unit energy, demand reduction, and energy cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate per-unit energy, demand reduction, and energy cost savings.
- Section 2.4 –Cost and Cost Effectiveness presents the lifecycle cost and cost-effectiveness analysis. This includes a discussion of the materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs, i.e., equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.

- Section 2.5 – First-Year Statewide Impacts presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2025 code takes effect. This includes the amount of energy that would be saved by California building owners and tenants and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also reported in this section.
- Section 2.6 – Addressing Energy Equity and Environmental Justice presents the potential impacts of proposed code changes on disproportionately impacted populations (DIPs), as well as a summary of research and engagement methods.

Section 3 – Air-Cooled Chiller Threshold

- Section 3.1 – Measure Description of this CASE Report provides a description of the measure and its background. This section also presents a detailed description of how this code change is accomplished in the various sections and documents that make up the Title 24, Part 6 Standards.
- Section 3.2 – Market Analysis includes a review of the current market structure. Section 3.2.2 describes the feasibility issues associated with the code change, including whether the proposed measure overlaps or conflicts with other portions of the building standards, such as fire, seismic, and other safety standards, and whether technical, compliance, or enforceability challenges exist.
- Section 3.3 – Energy and Water Savings presents the per-unit energy, demand reduction, water, and cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate per-unit energy, demand reduction, and water, and cost savings.
- Section 3.4 – Cost and Cost Effectiveness presents the lifecycle cost and cost-effectiveness analysis. This includes a discussion of the materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs, i.e., equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.
- Section 3.5 – First-Year Statewide Impacts presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2025 code takes effect. This includes the amount of energy that would be saved by California building owners and tenants and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also reported in this section.

- Section 3.6 – Addressing Energy Equity and Environmental Justice presents the potential impacts of proposed code changes on DIPs, as well as a summary of research and engagement methods.

Section 4 – Blowdown Controls

- Section 4.1 – Measure Description of this CASE Report provides a description of the measure and its background. This section also presents a detailed description of how this code change is accomplished in the various sections and documents that make up the Title 24, Part 6 Standards.
- Section 4.2 – Market Analysis includes a review of the current market structure. Section 4.2.2 describes the feasibility issues associated with the code change, including whether the proposed measure overlaps or conflicts with other portions of the building standards, such as fire, seismic, and other safety standards, and whether technical, compliance, or enforceability challenges exist.
- Section 4.3 – Energy and Water Savings presents the per-unit energy, demand reduction, energy cost, water and water cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate per-unit energy, demand reduction, and energy cost savings.
- Section 4.4 – Cost and Cost presents the lifecycle cost and cost-effectiveness analysis. This includes a discussion of the materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs, i.e., equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.
- Section 4.5 – First-Year Statewide Impacts presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2025 code takes effect. This includes the amount of energy that would be saved by California building owners and tenants and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also reported in this section.
- Section 4.6 – Addressing Energy Equity and Environmental Justice presents the potential impacts of proposed code changes on DIPs, as well as a summary of research and engagement methods.

Section 5 – Proposed Revisions to Code Language

- Section 5.1 – Guide to Markup Language provides a summary of markup methods to the proposed code revisions.

- Section 5.2 – Standards presents the specific recommendations with deletions and additions to language for the Standards.
- Section 5.3 – Reference Appendices presents the specific recommendations with deletions and additions to language for the Reference Appendices.
- Section 5.4 – ACM Reference Manual presents the specific recommendations with deletions and additions to language for the Alternative Calculation Method (ACM) Reference Manual.
- Section 5.5 – Compliance Documents provides generalized proposed revisions to sections for the Compliance Manual and compliance documents.

Section 6 – Bibliography

- Section 6 presents the resources that the Statewide CASE Team used when developing this report.

Appendices

- Appendix A: Statewide Savings Methodology presents the methodology and assumptions used to calculate statewide energy impacts.
- Appendix B: Embedded Electricity in Water Methodology presents the methodology and assumptions used to calculate the electricity embedded in water use (e.g., electricity used to draw, move, or treat water) and the energy savings resulting from reduced water use.
- Appendix C: California Building Energy Code Compliance (CBECC) Software Specification presents relevant proposed changes to the compliance software (if any).
- Appendix D: Environmental Analysis presents the methodologies and assumptions used to calculate impacts on GHG emissions and water use and quality.
- Appendix E: Discussion of Impacts of Compliance Process on Market Actors presents how the recommended compliance process could impact identified market actors.
- Appendix F: Summary of Stakeholder Engagement documents the efforts made to engage and collaborate with market actors and experts.
- Appendix G: Energy Cost Savings in Nominal Dollars presents energy cost savings over the period of analysis in nominal dollars.
- Appendix H: Cost Estimation Details presents a summary of baseline and proposed costs for Measure 2 - Air-Cooled Threshold Measure along with the RSMeans Location Factors used throughout the report.

The California IOUs offer free energy code training, tools, and resources for those who need to understand and meet the requirements of Title 24, Part 6. The program recognizes that building codes are one of the most effective pathways to achieve energy savings and GHG reductions from buildings – and that well-informed industry professionals and consumers are key to making codes effective. With that in mind, the California IOUs provide tools and resources to help both those who enforce the code, as well as those who must follow it. Visit EnergyCodeAce.com to learn more and to access content, including a glossary of terms.

2. Cooling Tower Efficiency

2.1 Measure Description

2.1.1 Proposed Code Change

This measure proposes an increase of the prescriptive requirement for efficiency of axial fan, open-circuit cooling towers in condenser water systems of 900 gallons per minute (gpm) or greater established in 140.4(h)5 and 170.2(c)4Fv. This measure would apply to nonresidential and multifamily new construction and new systems serving additions. This measure also impacts alterations, except where the equipment is being mounted to an existing building.

The current 2022 Title 24, Part 6 Standards' prescriptive minimum efficiency for axial fan cooling towers is 60 gallons per minute per horsepower (gpm/hp), except for Climate Zones 1 and 16 which are subject to the mandatory minimum for all climate zones of 42.1 gpm/hp. The intent of this proposal is to update the prescriptive efficiency requirement from the statewide minimum of 60 gpm/hp (with the exception of Climate Zones 1 and 16) to climate zone specific values, increasing the requirement where cost effective. The proposal would update the Standard Design efficiency used in the compliance software to align with the prescriptive efficiency requirement for each zone. The code change would be implemented by introducing a table, shown in Table 8, that establishes climate zone specific minimum efficiencies based on cost effectiveness. The requirement for Climate Zones 1 and 16 would remain at the current mandatory minimum efficiency of 42.1 gpm/hp; Climate Zones 2-5, and 13-14 would remain at the current prescriptive minimum of 60 gpm/hp; Climate Zones 6, 7, 9, and 11-12 would be increased to 100 gpm/hp; and Climate Zones 8, 10, and 15 would be increased to 120 gpm/hp. The proposed code change applies to cooling towers in condenser water systems serving condenser water loops of 900 gpm or greater. The proposed code change does not recommend modifications to the existing mandatory minimum efficiency requirements.

Table 8: Proposed Cooling Tower Efficiencies by Climate Zone

Equipment Type	Prescriptive Minimum Efficiency (gpm/hp) by Climate Zone															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Propeller or axial fan Open-circuit cooling towers	42.1	60	60	60	60	100	100	120	100	120	100	100	60	60	120	42.1

Though not included in the Draft CASE Report, the Statewide CASE Team is also examining whether setting higher efficiency requirements for cooling towers that are part of chilled water systems with water-side economizers might be warranted. Chilled water systems with water-side economizers utilize the cooling towers to produce chilled water when outside air conditions allow, thus increasing the hours of operation of the cooling towers compared to systems without economizers. As a result, cooling tower efficiency improvements have the potential to have higher energy savings at sites with waterside economizers, though design considerations must be taken into account. *The CASE Team welcomes all stakeholder input and feedback pertaining to this system type.*

The proposal recommends using the existing test procedure and rating conditions to evaluate cooling tower efficiency, which are listed in Title 24, Part 6, Table 110.2-F Performance Requirements for Heat Rejection Equipment. The test procedures identified are the Cooling Technology Institute's (CTI) standards, CTI ATC-105 and CTI STD-201 RS, which require cooling tower efficiency ratings under the standardized conditions of 95°F entering water temperature, 85°F leaving water temperature, and 75°F entering air wet-bulb temperature.

Replacement towers (alterations) are exempted if they are building-mounted or inside of an existing building (an exception made during adoption of the prescriptive requirement due to physical constraints in these cases such as size and weight) but would have to meet the existing mandatory efficiency requirements in Section 110.2. Replacement towers (alterations) that do not meet the building-mounted exemption would be required to comply with the prescriptive efficiency requirements.

2.1.2 Justification and Background Information

2.1.2.1 Justification

This proposal is largely an incremental efficiency improvement to prescriptive requirements adopted during the 2019 Title 24 code cycle. During the 2019 code cycle, a prescriptive minimum efficiency of ≥80 gpm/hp was proposed for open-circuit cooling towers with axial fans. Due to the product efficiency at the time however, ultimately a prescriptive minimum efficiency of ≥60 gpm/hp was adopted for 2019 Title 24, Part 6. It has been six years since the research and analysis was performed, and in the time since, cooling tower technology has advanced. Additionally, the previous analysis proposed a uniform requirement across all climate zones, with the exception of Climate Zones 1 and 16. This proposal examines updating the prescriptive minimum efficiency to climate-zone specific values determined by a cost-effectiveness analysis, allowing cooling tower efficiency requirements to be tailored to climate specific impacts.

2.1.2.2 Background Information

Cooling towers are used to reject heat from a condenser water system by evaporating water in an airstream. Energy used by cooling towers takes the form of energy used by the cooling tower fan motor. The metric for cooling tower efficiency used in code language is “gpm/hp”, which compares the cooling capacity of the cooling tower (in gpm) as tested under standard conditions by the Cooling Technology Institute to the rated fan horsepower. The key technologies that result in improved cooling tower efficiencies are:

- Increased tower size to provide greater surface area of the water air interface for evaporation to occur and lower pressure drop in air stream.
- Optimized spray performance due to advances in computational and experimental research.
- Low pressure drop, high efficiency fans as characterized by induced draft axial fans.
- High efficiency motors.
- High efficiency propellers.
- High efficacy heat transfer membrane.

The American Society for Heating, Refrigerating, and Air-Conditioning Engineer (ASHRAE) Standard 90.1 and ASHRAE Technical Committee (TC) 8.6 – Cooling Towers and Evaporative condensers established the first cooling tower efficiency in 1999. The mandatory minimum efficiency was set at 38.2 gpm/hp for open towers with axial fans, as tested by CTI at standard conditions of 95°F entering water temperature, 85°F leaving water temperature, and 75°F entering wet bulb temperature. The ASHRAE standards were adopted into Title 24, Part 6 as part of the 2001 code cycle.

In 2005, a prescriptive requirement was adopted that limited the use of centrifugal fan cooling towers to condenser water systems with flow rates less than 900 gpm, with exceptions. This proposal effectively established axial fan cooling towers, which are more energy efficient, as the prescriptive option for condenser water systems greater than 900 gpm. In a similar measure, the 2005 code cycle also adopted a limitation on air-cooled chillers to provide no more than 300 tons of cooling capacity to chilled water plants, leading to water-cooled chiller systems with propeller or axial fan cooling towers for chilled water plants greater than 300 tons.

During the 2013 Title 24, Part 6 code cycle, the Statewide CASE Team proposed the first prescriptive requirements for minimum cooling tower efficiency, to exceed the mandatory 38.2 gpm/hp. Though cooling towers as high as 100 gpm/hp were found to be cost effective at the time, the measure was ultimately dropped from consideration due to concerns from ASHRAE TC 8.6 that the requirements would force a majority of projects to undergo the performance compliance method due to product availability at the time, and that the more expensive, high efficiency cooling towers would encourage new construction to pursue air-cooled plants over water-cooled plants.

Since the cooling tower efficiency requirements had not been updated for ten years, as an alternative to the proposed (and rejected) prescriptive requirements, Title 24, Part 6 increased the mandatory minimum cooling tower efficiency from 38.2 gpm/hp to 42.1 gpm/hp. The CEC also updated the 2013 ACM Reference Manual and compliance software to assume that a Standard Design cooling tower had an efficiency of 60 gpm/hp. The CEC assumed the Standard Design had an efficiency that exceeded the mandatory minimum requirement because, as presented in the 2013 Draft CASE Report, standard practice for cooling towers had moved to more efficient towers.

In 2019, cooling tower energy efficiency was examined again, as previous studies had demonstrated cost effectiveness at high efficiency values. The Statewide CASE Team proposed the addition of a prescriptive minimum efficiency requirement of 80 gpm/hp for open-circuit, axial fan cooling towers serving condenser water loops of 900 gpm or greater. In response to stakeholder concerns regarding product line availability and increased costs, the proposed efficiency increase was reduced. Ultimately, a prescriptive minimum efficiency requirement of 60 gpm/hp was adopted in 2019 Title 24, Part 6, with exceptions for buildings in Climate Zone 1 and 16, and replacement of cooling towers on existing rooftops or inside of existing buildings. Since the code change was prescriptive, projects with factors limiting the selection of high efficiency cooling towers can pursue the performance path, in which they need only to follow the mandatory requirement for cooling tower efficiency.

2.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manuals, and compliance documents would be modified by the proposed change.[5] See Section 5.2 of this report for detailed proposed revisions to code language.

2.1.3.1 Specific Purpose and Necessity of Proposed Code Changes

Each proposed change to language in Title 24, Part 1 and Part 6 as well as the reference appendices to Part 6 are described below. See Section 5.1 of this report for marked-up code language.

[5] Visit EnergyCodeAce.com for trainings, tools and resources to help people understand existing code requirements.

Section: 140.4(h)5

Specific Purpose: The specific purpose of the change to subsection 140.4(h)5 is to increase the efficiency requirement from 60 gpm/hp to 80-120 gpm/hp for axial fan, open circuit cooling towers with a design condenser water flow of 900 gpm for all climate zones for which the measure is cost effective through the introduction of a table of climate zone specific minimum efficiency requirements. The change would also eliminate an exception for Climate Zones 1 and 16 which would be redundant once the table is constructed, though required efficiencies for the two zones would not be altered.

Necessity: These changes are necessary to increase energy efficiency via cost-effective building design standards, as directed by California Public Resources Code Sections 25213 and 25402.

Section: 170.2(c)4Fv

Specific Purpose: The specific purpose of the change to subsection 170.2(c)4Fv is to increase the efficiency requirement to 80-120 gpm/hp for axial fan, open circuit cooling towers with a design condenser water flow of 900 gpm or greater serving multifamily buildings for all climate zone, aligning with the requirements for nonresidential systems. The change would also eliminate an exception for Climate Zones 1 and 16 which would be redundant once the table is constructed.

Necessity: These changes are necessary to increase energy efficiency via cost-effective building design standards, as directed by California Public Resources Code Sections 25213 and 25402.

2.1.3.2 Specific Purpose and Necessity of Changes to the Nonresidential ACM Reference Manual

The purpose and necessity of proposed changes to the Nonresidential ACM Reference Manual are described below. See Section 5.4 of this report for the detailed proposed revisions to the text of the ACM Reference Manual.

Section: Section 5.8.3 Cooling Towers

Specific Purpose: The specific purpose of the change to Section 5.8.3 is to increase the Standard Design fan horsepower minimum threshold to 80-120 gpm/hp dependent on climate zone for cooling towers with a design condenser water flow of 900 gpm or more in new construction, non-healthcare buildings in Climate Zones 2-15.

Necessity: These changes are necessary to align Standard Design with changes to Title 24 Part 6 in an effort to increase energy efficiency via cost-effective building design standards, as directed by California Public Resources Code Sections 25213 and 25402.

2.1.3.3 Summary of Changes to the Nonresidential Compliance Manual

Chapter 4, Section 4.7.2.10 of the 2022 Nonresidential Compliance Manual would need to be revised. The references to the existing efficiency minimum for cooling towers of 60 gpm/hp would need to be revised to reflect the new prescriptive requirement of 100 gpm/hp.

2.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. Examples of the revised forms are presented in Section 5.5.

- NRCC-MCH-E – Table M would need to be revised to include the new min efficiency (GPM/HP) in line with the proposed requirements of Title 24, Part 6 140.4(h)5 and 170.2(c)4Fv.

2.1.4 Regulatory Context

2.1.4.1 Determination of Inconsistency or Incompatibility with Existing State Laws and Regulations

This proposed measure is relevant to the existing Title 24, Part 6 rules pertaining to cooling tower efficiency. Section 110.2, Table 110.2-F establishes the minimum required efficiency at 42.1 gpm/hp. A prescriptive minimum cooling tower efficiency of 60 gpm/hp is set in Section 140.4(h)5 for nonresidential and 170.2(c)4Fv for multifamily, for cooling towers serving condenser water loops greater than 900 gpm.

The existing Title 24, Part 6 Section 140.4(j) and 170.2(c)4H are also relevant to the proposal in that they set a prescriptive maximum threshold of 300 tons of capacity provided by air-cooled chillers in nonresidential and multifamily buildings. Chiller plants above this capacity following the prescriptive path must thus use water-cooled chillers and, in turn, cooling towers.

Similarly, the existing prescriptive requirements in Title 24, Part 6 140.4(h)3 and 170.2(c)4Fiii set a limitation on the use of centrifugal fan cooling towers, prescribing that open cooling towers with a combined rated capacity of greater than 900 gpm shall use propeller or axial fans in nonresidential and multifamily buildings. This limitation has an exception for centrifugal fan cooling towers that exceed the mandatory requirements for propeller fan cooling towers of Table 110.2-F (≥42.1 gpm/hp). As a result, some customers may be motivated to pursue centrifugal fans as an alternative to the higher efficiency propeller fans required by the proposal. However, costs and availability of centrifugal fans would likely minimize this impact, as discussed in Section 2.2.2.

In the original adoption of the cooling tower prescriptive minimum efficiency requirement, the threshold of 900 gpm condenser loops was selected intentionally to provide cohesiveness with the 300 ton air cooled chiller limitation. At CTI's standard conditions, 900 gpm is equivalent to a capacity of 300 tons. When viewed comprehensively, the result is that when pursuing the prescriptive path, a chilled water plant greater than 300 tons of capacity is required to be water-cooled, and thus have a cooling tower. If using an open-circuit cooling tower, it is required to be a propeller or axial fan cooling tower with an efficiency of 60 gpm/hp or greater, with the exception of projects in Climate Zones 1 and 16, or projects replacing existing towers inside a building or on a roof.

This proposal is not relevant to other parts of the California Building Standards Code (https://www.dgs.ca.gov/BSC/Codes). Changes outside of Title 24, Part 6 are not needed.

There are no relevant state or local laws or regulations.

2.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

2.1.4.3 Difference From Existing Model Codes and Industry Standards

Cooling tower efficiency minimum standards are provided in ASHRAE 90.1-2019. Table 6.8.1-7 of the standards establishes a mandatory minimum efficiency requirement of 40.2 gpm/hp for open-circuit cooling towers with propeller or axial fans, as tested by the Cooling Technology Institute (CTI) using standards CTI STD-201 RS and CTI ATC-105.

The current mandatory requirements for cooling tower efficiency in Table 110.2-F of the 2022 Title 24, Part 6 differ from the ASHRAE 90.1, requiring a minimum efficiency of 42.1 gpm/hp for open-circuit cooling towers with propeller or axial fans, as tested under CTI STD-201 RS and CTI ATC-105. The 2022 Title 24, Part 6 prescriptive requirements of Section 140.4(h)5 and 170.2(c)4Fv go further, requiring a minimum efficiency of 60 gpm/hp for open-circuit, axial fan cooling towers with design condenser water flow of 900 gpm or greater, with exceptions for buildings in Climate Zone 1 or 16, and replacement of cooling towers inside an existing building or on an existing roof.

2.1.5 Compliance and Enforcement

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. This section describes how to comply with the proposed code change. It also describes the compliance verification process. Appendix E presents how the proposed changes could impact various market actors.

The compliance verification activities related to this measure that need to occur during each phase of the project are described below:

- **Design Phase:** As an increase in an already established prescriptive minimum efficiency, the proposed code change would not result in significant changes to the design phase. When pursuing the prescriptive path of the code, the mechanical design engineer would first assess whether the code requirements would be triggered by the project based on proposed cooling tower capacity. The mechanical designer would coordinate with the manufacturer to select and specify code-compliant equipment that meets the design conditions unique to the site and document that on project plans and specifications. More efficient towers may be larger and heavier and would require coordination with the architectural and structural teams to ensure sufficient space and structure is available. However, the engineering and architectural teams should already be in close coordination as part of any cooling tower placement.
- **Permit Application Phase:** No major changes are expected to the permit application phase. The mechanical designer submits the scope of work, plan set, and Title 24, Part 6 compliance paperwork. The plans examiner would need to ensure code triggers are correctly accounted for and verify the new proposed cooling tower efficiency on NRCC-MCH-E for new systems using the prescriptive compliance path.
- **Construction Phase:** The proposed code change would not impact the construction phase. HVAC contractors would install the required equipment and provide Certificates of Installation for NRCI-MCH-E.
- **Inspection Phase:** The inspection phase would be minimally impacted. A building department inspector inspects equipment and all compliance documents to verify they are in compliance with the new prescriptive cooling tower efficiency.

2.2 Market Analysis

2.2.1 Current Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general as well as individual market actors. Information was gathered about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, CEC staff, and a wide range of industry actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during public stakeholder meetings that the Statewide CASE Team held on October 25, 2022 and February 13, 2023.

Cooling towers are produced by three major manufacturers: SPX Cooling Technologies Inc., Evapco Inc., and Baltimore Aircoil Company (BAC), identified by the number of products that they have rated and registered with the CTI, who establishes standards and certifies that the equipment will perform in accordance with the published ratings

Key market actors in the procurement and installation of a new cooling tower consist of the building owner, manufacturer representative or partnering sales company, the manufacturer, design engineer, HVAC contractor, and the plans examiner and building inspection team. There are many pathways by which the process can take place. Projects can start, for example, with the building owner working with a mechanical design engineer or with the owner reaching out to the manufacturer or sales partner directly. From there, the mechanical designer and manufacturer representatives would coordinate to select a cooling tower that meets the owner's design conditions. The designer would then submit plans to the examiner for permitting, after which the equipment would be procured and installed by the HVAC contractor. Once installed, the project would be finalized by the building inspector, ensuring that the installation took place as permitted.

Due to the proprietary nature of the product, no sales and installation data is publicly available.

2.2.2 Technical Feasibility and Market Availability

Based on data available from CTI’s certification directory and directly from manufacturers’ publicly available data, each of the three major manufacturers currently provides high-efficiency cooling towers that meet the requirements of the proposed code change (Cooling Technology Institute n.d.). The data show that for cooling towers of 900-1,200 gpm, approximately 44 percent of units available from SPX Cooling Technologies Inc., Evapco Inc., and BAC have an efficiency of 80 gpm/hp or higher, 34 percent have an efficiency of 100 gpm/hp or higher, and 15 percent have an efficiency of 120 gpm/hp or higher.

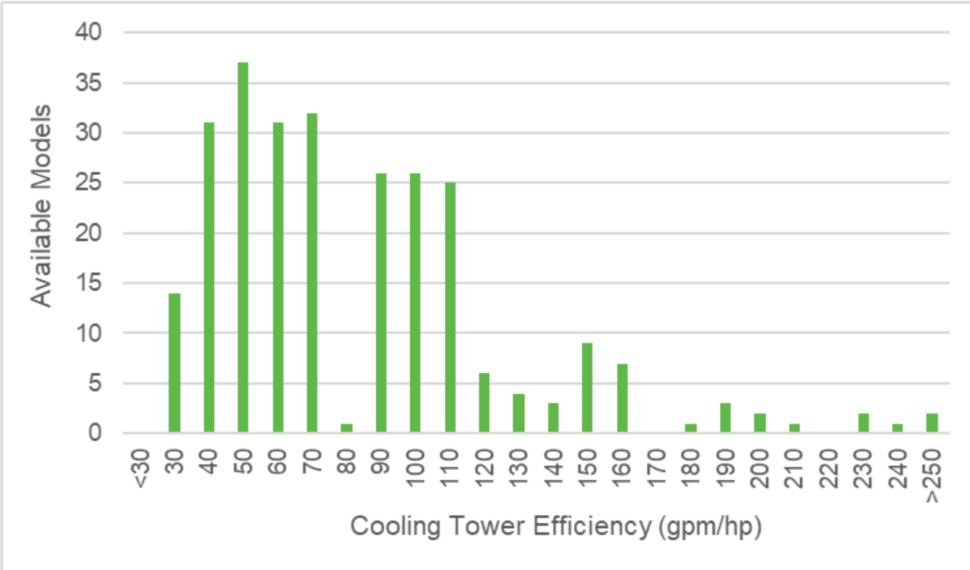

Figure 1: Market availability of cooling tower efficiency for 900-1,200 gpm units.

One technical barrier in the adoption of more efficient cooling towers is in the impact on size and weight. Due to the nature of achieving improved performance, the primary method for which is increasing the area of heat exchange, more efficient cooling towers are larger and heavier than standard efficiency cooling towers. Figure 2 to Figure **4** provide demonstrations of this trend, comparing operating weight (lbs), cooling tower footprint (ft^2), and height (ft) to cooling tower efficiency for single cell and two cell units of 900-1,200 gpm in capacity. Data were collected from manufacturer engineering data documentation and software for product selection (SPX Cooling Technologies n.d., Evapco n.d., Baltimore Aircoil Company n.d.).

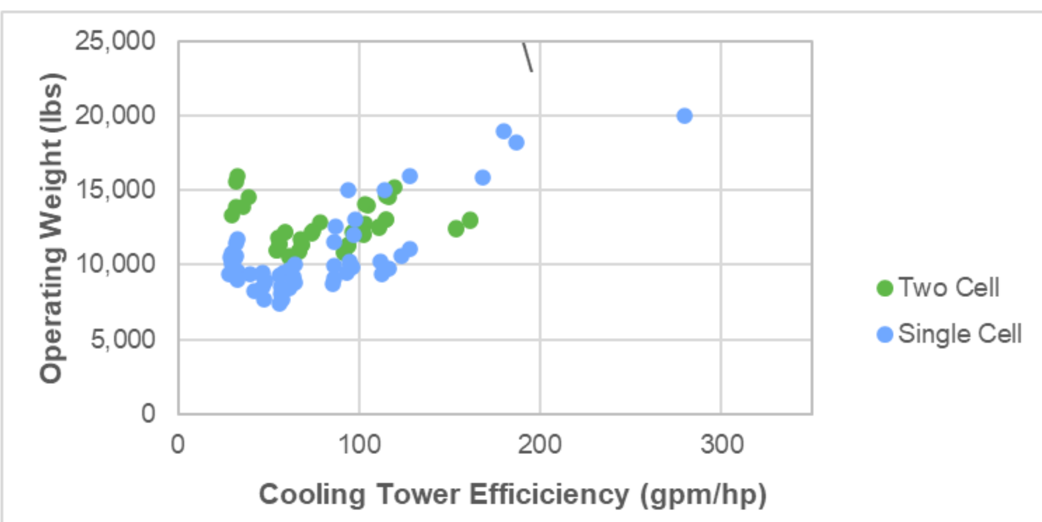

Figure 2: Cooling tower operating weight (lbs) versus efficiency (gpm/hp) for units of approximately 900-1,200 gpm capacity.

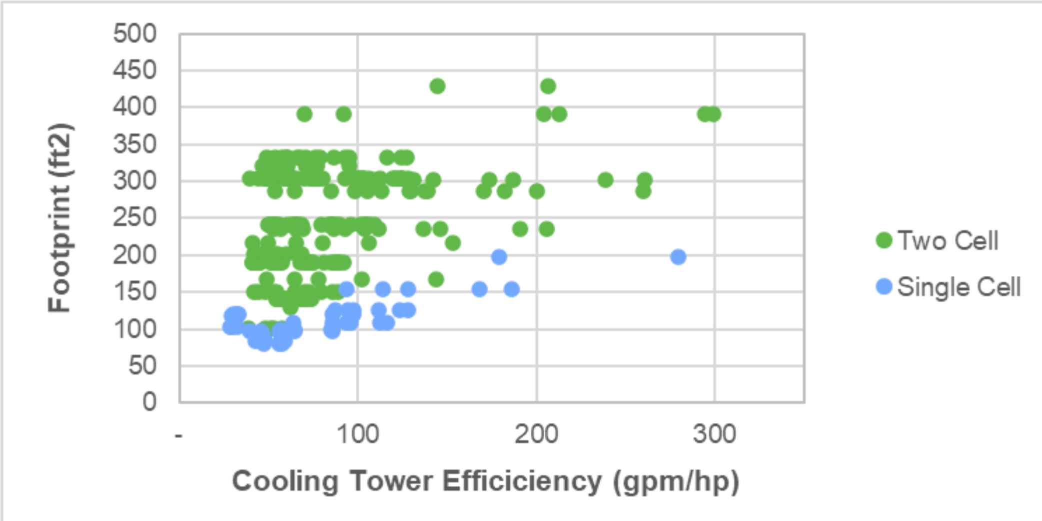

Figure 3: Cooling tower footprint (ft^2) versus efficiency (gpm/hp) for units of approximately 900-1,200 gpm capacity.

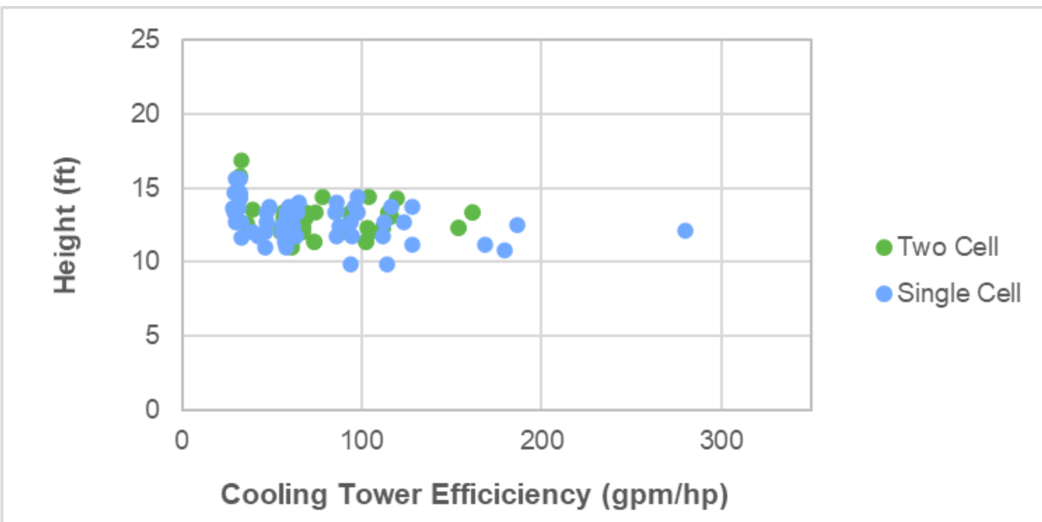

Figure 4: Cooling tower height (ft) versus efficiency (gpm/hp) for units of approximately 900-1,200 gpm capacity.

Based on the engineering data available, cooling tower operating weight and footprint are significantly impacted by increases in efficiency. A 900-1,200 gpm unit is estimated to have a 4-40 percent heavier operating weight (which includes water weight) and a -2-21 percent larger footprint for an increase to 80-120 gpm/hp. A weaker impact was observed between cooling tower height and efficiency. The average height increase for a 900-1,200 gpm unit was found to range from 3 percent shorter to 12 percent taller, and with a small magnitude of difference, only 0.4-1.7 ft. Table 9 summarizes the typical size and weight increases observed with increasing efficiency for cooling towers of 900-1,200 gpm in capacity.

Table 9: Average Cooling Tower Physical Specifications and Efficiency: 900-1,200 gpm capacity

Cooling Tower Efficiency (gpm/hp)	Average Operating Weight (lbs)	Increase in Operating Weight from Baseline	Average Footprint (ft^2)	Increase in Footprint from Baseline	Average Height (ft)	Increase in Height from Baseline
60 (baseline)	12,645	0%	117.9	0%	13.7	0%
80	13,134	4%	115.4	-2%	13.3	-3%
100	16,745	32%	138.5	17%	14.9	9%
120	17,643	40%	143.2	21%	15.3	12%

To overcome this barrier, designers must work closely with building owners to ensure all design goals are achieved by the selected unit. Costs associated with potential structural improvements to support increased weight are considered in Section 2.4.3. Cost effectiveness of higher efficiency cooling towers should be emphasized to ensure building owner satisfaction. For sites in which space and structural requirements are a limiting factor, the project can pursue the performance path which allows selection of a unit meeting the existing mandatory minimum efficiency of 42.1 gpm/hp.

According to the 2015 ASHRAE Handbook for HVAC Applications, the equipment useful life of a cooling tower is 20 years (ASHRAE 2015). With proper maintenance, cooling towers are anticipated to maintain performance throughout their lifetime, with the average replacement occurring at 17.5 years according to the ASHRAE Owning and Operating Cost Database (ASHRAE n.d.). As such, it is expected that cooling towers would effectively deliver savings over a full period of analysis used in the cost-effectiveness analysis presented in Section 0.

As mentioned in Section 2.1.4.1, increasing the prescriptive requirements for axial fan cooling towers has the potential to encourage designers and customers to select centrifugal fans, which are allowed for condenser water loops exceeding 900 gpm when they exceed the mandatory axial fan efficiency of 42.1 gpm/hp. However, costs and availability of centrifugal fans would likely minimize this impact. Based on cooling tower product selection data, for cooling towers between 300-1,800 gpm and an efficiency between 40-60 gpm/hp, centrifugal cooling towers cost an average of 2.2 times that of axial fan cooling towers. For the same capacity range, there are also approximately 13 times as many axial fan cooling towers as centrifugal fan units that meet exceed the mandatory minimum requirement of 42.1 gpm/hp, with only 11 percent of centrifugal units meeting the requirement.

2.2.3 Market Impacts and Economic Assessments

2.2.3.1 Impact on Builders

Builders of residential and commercial structures are directly impacted by many of the measures proposed by the Statewide CASE Team for the 2025 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California’s construction industry comprises approximately 93,000 business establishments and 943,000 employees (see Table 10). For 2022, total estimated payroll would be about $78 billion. Nearly 72,000 of these business establishments and 473,000 employees are engaged in the residential building sector, while another 17,600 establishments and 369,000 employees focus on the commercial sector. The remainder of establishments and employees work in industrial, utilities, infrastructure, and other heavy construction roles (the industrial sector).

Table 10: California Construction Industry, Establishments, Employment, and Payroll in 2022 (Estimated)

Building Type	Construction Sectors	Establish-ments	Employ-ment	Annual Payroll (Billions $)
Residential	**All**	**71,889**	**472,974**	**31.2**
Residential	Building Construction Contractors	27,948	130,580	9.8
Residential	Foundation, Structure, & Building Exterior	7,891	83,575	5.0
Residential	Building Equipment Contractors	18,108	125,559	8.5
Residential	Building Finishing Contractors	17,942	133,260	8.0
Commercial	**All**	**17,621**	**368,810**	**35.0**
Commercial	Building Construction Contractors	4,919	83,028	9.0
Commercial	Foundation, Structure, & Building Exterior	2,194	59,110	5.0
Commercial	Building Equipment Contractors	6,039	139,442	13.5
Commercial	Building Finishing Contractors	4,469	87,230	7.4
Industrial, Utilities, Infrastructure, & Other (Industrial+)	**All**	**4,206**	**101,002**	**11.4**
Industrial+	Building Construction	288	3,995	0.4
Industrial+	Utility System Construction	1,761	50,126	5.5
Industrial+	Land Subdivision	907	6,550	1.0

Building Type	Construction Sectors	Establish-ments	Employ-ment	Annual Payroll (Billions $)
Industrial+	Highway, Street, and Bridge Construction	799	28,726	3.1
Industrial+	Other Heavy Construction	451	11,605	1.4

Source: (State of California n.d.)

The proposed change to cooling tower efficiency would likely affect commercial builders but would not impact firms that focus on construction and retrofit of industrial buildings, utility systems, public infrastructure, or other heavy construction. The effects on the residential and commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 11 shows the residential building subsectors and Table 12 shows the commercial building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report. Subsectors were identified on the basis of which components of the construction phase are involved in the installation of cooling tower systems for multifamily and nonresidential buildings, which involves aspects of structural and foundational work to support equipment, HVAC work, electrical work, plumbing, and site preparation. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 2.2.4 Economic Impacts.

Table 11: Specific Subsectors of the California Residential Building Industry by Subsector in 2022 (Estimated)

Residential Building Subsector	Establishments	Employment	Annual Payroll (Billions $)
New multifamily general contractors	421	6,344	0.7
Residential poured foundation contractors	1,505	16,369	1.1
Residential Structural Steel Contractors	275	3,207	0.2
Residential Roofing Contractors	2,600	18,918	1.1
Residential Electrical Contractors	7,857	48,366	3.3
Residential plumbing and HVAC contractors	9,852	75,404	5.1
Residential Site Preparation Contractors	1,418	11,526	0.9

Source: (State of California n.d.)

Table 12: 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 $)
Commercial Building Construction	4,919	83,028	9.0
Nonresidential poured foundation contractors	529	18,159	1.6
Nonresidential structural steel contractors	363	13,110	1.1
Nonresidential Roofing Contractors	354	10,382	0.9
Nonresidential Electrical Contractors	3,137	74,277	7.0
Nonresidential plumbing & HVAC contractors	2,346	55,572	5.5
Nonresidential site preparation contractors	1,159	18,322	1.6
All other Nonresidential trade contractors	940	18,027	1.6

Source: (State of California n.d.)

2.2.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle, and building designers and energy consultants engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

As this measure proposes a simple incremental change to an existing prescriptive efficiency requirement, minimal impacts are anticipated on workflows in relation to increased cooling tower efficiency. Beyond ensuring key market actors understand the new requirements, no additional training is anticipated as a result of this proposed code change.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 13 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for the cooling tower efficiency measure to affect firms that focus on nonresidential and multifamily construction.

There is not a North American Industry Classification System (NAICS)[3] code specific to energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[4] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 13 provides an upper bound indication of the size of this sector in California.

Table 13: California Building Designer and Energy Consultant Sectors in 2022 (Estimated)

Sector	Establishments	Employment	Annual Payroll (Millions $)
Architectural Services [a]	4,134	31,478	3,623.3
Building Inspection Services [b]	1,035	3,567	280.7

Source: (State of California n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures.

b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services

2.2.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health (DOSH). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

2.2.3.4 Impact on Building Owners and Occupants

Commercial Buildings

The commercial building sector includes a wide array of building types, including offices, restaurants and lodging, retail, and mixed-use establishments, and warehouses (including refrigerated) (Kenney 2019). Energy use by occupants of commercial buildings also varies considerably, with electricity used primarily for lighting, space cooling and conditioning, and refrigeration, while natural gas is used primarily for water heating and space heating. According to information published in the 2019 California Energy Efficiency Action Plan, there is more than 7.5 billion square feet of commercial floor space in California consuming 19 percent of California’s total annual energy use (Kenney 2019). The diversity of building and business types within this sector creates a challenge for disseminating information on energy and water efficiency solutions, as does the variability in sophistication of building owners and the relationships between building owners and occupants.

Building owners and occupants would benefit from lower energy bills. As discussed in Section 2.2.4.1, when building occupants save on energy bills, they tend to spend it elsewhere in the economy thereby creating jobs and economic growth for the California economy. The Statewide CASE Team does not expect the proposed code change for the 2025 code cycle to impact building owners or occupants adversely.

2.2.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)

The proposed code change would result in increased demand for higher efficiency open-circuit axial fan cooling towers to serve condenser water loops greater than 900 gpm in capacity. In itself, this measure is not anticipated to have an impact to cooling tower sales since existing 2022 Title 24, Part 6 requires water-cooled chilled water systems for chilled water plants greater than 300 tons, in line with the equipment capacities impacted by this measure. If pursuing the prescriptive path, cooling tower selection would be pushed toward higher efficiency options, which are currently offered by all major manufacturers. Less efficient options, meeting the mandatory minimum efficiency, may still be selected by pursuing the performance path.

When examined in tandem with the effects of the air-cooled threshold measure proposed in Section 3, the cooling efficiency measure risks leading to decreases in cooling tower sales. Measure 2 proposes adding an exception to the prescriptive limitation that states air-cooled chillers can only provide up to 300 tons of capacity. Increased cooling tower efficiency results in higher cost equipment, so by requiring more efficient cooling towers for units serving condenser water loops over 900 gpm (300 tons), while introducing an exception that expands the potential applications for air-cooled chillers, projects over 300 tons may be encouraged to select the less expensive air-cooled chiller plants. Note that though this may have adverse impacts on energy consumption (since air-cooled chillers are less energy efficient than water-cooled chillers), increasing the prevalence of air-cooled chillers has significant potential for statewide water savings. Further discussion of the trade-off between air-cooled and water-cooled chilled water plants, including the water and energy impacts of the air-cooled chiller threshold measure is provided in more detail in Section 3.

2.2.3.6 Impact on Building Inspectors

Table 14 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing education and training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 14: Employment in California State and Government Agencies with Building Inspectors in 2022 (Estimated)

Sector	Govt.	Establishments	Employment	Annual Payroll (Million $)
Administration of Housing Programs[a]	State	18	265	29.0
	Local	38	3,060	248.6
Urban and Rural Development Admin[b]	State	38	764	71.3
	Local	52	2,481	211.5

Source: (State of California, Employment Development Department n.d.)

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.

b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

2.2.3.7 Impact on Statewide Employment

As described in Sections 2.2.3.1 through 2.2.3.6, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 2.2.4, the Statewide CASE Team estimated the proposed change in cooling tower efficiency would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in cooling tower efficiency would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

2.2.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software[6], along with economic information from published sources, and professional judgement to develop estimates of the economic impacts associated with each of the proposed code changes. Conceptually, IMPLAN estimates jobs created as a function of incoming cash flow in different sectors of the economy, due to implementing a code or a standard. The jobs created are typically categorized into direct, indirect, and induced employment. For example, cash flow into a manufacturing plant captures direct employment (jobs created in the manufacturing plant), indirect employment (jobs created in the sectors that provide raw materials to the manufacturing plant) and induced employment (jobs

[6] IMPLAN employs economic data and advanced economic impact modeling to estimate economic impacts for interventions like changes to the California Title 24, Part 6 code. For more information on the IMPLAN modeling process, see www.IMPLAN.com.

created in the larger economy due to purchasing habits of people newly employed in the manufacturing plant). Eventually, IMPLAN computes the total number of jobs created due to a code. The assumptions of IMPLAN include constant returns to scale, fixed input structure, industry homogeneity, no supply constraints, fixed technology, and constant byproduct coefficients. The model is also static in nature and is a simplification of how jobs are created in the macro-economy.

The economic impacts developed for this report are only estimates and are based on limited and to some extent speculative information. The IMPLAN model provides a relatively simple representation of the California economy and, though the Statewide CASE Team is confident that the direction and approximate magnitude of the estimated economic impacts are reasonable, it is important to understand that the IMPLAN model is a simplification of extremely complex actions and interactions of individual, businesses, and other organizations as they respond to changes in energy efficiency codes. In all aspect of this economic analysis, the CASE Authors rely on conservative assumptions regarding the likely economic benefits associated with the proposed code change. By following this approach, the economic impacts presented below represent lower bound estimates of the actual benefits associated with this proposed code change.

Adoption of this code change proposal would result in relatively modest economic impacts through the additional direct spending by those in the commercial building industry, architects, energy consultants, and building inspectors. The Statewide CASE Team does not anticipate that money saved by commercial building owners or other organizations affected by the proposed 2025 code cycle regulations would result in additional spending by those businesses.

2.2.4.1 Creation or Elimination of Jobs

The Statewide CASE Team does not anticipate that the measures proposed for the 2025 code cycle regulation would lead to the creation of new *types* of jobs or the elimination of *existing* types of jobs. In other words, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. Rather, the estimates of economic impacts discussed in Section 2.2.4 would lead to modest changes in employment of existing jobs.

2.2.4.2 Creation or Elimination of Businesses in California

As stated in Section 2.2.4.1, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. The proposed change represents a modest change to prescriptive cooling tower efficiency requirements, which would not excessively burden or competitively disadvantage California businesses – nor would it necessarily lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not foresee any new businesses being created, nor does the Statewide CASE Team think any existing businesses would be eliminated due to the proposed code changes.

2.2.4.3 Competitive Advantages or Disadvantages for Businesses in California

The proposed code changes would apply to all businesses incorporated in California, regardless of whether the business is located inside or outside of the state.[7] Therefore, the Statewide CASE Team does not anticipate that these measures proposed for the 2025 code cycle regulation would have an adverse effect on the competitiveness of California businesses. Likewise, the Statewide CASE Team does not anticipate businesses located outside of California would be advantaged or disadvantaged.

2.2.4.4 Increase or Decrease of Investments in the State of California

The Statewide CASE Team analyzed national data on corporate profits and capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[8] As Table 15 shows, between 2017 and 2021, NPDI as a percentage of corporate profits ranged from a low of 18 in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 35 percent in 2019, with an average of 26 percent. While only an approximation of the proportion of business income used for net capital investment, the Statewide CASE Team believes it provides a reasonable estimate of the proportion of proprietor income that would be reinvested by business owners into expanding their capital stock.

Table 15: Net Domestic Private Investment and Corporate Profits, U.S.

Year	Net Domestic Private Investment by Businesses, Billions of Dollars	Corporate Profits After Taxes, Billions of Dollars	Ratio of Net Private Investment to Corporate Profits (Percent)
2017	518.473	1882.460	28
2018	636.846	1977.478	32
2019	690.865	1952.432	35
2020	343.620	1908.433	18
2021	506.331	2619.977	19
5-Year Average	**539.227**	**2,068.156**	**26**

Source: (Federal Reserve Economic Data (FRED) n.d.)

[7] Gov. Code, §§ 11346.3(c)(1)(C), 11346.3(a)(2); 1 CCR § 2003(a)(3) Competitive advantages or disadvantages for California businesses currently doing business in the state.

[8] Net private domestic investment is the total amount of investment in capital by the business sector that is used to expand the capital stock, rather than maintain or replace due to depreciation. Corporate profit is the money left after a corporation pays its expenses.

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to significant change (increase or decrease) in investment, directly or indirectly, in any affected sectors of California's economy. Nevertheless, the Statewide CASE Team is able to derive a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on proprietor income, which we use a conservative estimate of corporate profits, a portion of which we assume would be allocated to net business investment.[9]

2.2.4.5 Incentives for Innovation in Products, Materials, or Processes

By increasing prescriptive cooling tower efficiency minimum requirements, building design teams would be motivated to select higher efficiency units. Cooling tower manufacturers would be motivated to develop technologies that improve efficiency.

2.2.4.6 Effects on the State General Fund, State Special Funds, and Local Governments

The Statewide CASE Team does not expect the proposed code changes would have a measurable impact on California's General Fund, any state special funds, or local government funds.

Cost of Enforcement

Cost to the State: State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals. New construction of state buildings designed with cooling towers, and existing buildings with cooling towers to be replaced would incur additional costs to comply with the proposed code changes. However, the proposed code changes have been found to be cost effective over the life of the measure.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are

[9] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 15.

numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 2.1.5 and Appendix E, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

2.2.4.7 Impacts on Specific Persons

While the objective of any of the Statewide CASE Team's proposal is to promote energy efficiency, the Statewide CASE Team recognizes that there is the potential that a proposed code change may result in unintended consequences. The proposed code change is not expected to result in impacts on specific persons or groups of persons that differ from impacts to persons generally. Refer to Section 2.6 for more details addressing energy equity and environmental justice.

2.2.5 Fiscal Impacts

2.2.5.1 Mandates on Local Agencies or School Districts

The proposed measure would impact building of in various market segments and could impose a mandate on school districts and local agencies that own buildings with water-cooled chilled water systems. The extent of the mandate would depend on the specific circumstances of each facility.

2.2.5.2 Costs to Local Agencies or School Districts

The proposed measure may result in added costs to local agencies or school districts which could potentially require reimbursement pursuant to California Constitution, Government Code sections 17500 et seq. School districts and local agencies that own or operate facilities with water-cooled chilled water systems or build new construction facilities with water-cooled chilled water systems may incur increased costs to comply with the proposed measure. The extent of the costs would depend on the specific circumstances of each facility.

2.2.5.3 Costs or Savings to Any State Agency

The proposed measure may result in costs and savings for any state agency that owns or constructs a building with water-cooled chilled water systems. The extent of the costs and savings would depend on the specific circumstances of each facility.

2.2.5.4 Other Non-Discretionary Cost or Savings Imposed on Local Agencies

There are no added non-discretionary costs or savings to local agencies.

2.2.5.5 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state.

2.3 Energy Savings

The Statewide CASE Team gathered stakeholder input to inform the energy savings analysis. Stakeholder input was used to understand key factors influencing energy savings estimates and further feedback on the Draft CASE Report is welcome. In the development of this analysis, the Statewide CASE Team held a meeting with one major cooling tower manufacturer and received feedback from two major cooling tower manufacturers and cooling tower interest groups following the February 13th, 2023, Stakeholder meeting.

Key takeaways from the feedback were primarily focused on ensuring that all aspects of the analysis have been considered in developing energy savings, understanding market impacts, and estimating cost impacts. Stakeholders demonstrated concern with the magnitude of the proposed code change to the prescriptive efficiency minimum, and the impact the change would have on the existing product lines. The Statewide CASE Team performed a thorough analysis to ensure that the proposed code change is cost effective. Additionally, as a proposed code change to a prescriptive requirement, products that do not meet the new proposed value can be installed by utilizing the performance path. See Appendix F for a summary of stakeholder engagement.

Energy savings benefits may have potential to disproportionately impact DIPs. Refer to Section 2.6 for more details addressing energy equity and environmental justice.

2.3.1 Energy Savings Methodology

2.3.1.1 Key Assumptions for Energy Savings Analysis

The Statewide CASE Team used EnergyPlus to conduct the energy and water savings analysis for the air-cooled chiller threshold measure. Energy models are sourced from the California Building Energy Code Compliance (CBECC) software for commercial buildings prototype building models and are modified to include the proposed changes to the energy standards.

The energy savings analysis of the cooling tower efficiency measure assesses the impacts of increasing the prescriptive minimum efficiency for cooling towers from 60 gpm/hp to a higher efficiency level. To determine the impacts, comparisons between buildings compliant with the existing 2022 Title 24, Part 6 Standards and buildings compliant with the proposed measure were examined. In practice, this took the form of comparing the energy used by a building with a baseline minimally code-compliant cooling tower to the same building with a cooling tower meeting the proposed code change efficiency. The proposed efficiency was developed by running iterations of the proposed model at efficiencies of 80 gpm/hp, 100 gpm/hp, and 120 gpm/hp, selected based on current cooling tower product availability, in order to determine the highest cooling tower efficiency that is cost effective for each of California's climate zones.

Ultimately, the model results presented in this report represent, when possible, the maximum cooling tower efficiency that achieved cost effectiveness which reflects the proposed code change. For climate zones for which no examined cooling tower efficiency was found to be cost-effective, the model results presented reflect the efficiency that maximized the benefit-to-cost ratio for given climate zone. The efficiencies for which results are presented are shown in Table 16.

Table 16: Baseline and Proposed Cooling Tower Efficiency by Climate Zone

Climate Zone	Baseline Cooling Tower Efficiency (gpm/hp)	Proposed Cooling Tower Efficiency (gpm/hp)
1	42.1	100.0
2	60.0	100.0
3	60.0	100.0
4	60.0	100.0
5	60.0	100.0
6	60.0	100.0
7	60.0	100.0
8	60.0	120.0
9	60.0	100.0
10	60.0	120.0
11	60.0	100.0
12	60.0	100.0
13	60.0	100.0
14	60.0	100.0
15	60.0	120.0
16	42.1	100.0

The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone specific Life Cycle Cost Hourly Factors when calculating energy and energy cost impacts. The proposed code change for the cooling tower efficiency measure is applicable to new construction, additions, and alterations.

2.3.1.2 Energy Savings Methodology per Prototypical Building

The Statewide CASE Team measured per unit energy savings expected from the proposed code changes in several ways in order to quantify key impacts. First, savings are calculated by fuel type. Electricity savings are measured in terms of both energy usage and peak demand reduction. Natural gas savings are quantified in terms of energy usage. Second, the Statewide CASE Team calculated Source Energy Savings. Source Energy represents the total amount of raw fuel required to operate a building. In addition to all energy used from on-site production, source energy incorporates all transmission, delivery, and production losses. The hourly Source Energy values provided by CEC are strongly correlated with GHG emissions.[10] Finally, the Statewide CASE Team calculated Long-term Systemwide Cost (LSC) Savings, formerly known as Time Dependent Valuation (TDV) Energy Cost Savings. LSC Savings are calculated using hourly energy cost metrics for both electricity and natural gas provided by the CEC. These LSC hourly factors are projected over the 30-year life of the building and incorporate the hourly cost of marginal generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO2 emissions.[10]

The CEC directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries for different types of buildings. All 2025 prototype models can be obtained by downloading the CBECC software from the NORESCO Title 24 Nonresidential Compliance Software website (NORESCO n.d.). Prototypes for this measure were selected as those for which the Standard Design central plant consists of water-cooled chillers. The Draft CASE Report presents the analysis results for the OfficeLarge prototype, which was available for analysis at the time of the report. Prototypes for the Hospital and SchoolLarge will be examined for the Final CASE Report, once available. The measure would also impact multifamily buildings that have cooling towers, however, a multifamily model prototype with a cooling tower of significant capacity is unavailable, and thus simulation results were not developed. However, since stakeholder input and additional resources demonstrate a minimal portion of multifamily buildings as having cooling towers, with the most common application being small cooling towers to serve common spaces, a comprehensive analysis of multifamily specific savings was not performed. For multifamily buildings and all other building types anticipated to be impacted for which no prototype model was available at the time of the report, average per unit savings were assumed to be representative and used for statewide savings analyses.

A summary of the prototype buildings to be used in the Statewide CASE Team are presented in Table 17, however, again note that only the OfficeLarge results are presented in the Draft CASE Report. The same impacts are anticipated on both new

[10] See Hourly Factors for Source Energy, Long-term Systemwide Cost, and Greenhouse Gas Emissions at https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

construction and addition projects, and alteration projects, and thus the same prototypes were used for each.

Table 17: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Hospital	5	241,374	5-Story Hospital plus basement U.S. DOE prototype model
OfficeLarge	12	498,589	12 story + 1 basement office building with 5 zones and a ceiling plenum on each floor. Window-to-wall ratio (WWR) of 0.40. Standard Design HVAC system of two centrifugal water-cooled chillers
SchoolLarge	2	210,866	High school with window-to-wall ratio of 35% and SRR 1.4%. Standard Design HVAC system of water-cooled chiller

The Statewide CASE Team estimated LSC, Source Energy, electricity, natural gas, peak demand, and GHG impacts by simulating the proposed code change in EnergyPlus using prototypical buildings and rulesets from the 2025 Research Version of the California Building Energy Code Compliance (CBECC) software.

CBECC generates two models based on user inputs: the Standard Design and the Proposed Design. ￼ The Standard Design representsthe geometry of the prototypical building and a design that uses a set of features that result in a LSC budget and Source Energy budget that is minimally compliant with 2022 Title 24, Part 6 code requirements. Features used in the Standard Design are described in the 2022 Nonresidential ACM Reference Manual. The Proposed Design represents the same geometry as the Standard Design, but it assumes the energy features that the software user describes with user inputs. To develop savings estimates for the proposed code changes, the Statewide CASE Team created a Standard Design and Proposed Design for each prototypical building with the Standard Design representing compliance with 2022 code and the Proposed Design representing compliance with the proposed requirements. Comparing the energy impacts of the Standard Design to the Proposed Design reveals the impacts of the proposed code change relative to a building that is minimally compliant with the 2022 Title 24, Part 6.

There is an existing Title 24, Part 6 requirement that covers the building system in question and applies to both new construction/additions and alterations, so the Standard Design is minimally compliant with the 2022 Title 24 requirements.

Pertaining to this measure, the Standard Design HVAC system includes two cooling towers minimally compliant with Title 24, Part 6 requirements: a prescriptive minimum efficiency of 60 gpm/hp for Climate Zones 2-15 and a mandatory minimum efficiency of 42.1 gpm/hp for Climate Zones 1 and 16. The cooling tower capacities vary between climate zones due to design wet bulb temperatures, and each was assumed as the rated capacity required to meet the design cooling load.

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 18 presents precisely which parameters were modified for the OfficeLarge prototype and what values were used in the Standard Design and Proposed Design.

Specifically, the proposed conditions assume a cooling tower efficiency of 100-120 gpm/hp for the two building cooling towers. The proposed measure is climate-sensitive and was thus modeled for all climate zones.

Table 18: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
OfficeLarge	Climate Zones 1 and 16	CoolingTower: VariableSpeed	Design Fan Power	Design Water Flow Rate/Design Fan Power: 42.1 gpm/hp	Design Water Flow Rate/Design Fan Power: 100, 120 gpm/hp
OfficeLarge	Climate Zones 2-15	CoolingTower: VariableSpeed	Design Fan Power	Design Water Flow Rate/Design Fan Power: 60 gpm/hp	Design Water Flow Rate/Design Fan Power: 100, 120 gpm/hp

EnergyPlus calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/yr) and therms per year (therms/yr). The Statewide Case Team then applied the 2025 LSC hourly factors to calculate Long-term Systemwide Cost in2026 present value dollars (2026 PV$), Source Energy hourly factors to calculate Source Energy Use in kilo British thermal units per year (kBtu/yr), and hourly GHG emissions factors to calculate annual GHG emissions in metric tons of carbon dioxide emissions equivalent per year (MT or “tonnes” CO_2e/yr).EnergyPlus also calculates annual peak electricity demand measured in kilowatts (kW).

The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone specific LSC hourly factors when calculating energy and energy cost impacts.

Per-unit energy impacts for nonresidential buildings are presented in savings per square foot. Annual energy, GHG, and peak demand impacts for each prototype building were translated into impacts per square foot by dividing by the floor area of the prototype building. This step allows for an easier comparison of savings across different building types and enables a calculation of statewide savings using the construction forecast that is published in terms of floor area by building type.

2.3.1.3 Statewide Energy Savings Methodology

The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the CEC provided. Savings for building types for which no prototype model was available at the time of this report were estimated by applying the average per-unit energy impacts of the available models. The Statewide Construction Forecasts estimate new construction/additions that would occur in 2026, the first year that the 2025 Title 24, Part 6 requirements are in effect. They also estimate the amount of total existing building stock in 2026, which the Statewide CASE Team used to approximate savings from building alterations. The construction forecast provides construction (new construction/additions and existing building stock) by building type and climate zone, as shown in Appendix A.

Appendix A presents additional information about the methodology and assumptions used to calculate statewide energy impacts.

2.3.2 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions per unit for the OfficeLarge prototype are presented in Table 19 through Table 22 for new construction/additions and Table 23 through Table 26 for alterations. The per-unit energy savings figures do not account for naturally occurring market adoption or compliance rates. Per-unit savings for the first year are expected to range from 14,290 to 482,574 kWh/yr. The measure is anticipated to have very minor peak demand reductions are expected from the proposed code change.

The analysis demonstrates a wide variation in savings results depending on climate zone and proposed efficiency. Cooling tower performance is heavily dependent on heating degree days and outside air dry-bulb temperature, which influence the thermal capacity and runtime. Cooling towers in warm dry climates were observed to have significantly higher annual electricity savings, such as Climate Zone 15, which had an estimate savings of 2.5 times the average savings.

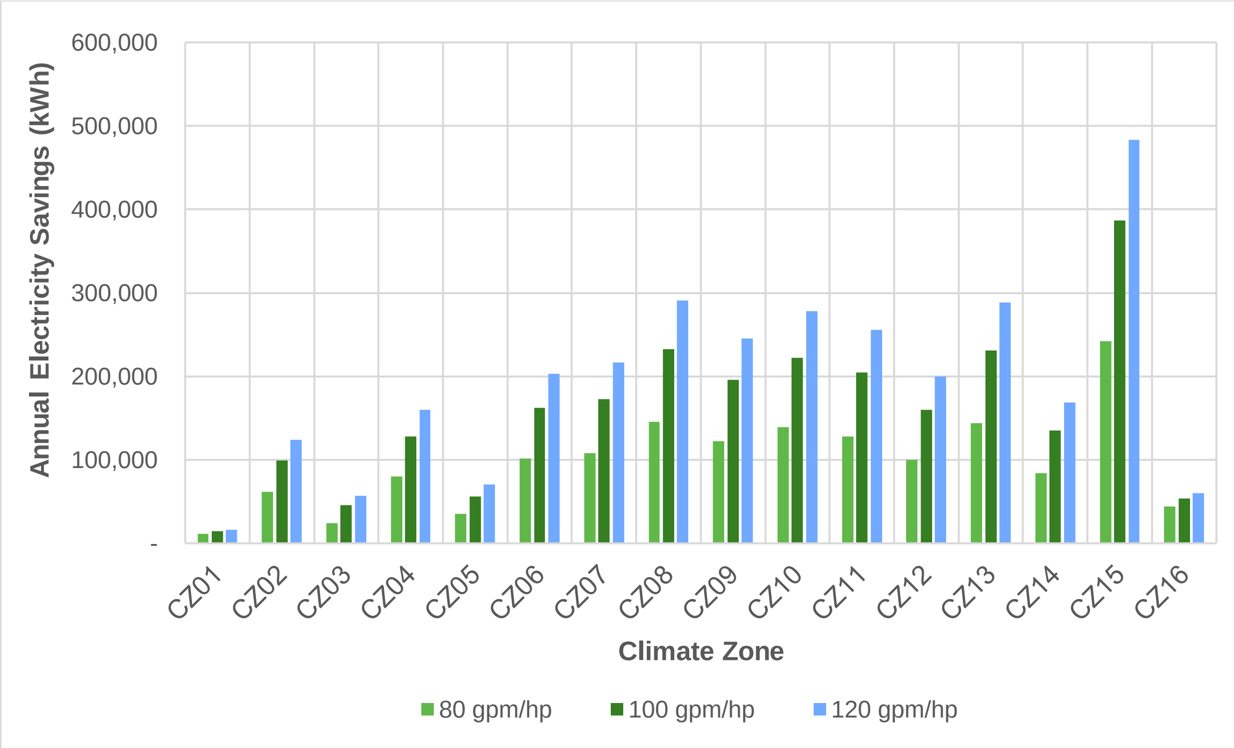

Figure 5: Annual Electricity Savings by Climate Zone and Efficiency

Table 19: First Year Electricity Savings (kWh) Per Square Foot by Climate Zone (CZ), New Construction/Additions - Cooling Tower Efficiency

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
OfficeLarge	0.00	0.02	0.01	0.02	0.01	0.03	0.03	0.05	0.03	0.05	0.04	0.03	0.04	0.02	0.08	0.01

Table 20: First Year Peak Demand Reduction (kW) Per Square Foot by Climate Zone (CZ), New Construction/Additions – Cooling Tower Efficiency

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
OfficeLarge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 21: First Year Source Energy Savings (kBtu) Per Square Foot by Climate Zone (CZ), New Construction/Additions – Cooling Tower Efficiency

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
OfficeLarge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 22: First Year Long-term Systemwide Cost Savings (2026 PV$) Per Square Foot by Climate Zone (CZ), New Construction – Cooling Tower Efficiency

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
OfficeLarge	0.01	0.07	0.03	0.10	0.04	0.13	0.15	0.23	0.16	0.22	0.17	0.12	0.20	0.11	0.41	0.04

Table 23: First Year Electricity Savings (kWh) Per Square Foot by Climate Zone (CZ), Alterations - Cooling Tower Efficiency

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
OfficeLarge	0.00	0.02	0.01	0.02	0.01	0.03	0.03	0.05	0.03	0.05	0.04	0.03	0.04	0.02	0.08	0.01

Table 24: First Year Peak Demand Reduction (kW) Per Square Foot by Climate Zone (CZ), Alterations – Cooling Tower Efficiency

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
OfficeLarge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 25: First Year Source Energy Savings (kBtu) Per Square Foot by Climate Zone (CZ), Alterations – Cooling Tower Efficiency

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
OfficeLarge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 26: First Year Long-term Systemwide Cost Savings (2026 PV$) Per Square Foot, Alterations – Cooling Tower Efficiency

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
OfficeLarge	0.01	0.07	0.03	0.10	0.04	0.13	0.15	0.23	0.16	0.22	0.17	0.12	0.20	0.11	0.41	0.04

2.4 Cost and Cost Effectiveness

2.4.1 Energy Cost Savings Methodology

Energy cost savings were calculated by applying the LSC hourly factors to the energy savings estimates that were derived using the methodology described in Section 2.3.1. LSC hourly factors are a normalized metric to calculate energy cost savings that accounts for the variable cost of electricity and natural gas for each hour of the year, along with how costs are expected to change over the period of analysis. In this case, the period of analysis used is 30 years.

The CEC requested LSC savings over the 30-year period of analysis in both 2026 present value dollars (2026 PV$) and nominal dollars. The cost-effectiveness analysis uses LSC values in 2026 PV$. Costs and cost effectiveness using and 2026 PV$ are presented in Section 2.4 of this report. CEC uses results in nominal dollars to complete the Economic and Fiscal Impacts Statement (From 399) for the entire package of proposed change to Title 24, Part 6. Appendix G presents LSC savings results in nominal dollars.

The proposed code change for the cooling tower efficiency measure applies to new construction buildings and additions. Energy cost savings for alterations are the same as energy cost savings for new construction and additions. Since the measure as proposed is an increase in the prescriptive minimum efficiency for cooling towers, the proposed and baseline cases for alterations and new construction projects are the same.

2.4.2 Energy Cost Savings Results

Per-unit energy cost savings for newly constructed buildings, additions, and alterations in terms of LSC savings realized over the 30-year period of analysis are presented in 2026 present value dollars (2026 PV$) in Table 27 through Table 30.

The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods, however this measure was found to have negligible impacts (0 percent) on peak demand relative to the baseline.

Any time code changes impact cost, there is potential to disproportionately impact DIPs. Refer to Section 2.6 for more details addressing energy equity and environmental justice.

Table 27: 2026 PV Long-term Systemwide Cost Savings Over 30-Year Period of Analysis – Per Prototype Square Foot – New Construction and Additions– OfficeLarge Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.13	0.00	0.13
7	0.15	0.00	0.15
8	0.23	0.00	0.23
9	0.16	0.00	0.16
10	0.22	0.00	0.22
11	0.17	0.00	0.17
12	0.12	0.00	0.12
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.41	0.00	0.41
16	0.00	0.00	0.00

Table 28: 2026 PV Long-term Systemwide Cost Over 30-Year Period of Analysis – Per Prototype Square Foot – Alterations– OfficeLarge Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.13	0.00	0.13
7	0.15	0.00	0.15
8	0.23	0.00	0.23
9	0.16	0.00	0.16
10	0.22	0.00	0.22
11	0.17	0.00	0.17
12	0.12	0.00	0.12
13	0.20	0.00	0.20
14	0.00	0.00	0.00
15	0.41	0.00	0.41
16	0.00	0.00	0.00

Table 29: Average 2026 PV Long-term Systemwide Cost Savings Over 30-Year Period of Analysis – Per Prototype Square Foot – New Construction and Additions – All Prototypes

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.13	0.00	0.13
7	0.15	0.00	0.15
8	0.23	0.00	0.23
9	0.16	0.00	0.16
10	0.22	0.00	0.22
11	0.17	0.00	0.17
12	0.12	0.00	0.12
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.41	0.00	0.41
16	0.00	0.00	0.00

Table 30: Average 2026 PV Long-term Systemwide Cost Savings Over 30-Year Period of Analysis – Per Prototype Square Foot – Alterations – All Prototypes

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.13	0.00	0.13
7	0.15	0.00	0.15
8	0.23	0.00	0.23
9	0.16	0.00	0.16
10	0.22	0.00	0.22
11	0.17	0.00	0.17
12	0.12	0.00	0.12
13	0.20	0.00	0.20
14	0.00	0.00	0.00
15	0.41	0.00	0.41
16	0.00	0.00	0.00

2.4.3 Incremental First Cost

Incremental first cost is the initial cost to adopt the proposed equipment or building practices when compared to the cost of the equivalent baseline project. To estimate incremental first costs for the air-cooled chiller threshold measure, the Statewide CASE Team utilized several sources, as discussed below.

Costs for the baseline consider the cost of a new cooling tower, minimally code-compliant to existing 2022 Title 24, Part 6 rules, with a prescriptive minimum efficiency of 60 gpm/hp. Baseline costs were developed based on RSMeans Building Construction Data 2021 which provides a cost of $204 per ton (Gordian 2021). Since the measure is climate sensitive, the required cooling capacity varies by climate zone based on design conditions for the climate zone reference city, and baseline costs were estimated for each required capacity as determined by the EnergyPlus auto-sizing function. To account for California specific cost impacts, the RSMeans baseline cost were adjusted using the total RSMeans Location Factors for the city nearest each climate zone reference city (See Appendix H).

Higher efficiency cooling towers typically result in increased costs primarily driven by the increased physical size of the heat transfer surface required to achieve the higher efficiency, thus requiring more material, cooling tower fill, etc. Additional options can be selected to increase efficiency, such as velocity recovery stacks, however, the analysis was performed considering the most basic, lowest cost option, and thus these options were not included in the proposed design. The incremental cost for the analysis was determined using data provided by cooling tower manufacturer's equipment selection software, which reports a cost ratio for each cooling tower compared to the lowest cost option that meets given design conditions (Baltimore Aircoil Company n.d.). For this analysis, the design conditions were set to select the baseline, minimally code-compliant cooling tower at the required capacity for each climate zone under CTI rating conditions of 95°F entering water temperature, 85°F leaving water temperature, and 75°F entering wetbulb temperature. Additionally, the cost ratio was adjusted to ensure the reference unit (i.e. the unit with a cost ratio of one) was the lowest cost unit meeting the baseline efficiency requirement of 60 gpm/hp. Linear regressions of the incremental cost versus cooling tower capacity for each efficiency level were created to interpolate the efficiency at each capacity. Table 31 presents a breakdown of the estimated incremental costs of cooling towers by capacity (gpm) and efficiency (gpm/hp). Labor costs are expected to be the same between the baseline and incremental models.

The Statewide CASE Team is continuing to collect cost data and would welcome input on these incremental first costs.

Table 31: Cooling Tower Incremental Cost by Capacity and Efficiency

Cooling Tower Capacity (gpm)	Incremental Cost (%), 80 gpm/hp	Incremental Cost (%), 100 gpm/hp	Incremental Cost (%), 120 gpm/hp
300-399	15%	15%	24%
400-499	16%	19%	29%
500-599	16%	23%	33%
600-699	17%	26%	37%
700-799	17%	30%	42%
800-899	18%	34%	46%
900-999	18%	37%	50%
1,000-1,099	19%	41%	55%
1,100-1,199	19%	45%	59%
1,200-1,299	20%	48%	64%
1,300-1,399	21%	52%	68%
1,400-1,499	21%	56%	72%

An additional component of the incremental cost between the baseline efficiency cooling tower and the proposed higher efficiency cooling tower is the potential need for increased structural support due to the higher weight associated with increased efficiency (see Section 2.2.2). This increased cost would be applicable to cooling towers installed on building rooftops. Table 32 presents the average cooling tower operating weight by efficiency along with the estimated increased structural cost for higher efficiency cooling towers. Cost increases were estimated assuming $2,413.96 of additional structural steel costs for approximately 5,000 lbs. of additional weight based on estimates from the *2019 Prescriptive Efficiency Requirements for Cooling Towers CASE Report* developed during the 2019 Title 24, Part 6 Code Cycle, adjusted to 2023 dollars (U.S. Bureau of Labor Statistics n.d., California Energy Codes and Standards 2018).

Table 32: Estimated Increased Structural Costs by Cooling Tower Efficiency

Cooling Tower Efficiency	Average Operating Weight (lbs.)	Average Weight Increase Over Baseline (lbs.)	Estimated Increased Structural Costs ($)
60 gpm/hp	12,645	N/A	N/A
80 gpm/hp	13,134	489	$236.09
100 gpm/hp	16,745	4,100	$1,979.45
120 gpm/hp	17,643	4,998	$2,412.99

The final incremental first cost is captured by the equation:

$$Incremental\ First\ Cost_{CZ} = \$204/ton * RSMeans\ Location\ Factor_{CZ}/100 * (\%\ Incremenatl\ Cost\ by\ Efficiency\ and\ Capacity) + Structural\ Cost\ Increase\ by\ Efficiency$$

The incremental cost of this measure is likely to change overtime. As more efficient cooling towers become normalized, and further improvements are made, higher efficiency cooling towers are anticipated to become cheaper.

2.4.4 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is 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.

The present value of equipment maintenance costs (or savings) are calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2025 Life Cycle Cost Hourly Factors. The present value of maintenance costs that occurs in the n^{th} year is calculated as follows:

$$\text{Present Value of Maintenance Cost} = \text{Maintenance Cost} \times \left\lfloor \frac{1}{1+d} \right\rfloor^{n}$$

For the cooling tower efficiency increase, maintenance activities and intervals are not expected to change with the proposed code changes, and thus maintenance costs are not expected to increase. The Statewide CASE Team is continuing to collect data and would welcome input on assumptions for incremental maintenance costs.

In terms of maintenance, Cooling towers require specific activities for proper operations due to exposure to water and to the outdoors. ASHRAE provides guidelines for cooling tower maintenance in ASHRAE Standard 180, Table 5-10 (American Society of Heating, Refrigeration, and Air-Conditioning Engineers n.d.). Based on the ASHRAE guidelines, the primary maintenance activity for cooling towers is chemical testing and water treatment, which needs to be checked monthly for open systems to ensure proper operation and reduce potential for scaling. Additional maintenance activities should occur quarterly, semiannually, and annually, and are summarized in Table 33.

Table 33: Cooling Tower Maintenance Guidelines

Monthly	Perform chemical testing of system water (open systems)
Quarterly	Perform chemical testing of system water (closed systems) Check water system ultraviolet lamp Check chemical injector device Check drive system Check belt for wear Check sheaves for alignment Check for fouling and corrosion
Semiannually	Check control system operations Check variable-frequency drive for proper operation Inspect pumps and components
Annually	Check control box for dirt and debris Check fan blades and housing Assess field-serviceable bearings Check for proper fluid flow and leaks Check for proper damper operation Check motors and pumps for proper operation

According to the 2015 ASHRAE Handbook for HVAC Applications, the equipment useful life of a cooling tower is 20 years (ASHRAE 2015). With proper maintenance, cooling towers are anticipated to maintain performance throughout the lifetime, with the average replacement occurring at 17.5 years according to the ASHRAE Owning and Operating Cost Database (ASHRAE n.d.).

2.4.5 Cost Effectiveness

This measure proposes a primary prescriptive requirement. As such, a cost analysis is required to demonstrate that the measure is cost effective over the 30-year period of analysis.

The CEC establishes the procedures for calculating cost effectiveness. The Statewide CASE Team collaborated with CEC staff to confirm that the methodology in this report is consistent with their guidelines, including which costs were included in the analysis. The incremental first cost and incremental maintenance costs over the 30-year period of analysis were included. The LSC savings from electricity were also included in the evaluation. Design costs were not included nor were the incremental costs of code compliance verification.

According to the CEC's definitions, a measure is cost effective if the benefit-to-cost (B/C) ratio is greater than 1.0. The B/C ratio is calculated by dividing the cost benefits realized over 30 years by the total incremental costs, which includes maintenance costs for 30 years. The B/C ratio was calculated using 2026 PV costs and cost savings.

Results of the per-unit cost-effectiveness analyses are presented in Table 34 and Table 35 for new construction/additions and alterations, respectively, for the OfficeLarge prototype. Results for the Hospital, and SchoolLarge prototypes will be included in the analysis for the Final CASE Report.

Based on the analysis, the proposed measure saves money over the 30-year period of analysis relative to existing conditions. The proposed code change is cost effective in Climate Zones 6-12, and 15 for new construction and additions. For alterations, the proposed code change is cost effective in Climate Zones 6-13, and 15. Note that cost effectiveness is not presented for new construction projects in Climate Zones 1, 2, 5, and 13 for which no office construction is forecasted in 2026, nor in Climate Zones 4 and 14, for which no change is proposed as no cost effective efficiency was found.

Table 34: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction/Additions

Climate Zone	Benefits LSC Savings + Other PV Savings [a] (2026 PV$)	Costs Total Incremental PV Costs [b] (2026 PV$)	Benefit-to-Cost Ratio
1	$0.00	$0.00	-
2	$0.00	$0.00	-
3	$0.00	$0.00	-
4	$0.00	$0.00	-
5	$0.00	$0.00	-
6	$0.14	$0.13	1.14
7	$0.17	$0.16	1.03
8	$0.26	$0.24	1.11
9	$0.18	$0.16	1.08
10	$0.25	$0.20	1.25
11	$0.20	$0.18	1.09
12	$0.14	$0.14	1.02
13	$0.00	$0.00	-
14	$0.00	$0.00	-
15	$0.45	$0.27	1.64
16	$0.00	$0.00	-

a. **Benefits: Long-term Systemwide Cost Savings + Other PV Savings:** Benefits include Life Cycle Energy Cost Savings over the period of analysis (Energy + Environmental Economics 2016, 51-53). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost, incremental PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at end of CASE analysis period.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis if PV of proposed costs is greater than PV of current costs. Costs are discounted at a real (inflation-adjusted) three percent. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

Table 35: 30-Year Cost-Effectiveness Summary Per Square Foot – Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings[a] (2026 PV$)	Costs Total Incremental PV Costs[b] (2026 PV$)	Benefit-to-Cost Ratio
1	$0.00	$0.00	-
2	$0.00	$0.00	-
3	$0.00	$0.00	-
4	$0.00	$0.00	-
5	$0.00	$0.00	-
6	$0.14	$0.13	1.15
7	$0.17	$0.16	1.04
8	$0.26	$0.24	1.11
9	$0.18	$0.16	1.09
10	$0.25	$0.20	1.25
11	$0.20	$0.18	1.10
12	$0.14	$0.14	1.03
13	$0.22	$0.17	1.26
14	$0.00	$0.00	-
15	$0.45	$0.27	1.64
16	$0.00	$0.00	-

a. **Benefits: Long-term Systemwide Cost Savings + Other PV Savings: Benefits** include Life Cycle Energy Cost Savings over the period of analysis (Energy + Environmental Economics 2016, 51-53). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost, incremental PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at end of the CASE analysis period.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis if PV of proposed costs is greater than PV of current costs. Costs are discounted at a real (inflation-adjusted) three percent rate. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the Benefit-to-Cost ratio is infinite.

2.5 First-Year Statewide Impacts

2.5.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction and additions by multiplying the per-unit savings, which are presented in

Section 2.3.2, by assumptions about the percentage of newly constructed buildings that would be impacted by the proposed code. As mentioned in Section 2.3.1.3, savings for building types for which no prototype model was available at the time of this report were estimated by applying the average per-unit energy impacts of the available models. The statewide new construction forecast for 2026 is presented in Appendix A, as are the Statewide CASE Team's assumptions about the percentage of new construction that would be impacted by the proposal (by climate zone and building type).

The proposed code change applies to alterations. To determine the percentage of existing buildings impacted by these two measures, it was estimated that based on an equipment useful life of 20 years per the ASHRAE handbook (ASHRAE 2015), five percent of existing cooling towers are replaced each year. Multiplying this turnover rate by the percent of each building type estimated to have cooling towers provides the estimates for the Statewide impacts of the proposed code change on alterations. For the Draft CASE Report, the portion of existing buildings exempted from the requirement due to cooling towers mounted to rooftops was not accounted for. The Statewide CASE Team is continuing to collect data and would welcome data and input for accurately accounting for this impact.

The first-year energy impacts represent the first-year annual savings from all buildings that were completed in 2026. The 30-year energy cost savings represent the energy cost savings over the entire 30-year analysis period. The statewide savings estimates do not take naturally occurring market adoption or compliance rates into account.

The tables below present the first-year statewide energy and energy cost savings from newly constructed buildings and additions (Table 36) and alterations (Table 37) by climate zone. Table 38 presents first-year statewide savings from new construction, additions, and alterations.

Statewide savings estimates take into account estimates for the prevalence of chilled-water systems based on building type. These estimates were formulated based on microdata from the 2018 Commercial Building Energy Consumption Survey, which shows that 1.5 percent of buildings in the U.S. Census Pacific Division have water-cooled chillers, and in turn cooling towers, with variations based on building type. Further details of the methodology for this estimate are provided in Appendix A.

Chilled-water systems have been found to have limited prevalence in multifamily buildings. During the February 13th stakeholder meeting, four stakeholders reported that approximately 1-10 percent of their multifamily projects utilize cooling towers, while one reported 20-30 percent. Data from the *2015 Fannie Mae Multifamily Energy and Water Market Research Survey* validates this observation, showing no commercial cooling towers in the 954 multifamily buildings surveyed nationwide (Fannie Mae 2015). When used, cooling towers in multifamily buildings are primarily used for conditioning common spaces, accounting for a fraction of the total floor area of the building. As a result, for the purpose of this analysis, the Statewide CASE Team has conservatively assumed that 1 percent of the high-rise and midrise multifamily buildings in California have cooling towers.

While a statewide analysis is crucial to understanding broader effects of code change proposals, there is potential to disproportionately impact DIPs that needs to be considered. Refer to Section 2.6 for more details addressing energy equity and environmental justice.

Table 36: Statewide Energy and Energy Cost Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year[a] 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 2026 PV$)
1	0	0	0	0	0	$0.00
2	0	0	0	0	0	$0.00
3	0	0	0	0	0	$0.00
4	0	0	0	0	0	$0.00
5	0	0	0	0	0	$0.00
6	1,009,907	0.03	0.001	0	0	$0.13
7	655,709	0.02	0.001	0	0	$0.10
8	1,573,915	0.08	0.001	0	0	$0.37
9	2,810,630	0.10	0.002	0	0	$0.44
10	562,670	0.03	0	0	0	$0.13
11	153,867	0.01	0	0	0	$0.03
12	861,188	0.02	0	0	0	$0.11
13	193,687	0.01	0	0	0	$0.04
14	0	0	0	0	0	$0.00
15	63,257	0.01	0	0	0	$0.03
16	0	0	0	0	0	$0.00
Total	**7,884,830**	**0.29**	**0.01**	**0**	**0**	**$1.36**

a. First-year savings from all buildings completed statewide in 2026.

Table 37: Statewide Energy and Energy Cost Impacts – Alterations

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year[a] 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 2026 PV$)
1	0	0	0	0	0	$0.00
2	0	0	0	0	0	$0.00
3	0	0	0	0	0	$0.00
4	0	0	0	0	0	$0.00
5	0	0	0	0	0	$0.00
6	3,324,827	0.09	0	0	0	$0.43
7	2,598,697	0.08	0	0	0	$0.38
8	5,223,714	0.26	0.01	0	0	$1.22
9	9,372,695	0.32	0.01	0	0	$1.47
10	2,701,430	0.13	0	0	0	$0.60
11	302,694	0.01	0	0	0	$0.05
12	3,369,164	0.09	0	0	0	$0.42
13	745,656	0.03	0	0	0	$0.15
14	0	0.	0	0	0	$0.00
15	271,386	0.02	0	0	0	$0.11
16	0	0.	0	0	0	$0.00
Total	**27,910,263**	**1.03**	**0.02**	**0**	**0**	**$4.84**

a. First-year savings from all buildings completed statewide in 2026.

Table 38: Statewide Energy and Energy Cost Impacts – 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 (PV$ Million)
New Construction & Additions	0.3	0.0	-	-	1
Alterations	1.0	0.0	-	-	5
Total	**1.3**	**0.0**	**-**	**-**	**6**

a. First-year savings from all alterations completed statewide in 2026.

2.5.2 Statewide Greenhouse Gas (GHG) Emissions Reductions

The Statewide CASE Team calculated avoided GHG emissions associated with energy consumption using the hourly GHG emissions factors that CEC developed along with the 2025 LSC hourly factors and an assumed cost of $123.15 per metric tons of carbon dioxide equivalent emissions (metric tons CO2e).

The monetary value of avoided GHG emissions is based on a proxy for permit costs (not social costs).[11] The cost-effectiveness analysis presented in Section 0 of this report does not include the cost savings from avoided GHG emissions. To demonstrate the cost savings of avoided GHG emissions, the Statewide CASE Team disaggregated the value of avoided GHG emissions from the other economic impacts.

Table 39 presents the estimated first-year avoided GHG emissions of the proposed code change. During the first year, GHG emissions of 34 (metric tons CO2e) would be avoided.

Table 39: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO2e)	Natural Gas Savings[a] (Million Therms/yr)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO2e)	Total Reduced GHG Emissions[b] (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions[c] ($)
Cooling Tower Efficiency	1.3	45	0	0	45	5,520
Total	**1.3**	**45**	**0**	**0**	**45**	**5,520**

a. First-year savings from all applicable newly constructed buildings, additions, and alterations completed statewide in 2026.

b. GHG emissions savings were calculated using hourly GHG emissions factors published alongside the LSC hourly factors published by the CEC here: https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

c. The monetary value of avoided GHG emissions is based on a proxy for permit costs (not social costs) derived from the 2022 TDV Update Model published by CEC here: https://www.energy.ca.gov/files/tdv-2022-update-model

2.5.3 Statewide Water Use Impacts

The proposed code change would not result in water savings.

[11] The permit cost of carbon is equivalent to the market value of a unit of GHG emissions in the California Cap-and-Trade program, while social cost of carbon is an estimate of the total economic value of damage done per unit of GHG emissions. Social costs tend to be greater than permit costs. See more on the Cap-and-Trade Program on the California Air Resources Board website: https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program.

2.5.4 Statewide Material Impacts

Cooling towers are constructed primarily of steel, either galvanized or stainless. Fiberglass cooling towers are available for certain applications, though they make up a minor portion of available units, and are ignored in the analysis of this measure.

Higher efficiency cooling towers are larger and heavier resulting in increased construction materials, not including structural materials. Based on the engineering data for available units, higher efficiency cooling towers have an average shipping weight approximately 1,400 lbs. heavier than a baseline 60 gpm/hp unit (Baltimore Aircoil Company n.d., Evapco n.d., SPX Cooling Technologies n.d.).

Table 40: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per Square Foot)	First-Year [a] Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO2e)
Mercury	No Change	0	0	0
Lead	No Change	0	0	0
Copper	No Change	0	0	0
Steel	Increase	0.147	5,268,046	-2897
Plastic	No Change	0	0	0
Others	No Change	0	0	0
TOTAL	-	0.147	**5,268,046**	**-2897**

a. First-year savings from all buildings completed statewide in 2026.

2.5.5 Other Non-Energy Impacts

No non-energy impacts are anticipated from the proposed code change.

2.6 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in DIPs and the role this history plays in the environmental justice issues that persist today. DIPs refer to the areas throughout California that most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes, as well as high incidence of asthma and heart disease. DIPs also incorporate race, class, and gender since these intersecting identity factors affect how people frame issues, interpret, and experience the world.12 While the term disadvantaged communities (DACs) is often used in the energy industry and state agencies, the Statewide CASE Team chose to use terminology that is more acceptable to and less stigmatizing for those it seeks to describe (DC Fiscal Policy Institute 2017).

Including impacted communities in the decision-making process, ensuring that the benefits and burdens of the energy sector are evenly distributed, and grappling with the unjust legacies of the past all serve as critical steps to achieving energy equity. Code change proposals must be developed and adopted with intentional screening for unintended consequences, otherwise they risk perpetuating systemic injustices and oppression.

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice, therefore reducing the impacts of disparities in DIPs. The Statewide CASE Team does not recommend further research or action at this time.

2.6.1 Research Methods and Engagement

Cooling towers are common on commercial and institutional facilities and are not expected to impact energy equity or environmental justice in any specific way.

[12] Environmental disparities have been shown to be associated with unequal harmful environmental exposure correlated with race/ethnicity, gender, and socioeconomic status. For example, chronic diseases, such as respiratory diseases, cardiovascular disease, and cancer, associated with environmental exposure have been shown to occur in higher rates in the LGBTQ+ population than in the cisgender, heterosexual population (Goldsmith and Bell 2021). Socioeconomic inequities, climate, energy, and other inequities are inextricably linked and often mutually reinforcing.

3. Air-Cooled Chiller Threshold

3.1 Measure Description

3.1.1 Proposed Code Change

This measure proposes adding an exception to the prescriptive requirement in Title 24, Part 6 140.4(j) and 170.2(c)4H which currently limits air-cooled chillers to providing no more than 300 tons of cooling capacity. The exception would allow for air-cooled chillers in excess of this 300-ton capacity for high efficiency air-cooled chillers that meet certain efficiency requirements. This measure would apply to nonresidential and multifamily new construction and new systems serving additions. Alterations are not expected to be impacted due to the nature of design and selection of chiller type and supplementary equipment.

Projects are exempted from the current requirement at sites where the water quality fails to meet manufacturer's requirements for the use of water-cooled chillers, for chillers that are used to charge a thermal storage system with a design temperature of less than 40°F, and for systems serving healthcare facilities.

This measure also proposes adding an exception for heating-only air-to-water heat pumps and a limited exception for chillers using heat recovery. The current language arguably does not apply to heating-only air-to-water heat pumps as it specifically references chilled water plants, but the proposed exception would clarify this current ambiguity. The exception for chillers with heat recovery would allow for air-cooled chillers in excess of the 300-ton threshold where the difference in cooling capacity and recovered heat capacity is no more than 300 tons per plant.

As the exceptions for heating only air-to-water heat pumps and chillers with heat recovery are primarily clarifications to the code language to ensure that it is impacting the intended equipment – air-cooled chillers – these exceptions are assumed to have limited to negligible impacts on statewide energy consumption and the Statewide CASE Team has not performed an associated cost-effectiveness analysis. As such, the primary focus of the analysis of this measure is on the exception for high-efficiency chillers which has a more direct impact on both on-site and statewide energy use.

3.1.2 Justification and Background Information

3.1.2.1 Justification

In recent years, water consumption has come to the forefront of concerns in the state of California. According to the State of California Water Year 2021 report, the water year ending September 30, 2021 was the second driest year on record based on statewide runoff, following 2020 which was the fifth driest year (California Department of Water Resources 2021). As such, methods for achieving water savings in California are of prime importance.

This proposal revisits the 300-ton limitation on air-cooled chillers adopted during the 2005 Title 24, Part 6 code cycle, which was proposed in an effort to achieve energy savings. Water-cooled chillers are typically more energy efficient than air-cooled chillers, and at the time provided a cost-effective solution to achieving energy savings. Air-cooled chillers, however, provide a significant opportunity for water savings by eliminating the use of a cooling tower, the primary source of water losses in a water-cooled system resulting from losses to evaporation, blowdown, and drift.

The Los Angeles Better Buildings Challenge reports that cooling towers account for an average of 40 percent of a building's water demand. According to Water Sense of the Environmental Protection Agency, regardless of cooling tower efficiency, 1.8 gallons of water are evaporated for every ton-hour of cooling (Environmental Protection Agency n.d.). As an example, for a 300-ton chiller serving an office in the city of Sacramento, CA, with an estimated equivalent full load hours (EFLH) of 1080 hours, this would equate to approximately 583,200 gallons of evaporative losses from the cooling tower per year (Water Management Inc. n.d.). By increasing the maximum cooling capacity threshold of 300-tons, air-cooled chillers could be used in more applications and achieve water savings statewide.

Additionally, since the threshold was adopted in 2005, air-cooled chillers have increased in efficiency, with the advancement of technologies such as oil-free magnetic bearing centrifugal compressors. With these improvements, it may be possible that the energy penalty typically associated with air-cooled chillers can be eliminated, and in certain use cases air-cooled chillers can meet or exceed the efficiency of a minimum code-compliant water-cooled chiller.

Air-to-water heat pumps and heat recovery chillers were not widely available or considered during the 2005 CASE Report and not included in the original cost-effectiveness calculations. These technologies are being increasingly utilized in California as more buildings shift to all-electric designs. Given the fact that these systems were not initially intended to be covered by this provision and their benefits in terms of reducing greenhouse gas emissions and improving efficiency through heat recovery, this CASE Report recommends an exception for these system types.

3.1.2.2 Background Information

Air-cooled chillers operate at lower energy efficiencies than water-cooled chillers. 2022 Title 24, Part 6 sets mandatory minimum efficiency requirements for air-cooled chillers at 9.7-10.1 EER depending on the compliance path (Path A or Path B). Water-cooled chillers are required to have minimum efficiencies of 0.56-0.78 kW/ton (equivalent to

15.4-21.4 EER) depending on selected configuration and capacity, demonstrating significantly higher efficiency levels.

During the 2005 Title 24, Part 6 code cycle, the Statewide CASE Team examined the impacts of these efficiency differences on potential energy savings and cost effectiveness. A comparison of energy savings, water cost impacts, and installation costs demonstrated that the efficiency gains resulted in water-cooled chillers being cost effective at capacities above 250 tons in all climate zones. Based on these results, the 2005 Title 24, Part 6 adopted language that limits air-cooled chillers to providing no more than 300 tons of cooling capacity, with exceptions. A limitation on air-cooled chiller capacity was also established to prevent a shift in the chiller market in response to the 2001 adoption of the first cooling tower mandatory minimum efficiency requirement. At the time, increased cooling tower efficiencies were anticipated to increase the size and cost of water-cooled systems, potentially making less efficient, less expensive air-cooled systems more attractive.

In the 20 years between the 2005 and 2025 code cycles, new factors have led to reexamining the air-cooled chiller threshold and statewide impacts. Water consumption is a growing concern in the state of California, and air-cooled chillers as an alternative to water-cooled chillers provide a potential source of water savings. Additionally, increases in air-cooled chiller efficiency and water utility rates since 2005 have implications for the energy impacts and cost effectiveness of water-cooled chillers compared to air-cooled chillers.

3.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manuals, and compliance documents would be modified by the proposed change.[13] See Section 5 of this report for detailed proposed revisions to code language.

3.1.3.1 Specific Purpose and Necessity of Proposed Code Changes

Each proposed change to language in Title 24, Part 1 and Part 6 as well as the reference appendices to Part 6 are described below. See Section 5.2 of this report for marked-up code language.

Sections: 140.4(j), 170.2(c)4H

Specific Purpose: The specific purpose of the change in the subsections 140.4(j) is to add an exception to the limit on air-cooled chillers, in order to allow air-cooled chillers

[13] Visit EnergyCodeAce.com for trainings, tools and resources to help people understand existing code requirements.

that meet or exceed the required efficiency threshold of 10.72 EER and 20.10 IPLV to provide more than 300 tons in cooling capacity. The changes also provide exceptions for air-to-water heat pumps and heat recovery chillers.

Necessity: These changes are necessary to increase efficiency in the use of water via cost-effective building design standards.

3.1.3.2 Specific Purpose and Necessity of Changes to the Nonresidential ACM Reference Manual

The proposed code change would not modify the ACM Reference Manual.

3.1.3.3 Summary of Changes to the Nonresidential Compliance Manual

Chapter 4.7.2.12 of the Nonresidential Compliance Manual would need to be updated to align with the exception to the existing air-cooled chiller limitation in 140.4(j) and 170.2(c)4H for high efficiency chillers. Adjustment to allow for the exceptions for heating-only air-to-water heat pumps and heat recovery chillers would also need to be added.

3.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. Examples of the revised documents are presented in Section 5.5.

- NRCC-MCH-E – The compliance document would need to be adjusted to include a line item for Air-Cooled Chiller Limitation to reflect the existing code rules in Title 24, Part 6 140.4(j) and 170.2(c)4H and account for an exception for chillers that meet or exceed the 10.72 EER/20.1 IPLV efficiency threshold.
- 2022-NRCC-CXR-E – The compliance document would need to be adjusted regarding the line item in the Chillers and Boilers table for Section 140.4(i) related to the 300-ton limit on Air-Cooled Chillers.

3.1.4 Regulatory Context

3.1.4.1 Determination of Inconsistency or Incompatibility with Existing State Laws and Regulations

This proposed measure pertains to the existing 2022 Title 24, Part 6 rules concerning limitations on air-cooled chillers. A prescriptive limitation that air-cooled chillers would provide no more than 300 tons of cooling capacity to chilled water plants is established in 140.4(j) for nonresidential buildings and 170.2(c)4H for multifamily buildings.

Additionally, as discussed in Section 2.1.4.1, this measure is relevant to Title 24, Part 6 sections pertaining to open-circuit cooling towers which have established the same 300 ton/900 gpm threshold to provide cohesiveness across the code. Sections

140.4(h)5 and 170.2(c)4Fv establish a prescriptive minimum efficiency for open-circuit, propeller or axial fan cooling towers serving condenser water loops greater than 900 gpm. Similarly, the existing prescriptive requirements in Title 24, Part 6 140.4(h)3 and 170.2(c)4iii set a limitation on the use of centrifugal fan cooling towers, prescribing that open cooling towers with a combined rated capacity of greater than 900 gpm shall use propeller or axial fans.

The proposed measure, which comprises adding an exception to the limitation prescribed in 140.4(j) and 170.2(c)4H for high efficiency air-cooled chillers, and the clarifying exceptions for heating-only air-to-water heat pumps and heat recovery chillers, is not anticipated to result in any inconsistencies or loopholes in the aforementioned Title 24, Part 6 sections.

This proposal is not relevant to other parts of the California Building Standards Code (https://www.dgs.ca.gov/BSC/Codes). Changes outside of Title 24, Part 6 are not needed.

There are no relevant state or local laws or regulations.

3.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

3.1.4.3 Difference From Existing Model Codes and Industry Standards

There are no relevant industry standards or model codes.

3.1.5 Compliance and Enforcement

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. This section describes how to comply with the proposed code change. It also describes the compliance verification process. Appendix E presents how the proposed changes could impact various market actors.

The compliance verification activities related to this measure that need to occur during each phase of the project are described below:

- **Design Phase:** The proposed change would result in notable changes to the design phase. By introducing exceptions to the limitation on air-cooled chiller capacity for high efficiency chillers, decisions between air-cooled and water-cooled chillers would be expanded to a wider range of projects. The exceptions for heating-only air-to-water heat pumps and chillers with heat recovery would also clarify and expand the use cases for those systems. The mechanical design engineer would need to be aware of the new code rules and consider occupant needs and limitations in the selection of appropriate equipment. Considerations for air-cooled chillers include a trade-off between exterior and interior space, increased size and weight compared to cooling towers, and a potential trade-off between energy efficiency and water efficiency. Mechanical designers would need to coordinate with building owners, architectural teams, and structural teams to ensure design considerations align with construction goals, however these teams should already be in close coordination.

- **Permit Application Phase:** No major changes are expected to the permit application phase. The mechanical designer submits scope of work, plan set, and Title 24, Part 6 compliance paperwork. The plans examiner would need to ensure code triggers are correctly accounted for and verify the new proposed cooling tower efficiency on NRCC-MCH-E for new systems using the prescriptive compliance path.
- **Construction Phase:** The proposed code change would not impact the construction phase. HVAC contractors would install the required equipment and provide Certificates of Installation for NRCI-MCH-E.
- **Inspection Phase:** The inspection phase would be minimally impacted. A building department inspector would inspect equipment and all forms to verify they are in compliance, being aware of the new allowances for air-cooled chiller capacity.

3.2 Market Analysis

3.2.1 Current Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general as well as individual market actors. Information was gathered about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, CEC staff, and a wide range of industry actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during public stakeholder meetings that the Statewide CASE Team held on October 25, 2022 and February 13, 2023.

3.2.2 Technical Feasibility and Market Availability

Chillers are produced by several major manufacturers, of which Trane, Carrier, Daikin, and York play a dominant role. Air-cooled chillers from these four manufacturers are offered in capacities ranging from 10-575 tons and full load efficiencies from 9.35-

20.01 EER and 13.70-25.72 IPLV, with the highest efficiencies achieved by oil-free magnetic bearing centrifugal compressors followed by screw compressors. Air-cooled chiller efficiencies have improved since the 2005 Title 24, Part 6 code cycle when the 300-ton limitation was adopted, for which the Statewide CASE Report team used an assumed efficiency of 2.8 COP or 9.55 EER. Water-cooled chillers from major manufacturers are available in capacities from 30-6,000 tons and rated full-load efficiencies from 0.49-0.75 kW/ton (16-24.5 EER), with most options significantly higher in energy efficiency and cooling capacity than air-cooled options. Using data from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Directory of Certified Product Performance, a comparison of the number of available models from the major manufacturers (Carrier, Daikin, Trane, and York) at each capacity level is shown in Figure 6 for air-cooled and water-cooled chillers (Air-Conditioning, Heating, and Refrigeration Institute n.d.). The table demonstrates that though water-cooled chillers are more readily available at larger capacities, sufficient air-cooled chiller models are available to exceed the existing 300-ton limitation. Additionally, engineering data from each of the major manufacturers shows at least one product line with units exceeding the proposed minimum efficiency (10.72 EER/20.1 IPLV) to qualify for an exception to the air-cooled chillers limitation.

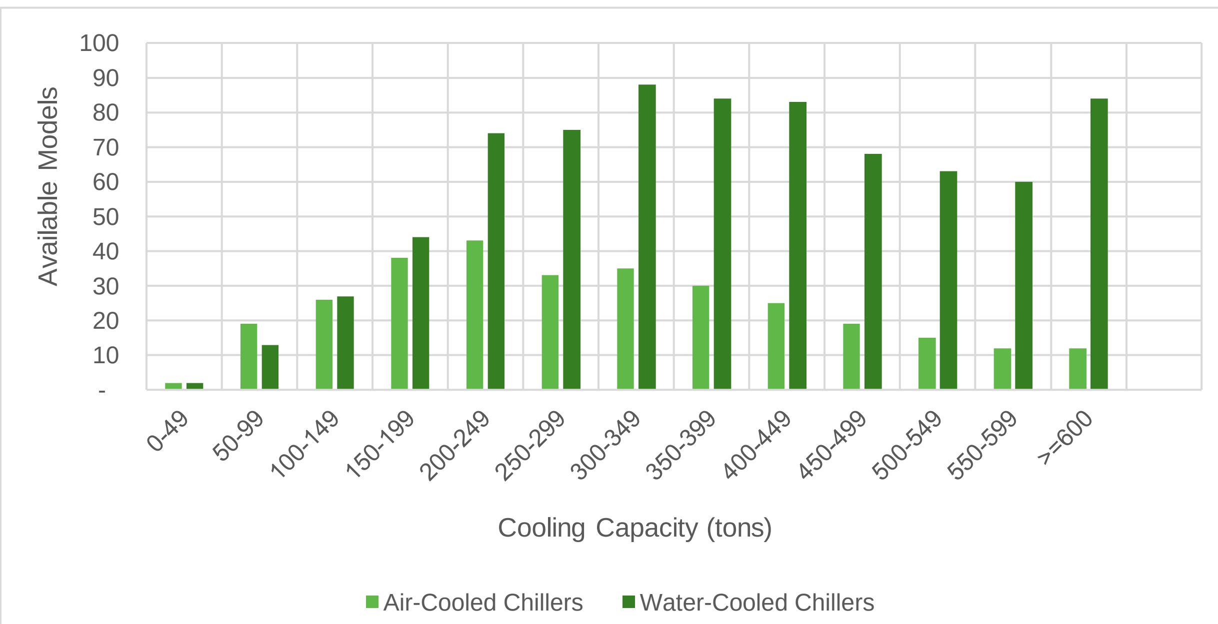

Figure 6: Available chiller capacities: Air-cooled versus water-cooled

As the proposed measure consists of the adding exceptions to the 300-ton cooling capacity limitation on air-cooled chillers, the measure does not result in a requirement of one product over another, but rather in the option to select air-cooled chillers across a wider range of projects. One factor in the selection of air-cooled chillers would be in the impacts on size, weight, and installation location compared to their water-cooled counterparts. Air-cooled chillers are installed on the exterior of the facility, and when considered as an alternative to water-cooled chillers would be installed in the space otherwise allocated to the cooling towers. As such, a comparison of air-cooled chiller and cooling tower size and weight for like-sized systems is valuable at ascertaining the impact on design.

Figure 7 shows a comparison between air-cooled chiller footprint and cooling tower footprint in square feet versus the rated chiller capacity as collected from the engineering data specifications for major chiller and cooling tower manufacturers (Baltimore Aircoil Company n.d., Evapco n.d., SPX Cooling Technologies n.d., Carrier Global Corporation n.d., Trane n.d.).[14] As demonstrated in the figure, air-cooled chillers have a larger footprint than cooling towers for the same sized chilled water plant, on average fifty percent larger. The increased exterior footprint of the air-cooled chillers would need to be accounted for during the design phase of the project, with a trade-off of newly available interior space due to the elimination of the indoor water-cooled chiller and supplemental equipment.

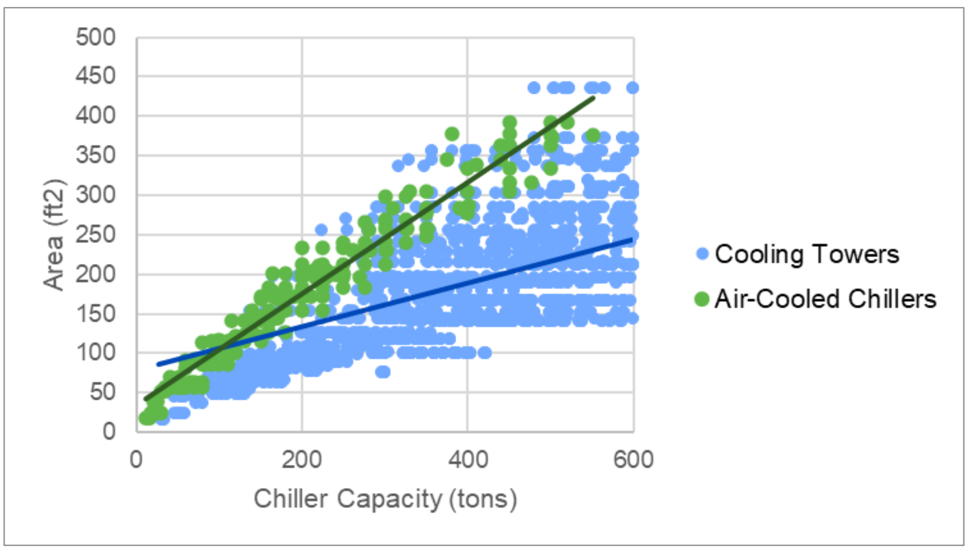

Figure 7: Comparison of air-cooled chiller and cooling tower equipment footprint (ft^2) versus rated chiller capacity (tons).

Compared to footprints, operating weights (which include the weight of water) appear to be more similar between air-cooled chillers and cooling towers. Figure 8 shows a comparison between air-cooled chiller and cooling tower operating weights versus the rated chiller capacity as collected from major manufacturers (Baltimore Aircoil Company

[14] For comparison purposes, the cooling towers are assumed to serve chillers with rated cooling capacities that are 80 percent of the nominal cooling tower capacities.

n.d., Evapco n.d., SPX Cooling Technologies n.d., Carrier Global Corporation n.d., Trane n.d.).[15] As demonstrated in the figure, air-cooled chillers have higher operating weights than cooling towers for the same sized chilled water plant, though on average only 13 percent higher, with a wide variability observed in cooling tower weights. As discussed in Section 2.2.2, higher cooling tower operating weights are generally associated with higher efficiency units. As a result of higher weights, in some applications, such as where roof installation is desired, structural improvements may be required to support air-cooled chillers resulting in increased installation costs.

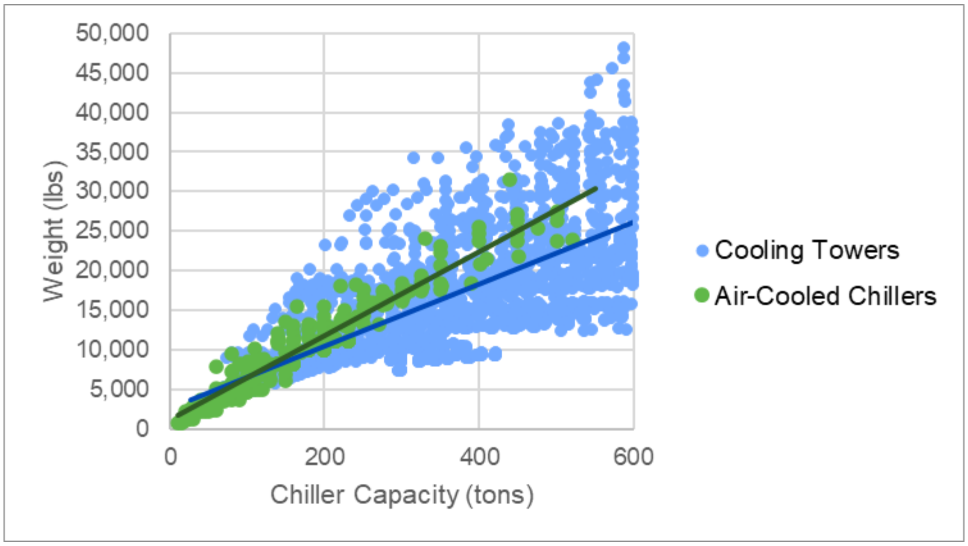

Figure 8: Comparison of air-cooled chiller and cooling tower operating weight (lbs) versus rated chiller capacity (tons).

3.2.3 Market Impacts and Economic Assessments

3.2.3.1 Impact on Builders

Builders of residential and commercial structures are directly impacted by many of the measures proposed by the Statewide CASE Team for the 2025 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California's construction industry comprises approximately 93,000 business establishments and 943,000 employees (see Table 41). For 2022, total estimated payroll will be about $78 billion. Nearly 72,000 of these business establishments and 473,000 employees are engaged in the residential building sector, while another 17,600

[15] For comparison purposes, the cooling towers are assumed to serve chillers with rated cooling capacities that are 80 percent of the nominal cooling tower capacities.

establishments and 369,000 employees focus on the commercial sector. The remainder of establishments and employees work in industrial, utilities, infrastructure, and other heavy construction roles (the industrial sector).

Table 41: California Construction Industry, Establishments, Employment, and Payroll in 2022 (Estimated)

Building Type	Construction Sectors	Establish-ments	Employ-ment	Annual Payroll (Billions $)
Residential	**All**	**71,889**	**472,974**	**31.2**
Residential	Building Construction Contractors	27,948	130,580	9.8
Residential	Foundation, Structure, & Building Exterior	7,891	83,575	5.0
Residential	Building Equipment Contractors	18,108	125,559	8.5
Residential	Building Finishing Contractors	17,942	133,260	8.0
Commercial	**All**	**17,621**	**368,810**	**35.0**
Commercial	Building Construction Contractors	4,919	83,028	9.0
Commercial	Foundation, Structure, & Building Exterior	2,194	59,110	5.0
Commercial	Building Equipment Contractors	6,039	139,442	13.5
Commercial	Building Finishing Contractors	4,469	87,230	7.4
Industrial, Utilities, Infrastructure, & Other (Industrial+)	**All**	**4,206**	**101,002**	**11.4**
Industrial+	Building Construction	288	3,995	0.4
Industrial+	Utility System Construction	1,761	50,126	5.5
Industrial+	Land Subdivision	907	6,550	1.0
Industrial+	Highway, Street, and Bridge Construction	799	28,726	3.1
Industrial+	Other Heavy Construction	451	11,605	1.4

Source: (State of California n.d.)

The proposed change to the air-cooled chiller threshold would likely affect commercial builders but would not impact firms that focus on construction and retrofit of industrial buildings, utility systems, public infrastructure, or other heavy construction. The effects on the commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 42 shows the residential building subsectors and Table 43 shows the commercial building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report. Subsectors were identified by which components of the construction phase are involved in the installation of chiller systems for multifamily and nonresidential buildings, which involves aspects of structural and foundational work to support equipment, HVAC work, electrical work, plumbing, and site preparation. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 3.2.4 Economic Impacts.

Table 42: Specific Subsectors of the California Residential Building Industry by Subsector in 2022 (Estimated)

Residential Building Subsector	Establishments	Employment	Annual Payroll (Billions $)
New multifamily general contractors	421	6,344	0.7
Residential poured foundation contractors	1,505	16,369	1.1
Residential Structural Steel Contractors	275	3,207	0.2
Residential Roofing Contractors	2,600	18,918	1.1
Residential Electrical Contractors	7,857	48,366	3.3
Residential plumbing and HVAC contractors	9,852	75,404	5.1
Residential Site Preparation Contractors	1,418	11,526	0.9

Source: (State of California n.d.)

Table 43: 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 $)
Commercial Building Construction	4,919	83,028	9.0
Nonresidential poured foundation contractors	529	18,159	1.6
Nonresidential structural steel contractors	363	13,110	1.1
Nonresidential Roofing Contractors	354	10,382	0.9
Nonresidential Electrical Contractors	3,137	74,277	7.0
Nonresidential plumbing & HVAC contractors	2,346	55,572	5.5
Nonresidential site preparation contractors	1,159	18,322	1.6
All other Nonresidential trade contractors	940	18,027	1.6

Source: (State of California n.d.)

3.2.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle, and building designers and energy consultants engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

As an introduction of exceptions to an existing prescriptive requirement, minimal impacts are anticipated on workflows in relation to the air-cooled threshold measure. Building designers should understand new allowances based on the proposed code change, which expands the potential projects for which air-cooled chillers can be use and would thus influence the equipment selection process. Workflows of buildings, architects, engineers, and energy consultants are not anticipated to be impacted. Beyond ensuring key market actors understand the new exceptions, no additional training is anticipated as a result of this proposed code change.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 44 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for the air-cooled chiller threshold measure to affect firms that focus on nonresidential and multifamily construction.

There is not a North American Industry Classification System (NAICS)[3] code specific to energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[4] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 44 provides an upper bound indication of the size of this sector in California.

Table 44: California Building Designer and Energy Consultant Sectors in 2022 (Estimated)

Sector	Establishments	Employment	Annual Payroll (Millions $)
Architectural Services [a]	4,134	31,478	3,623.3
Building Inspection Services [b]	1,035	3,567	280.7

Source: (State of California n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures.

b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services

3.2.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health (DOSH). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

3.2.3.4 Impact on Building Owners and Occupants

Commercial Buildings

The commercial building sector includes a wide array of building types, including offices, restaurants and lodging, retail, and mixed-use establishments, and warehouses (including refrigerated) (Kenney 2019). Energy use by occupants of commercial buildings also varies considerably, with electricity used primarily for lighting, space cooling and conditioning, and refrigeration, while natural gas is used primarily for water heating and space heating. According to information published in the 2019 California Energy Efficiency Action Plan, there is more than 7.5 billion square feet of commercial floor space in California consuming 19 percent of California's total annual energy use (Kenney 2019). The diversity of building and business types within this sector creates a challenge for disseminating information on energy and water efficiency solutions, as does the variability in sophistication of building owners and the relationships between building owners and occupants.

Estimating Impacts

Building owners and occupants would benefit from lower energy bills. As discussed in Section 3.2.4.1, when building occupants save on energy bills, they tend to spend it elsewhere in the economy thereby creating jobs and economic growth for the California economy. The Statewide CASE Team does not expect the proposed code change for the 2025 code cycle to impact building owners or occupants adversely.

3.2.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)

The proposed code change would result in increased demand for higher efficiency air-cooled chillers. By providing an exception for units that achieve a certain minimum efficiency, more customers are likely to demand higher efficiency chillers in order to avoid the increased costs, space requirements, and complexity of water-cooled chiller systems.

As discussed in Section 2.2.3.5, when examined in tandem with the effects of the cooling tower efficiency measure proposed in Section 2, the new exceptions to the air-cooled chiller threshold risks leading to decreases in cooling tower sales. Measure 1 proposes increasing the prescriptive minimum efficiency for cooling towers in certain climate zones, which results in an increase in cooling tower costs. Increased cooling tower efficiency results in higher cost equipment, so by requiring more efficient cooling towers for units serving condenser water loops over 900 gpm (300 tons), while also providing a new exception for high-efficiency air-cooled chillers, projects over 300 tons may be encouraged to select the less expensive air-cooled chiller plants.

However, the analysis demonstrates that though this has the potential to have adverse impacts on energy consumption, increasing the prevalence of air-cooled chillers has significant potential for statewide water savings, and the reduced costs of air-cooled chiller plants make the measure a cost-effective option. Further discussion of the trade-off between air-cooled and water-cooled chilled water plants, including the water and energy impacts of the air-cooled chiller threshold measure is provided in more detail later in this section.

3.2.3.6 Impact on Building Inspectors

Table 45 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing education and training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 45: Employment in California State and Government Agencies with Building Inspectors in 2022 (Estimated)

Sector	Govt.	Establishments	Employment	Annual Payroll (Million $)
Administration of Housing Programs[a]	State	18	265	29.0
	Local	38	3,060	248.6
Urban and Rural Development Admin[b]	State	38	764	71.3
	Local	52	2,481	211.5

Source: (State of California, Employment Development Department n.d.)

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.

b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

3.2.3.7 Impact on Statewide Employment

As described in Sections 3.2.3.1 through 3.2.3.6, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 3.2.4, the Statewide CASE Team estimated the proposed change in the air-cooled chiller threshold would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in the air-cooled chiller threshold would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

3.2.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software[16], along with economic information from published sources, and professional judgement to develop estimates of the economic impacts associated with each of the proposed code changes. Conceptually, IMPLAN estimates jobs created as a function of incoming cash flow in different sectors of the economy, due to implementing a code or a standard. The jobs created are typically categorized into direct, indirect, and induced employment. For example, cash flow into a manufacturing plant captures direct employment (jobs created in the manufacturing plant), indirect employment (jobs created in the sectors that provide raw materials to the manufacturing plant) and induced employment (jobs created in the larger economy due to purchasing habits of people newly employed in the manufacturing plant). Eventually, IMPLAN computes the total number of jobs created due to a code. The assumptions of IMPLAN include constant returns to scale, fixed input structure, industry homogeneity, no supply constraints, fixed technology, and constant byproduct coefficients. The model is also static in nature and is a simplification of how jobs are created in the macro-economy.

The economic impacts developed for this report are only estimates and are based on limited and to some extent speculative information. The IMPLAN model provides a relatively simple representation of the California economy and, though the Statewide CASE Team is confident that the direction and approximate magnitude of the estimated economic impacts are reasonable, it is important to understand that the IMPLAN model is a simplification of extremely complex actions and interactions of individual, businesses, and other organizations as they respond to changes in energy efficiency codes. In all aspect of this economic analysis, the CASE Authors rely on conservative assumptions regarding the likely economic benefits associated with the proposed code change. By following this approach, the economic impacts presented below represent lower bound estimates of the actual benefits associated with this proposed code change.

Adoption of this code change proposal would result in relatively modest economic impacts through the additional direct spending by those in the commercial building industry, architects, energy consultants, and building inspectors. The Statewide CASE

[16] IMPLAN employs economic data and advanced economic impact modeling to estimate economic impacts for interventions like changes to the California Title 24, Part 6 code. For more information on the IMPLAN modeling process, see www.IMPLAN.com.

Team does not anticipate that money saved by commercial building owners or other organizations affected by the proposed 2025 code cycle regulations would result in additional spending by those businesses.

Table 46: Estimated Impact that Adoption of the Proposed Measure would have on the California [Residential/Commercial] Construction

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
Direct Effects (Additional spending by Commercial Builders)	11.8	$937,520	$1,411,531	$3,054,123
Indirect Effect (Additional spending by firms supporting Commercial Builders)	6.9	$541,928	$930,371	$1,628,820
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	6.2	$425,137	$761,203	$1,211,551
Total Economic Impacts	**24.9**	**$1,904,585**	**$3,103,105**	**$5,894,494**

Source: CASE Team analysis of data from the IMPLAN modeling software.

Table 47: Estimated Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultants Sectors

Type of Economic Impact	Employment (Jobs)	Labor Income (Million)	Total Value Added (Million)	Output (Million)
Direct Effects (Additional spending by Building Designers & Energy Consultants)	0.2	$17,917	$17,738	$28,036
Indirect Effect (Additional spending by firms supporting Bldg. Designers & Energy Consultants)	0.1	$5,335	$7,414	$11,936
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	0.1	$6,686	$11,973	$19,057
Total Economic Impacts	**0.3**	**$29,938**	**$37,126**	**$59,029**

Source: CASE Team analysis of data from the IMPLAN modeling software.

3.2.4.1 Creation or Elimination of Jobs

The Statewide CASE Team does not anticipate that the measures proposed for the 2025 code cycle regulation would lead to the creation of new *types* of jobs or the elimination of *existing* types of jobs. In other words, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. Rather, the estimates of economic impacts discussed in Section 3.2.4 would lead to modest changes in employment of existing jobs.

3.2.4.2 Creation or Elimination of Businesses in California

As stated in Section 3.2.4.1, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. The proposed change represents a modest change to the limitation on air-cooled chillers in HVAC applications, which would not excessively burden or competitively disadvantage California businesses – nor would it necessarily lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not foresee any new businesses being created, nor does the Statewide CASE Team think any existing businesses would be eliminated due to the proposed code changes.

3.2.4.3 Competitive Advantages or Disadvantages for Businesses in California

The proposed code changes would apply to all businesses incorporated in California, regardless of whether the business is located inside or outside of the state. Therefore, the Statewide CASE Team does not anticipate that these measures proposed for the 2025 code cycle regulation would have an adverse effect on the competitiveness of California businesses. Likewise, the Statewide CASE Team does not anticipate businesses located outside of California would be advantaged or disadvantaged.

3.2.4.4 Increase or Decrease of Investments in the State of California

The Statewide CASE Team analyzed national data on corporate profits and capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[17] As Table 48 shows, between 2017 and 2021, NPDI as a percentage of corporate profits ranged from a low of 18 in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 35 percent in 2019, with an average of 26 percent. While only an approximation of the proportion of business income used for net capital investment, the Statewide CASE Team believes it provides a reasonable estimate of the proportion of proprietor income that would be reinvested by business owners into expanding their capital stock.

[17] Net private domestic investment is the total amount of investment in capital by the business sector that is used to expand the capital stock, rather than maintain or replace due to depreciation. Corporate profit is the money left after a corporation pays its expenses.

Table 48: Net Domestic Private Investment and Corporate Profits, U.S.

Year	Net Domestic Private Investment by Businesses, Billions of Dollars	Corporate Profits After Taxes, Billions of Dollars	Ratio of Net Private Investment to Corporate Profits (Percent)
2017	518.473	1882.460	28
2018	636.846	1977.478	32
2019	690.865	1952.432	35
2020	343.620	1908.433	18
2021	506.331	2619.977	19
5-Year Average	***529.227***	***2068.1566***	**26**

Source: (Federal Reserve Economic Data (FRED) n.d.)

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to significant change (increase or decrease) in investment, directly or indirectly, in any affected sectors of California's economy. Nevertheless, the Statewide CASE Team is able to derive a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on proprietor income, which we use a conservative estimate of corporate profits, a portion of which we assume would be allocated to net business investment.[18]

3.2.4.5 Incentives for Innovation in Products, Materials, or Processes

By introducing an exception to the limitation on air-cooled chiller capacity for air-cooled chillers that exceed the proposed minimum efficiency, the proposed code language is anticipated to increase demand for high efficiency models. Air-cooled chillers have been improving in efficiency since establishing the threshold in 2005, with advancements such as variable speed screw compressors and oil free magnetic bearing centrifugal compressors, though availability of some of these technologies is not yet widespread. The increase in demand for high efficiency air-cooled chillers would likely have the effect of motivating manufacturers to adopt and improve existing technologies and develop new technologies that meet the design conditions.

The exceptions for heating air-to-water heat pumps and chillers with heat recovery are anticipated to have limited or no impact on manufacturers and distributed, as it is likely many building owners and designers have been operating on the belief that the existing threshold for air-cooled chillers does not apply to these equipment types.

[18] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 15.

3.2.4.6 Effects on the State General Fund, State Special Funds, and Local Governments

The Statewide CASE Team does not expect the proposed code changes would have a measurable impact on California's General Fund, any state special funds, or local government funds.

Cost of Enforcement

Cost to the State: State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals.

As the proposed code change consists of exceptions to a prescriptive requirement, no specific requirement would be imposed on state buildings. New construction state buildings would have a wider range of products available for use in chilled water system design, if meeting certain criteria. Additionally, since the proposed air-cooled chillers are less expensive than the water-cooled systems prescriptively required by code, new construction state buildings can achieve construction cost savings through their selection.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 3.1.5 and Appendix E, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

3.2.4.7 Impacts on Specific Persons

While the objective of any of the Statewide CASE Team's proposal is to promote energy efficiency, the Statewide CASE Team recognizes that there is the potential that a proposed code change may result in unintended consequences. However, as an introduction of exceptions to a prescriptive requirement, and thus not a requirement in itself, the proposed code change is not anticipated to have impacts on any specific persons. Refer to Section 3.6 for more details addressing energy equity and environmental justice.

3.2.5 Fiscal Impacts

3.2.5.1 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts. Since the proposed code change is an introduction of exceptions to an existing prescriptive requirement, the code change does not impose new mandates but rather broadens the options for HVAC equipment design.

3.2.5.2 Costs to Local Agencies or School Districts

There are no costs to local agencies or school districts. As an introduction of exceptions to an existing prescriptive requirement, no local agency or school district would be required to incur additional costs to achieve compliance.

3.2.5.3 Costs or Savings to Any State Agency

There are no costs anticipated to be incurred by any state agencies. Savings by state agencies may be achieved in water costs and in construction costs if the design of the state agency building opts to take advantage of the exceptions introduced, and install less costly, less water intensive equipment.

3.2.5.4 Other Non-Discretionary Cost or Savings Imposed on Local Agencies

There are no non-discretionary costs added to local agencies as the proposed code language does not require local agencies to incur additional costs to achieve compliance. Local agencies may observe water cost savings for any that opt to take advantage of the proposed exceptions to the limitation on air-cooled chillers.

3.2.5.5 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state.

3.3 Energy and Water Savings

The Statewide CASE Team gathered stakeholder input to inform the energy savings analysis. The Statewide CASE Team held meetings with two chiller manufacturers and one cooling tower manufacturer, and held one stakeholder meeting on February 13th, 2023 with 63 attendees. Stakeholders provided valuable input on the direction and mechanism for achieving the intended effect of the measure. The original intent of the proposed measure examined elimination or increase of the existing 300-ton limitation on air-cooled chillers. Due to concern with the potential market impacts and adverse impacts on energy consumption, the Statewide CASE Team instead examined the identification of a minimum efficiency level for which an exception to the limitation could be provided.

Stakeholders also encouraged the Statewide CASE Team to examine the impacts of this proposed code change on water consumption at California power plants, to ensure that the potential increase in energy use associated with air-cooled chillers does not have the unintended impact of negating on-site water savings with water consumption for generation. Stakeholders were also helpful in highlighting the various components of incremental costs to consider, and chiller manufacturers were helpful in providing chiller curves to use in the analysis and identifying high efficiency air-cooled chiller technologies and capabilities. See Appendix F for a summary of stakeholder engagement.

Energy savings benefits may have potential to disproportionately impact DIPs. Refer to Section 3.6 for more details addressing energy equity and environmental justice.

3.3.1 Energy and Water Savings Methodology

3.3.1.1 Key Assumptions for Energy and Water Savings Analysis

The Statewide CASE Team used EnergyPlus to conduct the energy and water savings analysis for the air-cooled chiller threshold measure. Building models are sourced from the California Building Energy Code Compliance (CBECC) software for commercial buildings (CBECC) prototypical building models and are modified to include the proposed changes to the energy standards.

The energy and water savings analysis of the air-cooled threshold measure assesses the impacts of increasing the prescriptive 300-ton cooling capacity limitation for air-cooled chillers. To determine the impacts, comparisons between buildings compliant with the existing 2022 Title 24, Part 6 Standards and buildings compliant with the proposed measure were examined. In practice, this took the form of comparing the water and energy used by a building with baseline minimally code-compliant water-cooled chillers and cooling towers to the same building with proposed air-cooled chillers. Performance of this method requires assumptions for water-cooled chiller performance, cooling tower performance, air-cooled chiller performance, and all related subsystems.

The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone specific LSC Hourly Factors when calculating energy and energy cost impacts. The proposed code change for the air-cooled chiller threshold measure is applicable to new construction and additions, and is not applicable to alterations.

The Standard Design, consisted of centrifugal water-cooled chillers and cooling towers assumed to have the 2022 Title 24, Part 6 code-minimum efficiency applicable to the required system capacity, which varies by climate zone and prototype. Default performance curves were used as outlined in Section 5.8.2 of the ACM Reference manual, which assigns Path B chiller curves for the Standard Design. All additional components and conditions were assumed to comply with the 2022 Title 24, Part 6 building code.

For the Proposed Design air-cooled chiller systems, several iterations of chiller design were modeled to identify the efficiency and capacity for which the measure is cost effective. Path B compliance was assumed for the Proposed Design air-cooled chillers to align with the prescriptive requirement in 2022 Tile 24, Part 6 140.4(i). Ultimately, the air-cooled chiller performance curves were updated to reflect a high efficiency chiller of 10.72 EER and 20.1 IPLV. All additional components and conditions were assumed to comply with the 2022 Title 24, Part 6 building code. Note that the air-cooled chiller curves used in this analysis are approximately four years old at this time. *The Statewide CASE Team is continuing to collect data to examine the highest efficiency air-cooled chillers on the market today and welcomes any input on performance data to support this analysis.*

3.3.1.2 Energy and Water Savings Methodology per Prototypical Building

The Statewide CASE Team measured per unit energy savings expected from the proposed code changes in several ways in order to quantify key impacts. First, savings are calculated by fuel type. Electricity savings are measured in terms of both energy usage and peak demand reduction. Natural gas savings are quantified in terms of energy usage. Second, the Statewide CASE Team calculated Source Energy Savings. Source Energy represents the total amount of raw fuel required to operate a building. In addition to all energy used from on-site production, source energy incorporates all transmission, delivery, and production losses. The hourly Source Energy values provided by CEC are strongly correlated with GHG emissions.[19] Finally, the Statewide CASE Team calculated LSC Savings, formerly known as Time Dependent Valuation (TDV) Energy Cost Savings. LSC Savings are calculated using hourly energy cost metrics for both electricity and natural gas provided by the CEC. LSC hourly factors are projected over the 30-year life of the building and incorporate the hourly cost of marginal

[19] See Hourly Factors for Source Energy, Long-term Systemwide Cost, and Greenhouse Gas Emissions at https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO_2 emissions.[20]

The CEC directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries for different types of buildings. Prototypes for this measure were selected as those for which the Standard Design central plant consists of water-cooled chillers. The Draft CASE Report presents the analysis results for the OfficeLarge prototype, which was available for analysis at the time of the report. Prototypes for the Hospital and SchoolLarge will be examined for the Final CASE Report, once available. For multifamily buildings and all other building types anticipated to be impacted for which no prototype model was available at the time of the report, average per unit savings were assumed to be representative and used for statewide savings analyses.

The prototype buildings to be used in the Statewide CASE Team analysis are presented in Table 49. All 2025 prototype models can be obtained by downloading the CBECC software from the NORESCO Title 24 Nonresidential Compliance Software website (NORESCO n.d.).

Table 49: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Hospital	5	241,374	5-Story Hospital plus basement U.S. DOE prototype model
OfficeLarge	12	498,589	12 story + 1 basement office building with 5 zones and a ceiling plenum on each floor. Window-to-wall ratio (WWR) of 0.40. Standard Design HVAC system of two centrifugal water-cooled chillers
SchoolLarge	2	210,866	High school with WWR of 35% and SRR 1.4%. Standard Design HVAC system of water-cooled chiller

The Statewide CASE Team estimated LSC, Source Energy, electricity, natural gas, peak demand, and GHG impacts by simulating the proposed code change in EnergyPlus using prototypical buildings and rulesets from the 2025 Research Version of the California Building Energy Code Compliance (CBECC) software.

[20] See Hourly Factors for Source Energy, Long-term Systemwide Cost, and Greenhouse Gas Emissions at https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

CBECC generates two models based on user inputs: the Standard Design and the Proposed Design.[21] The Standard Design represents the geometry of the prototypical building and a design that uses a set of features that result in a LSC budget and Source Energy budget that is minimally compliant with 2022 Title 24, Part 6 code requirements. Features used in the Standard Design are described in the 2022 Nonresidential ACM Reference Manual. The Proposed Design represents the same geometry as the Standard Design, but it assumes the energy features that the software user describes with user inputs. To develop savings estimates for the proposed code changes, the Statewide CASE Team created a Standard Design and Proposed Design for each prototypical building with the Standard Design representing compliance with 2022 code and the Proposed Design representing compliance with the proposed requirements. Comparing the energy impacts of the Standard Design to the Proposed Design reveals the impacts of the proposed code change relative to a building that is minimally compliant with the 2022 Title 24, Part 6.

There is an existing Title 24, Part 6 requirement that covers the building system in question and applies to both new construction/additions and alterations, so the Standard Design is minimally compliant with the 2022 Title 24 requirements.

As discussed above, pertaining to this measure, the Standard Design HVAC system consists of two Path B water-cooled centrifugal chillers with efficiencies of 0.595 kW/ton and 0.390 IPLV for capacities between 300-400 tons, and 0.585 kW/ton and 0.380 IPLV for capacities between 400-600 tons. The chiller capacities vary between climate zone with each set to the rated capacity required to meet the design cooling load.

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 50 presents precisely which parameters were modified and what values were used in the Standard Design and Proposed Design for the OfficeLarge prototype.

Specifically, the proposed conditions assume the central chilled water plant consists of two air-cooled screw chillers with higher than code-minimum efficiency. A preliminary analysis examined air-cooled chiller efficiencies ranging from code minimum (9.7 EER/15.8 IPLV) to 18 EER/28 IPLV (not available on the market) to examine the impact and trade-off on water and energy consumption. Following this analysis, efficiency curves for the highest efficiency air-cooled chiller that the Statewide CASE Team had on file was selected to minimize the energy penalty and maximize cost effectiveness. Thus, air-cooled chiller performance curves were updated to reflect a high efficiency chiller of 10.72 EER/20.1 IPLV. As indicated previously, the chiller curves utilized were

[21] CBECC-Res creates a third model, the Reference Design, that represents a building similar to the Proposed Design, but with construction and equipment parameters that are minimally compliant with the 2006 International Energy Conservation Code (IECC). The Statewide CASE Team did not use the Reference Design for energy impacts evaluations.

four years old, and the Statewide CASE Team is pursuing more up-to-date efficiency curves to reflect advancements in air-cooled chiller technologies. *The Statewide CASE Team welcomes input on air-cooled chiller efficiency and performance data to support this effort*. As with the Standard Design, the chiller capacities vary between climate zones, with each set to the rated capacity required to meet the design cooling load.

In addition to the impact of air-cooled chiller efficiency, a component of this measure examined the impact of air-cooled chiller capacity on the cost effectiveness on the measure to determine if the proposed exception needs a cooling capacity limitation. As such, a comparison of energy and water use for various air-cooled and water-cooled chiller capacities was performed, examining the results for a 200-ton plant, 300-ton plant, 400-ton plant, 600-ton plant, and a plant of the required capacity of the prototype model for each climate zone. However, since the analysis utilizes prototype building models, with predefined design cooling capacities based on the prototype building characteristics, it was not possible to adjust modeling inputs to represent the various desired capacities. To provide estimates at various capacities, water and energy use were assumed to scale linearly as chiller capacity changes, with variations by climate zone. *The Statewide CASE Team welcomes input on this assumption*. Because incremental project costs are based on costs per ton of chiller capacity, the costs will also scale with chiller size, providing a consistent method for cost-benefit analysis even though modeling was performed for pre-defined chiller capacities. The results of this analysis demonstrated that the high efficiency air-cooled chiller was cost effective in all climate zones, and thus it is not necessary to add a cooling capacity threshold to the proposed exception.

Table 50: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
OfficeLarge	All	CoolingTower: VariableSpeed	N/A	N/A	Remove CoolingTower: VariableSpeed
OfficeLarge	All	Pump:Constant Speed	N/A	N/A	Remove Pump:ConstantSpeed
OfficeLarge	All	Chiller:Electric: EIR	Condenser Type	WaterCooled	AirCooled
OfficeLarge	All	Chiller:Electric: EIR	Reference COP {W/W}	6.01196	3.1417

EnergyPlus calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/yr) and therms per year (therms/yr). It then applies the 2025 LSC hourly factors to calculate Long-term Systemwide Cost (LSC) savings in 2026 Present Value dollars (2026 PV$), Source Energy factors to calculate Source Energy Use in kilo British thermal units per year (kBtu/yr), and hourly GHG emissions factors to calculate annual GHG emissions in metric tons of carbon dioxide emissions equivalent per year (MT or "tonnes" CO2e/yr). EnergyPlus also calculates annual peak electricity demand measured in kilowatts (kW).

The energy impacts of the proposed code change do vary by climate zone. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone specific LSC hourly factors when calculating energy and energy cost impacts.

Per-unit energy impacts for nonresidential buildings are presented in savings per square foot. Annual energy, GHG, and peak demand impacts for each prototype building were translated into impacts per square foot by dividing by the floor area of the prototype building. This step allows for an easier comparison of savings across different building types and enables a calculation of statewide savings using the construction forecast that is published in terms of floor area by building type.

3.3.1.3 Statewide Energy Savings Methodology

The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the CEC provided. Savings for building types for which no prototype model was available at the time of this report were estimated by applying the average per-unit energy impacts of the available models. The Statewide Construction Forecasts estimate new construction/additions that would occur in 2026, the first year that the 2025 Title 24, Part 6 requirements are in effect. They also estimate the amount of total existing building stock in 2026, which the Statewide CASE Team used to approximate savings from building alterations. The construction forecast provides construction (new construction/additions and existing building stock) by building type and climate zone, as shown in Appendix A.

Appendix A presents additional information about the methodology and assumptions used to calculate statewide energy impacts. The air-cooled threshold exception was assumed to apply to all chilled water systems exceeding 300 tons, estimated by gathering data from the CBECS 2018 dataset for the Pacific Region for each building type. *The Statewide CASE Team continues to gather data for estimating statewide impacts and welcomes any data representing sales and HVAC selection throughout the State of California.*

3.3.2 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions per unit are presented in Table 51 through Table 55. The per-unit energy savings figures do not account for naturally occurring market adoption or compliance rates. For the installation of an air-cooled chiller of 10.72 EER and 20.1 IPLV, an energy penalty (i.e. negative electricity savings) was observed in all zones. Per-unit savings for the first year are expected to range from negative 20,266 kWh/yr to negative 654,807 kWh/yr. depending upon climate zone. Demand reductions/increases are expected to range between -3.98 kW and 9.88 kW depending on climate zone.

The electricity penalty varies widely by climate zone with hot, dry climate zones such as Climate Zone 15 observing the largest energy penalty for the installation of an air-cooled chiller instead of a water-cooled chiller. The proposed code change has a significant impact on HVAC energy use, increasing energy use by 6-51 percent depending on climate zone. This includes a minor increase in gas consumption, resulting from the removal of the water-cooled chiller which generates heat during operation, and thus contributes to lower heat use during the heating seasons. The proposed code change would eliminate on-site energy consumption for heat rejection (by eliminating the cooling tower system), though the energy penalty is still significant resulting from the reduced efficiency of the air-cooled system compared to the water-cooled system. However, water savings from the proposed measure are significant, as discussed in Section 3.3.3.

The Statewide CASE Team is continuing to examine options that may aid in eliminating the energy penalty currently observed by the air-cooled chillers in the proposed design. This includes identifying higher efficiency air-cooled chillers than the current proposed design, which is using 4-year old chiller curves and a rating of 10.72 EER/20.1 IPLV. The Statewide CASE Team welcomes all input and data that would support this ongoing effort.

Table 51: First Year Electricity Savings (kWh) Per Square Foot by Climate Zone (CZ) – Air-Cooled Chiller Threshold

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
OfficeLarge	-0.04	-0.32	-0.15	-0.53	-0.21	-0.31	-0.32	-0.51	-0.52	-0.66	-0.68	-0.45	-0.68	-0.73	-1.31	-0.23

Table 52: First Year Peak Demand Reduction (kW) Per Square Foot by Climate Zone (CZ) – Air-Cooled Chiller Threshold

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
OfficeLarge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	0.00	-0.01	0.00	-0.02	-0.01

Table 53: First Year Natural Gas Savings (kBtu) Per Square Foot by Climate Zone (CZ) – Air-Cooled Chiller Threshold

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
OfficeLarge	-0.01	-0.02	0.00	-0.02	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01	-0.04	-0.01	-0.03	0.00	-0.04

Table 54: First Year Source Energy Savings (kBtu) Per Square Foot by Climate Zone (CZ) – Air-Cooled Chiller Threshold

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
OfficeLarge	-0.01	-0.02	0.00	-0.02	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01	-0.03	-0.01	-0.02	0.00	-0.04

Table 55: First Year Long-term Systemwide Cost Savings (2026 PV$) Per Square Foot by Climate Zone (CZ) – Air-Cooled Chiller Threshold

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
OfficeLarge	-0.20	-1.26	-0.60	-2.34	-0.86	-1.39	-1.50	-2.29	-2.38	-2.93	-3.01	-1.94	-3.15	-3.26	-6.12	-1.03

3.3.3 Per-Unit Water Impacts Results

Water savings and peak demand reductions per unit are presented in Table 56 for all examined prototypes. The per-unit water savings figures do not account for naturally occurring market adoption or compliance rates. Per-unit savings for the first year are expected to range from 135,541 to 4,911,372 gallons/yr depending upon climate zone.

Water savings for this measure occur as a result of eliminating cooling towers from the chilled water system, in turn eliminating water losses from evaporation, drift, and blowdown. Estimated water savings have wide variation by climate zone due to the variation in cooling load depending on climate conditions. Based on the results, this measure is expected to reduce on-site water consumption by 16 to 93 percent for the OfficeLarge prototype.

Table 56: First Year Water Savings (gallons) Per Square Foot by Climate Zone (CZ)– Air-Cooled Chiller Threshold

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
OfficeLarge	0.27	2.49	1.23	3.78	1.59	2.89	3.11	4.67	4.47	5.25	5.17	3.68	5.43	4.85	9.85	1.82

3.4 Cost and Cost Effectiveness

3.4.1 Energy Cost Savings Methodology

Energy cost savings were calculated by applying the LSC hourly factors to the energy savings estimates that were derived using the methodology described in Section 3.3.1. LSC hourly factors are a normalized metric to calculate energy cost savings that accounts for the variable cost of electricity and natural gas for each hour of the year, along with how costs are expected to change over the period of analysis.

The CEC requested LSC savings over the 30-year period of analysis in both 2026 present value dollars (2026 PV$) and nominal dollars. The cost-effectiveness analysis uses LSC values in 2026 PV$. Costs and cost effectiveness used and 2026 PV$ are presented in Section 3.4 of this report. CEC uses results in nominal dollars to complete the Economic and Fiscal Impacts Statement (From 399) for the entire package of proposed change to Title 24, Part 6. Appendix G presents LSC savings results in nominal dollars.

The proposed code change for the air-cooled chiller threshold measure applies to new construction buildings and additions.

3.4.2 Water Cost Savings Methodology

Water cost savings were calculated by applying water service charges ($/kgal) and sewer service charges ($/kgal) to the water savings estimates that were derived using the methodology described in Section 3.3.1. Water and sewer service charges for the analysis were determined by collecting current rates from websites for water utilities serving the ten most populated cities in California and determining the population weighted average. Utility flat fees such as monthly meter charges were excluded from the survey as they will not be impacted by measure savings. Table 57 provides a summary of the water costs collected for each city and the population weighted averages used for the water cost savings in this report, $8.13/kgal for water service and $6.11/kgal for sewer service. Note that utilities typically provide volumetric service rates in dollars per hundred cubic feet of water ($/hcf or $/ccf) which were converted to dollars per kilogallon (kgal) to align with building model water savings outputs.[22]

Table 57: 2022-2023 Water utility service charges

City	Population	Water Service Charges ($/hcf)	Water Service Charges ($/kgal)	Sewer Service Charges ($/hcf)	Sewer Service Charges ($/kgal)
Los Angeles	3,849,297	$7.17	$9.58	$5.80	$7.75
San Diego	1,381,611	$6.55	$8.76	$3.32	$4.44
San Jose	983,489	$5.96	$7.97	$5.83	$7.79
San Francisco	815,201	$10.55	$14.10	$9.46	$12.65
Fresno	544,510	$1.74	$2.33	$3.40	$4.55
Sacramento	525,041	$1.42	$1.90	-	-
Long Beach	456,062	$3.81	$5.10	$0.39	$0.53
Oakland	433,823	$6.47	$8.65	$2.74	$3.66
Bakersfield	407,615	$2.16	$2.88	$1.94	$2.59
Anaheim	345,940	$2.96	$3.96	$0.40	$0.53
All (Population Weighted Average)	-	$6.08	**$8.13**	$4.57	**$6.11**

Water and sewer costs are anticipated to increase significantly during the analysis period, as demonstrated in the U.S Department of Energy's *2017 Water and Wastewater Annual Price Escalation Rates for Selected Cities* across the United States report, which found average annual price escalation rates in California cities of 2.91-7.31 percent for water utilities and 3.12 - 8.33 percent for wastewater utilities over the period of 2008 to 2016 (U.S. DOE - Federal Energy Management Program 2017). For the purpose of this analysis, the minimum escalation rates were assumed to produce conservative estimates, 2.91 and 3.12 percent for water and wastewater, respectively. The escalation rates were applied to the 30-year period of analysis to determine the 30-

[22] One hundred cubic feet of water is equivalent to 0.748 kilogallons.

Year Life Cycle Cost Savings associated with water savings, and to align with the 30-year life cycle energy cost methodology, a 3 percent discount rate was applied.

3.4.3 Energy and Water Cost Savings Results

Per-unit energy cost savings for newly constructed buildings and additions that are realized over the 30-year period of analysis are presented in 2026 present value dollars (2026 PV$) in Table 58 for the OfficeLarge prototype. The table also presents the 30-year lifecycle water cost savings which are included in the later cost-effectiveness analysis.

The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Any time code changes impact cost, there is potential to disproportionately impact DIPs. Refer to Section 3.6 for more details addressing energy equity and environmental justice.

Table 58: 2026 PV Long-term Systemwide Cost Savings Over 30-Year Period of Analysis – Per Prototype Square Foot – New Construction – OfficeLarge Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Total 30-Year LSC Savings (2026 PV$)	30-Year Lifecycle Water Cost Savings (PV$)
1	0.0	0.0	0.0	0.00
2	0.0	0.0	0.0	0.00
3	-0.60	0.00	-0.60	0.81
4	-2.33	-0.01	-2.34	2.49
5	0.0	0.0	0.0	0.00
6	-1.39	0.00	-1.39	1.90
7	-1.51	0.00	-1.50	2.04
8	-2.29	0.00	-2.29	3.07
9	-2.38	0.00	-2.38	2.94
10	-2.93	0.00	-2.93	3.46
11	-3.01	-0.01	-3.01	3.40
12	-1.92	-0.02	-1.94	2.42
13	0.0	0.0	0.0	0.00
14	-3.24	-0.02	-3.26	3.19
15	-6.12	0.00	-6.12	6.48
16	-1.01	-0.02	-1.03	1.20

3.4.4 Incremental First Cost

Incremental first cost is the initial cost to adopt the proposed equipment or building practices when compared to the cost of the equivalent baseline project. To estimate incremental first costs for the air-cooled chiller threshold measure, the Statewide CASE Team utilized several sources, as discussed below.

Costs for the proposed air-cooled screw chillers were obtained from CPUC Workpaper SWHC052 for Path B Air-Cooled Chillers, approved January 1, 2022, which estimates average chiller costs from a combination of chiller distributor survey and extrapolation of historical CPUC energy efficiency measure data (California Public Utilities Commission 2022). The workpaper shows Path B code minimum air-cooled chiller costs ranging from $747.01-$1,057.28 per ton for units of 200-599 tons of capacity. No additional components were included for the proposed air-cooled screw chillers as all supplementary equipment such as primary pumping systems and secondary pumping systems are assumed to be the same in the baseline and proposed cases. A summary of the cost estimates for high efficiency air-cooled screw chillers is shown in Table 59.

Costs for the baseline include costs specific to the water-cooled chilled water system: water-cooled centrifugal chillers, cooling towers, condenser water pumps, and piping for the condenser water system. To obtain costs for the water-cooled chillers, the Statewide CASE Team reviewed costs reported in Workpapers published by the CPUC. Costs for water-cooled centrifugal chillers were obtained from Workpaper SWHC005 for Water-Cooled Chillers, approved January 1, 2022, which estimates average chiller costs from a combination of chiller distributor survey and extrapolation of historical CPUC energy efficiency measure data (California Public Utilities Commission 2022). The workpaper shows water-cooled chiller costs ranging from $463.55-$678.89 per ton for Path B code minimum efficiency units of 200-599 tons of capacity. A summary of the cost estimates for code-minimum water-cooled chillers is shown in Table 59.

Table 59: Water-Cooled and Air-Cooled Chiller Cost Estimates ($/ton)

Chiller type	Cooling Capacity Range (tons)	Cost ($/ton)
Path B Water-Cooled Centrifugal Chiller – Code Minimum	<150 tons	$660.00
	150-399 tons	$656.89
	300-599 tons	$515.13
	400-599 tons	$448.53
	>=600 tons	$392.57
Path B Air-Cooled Screw Chiller – High Efficiency	<150 tons	$1,057.28
	>=150 tons	$747.01

Cooling tower costs were estimated based on RSMeans Building Construction Cost Data 2021 as outlined in Section 2.4.3, estimating $204/ton for a 2022 Title 24, Part 6 code-minimum cooling tower, adjusted for each zone based on RSMeans Location Factors. Condenser water pump and piping costs were also estimated using RSMeans Building Construction Cost Data 2021 at a rate of $177/ton of cooling tower capacity. Condenser water treatment costs were estimated as $5,300 per unit (Building Green n.d.).

Because of the dependence on rated cooling capacity, estimated first costs vary by zone and prototype. Example costs by component for the baseline and proposed case are shown in Table 60: Baseline First Costs and Assumptions – Air-Cooled Chiller Threshold Measure – OfficeLarge Prototype – Climate Zone 1 for the OfficeLarge Climate Zone 1. Further details on the incremental cost estimates for each climate zone can be found in Appendix H.

Table 60: Baseline First Costs and Assumptions – Air-Cooled Chiller Threshold Measure – OfficeLarge Prototype – Climate Zone 1

Case	System	Cost
Baseline	Path B, Water-Cooled Centrifugal Chillers	$386,699
	Cooling Towers	$163,059
	Condenser Piping and Pumps	$120,202
	Condenser Water Treatment System	$5,300
	Total Baseline Cost	$675,260
Proposed	Path B, Air-Cooled Screw Chillers	$425,500
	Total Proposed Cost	$425,500
Incremental	**Total Incremental Cost**	**$(249,759)**

Chillers: (2) 285-ton units; Cooling Towers: (2) 340-ton units

Air-cooled chiller systems are estimated to be cheaper for each of the examined capacities. Though Path B air-cooled chillers are estimated to be more expensive per ton than baseline water-cooled chillers, the elimination of the condenser water systems – cooling towers, condenser pumps, piping, and water treatment – results in a less expensive overall system.

The Statewide CASE Team is continuing to collect cost data and would welcome input on these incremental first costs.

3.4.5 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is 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. The present value of equipment maintenance costs (or savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2025 Life Cycle Cost Hourly Factors. The present value of maintenance costs that occurs in the nth year is calculated as follows:

$$\text{Present Value of Maintenance Cost} = \text{Maintenance Cost} \times \left\lfloor \frac{1}{1+\mathrm{d}} \right\rfloor^{n}$$

Air-cooled chilled water systems are estimated to have lower annual maintenance costs due to the presence of condenser water systems – cooling towers, condenser pumps, chemical water treatment systems (industry standard practice according to stakeholder feedback), etc. – in water-cooled systems. Cooling towers and associated equipment require specific maintenance activities for proper operations due to exposure to water and to the outdoors. ASHRAE provides guidelines for cooling tower maintenance in ASHRAE Standard 180, Table 5-10 (American Society of Heating, Refrigeration, and Air-Conditioning Engineers n.d.). Based on the ASHRAE guidelines, the primary maintenance activity for cooling towers is chemical testing and water treatment, which needs to be checked monthly for open systems to ensure proper operation and reduce potential for scaling. Additional maintenance activities should occur quarterly, semiannually, and annually, and are summarized in Table 61.

Table 61: Cooling Tower Maintenance Guidelines

Monthly	Perform chemical testing of system water (open systems)
Quarterly	Perform chemical testing of system water (closed systems) Check water system ultraviolet lamp Check chemical injector device Check drive system Check belt for wear Check sheaves for alignment Check for fouling and corrosion
Semiannually	Check control system operations Check variable-frequency drive for proper operation Inspect pumps and components
Annually	Check control box for dirt and debris Check fan blades and housing Assess field-serviceable bearings Check for proper fluid flow and leaks Check for proper damper operation Check motors and pumps for proper operation

According to the 2015 ASHRAE Handbook for HVAC Applications, the equipment useful life of a cooling tower is 20 years (ASHRAE 2015). With proper maintenance, cooling towers are anticipated to maintain performance throughout their lifetime, with the average replacement occurring at 17.5 years according to the ASHRAE Owning and Operating Cost Database (ASHRAE n.d.).

Annual maintenance costs for the cooling tower and condenser water system were determined by estimating the annual hours associated with each of the monthly, quarterly, semiannual, and annual maintenance tasks and apply labor rates from RSMeans Building Cost Data 2021, along with an average location factor adjustment for cities in California. Table 62 summarizes the estimated maintenance costs. Annual water treatment costs were assumed to be $30/ton of cooling tower capacity (Building Green n.d.).

Table 62: Estimated Annual Maintenance Costs - Cooling Towers

Task Frequency	Estimated Annual Hours	Labor Rate	Total
Monthly	1	$79.63	$79.63
Quarterly	8	$79.63	$637.01
Semiannual	6	$79.63	$477.76
Annual	6	$79.63	$477.76
Total Annual Maintenance Costs	21	$79.63	**$1,672.15**

3.4.6 Cost Effectiveness

This measure proposes a primary prescriptive requirement. As such, a cost analysis is required to demonstrate that the measure is cost effective over the 30-year period of analysis.

The CEC establishes the procedures for calculating cost effectiveness. The Statewide CASE Team collaborated with CEC staff to confirm that the methodology in this report is consistent with their guidelines, including which costs were included in the analysis. The incremental first cost and incremental maintenance costs over the 30-year period of analysis were included. The LSC impacts from electricity and natural gas were also included in the evaluation, as were the 30-year life cycle water cost savings. Design costs were not included nor were the incremental costs of code compliance verification.

According to the CEC's definitions, a measure is cost effective if the benefit-to-cost (B/C) ratio is greater than 1.0. The B/C ratio is calculated by dividing the cost benefits realized over 30 years by the total incremental costs. For the air-cooled threshold measure, benefits include the 30-year life cycle water cost savings and the incremental first cost savings (since the proposed first cost is less than the baseline first cost), and incremental PV maintenance cost savings (since the proposed maintenance costs are less than the baseline maintenance costs). The costs of the B/C ratio consist of the LSC Savings (since the measure observes an energy penalty in each climate zone) and the incremental residual value.

Results of the per-unit cost-effectiveness analyses are presented in Table 63 for new construction/additions. The proposed measure saves money over the 30-year period of analysis relative to the existing conditions. The proposed code change is cost effective in every climate zone.

Table 63: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction/Additions

Climate Zone	Benefits - 30-Year Life Cycle Water Savings + Other PV Savings (2026 PV$)	Costs - LSC Savings +Total Incremental PV Costs (2026 PV$)	Benefit-to-Cost Ratio
1	$0.00	$0.00	Infinite
2	$0.00	$0.00	Infinite
3	$2.20	$0.65	3.41
4	$4.07	$2.39	1.70
5	$0.00	$0.00	Infinite
6	$3.36	$1.43	2.34
7	$3.62	$1.55	2.33
8	$4.65	$2.34	1.99
9	$4.53	$2.43	1.87
10	$4.96	$2.97	1.67
11	$5.09	$3.06	1.66
12	$3.98	$1.99	2.00
13	$0.00	$0.00	Infinite
14	$4.75	$3.30	1.44
15	$8.31	$6.16	1.35
16	$2.44	$1.08	2.26

3.5 First-Year Statewide Impacts

3.5.1 Statewide Energy, Water, and Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction and additions by multiplying the per-unit savings, which are presented in Section 3.3.2, by assumptions about the percentage of newly constructed buildings that would be impacted by the proposed code. As mentioned in Section 3.3.1.3, savings for building types for which no prototype model was available at the time of this report were estimated by applying the average per-unit energy impacts of the available models. The statewide new construction forecast for 2026 is presented in Appendix A, as are the Statewide CASE Team's assumptions about the percentage of new construction that would be impacted by the proposal (by climate zone and building type).

No statewide savings from alterations are attributed to the air-cooled chiller threshold measure.

The first-year energy impacts represent the first-year annual savings from all buildings that were completed in 2026. The 30-year energy cost savings represent the energy cost savings over the entire 30-year analysis period. The statewide savings estimates do not take naturally occurring market adoption or compliance rates into account.

The tables below present the first-year statewide energy, water, and cost savings from energy and water from newly constructed buildings and additions (Table 64) by climate zone. Table 65 presents first-year statewide savings from new construction and additions.

Statewide savings estimates for the air-cooled chiller threshold measure consider estimates for the prevalence of chilled-water systems based on building type. These estimates were formulated based on microdata from the 2018 Commercial Building Energy Consumption Survey, which shows that 1.5 percent of all buildings in the U.S. Census Pacific Division have water-cooled chillers, with variations depending on building type. Further details of the methodology for this estimate are provided in Appendix A.

While a statewide analysis is crucial to understanding broader effects of code change proposals, there is potential to disproportionately impact DIPs that needs to be considered. Refer to Section 3.6 for more details addressing energy equity and environmental justice.

Table 64: Statewide Energy and Energy Cost Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	First-Year[a] Water Savings (Gallons)	30-Year Present Valued Energy and Water Cost Savings (Million 2026 PV$)
1	1,396	(0.000)	(0.000)	(0.000)	(0.000)	379	$0.00
2	22,801	(0.007)	(0.000)	(0.000)	(0.000)	56,732	$0.01
3	1,116,108	(0.165)	(0.002)	(0.000)	(0.004)	1,369,535	$0.23
4	556,623	(0.296)	(0.002)	(0.000)	(0.011)	2,106,768	$0.08
5	8,469	(0.002)	(0.000)	(0.000)	(0.000)	13,500	$0.00
6	458,287	(0.142)	(0.002)	0.000	0.000	1,325,066	$0.24
7	286,703	(0.090)	(0.001)	0.000	0.001	890,477	$0.15
8	730,366	(0.374)	(0.004)	(0.000)	(0.002)	3,408,051	$0.57
9	1,295,539	(0.679)	(0.008)	(0.000)	(0.001)	5,792,803	$0.73
10	185,074	(0.122)	(0.001)	(0.000)	(0.000)	972,077	$0.10
11	49,606	(0.034)	(0.000)	(0.000)	(0.001)	256,635	$0.02
12	243,399	(0.108)	(0.001)	(0.000)	(0.008)	895,026	$0.12
13	32,808	(0.022)	(0.000)	(0.000)	(0.000)	178,121	$0.01
14	71,559	(0.052)	(0.001)	(0.000)	(0.002)	347,029	$0.00
15	12,298	(0.016)	(0.000)	0.000	0.000	121,138	$0.00
16	19,169	(0.004)	(0.000)	(0.000)	(0.001)	34,845	$0.00
Total	**5,090,204**	**(2.114)**	**(0.022)**	**(0.000)**	**(0.029)**	**17,768,182**	**$2.26**

a. First-year savings from all buildings completed statewide in 2026.

Table 65: Statewide Energy and Energy Cost Impacts – New Construction and Additions

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)	First-Year[a] Water Savings (Million gallons)	30-Year Present Valued LSC Savings (PV$ Million)
New Construction & Additions	(2.1)	(0.02)	(0.00)	(0.03)	17.8	$1.9
Alterations	0.0	0.00	0.00	0.00	0	0
Total	**(2.1)**	**(0.02)**	**(0.00)**	**(0.03)**	17.8	$1.9

a. First-year savings from all newly constructed buildings and alterations completed statewide in 2026.

3.5.2 Statewide Greenhouse Gas (GHG) Emissions Reductions

The Statewide CASE Team calculated GHG emissions associated with energy consumption using the hourly GHG emissions factors that CEC developed along with the 2025 LSC hourly factors and an assumed cost of $123.15 per metric tons of carbon dioxide equivalent emissions (metric tons CO2e).

The 2025 Life Cycle Cost Hourly Factors used in the lifecycle cost-effectiveness analysis include the monetary value of avoided GHG emissions based on a proxy for permit costs (not social costs).[23] The Cost-Effectiveness Analysis presented in Section 3.4 of this report does not include cost savings from avoided GHG emissions. To demonstrate the cost impacts of GHG emissions, the Statewide CASE Team disaggregated the value of GHG emissions from the other economic impacts.

Table 66 presents the estimated first-year GHG emissions impacts of the proposed code change. Because of the increase in electricity consumption when comparing air-cooled chillers to water-cooled, during the first year, an additional GHG emissions of 69 metric tons of CO2e would be created. Again, note however, the significant statewide water savings achieved.

Table 66: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings[b] (Metric Tons CO2e)	Natural Gas Savings[a] (Million Therms/yr)	Reduced GHG Emissions from Natural Gas Savings[b] (Metric Tons CO2e)	Total Reduced GHG Emissions[a] (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions[c] ($)
ACC Threshold	-2	-62	0.00	-2	-64	-7,880
TOTAL	**-2**	**-62**	**0.00**	**-2**	**-64**	**-7,880**

a. First-year savings from all applicable newly constructed buildings, additions, and alterations completed statewide in 2026.

b. GHG emissions were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and Source Energy hourly factors by CEC here: https://www.energy.ca.gov/files/2025-energy-code-hourly-factors

c. The monetary value of avoided GHG emissions is based on a proxy for permit costs (not social costs) derived from the 2022 TDV Update Model published by CEC here: https://www.energy.ca.gov/files/tdv-2022-update-model

[23] The permit cost of carbon is equivalent to the market value of a unit of GHG emissions in the California Cap-and-Trade program, while social cost of carbon is an estimate of the total economic value of damage done per unit of GHG emissions. Social costs tend to be greater than permit costs. See more on the Cap-and-Trade Program on the California Air Resources Board website: https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program.

3.5.3 Statewide Water Use Impacts

Water savings is the primary motivation for the air-cooled chiller threshold measure, which expands the use cases for air-cooled chillers statewide. Water savings were estimated using the same methodology as energy impacts, relying on the CBECC prototypes and EnergyPlus modeling as outlined in Section 3.3.1. Statewide water savings were estimated using the same methodology as outlined in Section 3.5.1 pertaining to statewide energy impacts.

Impacts on water use are presented in Table 67, which include on-site water savings and the embedded electricity of the water saved. Though an important factor of consideration, the embedded electricity of the water savings is not included in the overall statewide energy savings or cost effectiveness analyses. The embedded electricity estimate was derived from a 2022 research analysis conducted under the auspices of CPUC Rulemaking 13-12-011 that quantified the embedded electricity savings from IOU programs that save both water and energy (SBW Consulting, Inc. 2022). It was assumed that all water savings for this measure occurred indoors, and the embedded electricity value was 5,440 kWh/million gallons of water. Though cooling towers are outdoor equipment, the estimation of embedded electricity in water used indoors includes wastewater collection and wastewater treatment, a component of commercial cooling tower water consumption, which are not included in the estimate of embedded electricity in water used outdoors. The embedded electricity estimate was derived from a 2022 research analysis conducted under the auspices of CPUC Rulemaking 13-12-011 that quantified the embedded electricity savings from IOU programs that save both water and energy (SBW Consulting, Inc. 2022). See Appendix B for additional information on the embedded electricity savings estimates.

At the suggestion of stakeholders, due to the potential energy penalty of selecting air-cooled chillers, water use from power generation was also examined to ensure that the water savings achieved on site is not negated by water increases to generate the power. Ultimately, based on the weighted average water consumption for thermoelectric generation in California, the impact of increased water consumption for generation due to the on-site energy penalty is an average of 2.8 percent of the on-site water savings. This estimate was determined from a value of 0.44 gallons/kWh of thermoelectric generation estimated by the University of Santa Barbara (Theresa Pistochini 2011), applied to the 2021 California power mix which included 51 percent thermoelectric generation (California Energy Commission 2021). The analysis examines only thermoelectric impacts based on the assumptions that renewables (e.g., wind and solar) use no water consumption, nuclear power water consumption is primarily seawater, and water consumption from hydroelectric plants is primarily from evaporation from dam sites which provide uses beyond electricity generation.

Table 67: Impacts on Water Use and Embedded Electricity in Water

Impact	On-Site Indoor Water Savings (Gallons/Year)	On-site Outdoor Water Savings (Gallons/Year)	Embedded Electricity Savings[a] (kWh/Year)
Average Per Square Foot Impacts	3	0	0
First-Year[b] Statewide Impacts for New Construction & Additions	17,768,182	0	96,659
First-Year[b] Statewide Impacts for Alterations	0	0	0
First-Year[b] Total Statewide Impacts	17,768,182	0	96,659

a. Assumes embedded energy factor of 5,440 kWh per million gallons of water for indoor use (SBW Consulting, Inc. 2022).

b. First-year savings from all buildings completed statewide in 2026.

For more details involving water use and water impacts quality, refer to Appendix B.

3.5.4 Statewide Material Impacts

The introduction of exceptions to the 300-ton air-cooled chiller threshold limitation is anticipated to have statewide material impacts. New construction facilities that select air-cooled chillers as opposed to the baseline water-cooled chillers require less supplementary equipment such as cooling towers, condenser piping and pumps, and cooling tower water treatment equipment each of which is primarily constructed of steel, most often galvanized. Stainless steel is another cooling tower material type, though used in specific applications comprising a smaller percentage of overall projects. Based on publicly available engineering specifications, the average code-minimum (60 gpm/hp) open-circuit, axial-fan cooling tower has a shipping weight of 6,700 lbs. (SPX Cooling Technologies n.d., Evapco n.d., Baltimore Aircoil Company n.d.). For a common cooling tower application, assuming two 10 hp pumps at 164 lbs. each, 30 ft of black steel piping at 4.366 lb./ft, and a 500 lb. water treatment plant, an additional 960 lbs. of steel was estimated. The resulting impacts on statewide materials and embodied GHG emissions are shown in Table 68. For more information on the Statewide CASE Team's methodology and assumptions used to calculate embodied GHG emissions, see Appendix D.

Table 68: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per Square Foot)	First-Year [a] Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO2e)
Mercury	No Change	0.000000	0	0
Lead	No Change	0.000000	0	0
Copper	No Change	0.000000	0	0
Steel	Decrease	-0.012756	-64,931	36
Plastic	No Change	0.000000	0	0
TOTAL	-	-0.012756	**-64,931**	**36**

a. First-year savings from all buildings completed statewide in 2026.

3.5.5 Other Non-Energy Impacts

No non-energy impacts are anticipated from the proposed code change.

3.6 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in DIPs and the role this history plays in the environmental justice issues that persist today. DIPs refer to the areas throughout California that most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes, as well as high incidence of asthma and heart disease. DIPs also incorporate race, class, and gender since these intersecting identity factors affect how people frame issues, interpret, and experience the world.[24] While the term disadvantaged communities (DACs) is often used in the energy industry and state agencies, the Statewide CASE Team chose to use terminology that is more acceptable to and less stigmatizing for those it seeks to describe (DC Fiscal Policy Institute 2017).

Including impacted communities in the decision-making process, ensuring that the benefits and burdens of the energy sector are evenly distributed, and grappling with the unjust legacies of the past all serve as critical steps to achieving energy equity. Code change proposals must be developed and adopted with intentional screening for

[24] Environmental disparities have been shown to be associated with unequal harmful environmental exposure correlated with race/ethnicity, gender, and socioeconomic status. For example, chronic diseases, such as respiratory diseases, cardiovascular disease, and cancer, associated with environmental exposure have been shown to occur in higher rates in the LGBTQ+ population than in the cisgender, heterosexual population (Goldsmith and Bell 2021). Socioeconomic inequities, climate, energy, and other inequities are inextricably linked and often mutually reinforcing.

unintended consequences, otherwise they risk perpetuating systemic injustices and oppression.

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice, therefore reducing the impacts of disparities in DIPs. The Statewide CASE Team does not recommend further research or action at this time.

3.6.1 Research Methods and Engagement

Chillers are common on commercial and institutional facilities and are not expected to impact energy equity or environmental justice in any specific way.

4. Blowdown Controls

4.1 Measure Description

4.1.1 Proposed Code Change

This measure would update the mandatory language in Section 110.2(e) which currently requires all open- and closed-circuit cooling towers 150 tons and larger to:

- Be equipped with either conductivity or flow-based controls that automate system bleed and chemical feed in order to maximize cycles of concentration and reduce cooling tower blowdown.
- Be equipped with a makeup water flow meter and overflow alarm that alerts to a makeup water valve failure.
- Have efficient drift eliminators installed.
- Document the maximum achievable cycles of concentration achievable given local water quality conditions and a Langelier Saturation Index (LSI) of 2.5 or less.

The proposed measure would revise Section 110.2(e) and the associated cycles of concentration compliance document as follows:

- Require the use of conductivity-based controls (eliminate the option to use flow-based controls).
- Update the NRCC-MCH-E compliance document to require the designer to maximize cycles of concentration. While this is currently required by Section 110.2(e), the current NRCC-MCH-E form will pass any cycles of concentration that achieves an LSI of 2.5 or less.
- Add thresholds for silica and other recirculating water properties in line with ANSI/ASHRAE Standard 189.1-2020.
- Add an acceptance test to verify installation and programming of controls to achieve documented cycles of concentration and overflow alarms.

Section 110.2(e) currently applies to both new construction, additions, and alterations in both nonresidential and multifamily buildings, and this would remain the same with the proposed changes. Since this is a mandatory measure, it would not affect the compliance software.

4.1.2 Justification and Background Information

4.1.2.1 Justification

Cooling towers in nonresidential and multifamily buildings represent a significant opportunity to reduce water use in California. Cooling towers account for an estimated 20 to 40 percent of water demand in buildings that include water-cooled chillers (Tomberlin, Dean and Deru, Continuous Monitoring and Partial Water Softening for Cooling Tower Water Treatment 2020) (U.S. Department of Energy 2016). Blowdown and the consequent makeup water use represent a significant source of cooling tower water usage, providing the most significant opportunity for conservation according to the U.S. DOE Federal Energy Management Program (FEMP) (U.S. DOE Federal Energy Management Program n.d.).

In 2013, Title 24, Part 6 introduced requirements to limit blowdown water usage through controls aimed at maximizing achieved cycles of concentration. However, the benefits of these requirements have not been fully realized as the NRC-MCH-E form does not actually require the designer to maximize cycles of concentration and there is no mechanism in place to ensure that controls are programmed to achieve maximum cycles of concentration in the field. Furthermore, the allowance of flow-based controls permits sites to manage cycles of concentration without responding to actual water quality, increasing water use from towers that use flow-based controls. Stakeholders have also raised the need to be able to control based on other recirculating water parameters, such as silica.

Additionally, a variety of technologies that were not considered in the original CASE Report (Statewide CASE Team 2013) have been developed to improve water quality in cooling towers since the previous CASE Report, increasing achievable cycles of concentration. These include electrolysis/ionization, ozonation, and water softening systems. These systems have demonstrated cost effectiveness in retrofit applications and have the potential to increase cycles of concentration from typical values between two and five to cycles of concentration as high as 80 (U.S. Department of Energy 2020).[25] While these systems are not directly required by the proposed changes, they represent a further opportunity to maximize cycles of concentration and reduce blowdown.

4.1.2.2 Background Information

Cooling towers use water through evaporation, drift, and blowdown. Blowdown is the process of removing water from the cooling tower to eliminate the dissolved solids and chemicals that have accumulated during the cooling tower's operation. Removing these solids and chemicals reduces the potential for corrosion, scale, fouling, and biological growth which can reduce the lifetime and efficacy of both the cooling tower and chiller.

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[25] Note that water savings typically diminish at around 7 to 10 cycles of concentration.

Cycles of concentration refers to the ratio of dissolved solids or chemicals in the blowdown water compared to the makeup water; effectively how concentrated the cooling tower water is allowed to get before it is removed from the tower through blowdown.

Conventional cooling water management involves the use of chemicals to manage corrosion, scale, fouling, and biological growth. The requirements included in 2013 Title 24, Part 6 to maximize cycles of concentration and limit blowdown were based on these conventional chemical management methods and the controllers available at the time.

However, the NRCC-MCH-E form implementing this requirement does not actually require the designer to calculate maximum cycles of concentration. Anecdotal information from design engineers also suggests that controls are not being programmed to achieve maximum cycles of concentration in the field and that overflow alarms are not being installed consistently. Research into available controllers shows that many available options include both flow- and conductivity-based control options. This model availability shows the feasibility of requiring conductivity-based controls only, which would ensure that the tower operation is responding to actual water quality.

This measure addresses these issues by updating the NRCC-MCH-E form to actually require designers to maximize cycles of concentration and adds an acceptance test to verify installation of conductivity-based controls that are programmed to achieve the maximum cycles of concentration determined. These modifications would help realize the original water savings potential of the 2013 measure, which have not been fully realized to date due to the issues described.

In addition to the specific changes mentioned above, since the 2013 CASE Report there has been development of new water treatment technologies for cooling towers that can significantly increase cycles of concentration while minimizing or eliminating chemical management. A major driver for these technologies has been their implementation at federal facilities run by the General Services Administration (GSA) and studied by the National Renewable Energy Lab (NREL). While a typical cooling tower would have a cycles of concentration between 2 and 5, these technologies can increase cycles of concentration to values as high as 80. Based on available case studies on the implementation of these technologies in existing buildings, they can reduce water use by 20 to 32 percent, with an average savings across case studies of 24 percent. (Tomberlin, Dean and Deru, Continuous Monitoring and Partial Water Softening for Cooling Tower Water Treatment 2020) (Tomberlin, Dean and Deru, Electrochemical Water Treatment for Cooling Towers 2018) (Cutler, et al. 2018) (Deru and Bonnema 2019) (U.S. Department of Energy 2016)

These systems include:

- Water softening: Water softening removes hardness in water using salts or other methods which eliminates the need for corrosion or scale inhibiting chemicals and greatly reduces the need for biocide chemicals.
- Electrolysis: Electrolysis can be used to precipitate minerals and kill biological growth.
- Centrifugal separators: Centrifugal separators use cavitation to precipitate mineral solids.
- Ozonation/Advanced oxidation process: Ozonation and advanced oxidation process use various methods to create hydroxyl (OH-) free radicals that react with dissolved solids and eliminate the need for scale and corrosion inhibitors.

Additionally, the Department of Energy's Better Buildings Initiative has partnered with the City of Los Angeles to provide incentives and technical assistance for measures that save water in cooling towers. Through this program they offer specific dollar incentives for upgrading conductivity controllers, pH control through acid-based treatment, water softening, reverse osmosis, and other non-chemical treatment methods, such as micro filtration (U.S. Department of Energy 2016). Additionally, LADWP offers incentives through their Technical Assistance Program that offers free cooling tower assessments and incentives of up to $2,000,000 for projects that reduce potable water use by 50,000 gallons or more over two years (Los Angeles Department of Water and Power n.d.). This includes a monitored standard treatment program, a pH control program, or a water softening treatment program.

While these technologies represent a potential methodology to further reduce blowdown in cooling towers, they are not directly included in the proposed CASE measure. This is for two primary reasons:

- The CASE authors were unable to identify any studies showing long-term performance, persistence of savings, and any potential negative cooling tower impacts.
- The CASE authors were unable to identify any standard rating or testing system to verify performance of these system types, the effectiveness of which can vary by vendor.

The CASE authors would welcome additional data on these system types and their readiness for inclusion in building codes.

4.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manuals, and compliance documents would be modified by the proposed change.[26] See Section 5.1 of this report for detailed proposed revisions to code language.

4.1.3.1 Specific Purpose and Necessity of Proposed Code Changes

Each proposed change to language in Title 24, Part 1 and Part 6 as well as the reference appendices to Part 6 are described below. See Section 5.2 of this report for marked-up code language.

Section: 110.2(e)

Specific Purpose: The specific purpose is to increase the cycles of concentration achieved for closed-circuit and open-circuit cooling towers.

Necessity: These changes are necessary to increase water savings via cost-effective building design standards, as directed by California Public Resources Code Sections 25213 and 25402.

Section: Nonresidential Appendix 7.5

Specific Purpose: The specific purpose is to add a mechanical acceptance test to verify the installation of cooling tower conductivity controls, documentation of maximum cycles of concentration, programming of controls to not allow blowdown until parameter target thresholds are reached, and installation and programming of overflow alarms.

Necessity: These changes are necessary to increase water savings via cost-effective building design standards, as directed by California Public Resources Code Sections 25213 and 25402.

4.1.3.2 Specific Purpose and Necessity of Changes to the Nonresidential ACM Reference Manual

The proposed code change would not modify the ACM Reference Manual.

4.1.3.3 Summary of Changes to the Nonresidential Compliance Manual

Chapter 4, Section 4.2.7 of the 2022 Nonresidential Compliance Manual would need to be revised. This section discusses the requirements for cycles of concentration and references a weblink to the CEC's LSI calculator and the NRCC-MCH-E form. Both would need to be updated to reference the new calculator and NRCC-MCH-E form locations. Additionally, the cycles of concentration calculator weblink appears in Section 4.6.1 and would need updating to reflect the new compliance document location.

[26] Visit EnergyCodeAce.com for trainings, tools and resources to help people understand existing code requirements.

4.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. Examples of the revised documents are presented in Section 5.5.

- NRCC-MCH-E Maximum Cycles of Calculation Worksheet – This compliance document would be updated to require the designer to achieve maximum cycles of concentration for an LSI of 2.5.

4.1.4 Regulatory Context

4.1.4.1 Determination of Inconsistency or Incompatibility with Existing State Laws and Regulations

There are no relevant state or local laws or regulations.

4.1.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

4.1.4.3 Difference From Existing Model Codes and Industry Standards

The 2021 International Green Construction Code (IgCC/ASHRAE/ANSI 189.1-2020) Section 601.3.2.3 requires conductivity controllers that may not allow blowdown until one or more of the parameters in the table below meets 90 percent of the threshold identified.

RECIRCULATING WATER PARAMETERS	MAXIMUM VALUE
Conductivity (micro-ohms)	3300
Total dissolved solids (ppm)	2050
Total alkalinity as $CaCO_3$ (ppm) excluding galvanized steel	600
Total alkalinity as $CaCO_3$ (ppm) galvanized steel (passivated)	500
Calcium hardness as $CaCO_3$ (ppm)	600
Chlorides as Cl (ppm)	300
Sulfates (ppm)	250
Silica (ppm)	150
Langelier Saturation Index (LSI)	+2.8

Figure 9: 2021 IgCC Table 601.3.2.3 Recirculating Water Properties for Open-Circuit Cooling-Tower Construction

The 2020 City of Los Angeles Green Building Code Section 4.305.3 also includes several code requirements for new cooling towers. It requires:

- A minimum of six cycles of concentration
- 50 percent of makeup water must be non-potable for buildings less than or equal to 25 stories.
- 100 percent of makeup water must be non-potable for buildings greater than 25 stories.

4.1.5 Compliance and Enforcement

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. This section describes how to comply with the proposed code change. It also describes the compliance verification process. Appendix E presents how the proposed changes could impact various market actors.

The compliance verification activities related to this measure that need to occur during each phase of the project are described below:

- **Design Phase:** Mechanical engineer designs cooling tower and associated water treatment system and/or plan in coordination with building owner and architect. Mechanical engineer completes cycles of concentration compliance document.
- **Permit Application Phase:** Mechanical engineer submits cycles of concentration compliance document along with other permit documents. The form clearly states whether the design passes by stating “pass” or “fail” based on the input values. Plan checker reviews to confirm that the form indicates a “pass.”
- **Construction Phase:** General contractor hires mechanical subcontractor to install central plant including water-cooled chiller(s), cooling tower(s) and associated piping, valves, and controls. Mechanical subcontractor works with cooling tower water treatment system vendor and controls vendors to ensure proper installation of these systems. Mechanical designer conducts punch walk to ensure proper installation. Mechanical acceptance tester would conduct acceptance test to ensure installation and programming of water treatment system and controls.
- **Inspection Phase:** Code inspector confirms the testing and acceptance forms have been completed during their inspection.

4.2 Market Analysis

4.2.1 Current Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general as well as individual market actors. Information was gathered about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, CEC staff, and a wide range of industry actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during a public stakeholder meeting that the Statewide CASE Team held on February 13, 2023. (Statewide CASE Team 2023)

Key market actors include the building owner, design engineer, cooling tower manufacturers, chiller manufacturers, controls vendors, chemical and/or water treatment system vendor, distributor, HVAC contractor, and building inspector. Typically, the design engineer works in coordination with the owner, manufacturer/distributor, and water treatment system vendor to design a water quality control strategy. In most cases, this involves chemical treatment which is provided on an ongoing basis by the chemical treatment vendor. The design engineer is also responsible for specifying the required controls, overflow alarms, and drift eliminators, as well as calculating the maximum cycles of concentration achievable using the NRCC-MCH-E compliance document.

4.2.2 Technical Feasibility and Market Availability

The Statewide CASE Team determined the following barriers that currently inhibit the achievement of reduced cooling tower blowdown through conversations with building design engineers and cooling tower experts:

- The NRCC-MCH-E cycles of concentration compliance document does not actually require the designer to maximize cycles of concentration and instead will pass any value that results in an LSI of 2.5 or less. For example, a cycles of concentration of 1, which is equivalent to once-through-cooling, is permissible using the compliance document.
- The vast majority of designers do not specify the overflow alarm required by 2022 Title 24, Part 6 section 110.2(e).
- Stakeholders raised the need to be able to control other water quality parameters besides LSI and specifically raised the need to control the concentration of silica.
- Cooling tower controls can fail or drift over time, reducing achieved cycles of concentration in the field. Adding an acceptance test could help mitigate this issue

by verifying that controls are properly installed at time of building occupancy and to verify that overflow alarms are installed and functioning.

In addition to these barriers, the Statewide CASE Team found that the vast majority of the market already uses conductivity-based controls and that most controllers available include both flow- and conductivity-based options. The CASE Team was unable to identify any flow-based controls available that also met the current requirement for automated bleed (the flow-based controls identified were purely for the purpose of chemical feed). *The CASE Team is seeking further information from stakeholders on the prevalence of flow-based controls.*

The allowance of flow-based controls could lead to reduced cycles of concentration as these do not respond to actual water quality and are likely controlled conservatively to maintain cooling tower water quality. Examples of identified controllers that appear to comply with 2022 Title 24, Part 6 Section 110.2(e) are listed in Figure 10.

Manufacturer	Control type	Model Name
Advantage Controls	Conductivity- and flow-based models[27]	Nanotron
Chemtrol	Conductivity-based	CT110
Lakewood	Conductivity/flow-based	Model 140
Walchem	Conductivity-based	WCT600

Figure 10: Cooling tower controller models and control types.

Finally, the Statewide CASE Team identified a variety of water treatment systems that have been developed over the past decade and appear to achieve significant improvements in cycles of concentration. These have been primarily studied by NREL at GSA and other government facilities (U.S. Department of Energy 2020). While these systems show potential promise for reducing cooling tower water use, two barriers were identified that prevented these technologies from being specifically integrated into the measure proposal. The first was the longevity of available studies: the Statewide CASE Team was unable to identify any studies showing long-term (5 years or longer) performance of these systems. The second was the lack of a performance standard or test procedure that could be used to define the performance of these water treatment systems. These systems were therefore not directly incorporated into the measure proposal. *The CASE Team is seeking further information on the long-term performance of these water treatment systems to improve cycles of concentration.*

[27] Note that the flow-based model does not appear to comply with 2022 Title 24, Part 6 Section 110.2(e).

4.2.3 Market Impacts and Economic Assessments

4.2.3.1 Impact on Builders

Builders of residential and commercial structures are directly impacted by many of the measures proposed by the Statewide CASE Team for the 2025 code cycle. The impacts of the proposed blowdown measure on builders would be minimal as installation of conductivity controls are already widely utilized for cooling tower water quality management. Builders would be subject to an acceptance test which would require them to program controls to meet the target parameter thresholds and to properly install overflow alarms. These acceptance tests would verify that work is done correctly and may require the builder to adjust practices to ensure that the cooling tower passes the acceptance test. It would also require builders to plan the acceptance test into the project schedule. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California's construction industry comprises approximately 93,000 business establishments and 943,000 employees (see Table 69). For 2022, total estimated payroll will be about $78 billion. Nearly 72,000 of these business establishments and 473,000 employees are engaged in the residential building sector, while another 17,600 establishments and 369,000 employees focus on the commercial sector. The remainder of establishments and employees work in industrial, utilities, infrastructure, and other heavy construction roles (the industrial sector).

Table 69: California Construction Industry, Establishments, Employment, and Payroll in 2022 (Estimated)

Building Type	Construction Sectors	Establish-ments	Employ-ment	Annual Payroll (Billions $)
Residential	**All**	**71,889**	**472,974**	**31.2**
Residential	Building Construction Contractors	27,948	130,580	9.8
Residential	Foundation, Structure, & Building Exterior	7,891	83,575	5.0
Residential	Building Equipment Contractors	18,108	125,559	8.5
Residential	Building Finishing Contractors	17,942	133,260	8.0
Commercial	**All**	**17,621**	**368,810**	**35.0**
Commercial	Building Construction Contractors	4,919	83,028	9.0
Commercial	Foundation, Structure, & Building Exterior	2,194	59,110	5.0
Commercial	Building Equipment Contractors	6,039	139,442	13.5
Commercial	Building Finishing Contractors	4,469	87,230	7.4

Building Type	Construction Sectors	Establish-ments	Employ-ment	Annual Payroll (Billions $)
Industrial, Utilities, Infrastructure, & Other (Industrial+)	**All**	**4,206**	**101,002**	**11.4**
Industrial+	Building Construction	288	3,995	0.4
Industrial+	Utility System Construction	1,761	50,126	5.5
Industrial+	Land Subdivision	907	6,550	1.0
Industrial+	Highway, Street, & Bridge Construction	799	28,726	3.1
Industrial+	Other Heavy Construction	451	11,605	1.4

Source: (State of California n.d.)

The proposed change to blowdown controls would likely affect commercial builders but would not impact firms that focus on construction and retrofit of industrial buildings, utility systems, public infrastructure, or other heavy construction. The effects on the commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 69 shows the overall estimated establishments, employment, and payroll by building type and subsector and Table 70 shows the commercial building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report. Subsectors were identified on the basis of which components of the construction phase are involved in the installation of cooling tower systems for multifamily and nonresidential buildings, which involves aspects of structural and foundational work to support equipment, HVAC work, electrical work, plumbing, and site preparation. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 4.2.4 Economic Impacts.

Table 70: 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 $)
Commercial Building Construction	4,919	83,028	9.0
Nonresidential Electrical Contractors	3,137	74,277	7.0
Nonresidential plumbing & HVAC contractors	2,346	55,572	5.5
Other Nonresidential equipment contractors	556	9,594	1.0

Source: (State of California n.d.)

4.2.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes is within the normal practices of building designers. Impacts on building designers would be minimal as they are already specifying water treatment systems and controls for cooling towers and would just need to adjust these practices to ensure that maximum cycles of concentration are achieved. It would also provide some extra flexibility through the addition of other water quality control parameters. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle, and building designers and energy consultants engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 71 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts of the updated blowdown control requirements to affect firms that focus on multifamily and nonresidential construction.

There is not a North American Industry Classification System (NAICS)[3] code specific to energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[4] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 71 provides an upper bound indication of the size of this sector in California.

Table 71: California Building Designer and Energy Consultant Sectors in 2022 (Estimated)

Sector	Establishments	Employment	Annual Payroll (Millions $)
Architectural Services [a]	4,134	31,478	3,623.3
Building Inspection Services [b]	1,035	3,567	280.7

Source: (State of California n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures.

b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services

4.2.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California

Division of Occupational Safety and Health (DOSH). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building. It may have positive impacts on health and safety, as some end-users may choose to comply with the code through non-chemical water treatment systems. This would improve occupational health and safety as chemicals would not have to be transported, hauled up to the roof, and transferred into the chemical treatment barrels.

4.2.3.4 Impact on Building Owners and Occupants

Commercial Buildings

The commercial building sector includes a wide array of building types, including offices, restaurants and lodging, retail, and mixed-use establishments, and warehouses (including refrigerated) (Kenney 2019). Energy use by occupants of commercial buildings also varies considerably, with electricity used primarily for lighting, space cooling and conditioning, and refrigeration, while natural gas is used primarily for water heating and space heating. According to information published in the 2019 California Energy Efficiency Action Plan, there is more than 7.5 billion square feet of commercial floor space in California consuming 19 percent of California's total annual energy use (Kenney 2019). The diversity of building and business types within this sector creates a challenge for disseminating information on energy and water efficiency solutions, as does the variability in sophistication of building owners and the relationships between building owners and occupants.

Building owners and occupants would benefit from lower water bills. As discussed in Section 4.2.4.1, when building occupants save on bills, they tend to spend it elsewhere in the economy thereby creating jobs and economic growth for the California economy. The Statewide CASE Team does not expect the proposed code change for the 2025 code cycle to impact building owners or occupants adversely.

4.2.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)

The Statewide CASE Team anticipates the proposed change would have no material impact on California component retailers. *The CASE Team seeks further input from stakeholders on this issue, in particular if manufacturers of flow-based controls would be impacted.*

4.2.3.6 Impact on Building Inspectors

Table 72 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing education and training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 72: Employment in California State and Government Agencies with Building Inspectors in 2022 (Estimated)

Sector	Govt.	Establishments	Employment	Annual Payroll (Million $)
Administration of Housing Programs[a]	State	18	265	29.0
	Local	38	3,060	248.6
Urban and Rural Development Admin[b]	State	38	764	71.3
	Local	52	2,481	211.5

Source: (State of California, Employment Development Department n.d.)

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.

b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

4.2.3.7 Impact on Statewide Employment

As described in Sections 4.2.3.1 through 4.2.3.6, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 4.2.4, the Statewide CASE Team estimated the proposed change in blowdown control requirements would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how water savings associated with the proposed change in blowdown control requirements would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

4.2.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software[28], along with economic information from published sources, and professional

[28] IMPLAN employs economic data and advanced economic impact modeling to estimate economic impacts for interventions like changes to the California Title 24, Part 6 code. For more information on the IMPLAN modeling process, see www.IMPLAN.com.

judgement to develop estimates of the economic impacts associated with each of the proposed code changes. Conceptually, IMPLAN estimates jobs created as a function of incoming cash flow in different sectors of the economy, due to implementing a code or a standard. The jobs created are typically categorized into direct, indirect, and induced employment. For example, cash flow into a manufacturing plant captures direct employment (jobs created in the manufacturing plant), indirect employment (jobs created in the sectors that provide raw materials to the manufacturing plant) and induced employment (jobs created in the larger economy due to purchasing habits of people newly employed in the manufacturing plant). Eventually, IMPLAN computes the total number of jobs created due to a code. The assumptions of IMPLAN include constant returns to scale, fixed input structure, industry homogeneity, no supply constraints, fixed technology, and constant byproduct coefficients. The model is also static in nature and is a simplification of how jobs are created in the macro-economy.

The economic impacts developed for this report are only estimates and are based on limited and to some extent speculative information. The IMPLAN model provides a relatively simple representation of the California economy and, though the Statewide CASE Team is confident that the direction and approximate magnitude of the estimated economic impacts are reasonable, it is important to understand that the IMPLAN model is a simplification of extremely complex actions and interactions of individual, businesses, and other organizations as they respond to changes in energy efficiency codes. In all aspects of this economic analysis, the CASE Authors rely on conservative assumptions regarding the likely economic benefits associated with the proposed code change. By following this approach, the economic impacts presented below represent lower bound estimates of the actual benefits associated with this proposed code change.

Adoption of this code change proposal would result in relatively modest economic impacts through the additional direct spending by those in the commercial building industry. The Statewide CASE Team does not anticipate that money saved by commercial building owners or other organizations affected by the proposed 2025 code cycle regulations would result in additional spending by those businesses.

4.2.4.1 Creation or Elimination of Jobs

The Statewide CASE Team does not anticipate that the measures proposed for the 2025 code cycle regulation would lead to the creation of new *types* of jobs or the elimination of *existing* types of jobs. In other words, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. Rather, the estimates of economic impacts discussed in Section 4.2.4 would lead to modest changes in employment of existing jobs.

4.2.4.2 Creation or Elimination of Businesses in California

As stated in Section 4.2.4.1, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. The proposed change represents a modest change to the blowdown control requirements, which would not excessively burden or competitively disadvantage California businesses – nor would it necessarily lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not foresee any new businesses being created, nor does the Statewide CASE Team think any existing businesses would be eliminated due to the proposed code changes.

4.2.4.3 Competitive Advantages or Disadvantages for Businesses in California

The proposed code changes would apply to all businesses incorporated in California, regardless of whether the business is located inside or outside of the state. Therefore, the Statewide CASE Team does not anticipate that these measures proposed for the 2025 code cycle regulation would have an adverse effect on the competitiveness of California businesses. Likewise, the Statewide CASE Team does not anticipate businesses located outside of California would be advantaged or disadvantaged.

4.2.4.4 Increase or Decrease of Investments in the State of California

The Statewide CASE Team analyzed national data on corporate profits and capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[29] As Table 73 shows, between 2017 and 2021, NPDI as a percentage of corporate profits ranged from a low of 18 in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 35 percent in 2019, with an average of 26 percent. While only an approximation of the proportion of business income used for net capital investment, the Statewide CASE Team believes it provides a reasonable estimate of the proportion of proprietor income that would be reinvested by business owners into expanding their capital stock.

Table 73: Net Domestic Private Investment and Corporate Profits, U.S.

Year	Net Domestic Private Investment by Businesses, Billions of Dollars	Corporate Profits After Taxes, Billions of Dollars	Ratio of Net Private Investment to Corporate Profits (Percent)
2017	518.473	1882.460	28

[29] Net private domestic investment is the total amount of investment in capital by the business sector that is used to expand the capital stock, rather than maintain or replace due to depreciation. Corporate profit is the money left after a corporation pays its expenses.

2018	636.846	1977.478	32
2019	690.865	1952.432	35
2020	343.620	1908.433	18
2021	506.331	2619.977	19
5-Year Average	***539.227***	***2068.156***	**26**

Source: (Federal Reserve Economic Data (FRED) n.d.)

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to significant change (increase or decrease) in investment, directly or indirectly, in any affected sectors of California's economy. Nevertheless, the Statewide CASE Team is able to derive a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on proprietor income, which we use a conservative estimate of corporate profits, a portion of which we assume would be allocated to net business investment.[30]

4.2.4.5 Incentives for Innovation in Products, Materials, or Processes

This proposal is performance-based and technology-neutral in that it requires a building to achieve the identified maximum cycles of concentration but does not specify how this cycles of concentration must be achieved. It also sets cycles of concentration targets based on an LSI threshold, which would allow many possible treatment options to be utilized. This would help drive innovation in the development of cooling tower water treatment systems by giving designers flexibility in how they meet these requirements.

4.2.4.6 Effects on the State General Fund, State Special Funds, and Local Governments

The Statewide CASE Team does not expect the proposed code changes would have a measurable impact on the California's General Fund, any state special funds, or local government funds.

Cost of Enforcement

Cost to the State: State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals. The proposal would likely impact newly

[30] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 15.

constructed state buildings that have cooling towers. These proposed code changes have been found to be cost effective.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 4.1.5 and Appendix E, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

4.2.4.7 Impacts on Specific Persons

While the objective of any of the Statewide CASE Team's proposal is to promote energy efficiency, the Statewide CASE Team recognizes that there is the potential that a proposed code change may result in unintended consequences. The Statewide CASE Team does not anticipate that impacts on any specific group or group of persons would differ from the impacts to persons generally, as the impacts would apply uniformly to large commercial buildings that have cooling towers Refer to Section 4.6 for more details addressing energy equity and environmental justice.

4.2.5 Fiscal Impacts

4.2.5.1 Mandates on Local Agencies or School Districts

There are no relevant mandates to local agencies or school districts. The proposed code change would affect local agencies and school districts to the extent they construct buildings with cooling towers, but this effect would be no different than any other building with a cooling tower subject to 2025 Title 24 Part 6.

4.2.5.2 Costs to Local Agencies or School Districts

There are no costs to local agencies or school districts as the measure proposed results in life cycle cost savings.

4.2.5.3 Costs or Savings to Any State Agency

If state agencies construct buildings with cooling towers, there would be lifecycle cost savings from the proposed measure.

4.2.5.4 Other Non-Discretionary Cost or Savings Imposed on Local Agencies

There are no added non-discretionary costs or savings to local agencies as the measures proposed are cost effective over their lifetime and only apply to buildings constructed with cooling towers.

4.2.5.5 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state as this measure does not affect federal funding.

4.3 Energy and Water Savings

The proposed code change would result in water savings but would not result in any direct energy savings. It would result in statewide energy savings due to the embedded energy associated with water use. The Statewide CASE Team gathered stakeholder input to inform the energy and water savings analysis. Stakeholder outreach included discussions with building designers, cooling tower manufacturers, outreach to cooling tower controls vendors, national laboratories, and water efficiency experts. See Appendix F for a summary of stakeholder engagement.

Energy savings benefits may have potential to disproportionately impact DIPs. Refer to Section 4.6 for more details addressing energy equity and environmental justice.

4.3.1 Energy and Water Savings Methodology

4.3.1.1 Key Assumptions for Water Savings Analysis

The Statewide CASE Team used EnergyPlus to conduct the water savings analysis for the blowdown controls measure. There are no direct energy savings from this measure but there are indirect statewide energy savings from the energy embedded in water use. The models were sourced from the California Building Energy Code Compliance (CBECC) software for commercial buildings prototype building models and modified to include the baseline and proposed cycles of concentration. The two available prototype building models that include a cooling tower (Hospital, Large Office) were modeled in all 16 climate zones.

The baseline cycles of concentration was established based on research conducted for the 2013 CASE Report and conversations with stakeholders. The 2013 CASE Report identified a baseline cycles of concentration of 3.5 (Statewide CASE Team 2013). Since the Statewide CASE Team found that conductivity controls were widely used prior to the implementation of 2013 Title 24, Part 6 and the cycles of concentration calculator does not require designers to maximize cycles of concentration, it was assumed that this baseline cycles of concentration value was still appropriate. Conversations with designers and cooling tower experts validated this assumption.

The proposed cycles of concentration was established based on the weighted average of the maximum cycles of concentration achievable at an LSI of 2.5 in the 10 most populous cities in California. Publicly available water quality data from local water districts available in annual water quality reports was used in combination with the NRCC-MCH-E compliance document to determine the maximum cycles of concentration achievable in each city.

Table 74: Maximum Cycles of Concentration Achievable in the 10 Most Populous Cities in California at an LSI of 2.5

Population Rank	City	Utility	Maximum Cycles of Concentration
1	Los Angeles	LADWP	3.35
2	San Diego	San Diego Public Utility District	2.88
3	San Jose	San Jose Municipal Water System	3.70
4	San Francisco	San Francisco Water Power Sewer	17.06
5	Fresno	City of Fresno Water Division	N/A[31]
6	Sacramento	Sacramento Department of Utilities	5.11
7	Long Beach	Long Beach Water District	4.25
8	Oakland	East Bay Municipal Utility District	7.9
9	Bakersfield	Cal Water (Bakersfield)	8.39
10	Anaheim	Orange County Water District	11.5
N/A	All	All	5.2 (weighted average)

4.3.1.2 Water Savings Methodology per Prototypical Building

Water savings were measured in gallons of water saved per square foot in the proposed versus baseline scenarios for the prototypical buildings modeled. The CEC directed the Statewide CASE Team to model the water savings impacts using specific prototypical building models that represent typical building geometries for different types of buildings. The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 75.

All 2025 prototype models can be obtained by downloading the CBECC software from the NORESCO Title 24 Nonresidential Compliance Software website (NORESCO n.d.).

[31] Available water quality data from the City of Fresno was not sufficient to determine the maximum of cycles of concentration.

Table 75: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Hospital	5	241,374	5-Story Hospital plus basement U.S. DOE prototype model
OfficeLarge	12	498,589	12 story + 1 basement office building with 5 zones and a ceiling plenum on each floor. Window-to-wall ratio (WWR) of 0.40. Standard Design HVAC system of two centrifugal water-cooled chillers

The Statewide CASE Team estimated Life Cycle water impacts by simulating the proposed code change in EnergyPlus using prototypical buildings and rulesets from the 2025 Research Version of the California Building Energy Code Compliance (CBECC) software.

CBECC generates two models based on user inputs: the Standard Design and the Proposed Design. [32] The Standard Design represents the geometry of the prototypical building and a design that uses a set of features that result in a LSC budget and Source Energy budget that is minimally compliant with 2022 Title 24, Part 6 code requirements. Features used in the Standard Design are described in the 2022 Nonresidential ACM Reference Manual. The Proposed Design represents the same geometry as the Standard Design, but it assumes the energy features that the software user describes with user inputs. To develop savings estimates for the proposed code changes, the Statewide CASE Team created a Standard Design and Proposed Design for each prototypical building with the Standard Design representing compliance with 2022 code and the Proposed Design representing compliance with the proposed requirements. Comparing the energy impacts of the Standard Design to the Proposed Design reveals the impacts of the proposed code change relative to a building that is minimally compliant with the 2022 Title 24, Part 6 requirements.

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 76 presents precisely which parameters were modified and what values were used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume that the building achieves a cycles of concentration of 5.2.

[32] CBECC-Res creates a third model, the Reference Design, that represents a building similar to the Proposed Design, but with construction and equipment parameters that are minimally compliant with the 2006 International Energy Conservation Code (IECC). The Statewide CASE Team did not use the Reference Design for energy impacts evaluations.

Table 76: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Hospital	All	CoolingTower: VariableSpeed	Blowdown Concentration Ratio	3.5	5.2
OfficeLarge	All	CoolingTower: VariableSpeed	Blowdown Concentration Ratio	3.5	5.2

Energy Plus calculates whole-building water consumption for every hour of the year measured in gallons.

The water impacts of the proposed code change do vary by climate zone. The Statewide CASE Team simulated the water impacts in every climate zone.

Per-unit water impacts for multifamily buildings are presented in savings per residential unit. Annual water impacts for each prototype building were translated into impacts per dwelling unit by dividing by the number of dwelling units in the prototype building. This step enables a calculation of statewide savings using the construction forecast that is published in terms of number of multifamily dwelling units by climate zone.

Per-unit water impacts for nonresidential buildings are presented in savings per square foot. Annual water impacts for each prototype building were translated into impacts per square foot by dividing by the floor area of the prototype building. This step allows for an easier comparison of savings across different building types and enables a calculation of statewide savings using the construction forecast that is published in terms of floor area by building type.

4.3.1.3 Statewide Energy and Water Savings Methodology

The per-unit water impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the CEC provided. Savings for building types for which no prototype model was available at the time of this report were estimated by applying the average per-unit energy impacts of the available models. The Statewide Construction Forecasts estimate new construction/additions that would occur in 2026, the first year that the 2025 Title 24, Part 6 requirements are in effect. They also estimate the amount of total existing building stock in 2026, which the Statewide CASE Team used to approximate savings from building alterations. The construction forecast provides construction (new construction/additions and existing building stock) by building type and climate zone, as shown in Appendix A.

Statewide energy savings due to the embedded energy in water use were calculated based on the gallons of water saved as documented in Appendix B.

Appendix A presents additional information about the methodology and assumptions used to calculate statewide impacts.

4.3.2 Per-Unit Water Impacts Results

Water savings per square foot are presented in Table 77. The per-unit energy savings figures do not account for naturally occurring market adoption or compliance rates.

Table 77: First Year Water Savings (Gallons) Per Square Foot by Climate Zone (CZ) – Blowdown Controls

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
Hospital	0.03	0.44	0.22	0.70	0.29	0.56	0.61	0.91	0.86	1.02	1.06	0.72	1.14	0.98	2.04	0.35
OfficeLarge	0.05	0.27	0.13	0.41	0.17	0.31	0.34	0.50	0.48	0.57	0.56	0.40	0.59	0.52	1.06	0.20

4.4 Cost and Cost Effectiveness

4.4.1 Water Cost Savings Methodology

The blowdown measure does not result in any direct energy savings but does result in water savings. Water cost savings were calculated by applying water service charges ($/kgal) and sewer service charges ($/kgal) to the water savings estimates that were derived using the methodology described in Section 4.3.1. Water and sewer service charges for the analysis were determined by collecting current rates from websites for water utilities serving the ten most populated cities in California and determining the population weighted average. Utility flat fees such as monthly meter charges were excluded from the survey as they will not be impacted by measure savings. Table 78 provides a summary of the water costs collected for each city and the population weighted averages used for the water cost savings in this report, $8.13/kgal for water service and $6.11/kgal for sewer service. Note that utilities typically provide volumetric service rates in dollars per hundred cubic feet of water ($/hcf or $/ccf) which were converted to dollars per kilogallon (kgal) to align with building model water savings outputs.[33]

Table 78: 2022-2023 Water utility service charges

City	Population	Water Service Charges ($/hcf)	Water Service Charges ($/kgal)	Sewer Service Charges ($/hcf)	Sewer Service Charges ($/kgal)
Los Angeles	3,849,297	$7.17	$9.58	$5.80	$7.75
San Diego	1,381,611	$6.55	$8.76	$3.32	$4.44
San Jose	983,489	$5.96	$7.97	$5.83	$7.79

[33] One hundred cubic feet of water is equivalent to 0.748 kilogallons.

San Francisco	815,201	$10.55	$14.10	$9.46	$12.65
Fresno	544,510	$1.74	$2.33	$3.40	$4.55
Sacramento	525,041	$1.42	$1.90	-	-
Long Beach	456,062	$3.81	$5.10	$0.39	$0.53
Oakland	433,823	$6.47	$8.65	$2.74	$3.66
Bakersfield	407,615	$2.16	$2.88	$1.94	$2.59
Anaheim	345,940	$2.96	$3.96	$0.40	$0.53
All (Population Weighted Average)	-	$6.08	**$8.13**	$4.57	**$6.11**

Water and sewer costs are anticipated to increase significantly during the analysis period, as demonstrated in the U.S Department of Energy's *2017 Water and Wastewater Annual Price Escalation Rates for* Selected *Cities* across the United States report, which found average annual price escalation rates in California cities of 2.91-7.31 percent for water utilities and 3.12 - 8.33 percent for wastewater utilities over the period of 2008 to 2016 (U.S. DOE - Federal Energy Management Program 2017). For the purpose of this analysis, the minimum escalation rates were assumed to produce conservative estimates, 2.91 and 3.12 percent for water and wastewater, respectively. The escalation rates were applied to the 30-year period of analysis to determine the 30-Year Life Cycle Cost Savings associated with water savings, and to align with the 30-year life cycle energy cost methodology, a 3 percent discount rate was applied.

4.4.2 Water Cost Savings Results

Per-unit water cost savings for newly constructed buildings, additions, and alterations that are realized over the 30-year period of analysis are presented in 2026 present value dollars (2026 PV$) in Table 79 through Table 82.

Any time code changes impact cost, there is potential to disproportionately impact DIPs. Refer to Section 4.6 for more details addressing energy equity and environmental justice.

Table 79: 2026 PV Life Cycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction and Additions – Large Office

Climate Zone	30-Year Life Cycle Water Cost Savings (2026 PV$)
1	
2	
3	0.75
4	1.52
5	
6	1.25
7	1.32
8	1.78
9	1.73
10	1.96
11	1.94
12	1.49
13	

14	1.84
15	3.34
16	0.93

Table 80: 2026 PV Life Cycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Alterations – Large Office

Climate Zone	30-Year Life Cycle Water Cost Savings (2026 PV$)
1	0.48
2	1.13
3	0.75
4	1.52
5	0.86
6	1.25
7	1.32
8	1.78
9	1.73
10	1.96
11	1.94
12	1.49
13	2.01
14	1.84
15	3.34
16	0.93

Table 81: 2026 PV Life Cycle Energy Cost Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction and Additions – Hospital

Climate Zone	30-Year Life Cycle Water Cost Savings (2026 PV$)
1	1.05
2	2.18
3	1.57
4	2.89
5	1.76
6	2.50
7	2.66
8	3.48
9	3.34
10	3.78
11	3.88
12	2.94
13	4.11
14	3.66
15	6.62
16	1.91

Table 82: 2026 PV Life Cycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Alterations – Hospital

Climate Zone	30-Year Life Cycle Water Cost Savings (2026 PV$)
1	1.05
2	2.18
3	1.57
4	2.89
5	1.76
6	2.50
7	2.66
8	3.48
9	3.34
10	3.78
11	3.88
12	2.94
13	4.11
14	3.66
15	6.62
16	1.91

4.4.3 Incremental First Cost

The incremental cost of this measure was calculated as the cost of adding the acceptance test. Since the majority of the market already uses conductivity-based controls and the cycles of concentration required are not changing, there was assumed to be no incremental cost to these parts of the measure proposal. These assumptions were validated in conversations with stakeholders.

To estimate the cost of the new acceptance test, the Statewide CASE Team conservatively estimated that the test would take 6 hours. Using the RSMeans electrician rate adjusted to California ($109.04/hr), the Statewide CASE Team determined a total incremental first cost of $654 per building. This cost was checked against the RSMeans cost for cooling tower balancing of $547 to confirm that it was a reasonable estimate for the acceptance test.

The Statewide CASE Team is continuing to collect cost data and would welcome input on these incremental first costs.

4.4.4 Incremental Maintenance and Replacement Costs

Incremental maintenance cost is 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. The present value of equipment maintenance costs (or savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2025 Life Cycle Cost Hourly Factors. The present value of maintenance costs that occurs in the n^{th} year is calculated as follows:

$$\text{Present Value of Maintenance Cost} = \text{Maintenance Cost} \times \left\lfloor\frac{1}{1+\mathrm{d}}\right\rfloor^{\mathrm{n}}$$

The Statewide CASE Team did not find any change in incremental maintenance or replacement costs compared to the baseline scenario. The Statewide CASE Team would welcome further feedback on this finding.

4.4.5 Cost Effectiveness

This measure proposes a mandatory requirement. As such, a cost analysis is required to demonstrate that the measure is cost effective over the 30-year period of analysis.

The CEC establishes the procedures for calculating cost effectiveness. The Statewide CASE Team collaborated with CEC staff to confirm that the methodology in this report is consistent with their guidelines, including which costs were included in the analysis. The incremental first cost and incremental maintenance costs over the 30-year period of analysis were included. The Life Cycle Energy Cost Savings from water savings were also included in the evaluation. Design costs were not included nor were the incremental costs of code compliance verification.

According to the CEC's definitions, a measure is cost effective if the benefit-to-cost (B/C) ratio is greater than 1.0. The B/C ratio is calculated by dividing the cost benefits realized over 30 years by the total incremental costs, which includes maintenance costs for 30 years. The B/C ratio was calculated using 2026 PV costs and cost savings.

Results of the per-unit cost-effectiveness analyses are presented in Table 83 for new construction/additions and Table 84 for alterations.

Table 83: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction/Additions

Climate Zone	Benefits Life Cycle Energy Cost Savings + Other PV Savings [a] (2026 PV$)	Costs Total Incremental PV Costs [b] (2026 PV$)	Benefit-to-Cost Ratio
1	1.05	0.00271	387
2	2.18	0.00271	805
3	0.77	0.00134	575
4	1.55	0.00134	1,155
5	1.76	0.00271	648
6	1.28	0.00134	954
7	1.39	0.00139	1,002
8	1.81	0.00133	1,358
9	1.75	0.00133	1,313
10	2.24	0.00153	1,468
11	2.14	0.00146	1,468
12	1.65	0.00147	1,125
13	4.11	0.00271	1,516
14	1.95	0.00139	1,397
15	4.77	0.00192	2,483
16	1.01	0.00142	709

a. **Benefits: Life Cycle Energy Cost Savings + Other PV Savings:** Benefits include Life Cycle Energy Cost Savings over the period of analysis (Energy + Environmental Economics 2016, 51-53). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost, incremental PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at end of CASE analysis period.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis. Costs are discounted at a real (inflation-adjusted) three percent rate and if PV of proposed maintenance costs is greater than PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

Table 84: 30-Year Cost-Effectiveness Summary Per Square Foot – Alterations

Climate Zone	Benefits Life Cycle Energy Cost Savings + Other PV Savings [a] (2026 PV$)	Costs Total Incremental PV Costs [b] (2026 PV$)	Benefit-to-Cost Ratio
1	0.80	0.00210	380
2	1.38	0.00165	840
3	0.78	0.00135	575
4	1.56	0.00135	1,154
5	1.04	0.00158	655
6	1.28	0.00135	954
7	1.36	0.00136	1,003
8	1.82	0.00134	1,357
9	1.76	0.00134	1,313
10	2.06	0.00139	1,484
11	2.47	0.00169	1,458
12	1.57	0.00139	1,129
13	2.38	0.00156	1,529
14	1.91	0.00136	1,399
15	3.64	0.00144	2,528
16	0.99	0.00139	709

a. **Benefits: Life Cycle Energy Cost Savings + Other PV Savings:** Benefits include Life Cycle Energy Cost Savings over the period of analysis (Energy + Environmental Economics 2016, 51-53). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost, incremental PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at end of CASE analysis period.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis. Costs are discounted at a real (inflation-adjusted) three percent rate and if PV of proposed maintenance costs is greater than PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

4.5 First-Year Statewide Impacts

4.5.1 Statewide Energy, Water, and Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction and additions by multiplying the per-unit savings, which are presented in Section 4.3.2, by assumptions about the percentage of newly constructed buildings that would be impacted by the proposed code. As mentioned in Section 4.3.1.3, savings for building types for which no prototype model was available at the time of this report were estimated by applying the average per-unit energy impacts of the available models. The statewide new construction forecast for 2026 is presented in Appendix A, as are the Statewide CASE Team's assumptions about the percentage of new construction that would be impacted by the proposal (by climate zone and building type).

The first-year energy impacts represent the first-year annual savings from all buildings that were completed in 2026. The 30-year energy cost savings represent the energy cost savings over the entire 30-year analysis period. The statewide savings estimates do not take naturally occurring market adoption or compliance rates into account.

The tables below present the first-year statewide energy and energy cost savings from newly constructed buildings and additions (Table 85) and alterations (Table 86) by climate zone.

While a statewide analysis is crucial to understanding broader effects of code change proposals, there is potential to disproportionately impact DIPs that needs to be considered. Refer to Section 4.6 for more details addressing energy equity and environmental justice.

Table 85: Statewide Energy and Energy Cost Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 Million Square Feet	First-Year[a] Water Savings (Gallons)	30-Year Present Valued Energy Water Savings (Million 2026 PV$)
1	21,094	906	$0.02
2	113,265	40,938	$0.19
3	2,140,593	308,214	$1.84
4	1,067,987	478,867	$1.83
5	59,636	13,970	$0.08
6	1,009,907	353,621	$1.46
7	655,709	256,866	$1.04
8	1,573,915	883,145	$3.19
9	2,810,630	1,499,982	$5.47

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 Million Square Feet	First-Year[a] Water Savings (Gallons)	30-Year Present Valued Energy Water Savings (Million 2026 PV$)
10	562,670	410,095	$1.47
11	153,867	112,192	$0.40
12	861,188	439,522	$1.72
13	193,687	170,093	$0.61
14	185,610	117,786	$0.42
15	63,257	97,490	$0.31
16	54,670	13,094	$0.07
Total	**11,527,684**	**5,196,780**	**$20.11**

a. First-year savings from all buildings completed statewide in 2026.

Table 86: Statewide Energy and Energy Cost Impacts – Alterations

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 Million Square Feet	First-Year[a] Water Savings (Gallons)	30-Year Present Valued Water Cost Savings (Million 2026 PV$)
1	39,979	1,731	$0.03
2	419,100	144,356	$0.67
3	4,876,310	711,535	$4.28
4	2,598,869	1,182,497	$4.52
5	180,982	39,723	$0.22
6	3,324,827	1,147,637	$4.72
7	2,598,697	987,378	$3.98
8	5,223,714	2,881,512	$10.37
9	9,372,695	4,885,288	$17.73
10	2,701,430	1,830,913	$6.50
11	302,694	234,090	$0.84
12	3,369,164	1,580,013	$6.12
13	745,656	591,752	$2.09
14	765,371	462,952	$1.66
15	271,386	372,312	$1.19
16	197,526	45,296	$0.23
Total	**36,988,400**	**17,098,984**	**$65.13**

a. First-year savings from all buildings completed statewide in 2026.

4.5.2 Statewide Greenhouse Gas (GHG) Emissions Reductions

Since there are no direct energy savings from this measure, the Statewide CASE Team did not calculate avoided GHG emissions for this measure.

4.5.3 Statewide Embedded Energy from Water Use Impacts

This measure is primarily a water savings measure. Statewide water savings are presented in Section 4.5.1. It was assumed that all water savings occurred indoors, and the embedded electricity value was 5,440 kWh/million gallons of water. The embedded electricity estimate was derived from a 2022 research analysis conducted under the auspices of CPUC Rulemaking 13-12-011 that quantified the embedded electricity savings from IOU programs that save both water and energy (SBW Consulting, Inc. 2022). See Appendix B for additional information on the embedded electricity savings estimates.

Table 87: Impacts on Water Use and Embedded Electricity in Water

Impact	On-Site Indoor Water Savings (Gallons/Year)	On-site Outdoor Water Savings (Gallons/Year)	Embedded Electricity Savings[a] (kWh/Year)
Average Per Square Foot Impacts	0.45	-	0.0025
First-Year[b] Statewide Impacts for New Construction & Additions	5,196,780	-	28,270
First-Year[b] Statewide Impacts for Alterations	17,098,984	-	93,018
First-Year[b] Total Statewide Impacts	22,295,764	-	121,289

a. Assumes embedded energy factor 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).

b. First-year savings from all buildings completed statewide in 2026.

For more details involving water use and water impacts quality, refer to Appendix B.

4.5.4 Statewide Material Impacts

There are no statewide material impacts.

4.5.5 Other Non-Energy Impacts

The proposed measure may reduce the use of chemical treatment, reducing the health and safety risks associated with transporting, using and disposing of water treatment chemicals.

4.6 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in DIPs and the role this history plays in the environmental justice issues that persist today. DIPs refer to the areas throughout California that most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes, as well as high incidence of asthma and heart disease. DIPs also incorporate race, class, and gender since these intersecting identity factors affect how people frame issues, interpret, and experience the world.[34] While the term disadvantaged communities (DACs) is often used in the energy industry and state agencies, the Statewide CASE Team chose to use terminology that is more acceptable to and less stigmatizing for those it seeks to describe (DC Fiscal Policy Institute 2017).

Including impacted communities in the decision-making process, ensuring that the benefits and burdens of the energy sector are evenly distributed, and grappling with the unjust legacies of the past all serve as critical steps to achieving energy equity. Code change proposals must be developed and adopted with intentional screening for unintended consequences, otherwise they risk perpetuating systemic injustices and oppression.

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice, therefore reducing the impacts of disparities in DIPs. The Statewide CASE Team does not recommend further research or action at this time.

[34] Environmental disparities have been shown to be associated with unequal harmful environmental exposure correlated with race/ethnicity, gender, and socioeconomic status. For example, chronic diseases, such as respiratory diseases, cardiovascular disease, and cancer, associated with environmental exposure have been shown to occur in higher rates in the LGBTQ+ population than in the cisgender, heterosexual population (Goldsmith and Bell 2021). Socioeconomic inequities, climate, energy, and other inequities are inextricably linked and often mutually reinforcing.

5. Proposed Revisions to Code Language

5.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2022 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

5.2 Standards

SECTION 110.2 – MANDATORY REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

(e) Open and Closed-Circuit Cooling Towers. All open and closed cooling tower installations shall comply with the following:

1. Be equipped with Conductivity ~~or flow based~~ controls that maximize cycles of concentration based on local water quality conditions. Controls shall automate system bleed and chemical feed (if applicable) based on conductivity~~, or in proportion to metered makeup volume, metered bleed volume, recirculating pump run time, or bleed time~~. Conductivity controllers shall be installed in accordance with manufacturer's specifications in order to maximize accuracy.
2. Documentation of Maximum Achievable Cycles of Concentration. Building owners shall document the maximum cycles of concentration based on local water supply as reported annually by the local water supplier, and using ~~the calculator approved by the Energy~~ the calculator embedded in the NRCC-MCH-E compliance document. The calculator is intended to determine maximum cycles based on a Langelier Saturation Index (LSI) of 2.5 or less. Building owner shall document maximum cycles of concentration on the mechanical compliance form which shall be reviewed and signed by the Professional Engineer (P.E.) of Record.
3. Cooling towers shall not allow blowdown until one or more of the parameters in Table X reaches 90 percent of more of the maximum value specified:

Table X:

Recirculating Water Parameters	Maximum Values
Conductivity (micro-ohms)	2970
Total dissolved solids (ppm)	1845
Total alkalinity as CaCO23 (ppm) excluding galvanized steel	540

Total alkalinity as CaCO3 (ppm) galvanize steel (passivated)	450
Calcium hardness as CaCO3 (ppm)	540
Chlorides as Cl (ppm)	270
Sulfates (ppm)	225
Silica (ppm)	135
LSI	2.5

4. Be equipped with a Flow Meter with an analog output for flow either hardwired or available through a gateway on the makeup water line.
5. Be equipped with an Overflow Alarm to prevent overflow of the sump in case of makeup water valve failure. Overflow alarm shall send an audible signal or provide an alert via the Energy Management Control System to the tower operator in case of sump overflow.
6. Be equipped with Efficient Drift Eliminators that achieve drift reduction to 0.002 percent of the circulated water volume for counter-flow towers and 0.005 percent for cross-flow towers.
7. Before an occupancy permit is granted, conductivity controls shall be verified according to NA 5.18.

EXCEPTION to Section 110.2(e): Open and closed-circuit cooling towers with rated capacity < 150 tons.

SECTION 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

(h) Heat Rejection Systems. Heat rejection equipment used in comfort cooling systems, such as air-cooled condensers, open cooling towers, closed-circuit cooling towers and evaporative condensers shall include the following:

1. **Fan Speed Control.** Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at 2/3 of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature or pressure of the heat rejection device.

EXCEPTION 1 to Section 140.4(h)1: Heat rejection devices included as an integral part of the equipment listed in TABLE 110.2-A through TABLE 110.2-N.

EXCEPTION 2 to Section 140.4(h)1: Condenser fans serving multiple refrigerant circuits.

EXCEPTION 3 to Section 140.4(h)1: Condenser fans serving flooded condensers.

EXCEPTION 4 to Section 140.4(h)1: Up to one third of the fans on a condenser or tower with multiple fans where the lead fans comply with the speed control requirement.

2. **Tower Flow Turndown.** Open cooling towers configured with multiple condenser water pumps shall be designed so that all cells can be run in parallel with the larger of:

   A. The flow that is produced by the smallest pump; or

   B. 50 percent of the design flow for the cell.

3. **Limitation on Centrifugal Fan Cooling Towers.** Open cooling towers with a combined rated capacity of 900 gpm and greater at 95°F condenser water return, 85°F condenser water supply, and 75°F outdoor wet-bulb temperature, shall use propeller fans and shall not use centrifugal fans.

   EXCEPTION 1 to Section 140.4(h)3: Cooling towers that are ducted (inlet or discharge) or have an external sound trap that requires external static pressure capability.

   EXCEPTION 2 to Section 140.4(h)3: Cooling towers that meet the energy efficiency requirement for propeller fan towers in Section 110.2, TABLE 110.2-F.

4. **Multiple Cell Heat Rejection Equipment.** Multiple cell heat rejection equipment with variable speed fan drives shall:

   A. Operate the maximum number of fans allowed that comply with the manufacturer’s requirements for all system components, and

   B. Control all operating fans to the same speed. Minimum fan speed shall comply with the minimum allowable speed of the fan drive as specified by the manufactures recommendation. Staging of fans is allowed once the fans are at their minimum operating speed.

5. **Cooling tower efficiency.** Axial fan, open-circuit cooling towers serving condenser water loops for chilled water plants with a total of 900 gpm or greater, shall have a rated efficiency ~~of no less than 60 gpm/hp~~ that meets or exceeds the requirements of Table 140.4-I when rated in accordance with the conditions as listed in Table 110.2-F.

Table 140.4-I PRESCRIPTIVE PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	**Prescriptive Minimum Efficiency (gpm/hp)**															
	Climate Zone															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Propeller or axial fan Open-circuit cooling towers	42.1	60	60	60	60	100	100	120	100	120	100	100	60	60	120	42.1

EXCEPTION 1 to Section 140.4(h)5: Replacement of existing cooling towers that are inside an existing building or on an existing roof.

~~**EXCEPTION 2 to Section 140.4(h)5:** Cooling towers serving buildings in Climate Zone 1 or 16.~~

(i) Minimum chiller efficiency. Chillers shall meet or exceed Path B from Table 110.2-D.

Exception 1 to Section 140.4(i): Chillers with electrical service > 600V.

Exception 2 to Section 140.4(i): Chillers attached to a heat recovery system with a design heat recovery capacity > 40 percent of the design chiller cooling capacity.

Exception 3 to Section 140.4(i): Chillers used to charge thermal energy storage systems where the charging temperature is < 40°F.

Exception 4 to Section 140.4(i): In buildings with more than three chillers, only three chillers are required to meet the Path B efficiencies.

(j) Limitation of Air-Cooled Chillers. Chilled water plants shall not have more than 300 tons of cooling provided by air-cooled chillers.

Exception 1 to Section 140.4(j): Where the water quality at the building site fails to meet manufacturer's specifications for the use of water-cooled chillers.

Exception 2 to Section 140.4(j): Chillers that are used to charge a thermal energy storage system with a design temperature of less than 40° F (4° C).

Exception 3 to Section 140.4(j): Systems serving healthcare facilities.

Exception 4 to Section 140.4(j): Air-to-water heat pumps that provide space or hydronic heating only.

Exception 5 to Section 140.4(j): Air-cooled chillers with Path B efficiencies of ≥10.72 EER and ≥20.1 IPLV when rated in accordance with the testing procedures of Table 110.2-D.

Exception 6 to Section 140.4(j): Air-cooled chillers with heat recovery where the cooling capacity minus the recovered heating capacity of air-cooled chillers is no more than 300 tons per chilled water plant.

SECTION 170.2 – PRESCRIPTIVE APPROACH

F. Heat rejection systems. Heat rejection equipment used in comfort cooling systems such as air-cooled condensers, open cooling towers, closed-circuit cooling towers and evaporative condensers shall include the following:

i. **Fan speed control.** Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at 2/3 of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature or pressure of the heat rejection device.

Exception 1 to Section 170.2(c)4Fi: Heat rejection devices included as an integral part of the equipment listed in Table 110.2-A through Table 110.2-N.

Exception 2 to Section 170.2(c)4Fi: Condenser fans serving multiple refrigerant circuits.

Exception 3 to Section 170.2(c)4Fi: Condenser fans serving flooded condensers.

Exception 4 to Section 170.2(c)4Fi: Up to one-third of the fans on a condenser or tower with multiple fans where the lead fans comply with the speed control requirement.

ii. **Tower flow turndown.** Open cooling towers configured with multiple condenser water pumps shall be designed so that all cells can be run in parallel with the larger of:

   a. The flow that is produced by the smallest pump; or
   b. 50 percent of the design flow for the cell.

iii. **Limitation on centrifugal fan cooling towers.** Open cooling towers with a combined rated capacity of 900 gpm and greater at 95°F condenser water return, 85°F condenser water supply and 75°F outdoor wet- bulb temperature shall use propeller fans and shall not use centrifugal fans.

Exception 1 to Section 170.2(c)4Fiii: Cooling towers that are ducted (inlet or discharge) or have an external sound trap that requires external static pressure capability.

Exception 2 to Section 170.2(c)4Fiii: Cooling towers that meet the energy efficiency requirement for propeller fan towers in Section 110.2, Table 110.2-F.

iv. **Multiple cell heat rejection equipment.** Multiple cell heat rejection equipment with variable speed fan drives shall:

   a. Operate the maximum number of fans allowed that comply with the manufacturer's requirements for all system components, and
   b. Control all operating fans to the same speed. Minimum fan speed shall comply with the minimum allowable speed of the fan drive as specified by the manufacturer's recommendation. Staging of fans is allowed once the fans are at their minimum operating speed.

v. **Cooling tower efficiency.** Axial fan, open-circuit cooling towers serving condenser water loops for chilled water plants with a total of 900 gpm or greater shall have a rated efficiency ~~of no less than 60 gpm/hp~~ that meets or exceeds the requirements of Table 170.2-I when rated in accordance with the conditions as listed in Table 110.2-F.

Table 170.2-I PRESCRIPTIVE PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	Prescriptive Minimum Efficiency (gpm/hp)															
	Climate Zone															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Propeller or axial fan Open-circuit cooling towers	42.1	60	60	60	60	100	100	120	100	120	100	100	60	60	120	42.1

vi.

Exception 1 to Section 170.2(c)4Fv: Replacement of existing cooling towers that are inside an existing building or on an existing roof.

~~**Exception 2 to Section 170.2(c)4Fv:** Cooling towers serving buildings in Climate Zone 1 or 16.~~

G. Minimum chiller efficiency. Chillers shall meet or exceed Path B from Table 110.2-D.

Exception 1 to Section 170.2(c)4G**:** Chillers with electrical service > 600 V.

Exception 2 to Section 170.2(c)4G: Chillers attached to a heat recovery system with a design heat recovery capacity > 40 percent of the design chiller cooling capacity.

Exception 3 to Section 170.2(c)4G: Chillers used to charge thermal energy storage systems where the charging temperature is < 40°F.

Exception 4 to Section 170.2(c)4G: In buildings with more than three chillers, only three chillers are required to meet the Path B efficiencies.

H. Limitation of air-cooled chillers. Chilled water plants shall not have more than 300 tons of cooling provided by air-cooled chillers without heat recovery. Where heat is recovered from air-cooled chillers, the cooling capacity minus the recovered heating capacity of air-cooled chillers, shall be no more than 300 tons per chilled water plant

Exception 1 to Section 170.2(c)4H: Where the water quality at the building site fails to meet manufacturer's specifications for the use of water-cooled chillers.

Exception 2 to Section 170.2(c)4H: Chillers that are used to charge a thermal energy storage system with a design temperature of less than 40°F (4°C).

Exception 3 to Section 170.2(c)4H: Air-to-water heat pumps that provide space or hydronic heating only.

Exception 4 to Section 170.2(c)4H: Air-cooled chillers with Path B efficiencies of ≥10.72 EER and ≥20.1 IPLV when rated in accordance with the testing procedures of Table 110.2-D.

5.3 Reference Appendices

5.3.1 NA7.5.18 Cooling Tower Conductivity Controls

The following acceptance tests apply to all open- and closed-circuit cooling towers.

5.3.1.1 NA7.5.18.1 Construction Inspection

Prior to functional testing, verify and document the following:

(a) The conductivity controls, makeup water flow meter(s), and overflow alarms are installed as specified on the plans.

(b) Maximum achievable cycles of concentration is documented on the NRCC-MCH-E compliance document.

(c) Blowdown control sequence is available and documented in the building documents.

(d) Controls are programmed to automate bleed at an LSI of no less than 2.5 and/or the maximum cycles of concentration documented on the NRCC-MCH-E form.

(e) Controls shall be programmed so as not to allow blowdown until one or more of the parameters in Table X reaches the specified value:

Table X:

Recirculating Water Parameters	Maximum Values
Conductivity (micro-ohms)	2970
Total dissolved solids (ppm)	1845
Total alkalinity as CaCO23 (ppm) excluding galvanized steel	540
Total alkalinity as CaCO3 (ppm) galvanize steel (passivated)	450
Calcium hardness as CaCO3 (ppm)	540
Chlorides as Cl (ppm)	270
Sulfates (ppm)	225

Silica (ppm)	135
LSI	2.5

5.3.1.2 NA7.5.18.2 Functional Testing

Step 1: Override the makeup water valve to open until the tower water is above the maximum fill level. Close the makeup water valve. Verify that the overflow alarm is triggered either through an audible signal or via alert to the Energy Management Control System.

Step 2: Restore the makeup water control parameter to automatic control.

5.4 ACM Reference Manual

Proposed standards modify the following sections

5.8.3 Cooling Towers

COOLING TOWER TOTAL FAN HORSEPOWER

Applicability: All cooling towers.

Definition: The sum of the nameplate rated horsepower (hp) of all fan motors on the cooling tower. Pony motors should not be included.

Units: Gpm/hp or unitless if energy input ratio (EIR) is specified (if the nominal tons but not the condenser water flow is specified, the condenser design water flow shall be 3.0 gpm per nominal cooling ton).

Input Restrictions: As designed, but the cooling towers shall meet minimum performance requirements in Table 110.2-G of the Energy Code.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, the cooling tower fan horsepower is ~~60~~ 100 gpm/hp, with the following exceptions:

Cooling towers in climate zones 1 or 16 shall set the standard design to the mandatory minimum, 42.1 gpm/hp

Cooling towers with a design condenser water flow of 900 gpm or less shall set the standard design to the mandatory minimum, 42.1 gpm/hp

Standard Design: Existing Buildings: 42.1 gpm/hp.

5.5 Compliance Documents

For the air-cooled chiller threshold measure, compliance document 2022-NRCC-MCH-E would need to be revised. The compliance document would need to be adjusted to remove the line item for Air-Cooled Chiller Limitation and Note 5, which pertain to the existing code rules in Title 24, Part 6 140.4(j). Furthermore, compliance document 2022-NRCC-CXR-E would need to be adjusted to remove the line item in the Chillers and Boilers table for Section 140.4(i) related to the 300-ton limit on Air-Cooled Chillers. These changes are necessary to match the removal of the Air-Cooled Chiller exception in the standard.

In addition, Chapter 4, Section 4.7.2.12 in the 2022 Nonresidential Compliance Manual would need to be revised to increase the 300-ton system threshold and language stating that water-cooled chillers always provide a higher lifecycle cost compared to air-cooled chillers. The answer to example 4-60 would also need to be revised as it currently references the prohibition on air-cooled chiller systems in excess of 300-tons.

For the cooling tower efficiency measure, Chapter 4, Section 4.7.2.10 of the 2022 Nonresidential Compliance Manual would need to be revised. References to the existing efficiency minimum for cooling towers of 60 gpm/hp would need to be revised to reflect the new prescriptive requirement of 100 gpm/hp.

For the blowdown controls measure, Chapter 4, Section 4.2.7 of the 2022 Nonresidential Compliance Manual would need to be revised. This section discusses the requirements for cycles of concentration and references a weblink to the CEC's LSI calculator and the NRCC-MCH-06 form. Both would need to be updated to reference the new calculator and NRCC form locations. Additionally, the LSI calculator weblink appears in Section 4.6.1 and would need updating to reflect the new calculator location.

Additionally, the compliance document NRCC-MCH-06E Maximum Cycles of Calculation Worksheet would need to be updated to require calculation of maximum cycles of concentration based on the site water quality, a correction to the existing calculator that simply states whether the entered data results in values meeting the threshold.

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Appendix A: Statewide Savings Methodology

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide construction forecasts that the CEC provided (California Energy Commission 2022).For impacted buildings for which no model prototypes were available at the time of the report, average per-unit savings by climate zone from available prototype results were used. The CEC provided the construction estimates on March 27, 2023 at the Staff Workshop on Triennial California Energy Code Measure Proposal Template.

Residential Buildings

For Multifamily

The Statewide CASE Team followed guidance provided in the CEC's New Measure Proposal Template (developed by the CEC) to calculate statewide energy savings using the CEC's construction forecasts, including a request to assume a statewide weighting as follows: Low-Rise Garden (four percent), Loaded Corridor (33 percent), Mid-Rise Mixed-Use (58 percent) and High-Rise Mixed Use (two percent). See Section 2.3.2 of the CEC's New Measure Proposal Template.

The Statewide CASE Team did not make any changes to the CEC's construction estimates.

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by the CEC's statewide construction forecasts. The Statewide CASE Team made assumptions about the percentage of buildings in each climate zone that would be impacted by the proposed code change.

Table 88**Error! Reference source not found.** through Table 90 presents the number of dwelling units, both newly constructed and existing, that the Statewide CASE Team assumed would be impacted by the proposed code change during the first year the 2025 code is in effect.

Based on available market studies and stakeholder input, the proposed code change is anticipated to have limited to negligible impact on multifamily buildings. During the February 13th Stakeholder Meeting, 4 of 5 respondents indicated that 1-10 percent of their multifamily buildings utilize cooling towers (and, by association, presumably water-cooled chillers). Additionally, data from the *2015 Fannie Mae Multifamily Energy and Water Market Research Survey* validates this observation, showing no commercial cooling towers in the 954 multifamily buildings surveyed nationwide (Fannie Mae 2015). When used, cooling towers in multifamily buildings are primarily used for conditioning common spaces, accounting for a fraction of the total floor area of the building. As a result, for the purpose of this analysis, the Statewide CASE Team has conservatively assumed that 1 percent of the high-rise and mid-rise multifamily buildings in California have cooling towers.

Table 88: Estimated New Construction and Existing Building Stock for Multifamily Buildings by Climate Zone, Cooling Tower Efficiency

Building Climate Zone	Total Dwelling Units Completed in 2026 (New Construction) [A]	Percent of New Dwelling Units Impacted by Proposal [B]	New Dwelling Units Impacted by Proposal in 2026 C = A x B	Total Existing Dwelling Units in 2026 [D]	Percent of Existing Dwelling Units Impacted by Proposal [E]	Dwelling Units Impacted by Proposal in 2026 F = D x E
1	144	0%	0	17,558	0%	0
2	1,391	0%	0	105,894	0%	0
3	7,699	0%	0	553,186	0%	0
4	3,417	0%	0	288,786	0%	0
5	285	0%	0	45,671	0%	0
6	2,243	1%	14	322,513	1%	2,032
7	5,156	1%	32	307,272	1%	1,936
8	8,600	1%	54	515,137	1%	3,245
9	10,302	1%	65	1,117,605	1%	7,041
10	4,306	1%	27	329,302	1%	2,075
11	1,173	1%	7	85,339	1%	538
12	5,537	1%	35	471,876	1%	2,973
13	1,009	1%	6	157,075	1%	990
14	1,446	0%	0	83,480	0%	0
15	373	1%	2	41,152	1%	259
16	187	0%	0	28,066	0%	0
TOTAL	**53,268**		**244**	**4,310,108**		**21,088**

Table 89: Estimated New Construction and Existing Building Stock for Multifamily Buildings by Climate Zone, Air-Cooled Chiller Threshold

Building Climate Zone	Total Dwelling Units Completed in 2026 (New Construction) [A]	Percent of New Dwelling Units Impacted by Proposal [B]	New Dwelling Units Impacted by Proposal in 2026 C = A x B	Total Existing Dwelling Units in 2026 [D]	Percent of Existing Dwelling Units Impacted by Proposal [E]	Dwelling Units Impacted by Proposal in 2026 F = D x E
1	144	1%	1	17,558	0%	0
2	1,391	1%	9	105,894	0%	0
3	7,699	1%	49	553,186	0%	0
4	3,417	1%	22	288,786	0%	0
5	285	1%	2	45,671	0%	0
6	2,243	1%	14	322,513	0%	0
7	5,156	1%	32	307,272	0%	0
8	8,600	1%	54	515,137	0%	0
9	10,302	1%	65	1,117,605	0%	0
10	4,306	1%	27	329,302	0%	0
11	1,173	1%	7	85,339	0%	0
12	5,537	1%	35	471,876	0%	0
13	1,009	1%	6	157,075	0%	0
14	1,446	1%	9	83,480	0%	0
15	373	1%	2	41,152	0%	0
16	187	1%	1	28,066	0%	0
TOTAL	**53,268**		**336**	**4,310,108**		**0**

Table 90: Estimated New Construction and Existing Building Stock for Multifamily Buildings by Climate Zone, Blowdown Controls

Building Climate Zone	Total Dwelling Units Completed in 2026 (New Construction) [A]	Percent of New Dwelling Units Impacted by Proposal [B]	New Dwelling Units Impacted by Proposal in 2026 C = A x B	Total Existing Dwelling Units in 2026 [D]	Percent of Existing Dwelling Units Impacted by Proposal [E]	Dwelling Units Impacted by Proposal in 2026 F = D x E
1	144	1%	1	17,558	1%	111
2	1,391	1%	9	105,894	1%	667
3	7,699	1%	49	553,186	1%	3,485
4	3,417	1%	22	288,786	1%	1,819
5	285	1%	2	45,671	1%	288
6	2,243	1%	14	322,513	1%	2,032
7	5,156	1%	32	307,272	1%	1,936
8	8,600	1%	54	515,137	1%	3,245
9	10,302	1%	65	1,117,605	1%	7,041
10	4,306	1%	27	329,302	1%	2,075
11	1,173	1%	7	85,339	1%	538
12	5,537	1%	35	471,876	1%	2,973
13	1,009	1%	6	157,075	1%	990
14	1,446	1%	9	83,480	1%	526
15	373	1%	2	41,152	1%	259
16	187	1%	1	28,066	1%	177
TOTAL	**53,268**		**336**	**4,310,108**		**28,160**

Nonresidential Buildings

To calculate first-year statewide savings, the Statewide CASE Team multiplied the per-unit savings by statewide construction estimates for the first year the standards would be in effect (2026). The nonresidential new construction forecast is presented in Table 91 and nonresidential existing statewide building stock is presented in Table 92. The projected nonresidential new construction that would be impacted by the proposed code change in 2026 is presented in Table 93 through Table 95. The projected nonresidential existing statewide building stock that would be impacted by the proposed code change because of alterations in 2026 is presented in Table 96 through Table 98. This section describes how the Statewide CASE Team developed these estimates.

The CEC Building Standards Office provided the nonresidential construction forecast, which is available for public review on the CEC's website:

https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

The construction forecast presents the total floorspace of newly constructed buildings in 2026 by building type and climate zone. The building types included in the CECs' forecast are summarized in Table 91.

The Statewide CASE Team made assumptions about the percentage of newly constructed floorspace that would be impacted by the proposed code change. Table 99 through Table 101 presents the assumed percentage of floorspace that would be impacted by the proposed code change by building type. If a proposed code change does not apply to a specific building type, it is assumed that zero percent of the floorspace would be impacted by the proposal. If the assumed percentage is non-zero, but less than 100 percent, it is an indication that some but not all buildings would be impacted by the proposal. Table 102 through Table 104 resents percentage of floorspace assumed to be impacted by the proposed change by climate zone.

Estimates for the percentage of impacted floorspace were developed by assessing the prevalence of cooling towers, air-cooled chillers, and water-cooled chillers in the state of California, delineated by market segment. In this effort, the Statewide CASE Team performed an analysis of microdata from the 2018 Commercial Building Energy Consumption Survey from the Energy Information Administration (Energy Information Administration 2018). In addition to energy consumption data, the survey captures several pieces of data relevant to the proposed code changes including building type, location, floor area (ft^2), and HVAC details. The location data is provided in U.S. Census divisions, for which California falls under the Pacific Division (which also includes Washington and Oregon). The HVAC details provided include which buildings have chillers, and whether the chillers are air-cooled or water-cooled.

By examining the HVAC details for buildings in the Pacific Census Division, the Statewide CASE Team found a wide range of prevalence of water-cooled chillers and cooling towers, with office buildings observing the largest use at 50 percent of buildings utilizing the systems. The portion for each CEC prototype was estimated by mapping the CBECS data to the CEC prototypes. Individual buildings from the CBECS microdata were assigned to CEC prototypes by building type, and when applicable, floor area. Estimates for the air-cooled chiller threshold measure were also adjusted to only apply to the percent of buildings estimated to have greater than 300 tons of chiller capacity using the average floor area per ton of cooling (ft^2/ton) determined from the OfficeLarge prototype model as a rule of thumb for cooling capacity. Thus, it is estimated that depending on building type up to 50 percent of newly constructed buildings and additions would be impacted by the cooling tower efficiency, blowdown, and air-cooled threshold measures, as outlined in Table 102 to Table 104. The air-cooled threshold measure was adjusted to account only for chiller systems of greater than 300 tons.

The cooling tower efficiency measure and blowdown measure apply to alterations. To estimate the percentage of existing buildings impacted by these two measures, it was estimated that based on an equipment useful life of 20 years, 5 percent of existing cooling towers are replaced each year. Multiplying this turnover rate by the percent of each building type estimated to have cooling towers provides the estimates for the Statewide impacts of the cooling tower efficiency measure and blowdown measure on existing buildings, as outlined in Table 99 to Table 104.

The cooling tower efficiency was not found to be cost effective in Climate Zones 1-5, 13-14, and 16 for new construction buildings and additions, and Climate Zones 1-5, 14, and 16 for alterations The blowdown and air-cooled chiller threshold measures are applicable to all climate zones.

Table 91: Estimated New Nonresidential Construction in 2026 (Million Square Feet)

Building Type	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
Large Office	0.00	0.00	3.23	1.58	0.00	1.42	0.83	2.29	4.15	0.39	0.11	0.57	0.00	0.20	0.01	0.05	14.84
Medium Office	0.13	0.48	1.37	0.74	0.37	1.20	0.80	1.65	3.18	1.17	0.27	2.80	0.59	0.35	0.26	0.10	15.47
Small Office	0.01	0.44	0.19	0.02	0.06	0.15	0.23	0.16	0.36	0.42	0.09	0.54	0.39	0.04	0.11	0.03	3.24
Large Retail	0.00	0.00	1.10	0.55	0.15	0.70	0.37	0.83	1.66	0.63	0.30	1.30	0.36	0.14	0.18	0.06	8.34
Medium Retail	0.08	0.35	0.79	0.45	0.09	0.60	0.29	0.86	1.42	0.82	0.14	0.63	0.38	0.18	0.12	0.08	7.29
Strip Mall	0.00	0.15	0.50	0.23	0.01	0.56	0.49	0.99	1.07	1.35	0.07	0.59	0.33	0.32	0.10	0.06	6.81
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.01	0.13	0.88	0.44	0.04	0.59	0.61	0.91	1.42	0.85	0.35	1.15	0.61	0.17	0.09	0.07	8.31
Small School	0.07	0.27	0.46	0.23	0.14	0.32	0.29	0.35	0.66	0.35	0.10	0.78	0.30	0.11	0.04	0.04	4.50
Non-refrigerated Warehouse	0.06	0.37	2.16	1.12	0.18	1.36	0.71	1.95	3.01	1.36	0.63	2.84	0.82	0.36	0.37	0.14	17.44
Hotel	0.04	0.22	1.03	0.53	0.11	0.55	0.48	0.78	1.18	0.57	0.15	0.80	0.26	0.14	0.12	0.04	7.02
Assembly	0.01	0.39	1.58	0.56	0.06	0.79	0.80	1.43	1.82	1.14	0.17	1.41	0.30	0.25	0.12	0.08	10.92
Hospital	0.03	0.17	0.84	0.44	0.08	0.33	0.55	0.44	0.79	0.81	0.15	0.83	0.27	0.14	0.12	0.05	6.03
Laboratory	0.00	0.05	0.63	0.36	0.02	0.07	0.05	0.10	0.12	0.06	0.01	0.05	0.01	0.01	0.01	0.00	1.57
Restaurant	0.01	0.08	0.33	0.17	0.03	0.34	0.20	0.49	0.82	0.41	0.07	0.31	0.14	0.10	0.05	0.03	3.59
Enclosed Parking Garage	0.00	0.01	1.83	1.25	0.00	2.59	0.71	2.27	1.53	0.05	0.00	0.04	0.00	0.02	0.00	0.01	10.29
Open Parking Garage	0.00	0.12	2.47	1.68	0.06	3.65	1.20	3.20	2.16	0.65	0.02	0.53	0.04	0.20	0.05	0.09	16.12
Grocery	0.01	0.05	0.10	0.06	0.01	0.05	0.02	0.05	0.09	0.05	0.01	0.04	0.02	0.01	0.01	0.01	0.58
Refrigerated Warehouse	0.00	0.00	0.06	0.05	0.01	0.02	0.00	0.01	0.01	0.04	0.00	0.07	0.12	0.01	0.01	0.01	0.41
Controlled-environment Horticulture	0.09	0.08	0.32	0.04	0.20	0.26	0.00	0.02	0.03	0.28	0.30	0.31	0.09	0.01	0.05	0.00	2.08
Vehicle Service	0.00	0.08	0.55	0.36	0.03	0.55	0.34	0.80	1.81	0.57	0.02	0.39	0.25	0.20	0.06	0.05	6.05
Manufacturing	0.01	0.13	0.40	0.19	0.06	0.13	0.09	0.11	0.10	0.11	0.06	0.16	0.02	0.02	0.02	0.01	1.62
Unassigned	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
TOTAL	**0.56**	**3.56**	**20.84**	**11.46**	**1.71**	**16.22**	**9.07**	**19.68**	**27.39**	**12.11**	**3.03**	**16.15**	**5.29**	**2.97**	**1.88**	**1.02**	**152.94**

Table 92: Estimated Existing Floorspace in 2026 (Million Square Feet)

Building Type	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
Large Office	0.13	3.10	139.80	72.35	1.83	99.54	72.71	162.60	303.10	58.48	2.61	78.61	9.26	20.27	4.43	4.66	1,033
Medium Office	3.38	30.99	78.79	42.28	13.32	47.81	43.87	59.11	86.34	66.69	16.94	101.70	25.18	13.33	10.25	4.06	644
Small Office	4.18	12.75	22.19	11.33	7.50	13.22	8.52	13.28	20.88	24.43	10.60	43.94	21.47	4.99	6.18	2.68	228
Large Retail	1.00	8.67	58.68	26.90	4.20	31.96	25.34	43.46	66.53	53.31	11.40	58.16	22.51	10.91	9.40	3.21	436
Medium Retail	1.18	13.11	44.52	25.74	5.43	44.27	34.66	66.72	108.20	66.89	10.37	60.50	24.15	15.53	8.77	5.17	535
Strip Mall	3.34	9.84	37.42	18.43	5.10	40.23	28.29	55.76	83.70	66.92	12.25	48.37	24.18	15.27	8.70	4.59	462
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Large School	0.76	8.02	34.83	13.95	2.07	28.37	22.54	42.91	73.58	56.01	10.13	53.38	26.41	12.06	7.62	3.59	396
Small School	2.23	11.13	25.57	9.98	6.06	25.69	14.96	34.44	54.31	33.03	13.50	42.08	23.44	8.72	4.25	3.65	313
Non-refrigerated Warehouse	3.33	20.22	108.30	53.43	9.80	89.98	51.48	128.40	207.30	182.70	33.73	148.30	51.08	38.87	29.05	11.63	1,168
Hotel	1.77	10.52	48.10	24.73	5.01	30.49	32.66	41.97	66.01	37.09	7.22	40.53	13.08	8.01	5.88	2.44	376
Assembly	4.33	18.18	91.34	45.06	6.59	57.25	40.90	89.14	120.20	91.75	16.35	69.72	30.13	18.95	11.83	6.44	718
Hospital	1.87	11.09	48.33	24.67	5.06	28.25	27.15	40.77	69.88	39.60	11.11	53.18	22.49	8.80	5.03	3.23	401
Laboratory	0.18	4.01	36.93	28.06	1.53	12.21	17.19	15.61	19.31	10.81	0.68	12.14	4.40	1.72	0.39	0.57	166
Restaurant	0.61	3.62	14.72	7.49	1.55	16.46	10.73	23.78	40.00	32.41	3.52	16.95	7.74	6.86	3.45	1.90	192
Enclosed Parking Garage	0.02	0.54	40.71	30.94	0.30	29.15	20.67	58.41	72.53	2.67	0.35	3.09	0.49	0.85	0.17	0.43	261
Open Parking Garage	0.22	7.02	55.03	41.82	3.86	41.14	35.17	82.44	102.40	34.57	4.46	39.96	6.31	11.05	2.16	5.62	473
Grocery	0.10	1.70	5.87	3.56	0.75	3.42	2.08	4.01	6.95	4.02	0.65	3.74	1.45	0.93	0.54	0.38	40
Refrigerated Warehouse	0.00	0.46	0.91	0.21	0.39	0.46	0.02	0.42	0.79	0.65	0.26	2.15	3.91	0.18	0.19	0.14	11
Controlled-environment Horticulture	0.70	0.46	2.62	1.07	6.33	8.26	1.07	0.74	1.60	3.61	2.51	4.53	5.36	0.47	0.64	0.23	40
Vehicle Service	0.91	6.18	33.65	15.98	2.97	33.73	23.08	49.52	81.78	56.54	6.30	38.32	18.24	15.09	6.18	3.54	392
Manufacturing	4.11	16.89	61.93	79.55	5.59	73.33	33.27	122.70	168.10	49.58	12.86	57.01	25.97	16.98	5.15	9.27	742
Unassigned	0.36	6.58	9.03	6.32	0.22	2.58	0.77	3.78	7.87	2.55	3.37	14.35	2.94	0.77	0.40	1.03	63
TOTAL	**34.68**	**205.07**	**999.26**	**583.86**	**95.46**	**757.79**	**547.13**	**1139.97**	**1761.35**	**974.31**	**191.16**	**990.71**	**370.19**	**230.62**	**130.66**	**78.47**	**9,091**

Table 93: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (Million Square Feet), Cooling Tower Efficiency

Building Type	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
Large Office	0.00	0.00	0.00	0.00	0.00	0.71	0.41	1.15	2.08	0.20	0.05	0.29	0.00	0.00	0.01	0.00	**4.91**
Medium Office	0.00	0.00	0.00	0.00	0.00	0.13	0.09	0.17	0.34	0.12	0.03	0.30	0.06	0.00	0.03	0.00	**1.26**
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Medium Retail	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.04	0.07	0.04	0.01	0.03	0.02	0.00	0.01	0.00	**0.24**
Strip Mall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Large School	0.00	0.00	0.00	0.00	0.00	0.08	0.09	0.13	0.20	0.12	0.05	0.16	0.09	0.00	0.01	0.00	**0.92**
Small School	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Hotel	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.07**
Assembly	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.00	0.02	0.00	0.00	0.00	0.00	**0.10**
Hospital	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.04	0.01	0.04	0.01	0.00	0.01	0.00	**0.19**
Laboratory	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.02	0.03	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.10**
Restaurant	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.09**
Enclosed Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Open Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Grocery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
Controlled-environment Horticulture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Vehicle Service	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Unassigned	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
TOTAL	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**0.7**	**1.6**	**2.8**	**0.6**	**0.2**	**0.9**	**0.2**	**0.0**	**0.1**	**0.0**	**7.9**

Table 94: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (Million Square Feet), Air-Cooled Chiller Threshold

Building Type	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
Large Office	0.00	0.00	0.92	0.45	0.00	0.41	0.24	0.65	1.18	0.11	0.03	0.16	0.00	0.06	0.00	0.01	**4.23**
Medium Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Medium Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Strip Mall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	**0.04**
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Large School	0.00	0.00	0.03	0.01	0.00	0.02	0.02	0.03	0.05	0.03	0.01	0.04	0.02	0.01	0.00	0.00	**0.27**
Small School	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Hotel	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.09**
Assembly	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.02**
Hospital	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.11**
Laboratory	0.00	0.01	0.13	0.07	0.00	0.02	0.01	0.02	0.03	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.32**
Restaurant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Enclosed Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Open Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Grocery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Controlled-environment Horticulture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Vehicle Service	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Unassigned	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
TOTAL	**0.0**	**0.0**	**1.1**	**0.6**	**0.0**	**0.5**	**0.3**	**0.7**	**1.3**	**0.2**	**0.0**	**0.2**	**0.0**	**0.1**	**0.0**	**0.0**	**5.1**

Table 95: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (Million Square Feet), Blowdown Controls

Building Type	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
Large Office	0.00	0.00	1.62	0.79	0.00	0.71	0.41	1.15	2.08	0.20	0.05	0.29	0.00	0.10	0.01	0.03	**7.45**
Medium Office	0.01	0.05	0.15	0.08	0.04	0.13	0.09	0.17	0.34	0.12	0.03	0.30	0.06	0.04	0.03	0.01	**1.63**
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Medium Retail	0.00	0.02	0.04	0.02	0.00	0.03	0.01	0.04	0.07	0.04	0.01	0.03	0.02	0.01	0.01	0.00	**0.34**
Strip Mall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Large School	0.00	0.02	0.12	0.06	0.01	0.08	0.09	0.13	0.20	0.12	0.05	0.16	0.09	0.02	0.01	0.01	**1.17**
Small School	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Hotel	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.10**
Assembly	0.00	0.00	0.02	0.01	0.00	0.01	0.01	0.02	0.02	0.01	0.00	0.02	0.00	0.00	0.00	0.00	**0.13**
Hospital	0.00	0.01	0.04	0.02	0.00	0.01	0.02	0.02	0.03	0.04	0.01	0.04	0.01	0.01	0.01	0.00	**0.27**
Laboratory	0.00	0.01	0.13	0.07	0.00	0.02	0.01	0.02	0.03	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.32**
Restaurant	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.02	0.03	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.11**
Enclosed Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Open Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Grocery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
Controlled-environment Horticulture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Vehicle Service	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Unassigned	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
TOTAL	**0.0**	**0.1**	**2.1**	**1.1**	**0.1**	**1.0**	**0.7**	**1.6**	**2.8**	**0.6**	**0.2**	**0.9**	**0.2**	**0.2**	**0.1**	**0.1**	**11.5**

Table 96: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (Million Square Feet), Cooling Tower Efficiency

Building Type	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
Large Office	0.00	0.00	0.00	0.00	0.00	2.50	1.82	4.08	7.61	1.47	0.07	1.97	0.23	0.00	0.11	0.00	**19.86**
Medium Office	0.00	0.00	0.00	0.00	0.00	0.25	0.23	0.31	0.46	0.35	0.09	0.54	0.13	0.00	0.05	0.00	**2.42**
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Medium Retail	0.00	0.00	0.00	0.00	0.00	0.10	0.08	0.15	0.25	0.15	0.02	0.14	0.06	0.00	0.02	0.00	**0.98**
Strip Mall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Large School	0.00	0.00	0.00	0.00	0.00	0.20	0.16	0.30	0.52	0.39	0.07	0.37	0.19	0.00	0.05	0.00	**2.25**
Small School	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
Hotel	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.03	0.05	0.03	0.01	0.03	0.01	0.00	0.00	0.00	**0.20**
Assembly	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.05	0.07	0.05	0.01	0.04	0.02	0.00	0.01	0.00	**0.32**
Hospital	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.09	0.15	0.09	0.02	0.12	0.05	0.00	0.01	0.00	**0.66**
Laboratory	0.00	0.00	0.00	0.00	0.00	0.13	0.18	0.16	0.20	0.11	0.01	0.13	0.05	0.00	0.00	0.00	**0.96**
Restaurant	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.04	0.06	0.05	0.01	0.03	0.01	0.00	0.01	0.00	**0.25**
Enclosed Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Open Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Grocery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
Controlled-environment Horticulture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Vehicle Service	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Unassigned	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
TOTAL	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.3**	**2.6**	**5.2**	**9.4**	**2.7**	**0.3**	**3.4**	**0.7**	**0.0**	**0.3**	**0.0**	**27.9**

Table 97: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (Million Square Feet), Air-Cooled Chiller Threshold

Building Type	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
Large Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medium Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medium Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Strip Mall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small School	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hotel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assembly	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hospital	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Laboratory	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Enclosed Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grocery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Controlled-environment Horticulture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vehicle Service	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unassigned	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Table 98: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (Million Square Feet), Blowdown Controls

Building Type	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
Large Office	0.00	0.08	3.51	1.82	0.05	2.50	1.82	4.08	7.61	1.47	0.07	1.97	0.23	0.51	0.11	0.12	25.94
Medium Office	0.02	0.16	0.42	0.22	0.07	0.25	0.23	0.31	0.46	0.35	0.09	0.54	0.13	0.07	0.05	0.02	3.40
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medium Retail	0.00	0.03	0.10	0.06	0.01	0.10	0.08	0.15	0.25	0.15	0.02	0.14	0.06	0.04	0.02	0.01	1.23
Strip Mall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.01	0.06	0.24	0.10	0.01	0.20	0.16	0.30	0.52	0.39	0.07	0.37	0.19	0.08	0.05	0.03	2.78
Small School	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Hotel	0.00	0.01	0.03	0.02	0.00	0.02	0.02	0.03	0.05	0.03	0.01	0.03	0.01	0.01	0.00	0.00	0.27
Assembly	0.00	0.01	0.05	0.03	0.00	0.03	0.02	0.05	0.07	0.05	0.01	0.04	0.02	0.01	0.01	0.00	0.43
Hospital	0.00	0.02	0.11	0.05	0.01	0.06	0.06	0.09	0.15	0.09	0.02	0.12	0.05	0.02	0.01	0.01	0.88
Laboratory	0.00	0.04	0.38	0.29	0.02	0.13	0.18	0.16	0.20	0.11	0.01	0.13	0.05	0.02	0.00	0.01	1.71
Restaurant	0.00	0.01	0.02	0.01	0.00	0.03	0.02	0.04	0.06	0.05	0.01	0.03	0.01	0.01	0.01	0.00	0.31
Enclosed Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open Parking Garage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grocery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Refrigerated Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Controlled-environment Horticulture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vehicle Service	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unassigned	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**0.0**	**0.4**	**4.9**	**2.6**	**0.2**	**3.3**	**2.6**	**5.2**	**9.4**	**2.7**	**0.3**	**3.4**	**0.7**	**0.8**	**0.3**	**0.2**	**37.0**

Table 99: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type – Cooling Tower Efficiency

Building Type	New Construction Impacted (Percent Square Footage)	Alterations Impacted (Percent Square Footage)
Large Office	50%	3%
Medium Office	11%	1%
Small Office	0%	0%
Large Retail	0%	0%
Medium Retail	5%	0%
Strip Mall	0%	0%
Mixed-use Retail	0%	0%
Large School	14%	1%
Small School	0%	0%
Non-refrigerated Warehouse	0%	0%
Hotel	1%	0%
Assembly	1%	0%
Hospital	4%	0%
Laboratory	21%	1%
Restaurant	3%	0%
Enclosed Parking Garage	0%	0%
Open Parking Garage	0%	0%
Grocery	0%	0%
Refrigerated Warehouse	2%	0%
Controlled-environment Horticulture	0%	0%
Vehicle Service	0%	0%
Manufacturing	0%	0%
Unassigned	0%	0%

Table 100: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type – Air-Cooled Chiller Threshold

Building Type	New Construction Impacted (Percent Square Footage)	Alterations Impacted (Percent Square Footage)
Large Office	29%	0%
Medium Office	0%	0%
Small Office	0%	0%
Large Retail	0%	0%
Medium Retail	0%	0%
Strip Mall	1%	0%
Mixed-use Retail	0%	0%
Large School	3%	0%
Small School	0%	0%
Non-refrigerated Warehouse	0%	0%
Hotel	1%	0%
Assembly	0%	0%
Hospital	2%	0%
Laboratory	21%	0%
Restaurant	0%	0%
Enclosed Parking Garage	0%	0%
Open Parking Garage	0%	0%
Grocery	0%	0%
Refrigerated Warehouse	0%	0%
Controlled-environment Horticulture	0%	0%
Vehicle Service	0%	0%
Manufacturing	0%	0%
Unassigned	0%	0%

Table 101: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type, Blowdown Controls

Building Type	New Construction Impacted (Percent Square Footage)	Alterations Impacted (Percent Square Footage)
Large Office	50%	3%
Medium Office	11%	1%
Small Office	0%	0%
Large Retail	0%	0%
Medium Retail	5%	0%
Strip Mall	0%	0%
Mixed-use Retail	0%	0%
Large School	14%	1%
Small School	0%	0%
Non-refrigerated Warehouse	0%	0%
Hotel	1%	0%
Assembly	1%	0%
Hospital	4%	0%
Laboratory	21%	1%
Restaurant	3%	0%
Enclosed Parking Garage	0%	0%
Open Parking Garage	0%	0%
Grocery	0%	0%
Refrigerated Warehouse	2%	0%
Controlled-environment Horticulture	0%	0%
Vehicle Service	0%	0%
Manufacturing	0%	0%
Unassigned	0%	0%

Table 102: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone – Cooling Tower Efficiency

Climate Zone	New Construction Impacted (Percent Square Footage)	Alterations Impacted (Percent Square Footage)
1	0%	0%
2	0%	0%
3	0%	0%
4	0%	0%
5	0%	0%
6	6%	0%
7	7%	0%
8	8%	0%
9	10%	1%
10	5%	0%
11	5%	0%
12	5%	0%
13	0%	0%
14	0%	0%
15	3%	0%
16	0%	0%

Table 103: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone – Air-Cooled Chiller Threshold

Climate Zone	New Construction Impacted (Percent Square Footage)	Alterations Impacted (Percent Square Footage)
1	0%	0%
2	1%	0%
3	5%	0%
4	5%	0%
5	0%	0%
6	3%	0%
7	3%	0%
8	4%	0%
9	5%	0%
10	2%	0%
11	2%	0%
12	2%	0%
13	1%	0%
14	2%	0%
15	1%	0%
16	2%	0%

Table 104: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone, Blowdown Controls

Climate Zone	New Construction Impacted (Percent Square Footage)	Alterations Impacted (Percent Square Footage)
1	4%	0%
2	3%	0%
3	10%	0%
4	9%	0%
5	3%	0%
6	6%	0%
7	7%	0%
8	8%	0%
9	10%	1%
10	5%	0%
11	5%	0%
12	5%	0%
13	4%	0%
14	6%	0%
15	3%	0%
16	5%	0%

Appendix B: Embedded Electricity in Water Methodology

The Statewide CASE Team assumed the following embedded electricity in water values: 5,440 kWh/million gallons of water for indoor water use and 3,280 kWh/million gallons for outdoor water use (SBW Consulting, Inc. 2022). Embedded electricity use for indoor water use includes electricity used for water extraction, conveyance, treatment to potable quality, water distribution, wastewater collection, and wastewater treatment. Embedded electricity for outdoor water use includes all energy uses upstream of the customer; it does not include wastewater collection or wastewater treatment. The embedded electricity values do not include on-site energy consumption associated with water usage such as is the energy required for water heating or on-site pumping. On-site energy impacts are accounted for in the energy savings estimates presented in Section 2.3 of this report.

These embedded electricity values were derived from research conducted for CPUC Rulemaking 13-12-011. The CPUC study aimed to quantify the embedded electricity savings associated with IOU incentive programs that result in water savings, and the findings represent the most up-to-date research by the CPUC on embedded energy in water throughout California (California Public Utilities Commission 2015a, California Public Utilities Commission (CPUC) 2015b). This study resulted in the Water-Energy (W-E) Calculator 1.0, which was updated in February 2022 to Version 2.0 (SBW Consulting, Inc. 2022). The CPUC analysis was limited to evaluating the embedded electricity in water and does not include embedded natural gas in water. For this reason, this CASE Report does not include estimates of embedded natural gas savings associated with water reductions, though the embedded electricity values can be assumed to have the same associated emissions factors as grid-demanded electricity in general.

Appendix C: California Building Energy Code Compliance (CBECC) Software Specification

Introduction

The purpose of this appendix is to present proposed revisions to CBECC for commercial buildings (CBECC) along with the supporting documentation that the CEC staff and the technical support contractors would need to approve and implement the software revisions.

Technical Basis for Software Change

As described in Section 2.1.1, the proposed code change would increase the prescriptive efficiency required for axial fan, open-circuit cooling towers in condenser water systems of 900 gallons per minute (gpm) or greater to 100 gpm/hp. This is an incremental efficiency improvement from the current requirement of 60 gpm/hp based on improvement in available cooling tower efficiency.

Description of Software Change

Background Information for Software Change

The Statewide CASE Team recommends that the prescriptive baseline value in the ACM Reference Manual Standard Design be updated from the current value of 60 gpm/hp to 100 gpm/hp for axial fan, open-circuit cooling towers serving condenser water loops of 900 gpm or greater. This change would reflect the update recommended to the prescriptive standards in Section 5.1.

Existing CBECC Building Energy Modeling Capabilities

The 2022 Nonresidential ACM Reference Manual Section 5.8.3 currently specifies that the Standard Design cooling tower total fan horsepower is 60 gpm/hp for all cooling towers with a design condenser water flow greater than 900 gpm except in healthcare facilities and Climate Zones 1 and 16.

Summary of Proposed Revisions to CBECC

Section 5.8.3 of the Nonresidential ACM Reference Manual should be updated to reference a total fan horsepower of 100 gpm/hp instead of the current 60 gpm/hp.

User Inputs to CBECC

No changes to the user inputs are needed to support this measure.

Simulation Engine Inputs

This section will be completed for the Final CASE Report.

Simulation Engine Output Variables

This section will be completed for the Final CASE Report.

Compliance Report

No change needs to be made for the compliance report for this CASE measure.

Compliance Verification

The existing compliance reports are sufficient for the proposed measure. No changes are needed.

Testing and Confirming CBECC Building Energy Modeling

The existing testing and confirmation process are sufficient for the proposed measure. No changes are needed.

Description of Changes to ACM Reference Manual

This information is available in Section 5.4.

Appendix D: Environmental Analysis

Potential Significant Environmental Effect of Proposal

The CEC is the lead agency under the California Environmental Quality Act (CEQA) for the 2025 Energy Code and must evaluate any potential significant environmental effects resulting from the proposed standards. A “significant effect on the environment” is “a substantial adverse change in the physical conditions which exist in the area affected by the proposed project.” (Cal. Code Regs., tit. 14, § 15002(g).)

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 determined that the proposal would not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

The proposal would directly benefit the environment through energy savings due to increased cooling tower efficiency and decreased water use due to reduction in blowdown and other cooling tower related water losses. The reduction in energy use would result in less GHG emissions and other pollutions. The energy and water savings are detailed in Sections 2.3, 3.3, and 4.3 and GHG emissions impacts are detailed in Sections 2.5.2, 3.5.2, and 4.5.2.

Direct Adverse Environmental Impacts

The proposed code change would not result in any direct adverse environmental impacts.

Indirect Environmental Impacts

Indirect Environmental Benefits

The proposed code change would not result in any indirect environmental benefits impacts.

Indirect Adverse Environmental Impacts

The proposed code change would not result in any indirect adverse environmental impacts.

Mitigation Measures

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 did not determine this measure would result in significant direct or indirect adverse environmental impacts and therefore, did not develop any alternatives to the proposal.

Water Use and Water Quality Impacts Methodology

The proposed code change, in particular the air-cooled chiller threshold measure and the blowdown controls measure, would have significant impacts on water consumption. Methodology and estimates of the water impacts are provided in Sections 3.3 and 4.3.

Embodied Carbon in Materials

Accounting for embodied carbon emissions is important for understanding the full picture of a proposed code change's environmental impacts. The embodied carbon in materials analysis accounts specifically for emissions produced during the "cradle-to-gate" phase: emissions produced from material extraction, manufacturing, and transportation. Understanding these emissions ensures the proposed measure considers these early stages of materials production and manufacturing instead of emissions reductions from energy efficiency alone.

The Statewide CASE Team calculated emissions impacts associated with embodied carbon from the change in materials as a result of the proposed measures. The calculation builds off the materials impacts outlined in Sections 2.5.4, 3.5.4, and 4.5.4, see section for more details on the materials impact analysis.

After calculating the materials impacts, the Statewide CASE Team applied average embodied carbon emissions for each material. The embodied carbon emissions are based on industry-wide environmental product declarations (EPDs).[35, 36] These industry-wide EPDs provide global warming potential (GWP) values per weight of specific materials.[37] The Statewide CASE Team chose the industry-wide average for GWP values in the EPDs because the materials accounted for in the statewide calculation will have a range of embodied carbon; i.e. some materials like concrete have a wide range of embodied carbon depending on the manufacturer's processes, source of the materials, etc. The Statewide CASE Team assumes that most building projects will not specify low embodied carbon products. Therefore, an average is appropriate for a statewide estimate.

First year statewide impacts per material (in pounds) were multiplied by the GWP impacts for each material. This provides the total statewide embodied carbon impact for each material. If a material's use is increased, then there is an increase in embodied carbon impacts (additional emissions). If a material's use is decreased, then there is a decrease in embodied carbon impacts (emissions reduced). The total emissions reductions from this measure are the total GHG emissions reductions from Sections 2.5.2, 3.5.2, and 4.5.2 combined with emissions reductions (or additional emissions) from embodied carbon in Sections 2.5.4, 3.5.4, and.

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[35] EPDs are documents which disclose a variety of environmental impacts, including embodied carbon emissions. These documents are based on lifecycle assessments on specific products and materials. Industry-wide EPDs disclose environmental impacts for one product for all (or most) manufacturers in a specified area and are often developed through the coordination of multiple manufacturers and/or associations. A manufacturer specific EPD only examines one product from one manufacturer. Therefore, an industry-wide EPD discloses all the environmental impacts from the entire industry (for a specific product/material) but a manufacturer specific EPD only factors one manufacturer.

[36] An industry wide EPD was not used for mercury, lead, copper, plastics, and refrigerants. Global warming potential values of mercury, lead and copper are based on data provided in a Life Cycle Assessment (LCA) conducted by Yale University in 2014. The GWP value for plastic is based on a LCA conducted by Franklin Associates, which capture roughly 59 percent of the U.S.' total production of PVC and HDPE production. The GWP values for refrigerants are based on data provided by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

[37] GWP values for concrete and wood were in units of kg CO2 equivalent by volume of the material rather than by weight. An average density of each material was used to convert volume to weight.

Appendix E: Discussion of Impacts of Compliance Process on Market Actors

This appendix discusses how the recommended compliance process, described in Sections 2.1.5, 3.1.5, and 4.1.5, could impact various market actors. Table 105 identifies the market actors who would play a role in complying with the proposed change, the tasks for which they are responsible, how the proposed code change could impact their existing workflow, and ways negative impacts could be mitigated. The information contained in Table 105 through Table 107 is a summary of key feedback the Statewide CASE Team received when speaking to market actors about the compliance implications of the proposed code changes. Appendix F summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the code change proposal, including gathering information on the compliance process.

The proposed code change consists of three measures, each of which has specific anticipated impacts on market actors:

- **Cooling Tower Efficiency:** As an increase to an already established prescriptive minimum efficiency, the proposed code change would not result in significant changes to the design phase. In the same process as current code requires, building owners, designers, and product manufacturers would need to coordinate to select equipment that meets new code requirements, building specifications, and budget. Energy consultants would need to be aware of new codes, and whether the owner is opting to meet new, more stringent requirements, or pursue the performance path, which would require a building model. More efficient towers may be larger and heavier and would require coordination between the mechanical, architectural, and structural teams to ensure sufficient space and structure is available. However, the engineering and architectural teams would already be in close coordination as part of any cooling tower placement. The proposed code changes would not impact plumbing and electrical requirements, and plumbing and electrical designers and installers would not see changes to their workflow. HVAC installation teams would not see significant changes to current tasks, beyond the potential for installation of heavier/larger equipment which could increase associated equipment or labor costs. Plans examiners and inspectors, whose role is to ensure that proper forms are completed, grant permits, and verify compliance would see no difference to code beyond understanding the new cooling tower minimum efficiency requirements.
- **Air-Cooled Chiller Threshold:** By adding exceptions to the limitation on air-cooled chiller capacity for chillers of certain efficiencies or function, decisions involving selecting air-cooled and water-cooled chillers would be expanded to a

wider range of projects, though no requirement would be put in place by the proposed code change. The mechanical design engineer would need to be aware of the new code requirements and consider occupant needs and limitations in selection of appropriate equipment. Mechanical designers would need to coordinate with building owners, architectural teams, and structural teams to ensure design considerations align with construction goals, however these teams should already be in close coordination. Building owners would need to understand new available options for larger systems, and the trade-offs between air-cooled chillers and water-cooled chillers including impacts on energy, maintenance, water consumption, and interior and exterior space. Energy consultants may be requested to play a larger role in the decision-making process, providing estimations of energy savings and water savings between the two system types. Plumbing designers, electrical designers, and HVAC installers may see increased prevalence of air-cooled chiller installations, but workflow would not be changed for an individual project. Plans examiners and inspectors, whose role is to ensure proper form completion, grant permits, and verify compliance, would be required to understand new code allowances for air-cooled chiller applications, but specific workflow is not expected to be impacted.

- **Blowdown Controls:** The mechanical designer would be required to complete the cycles of concentration compliance document, and design a “Passing” system, working with building owners and architects to collect required information. Though they would not be required by the proposed code changes, plumbing designers, electrical designers, and installation teams may see increased prevalence of advanced water treatment systems, which would require familiarization and potential additional labor. Plans examiners and inspectors, whose role is to ensure proper form completion, grant permits, and verify compliance, would be required to understand new code requirements including requirements for cycles of concentration and updates to the NRCC-MCH_E calculation worksheet. Inspectors, mechanical designers, and building owners would also be required to coordinate with the ATT due to the newly established acceptance testing requirements. ATTs would need to understand the proposed acceptance test and compliance requirements.

Table 105 to Table 107 identifies the market actors who would play a role in complying with the proposed change, the tasks for which they would be responsible, their objectives in completing the tasks, how the proposed code change could impact their existing workflow, and ways negative impacts could be mitigated.

Table 105: Roles of Market Actors in the Proposed Compliance Process – Cooling Tower Efficiency

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Building Owner	• Provides funding • Provides Owner Project Requirements (OPR)	Impacts on project costs	Code change would require selection of meeting new prescriptive requirements for cooling tower	Code training on updates including cooling tower efficiency
Mechanical/ HVAC Designer	• Load calculations • Design mechanical system and details • Specify of equipment	• Mechanical equipment must be more efficient • Higher efficiency equipment has higher project costs • New code changes and requirements to identify	Updates to CEC-NRCC-MCH-E form	Code training on updates including cooling tower efficiency
Product Manufacturer	• Specification of equipment • Manufacture of compliant products • Work with distributors	Some existing products may not meet new requirements	Updates to CEC-NRCC-MCH-E form	Code training on updates including cooling tower efficiency
Energy Consultant	• Coordinate Title 24, Part 6 requirement with team • Construct energy compliance model (performance path only)	More stringent requirements to meet New code changes and requirements to identify	Updates to CBECC modeling software	Software training on updates including cooling tower efficiency
Plans Examiner	• Verifies building is designed to code • Reviews NRCC documents • Issues building permit	New code changes and requirements to be aware of	Updates to CEC-NRCC-MCH-E form	Code training on updates including cooling tower efficiency
CEC	Establishes of code requirements	N/A	N/A	N/A
Plumbing Designer	Installation of cooling tower plumbing system	N/A	N/A	N/A
Electrical Designer	Installation and design of cooling tower electrical system	N/A	N/A	N/A
Commissioning Agent	N/A	N/A	N/A	N/A

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Architect	Inform load calculations	Additional coordination and space required for potentially larger mechanical equipment	N/A	N/A
HVAC/Controls Subcontractor/ Installer	• Installation of cooling tower and controls • Selection of correct equipment	• Heavier/larger equipment to install • May increase equipment/labor costs	N/A	N/A
Inspector	• Verifies compliant installation • Reviews NRCI/NRCA documents • Issues Certificate of Occupancy	New code changes and requirements to be aware of	Updates to CEC-NRCC-MCH-E form	Code training on updates including cooling tower efficiency

Table 106: Roles of Market Actors in the Proposed Compliance Process – Air-Cooled Chiller Threshold

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Building Owner	• Provides funding • Provides Owner Project Requirements (OPR)	• Potential reduction in project costs • Incorporation of water-energy nexus into Owner Project Requirements	Building owner would need to understand allowances for equipment selection from new air-cooled chiller exceptions requirements for compliance documentation	Code training on updates including air-cooled chiller threshold
Mechanical/ HVAC Designer	• Load calculations • Design mechanical system and details Specify of equipment and system design	• New code changes and requirements to identify • Wider range of use for air-cooled chillers • Different locations, physical sizes, water systems, and layouts to consider when selecting system types.	Updates to CEC-NRCC-MCH-E	Code training on updates including air-cooled chiller threshold

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Energy Consultant	• Coordinate Title 24, Part 6 requirement with team • Construct energy compliance model (performance path only)	Calculation of water savings between air-cooled and water-cooled chillers	Updates to CEC-NRCC-MCH-E	Code training on updates including air-cooled chiller threshold
Product Manufacturer	• Specification of equipment • Manufacture of compliant products • Work with distributors	Understanding of new allowances for air-cooled chiller uses.	Updates to CEC-NRCC-MCH-E	Code training on updates including air-cooled chiller threshold
Plans Examiner	• Verifies building is designed to code • Reviews NRCC documents • Issues building permit	• New code changes and requirements to be aware of • Understanding of new allowances for air-cooled chiller uses.	Updates to CEC-NRCC-MCH-E	Code training on updates including air-cooled chiller threshold
CEC	Establishes of code requirements	N/A	N/A	N/A
Plumbing Designer	Installation of chilled water plumbing system	No anticipated changes	N/A	N/A
Electrical Designer	Installation and design of chilled water electrical system	No anticipated changes	N/A	N/A
Commissioning Agent	N/A	N/A	N/A	N/A
Architect	Inform load calculations	Additional coordination and space required for mechanical equipment	N/A	N/A
HVAC/Controls Subcontractor/ Installer	• Installation of chilled water system and controls • Selection of correct equipment • Coordination with ATT	• New code changes and requirements to be aware of • Potential changes to system physical aspects for HVAC system (location, piping system, etc.)	Updates to CEC-NRCC-MCH-E	Code training on updates including air-cooled chiller threshold
Inspector	• Verifies compliant installation • Reviews NRCI/NRCA documents • Issues Certificate of Occupancy	New code changes and requirements to be aware of	Updates to CEC-NRCC-MCH-E	Code training on updates including air-cooled chiller threshold

Table 107: Roles of Market Actors in the Proposed Compliance Process – Blowdown Controls

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Building Owner	• Provides funding • Provides Owner Project Requirements (OPR)	Impacts on project costs	Requirement of acceptance test	Training on Maximum Cycles of Concentration and benefits of blowdown controls
Mechanical/ HVAC Designer	• Load calculations • Design mechanical system and details • Specify of equipment • Perform LSI/Cycles of Concentration calculations	Requires coordination and specification water treatment to achieve documented LSI/cycles of concentration	Updates to NRCC-MCH-E Maximum Cycles of Concentration Calculation Worksheet	Training on use of Maximum Cycles of Concentration Calculator and worksheet
Product Manufacturer	• Specification of equipment • Manufacture of compliant products • Work with distributors	• Addition of acceptance test for product which may require more performance guarantees • Coordination with designers to ensure product meets Title 24, Part 6 requirements	Requirement of acceptance test	Training on use of Maximum Cycles of Concentration Calculator and worksheet
Plans Examiner	• Verifies building is designed to code • Reviews NRCC documents • Issues building permit	• New code changes and requirements to be aware of • Awareness and understanding of cycles of cycles of concentration compliance	Updates to NRCC-MCH-E Maximum Cycles of Concentration Calculation Worksheet	Code training and training on use of Maximum Cycles of Concentration Calculator and worksheet
CEC	Establishes of code requirements	N/A	N/A	N/A
Plumbing Designer	Installation of cooling tower plumbing system	No anticipated changes	N/A	N/A
Electrical Designer	Installation and design of cooling tower electrical system	No anticipated changes	N/A	N/A
Commissioning Agent	N/A	N/A	N/A	N/A
Architect	Inform load calculations	N/A	N/A	N/A

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
HVAC/Controls Subcontractor/ Installer	• Potential installation advance water treatment systems and controls • Selection of correct equipment • Coordination with ATT	No direct impact anticipated	N/A	N/A
Inspector	• Verifies compliant installation • Reviews NRCI/NRCA documents • Issues Certificate of Occupancy	New code changes and requirements to be aware of	• Requirement of new acceptance test • Updates to NRCC-MCH-E Maximum Cycles of Concentration Calculation Worksheet	Code training and training on use of Maximum Cycles of Concentration Calculator and worksheet and acceptance tests
ATT	• Conduct blowdown controls acceptance test • Document functional performance testing • Ensure facility manager training	Be aware of new acceptance test requirements and procedures for cooling tower blowdown controls	• Requirement of new acceptance test • Updates to NRCC-MCH-E Maximum Cycles of Concentration Calculation Worksheet	Code training and training on use of Maximum Cycles of Concentration Calculator and worksheet and acceptance tests

Appendix F: Summary of Stakeholder Engagement

Collaborating with stakeholders that might be impacted by proposed changes is a critical aspect of the Statewide CASE Team's efforts. The Statewide CASE Team aims to work with interested parties to identify and address issues associated with the proposed code changes so that the proposals presented to the CEC in this Draft CASE Report are generally supported. Public stakeholders provide valuable feedback on draft analyses and help identify and address challenges to adoption including: cost effectiveness; market barriers; technical barriers; compliance and enforcement challenges; or 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 that the Statewide CASE Team conducted when developing and refining the recommendations presented in this report.

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 stakeholder 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 provide transparency in what the Statewide CASE Team is considering for code change proposals, during these meetings the Statewide CASE Team asks for feedback on:

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

The Statewide CASE Team hosted two stakeholder meetings for Cooling Towers via webinar described in Table 108. Please see below for dates and links to event pages on 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.

Table 108: Utility-Sponsored Stakeholder Meetings

Meeting Name	Meeting Date	Event Page from Title24stakeholders.com
Welcome to the 2025 Energy Code Cycle Stakeholder Meeting – Nonresidential	Tuesday, October 25, 2022	https://title24stakeholders.com/event/welcome-to-the-2025-energy-code-cycle-stakeholder-meeting-nonresidential/
Nonresidential Cooling Towers Utility-Sponsored Stakeholder Meeting	Monday, February 13, 2023	https://title24stakeholders.com/event/nonresidential-cooling-towers-utility-sponsored-stakeholder-meeting/

The first round of utility-sponsored stakeholder meetings occurred in October 2022 and were important for providing transparency and an early forum for stakeholders to offer feedback on measures being pursued 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. The Statewide CASE Team also presented initial draft code language for stakeholders to review.

The second round of utility-sponsored stakeholder meetings occurred from January to February 2023 and provided updated details on proposed code changes. The second round of meetings introduced early results of energy, cost effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

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 entire Title 24 Stakeholders listserv, totaling over 3,000 individuals, and a second email was sent to a targeted list of individuals on the listserv depending on their subscription preferences. The Title 24 Stakeholders' website listserv is an opt-in service and includes individuals from a wide variety of industries and trades, including manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was posted on the Title 24 Stakeholders' LinkedIn page (and cross-promoted on the CEC LinkedIn page) two weeks before each meeting to reach out to individuals and larger organizations and channels outside of the listserv. The Statewide CASE Team conducted extensive personal outreach to stakeholders identified in initial work plans who had not yet opted into the listserv. Exported webinar meeting data captured attendance numbers and individual comments, and recorded outcomes of live attendee polls to 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 109.

Table 109: Engaged Stakeholders

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections
SPX Cooling Technologies, Inc.	Cooling Tower Manufacturer	2.2.1, 2.2.2, 2.5.4, 3.2.2
Evapco, Inc.	Cooling Tower Manufacturer	2.2.1, 2.2.2, 2.5.4, 3.2.2
BAC	Cooling Tower Manufacturer	2.2.1, 2.2.2, 2.5.4, 3.2.2
Carrier Corporation	Air-Cooled Chiller Manufacturer	3.2.2
Daikin	Air-Cooled Chiller Manufacturer	3.2.2
AHRI	Manufacturer Trade Association	3.2.2
Chem-Aqua	Chemical Treatment Manufacturer	
NREL	National Laboratory	4.1.2.2, 4.2.2
Erbeznik & Associates	Water Conservation Consultant	
Alliance for Water Efficiency	Water Efficiency Association	
California Water Efficiency Partnership	Water Efficiency Association	
NRDC	Efficiency Advocate Organization	
SBControl (Chemtrol)	Automated Chemical Treatment Vendor	4.2.2
Imegcorp	Engineering Consultants Company	
San Joaquin Chemicals	Chemical Treatment Vendor	

Appendix G: Energy Cost Savings in Nominal Dollars

The CEC requested energy cost savings over the 30-year period of analysis in both 2026 present value dollars (2026 PV$) and nominal dollars. The cost-effectiveness analysis uses energy cost values in 2026 PV$. Costs and cost effectiveness using and 2026 PV$ are presented in Sections 0, 3.4, and 4.4 of this report. This appendix presents energy cost savings in nominal dollars.

Table 110: Nominal Life Cycle Energy Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Cooling Tower Efficiency – New Construction/Additions – OfficeLarge

Climate Zone	30-Year LSC Electricity Savings (Nominal $)	30-Year LSC Natural Gas Savings (Nominal $)	Total 30-Year LSC Savings (Nominal $)
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0.29	0.00	0.29
7	0.33	0.00	0.33
8	0.53	0.00	0.53
9	0.36	0.00	0.36
10	0.50	0.00	0.50
11	0.39	0.00	0.39
12	0.28	0.00	0.28
13	0.44	0.00	0.44
14	0	0	0
15	0.93	0.00	0.93
16	0	0	0

Table 111: Nominal Life Cycle Energy Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Cooling Tower Efficiency – Alterations – OfficeLarge

Climate Zone	30-Year Life Cycle Electricity Cost Savings (Nominal $)	30-Year Life Cycle Natural Gas Cost Savings (Nominal $)	Total 30-Year Life Cycle Energy Cost Savings (Nominal $)
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0.29	0.00	0.29
7	0.33	0.00	0.33
8	0.53	0.00	0.53
9	0.36	0.00	0.36
10	0.50	0.00	0.50
11	0.39	0.00	0.39
12	0.28	0.00	0.28
13	0.44	0.00	0.44
14	0	0	0
15	0.93	0.00	0.93
16	0	0	0

Table 112: Nominal Life Cycle Energy and Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Air-Cooled Chiller Threshold – New Construction/Additions – OfficeLarge

Climate Zone	30-Year Life Cycle Electricity Cost Savings (Nominal $)	30-Year Life Cycle Natural Gas Cost Savings (Nominal $)	Total 30-Year Life Cycle Energy Cost Savings (Nominal $)	30-Year Life Cycle Water Cost Savings (Nominal $)
1	-	-	-	-
2	-	-	-	-
3	(1.35)	(0.01)	(1.36)	2.03
4	(5.25)	(0.03)	(5.29)	6.27
5	-	-	-	-
6	(3.13)	0.00	(3.13)	4.79
7	(3.40)	0.00	(3.39)	5.14
8	(5.18)	(0.00)	(5.18)	7.73
9	(5.37)	(0.00)	(5.37)	7.40
10	(6.61)	(0.00)	(6.61)	8.70
11	(6.79)	(0.02)	(6.81)	8.57
12	(4.34)	(0.05)	(4.39)	6.09
13	-	-	-	
14	(7.32)	(0.04)	(7.36)	8.03
15	(13.81)	0.00	(13.81)	16.31
16	(2.27)	(0.06)	(2.34)	3.01

Table 113: Nominal Life Cycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Blowdown Controls – New Construction/Additions – Hospital

Climate Zone	30-Year Life Cycle Water Cost Savings (Nominal $)
1	2.64
2	5.49
3	3.94
4	7.27
5	4.42
6	6.30
7	6.68
8	8.75
9	8.40
10	9.52
11	9.77
12	7.41
13	10.34
14	9.20
15	16.65
16	4.81

Table 114: Nominal Life Cycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Blowdown Controls – New Construction/Additions – OfficeLarge

Climate Zone	30-Year Life Cycle Water Cost Savings (Nominal $)
1	
2	
3	1.90
4	3.83
5	
6	3.15
7	3.31
8	4.49
9	4.34
10	4.93
11	4.88
12	3.75
13	
14	4.63
15	8.40
16	2.34

Appendix H: Cost Estimation Details

Table 115: Air-Cooled Threshold Cost Estimates – OfficeLarge Prototype – Climate Zones 1-6

-	-	CZ01	CZ02	CZ03	CZ04	CZ05	CZ06
System Description	Chillers:	(2) 285-ton units	(2) 398-ton units	(2) 364-ton units	(2) 411-ton units	(2) 344-ton units	(2) 399-ton units
	Cooling Towers:	(2) 340-ton units	(2) 464-ton units	(2) 424-ton units	(2) 479-ton units	(2) 400-ton units	(2) 465-ton units
Baseline	Path B, Water-Cooled Centrifugal Chillers	$386,699	$423,951	$387,396	$380,990	$318,516	$425,367
	Cooling Towers	$163,059	$231,280	$216,565	$247,871	$179,834	$206,931
	Condenser Piping and Pumps	$120,202	$164,214	$150,081	$169,476	$141,719	$164,719
	Condenser Water Treatment System	$5,300	$5,300	$5,300	$5,300	$5,300	$5,300
	Total Baseline Cost	$675,260	$824,745	$759,342	$803,637	$645,370	$802,317
Proposed	Path B, Air-Cooled Screw Chillers	$425,500	$594,865	$543,574	$613,963	$513,288	$596,852
	Total Proposed Cost	$425,500	$594,865	$543,574	$613,963	$513,288	$596,852
Incremental	Total Incremental Cost	-$249,759	-$229,879	-$215,768	-$189,673	-$132,082	-$205,464

Table 116: Air-Cooled Threshold Cost Estimates – OfficeLarge Prototype – Climate Zones 7-11

-	-	CZ07	CZ08	CZ09	CZ10	CZ11
System Description	Chillers:	(2) 433-ton units	(2) 432-ton units	(2) 433-ton units	(2) 410-ton units	(2) 452-ton units
	Cooling Towers:	(2) 504-ton units	(2) 503-ton units	(2) 504-ton units	(2) 477-ton units	(2) 526-ton units
Baseline	Path B, Water-Cooled Centrifugal Chillers	$401,409	$400,542	$401,523	$380,238	$419,149
	Cooling Towers	$225,058	$227,610	$230,021	$216,054	$254,717
	Condenser Piping and Pumps	$178,493	$178,075	$178,512	$169,034	$186,345
	Condenser Water Treatment System	$5,300	$5,300	$5,300	$5,300	$5,300
	Total Baseline Cost	$810,260	$811,528	$815,356	$770,626	$865,511
Proposed	Path B, Air-Cooled Screw Chillers	$646,869	$645,472	$647,053	$612,752	$675,457
	Total Proposed Cost	$646,869	$645,472	$647,053	$612,752	$675,457
Incremental	**Total Incremental Cost**	**-$163,391**	**-$166,056**	**-$168,303**	**-$157,874**	**-$190,054**

Table 117: Air-Cooled Threshold Cost Estimates – OfficeLarge Prototype – Climate Zones 12-16

-	-	CZ12	CZ13	CZ14	CZ15	CZ16
System Description	Chillers:	(2) 421-ton units	(2) 457-ton units	(2) 430-ton units	(2) 506-ton units	(2) 329-ton units
	Cooling Towers:	(2) 490-ton units	(2) 532-ton units	(2) 501-ton units	(2) 589-ton units	(2) 383-ton units
Baseline	Path B, Water-Cooled Centrifugal Chillers	$390,181	$423,407	$398,534	$469,081	$350,297
	Cooling Towers	$229,732	$244,479	$220,033	$259,467	$183,782
	Condenser Piping and Pumps	$173,478	$188,218	$177,261	$208,450	$135,709
	Condenser Water Treatment System	$5,300	$5,300	$5,300	$5,300	$5,300
	Total Baseline Cost	$798,692	$861,404	$801,128	$942,297	$675,087
Proposed	Path B, Air-Cooled Screw Chillers	$628,776	$682,319	$642,236	$755,922	$491,518
	Total Proposed Cost	$628,776	$682,319	$642,236	$755,922	$491,518
Incremental	**Total Incremental Cost**	**-$169,916**	**-$179,084**	**-$158,892**	**-$186,375**	**-$183,569**

Table 118: RSMeans 2021 California Location Factors

Climate Zone	City	Materials Location Factor	Installation Location Factor	Total Location Factor
1	Eureka	102.6	137.6	117.7
2	Santa Rosa	101.2	149.8	122.2
3	Oakland	103.9	153.2	125.2
4	San Jose	103	158.4	126.9
5	San Luis Obispo	98.4	125.5	110.1
6	Long Beach	95.2	127.2	109
7	San Diego	100.3	121.3	109.4
8	Anaheim	99.5	125.9	110.9
9	Los Angeles	98.4	129.3	111.8
10	Riverside	99.4	126	110.9
11	Redding	107.8	132.6	118.6
12	Sacramento	101	133.1	114.9
13	Fresno	98.6	131.2	112.7
14	Mojave	95.6	123.6	107.7
15	Palm Springs	97.3	121.9	108
16	Susanville	107.3	131	117.5