Codes and Standards Enhancement (CASE) Initiative

2025 California Energy Code

Cooling Towers CASE Report

Nonresidential HVAC
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Executive Summary

This CASE Report presents justifications for code changes to cooling towers and blowdown controls that refine and build on prior code changes to Title 24, Part 6 approved by the CEC. The proposed code changes would apply to nonresidential and multifamily new construction, new systems serving additions, alterations (except for existing buildings), and both open-circuit and closed-circuit cooling towers 150 tons and larger. The two proposed measures would implement the following requirements:

- Increase the prescriptive minimum efficiency of ≥ 60 gallons per minute (GPM) per horsepower (HP) for axial, open-circuit cooling towers serving condenser water loops of 900 GPM or greater, established in Sections 140.4(h)5 and 170.2(c)4Fv.
- Eliminate exception for Climate Zones 1 and 16 and add a table of specific values determined by cost effectiveness, ranging from the current mandatory efficiency of 42.1 GPM/HP to 90 GPM/HP, which would increase efficiency to:
    - 70 GPM/HP in Climate Zones 2, 4, 5, and 12
    - 80 GPM/HP in Climate Zones 6, 7, 9, and 13
    - 90 GPM/HP in Climate Zones, 8, 10, and 15
- Strengthen mandatory blow-down control, outlined in Section 110.2(e), by urging designers to:
    - Replace flow-based controls with conductivity-based controls.
    - Indicate target maximum cycles of concentration in the NRCC-MCH-E compliance document based on the recirculating water properties established in ANSI/ASHRAE Standard 189.1-2020.
    - Program controls to not allow blowdown until one or more of the recirculating water parameter limits set in ANSI/ASHRAE Standard 189.1-2020 is met.
    - Add an acceptance test to verify installation and programming of controls to achieve documented cycles of concentration and overflow alarms.

The May 2023 Draft CASE Report included an additional measure — the air-cooled chiller threshold measure — which contemplated adding an exception to the current prescriptive requirements in Sections 140.4(j) and 170.2(c)4H limiting air-cooled chillers to 300 tons of cooling capacity. This proposed measure would have allowed an exception to this requirement for very high efficiency air-cooled chillers. This measure is not included in the Final CASE Report due to the energy penalty of even high-efficiency air-cooled chillers compared to minimum efficiency water-cooled equipment. The proposed language excepting air-to-water heat pumps and heat recovery chillers from the 300-ton limitation is maintained in this Final CASE Report. 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. This equipment was not widely available or analyzed as part of the original limitation and have since become a critical decarbonization technology necessitating this language update.

The proposed code changes would be cost-effective for all climate zones. For cooling tower efficiency, the benefit-to-cost (B/C) ratio over 30 years would range between 1.35 and 11.42, depending on the climate zone. For blowdown controls, the B/C ratio over 30 years would range between 2 and 137, depending on the climate zone. See Sections 3.4 and 4.4.[1] for the methodology, assumptions, and results of the cost-effectiveness analysis.

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.

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.

Proposal Description: 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) (except for Climate Zones 1 and 16, which are exempted and subject to the mandatory minimum 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 in Climate Zones 2 through 15to 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 90 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

[1] 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.

GPM or greater. The proposed code change does not recommend modifications to the existing mandatory minimum efficiency requirements.

Table 1: Proposed Cooling Tower Prescriptive Minimum Efficiencies (GPM/HP) by Climate Zone (CZ) – Propeller or axial fan, open-circuit cooling towers

Climate Zone	Prescriptive Minimum Efficiency (GPM/HP)
CZ01	42.1
CZ02	70
CZ03	60
CZ04	70
CZ05	70
CZ06	80
CZ07	80
CZ08	90
CZ09	80
CZ10	90
CZ11	60
CZ12	70
CZ13	80
CZ14	60
CZ15	90
CZ16	42.1

The proposal recommends using the existing test procedure and rating conditions to evaluate cooling tower efficiency established by consensus with the CEC and ASHRAE SSPC 90.1 Committee, which are listed in Title 24, Part 6, Table 110.2-F Performance Requirements for Heat Rejection Equipment. The standardized conditions are 95°F entering water temperature, 85°F leaving water temperature, and 75°F entering air wet-bulb temperature. The test procedures identified are the Cooling Technology Institute's (CTI) standards, CTI ATC-105 and CTI STD-201 RS.,

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.

This measure also proposes adding an exception for heating-only air-to-water heat pumps and a limited exception for chillers using heat recovery.

Proposal Description: 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).
- Require the designer to document target maximum cycles of concentration in the NRCC-MCH-E compliance document based on the recirculating water properties established in ANSI/ASHRAE Standard 189.1-2020.
- Require that controls be programmed to not allow blowdown until one or more of the recirculating water parameter limits set in ANSI/ASHRAE Standard 189.1-2020 is met.
- 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.

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 on 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 measures under consideration in this CASE Report build upon and update these current requirements.

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 (U.S. DOE Federal Energy Management Program n.d.). However, the benefits of the 2013 requirements have not been fully realized as the NRCC-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, as controlling to an LSI of 2.5 alone could result in scale depending on the makeup water characteristics. Stakeholders have also voiced the need to be able to adjust cycles of concentration over time, in response to actual water quality conditions which are highly variable. The proposed requirement would allow for this by having the design engineer document a target cycles of concentration and requiring controls that don't allow blowdown until one or more of the ANSI/ASHRAE 189.1-2020 parameters are exceeded. The target cycles of concentration provide information to the cooling tower operator and/or water treatment vendor as to what cycles of concentration should be achievable, allowing them to adjust their water quality management accordingly.

In addition to traditional chemical water treatment, 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).[2] While these non-chemical systems are not 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 manufacturer concerns about the impact of this proposal, ultimately a prescriptive minimum efficiency of ≥60 GPM/HP was adopted for 2019 Title 24, Part 6, despite the fact that higher levels had been found to be cost-effective. It has been six years since the research and analysis was performed to inform the 2019 proposal, and in the time since, energy costs have increased, and the market has had time to adjust to the 2019 requirements. The current proposal examines revising the prescriptive minimum efficiency to ≥ 70 to 90 GPM/HP in certain climate zones where it was found to be cost effective.

Scope of Code Change Proposal

Table 2 and Table 3 summarize the scope of the proposed changes and which sections of standards and compliance documents that would be modified as a result.

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

Proposal Name	Cooling Tower Efficiency
Type of Requirement	Prescriptive
Applicable Climate Zones	2, 4-10, 12-13, and 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

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

Table 3: 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

Table 4 presents a summary of the cooling towers that achieve the various efficiency levels. 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.).

Table 4: Cooling Tower Breakdown by Efficiency Level

Cooling Tower Efficiency (GPM/HP)	% of Cooling Towers Exceeding Efficiency: Single Cell	% of Cooling Towers Exceeding Efficiency: Two Cell
60	67%	63%
70	53%	48%
80	43%	37%
90	35%	28%
100	29%	20%
110	23%	14%
120	18%	9%

A variety of manufacturers produce cooling tower controls, including Advantage Controls, Chemtrol, Lakewood, and Walchem. Most controls available include conductivity controls.[3] The Statewide CASE Team determined the following barriers 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 would pass any value that results in an LSI of 2.5 or less. For example, a cycle of concentration of 1, which is equivalent to once-through-cooling, is permissible using the compliance document.
- Most 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

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

commented that controlling to LSI alone could result in scale under certain water quality conditions. 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.

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.

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) as well as meetings and emails with ten individual stakeholders. The Statewide CASE Team published a Draft CASE Report in May 2023 and received comments from four stakeholders. 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 appreciates the input from stakeholders in shaping this Final CASE Report. See Appendix F for a summary of stakeholder engagement.

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.

Addressing Energy Equity and Environmental Justice

This proposal primarily affects large nonresidential buildings (which 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 Marissa Lerner (mlerner@energy-solution.com) for further engagement. Full details addressing energy equity and environmental justice can be found in Sections 2 and 4.6 of this report.

1. Introduction

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 two 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
- 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, as well as feedback received in response to the Draft CASE Report published in May 2023.

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

Section 2 – Addressing Energy Equity and Environmental Justice

- Section 2.1 – General Equity Impacts provides background environmental justice concerns and their importance in this CASE Report.
    - Section 2.2 – Specific Impacts of the Proposal provides details on the potential impacts of this specific proposal as they pertain to energy equity and environmental justice.

Section 3 – Cooling Tower Efficiency

- 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 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 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 disproportionately impacted populations (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 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 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: Proposed Revisions to NRCC-MCH-E Compliance Document presents a summary of modifications made to the compliance form to align with the proposal of Measure 2.
- Appendix I: RSMeans 2021 California Location Factors presents the adjustment factors used in the cooling tower efficiency incremental first cost estimates.

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. Addressing Energy Equity and Environmental Justice

2.1 General Equity Impacts

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. 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). Similar to the California Public Utilities Commission (CPUC) definition, DIPs refer to the populations 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" (CPUC n.d.). DIPs also incorporate race, class, and gender since these intersecting identity factors affect how people frame issues, interpret, and experience the world.[4]

Including impacted communities in the decision-making process, ensuring that the benefits and burdens of the energy sector are evenly distributed, and facing the unjust legacies of the past all serve as critical steps to achieving energy equity. Recognizing the importance of engaging DIPs and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement. A participatory approach allows individuals to address problems, develop innovative ideas, and bring forth a different perspective. Please reach out to Sean Wynne (swynne@energy350.com) and Marissa Lerner (mlerner@energy-solution.com) for further engagement.

Energy equity and environmental justice (EEEJ) is a newly emphasized component of the Statewide CASE Team's work and is an evolving dialogue within California and beyond.[5] To

[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.

[5] The CEC defines energy equity as "the quality of being fair or just in the availability and distribution of energy programs" (CEC 2018). American Council for an Energy-Efficient Economy (ACEEE) defines

minimize the risk of perpetuating inequity, code change proposals are being developed with intentional consideration of the unintended consequences of proposals on DIPs. The Statewide CASE Team identified potential impacts via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. As the Statewide CASE Team continues to build relationships with CBOs, these partnerships would inform and further improve the identification of potential impacts. The Statewide CASE Team is open to additional peer-reviewed studies that contribute to or challenge the information on this topic presented in this report. The Statewide CASE Team is currently continuing outreach with CBOs and EEEJ Partners and the results of that outreach, as well as a summary of the 2025 code cycle EEEJ activities would be documented in the 2025 EEEJ Summary Report that is expected to be published on title24stakeholders.com by the end of 2023.

2.1.1 Procedural Equity and Stakeholder Engagement

As mentioned, representation from DIPs is crucial to considering factors and potential impacts that may otherwise be missed or misinterpreted. The Statewide CASE Team is committed to engaging with representatives from as many affected communities as possible. This code cycle, the Statewide CASE Team is focused on building relationships with CBOs and representatives of DIPs across California. To achieve this end, the Statewide CASE Team is prioritizing the following activities:

- Identification and outreach to relevant and interested CBOs
- Holding a series of working group meetings to solicit feedback from CBOs on code change proposals
- Developing a 2025 EEEJ Summary Report

In support of these efforts, the Statewide CASE team is also working to secure funds to provide fair compensation to those who engage with the Statewide CASE Team. While the 2025 code cycle will end, the Statewide CASE Team's EEEJ efforts will continue, as this is not an effort that can be "completed" in a single or even multiple code cycles. In future code cycles, the Statewide CASE Team is committed to furthering relationships with CBOs and inviting feedback on proposed code changes with a goal of engagement with these organizations representing DIPs throughout the code cycle. Strategies for future code cycles are being considered, including:

- Creating an advisory board of trusted CBOs that may provide consistent feedback on code change proposals throughout the development process
- Establishing a robust compensation structure that enables participation from CBOs and DIPs in the Statewide CASE Team's code development process
- Holding equity-focused stakeholder meetings to solicit feedback on code change proposals that seem more likely to have strong potential impacts

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energy equity as that which "aims to ensure that disadvantaged communities have equal access to clean energy and are not disproportionately affected by pollution. It requires the fair and just distribution of benefits in the energy system through intentional design of systems, technology, procedures, and policies" (ACEEE n.d.). Title 7, Planning and Land Use, of the California Government Code defines environmental justice as "the fair treatment and meaningful involvement of people of all races, cultures, incomes, and national origins, with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies" (State of California n.d.).

2.1.2 Potential Impacts on DIPs in Nonresidential Buildings

To assess potential inequity of proposals for nonresidential buildings the Statewide CASE Team considered which building types are used by DIPs most frequently and evaluated the allocation of impacts related to the following areas among all populations.

- **Cost:** People historically impacted by poverty and other historic systems of wealth distribution can be affected more severely by the incremental first cost of proposed code changes. Costs can also create an economic burden for DIPs that does not similarly affect other populations. See section(s) 3.4 and 4.4 for an estimate of energy cost savings from the current proposals.
- **Health:** Any potential health burdens from proposals could more severely affect DIPs that can have limited access to healthcare and live in areas affected by environmental and other health burdens. Several of the potential negative health impacts from buildings on DIPs are addressed by energy efficiency (Norton 2014., Cluett 2015, Rose 2020). For example, indoor air quality (IAQ) improvements through ventilation or removal of combustion appliances can lessen the incidents of asthma, chronic obstructive pulmonary disease (COPD), and some heart problems. Black and Latinx people are 56 percent and 63 percent more likely to be exposed to dangerous air pollution than white people, respectively (Tessum, et al. 2019). Water heating and building shell improvements can reduce stress levels associated with energy bills by lowering utility bill costs. Electrification can reduce the health consequences resulting from NOx, SO_2, and $PM_{2.5}$.
- **Resiliency:** DIPs are more vulnerable to the negative consequences of natural disasters, extreme temperatures, and weather events due to climate change. Black Americans are 40 percent more likely to currently live in areas with the highest projected increases in extreme heat related mortality rates, compared to other groups (EPA 2021). Similarly, natural disasters affect DIPs differently. Race and wealth affect the ability to evacuate for a natural disaster, as evidenced during Hurricane Harvey wherein White and wealthy residents were overrepresented by 19.8 percent among evacuees (Deng, et al. 2021). Proposals that improve buildings' resiliency to natural disasters and extreme weather could positively impact DIPs. For example, buildings with more insulation and tighter envelopes can reduce the health impacts of infiltration of poor quality air, reduce risk of moisture damage and related health impacts (mildew and mold), and help maintain thermal comfort during extreme weather events.
- **Comfort:** Thermal comfort and proper lighting are important considerations for any building where people work, though impacts are not proportional across all populations. Thermal comfort can also have serious health effects as heat related illness is on the rise in California. DIPs are at a greater risk for heat illness due in part to socioeconomic factors. From 2005 to 2015 the number of emergency room visits for heat related illness in California rose 67 percent for Black people, 53 percent for Asian Americans, and 63 percent for Latinx people (Abualsaud, Ostrovskiy and Mahfoud 2019). Studies have shown that not only do the effects of urban heat islands lead to higher mortality during heat waves, but those in large buildings are disproportionately affected (Smargiassi 2008, Laaidi 2012). These residents tend to be the elderly, people of color, and low-income households (Drehobl 2020, Blankenship 2020, IEA 2014). Comfort is not only a

nice quality to have in workplaces and schools, but it also has real world health impacts on people's health.

2.1.2.1 Potential Impacts by Building Type

Proposals for the following building types would not have disproportionate impacts because all populations use the buildings with the same relative frequency. While there may be impacts on costs, health, resiliency, or comfort, DIPs would not be affected more or less than any other population. It is unlikely that DIPs would pay a disparate share of the incremental first costs.

- Office buildings of all sizes
- Retail buildings of all sizes
- Non-refrigerated buildings
- Laboratories
- Open air parking garage
- Vehicle service

Below is a description of how the proposed code changes might impact DIPs by building type.

Mixed-Use Retail

DIPs use mixed-use retail buildings more frequently than other populations, so there is a possibility of uneven impacts. Rents are often higher in mixed-use retail. Historically, small and minority owned businesses face challenges such as discrimination, difficulty in securing funding, and a lack of social capital that impact start-up costs and ability to secure business locations (Morelix 2016). Impacts on health, resiliency, or comfort are not anticipated to be disproportionate.

Schools (Small and Large)

Incremental costs could have a larger impact on DIPs than the general population because school funding is linked with race and income in the United States (U.S). Jurisdictions with lower income populations where the tax base, funding, and capital improvement budgets may be more constrained may find it more challenging to accommodate the incremental first costs. Costs can affect educational quality, as incremental costs present a significant burden for schools with lower budgets. Analysis from the U.S. Government Accountability Office shows that students in poorer and smaller schools tend to have less access to college-prep courses and 80 percent of the students in these poorest schools were Black and Latinx (United States Government Accountability Office 2018). Incremental costs can deepen these educational inequalities by burdening schools with low budgets. Proposals would impact individuals attending and working at schools including those from DIPs. Proposals that impact health, resiliency, and comfort all have the potential to disproportionately impact those who attend or work in majority DIP schools, as those schools can less often afford considerations for those criteria.

Hotel

Proposals that impact health and resiliency have the potential to disproportionately impact those working or residing in hotels. California has used hotels for temporary housing, and unhoused people rely on these buildings for shelter on a regular basis and during extreme weather events. California's Project Roomkey offered temporary hotel housing for more than 42,000 unhoused Californians in the COVID-19 crisis (California Governer's Office of Emergency Services 2021). More than 1.6 million people are employed year-round in accommodation and food services with more than 49 percent of that industry identifying as Black, Asian American, or Latinx (U.S. BUREAU OF LABOR STATISTICS 2023). While the costs may increase for this nonresidential building type, the burden of that cost is unlikely to be disproportionate.

Hospital

Increased incremental costs for hospitals can present challenges to jurisdictions with lower income populations where the tax base, funding, and budgets may be more constrained. Proposed measures that impact health and resiliency have the potential to disproportionately impact those who attend or work in hospitals.

Restaurant

Proposals for restaurants could affect DIPs more significantly than the general population, particularly those who work in the foodservice industry, own a small business that is a restaurant, or rely on restaurants for food (especially those living in food deserts). An estimated 23.5 million Americans live in food deserts. Defined as an area with "limited access to a variety of healthy and affordable food" (Chapple n.d.). In these food deserts, restaurants can play a role in providing access to more food for DIPs. Access to restaurants with healthy food is also limited for many DIPs in food deserts. In South Los Angeles, neighborhoods with a higher percentage of Black residents only 27 percent of restaurants provided 5 or more healthy options, while in the more affluent West Los Angeles, 40 percent of restaurants offered 5 or more healthy options (Lewis, et al. 2005). Many of California's restaurants are owned by DIPs, and even more are staffed by DIPs. Of the 150,000 fast food employees in Los Angeles, 9 of 10 are people of color (UCLA Labor Center 2022) . Proposals that have high incremental costs and health effects could have notable impacts on DIPs.

Refrigerated Warehouse

Proposals that impact health, especially thermal comfort, or air quality impacts, have the potential to disproportionately impact those working in refrigerated warehouses, many of whom are from DIPs. While the costs may increase for this nonresidential building type, the burden of that cost is unlikely to be disproportionate.

2.2 Specific Impacts of the Proposal

Cooling towers are common on commercial and institutional facilities and would not impact energy equity or environmental justice in any specific way. The proposed measure would not impact the health or comfort of building occupants, and it is not expected to affect building resiliency to extreme weather events. While the measure has the potential to save energy, it is unlikely the utility bill energy savings would significantly impact DIPs since it's uncommon for this measure to apply in multifamily spaces. For details about nonresidential building impacts, refer to Section 2.1.2.

One manufacturer stakeholder did raise concerns over potential impacts to the cooling tower manufacturing facilities. Two of the three major cooling tower manufacturers are located in Madera, CA, a DIP area.[6] Impacts on these plants could potentially affect jobs in these communities. The CASE team has worked to mitigate these concerns by reducing the

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[6] Madera, CA is identified as a disadvantaged community under the SB 535 map: https://experience.arcgis.com/experience/1c21c53da8de48f1b946f3402fbae55c/page/SB-535-Disadvantaged-Communities/

stringency of the proposed requirements to reduce potential impacts to manufacturers and employment.

Keeping gainful employment opportunities for DIPs is valuable, however the Statewide CASE team also has environmental justice concerns about these factories. Manufacturing industry is often linked with pollution, environmental, damages, and health hazards to the surrounding populations. Studies show that “exposure from an area with heavy industry was related to a significantly lower lung function in school children” (Bergstra, Brunekreef and Burdorf 2018). The presence of these factories in DIP areas like Madera is of note as well. Black, Latinx, and other DIPs tend to live in areas with high levels of pollution from such industries. Analyses show the net gain from employment is outweighed by the environmental pollution. An investigation of industrial facilities showed that while Black employees held 10.4 percent of the jobs available, they also bore 17.4 percent exposure to the facility’s total potential chronic human health risk (Ash and Boyce 2018). Latinx workers took on more than 15 percent of exposure to pollution while only holding 9.8 percent of the jobs, and furthermore only 6.8 percent of the higher paying jobs (Ash and Boyce 2018). While jobs are important the Statewide CASE team also questions the nature of these jobs. With more time and research, the Statewide CASE team would seek to understand the terms of these jobs, whether they are equitable, or pay a living and humane wage to workers in these communities.

3. Cooling Tower Efficiency

3.1 Measure Description

3.1.1 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 5, 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, 4, 5, and 12 would be increased to 70 GPM/HP; Climate Zones 6, 7, 9, and 13 would be increased to 80 GPM/HP, and Climate Zones, 8, 10, and 15 would be increased to 90 GPM/HP. Proposed efficiencies were selected based on a combination of factors including cost-effectiveness, feedback from stakeholders on product availability and potential market impacts, and impacts on technical aspects cush as increased size and weight. 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 5: Proposed Cooling Tower Efficiencies by Climate Zone

Climate Zone	Prescriptive Minimum Efficiency (GPM/HP) – Propeller or axial fan, open-circuit cooling towers
CZ01	42.1
CZ02	70
CZ03	60
CZ04	70
CZ05	70
CZ06	80
CZ07	80

CZ08	90
CZ09	80
CZ10	90
CZ11	60
CZ12	70
CZ13	80
CZ14	60
CZ15	90
CZ16	42.1

The proposal maintains 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 establish cooling tower thermal performance ratings under the standardized conditions of 95°F entering water temperature, 85°F leaving water temperature, and 75°F entering air wet-bulb temperature. Cooling tower efficiency is then calculated from the thermal performance rating and cooling tower fan motor capacity (HP).

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.

3.1.2 Justification and Background Information

3.1.2.1 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. After discussions with stakeholders, and in part due to the product availability at the time, however, ultimately a prescriptive minimum efficiency of ≥60 GPM/HP was adopted for 2019 Title 24, Part 6, with the intent to examine increased levels in future code cycles. As it has been six years since the research and analysis for the original adoption, the measure has been proposed for update. 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.

3.1.2.2 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. Though technological advancements that improve cooling tower efficiency have been introduced since their invention, including high efficiency propellers, high efficacy heat transfer membranes, and others, the primary mode of increasing efficiency is by increasing the tower size to provide greater surface area of the water-air interface.

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 evaluated 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 are mandatory requirements of 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, 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.

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.[7] See Section 5.2 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 5.1 of this report for marked-up code language.

Section: 140.4(h)5

Specific Purpose: The specific purpose of the change to subsection 140.4(h)5 is to increase the prescriptive efficiency requirement from 60 GPM/HP to 70-90 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 70-90 GPM/HP for axial fan, open circuit cooling towers with a design condenser water flow of 900 GPM or greater serving multifamily buildings for climate zones 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.

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

3.1.3.2 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 set the Standard Design fan horsepower minimum threshold to 60-90 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.

3.1.3.3 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 60-90 GPM/HP based on climate zone.

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 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) per climate zone in line with the proposed requirements of Title 24, Part 6 140.4(h)5 and 170.2(c)4Fv.

3.1.4 Regulatory Context

3.1.4.1 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, 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 3.2.2.

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, or, again, centrifugal fans meeting the mandatory requirements for propeller fan cooling towers..

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

Cooling tower efficiency minimum standards are 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, based on thermal performance as evaluated 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, based on thermal performance as evaluated 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.

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 engage 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.

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 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 would 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 multiple pathways. 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 and the HVAC contractor procures and installs the equipment. Once installed, the building inspector finalizes the project and ensures that the installation took place as permitted.

Due to the proprietary nature of the product, data on sales and completed projects are not available to the public. The Statewide CASE Team worked to develop an understanding of the existing market status through discussions and data provided by stakeholders, as well as through data available through statewide and national HVAC and energy surveys and equipment directories.

3.2.2 Technical Feasibility and Market Availability

3.2.2.1 Product 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.). Stakeholders expressed concerns over the potential impact on increased efficiency levels on product availability. Figure 1 and Figure 2 for the distribution of cooling towers up to 5,999 GPM for single and two cell cooling towers. Table 6 shows a breakdown of the cooling tower availability which demonstrates that a significant portion of single and two-cell cooling towers exceed 70 GPM/HP, 53 percent, and 48 percent, respectively. Efficiencies of 100 GPM/HP and above, however have limited availability, with only 29 percent of single cell and 20 percent of two-cell units achieving that level of efficiency. Based on the limited product availability and stakeholder concerns, the Statewide CASE Team has decided to limit the proposed efficiency levels to 90 GPM/HP and below, depending on climate zone.

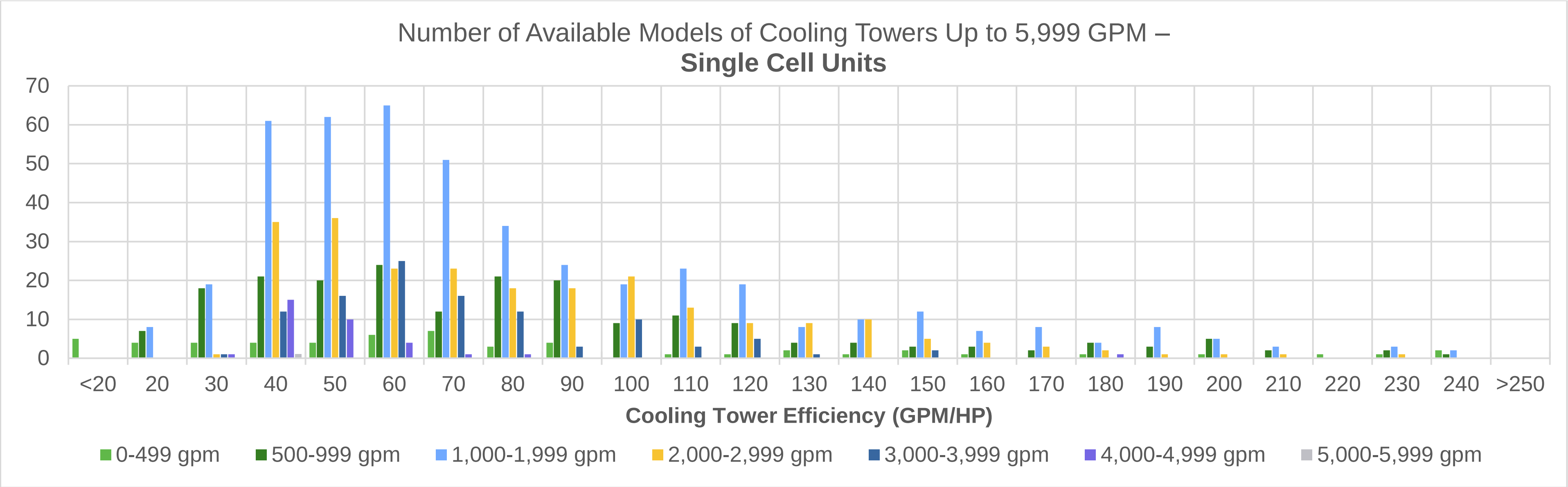

Figure 1: Market availability of cooling tower efficiency for single cell units up to 5,999 GPM.

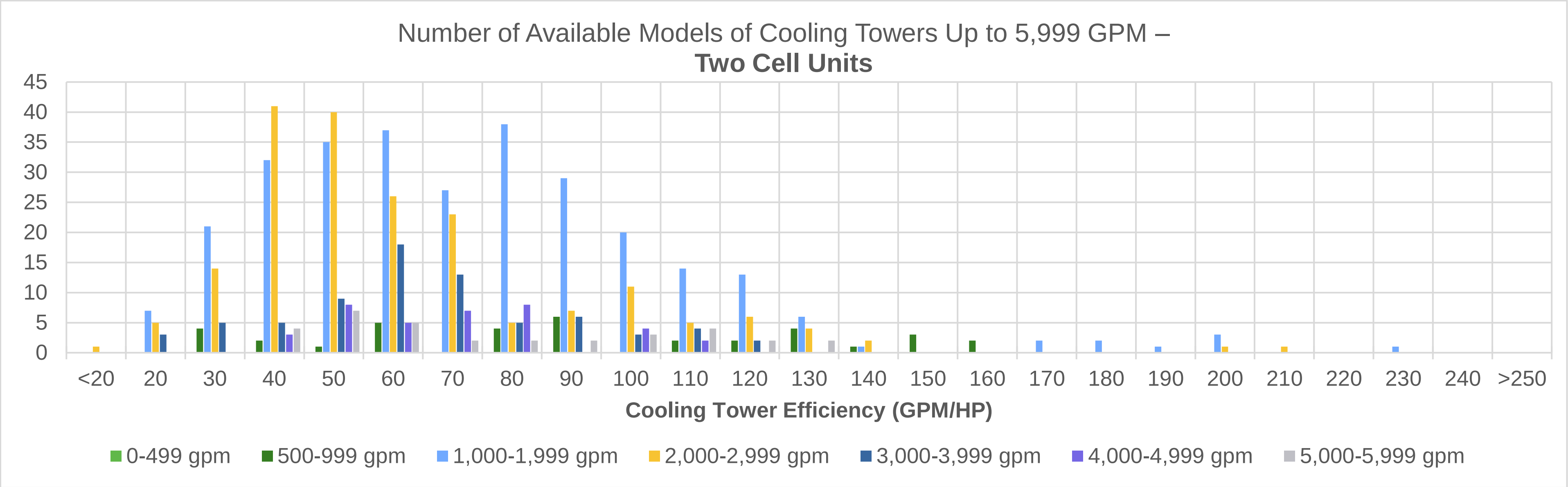

Figure 2: Market availability of cooling tower efficiency for two cell units up to 5,999 GPM.

Table 6: Cooling Tower Breakdown by Efficiency Level

Cooling Tower Efficiency (GPM/HP)	% of Cooling Towers Exceeding Efficiency: Single Cell	% of Cooling Towers Exceeding Efficiency: Two Cell
60	67%	63%
70	53%	48%
80	43%	37%
90	35%	28%
100	29%	20%
110	23%	14%
120	18%	9%

Based on discussions with a stakeholder, cooling towers in California are most commonly between 500 tons to 2,000 tons in capacity, or 1,500-6,000 nominal GPM, accounting for near 50 percent of projects in the state, and smaller portions falling above or below that range. A likely driver of the smaller share of units that are below 500 tons is the smaller cooling load and energy consumption of these sites, which may motivate them to examine other, less complex cooling options such as rooftop-units and air-cooled chillers, which are allowed as a portion of these sites would fall below the existing 300 ton prescriptive limitation on air-cooled chillers. Based on this data, the impacts on code changes for units of >500 tons, or 1,500 nominal GPM, is important and will be examined throughout this report.

3.2.2.2 Size and Weight

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 surface area of heat exchange, more efficient cooling towers are generally larger and heavier than standard efficiency cooling towers. Figure 3 to Figure 8 provide demonstrations of this trend, comparing operating weight (pounds.), cooling tower footprint (ft^2) and height (ft) to cooling tower efficiency for single cell and two cell units ranging from 500 to 6,000 GPM in capacity. Data were collected from manufacturer engineering data documentation and software for produce selection (Baltimore Aircoil Company n.d., Evapco n.d., SPX Cooling Technologies n.d.).

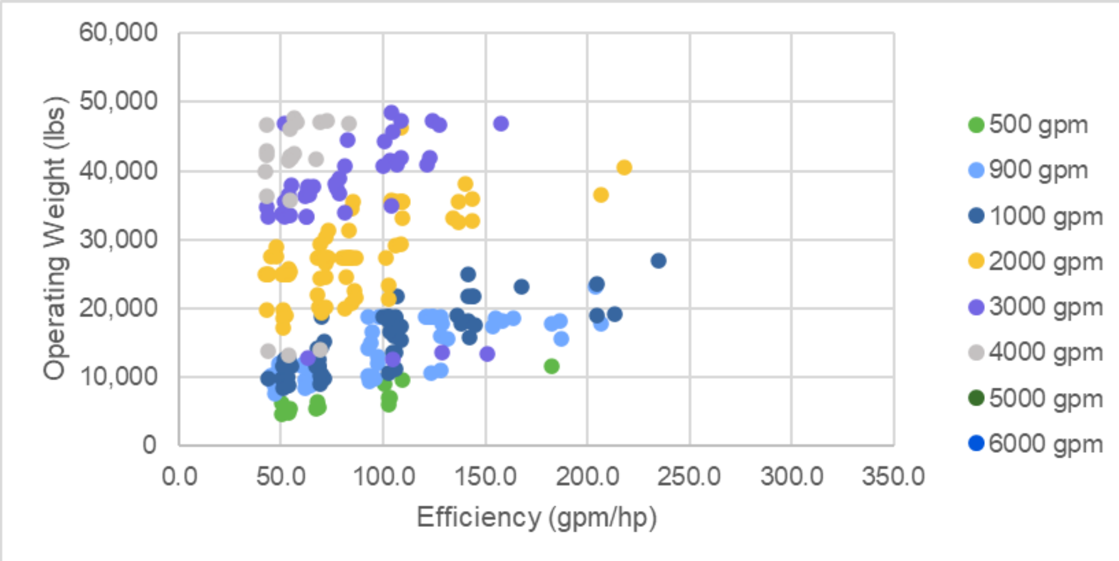

Figure 3: Cooling tower operating weight (pounds) versus efficiency (GPM/HP) by capacity – Single Cell

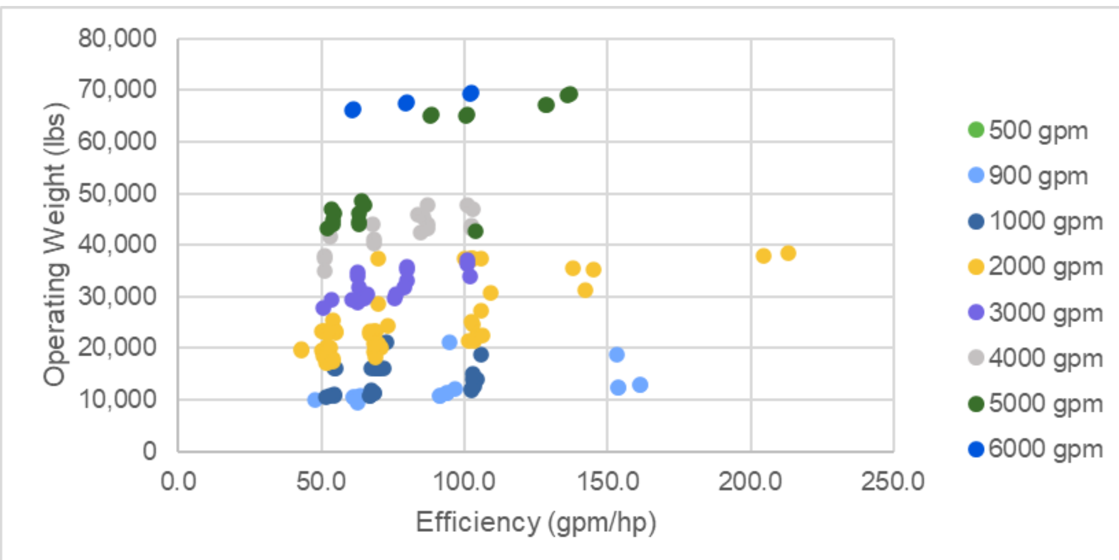

Figure 4: Cooling tower operating weight (pounds) versus efficiency (GPM/HP) by capacity – Two Cell

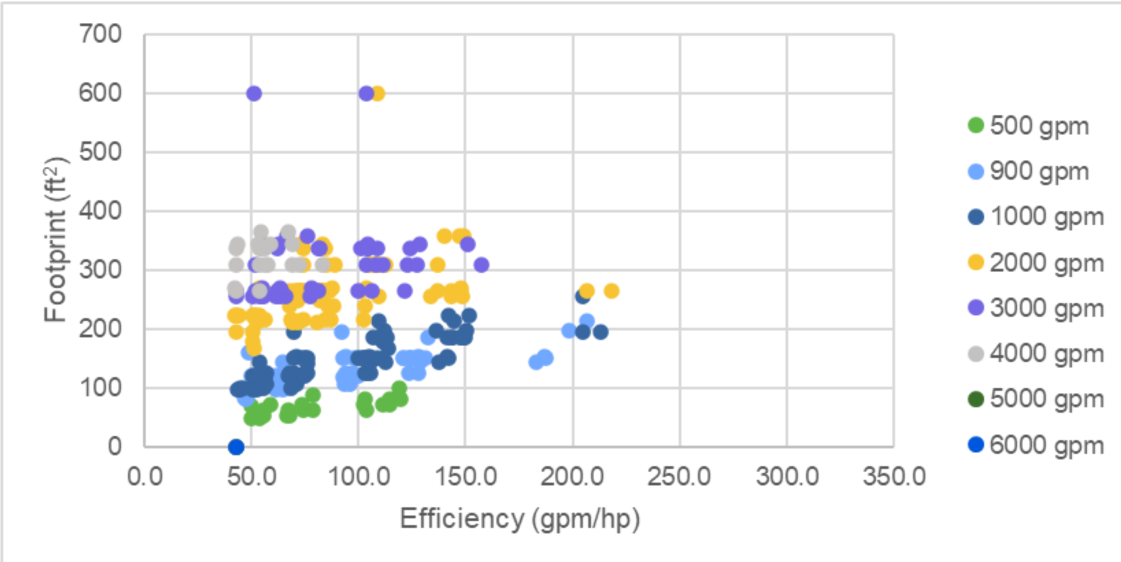

Figure 5: Cooling tower footprint (ft^2) versus efficiency (GPM/HP) by capacity – Single Cell.

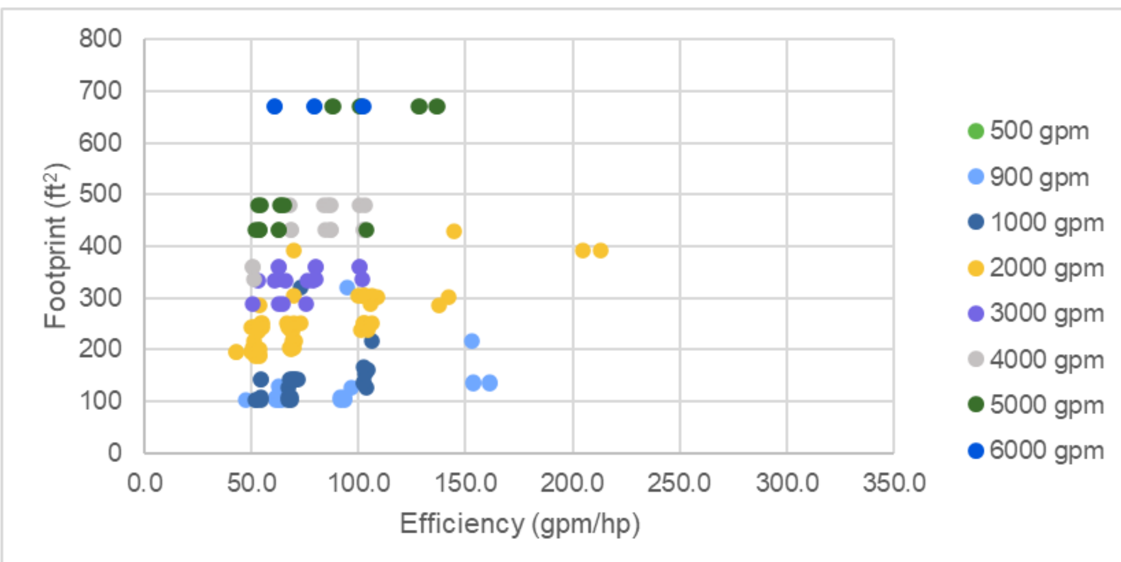

Figure 6: Cooling tower footprint (ft^2) versus efficiency (GPM/HP) by capacity – Two Cell

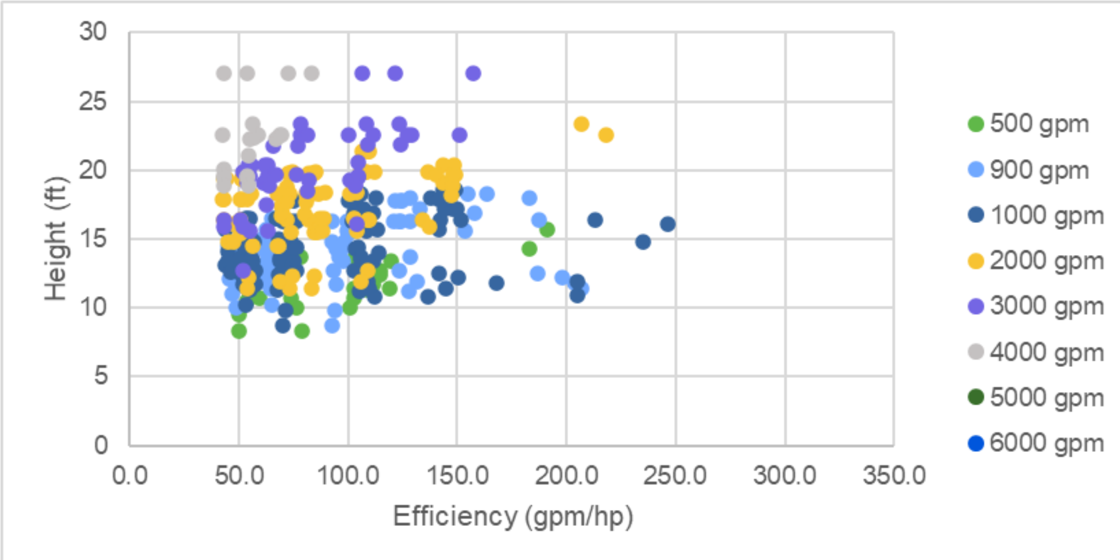

Figure 7: Cooling tower height (ft) versus efficiency (GPM/HP) by capacity – Single Cell.

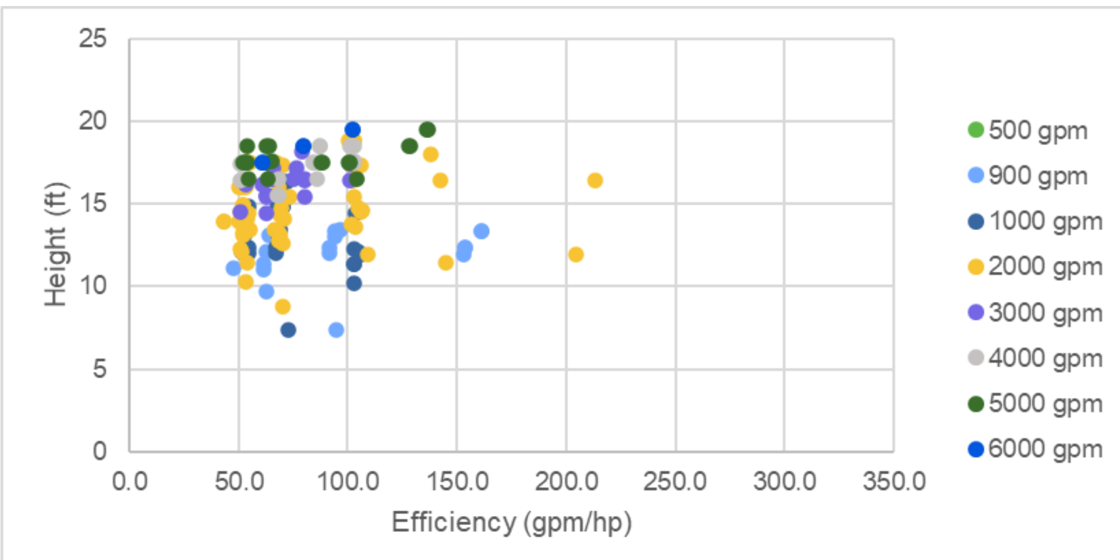

Figure 8: Cooling tower height (ft) versus efficiency (GPM/HP) by capacity – Two Cell

By utilizing manufacturer cooling tower selection software for cooling tower capacities of 500-5,000 GPM under nominal conditions of 95 °F entering water temperature, 85 °F leaving water temperature, and 78 °F entering wet bulb temperature, a comparison of "like-for-like" units was made, not limited to number of cells, but selected as having a reserve capacity of 10 percent or less. A summary of the typical incremental differences between baseline and higher efficient units is shown in Table 7 to Table 9 for operating weight, height, and footprint.

Table 7: Incremental Operating Weight and Cooling Tower Capacity

Cooling Tower Efficiency (GPM/HP)	500 GPM	1,000 GPM	2,000 GPM	3,000 GPM	4,000 GPM	5,000 GPM

60	0%	0%	0%	0%	0%	0%
70	32%	3%	9%	10%	2%	2%
80	18%	9%	15%	14%	7%	15%
90	17%	19%	25%	12%	28%	9%
100	32%	31%	28%	45%	30%	15%
110	32%	31%	23%	27%	26%	36%
120	38%	44%	46%	40%	42%	27%

Table 8: Incremental Footprint and Cooling Tower Capacity

Cooling Tower Efficiency (GPM/HP)	500 GPM	1,000 GPM	2,000 GPM	3,000 GPM	4,000 GPM	5,000 GPM
60	0%	0%	0%	0%	0%	0%
70	54%	-1%	-9%	-1%	-2%	2%
80	22%	5%	-2%	1%	3%	18%
90	29%	27%	2%	10%	3%	5%
100	54%	39%	-7%	83%	-5%	11%
110	54%	39%	3%	50%	5%	43%
120	39%	39%	14%	62%	13%	20%

Table 9: Incremental Height and Cooling Tower Capacity

Cooling Tower Efficiency (GPM/HP)	500 GPM	1,000 GPM	2,000 GPM	3,000 GPM	4,000 GPM	5,000 GPM
60	0%	0%	0%	0%	0%	0%
70	-4%	22%	18%	4%	22%	0%
80	9%	21%	16%	13%	12%	10%
90	9%	2%	27%	10%	17%	12%
100	-4%	-5%	43%	-31%	30%	13%
110	-4%	-5%	29%	-15%	18%	-2%
120	9%	5%	30%	-16%	27%	31%

The tables emphasize what was observed for the 800-1,500 GPM units, as well as what is demonstrated in the figures. Higher efficiency cooling towers have a significant impact on operating weight and footprint. The impact on operating weight is fairly consistent across all capacities observed, with 120 GPM/HP units an average 39 percent heavier than the baseline 60 GPM/HP units. The impact on footprint is more notable for smaller units, with 500 GPM units observing a 29-54 percent increase in footprint, whereas 5,000 GPM units have a zero to 31 percent increase. Height, however, is inconsistently impacted by efficiency, and though it appears to generally increase with efficiency, the trend is not as significant as that of the footprint. As such, increasing the cooling tower footprint appears to be the primary method for achieving higher efficiencies, with height used as a secondary lever. Examining the data from Table 7 and Table 8 shows certain capacity and efficiency combinations with a reduction in height or footprint compared to the baseline. These combinations also observed a large corresponding increase in footprint or height, respectively. This relationship implies that cooling tower size must be considered on a holistic basis when attempting to achieve higher efficiencies, as one or more of length, width, and height may be adjusted in order to achieve the increase in heat exchange surface area required to achieve the higher efficiency.

A notable trend is observed in the 3,000 GPM capacity range. There is a sharp increase in operating weight and footprint for efficiencies of 100 GPM/HP and above, along with a sharp decrease in cooling tower height. This trend is the result of an increase in the number of cells required to achieve the higher efficiency levels. For capacities below the 3,000 GPM threshold, increased efficiencies can be achieved without increasing the number of cells, while capacities of 4,000 GPM and above are already utilizing multiple cells in for the baseline efficiency. Cooling towers with a capacity of 3,000-4,000 GPM appear to mark the threshold for which the method of achieving higher efficiency levels is by increasing the number of cooling tower cells, having significant impacts on the physical size and weight of the system. As such, special care would need to be made for sites with mid-capacity cooling towers that may need additional cells to achieve higher efficiency levels.

Due to these significant physical impacts and concerns expressed by stakeholders, the Statewide CASE Team has adjusted the maximum proposed cooling tower efficiency to 90 GPM/HP to lessen the impact on physical characteristics and selection. Physical impacts would still be observed, however, particularly at sites in climate zones requiring the highest efficiency. 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 3.4.3. 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 2019 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 27.8 years in the state of California 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 3.4.

3.2.2.3 Centrifugal Fan Cooling Towers

As mentioned in Section 3.1.4.1, 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 or exceed the mandatory minimum requirement of 42.1 GPM/HP, with only 11 percent of centrifugal units meeting the requirement.

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 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
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 3.2.4 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.)

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 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.

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.

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 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.

Stakeholders have expressed concern that increased efficiency requirements, and in turn, size, weight, and cost of the cooling towers may motivate customers and designers to consider other HVAC system types to meet the cooling needs of their sites.

Again, as noted above, air-cooled chillers are restricted by the current 300-ton prescriptive limitation, and thus would only be allowed as an alternative for sites pursuing the performance path or falling below the 300-ton threshold. However, if the performance path is being utilized, cooling towers with efficiencies falling below the prescriptive requirements would also be an option.

Other potential HVAC system types include rooftop-units, variable-refrigerant-flow systems (VRF). To understand the potential to shift to these technologies, the Statewide CASE Team compared the available capacities, operating weights, and system footprints to like-sized water-cooled systems.

Rooftop-unit capacities vary significantly, with the largest available from three major manufacturers (York, Carrier, and Trane) capable of 100-150 tons of nominal cooling capacity. VRF systems are modular, utilizing multiple smaller units to achieve higher capacities, typically with a maximum of 20-40 tons of cooling capacity per outdoor unit. A VRF system examined from Carrier offers 6-36 tons of cooling capacity per outdoor unit. A survey of availability from four major manufacturers (Trane, Carrier, Daikin, and York), on the other hand, shows that water-cooled chillers (served by cooling towers) are available of capacities as high as 6,000 tons per chiller, significantly higher than those of the other systems.

Regarding size and weight, the Statewide CASE Team examined specifications for operating weight and footprint from mechanical specification documents for units of varying capacities. Since one of the primary concerns of stakeholders is the potential impact of increased cooling tower size and weight, generally located on rooftops or the exterior, the Statewide CASE Team limited focus to the comparisons for the outdoor units of alternate systems and did not examine impacts on interior space usage. A range of cooling capacities from 240 tons to 1,600 tons was considered, comparing the alternate system types to cooling towers selected using cooling tower manufacturer selection software for each capacity at nominal conditions, and the results are shown in Figure 9 and Figure 10. RTUs and VRFs were selected based on the maximum capacity per unit available. Figure 11 demonstrates the number of units that would be required to achieve the cooling capacity desired for each of the system types.

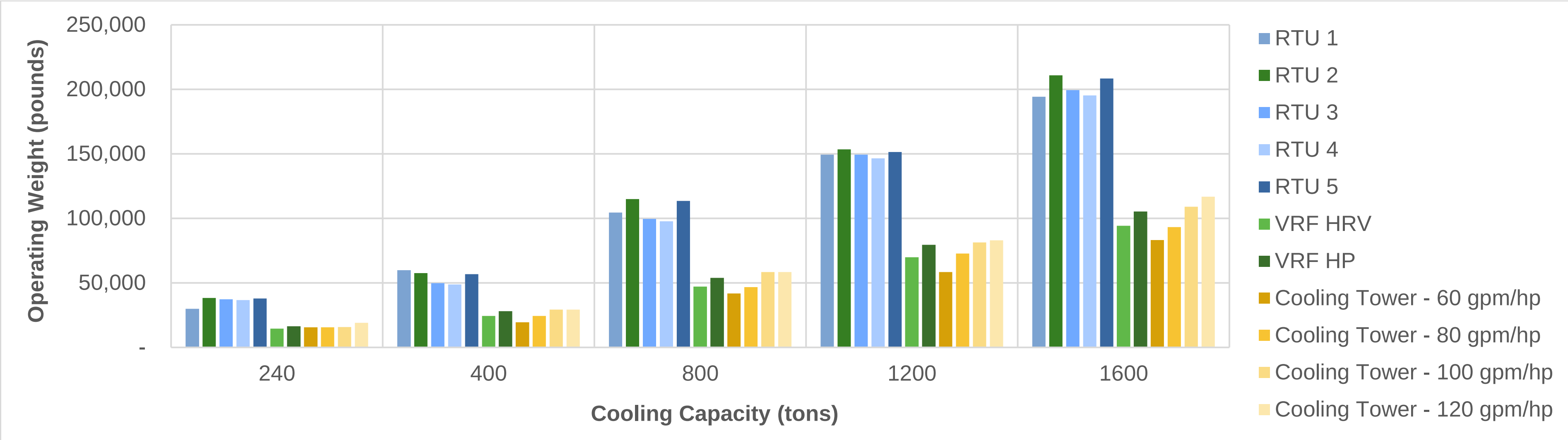

Figure 9: Comparison of cooling tower operating weight (pounds) to alternate HVAC types by cooling capacity

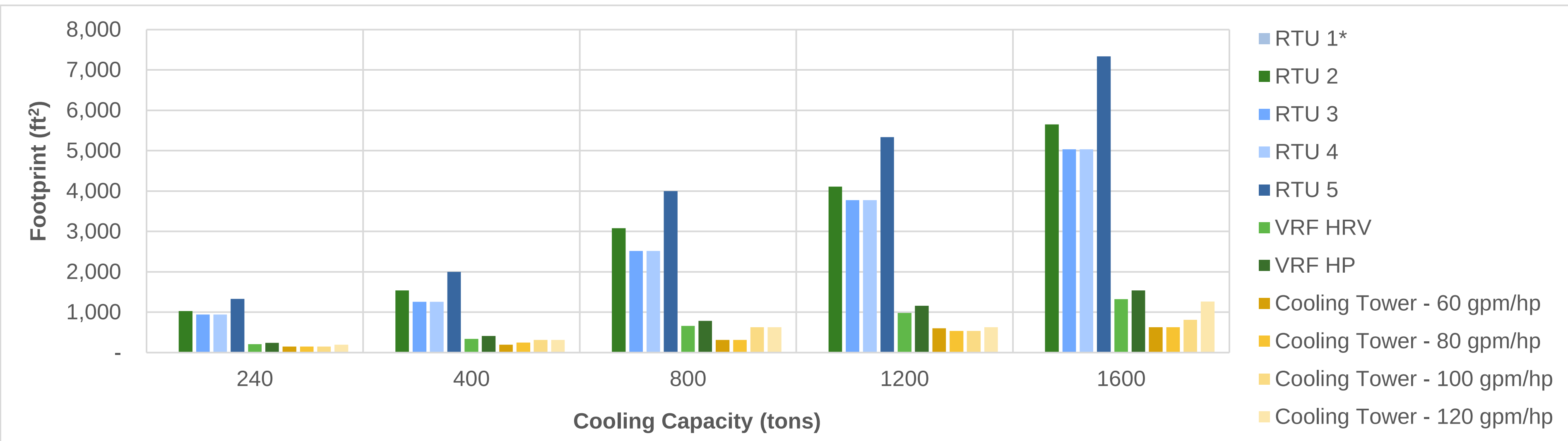

Figure 10: Comparison of cooling tower footprint (ft^2) to alternate HVAC types by cooling capacity

**Note no footprint data was available for RTU 1*

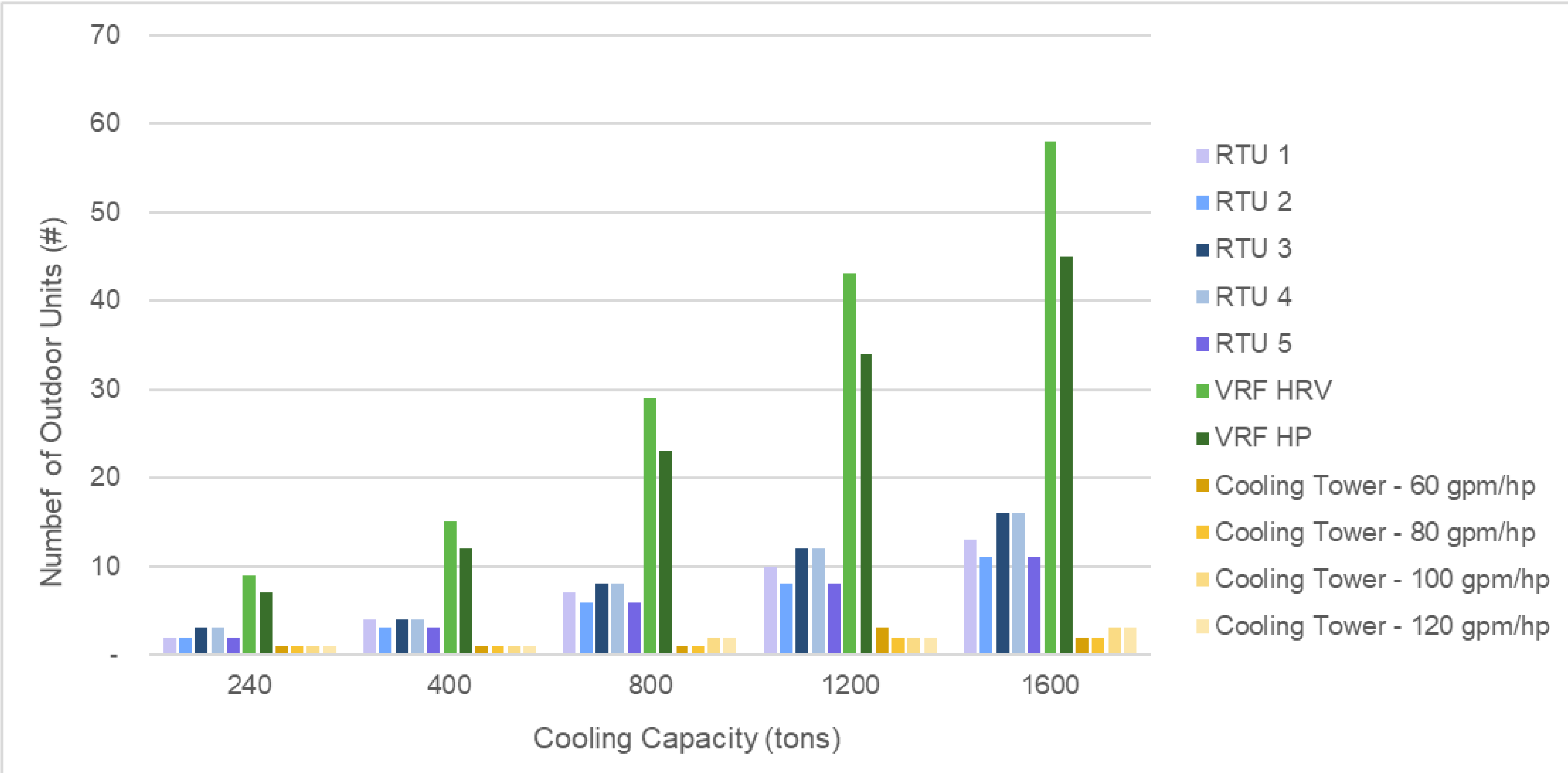

Figure 11: Comparison of number of cooling tower cells to number of outdoor units of alternate HVAC types by cooling capacity

As can be seen in the figures, rooftop units are significantly heavier and larger than the cooling towers of all efficiency levels. The average weight of the rooftop unit systems examined are 1.7 percent to 2.0 times higher than the highest efficiency cooling tower (120 GPM/HP), while the average footprint is 4.6 to 6.8 times higher. As a result, rooftop units are likely not a viable option as an alternative for sites looking to save space or weight. However, at the lower end of the capacity range, rooftop units may be an attractive alternative for sites looking for reduced costs or complexity, and reduced use of interior space.

The variable refrigerant flow systems examined are more competitive in terms of weight, with an average weight of two to 19 percent lower than the 100 GPM/HP and 120 GPM/HP cooling towers. The impact of this should be minimized by the proposal limiting the required efficiency levels to 90 GPM/HP and lower. Additionally, the VRF systems do have a significantly larger footprint, 13-70 percent larger than the 120 GPM/HP cooling towers.

To achieve higher cooling capacities with a VRF, a significantly higher number of outdoor units would be required, 20 or more for buildings of 800 tons or higher. In terms of costs, VRF systems are anticipated to be more expensive than chilled water systems, eight percent higher based on a 2012 study performed by Pacific Northwest National Laboratory for the General Services Administration (Pacific Northwest National Lab 2012). An additional challenge to using VRF systems for large buildings is the use of refrigerant as the cooling medium. VRF systems have limitations on the length of refrigerant lines (provided by manufacturers) which leads to ideal building design being those with smaller footprints or fewer stories. The higher use of refrigerant in VRF systems also introduces unique design challenges compared to chilled water systems due to refrigerant concentration limits established in ASHRAE Standard 15. Ultimately, these challenges typically lead VRF systems to be primarily used in smaller buildings though they do have the capability to be used in larger facilities in specific applications, particularly if used in combination with other HVAC system types. The PNNL/GSA study found that the target building for VRF applications is in the range of 5,000 ft^2 to 100,000 ft2 with larger buildings to be evaluated on a “case-by-case basis” (Pacific Northwest National Lab 2012), likely much smaller than a typical building requiring a 300 ton or greater chilled water plant.

3.2.3.6 Impact on Building Inspectors

Table 14 shows employment and payroll information for state and local government agencies in which 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.

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 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.

3.2.4 Economic Impacts

For the 2025 code cycle, the Statewide CASE Team used the IMPLAN model software[8], 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

[8] 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.

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 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.

Table 15: Estimated Impact that Adoption of the Proposed Measure would have on the California Commercial Construction Sector

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Commercial Builders)	0.9	$68,018	$78,607	$133,884
Indirect Effect (Additional spending by firms supporting Commercial Builders)	0.2	$18,528	$29,075	$53,543
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	0.4	$24,851	$44,494	$70,818
Total Economic Impacts	**1.5**	**$111,397**	**$152,176**	**$258,245**

Source: CASE Team analysis of data from the IMPLAN modeling software.[9]

[9] IMPLAN® model, 2020 Data, IMPLAN Group LLC, IMPLAN System (data and software), 16905 Northcross Dr., Suite 120, Huntersville, NC 28078 www.IMPLAN.com

Table 16: 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	Total Value Added	Output
Direct Effects (Additional spending by Building Designers & Energy Consultants)	0.8	$88,742	$87,854	$138,861
Indirect Effect (Additional spending by firms supporting Bldg. Designers & Energy Consultants)	0.3	$26,423	$36,723	$59,116
Induced Effect (Spending by employees of firms experiencing "direct" or "indirect" effects)	0.5	$33,115	$59,303	$94,389
Total Economic Impacts	**1.6**	**$148,281**	**$183,879**	**$292,366**

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

Table 17: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by Building Inspectors)	0.1	$11,193	$13,273	$16,129
Indirect Effect (Additional spending by firms supporting Building Inspectors)	0.0	$1,037	$1,614	$2,812
Induced Effect (Spending by employees of Building Inspection Bureaus and Departments)	0.1	$3,520	$6,306	$10,037
Total Economic Impacts	**0.2**	**$15,750**	**$21,194**	**$28,979**

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 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.

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.[10] 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).[11] As Table 18 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 18: 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.)

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 can 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

[10] 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.

[11] 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.

estimate of corporate profits, a portion of which we assume would be allocated to net business investment.[12]

3.2.4.5 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.

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 would allocate 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. Local governments update the building code on a triennial basis, in which they plan and budget for retraining each time. There are 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. The proposed code change would not impact specific persons or groups of people. Refer to Section 3.6 for more details addressing energy equity and environmental justice.

[12] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 18.

3.2.5 Fiscal Impacts

3.2.5.1 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.

3.2.5.2 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.

3.2.5.3 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.

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

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

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 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. In the development of this analysis, the Statewide CASE Team held meetings and received feedback from three major cooling tower manufacturers and three cooling tower interest groups following the February 13th, 2023, Stakeholder meeting and publication of the Draft CASE Report in May 2023.

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 for more details addressing energy equity and environmental justice.

3.3.1 Energy Savings Methodology

3.3.1.1 Key Assumptions for Energy Savings Analysis

The Statewide CASE Team used EnergyPlus to conduct the energy and water savings analysis for the cooling tower efficiency 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 70-120 GPM/HP in 10 GPM/HP increments, in order to determine the highest cooling tower efficiency that is cost effective for each of California's climate zones. Ultimately, the cooling tower efficiency proposed in each climate zone was selected based on a combination of factors including, but not limited to, energy savings potential, cost effectiveness, product availability, technical limitations, and stakeholder input. The results presented in this report represent the results for the proposed efficiency in each climate zone. For climate zones for which no examined cooling tower efficiency was found to be cost-effective, the model is shown as zero, i.e., no change from the baseline. A summary of the cooling tower model efficiencies is shown in Table 20.

The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone specific long-term systemwide 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.

3.3.1.2 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.[13] 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

[13] 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

of marginal generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO_2 emissions.[13]

The CEC directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries for diverse 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, and thus the Final CASE Report presents the analysis results for the OfficeLarge prototype. 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 19. The same impacts are anticipated on both new construction and addition projects, and alteration projects, and thus the same prototypes were used for each.

Table 19: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
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 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 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.

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 auto sized by CBECC per the method outlined in the 2022 Nonresidential ACM Reference Manual. Following auto sizing, CBECC adjusts the cooling tower capacity to nominal conditions of 95°F entering water temperature, 85°F leaving water temperature, and 78°F wet-bulb temperature using default cooling tower performance curves. The nominal cooling tower capacities for the OfficeLarge prototype are provided in Table 20, along with the efficiency of the Standard Design.

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 21 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 70-90 GPM/HP for the two building cooling towers. The proposed measure is climate-sensitive and was thus modeled for all climate zones.

Table 20: Nominal Cooling Tower Capacity and Modeled Efficiency – OfficeLarge Prototype

Climate Zone	Nominal Cooling Tower Capacity (GPM at 95°F EWT, 85°F LWT, 78°WBT)	Standard Design Cooling Tower Efficiency (GPM/HP at 95°F EWT, 85°F LWT, 75°WBT)	Proposed Design Cooling Tower Efficiency (GPM/HP at 95°F EWT, 85°F LWT, 75°WBT)
CZ01	815	42.1	42.1
CZ02	1,113	60	70
CZ03	1,018	60	60
CZ04	1,149	60	70
CZ05	961	60	70
CZ06	1,117	60	80
CZ07	1,210	60	80
CZ08	1,207	60	90
CZ09	1,210	60	80
CZ10	1,146	60	90
CZ11	1,263	60	60
CZ12	1,176	60	70

Climate Zone	Nominal Cooling Tower Capacity (GPM at 95°F EWT, 85°F LWT, 78°WBT)	Standard Design Cooling Tower Efficiency (GPM/HP at 95°F EWT, 85°F LWT, 75°WBT)	Proposed Design Cooling Tower Efficiency (GPM/HP at 95°F EWT, 85°F LWT, 75°WBT)
CZ13	1,276	60	80
CZ14	1,202	60	60
CZ15	1,413	60	90
CZ16	920	42.1	42.1

Table 21: Modifications Made to Parameters to Simulate Proposed Code Change–OfficeLarge Prototype

Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Climate Zones 1 and 16	CoolingTower: VariableSpeed	Design Fan Power	Design Water Flow Rate/Design Fan Power: 42.1 GPM/HP	N/A
Climate Zones 3, 11, 14	CoolingTower: VariableSpeed	Design Fan Power	Design Water Flow Rate/Design Fan Power: 60 GPM/HP	N/A
Climate Zones 2, 4, 5, 12	CoolingTower: VariableSpeed	Design Fan Power	Design Water Flow Rate/Design Fan Power: 60 GPM/HP	Design Water Flow Rate/Design Fan Power: 70 GPM/HP
Climate Zones 6, 7, 9, 13	CoolingTower: VariableSpeed	Design Fan Power	Design Water Flow Rate/Design Fan Power: 60 GPM/HP	Design Water Flow Rate/Design Fan Power: 80 GPM/HP
Climate Zones 8, 10, 15	CoolingTower: VariableSpeed	Design Fan Power	Design Water Flow Rate/Design Fan Power: 60 GPM/HP	Design Water Flow Rate/Design Fan Power: 90 GPM/HP

EnergyPlus calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/year) and therms per year (therms/year). The Statewide Case Team then applied the 2025 LSC hourly factors to calculate Long-term Systemwide Cost in 2026 present value dollars (2026 PV$), Source Energy hourly factors to calculate Source Energy Use in kilo British thermal units per year (kBtu/year), 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/year). 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.

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.

3.3.2 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions per unit for the OfficeLarge prototype are presented in Table 22 through Table 25 for new construction/additions and Table 26 through Table 29 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 0.006 to 0.19 kBtu/ft^2. 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 cooling degree days and outside air wet-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.

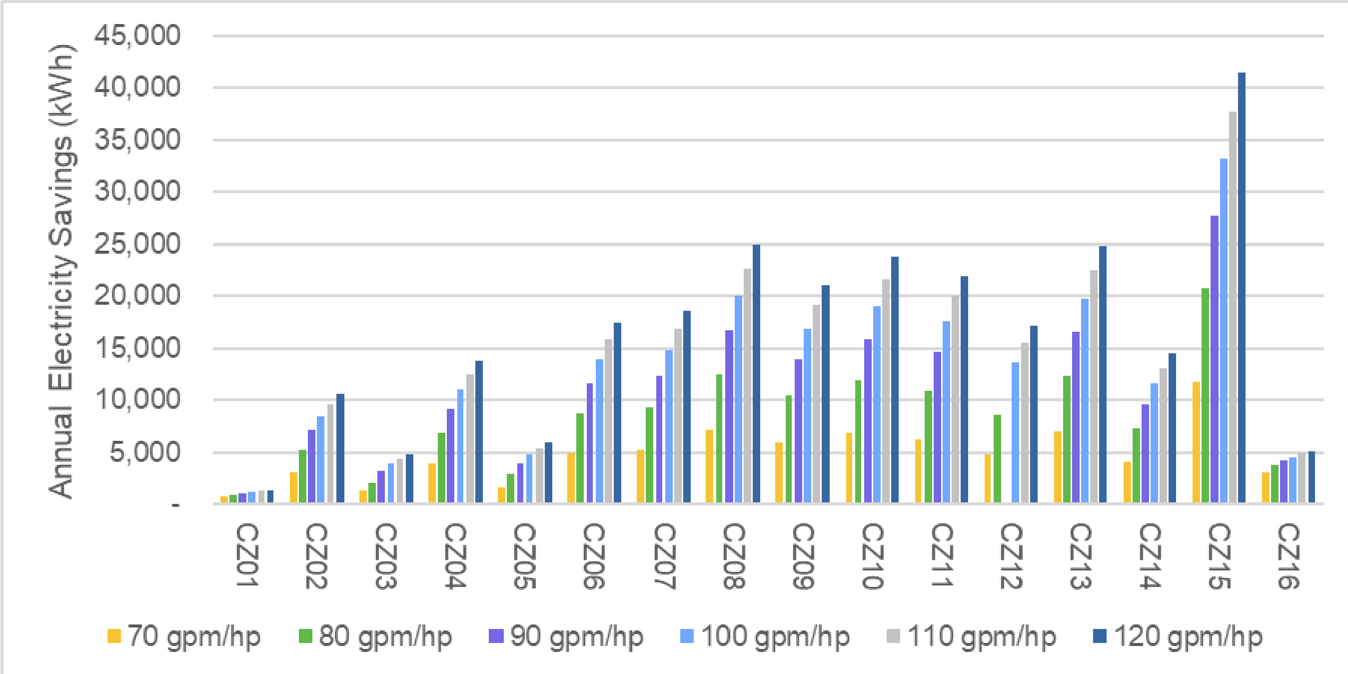

Figure 12: Annual Electricity Savings by Climate Zone and Efficiency

Table 22: 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	0.01	0.00	0.01	0.00	0.02	0.02	0.03	0.02	0.03	0.01	0.01	0.02	0.01	0.06	0.01

Table 23: 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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 24: 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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 25: First Year Long-term Systemwide Cost Savings (2026 PV$) 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	0.01	0.02	0.01	0.03	0.01	0.08	0.09	0.16	0.10	0.15	0.06	0.04	0.12	0.04	0.28	0.03

Table 26: 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	0.01	0.00	0.01	0.00	0.02	0.02	0.03	0.02	0.03	0.01	0.01	0.02	0.01	0.06	0.01

Table 27: 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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 28: 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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 29: 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	0.02	0.01	0.03	0.01	0.08	0.09	0.16	0.10	0.15	0.06	0.04	0.12	0.04	0.28	0.03

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. 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 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 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.

3.4.2 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 30 through Table 33.

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 (zero percent) on peak demand relative to the baseline.

Any time code changes impact cost, there is potential to disproportionately impact DIPs. Refer to Section 2.1 for more details addressing energy equity and environmental justice.

Table 30: 2026 PV LSC 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	0.03	0.00	0.03
5	0.00	0.00	0.00
6	0.08	0.00	0.08
7	0.09	0.00	0.09
8	0.16	0.00	0.16
9	0.10	0.00	0.10
10	0.15	0.00	0.15
11	0.00	0.00	0.00
12	0.04	0.00	0.04
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.28	0.00	0.28
16	0.00	0.00	0.00

Table 31: 2026 PV LSC Savings 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	0.02	0.00	0.02
3	0.00	0.00	0.00
4	0.03	0.00	0.03
5	0.01	0.00	0.01
6	0.08	0.00	0.08
7	0.09	0.00	0.09
8	0.16	0.00	0.16
9	0.10	0.00	0.10
10	0.15	0.00	0.15
11	0.00	0.00	0.00
12	0.04	0.00	0.04
13	0.12	0.00	0.12
14	0.00	0.00	0.00
15	0.28	0.00	0.28
16	0.00	0.00	0.00

Table 32: 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	0.02	0.00	0.02
3	0.00	0.00	0.00
4	0.03	0.00	0.03
5	0.01	0.00	0.01
6	0.08	0.00	0.08
7	0.09	0.00	0.09
8	0.16	0.00	0.16
9	0.10	0.00	0.10
10	0.15	0.00	0.15
11	0.00	0.00	0.00
12	0.04	0.00	0.04
13	0.12	0.00	0.12
14	0.00	0.00	0.00
15	0.28	0.00	0.28
16	0.00	0.00	0.00

Table 33: Average 2026 PV LSC 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	0.02	0.00	0.02
3	0.00	0.00	0.00
4	0.03	0.00	0.03
5	0.01	0.00	0.01
6	0.08	0.00	0.08
7	0.09	0.00	0.09
8	0.16	0.00	0.16
9	0.10	0.00	0.10
10	0.15	0.00	0.15
11	0.00	0.00	0.00
12	0.04	0.00	0.04
13	0.12	0.00	0.12
14	0.00	0.00	0.00
15	0.28	0.00	0.28
16	0.00	0.00	0.00

3.4.3 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 cooling tower efficiency 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 nominal capacity, at 95°F entering water temperature, 85°F leaving water temperature, and 78°F wet bulb temperature, as determined by the CBECC auto-sizing function. To account for California specific cost impacts, the RSMeans baseline cost was 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 (Baltimore Aircoil Company n.d., SPX Cooling Technologies n.d.). These selection software allow users to enter desired cooling tower specifications in the form of thermal performance (GPM for this analysis) under given design conditions, and provide a list of cooling towers meeting the specifications, along with various key criteria including efficiency (GPM/HP) and cost ratio (the estimated ratio of a given cooling tower's cost compared to that of the lowest cost option that meets the user's requirements).

For this analysis, the Statewide CASE Team used the selection software to identify the lowest cost cooling towers that meet the desired efficiency levels for a variety of capacities. To do so, the cooling tower capacity was entered in gallons per minute under nominal conditions of 95°F entering water temperature, 85°F leaving water temperature, and 78°F entering wet-bulb temperature, aligning with the conditions of the cooling tower capacities provided by the CBECC auto-sizing output. 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. The final incremental cost ratio presented for each efficiency and capacity is the average of the results from each of the software used. The Statewide CASE Team expects labor costs to be the same between the baseline and incremental models.

To provide an understanding of how a range of cooling tower capacities are impacted by efficiency increases, this method was first applied for cooling towers ranging from 500 to 5,000 GPM nominal capacity, with one or two cells. The results of this analysis are presented in Table 34, and show that higher capacity cooling towers generally experience higher cost increases at higher capacities than lower capacity units. For example, 500 GPM cooling towers with an efficiency of 120 GPM/HP have an estimated 11 percent increase in cost, while 5,000 GPM cooling towers with an efficiency of 120 GPM/HP have an estimated 29 percent increase in costs. A notable trend occurs for cooling towers of 3,000 GPM and 3,500 GPM, which saw an average 42 percent increase in costs for units 100 GPM/HP in efficiency or higher. This trend can be explained by the potential need for increased cooling tower cells to achieve the higher efficiency (i.e., to achieve the same thermal output with lower motor horsepower). Cooling towers around 3,000-4,000 GPM appear to be at the threshold of this requirement, with the baseline units requiring one cell and higher efficiency units (≥100 GPM/HP) requiring two cells. Cooling towers below 3,000 GPM and above 4,000 GPM were not observed to be similarly impacted as the baseline and higher efficiency units use the same number of cells.

Table 34 presents a breakdown of the estimated incremental costs of cooling towers by capacity (GPM) and efficiency (GPM/HP).

Table 34: Cooling Tower Incremental Cost by Capacity and Efficiency

Nominal Cooling Tower Capacity (GPM)	Incremental Cost (%), 70 GPM/HP	Incremental Cost (%), 80 GPM/HP	Incremental Cost (%), 90 GPM/HP	Incremental Cost (%), 100 GPM/HP	Incremental Cost (%), 110 GPM/HP	Incremental Cost (%), 120 GPM/HP
500	7%	7%	11%	11%	11%	11%
1,000	5%	7%	16%	16%	16%	19%
1,500	7%	13%	13%	21%	21%	21%
2,000	17%	17%	18%	22%	22%	27%
2,500	3%	9%	9%	9%	11%	16%
3,000	0%	5%	11%	35%	35%	40%
3,500	6%	17%	26%	45%	48%	50%
4,000	20%	20%	25%	25%	25%	34%
4,500	1%	4%	4%	14%	14%	23%
5,000	3%	8%	14%	16%	37%	29%

Next, the same method was applied to the specific cooling tower capacities required for each climate zone to provide a basis for calculation of cost-effectiveness using the model prototypes. The required nominal capacity for each climate zone was entered in the software, and the lowest cost cooling towers meeting each efficiency level were selected for comparison. A summary of the incremental cost factors for the OfficeLarge prototype in each climate zone is shown in Table 35. The same trend is notable for each of the climate zones, with a trend toward higher incremental costs at higher efficiencies. Note that for many climate zones, no incremental cost was identified for cooling towers at the lowest incremental efficiency of 70 GPM/HP. For these climate zones, the lowest cost cooling towers provided by the selection software that met the current prescriptive efficiency level of 60 GPM/HP, were found to already exceed 70 GPM/HP in efficiency. Thus, these cooling towers had an incremental cost of zero percent.

Table 35: Incremental Cooling Tower Cost Factors by Efficiency and Climate Zone - OfficeLarge

Climate Zone	Nominal Cooling Tower Capacity (GPM)	Incremental Cost (%), 70 GPM/HP	Incremental Cost (%), 80 GPM/HP	Incremental Cost (%), 90 GPM/HP	Incremental Cost (%), 100 GPM/HP	Incremental Cost (%), 110 GPM/HP	Incremental Cost (%), 120 GPM/HP
CZ01	814.9	11%	17%	17%	17%	26%	27%
CZ02	1,113.3	0%	6%	8%	22%	25%	25%
CZ03	1,017.5	8%	8%	16%	19%	19%	19%
CZ04	1,149.0	0%	8%	8%	23%	27%	27%
CZ05	960.8	0%	4%	13%	13%	13%	20%
CZ06	1,116.7	0%	8%	8%	22%	25%	25%
CZ07	1,210.1	6%	12%	17%	22%	29%	33%
CZ08	1,207.3	5%	12%	12%	22%	29%	33%
CZ09	1,210.3	6%	12%	17%	22%	29%	33%
CZ10	1,146.0	0%	8%	8%	23%	27%	27%
CZ11	1,263.4	12%	16%	24%	26%	28%	43%
CZ12	1,176.1	0%	12%	12%	24%	28%	28%
CZ13	1,276.1	4%	10%	19%	19%	21%	35%
CZ14	1,201.8	6%	12%	12%	22%	28%	28%
CZ15	1,413.2	8%	11%	14%	25%	25%	27%
CZ16	920.1	7%	11%	15%	15%	15%	27%

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 3.2.2). This increased cost would be applicable to cooling towers installed on building rooftops. Cost increases were estimated assuming $4,142.61 of additional structural steel costs for approximately 5,000 pounds of additional weight. This estimate was developed by adjusting the estimates from the *2019 Prescriptive Efficiency Requirements for Cooling Towers CASE Report* developed during the 2019 Title 24, Part 6 Code Cycle to 2023 dollars to account for inflation, and to recent steel prices using the annual producer price index of fabricated structural iron and steel from 2022 compared to that of 2019 (U.S. Bureau of Labor Statistics n.d., BLS Beta Labs n.d.). A summary of these adjustments is provided in Table 36. Table 37 presents the average cooling tower operating weight by efficiency along with the estimated increased structural cost for higher efficiency cooling towers. Average weights were used as opposed to specific weights for cooling towers in each climate zone to present a more conservative estimate of costs. The results were obtained by examining engineering data from manufacturers for open, axial fan cooling towers with one or two cells and a capacity of 450 GPM or more at CTI ATC-105 rating conditions. 450 GPM was chosen as the threshold as the minimum rated capacity that would likely be used to achieve a total rated capacity of 900 GPM (the capacity at which the requirement is triggered) using two single towers or one two-celled tower. The analysis includes one and two cell configurations to provide a more conservative, comprehensive analysis. Increased structural costs were assumed for all cooling tower replacements to provide a conservative estimate of cost effectiveness, though the portion of cooling towers that are not installed on roofs (which would comprise all alteration projects, due to the exception for cooling towers on existing roofs) would not incur this cost.

Table 36: Cost of Structural Improvements

2019 Cooling Towers CASE Report – Increased structural cost ($/5,000 additional weight)	Adjusted to 2023 Dollars (U.S. Bureau of Labor Statistics n.d.)	2019 Producer Price Index – Fabricated Structural Iron and Steel (BLS Beta Labs n.d.)	2022 Producer Price Index – Fabricated Structural Iron and Steel (BLS Beta Labs n.d.)	Incremental Cost Increase 2019 to 2022	2025 Cooling Tower CASE Report – Increased structural cost ($/5,000 pounds additional weight)
$2,000	$2,413.96	120.1	206.1	71.6%	$4,142.61

Table 37: Estimated Increased Structural Costs by Cooling Tower Efficiency

Cooling Tower Efficiency	Average Operating Weight (pounds) – Total system of ≥900 GPM	Average Weight Increase Over Baseline (pounds.)	Estimated Increased Structural Costs ($)
60 GPM/HP	13,078	N/A	N/A
70 GPM/HP	13,703	624	$517.11
80 GPM/HP	15,435	2,357	$1,952.63
90 GPM/HP	15,766	2,688	$2,226.90
100 GPM/HP	17,068	3,989	$3,305.11
110 GPM/HP	16,465	3,387	$2,805.94
120 GPM/HP	18,575	5,496	$4,553.76

Stakeholders stressed the importance of accounting for increased shipping costs of higher efficiency cooling towers due to the increased size and weight. Shipping costs for units meeting the specifications for each climate zone were estimated using an online cost estimation tool from a nationwide transportation company (Veritread n.d.). Shipping costs were estimated for two cooling towers meeting the required nominal capacity of the Large Office prototype, at each efficiency level (60, 70, 80, 90, 100, 110, and 120 GPM/HP) to be shipped from Olathe, Kansas (the site of a major cooling tower manufacturing facility) to the reference city of each climate zone. Specific cooling towers were selected using manufacturer selection software to ensure the results were representative of real life cooling tower dimensions and weights. For many climate zones and efficiency levels, the estimated incremental shipping cost of the cooling towers over the baseline was negligible and sometimes negative. To provide a conservative estimate of shipping impacts on the cost effectiveness, the Statewide CASE Team applied the incremental shipping costs at each efficiency level for Climate Zone 15, which was observed to be worst-case-scenario.

Table 38: Estimated Shipping Costs by Efficiency Level (EL) and Climate Zone

Climate Zone	Destination City	Miles	Est. Shipping Cost: EL 60	Est. Shipping Cost: EL 70	Est. Shipping Cost: EL 80	Est. Shipping Cost: EL 90	Est. Shipping Cost: EL 100	Est. Shipping Cost: EL 110	Est. Shipping Cost: EL 120
CZ01	Arcata	1,941	$4,642	$5,484	$5,484	$5,528	$5,528	$5,528	$5,528
CZ02	Santa Rosa	1,840	$5,282	$5,282	$5,302	$5,302	$5,338	$5,724	$5,724
CZ03	Oakland	1,824	$5,218	$5,248	$5,248	$5,302	$5,302	$5,302	$5,302
CZ04	San Jose-Reid	1,856	$5,320	$5,320	$5,048	$5,048	$5,376	$5,762	$5,762
CZ05	Santa Maria	1,747	$5,016	$5,016	$5,016	$5,094	$5,094	$5,094	$5,094
CZ06	Torrance	1,629	$4,726	$4,726	$4,656	$4,656	$4,684	$6,136	$6,136
CZ07	San Diego-Lindbergh	1,568	$4,536	$4,498	$4,498	$4,498	$4,498	$6,166	$7,462
CZ08	Fullerton	1,602	$4,590	$4,592	$4,592	$4,592	$4,580	$7,480	$7,566
CZ09	Burbank-Glendale	1,618	$4,626	$4,614	$4,630	$4,618	$4,618	$7,528	$7,616
CZ10	Riverside	1,581	$4,696	$4,528	$4,528	$4,530	$4,530	$7,416	$7,502
CZ11	Red Bluff	1,801	$5,204	$5,222	$5,240	$5,646	$5,646	$5,646	$7,252
CZ12	Sacramento	1,741	$5,050	$5,050	$5,096	$5,096	$5,102	$5,504	$5,504
CZ13	Fresno	1,676	$5,092	$5,092	$5,092	$5,534	$7,252	$7,252	$7,252
CZ14	Palmdale	1,521	$4,522	$4,498	$4,498	$4,498	$4,484	$7,318	$7,318
CZ15	Palm Springs-Intl	1,480	$4,304	$4,304	$5,930	$5,930	$5,966	$5,966	$7,252
CZ16	Blue Canyon	1,677	$4,854	$4,854	$4,854	$4,854	$4,854	$4,854	$4,894

Impacts on rigging and lifting was also examined for inclusion in incremental first costs based on stakeholder input. However, the incremental size and weight increases do not appear to require significant modifications to the equipment and process, and when necessary due to crane capacity, rate increases appear negligible when compared to the overall cooling tower costs. For example, based on available engineering data, a 25-ton hydraulic crane would be sufficient for most cooling towers under 5000 GPM in nominal capacity, and to upgrade to a 40-ton hydraulic crane would cost approximately $160 more per day (Bigge n.d.). As such rigging and lifting costs have not been included in the analysis.

The final incremental first cost is captured by the equation:

$$
\begin{aligned}
&Incremental\ First\ Cost_{CZ} \\
&\quad = \$204/ton * \frac{RSMeans\ Location\ Factor_{CZ}}{100} \\
&\quad * (\%\ Incremental\ Cost\ by\ Efficiency\ and\ Capacity) \\
&\quad + Structural\ Cost\ Increase\ by\ Efficiency \\
&\quad + Shipping\ Cost\ by\ Efficiency\ and\ climate\ zone
\end{aligned}
$$

A summary of the incremental costs used in each climate zone is shown in Table 39. Note that the incremental first costs are listed as $0 for climate zones for which no adjustment is being proposed from the existing prescriptive requirement.

Table 39: Incremental Cooling Tower Costs by Climate Zone

Climate Zone	Nominal Cooling Tower Capacity per tower (GPM)	Proposed Efficiency (GPM/HP)	Incremental Cooling Tower Cost Factor	Incremental Cooling Tower Cost ($)	Incremental Freight Cost ($)	Incremental Structural Cost ($)	Total Incremental Cost ($)
CZ01	814.9	42.1	11%	$0	$0	$0	$0
CZ02	1,113.3	70	0%	$0	$918	$517	$1,435
CZ03	1,017.5	60	8%	$0	$0	$0	$0
CZ04	1,149.0	70	0%	$0	$918	$517	$1,435
CZ05	960.8	70	0%	$0	$918	$517	$1,435
CZ06	1,116.7	80	8%	$14,013	$936	$1,953	$16,901
CZ07	1,210.1	80	12%	$21,629	$936	$1,953	$24,517
CZ08	1,207.3	90	12%	$20,780	$1,342	$2,227	$24,349
CZ09	1,210.3	80	12%	$21,839	$936	$1,953	$24,727
CZ10	1,146.0	90	8%	$14,564	$1,342	$2,227	$18,133
CZ11	1,263.4	60	12%	$0	$0	$0	$0
CZ12	1,176.1	70	0%	$0	$918	$517	$1,435
CZ13	1,276.1	80	10%	$18,770	$936	$1,953	$21,658
CZ14	1,201.8	60	6%	$0	$0	$0	$0
CZ15	1,413.2	90	14%	$29,347	$1,342	$2,227	$32,916
CZ16	920.1	42.1	7%	$0	$0	$0	$0

3.4.4 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 Statewide CASE Team calculated the present value of equipment maintenance costs (or savings) using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2025 LSC hourly factors. The present value of maintenance costs that occurs in the n^{th} year is below.

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

For the cooling tower efficiency increase, maintenance activities and intervals would not change with the proposed code changes, and thus maintenance costs would not 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 40.

Table 40: 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.). To account for this, the Statewide CASE Team included the cost of replacement at 20 years in the cost-effectiveness analysis, as opposed to cheaper refurbishment, establishing a likely conservative estimate of cost-effectiveness. Increased freight costs were included in the replacement costs, however increased structure costs were not based on the assumption the structure had been previously improved to meet the requirements.

Other potential replacements throughout the lifetime of the cooling tower include fan blades or systems and cooling tower motors. The cooling tower fan system for higher efficiency cooling towers is anticipated have higher material costs than the baseline due to the likely increased diameter and number of blades. However, the lifetime of the fan is assumed to be 20 years, equivalent to the lifetime of the cooling tower itself, and since the analysis assumes replacement of the cooling tower at the EUL, the fan replacement has been excluded from this analysis. Motors for high efficiency units are lower in rated horsepower. Therefore, they cost less than the baseline, and with an EUL of 15 years would be replaced within the lifetime of the cooling towers. However, to provide a conservative cost-effectiveness analysis, the reduced cost of the motors has been excluded from the analysis.

3.4.5 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 41 and Table 42 for new construction/additions and alterations, respectively, for the OfficeLarge prototype.

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 2, 4-10, 12, and 15 for new construction and additions. For alterations, the proposed code change is cost effective in Climate Zones 2, 4-10, 12-13, 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 1, 3, 11, 14, and 16 for all construction types, for which no change is proposed as no cost-effective efficiency was found.

Table 41: 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	$0.000	$0.000	
2	$0.000	$0.000	
3	$0.000	$0.000	
4	$0.023	$0.002	8.77
5	$0.000	$0.000	
6	$0.055	$0.032	1.70
7	$0.058	$0.042	1.35
8	$0.112	$0.050	2.241
9	$0.073	$0.051	1.43
10	$0.046	$0.016	2.86
11	$0.000	$0.000	
12	$0.013	$0.001	11.42
13	$0.000	$0.000	
14	$0.000	$0.000	
15	$0.025	$0.009	2.87
16	$0.000	$0.000	

Table 42: 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	$0.000	$0.000	
2	$0.004	$0.001	6.08
3	$0.000	$0.000	
4	$0.024	$0.002	8.77
5	$0.003	$0.001	3.53
6	$0.064	$0.037	1.70
7	$0.071	$0.051	1.35
8	$0.128	$0.057	2.24
9	$0.087	$0.060	1.43
10	$0.084	$0.029	2.86
11	$0.000	$0.000	
12	$0.026	$0.002	11.42
13	$0.040	$0.020	1.99
14	$0.000	$0.000	
15	$0.1184	$0.041	2.87
16	$0.000	$0.000	

1. **Benefits: Long-term Systemwide Cost Savings + Other PV Savings:** Benefits include LSC Savings over the period of analysis (California Energy Commission 2022). 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.
2. **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.

Stakeholders presented concerns regarding the potential cost-effectiveness of cooling towers with capacities exceeding those examined in the energy savings analysis. To understand the potential impact on a wider range of a capacities, the Statewide CASE Team performed an additional analysis to assess the potential cost-effectiveness of cooling towers ranging from 500 GPM to 5,000 GPM in nominal capacity, in 500 GPM increments. This analysis extrapolated the average savings results of the OfficeLarge prototype per-unit savings (kBtu/ft^2 and 2026 PV$/$ft^2$) from each of the impacted climate zones to characteristics of larger facilities. The building area in square feet associated with each capacity level was estimated using the average cooling load (btuh/ft^2) for the OfficeLarge prototype climate zones to align with the desired capacity. The incremental cost for the analysis utilized the same methodology as described in Section 3.4.3. Cooling tower selection software was used to develop a linear regression of cost factor to rated capacity in order to extrapolate the baseline cost per ton from RSMeans to larger capacity units.

Based on this analysis, higher efficiency levels were found to be cost effective across the entire range of examined capacities, with large units, greater than 4,000 GPM, found to be cost-effective for all efficiency levels (70-120 GPM/HP). There are specific use cases for which capacity and efficiency have a significant impact due to variations in cost factors, weight (requiring increased structure), etc. This was primarily observed for units in the range of 3,000-3,999 GPM, for which increasing to higher efficiency levels required the addition of another cooling tower cell. Below this capacity range, all efficiencies are achievable with a single cell, while above this capacity range, the baseline units are also utilizing multiple cells and thus the incremental costs are less significant.

To account for this impact, the Statewide CASE team has opted to recommend efficiency levels for each climate zone that are lower than the “most efficient deemed cost effective,” to allow more flexibility and fluctuations in incremental first costs.

3.5 First-Year Statewide Impacts

3.5.1 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 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).

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.

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 43) and alterations (Table 44) by climate zone. Table 45 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. Additionally, based on input from stakeholders, the Statewide CASE Team assumed that 50 percent of cooling tower customers pursue alternatives to the prescriptive efficiency requirement, either through exemptions for climate zones or for cooling towers located inside of existing buildings or on rooftops, or by pursuing the performance path. The savings accounted for this trend using a 50 percent factor in each of the impacted climate zones. 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 one to 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 one 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 for more details addressing energy equity and environmental justice.

Table 43: 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	69,756	0.00043	0	0	0	$0.00
3	0	0	0	0	0	$0.00
4	525,305	0.00414	0.00001	0	0	$0.02

5	34,813	0.00012	0.00002	0	0	$0.00
6	498,387	0.00871	0.00025	0	0	$0.04
7	323,280	0.00602	0.00020	0	0	$0.03
8	757,010	0.02530	0.00045	0	0	$0.12
9	1,359,933	0.02873	0.00054	0	0	$0.13
10	293,103	0.00936	0.00009	0	0	$0.04
11	0	0	0	0	0	$0.00
12	445,139	0.00438	0.00015	0	0	$0.02
13	102,477	0.00255	0.00001	0	0	$0.01
14	0	0	0	0	0	$0.00
15	33,948	0.00189	0	0	0	$0.01
16	0	0	0	0	0	$0.00
Total	**4,443,151**	**0.09162**	**0.00172**	**0**	**0**	**$0.43**

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

Table 44: 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	209,550	0.00128	0.00001	0	0	$0.00
3	0	0	0	0	0	$0.00
4	1,299,434	0.01024	0.00003	0	0	$0.04
5	90,491	0.00031	0.00003	0	0	$0.00
6	1,662,413	0.02905	0.00081	0	0	$0.13
7	1,299,349	0.02420	0.00078	0	0	$0.12
8	2,611,857	0.08728	0.00164	0	0	$0.41
9	4,686,348	0.09902	0.00180	0	0	$0.46
10	1,350,715	0.04313	0.00049	0	0	$0.20
11	0	0	0	0	0	$0.00
12	1,684,582	0.01658	0.00038	0	0	$0.07
13	372,828	0.00927	0.00007	0	0	$0.05
14	0	0	0	0	0	$0.00
15	135,693	0.00754	0.00007	0	0	$0.04
16	0	0	0	0	0	$0.00
Total	**15,403,260**	**0.32790**	**0.00611**	**0**	**0**	**$1.53**

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

Table 45: 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	0.09	0.00	0.00	0.00	0.43
Alterations	0.33	0.01	0.00	0.00	1.53
Total	**0.42**	**0.01**	**0.00**	**0.00**	**1.96**

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

3.5.2 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).[14] The cost-effectiveness analysis presented in Section 3.4 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 46 presents the estimated first-year avoided GHG emissions of the proposed code change. During the first year, GHG emissions of 14.2 (metric tons CO2e) would be avoided.

Table 46: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/year)	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	0.42	14.2	0.0	0.0	14.2	1,748
Total	**0.42**	**14.2**	**0.0**	**0.0**	**14.2**	**1,748**

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

3.5.3 Statewide Water Use Impacts

The proposed code change would not result in water savings.

3.5.4 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 346 pounds

[14] 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.

heavier than a baseline 60 GPM/HP unit (Baltimore Aircoil Company n.d., Evapco n.d., SPX Cooling Technologies n.d.), assumed to be steel for this analysis.

Larger towers also have larger volumes of fill material, typically constructed of plastic. Based on drawings of three sample cooling tower models, fill material comprises approximately 17-45 percent of a cooling tower's volume depending on tower configuration. Typical dry fill weights are 1.7 pound/ft^3 for 10-mil packs and 2.4 pound/ft^3 for 15-mil packs. Assuming the higher 2.4 pound/ft^3 for a conservative estimate, a typical cooling tower capacity would equal about 21 percent of the shipping weight. Based on the average incremental shipping weight of cooling towers between 70-90 GPM/HP in efficiency, this would result in an estimated increase of 92 pounds of plastic fill material per cooling tower. See Appendix D for more details.

Table 47: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per Square Foot)	First-Year [a] Statewide Impacts (Pounds)
Mercury	No Change	0	0
Lead	No Change	0	0
Copper	No Change	0	0
Steel	Increase	0.0074	146,563
Plastic	Increase	0.0020	38,962
Others	No Change	0	0
TOTAL	-		**185,525**

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 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 outside of any impacts mentioned in Section 2, therefore reducing the impacts of disparities in DIPs. The Statewide CASE Team does not recommend further research or action at this time.

Cooling towers are common on commercial and institutional facilities and are not expected to impact energy equity or environmental justice in any specific way. The Statewide CASE Team evaluated the proposed measure with the four criteria mentioned in Section 2.1.2 – cost, health, resiliency, and comfort. The proposed measure does not impact the health or comfort of building occupants, and it does not affect building resiliency to extreme weather events. While the measure has the potential to save energy, it is unlikely the utility bill energy savings would significantly impact DIPs since it's uncommon for this measure to apply in multifamily spaces. For details about nonresidential building impacts, refer to Section 2.1.2.

One stakeholder did raise concerns with impacts on the manufacturing facilities that two of the three major manufacturers have near Madera, CA.[15] Impacts on these plants could affect jobs in these communities. The CASE team has worked to mitigate these concerns by reducing the stringency of the proposed requirements in order to reduce these potential impacts on the manufacturer and resulting employment impacts.

[15] Madera, CA is identified as a disadvantaged community under the SB 535 map: https://experience.arcgis.com/experience/1c21c53da8de48f1b946f3402fbae55c/page/SB-535-Disadvantaged-Communities/

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).
- Require the designer to document target maximum cycles of concentration in the NRCC-MCH-E compliance document based on the recirculating water properties established in ANSI/ASHRAE Standard 189.1-2020. This target maximum cycles of concentration would be determined by the NRCC-MCH-E form based on the water quality data entered by the design engineer or water treatment professional, using water quality data available from the local water utility or site-specific data if available.
- Require that controls be programmed to not allow blowdown until one or more of the recirculating water parameter limits set in ANSI/ASHRAE Standard 189.1-2020 is met.
- 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 (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 NRCC-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, as controlling to an LSI of 2.5 alone could result in scale depending on the makeup water characteristics. Stakeholders have also voiced the need to be able to adjust cycles of concentration over time, in response to actual water quality conditions which are highly variable. The proposed requirement would allow for this by having the design engineer document a target cycles of concentration based on the ANSI/ASHRAE 189.1-2020 parameters and requiring controls that don't allow blowdown until one or more of these parameters are exceeded. The target cycles of concentration provide information to the cooling tower operator and/or water treatment vendor as to what cycles of concentration should be achievable, allowing them to adjust their water quality management accordingly.

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. While the use of these technologies is not required by the levels proposed in the CASE Report, their availability provides more options to building designers and operators for controlling water quality in addition to traditional chemical treatment. 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).[16] 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 makeup water use is driven by evaporation, drift, and blowdown (Deru and Bonnema 2019). 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. The requirements included in 2013 Title 24, Part 6 to

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

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 (the form would pass any value that does not exceed an LSI of 2.5). 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. Additionally, feedback from manufacturers indicated the need to control to other water quality parameters in addition to LSI. 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 calculate target maximum cycles of concentration based on the parameters included in ANSI/ASHRAE 189.1-2020. This target maximum cycles of concentration would be based on available water quality data from the local utility or water quality tests if available. The Statewide CASE Team proposes detailed instructions in the form to make sure that users interpret and apply utility water quality data correctly, at the recommendation of stakeholders.

The measure also adds an acceptance test to verify installation of conductivity-based controls that are programmed to not allow blowdown until one or more of the ANSI/ASHRAE 189.1-2020 parameters meets the identified thresholds as well as to ensure the installation and proper functioning of the overflow alarm. 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.

While the proposed requirements could be met by traditional chemical treatment, it is noteworthy that 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 cycles of concentration between two and five, 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.

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.[17] 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.

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

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 target 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 currently references a weblink to the CEC's LSI calculator and the NRCC-MCH-06 form, which are both outdated Section 4.2.7 should be updated to reflect the updated requirements and to include a link to the updated NRCC-MCH-E form, where the cycles of concentration calculator is housed.

4.1.3.4 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. An example of the revised documents presented in Section 5.5 includes:

- NRCC-MCH-E Maximum Cycles of Calculation Worksheet – This compliance document would require the designer to document maximum cycles of concentration based on the ANSI/ASHRAE 189.1-2020 parameters.

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. This measure proposes integrating these requirements into the Title 24, Part 6 requirements.

Table 48: 2021 IgCC Table 601.3.2.3 Recirculating Water Properties for Open-Circuit Cooling-Tower Construction

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

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 that indicates target cycles of concentration. Plan checker reviews to confirm that the form has been completed.
- **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 a 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 would pass any value that results in an LSI of 2.5 or less. For example, cycles of concentration of one, which is equivalent to once-through-cooling, is permissible using the compliance document.
- Most 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 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 Table 49.

Table 49: Cooling tower controller models and control types.

Manufacturer	Control type	Model Name
Advantage Controls	Conductivity- and flow-based models[18]	Nanotron
Chemtrol	Conductivity-based	CT110
Lakewood	Conductivity/flow-based	Model 140
Walchem	Conductivity-based	WCT600

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.

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. Notably, the acceptance test as written would not require the building to be occupied or have a load on the system, as it is focused on verifying the programming of controls and installation of an overflow alarm. 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.

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

California's construction industry comprises approximately 93,000 business establishments and 943,000 employees (see Table 50). 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 50: California Construction Industry, Establishments, Employment, and Payroll in 2022 (Estimated)

Building Type	Construction Sectors	Establishments	Employment	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, & 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 50 shows the overall estimated establishments, employment, and payroll by building type and subsector and Table 51 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 51: 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 52 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. 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 52 provides an upper bound indication of the size of this sector in California.

Table 52: 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 would not 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 end-users may choose to comply with the code through non-chemical water treatment systems. This would improve occupational health and safety as it would not require transporting chemicals, hauling them up to the roof, and transferring into 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.

4.2.3.6 Impact on Building Inspectors

Table 53 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 53: 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[19], 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

[19] 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.

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).[20] As Table 54 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 54: 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***	***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.[21]

4.2.4.5 Incentives for Innovation in Products, Materials, or Processes

This proposal is performance-based and technology-neutral in that it does not specify how the building must meet the identified target cycles of concentration. The target cycles of concentration are determined using the NRCC-MCH-E form. The designer inputs water quality data available from the local water utility into the form and the form calculates the target cycles

[20] 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.

[21] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 18.

of concentration based on the limiting parameter from ASHRAE/ANSI 189.1-2020. The proposal does not specify how these cycles must be met. 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 would allocate 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 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 Statewide CASE Team used models 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 present in all 16 climate zones.

The Statewide CASE Team established the baseline cycles of concentration based on research conducted for the 2013 CASE Report and conversations with stakeholders. The 2013 CASE Report identified baseline cycles of concentration of 3.5 (Statewide CASE Team 2013). Since the Statewide CASE Team found that conductivity controls were in place prior to the implementation of 2013 Title 24, Part 6, and the cycles of concentration calculator do not require designers to maximize cycles of concentration, these baseline cycles of concentration value would be appropriate. Conversations with designers and cooling tower experts validated this assumption.

The Statewide CASE Team established the proposed cycles of concentration based on the weighted average of the maximum target cycles of concentration achievable in each of California's climate zones based on water quality data from the most populous city in each climate zone with the necessary water quality data available. The maximum target cycles of concentration were determined using the proposed updated NRCC-MCH-E form. The form requires the user to input values for each of the parameters identified in ANSI/ASHRAE 189.1-2020 using local water quality data. The form calculates the achievable cycles of concentration for each of these parameters and then sets the target cycles of concentration as the minimum of these values, corresponding to the achievable cycles of concentration using the controlling parameter. This proposed compliance form is shown in Appendix H. Publicly available water quality data from local water districts available in annual water quality reports was used in combination with the proposed NRCC-MCH-E compliance document to determine the maximum target cycles of concentration achievable in each climate zone. Since water quality can vary dramatically within a given climate zone, these values were used to determine statewide average cycles of concentration weighted by the total construction forecast in each climate zone, rather than doing a climate zone specific analysis.

Table 55: Maximum Cycles of Concentration Achievable by Climate Zone using the Proposed NRCC-MCH-E form

Climate Zone	City	Utility	Maximum Cycles of Concentration
1	Eureka	Humboldt Bay Municipal Water District	7.4
2	Santa Rosa	Santa Rosa Water	3.1
3	San Francisco	San Francisco Water Power Sewer	14.6
4	San Jose	San Jose Municipal Water System	3.2
5	Santa Maria	City of Santa Maria	0.8
6	Long Beach	Long Beach Water District	1.7
7	San Diego	San Diego Public Utility District	1.3
8	Anaheim	Orange County Water District	1.2
9	Los Angeles	LADWP	1.5
10	Riverside	Riverside Public Utilities	3.2
11	Chico	Cal Water (Chico)	4.4
12	Sacramento	Sacramento Department of Utilities	4.2
13	Bakersfield	Cal Water (Bakersfield)	7.6
14	Lancaster	Cal Water (Antelope Valley District)	3.5
15	Indio	Indio Water Authority	3.4
16	Truckee	Truckee Donner Public Utility District	8.4
N/A	All	All	4.0 (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 56.

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 56: 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 lifecycle 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. [22] 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 57 presents precisely which parameters were modified and what values were used in the Standard Design and Proposed Design.

[22] CBECC-Res creates a third model, the Reference Design, which 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.

Specifically, the proposed conditions assume that the building achieves cycles of concentration of 4.0.

Table 57: 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	4.0
OfficeLarge	All	CoolingTower: VariableSpeed	Blowdown Concentration Ratio	3.5	4.0

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 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 58. The per-unit energy savings figures account for naturally occurring market adoption or compliance rates.

Table 58: First Year Water Savings (Gallons) Per Square Foot by Climate Zone (CZ) – Blowdown Controls

Prototype	Hospital	OfficeLarge
CZ 1	0.01	0.01
CZ 2	0.18	0.11
CZ 3	0.09	0.05
CZ 4	0.29	0.17
CZ 5	0.12	0.07
CZ 6	0.23	0.13
CZ 7	0.25	0.14
CZ 8	0.37	0.21
CZ 9	0.35	0.2
CZ 10	0.42	0.23
CZ 11	0.43	0.23
CZ 12	0.3	0.16
CZ 13	0.47	0.24
CZ 14	0.4	0.22
CZ 15	0.84	0.44
CZ 16	0.14	0.08

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. The Statewide CASE Team calculated water cost savings 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 59 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.[23]

Table 59: 2022-2023 Water utility service charges

City	Population	Water	Water	Sewer	Sewer

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

		Service Charges ($/hcf)	Service Charges ($/kgal)	Service Charges ($/hcf)	Service Charges ($/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-Year LSC savings associated with water savings, and to align with the 30-year life cycle energy cost methodology, a three percent discount rate was applied to future cost savings.

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 60 through Table 63.

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 60: 2026 PV Lifecycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction and Additions – Large Office

Climate Zone	30-Year Lifecycle Water Cost Savings (2026 PV$)
1	0.00
2	0.00
3	0.11
4	0.23
5	0.00
6	0.19
7	0.20

8	0.27
9	0.26
10	0.30
11	0.30
12	0.22
13	0.00
14	0.28
15	0.52
16	0.13

Table 61: 2026 PV Lifecycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Alterations – Large Office

Climate Zone	30-Year Lifecycle Water Cost Savings (2026 PV$)
1	0.06
2	0.17
3	0.11
4	0.23
5	0.12
6	0.19
7	0.20
8	0.27
9	0.26
10	0.30
11	0.30
12	0.22
13	0.31
14	0.28
15	0.52
16	0.13

Table 62: 2026 PV LSC Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction and Additions – Hospital

Climate Zone	30-Year Lifecycle Water Cost Savings (2026 PV$)
1	0.13
2	0.31
3	0.21
4	0.43
5	0.24
6	0.37
7	0.39
8	0.52
9	0.50
10	0.57
11	0.59
12	0.44
13	0.62
14	0.55
15	1.03
16	0.27

Table 63: 2026 PV Lifecycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Alterations – Hospital

Climate Zone	30-Year Lifecycle Water Cost Savings (2026 PV$)
1	0.13
2	0.31
3	0.21
4	0.43
5	0.24
6	0.37
7	0.39
8	0.52
9	0.50
10	0.57
11	0.59
12	0.44
13	0.62
14	0.55
15	1.03
16	0.27

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, 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/hour), 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.

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 LSC hourly factors. The present value of maintenance costs that occurs in the n^{th} year is calculated as follows:

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

The Statewide CASE Team did not find any change in incremental maintenance or replacement costs compared to the baseline scenario. While one stakeholder did point out that conductivity-based controls require more maintenance than flow-based controls, this incremental impact was assumed to be minimal given the fact that conductivity-based controls are already standard practice.

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 LSC savings from energy and lifecycle 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 64 for new construction/additions and Table 65 for alterations.

Table 64: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction/Additions

Climate Zone	Benefits Lifecycle Water Cost Savings + Other PV Savings [a] (2026 PV$/Square Foot)	Costs Total Incremental PV Costs [b] (2026 PV$/Square Foot)	Benefit-to-Cost Ratio
1	0.0003	0.00015	2
2	0.0040	0.00014	28
3	0.0164	0.00096	17
4	0.0493	0.00094	53
5	0.0024	0.00013	18
6	0.0356	0.00088	40
7	0.0367	0.00085	43
8	0.0605	0.00093	65
9	0.0585	0.00094	63
10	0.0394	0.00055	71
11	0.0347	0.00049	71
12	0.0245	0.00049	50
13	0.0110	0.00015	72
14	0.0485	0.00072	67
15	0.0409	0.00031	132
16	0.0154	0.00062	25

a. **Benefits: Lifecycle Water Cost Savings + Other PV Savings:** Benefits include LSC Savings over the period of analysis (California Energy Commission 2022). 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 65: 30-Year Cost-Effectiveness Summary Per Square Foot – Alterations

Climate Zone	Benefits Lifecycle Water Cost Savings + Other PV Savings [a] (2026 PV$/Square Foot)	Costs Total Incremental PV Costs [b] (2026 PV$/Square Foot)	Benefit-to-Cost Ratio
1	0.001	0.00038	3
2	0.013	0.00040	32
3	0.017	0.00100	17

4	0.051	0.00097	53
5	0.011	0.00050	21
6	0.042	0.00104	40
7	0.043	0.00098	43
8	0.070	0.00107	65
9	0.069	0.00111	62
10	0.058	0.00080	73
11	0.035	0.00050	70
12	0.044	0.00086	51
13	0.044	0.00059	75
14	0.064	0.00094	68
15	0.089	0.00065	137
16	0.022	0.00087	25

a. **Benefits: Lifecycle Water Cost Savings + Other PV Savings:** Benefits include LSC Savings over the period of analysis (California Energy Commission 2022). 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 66) and alterations (Table 67) 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 66: Statewide Energy and Energy Cost Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million sq. ft.)	First-Year[a] Water Savings (Gallons)	30-Year Present Valued Energy Water Savings (Million 2026 PV$)
1	22,296	295	$0.0001
2	139,512	20,690	$0.0086
3	2,093,826	126,549	$0.0525
4	1,050,610	198,034	$0.0821
5	69,626	6,699	$0.0028
6	996,773	146,975	$0.0610
7	646,560	106,382	$0.0441
8	1,514,020	356,062	$0.1477
9	2,719,866	609,133	$0.2526
10	586,205	178,332	$0.0740
11	166,750	51,032	$0.0212
12	890,277	189,539	$0.0786
13	204,955	73,988	$0.0307
14	186,724	49,787	$0.0206
15	67,897	43,211	$0.0179
16	56,608	5,685	$0.0024
Total	**11,412,505**	**2,162,391**	**$0.8968**

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

Table 67: 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	528	$0.0002
2	419,100	59,441	$0.0247
3	4,876,310	292,985	$0.1215
4	2,598,869	486,910	$0.2019
5	180,982	16,356	$0.0068
6	3,324,827	472,557	$0.1960
7	2,598,697	406,567	$0.1686

8	5,223,714	1,186,505	$0.4920
9	9,372,695	2,011,589	$0.8342
10	2,701,430	753,905	$0.3126
11	302,694	96,390	$0.0400
12	3,369,164	650,594	$0.2698
13	745,656	243,663	$0.1010
14	765,371	190,627	$0.0791
15	271,386	153,305	$0.0636
16	197,526	18,651	$0.0077
Total	**36,988,400**	**7,040,573**	**$2.9198**

d. 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 68: 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	0.2	0	0
First-Year[b] Statewide Impacts for New Construction & Additions	2,162,391	0	11,763
First-Year[b] Statewide Impacts for Alterations	7,040,573	0	38,301
First-Year[b] Total Statewide Impacts	9,202,965	0	50,064

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 water treatment chemicals, reducing the health and safety risks associated with their transportation, use, and disposal.

4.6 Addressing Energy Equity and Environmental Justice

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 outside of any impacts mentioned in Section 2 therefore reducing the impacts of disparities in DIPs. The Statewide CASE Team does not currently recommend further research or action.

4.6.1 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. The Statewide CASE Team evaluated the proposed measure with the four criteria mentioned in Section 2.1.2 – cost, health, resiliency, and comfort. The proposed measure does not impact the health or comfort of building occupants, and it does not affect building resiliency to extreme weather events. While the measure has the potential to save water, it's unlikely these water savings will significantly impact DIPs since it's uncommon for this measure to apply in multifamily spaces. For details about nonresidential building impacts, refer to Section 2.1.2.

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 the parameters identified in Table X. 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 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 crossflow 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 manufacturer's recommendation. Stage fans 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	70	60	70	70	80	80	90	80	90	60	70	80	60	90	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 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	70	60	70	70	80	80	90	80	90	60	70	80	60	90	42.1

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.

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 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.

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 are 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~~ 60-90 GPM/HP dependent on climate zone, 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 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 70-90 GPM/HP dependent on climate zone.

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.

6. Bibliography

n.d. http://bees.archenergy.com/Documents/Software/CBECC-Com_2016.3.0_SP1_Prototypes.zip.

Abualsaud, Rana, Grigory Ostrovskiy, and Ziyad Mahfoud. 2019. "Ethnicity-Based Inequality in Heat-Related Illness Is on the Rise in California." *Wilderness & Environmental Medicine* 100-103.

ACEEE. n.d. "Energy Equity." *ACEEE.org.* Accessed 2023. https://www.aceee.org/topic/energy-equity.

Air-Conditioning, Heating, and Refrigeration Institute. n.d. *Directory of Certified Product Performance.* Accessed February 2023. https://www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f.

American Society of Heating, Refrigeration, and Air-Conditioning Engineers. n.d. "ASHRAE 180 - Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems." Table 5-10.

Ash, Michael, and James K Boyce. 2018. "Racial disparities in pollution exposure and employment at US industrial facilities." *Proceedings of the National Academy of Sciences* , October 1.

ASHRAE. 2015. "2015 ASHRAE Handbook - HVAC Application." A37.

—. n.d. *HVAC Service Life Database.* Accessed December 2022. http://weblegacy.ashrae.org/publicdatabase/service_life.asp.

Association, National Energy Assistance Directors. 2011. "2011 National Energy Assistance Survey Final Report."

Baltimore Aircoil Company. n.d. *BAC Product Selection .* Accessed January 2022. https://www11.baltimoreaircoil.com/pss/web/home/.

—. n.d. *Baltimore Aircoil Company Cooling Towers.* Accessed December 2022. https://baltimoreaircoil.com/products/cooling-towers.

Bergstra, Arnold D, Bret Brunekreef, and Alex Burdorf. 2018. "The effect of industry-related air pollution on lung function and respiratory symptoms in school children." *Environmental Health*, March 27.

Bigge. n.d. "Published Crane Rental Rates (Per Hour)." *bigge.com.* Accessed 2023. https://www.bigge.com/crane-rental/operated-and-maintained/.

Black and Veatch Management Consulting. 2021. "2021 50 Largest Cities Water and Wastewater Report." *Black and Veatch.* Accessed December 7, 2022. https://bv.com/resources/2021-50-largest-cities-water-and-wastewater-report.

Blankenship, Britney: J Renner, H Werner, M Lerner, K Cunningham. 2020. *Hand-in-Hand: Environmental and Social Justice Communities and California Energy Code.* ACEEE Summer Study on Energy Efficiency in Buildings.

BLS Beta Labs. n.d. "BLS Beta Labs." *U.S. Bureau of Labor Statistics.* Accessed 2023. https://beta.bls.gov/dataViewer/view/timeseries/PCU33231233231212.

Building Green. n.d. *LEEDuser.* Accessed February 2023. https://leeduser.buildinggreen.com/.

BW Research Partnership. 2016. *Advanced Energy Jobs in California: Results of the 2016 California Advanced Energy.* Advanced Energy Economy Institute.

California Air Resouces Board. 2019. "Global Warming Potentials." https://www.arb.ca.gov/cc/inventory/background/gwp.htm#transition.

California Department of Water Resources. 2016. "California Counties by Hydrologic Regions." Accessed April 3, 2016. http://www.water.ca.gov/landwateruse/images/maps/California-County.pdf.

—. 2021. "Water Year 2021: An Extreme Year." Accessed 2022. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Water-Basics/Drought/Files/Publications-And-Reports/091521-Water-Year-2021-broch_v2.pdf.

California Energy Codes and Standards. 2018. *Prescriptive Efficiency Requirements.* August. Accessed March 7, 2023. http://title24stakeholders.com/wp-content/uploads/2019/01/T24-2019-CASE-Study-Results-Reports-Cooling-Towers_Final_with_Attachments.pdf.

California Energy Commission . 2022. "2025 Building Energy Efficiency Standards." *2025 Energy Code Hourly Factors.* Prepared for the California Energy Commission. Accessed March 21, 2023. https://efiling.energy.ca.gov/getdocument.aspx?tn=239439.

California Energy Commission. 2015. *2016 Building Energy Efficiency Standards: Frequently Asked Questions.* http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/2016_Building_Energy_Efficiency_Standards_FAQ.pdf.

—. 2021. *2021 Total System Electric Generation.* Accessed March 2023. https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation.

—. 2022. "Energy Code Data for Measure Proposals." *energy.ca.gov.* https://www.energy.ca.gov/title24/documents/2022_Energy_Code_Data_for_Measure_Proposals.xlsx.

—. 2022. "Final Staff Workshop on Energy Accounting for the 2025 Building Energy Efficiency Standards." *California Energy Commission.* Prepared for the California Energy Commission. November 10. https://www.energy.ca.gov/event/workshop/2022-11/final-staff-workshop-energy-accounting-2025-building-energy-efficiency.

—. 2022. "Housing and Commercial Construction Data - Excel." https://ww2.energy.ca.gov/title24/documents/2022_Energy_Code_Data_for_Measure_Proposals.xlsx.

—. 2018. "Impact Analysis: 2019 Update to the California Energy Efficiency Standards for Residential and Non-Residential Buildings." *energy.ca.gov.* June 29. https://www.energy.ca.gov/title24/2019standards/post_adoption/documents/2019_Impact_Analysis_Final_Report_2018-06-29.pdf.

California Governer's Office of Emergency Services. 2021. *Cal OES News.* August 3. Accessed 2023. https://news.caloes.ca.gov/project-roomkey-impact-to-date-and-looking-ahead/.

California Public Utilities Commission (CPUC). 2015b. "Water/Energy Cost-Effectiveness Analysis: Revised Final Report." Prepared by Navigant Consulting, Inc. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5360.

California Public Utilities Commission. 2022. *California Electronic Technical Reference Manual - SWHC005.* Accessed December 2022. https://www.caetrm.com/measure/SWHC005/03/.

—. 2022. *California Electronic Technical Reference Manual - SWHC052.* Accessed December 2022. https://www.caetrm.com/measure/SWHC052/02/.

—. 2015a. "Water/Energy Cost-Effectiveness Analysis: Errata to the Revised Final Report." Prepared by Navigant Consulting, Inc. . http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5350.

Carrier Global Corporation. n.d. *Carrier Air-Cooled Chillers.* Accessed December 2022. https://www.carrier.com/commercial/en/us/products/chillers-components/air-cooled-chillers/.

CEC. 2018. "Energy Equity Indicators Tracking Progress." *Energy.ca.gov.* June 25. Accessed 2023. https://www.energy.ca.gov/sites/default/files/2019-12/energy_equity_indicators_ada.pdf.

Chapple, Daniel. n.d. *Grocery Store Development in Recognized Food Deserts.* Sustainable Development Code . https://sustainablecitycode.org/brief/grocery-store-development-in-recognized-food-deserts/.

Cluett, Rachel, J Amann. 2015. "Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening." *American Council for an Energy-Efficiency Economy.*

Cooling Technology Institute. n.d. *Certification Directory.* Accessed November 2022. https://www.cti.org/certification-directory.

CPUC. n.d. "Disadvantaged Communities." Accessed 2023. https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/disadvantaged-communities#:~:text=What%20is%20a%20Disadvantaged%20Community,%2C%20health%2C%20and%20environmental%20burdens.

Cutler, Dylan, Jesse Dean, Jennifer Daw, and Dan Howett. 2018. *Alternative Water Treatment Technologies for Cooling Tower Applications.* NREL.

DC Fiscal Policy Institute. 2017. "Style Guide for Inclusive Language." *DCFPI.* December. https://www.dcfpi.org/wp-content/uploads/2017/12/Style-Guide-for-Inclusive-Language_Dec-2017.pdf.

Deng, Hengfang, Daniel P Aldrich, Michael M Danziger, Jianxi Gao, Nolan E Phillips, Sean P Cornelius, and Qi Ryan Wang. 2021. "High-resolution human mobility data reveal race and wealth disparities in disaster evacuation patterns." *Humanities & Social Sciences Communications.*

Deru, Michael, and Eric Bonnema. 2019. *Testing and Evaluation of a Chemical-Free Cooling Tower Water Treatment Technology.* Golden, CO: National Renewable Energy Laboratory. NREL/TP-5500-73911.

Drehobl, Ariel: L Ross: R Ayala. 2020. *How High are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burden Across the United States.* American Council for an Energy-Efficiency Economy.

Energy + Environmental Economics. 2016. "Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2019 Time Dependent Valuation (TDV) Data Sources and Inputs." Prepared for the California Energy Commission. July. http://docketpublic.energy.ca.gov/PublicDocuments/16-BSTD-06/TN212524_20160801T120224_2019_TDV_Methodology_Report_7222016.pdf.

Energy Information Administration. 2018. "Commercial Building Energy Consumption Survey." *2018 CBECS Survey Data.* Accessed 2022. https://www.eia.gov/consumption/commercial/data/2018/index.php?view=microdata.

Environmental Protection Agency. n.d. "Water Efficiency Management Guide Mechanical Systems." *WaterSense.* Accessed December 2022. https://www.epa.gov/sites/default/files/2017-12/documents/ws-commercialbuildings-waterscore-mechanical-systems-guide.pdf.

—. 2012. "WaterSense at Work - Best Management Practices for Commercial and Institutional Facilities." *Environmental Protection Agency.* October. Accessed January 27, 2023.

EPA. 2021. *Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts.* U.S. Environmental Protection Agency, EPA.

Ettenson, Lara , and Christa Heavey. 2015. *California's Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals.* Natural Resources Defense Council & Environmental Entrepreneurs (E2).

Evapco. n.d. *Evapco Factory Assembled Cooling Towers.* Accessed December 2022. https://www.evapco.com/products/cooling-towers-factory-assembled.

Fannie Mae. 2015. "Fannie Mae - Energy and Water Use Survey Database." *Fannie Mae Multifamily Energy and Water Market Research Survey.* February 17. Accessed March 2023. https://multifamily.fanniemae.com/media/6776/display.

Federal Reserve Economic Data (FRED). n.d. Accessed Sepember 14, 2022. https://fred.stlouisfed.org/release/tables?eid=258470&rid=144 .

—. n.d. *Data series relied on: Net Domestic Private Investment, Corporate Profits After Taxes.* Accessed September 18, 2022. https://fred.stlouisfed.org .

Goldman, Charles, Merrian C. Fuller, Elizabeth Stuart, Jane S Peters, Marjorie McRay, Nathaniel Albers, Susan Lutzenhiser, and Mersiha Spahic. 2010. *Energy Efficiency Services Sector: Workforce Size and Expectations for Growth.* Lawrence Berkeley National Laboratory.

Goldsmith, Leo, and Michelle L. Bell. 2021. "Queering Environmental Justice: Unequal Environmental Health Burden on the LGBTQ+ Community." *American Journal of Public Health.* https://ajph.aphapublications.org/doi/10.2105/AJPH.2021.306406.

Gordian. 2021. *RSMeans Building Construction Cost Data.* Accessed 2022. https://www.rsmeansonline.com/.

IEA. 2014. *Capturing the Multiple Benefits of Energy Efficiency.* International Energy Agency.

Kenney, Michael, Heather Bird, and Heriberto Rosales. 2019. *2019 California Energy Efficiency Action Plan.* Publication Number: CEC- 400-2019-010-CMF , California Energy Commission. Kenney, Michael, Heather Bird, and Heriberto Rosales. 2019. 2019 California Energy Efficiency Action Plan. California Energy Commission. Publication Number: CEC- 400-2019-010-CMF .

Laaidi, Karine: A Zeghnoun: B Dousset: P Bretin: S Vandentorren: E Giraudet: P Beaudeau. 2012. "The Impact of Heat Islands on Mortality in Paris during the August 2003 Heat Wave." *Environmental Health Perspectives.*

Lewis, LaVonna Blair, David C Sloane, Lori Miller Nascimento, Allison L Diamant, Joyce Jones Guinyard, Antronette K Yancey, and Gwendolyn Flynn. 2005. "African Americans' Access to Healthy Food Options in South Los Angeles Restaurants." *American Journal of Public Health.*

Los Angeles Department of Water and Power. n.d. "Water Conservation - Technical Assistance Program (TAP)." *LADWP.* Accessed December 2022. https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-water/a-w-conservation/a-w-c-customwaterprojectstap?_adf.ctrl-state=14qx83jc5y_4&_afrLoop=347429616211102.

Morelix, Alicia Robb and Arnobio. 2016. *Startup Financing Trends by Race: How Access to Capital Impacts Profitability.* Erwing Marion Kauffmann Foundation.

National Energy Assistance Directors' Association. 2011. *2011 National Energy Assistance Survey Final Report.* http://www.appriseinc.org/reports/Final%20NEADA%202011%20Report.pdf.

NORESCO. n.d. *CBECC Title-24 Compliance Software 2025.* Accessed December 2022. https://bees.noresco.com/software2025.html.

Norton, Ruth Ann, & B Brown. 2014. "Green & Healthy Homes Initiative: Improving Health, Economic, and Social Outcomes Through Integrated Housing Intervention." *Environmental Justice* Vol. 7 (Nbr. 6.).

Oh, Hyeon-Ju. 2020. "Exposure to respirable particles and TVOC in underground parking garages under different types of ventilation and their associated health effects." *Air Quality Atmosphere & Health.*

Pacific Northwest National Lab. 2012. "Variable Refrigerant Flow." December. Accessed 2023. https://www.gsa.gov/system/files/GPG_Variable_Refrigerant_Flow_12-2012.pdf.

Pew Research Center. 2023. *Attendance at religious services by race/ethnicity.* Accessed 2023. https://www.pewresearch.org/religion/religious-landscape-study/compare/attendance-at-religious-services/by/racial-and-ethnic-composition/.

Ramanathan, Lavanya. 2017. "Mall outside DC has found a niche: immigrants." *AP News*, January 16. https://apnews.com/article/--9557e5da878b4328af8aab985167039d.

Rose, Erin: Hawkins, Beth. 2020. *Background Data and Statistics on Low- Income Energy Use and Burden for the Weatherization Assistance Program: Update for Fiscal Year 2020.* Oak Ridge National Laboratory.

SBW Consulting, Inc. 2022. *Water-Energy Calculator 2.0 Project Report.* Project Report, San Francisco: California Public Utility Commission.

Smargiassi, Audrey: M Fournier: C Griot: Y Baudouin: T Kosatsky. 2008. "Prediction of the indoor temperatures of an urban area with an in-time regression mapping approach." *Journal of Exposure Science and Environmental Epidemiology.*

SPX Cooling Technologies . n.d. *Evaporative Cooling Towers.* Accessed December 2022. https://spxcooling.com/cooling-towers/.

SPX Cooling Technologies. n.d. *CoolSpec.* Accessed November 2022. 2022.

—. n.d. "CoolSpec." *SPX Cooling Technologies.* Accessed 2023. https://coolspec.com/.

State of California. n.d. *Employment Development Department, Quarterly Census of Employment and Wages (data search tool).* Accessed September 1, 2022. https://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=industry.

—. n.d. "Government Code Title 7 Division 1 Chapter 1.5 Article 4." *California Legislative Information.* Accessed 2023. https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?sectionNum=65040.12.&lawCode=GOV.

State of California, Employment Development Department. n.d. *Quarterly Census of Employment and Wages (data search tool).* Accessed September 1, 2022. https://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=industry.

Statewide CASE Team. 2013. "Cooling Tower Water Savings." 2013 California Building Energy Efficiency Standards, Codes and Standards Enhancement Initiative.

Statewide CASE Team. 2023. "Cooling Towers February 13th Stakeholder Meeting Presentation." https://title24stakeholders.com/wp-content/uploads/2023/02/2025-T24-Utility-Sponsored-Stakeholder-Meeting-1_Cooling-Towers-1.pdf.

Stone, Nehemiah, Jerry Nickelsburg, and William Yu. 2015. *Codes and Standards White Paper: Report - New Home Cost v. Price Study.* Pacific Gas and Electric Company. Accessed February 2, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/Migration-12-22-2015/Non-Regulatory/15-BSTD-01/TN%2075594%20April%202015%20Codes%20and%20Standards%20White%20Paper%20-%20Report%20-%20New%20Home%20Cost%20v%20Price%20Study.pdf.

Tessum, Christopher W., Joshua S. Apte, Andrew L. Goodkind, Nicholas Z. Muller, Kimberley A. Mullins, David A. Paolella, Stephen Polasky, et al. 2019. "Inequity in consumption of goods and services adds to racial–ethnic disparities in air pollution exposure." *PNSA* 113 (13). https://doi.org/10.1073/pnas.1818859116.

The Sarah Samuels Center for Public Health Research and Evaluation. 2016. *California FreshWorks Food Access Report.* The California Endowment.

Theresa Pistochini, Mark Modera. 2011. "Water-Use Efficiency for Alternative Cooling Technologies in Arid Climates." *Energy and Buildings, Volume 43, Issues 2–3, February–March 2011* 631-638.

Thornberg, Christopher, Hoyu Chong, and Adam Fowler. 2016. *California Green Innovation Index - 8th Edition.* Next 10.

Tomberlin, Gregg, Jesse Dean, and Michael Deru. 2020. "Continuous Monitoring and Partial Water Softening for Cooling Tower Water Treatment." NREL/TP7A40-76756.

Tomberlin, Gregg, Jesse Dean, and Michael Deru. 2018. *Electrochemical Water Treatment for Cooling Towers.* NREL.

Trane. n.d. *Trane Air-Cooled Chillers.* Accessed December 2022. https://www.trane.com/commercial/north-america/us/en/products-systems/chillers/air-cooled-chillers.html.

U.S. Bureau of Labor Statistics. n.d. *CPI Inflation Calculator.* Accessed March 2023. https://www.bls.gov/data/inflation_calculator.htm.

U.S. BUREAU OF LABOR STATISTICS. 2023. *U.S. Bureau of Labor Statistics.* January 25. Accessed 2023. https://www.bls.gov/cps/cpsaat18.htm.

U.S. Census Bureau, Population Division. 2014. "Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2014." http://factfinder2.census.gov/bkmk/table/1.0/en/PEP/2014/PEPANNRES/0400000US06.05000.

U.S. Department of Energy. 2020. "Improving Cooling Tower System Efficiency with Alternative Treatment Strategies." *Better Buildings Solution Center.* February 14. Accessed December 2022. https://betterbuildingssolutioncenter.energy.gov/videos/video-improving-cooling-tower-system-efficiency-alternative-water-treatment-strategies.

—. 2016. "Upgrade Cooling Tower Equipment and Operation." *Los Angeles Better Buildings Challenge.* Accessed December 2022. http://betterbuildingssolutioncenter.energy.gov/sites/default/files/tools/2016%20Cooling%20Tower%20Onesheet_6-9-2016.pdf.

U.S. DOE - Federal Energy Management Program. n.d. "Technical Evaluation of Side Stream Filtration for Cooling Towers." *Energy.gov.* Accessed December 2022. https://www.energy.gov/sites/prod/files/2013/10/f3/ssf_fact_sheet.pdf.

—. 2017. "Water and Wastewater Annual Price Escalation Rates for Selected Cities across the United States." September. Accessed January 2023. https://www.energy.gov/sites/prod/files/2017/10/f38/water_wastewater_escalation_rate_study.pdf.

U.S. DOE Federal Energy Management Program. n.d. *Best Management Practice #10: Cooling Tower Management.* Accessed February 2023. https://www.energy.gov/eere/femp/best-management-practice-10-cooling-tower-management.

U.S. EPA (United States Environmental Protection Agency). 2011. "Emission Factors for Greenhouse Gas Inventories." Accessed December 2, 2013. http://www.epa.gov/climateleadership/documents/emission-factors.pdf.

UCLA Labor Center. 2022. *Fast Food Frontline: COVID-19 and Working Conditions in Los Angeles.* Los Angeles: UCLA Labor Center.

United States Census Bureau. n.d. *Quick Facts 2019 and 2021.* Accessed September 12, 2022. United States Census Burhttps://data.census.gov/cedsci/table?t=Housing%20Units&g=0400000US06&tid=ACSCP5Y2020.CP04.

United States Environmental Protection Agency. 1995. "AP 42, Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources." https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors#5thed.

United States Environmental Protection Agency. 2018. "Emissions & Generation Resource Integrated Database (eGRID) 2016." https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.

United States Government Accountability Office . 2018. *K-12 EDUCATION Public High Schools with More Students in Poverty and Smaller Schools Provide Fewer Academic Offerings to Prepare for College.* United States Government Accountability Office .

Veritread. n.d. "Shipping Estimator." *www.veritread.com.* Accessed 2023. https://www.veritread.com/estimator/.

Water Management Inc. n.d. "Equivalent Full Load Cooling Hours/Year." *www.watermgt.com.* https://www.watermgt.com/Equivalent%20Full%20Load%20Cooling%20Hours.pdf.

Zabin, Carol, and Karen Chapple. 2011. *California Workforce Education & Training Needs Assessment: For Energy Efficiency, Distributed Generation, and Demand Reponse.* University of California, Berkeley Donald Vial Center on Employment in the Green Economomy. Accessed February 3, 2017. http://laborcenter.berkeley.edu/pdf/2011/WET_Appendices_ALL.pdf.

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. On March 27, 2023, the CEC provided the construction estimates 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 3.3.2 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 69 through Table 70 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 13, 2023 stakeholder meeting, five of five respondents indicated that one to 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 one percent of the high-rise and mid-rise multifamily buildings in California have cooling towers.

Table 69: 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	Percent of New Dwelling Units Impacted by	New Dwelling Units Impacted by Proposal in	Total Existing Dwelling Units in 2026 [D]	Percent of Existing Dwelling Units Impacted by	Dwelling Units Impacted by Proposal in

	Construction) [A]	Proposal [B]	2026 C = A x B		Proposal [E]	2026 F = D x E
1	144	0.0%	0	17,558	0.0%	0
2	1,391	0.3%	4	105,894	0.3%	334
3	7,699	0.0%	0	553,186	0.0%	0
4	3,417	0.3%	11	288,786	0.3%	910
5	285	0.3%	1	45,671	0.3%	144
6	2,243	0.3%	7	322,513	0.3%	1,016
7	5,156	0.3%	16	307,272	0.3%	968
8	8,600	0.3%	27	515,137	0.3%	1,623
9	10,302	0.3%	32	1,117,605	0.3%	3,520
10	4,306	0.3%	14	329,302	0.3%	1,037
11	1,173	0.0%	0	85,339	0.0%	0
12	5,537	0.3%	17	471,876	0.3%	1,486
13	1,009	0.3%	3	157,075	0.3%	495
14	1,446	0.0%	0	83,480	0.0%	0
15	373	0.3%	1	41,152	0.3%	130
16	187	0.0%	0	28,066	0.0%	0
TOTAL	**53,268**		**134**	**4,310,108**		**11,662**

Table 70: 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 71 and nonresidential existing statewide building stock is presented in Table 72. The projected nonresidential new construction that would be impacted by the proposed code change in 2026 is presented in Table 73 through Table 74. 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 75 through Table 76. 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.](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 71.

The Statewide CASE Team made assumptions about the percentage of newly constructed floorspace that would be impacted by the proposed code change. Table 77 through Table 78 present 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 79 through Table 80 present 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. 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 and blowdown, as outlined in Table 79 and Table 80. Additionally, based on input from stakeholders, the Statewide CASE Team assumed that 50 percent of cooling tower customers pursue alternatives to the prescriptive efficiency requirement, either through exemptions for climate zones or for cooling towers located inside of existing buildings or on rooftops, or by pursuing the performance path. The savings accounted for this trend using a 50 percent factor in each of the impacted climate zones for both new construction/additions and alterations.

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, 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 cooling tower efficiency measure and blowdown measure on existing buildings, as outlined in Table 77 to Table 80.

The cooling tower efficiency was found to be cost effective in Climate Zones 4, 6-10, 12, and 15 for new construction buildings and additions, and Climate Zones 2, 4-10, 12-13, and 15 for alterations. The blowdown measure is applicable to all climate zones.

Table 71: 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 72: 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 73: 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	0.36	0.00	0.32	0.19	0.52	0.93	0.09	0.00	0.13	0.00	0.00	0.00	0.00	**2.53**
Medium Office	0.00	0.03	0.00	0.04	0.02	0.06	0.04	0.09	0.17	0.06	0.00	0.15	0.03	0.00	0.01	0.00	**0.70**
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	0.01	0.00	0.01	0.00	0.01	0.01	0.02	0.03	0.02	0.00	0.01	0.01	0.00	0.00	0.00	**0.14**
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	0.01	0.00	0.03	0.00	0.04	0.04	0.06	0.09	0.05	0.00	0.07	0.04	0.00	0.01	0.00	**0.42**
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	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	**0.04**
Assembly	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.05**
Hospital	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.02	0.00	0.02	0.01	0.00	0.00	0.00	**0.10**
Laboratory	0.00	0.02	0.00	0.07	0.01	0.04	0.03	0.05	0.09	0.04	0.00	0.04	0.01	0.00	0.00	0.00	**0.40**
Restaurant	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.05**
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**	**0.1**	**0.0**	**0.5**	**0.0**	**0.5**	**0.3**	**0.8**	**1.4**	**0.3**	**0.0**	**0.4**	**0.1**	**0.0**	**0.0**	**0.0**	**4.4**

Table 74: 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	1.46	0.71	0.00	0.64	0.37	1.03	1.87	0.18	0.05	0.26	0.00	0.09	0.01	0.02	**6.68**
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	0.11	0.05	0.00	0.07	0.08	0.11	0.18	0.11	0.04	0.14	0.08	0.02	0.01	0.01	**1.03**
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	0.03	0.01	0.04	0.01	0.01	0.00	0.00	**0.26**
Laboratory	0.00	0.04	0.27	0.15	0.02	0.09	0.06	0.10	0.17	0.07	0.03	0.09	0.02	0.02	0.01	0.01	**1.12**
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**	**0.6**	**1.5**	**2.7**	**0.6**	**0.2**	**0.9**	**0.2**	**0.2**	**0.1**	**0.1**	**11.4**

Table 75: 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	0.04	0.00	0.91	0.02	1.25	0.91	2.04	3.80	0.73	0.00	0.99	0.12	0.00	0.06	0.00	**10.87**
Medium Office	0.00	0.08	0.00	0.11	0.04	0.13	0.12	0.16	0.23	0.18	0.00	0.27	0.07	0.00	0.03	0.00	**1.39**
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	0.00	0.03	0.01	0.05	0.04	0.08	0.12	0.08	0.00	0.07	0.03	0.00	0.01	0.00	**0.53**
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	0.03	0.00	0.05	0.01	0.10	0.08	0.15	0.26	0.20	0.00	0.19	0.09	0.00	0.03	0.00	**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	0.00	0.01	0.00	0.01	0.01	0.02	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	**0.11**
Assembly	0.00	0.01	0.00	0.01	0.00	0.02	0.01	0.03	0.04	0.03	0.00	0.02	0.01	0.00	0.00	0.00	**0.17**
Hospital	0.00	0.01	0.00	0.03	0.01	0.03	0.03	0.04	0.08	0.04	0.00	0.06	0.02	0.00	0.01	0.00	**0.36**
Laboratory	0.00	0.02	0.00	0.14	0.01	0.06	0.09	0.08	0.10	0.06	0.00	0.06	0.02	0.00	0.00	0.00	**0.65**
Restaurant	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.03	0.03	0.00	0.01	0.01	0.00	0.00	0.00	**0.13**
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**	**0.2**	**0.0**	**1.3**	**0.1**	**1.7**	**1.3**	**2.6**	**4.7**	**1.4**	**0.0**	**1.7**	**0.4**	**0.0**	**0.1**	**0.0**	**15.4**

Table 76: 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 77: 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 78: 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 79: 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%	0.0%
2	2.0%	0.1%
3	0.0%	0.0%
4	4.6%	0.2%
5	2.0%	0.1%
6	3.1%	0.2%
7	3.6%	0.2%
8	3.8%	0.2%
9	5.0%	0.3%
10	2.4%	0.1%
11	0.0%	0.0%
12	2.8%	0.2%
13	1.9%	0.1%
14	0.0%	0.0%
15	1.8%	0.1%
16	0.0%	0.0%

Table 80: 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	4%	0%
3	10%	0%
4	9%	0%
5	4%	0%
6	6%	0%
7	7%	0%
8	8%	0%
9	10%	1%
10	5%	0%
11	6%	0%
12	6%	0%
13	4%	0%
14	6%	0%
15	4%	0%
16	6%	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 3.3 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 3.1.1, 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 70-90 GPM/HP, dependent on climate zone. 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 70-90 GPM/HP dependent on climate zone 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 70-90 GPM/HP dependent on climate zone 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 3.3 and 4.3 and GHG emissions impacts are detailed in Sections 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 blowdown controls measure, would have significant impacts on water consumption. Methodology and estimates of the water impacts are provided in Section 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 presented in Sections 3.5.4 and 4.5.4. 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).[24, 25] These industry-wide EPDs provide global warming potential (GWP) values per weight of specific materials.[26] The Statewide CASE Team chose the industry-wide average for GWP values in the EPDs because the materials accounted for in the statewide calculation would have a range of embodied carbon. That is, 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 would 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

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[24] 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.

[25] 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 lifecycle 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.

[26] GWP values for concrete and wood were in units of kg CO_2 equivalent by volume of the material rather than by weight. An average density of each material was used to convert volume to weight.

impacts (emissions reduced). Table 81 presents estimated first-year GHG emissions impacts associated with embodied carbon.

A comprehensive accounting of buildings' GHG emissions would include operational emissions (e.g., emissions from energy use) and embodied carbon. Title 24, Part 6 addresses energy use in buildings and results in reductions in operational GHG emissions. The Statewide CASE Team has provided embodied carbon impacts of the proposed code changes, which could support an informed dialogue on how operational emissions and embodied emissions be considered together in the future. The information provided in this report is an incomplete accounting of whole-building embodied carbon and does not account for interactive effects that the proposal may have on other elements of the building design or material use. There may be instances where a specific system or component may increase emissions through embodied carbon but enable the building as a whole to have lower total emissions (operational plus building-wide embodied carbon).

Table 81: First-Year Embodied Carbon Emissions Impacts

Material	Impact	First-Year [a] Statewide Impacts (Pounds)	Embodied GHG Emissions Reductions (Metric Tons CO2e)
Steel	Increase	146,563	-81
Plastic	Increase	38,962	-33
TOTAL	-	**185,525**	**-114**

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

Appendix E: Discussion of Impacts of Compliance Process on Market Actors

This appendix discusses how the recommended compliance process, described in Sections 3.1.5 and 4.1.5, could impact various market actors. Table 82 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 82 through Table 83 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.
- **Blowdown Controls:** The mechanical designer would be required to complete the cycles of concentration compliance document, working with building owners and architects to collect required information. 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 82 to Table 83 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 82: 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 would the proposed measure impact the current task(s) or workflow?	How would 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
Architect	Inform load calculations	Additional coordination and space required for potentially larger mechanical equipment	N/A	N/A

Market Actor	Task(s) in current compliance process relating to the CASE measure	How would the proposed measure impact the current task(s) or workflow?	How would the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
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 83: 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 would the proposed measure impact the current task(s) or workflow?	How would 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 Form	Training on use of NRCC-MCH-E Form
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 NRCC-MCH-E Form

Market Actor	Task(s) in current compliance process relating to the CASE measure	How would the proposed measure impact the current task(s) or workflow?	How would the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
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 Form	Code training and training on use of NRCC-MCH-E Form
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
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 Form	Code training and training on use of updated NRCC-MCH-E form and acceptance tests
ATT	• Verify programming of blowdown controls and functionality of overflow alarms per acceptance test • Document results of acceptance testing	Be aware of new acceptance test requirements and procedures for cooling tower blowdown controls	• Requirement of new acceptance test • Updates to NRCC-MCH-E Form	Code training and training on use of NRCC-MCH-E Form and acceptance tests

Appendix F: Summary of Stakeholder Engagement

A critical aspect of the Statewide CASE Team's efforts is collaborating with stakeholders about the potential impact proposed changes. 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 Final CASE Report are supported. Public stakeholders provide valuable feedback on draft analyses and help identify and address challenges to adoption: cost effectiveness; market barriers; technical barriers; compliance and enforcement challenges; or potential impacts on human health or the environment. 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 84. 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 84: 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.

A Draft CASE Report was published in May 2023. The CASE Team received written comments from four stakeholders in response to the draft and also held meetings with these stakeholders to further discuss their comments. The CASE Team considered these comments carefully and made updates to the analysis and proposal in response to these comments as discussed in detail in the main report. The CASE Team appreciates the significant time and productive engagement from stakeholders on this proposal.

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 85.

Table 85: Engaged Stakeholders

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections

SPX Cooling Technologies, Inc.	Cooling Tower Manufacturer	3.2.1, 3.2.2, 3.5.4
Evapco, Inc.	Cooling Tower Manufacturer	3.2.1, 3.2.2, 3.5.4
BAC	Cooling Tower Manufacturer	3.2.1, 3.2.2, 3.5.4
Carrier Corporation	Air-Cooled Chiller Manufacturer	
Daikin	Air-Cooled Chiller Manufacturer	
AHRI	Manufacturer Trade Association	
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	
ASHRAE Technical Committees 3.6 and 8.6	Industry Group Technical Subcommittee	
Norman Wright	HVAC Distributor	

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 3.4 and 4.4 of this report. This appendix presents energy cost savings in nominal dollars.

Table 86: Nominal LSC 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	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.08	0.00	0.08
5	0.00	0.00	0.00
6	0.18	0.00	0.18
7	0.21	0.00	0.21
8	0.35	0.00	0.35
9	0.22	0.00	0.22
10	0.34	0.00	0.34
11	0.00	0.00	0.00
12	0.10	0.00	0.10
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.62	0.00	0.62
16	0.00	0.00	0.00

Table 87: Nominal LSC Savings Over 30-Year Period of Analysis – Per Square Foot – Cooling Tower Efficiency – Alterations – OfficeLarge

Climate Zone	30-Year LSC Electricity Savings (Nominal $)	30-Year LSC Natural Gas Savings (Nominal $)	Total 30-Year LSC Savings (Nominal $)
1	0.00	0.00	0.00
2	0.05	0.00	0.05
3	0.00	0.00	0.00
4	0.08	0.00	0.08
5	0.03	0.00	0.03
6	0.18	0.00	0.18
7	0.21	0.00	0.21
8	0.35	0.00	0.35
9	0.22	0.00	0.22
10	0.34	0.00	0.34
11	0.00	0.00	0.00
12	0.10	0.00	0.10
13	0.28	0.00	0.28
14	0.00	0.00	0.00
15	0.62	0.00	0.62
16	0.00	0.00	0.00

Table 88: Nominal Lifecycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Blowdown Controls – New Construction/Additions – Hospital

Climate Zone	30-Year Lifecycle Water Cost Savings (Nominal $)
1	0.01
2	0.19
3	0.10
4	0.30
5	0.12
6	0.24
7	0.26
8	0.39
9	0.37
10	0.44
11	0.45
12	0.31
13	0.49
14	0.42
15	0.88
16	0.15

Table 89: Nominal Lifecycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Blowdown Controls – New Construction/Additions – OfficeLarge

Climate Zone	30-Year Lifecycle Water Cost Savings (Nominal $)
1	N/A
2	N/A
3	0.06
4	0.18
5	N/A
6	0.13
7	0.14
8	0.22
9	0.21
10	0.24
11	0.24
12	0.17
13	N/A
14	0.22
15	0.46
16	0.08

Table 90: Nominal Lifecycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Blowdown Controls – Alterations – Hospital

Climate Zone	30-Year Lifecycle Water Cost Savings (Nominal $)
1	0.01
2	0.19
3	0.10
4	0.30
5	0.12
6	0.24
7	0.26
8	0.39
9	0.37
10	0.44
11	0.45
12	0.31
13	0.49
14	0.42
15	0.88
16	0.15

Table 91: Nominal Lifecycle Water Cost Savings Over 30-Year Period of Analysis – Per Square Foot – Blowdown Controls – Alterations – OfficeLarge

Climate Zone	30-Year Lifecycle Water Cost Savings (Nominal $)
1	0.01
2	0.12
3	0.06
4	0.18
5	0.07
6	0.13
7	0.14
8	0.22
9	0.21
10	0.24
11	0.24
12	0.17
13	0.25
14	0.22
15	0.46
16	0.08

Appendix H: Proposed Revisions to NRCC-MCH-E Compliance Document

The Final CASE Report proposes to update the existing NRCC-MCH-E compliance form to include the parameters and thresholds identified in ASHRAE/ANSI 189.1-2020 for conductivity, alkalinity, calcium hardness, total dissolved solids, chloride, sulfates, silica, and LSI. The proposed forms are shown in Figure 13 and Figure 14.

M. COOLING TOWERS

[d:OnlyUI] *Table Instructions: Complete the following Table for cooling towers with a rated capacity > 150 tons to demonstrate compliance with mandatory requirements in* §110.2(e)2. *This Table calculates the Maximum Cycles of Concentration using the Langelier Saturation Index (LSI) calculations per* §110.2(e)2. [d:/OnlyUI] [d:OnlyRG] *This table is used to demonstrate compliance with mandatory requirements in* §110.2(e)2 *for cooling towers with a rated capacity > 150 tons. This Table calculates the Maximum Cycles of Concentration using the Langelier Saturation Index (LSI) calculations per* §110.2(e)2. [d:/OnlyRG]

01	☐	Check the box if the project is showing calculations on the plans, or attaching the calculations instead of completing this Table.

02	03	04	05	06	07	08	09						11
Name or Item Tag	Design Conditions		Rated Conditions	Maximum Skin Temp (˚F)	Conductivity (micro-ohms)	M-Alkalinity	Calcium Hardness	Total Dissolved Solids (ppm)	Chlorides as Cl (ppm)	Sulfates (ppm)	Silica (ppm)	LSI	**Target Tower Cycles**
	Design GPM	Min Flow GPM	GPM/HP										
1				110	130.0	65.0	43.5	90.0	3.9	10.0		2.5	
				Maximum Cycles of Concentration Based on 189.1	22.8	8.3	12.4	20.5	69.2	22.5		7.4	**7.4**

Figure 13: Proposed NRCC-MCH-E compliance document

rate compliance with mandatory requirements in §110.2(e)2. *This Table calculates the Maximum Cycles of Concentration using the Langelier Saturation Index (LSI) calculations per* §110.2(e)2. [d:/OnlyUI] [d:OnlyRG] *This table is used to demonstrate compliance with mandatory requirements in* §110.2(e)2 *for cooling towers with a rated capacity > 150 tons. This Table calculates*

ns, or attaching the calculations instead of completing this Table.

06	07	08	09						11
Maximum Skin Temp (˚F)	Conductivity (micro-ohms)	M-Alkalinity	Calcium Hardness	Total Dissolved Solids (ppm)	Chlorides as Cl (ppm)	Sulfates (ppm)	Silica (ppm)	LSI	**Target Tower Cycles**
110	130	65	=87/2	90	3.9	10		2.5	
Maximum Cycles of Concentration Based on 189.1	=IFERROR(2970/G9,"")	=IFERROR(540/H9,"")	=IFERROR(540/I9,"")	=IFERROR(1845/J9,"")	=IFERROR(270/K9,"")	=IFERROR(225/L9,"")	=IFERROR(135/M9,"")	=10^((-1/2.038895)* (LOG(H9*0.9*1.219)-0.061105*LOG(G9*0.8)+0.55*LOG(I9*H9)+0.0050325*F9-5.95))	=MIN(G11:N11)

Figure 14: Proposed NRCC-MCH-E compliance document with equations shown.

Appendix I: RSMeans 2021 California Location Factors

Table 92: RSMeans 2021 California Location Factors

Building 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