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Final CASE Report - Nonresidential HVAC Controls

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Codes and Standards Enhancement (CASE) Initiative

2025 California Energy Code

Nonresidential HVAC Controls

Nonresidential HVAC

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Final CASE Report

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

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Executive Summary

The goal of this CASE Report is to present a cost-effective code change proposal that would require the use of detailed, uniform sequences of operation for heating, ventilation, and air conditioning (HVAC) systems. This measure would apply to all nonresidential building types, including new and replacement systems or alterations, with the exception of health care occupancies.

This analysis found that the proposed code change would generate energy savings in all climate zones. The first-year statewide electricity savings of this measure for new construction, additions, and alterations are 44.5 gigawatt-hours per year (GWh/y). Due to reduced cooling loads, the proposed code change would result in reduced outdoor water use at cooling towers. The first-year on-site outdoor water savings for new construction, additions, and alterations are 50,358,892 gallons.

Three California investor-owned utilities (IOUs)—Pacific Gas and Electric Company, San Diego Gas & 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 goal of the program is to prepare and submit proposals that would result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposals presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

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

Proposed Code Change

This CASE measure would add requirements for the use of control sequences from ASHRAE Guideline 36. The purpose of Guideline 36 is to provide detailed, uniform sequences of operation for HVAC systems that are intended to maximize energy efficiency and performance, provide control stability, and allow for real-time fault detection and diagnostics. Where there are existing prescriptive HVAC control requirements in the California Energy Code for direct digital control (DDC) systems, this measure would further require that the associated control sequences to be in accordance with Guideline 36. This measure would include a prescriptive requirement that controls programming for DDC systems using control logic from an CEC-certified Guideline 36 programming library, based on certification requirements in a new joint appendix.

This measure would apply to all nonresidential building types, including new and replacement systems or alterations, with the exception of health care occupancies. The proposal would include updates to acceptance tests, and the intent is to include compliance credits for the performance approach for projects that use certified Guideline 36 programming libraries.

This change would streamline the delivery of HVAC control systems and reduce the level of effort in design, construction, and commissioning. Guideline 36 saves energy, time, and effort, and it improves compliance with existing code requirements.

Table 1: Scope of Code Change Proposal

Type of Requirement	Prescriptive
Applicable Climate Zones	All
Modified Section(s) of Title 24, Part 6	100.1(b), 140.4(c)2, 140.4(d)2A, 140.4(e)2, 140.4(f), new section 140.4(r), 141.0(b), Appendix 1-A
Modified Title 24, Part 6 Appendices	New Joint Appendix
Would Compliance Software Be Modified	Yes
Modified Compliance Document(s)	2025-NRCC-MCH-E, 2025-NRCI-MCH-E, 2025-NRCA-MCH-18-A, 2025-NRCC-PRF-01-E

Cost Effectiveness

The proposed code change was found to be cost effective for all climate zones where it is proposed to be required. The benefit-to-cost (B/C) ratio over the 30-year period of analysis is infinite, because the proposed measure has no incremental cost compared to current standard practice. See Section 6.5 for the methodology, assumptions, and results of the cost-effectiveness analysis.

Addressing Energy Equity and Environmental Justice

The Statewide CASE Team reviewed published studies that considered how DIPs would be impacted by the proposed measure. The measure would reduce the impacts of disparities in DIPs. Full details addressing energy equity and environmental justice can be found in Section 2 of this report.

1. Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (CEC) 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 & 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. The CEC would 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 a code change proposal referencing American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Guideline 36. The report contains pertinent information supporting the proposed code change.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders including manufacturers, designers, contractors, 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 February 27, 2023 (Statewide CASE Team 2023).

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

- **Section 2: Addressing Energy Equity and Environmental Justice** presents the potential impacts of proposed code changes on disproportionately impacted populations (DIPs), as well as a summary of research and engagement methods.
- **Section 3: 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: Market Analysis** includes a review of the current market structure. Section 4.2 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, as well as whether technical, compliance, or enforceability challenges exist.
- **Section** 5**: Energy Savings** presents the per-unit energy, demand reduction, and Long-term Systemwide Cost (LSC) 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 LSC savings.
- **Section 6: 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** 7**: 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 on material, either increases or reductions, with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also reported in this section.
- **Section 8: Proposed Revisions to Code Language** concludes the report with specific recommendations with ~~strikeout~~ (deletions) and underlined (additions) language for the Standards, Reference Appendices, and Alternative Calculation Method (ACM) Reference Manual. Generalized proposed revisions to sections are included for the Compliance Manual and compliance forms.
- **Section** 9**: Bibliography** presents the resources that the Statewide CASE Team used when developing this report.
- **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 greenhouse gas (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 LSC savings over the period of analysis in nominal dollars.

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 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.[1]

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 Rupam Singla (RSingla@trccompanies.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

[1] 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.

beyond.[2] To 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. Results of that outreach as well as a summary of the 2025 code cycle EEEJ activities will 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 & 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 would come to an end, the Statewide CASE Team's EEEJ efforts would 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

[2] 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 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.).

with a goal of engagement with these organizations representing DIPs throughout the code cycle. Several strategies for future code cycles are being considered, including:

- Creating an advisory board of trusted community-based organizations 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

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 Cost and Cost Effectiveness 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, SO2, and PM2.5.
- **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, schools, etc., 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.

Appendix AOffice buildings of all sizes
Appendix BRetail buildings of all sizes
Appendix CNon-refrigerated buildings
Appendix DLaboratories
Appendix EOpen air parking garage
Appendix FVehicle service

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

Strip Mall

Proposals for the strip mall building type have the potential to create disproportionate impacts. The benefits of strip malls are complex and vary based on factors such as location, economic conditions, and community needs. Rents in strip malls are often more affordable than they would be in heavily trafficked or more upscale areas. Strip malls often serve as affordable business centers for DIPs. Some shop owners indicate strip mall stores feel like “the center of social life” (Ramanathan 2017). 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 costs to secure business locations. Black entrepreneurs are almost three times more likely to lose profitability due to start-up costs compared to white entrepreneurs (Morelix 2016). Increases in cost could disrupt these DIP-owned businesses even more.

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 many 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.

Assembly

While proposals to most assembly buildings would not have a disproportionate impact, some of the buildings such as places of worship, community or recreation centers, homeless shelters used for temporary housing, and libraries, for example could more significantly affect DIPs. Places of worship can be valuable community fixtures for DIPs. Forty-seven percent of Black people and 39 percent of Latinx people report attending religious services weekly, compared to only 32 percent for White people (Pew Research Center 2023). Churches and other community assembly buildings serve as significant spaces for spiritual, cultural, and economic resources for DIPs. Specifically, building types that provide shelter in times of extreme weather events; aid in disaster preparedness; or provide shelter, food, or other resources to those in need would be more likely to result in disproportional impacts. Shelters and churches serve DIP populations. 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.

Grocery

Proposals for groceries could affect DIPs more significantly than the general population, particularly those who work in grocery buildings, own a small grocery business, or depend upon a specific grocery as a food source in a food desert. An estimated 23.5 million Americans live in food deserts (Chapple n.d.). Defined as an area with "limited access to a variety of healthy and affordable food," food deserts put a significant health burden on DIPs. In California almost 1 million people live in food deserts (The Sarah Samuels Center for Public Health Research and Evaluation 2016). Living in a food desert can raise the price of living and cause people to travel further for food. Nearly two-thirds of Californians have reported feeling "very concerned" about paying for their rent with the rising cost of living (Public Policy Institute of California 2022). Even higher prices due to proposed measures and longer distances for food have the potential to harm DIPs. Proposals that impact incremental cost, health, resiliency, and comfort all have the potential to disproportionately impact those working in grocery buildings or relying on them as one of their only food sources in a food desert.

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

2.2.1 Research Methods and Engagement

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 other than reducing the impacts of disparities in DIPs. The Statewide CASE Team does not recommend further research or action at this time. There are no incremental first costs or incremental maintenance and replacement costs associated with this measure. Also, thermal comfort and indoor air quality is either improved by this measure or does not significantly change. As a result, the measure would unlikely have any significant impacts on energy equity or environmental justice.

3. Measure Description

3.1 Proposed Code Change

This CASE measure would add requirements for the use of control sequences from ASHRAE Guideline 36 in new HVAC systems. The purpose of Guideline 36 is to provide detailed, uniform sequences of operation for heating, ventilation, and air conditioning (HVAC) systems that are intended to maximize energy efficiency and performance, provide control stability, and allow for real-time fault detection and diagnostics (FDD). Where there are existing prescriptive HVAC control requirements in the energy standard for direct digital control (DDC) systems, this measure would require that the associated control sequences are in accordance with Guideline 36. This measure would include a prescriptive requirement that controls programming for DDC systems using control logic from a CEC-certified Guideline 36 programming library, based on certification requirements in a new joint appendix.

This measure would apply to all nonresidential buildings, including new and replacement systems or alterations, with the exception of health care occupancies that rely on airside VAV HVAC systems. New or replacement components of systems, such as added or replaced VAV terminal zones, would not be covered under this measure. The proposal would include updated acceptance tests, which provide compliance credits for projects that use certified Guideline 36 programming libraries.

3.2 Background Information and Justification

3.2.1 Background Information

ASHRAE Guideline 36 provides standardized sequence logic for the control of select HVAC systems and equipment. The ASHRAE Guideline 36 Committee established high-performance sequences based on a survey of existing logic that has been vetted and improved over decades through a consensus process. Guideline 36 is a set of standardized sequences that prioritizes energy efficiency, ease of operation, indoor air quality, thermal comfort, and code compliance. The guideline is under continuous maintenance, through a process overseen by a committee of volunteers. The guideline is republished every three years, incorporating any approved addenda since the last publication. Guideline 36 covers the following air handling systems: multiple-zone VAV air handling unit; dual-fan, dual-duct heating VAV air handling unit; and single-zone VAV air handling unit. Guideline 36 also covers chilled water plants, hot water plants, fan coil units, and numerous types of terminal units.

As a point of reference, the Best-in-Class (BIC) research project funded by the CEC (Cheng, Eubanks and Singla 2022) demonstrated the cost effectiveness and energy savings potential of installing optimized control sequences based on Guideline 36 in existing commercial buildings. The existing building conditions generally resemble those the Statewide CASE Team used for baseline building assumptions for savings analysis. Replacing building control systems achieved between 53 and 60 percent HVAC energy savings with six- to eight-year simple paybacks. Updating software control sequences in buildings that already had modern digital control systems (installed within 10 years) provided electricity savings of 12 to 23 percent with two- to seven-year simple paybacks. Figure 1 below shows that HVAC energy use intensities before and after retrofit for software-only retrofit sites (excluding hardware), with energy end uses broken out. Although the BIC software-only retrofit demonstration sites were all office buildings, ASHRAE Guideline 36 applies to all nonresidential buildings.

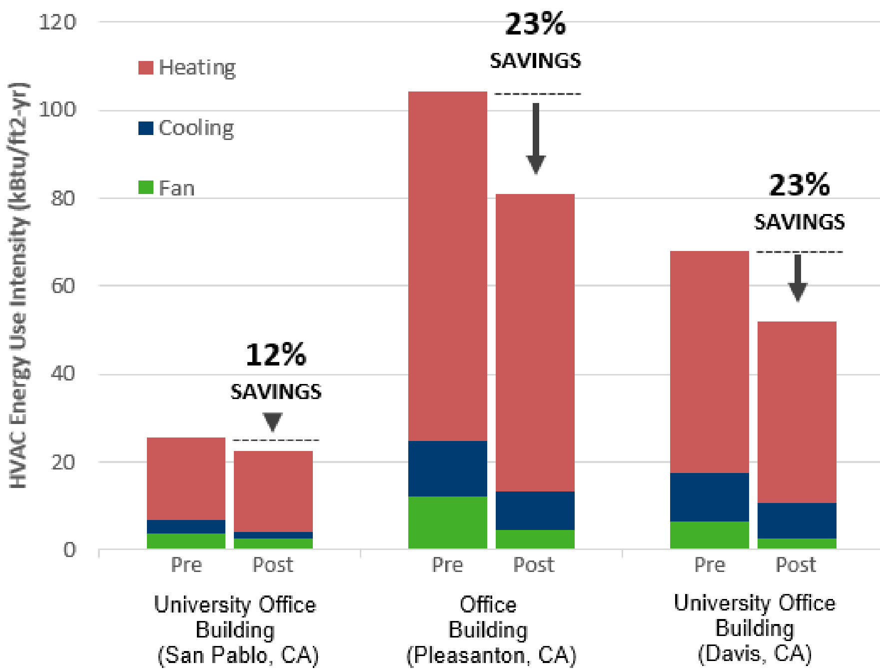

Figure 1: HVAC energy savings across retrofit sites, software-only retrofit sites.

Source: (Cheng, Paliaga and Singla 2022)

These demonstrations were cost effective as retrofit projects, whereas use of Guideline 36 in new construction would have significantly lower incremental first costs. Further, use of Guideline 36 in new construction is expected to reduce first costs with standardization and the use of manufacturer Guideline 36 programming libraries, which would reduce programming and troubleshooting efforts.

According to a simulation study of medium office buildings in three California climate zones, adapted from the U.S. DOE commercial reference building model, they achieved an average of 30 percent HVAC annual savings when using Guideline 36 control strategies relative to a wide range of baseline conditions representing current practice (Zhang, Blum, et al. 2022).

In addition to the energy savings potential, the BIC research project found that modern DDC systems are generally operated with custom programming logic created by the installing contractor. Though most building HVAC systems are generally similar, the current industry practice is to develop custom sequences and control programming for each application or to adapt logic from a similar recent project. In addition to the process inefficiency of reinventing the wheel for each project, this practice also introduces the risk of problems and operational inefficiencies, such as poorly written sequences or incorrectly implemented programs. Industry standardization around Guideline 36 offers a potential for market transformation by streamlining the building automation system (BAS) market processes through design, implementation, and operation. With standardization, BAS manufacturers can centrally pre-program and pre-validate the logic in their software libraries, which would improve quality and greatly reduce effort required on each project for programming and commissioning.

Many of the key HVAC control strategies in Guideline 36 are already required in concept by Title 24, Part 6, either as mandatory or prescriptive requirements. By adding the requirement to use Guideline 36 control sequences, the Statewide CASE Team anticipates that compliance with these existing requirements would improve by providing references to the sequences that describe how to effectively implement these control strategies. Further, use of certified Guideline 36 programming libraries would streamline the design, construction, and compliance processes, as well as improve quality and reduce first costs.

While Title 24, Part 6 has a robust set of HVAC controls requirements in both the mandatory and prescriptive sections, compliance with these requirements is often poor. The Statewide CASE Team's professional experience and research suggests that these deficiencies result from insufficient specification at design, insufficient attention to programming, or verification of control logic, as opposed to fundamental limitations of the control system hardware. The proposed requirement to use certified Guideline 36 programming libraries would address both challenges.

A recent Pacific Northwest National Laboratory (PNNL) report found an HVAC controls code requirement compliance rate of 60 percent based on a field survey of recently constructed buildings (Rosenberg, et al. 2017). Although none of the surveyed buildings are in California, the buildings studied span five states and 19 distinct enforcement jurisdictions across the Pacific Northwest, all of which have code requirements for common HVAC controls measures that are similar to California's Title 24, Part 6.

The controls installer found that for HVAC energy efficiency measures in particular, system capabilities consistently exceeded system configuration, as revealed in the same field study. Therefore, the control system was able to support the required energy savings strategies and sequences, even though it was not initially programmed to do so.

The PNNL report also notes that based on interviews with commissioning agents, the specification of controls requirements in design documents are often insufficient, lack detail, and rely on the judgement of the installing contractor. This is consistent with the Statewide CASE Team's professional judgement and experience.

Additional research that used BAS data to evaluate energy efficiency opportunities in 151 buildings nationwide, including 6 in California (Katipamula, et al. 2021), found that the most common opportunities were to add or repair supply and discharge air temperature reset logic and duct static pressure reset logic. Research (Crowe, et al. 2022), which analyzed 18 million rows of HVAC fault data from commercial buildings, further supports the finding that supply temperature setpoint reset and duct static pressure setpoint reset faults are common and frequently prevent these strategies from saving energy.

A study of third-party economizers on rooftop units (RTUs) in California (Fox, et al. 2021) further supports this conclusion. The study specifically investigated the field-installed electronic fault detection and control units required by Title 24 since 2013. The study found that only 12 percent of the controllers were correctly installed and programmed, and 23 percent of the units had no ability to modulate outside air at all, indicating that building inspectors were not enforcing acceptance testing requirements. Although the regulated equipment is different (packaged RTUs vs. field-programmed BAS), the Statewide CASE Team draws a clear analogy between the RTU FDD requirement and the existing code requirement for specific control strategies and resets—both are installed by contractors in the field, with only acceptance tests and inspections to enforce compliance.

The Statewide CASE Team notes that these problems are not recent or new. A 2002 literature review examining 40 case studies that documented 450 controls-related faults in 70 buildings found that more than one-third of the faults could be attributed to faulty or incomplete programming (Barwig, et al. 2002).

The proposed requirement to use certified Guideline 36 programming libraries would address the consistent process gaps at both the design and verification stages by shifting some responsibility for correct implementation of detailed control logic from the contractors to the BAS manufacturers. Adding this requirement does not necessarily introduce new burden to projects, rather, it provides a means and directs projects to available resources to streamline processes and improve quality and compliance. Title 24, Part 6 already requires that these measures be implemented; Guideline 36 provides direction on how to do so, and emerging tools make it easier to do so, as described in Section 4.2.

3.2.2 Justification

This measure streamlines the delivery of HVAC control systems and leverages major economies-of-scale to reduce the level of effort from design through construction and commissioning. Use of Guideline 36 improves quality using high-performance sequences of operation that have been peer reviewed and developed on a consensus basis by nationwide experts. As described below, compared to conventional design and construction practices, use of Guideline 36 control sequences saves energy, time, and effort, and it improves compliance with existing code requirements.

Guideline 36 provides an opportunity to streamline the BAS design, construction, and commissioning processes, as depicted in Figure 2:. By using Guideline 36, designers can save on engineering time compared to the business-as-usual approach of developing custom sequences of operation, points lists, and schematics. In construction, the controls contractor designs and installs the BAS software, an effort that would be reduced by using manufacturer Guideline 36 programming libraries. Guideline 36 would also streamline commissioning for both the contractor and the commissioning provider. By pretesting manufacturer programming at the factory, this would eliminate required field testing.

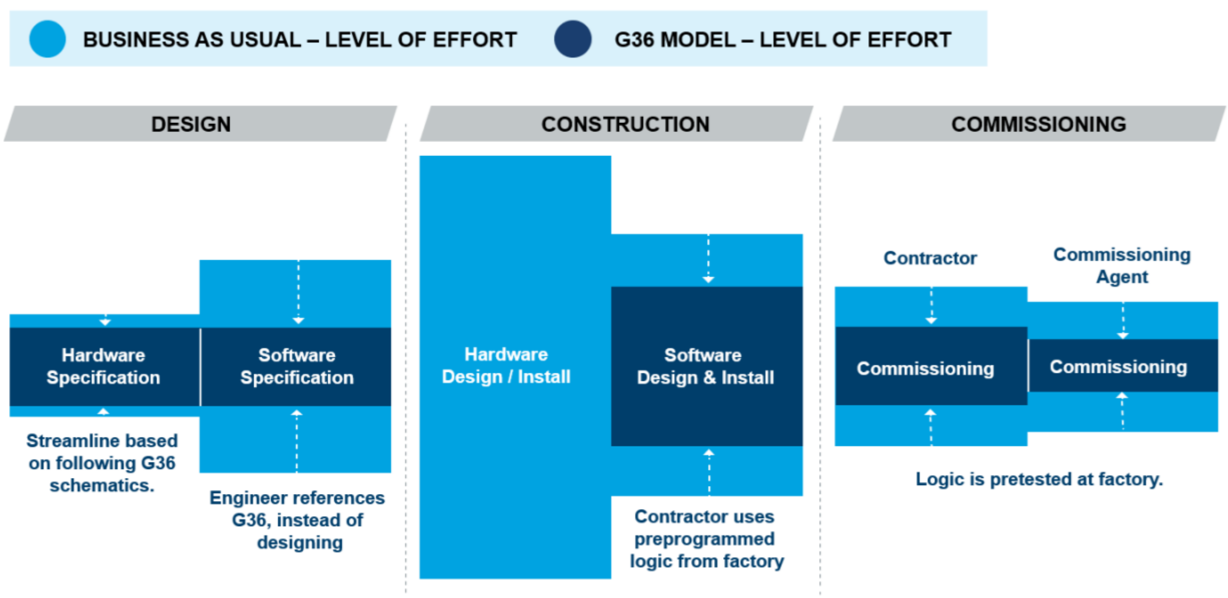

Figure 2: Reduced level of effort with Guideline 36.

Source: (Cheng, Paliaga and Singla 2022)

Guideline 36 provides value to a wide range of industry stakeholders throughout the design and construction process, as shown in Figure 3. With Guideline 36, facilities management, building owners, design engineers, controls contractors, controls manufacturers, and commissioning providers would secure cost savings and improved occupant comfort. Building owners would benefit from lower design and construction costs and improved thermal comfort, leading to fewer occupant complaints. Less effort would be required by design engineers, controls contractors, and commissioning providers to design, implement, and test systems, and they would see an increase in customer satisfaction. As a result, controls contractors and commissioning providers can expect an increase in market demand, which can have significant economic benefits.

	FACILITIES MANAGEMENT	OWNER	CONTROLS DESIGNER	CONTROLS CONTRACTOR	CONTROLS MANUFACTURER	COMMISSIONING AGENT
Energy		Reduced energy use and costs				
Implementation Effort	Reduced staff training and maintenance cost	Lower design and construction costs	Less effort to design	Less effort to implement		Less effort to test
Occupant	Fewer occupant complaints	Improved thermal comfort				
Building operations	Improved operations	Higher quality				
Market share				Increased market demand		
Customer satisfaction			Increased customer satisfaction			

Figure 3: Guideline 36 benefits across the HVAC industry.

3.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, reference appendices, ACM reference manuals, and compliance forms would be modified by the proposed change.[3] See Section 8 of this report for detailed proposed revisions to code language.

3.3.1 Specific Purpose and Necessity of Proposed Code Changes

Each proposed change to language in Title 24, Part 6 as well as the reference appendices to Part 6 are described below. See Section 8.2 of this report for marked-up code language.

Section: 100.1(b)

Specific Purpose: The specific purpose of this addition is to include a definition for Programming Library, a term that is used in other proposed changes.

Necessity: These changes are necessary to increase energy efficiency via cost-effective HVAC controls.

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

Section: 140.4(c)2

Specific Purpose: The specific purpose of this addition is to include a Guideline 36 compliance requirement for VAV system static pressure setpoint reset control.

Necessity: These changes are necessary to increase energy efficiency via cost-effective HVAC controls.

Section: 140.4(d)2.A.v.

Specific Purpose: The specific purpose of the addition is to include a Guideline 36 compliance requirement for space-conditioning zones with DDC.

Necessity: These changes are necessary to increase energy efficiency via cost-effective HVAC controls.

Section: 140.4(e)2.D.

Specific Purpose: The specific purpose of this addition is to include a Guideline 36 compliance requirement for economizers.

Necessity: These changes are necessary to increase energy efficiency via cost-effective HVAC controls.

Section: 140.4(f)3.

Specific Purpose: The specific purpose of this addition is to include a Guideline 36 compliance requirements for supply air temperature setpoint reset.

Necessity: These changes are necessary to increase energy efficiency via cost-effective HVAC controls.

Section: 140.4(r).

Specific Purpose: The specific purpose of this addition is to include a requirement for HVAC systems with DDC to use ASHRAE Guideline 36 programming libraries.

HVAC systems with DDC shall use controller logic originating from a programming library based on sequences of operation from ASHRAE Guideline 36.

Necessity: These changes are necessary to increase energy efficiency via cost-effective HVAC controls.

Section: 141.0(b)2C.

Specific Purpose: The specific purpose of this addition is to include an exception to ensure that sections 140.4(c)2C, 140.4(d)2Av, 140.4(e)2D, and 140.4(f)3, and 140.4(r) do not apply to alterations unless the space-conditioning systems are new or replacements.

Necessity: These changes are necessary to increase energy efficiency via cost-effective HVAC controls.

Section: Appendix 1-A

Specific Purpose: The specific purpose of this addition is to provide a complete reference to ASHRAE Guideline 36 High-Performance Sequences of Operation for HVAC Systems (2021).

Necessity: The addition is necessary to ensure that the users can reference the most current Guideline 36 publication from ASHRAE.

Section: JA15 Guideline 36 Programming Library Certification Submittal Requirements

Specific Purpose: The specific purpose of this additional appendix is to define the certification requirements for the programming libraries to be used for HVAC control systems as stated in Section 140.4(r). Each BAS manufacturer or controls supplier wishing to certify their G36 libraries should conform to the G36 library requirements of Title 24, Part 6. The manufacturers or controls suppliers can refer to JA15 for the programming library certification requirements, certification process, and declaration form.

Necessity: These changes are necessary to provide manufacturers or controls suppliers a method to comply with the Title 24, Section 140.4(r) certification requirement.

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

The purpose of this section is to present purpose and necessity of proposed changes to the Nonresidential and Multifamily Reference Manual. See Section 8.4 of this report for the detailed proposed revisions to the text of the ACM Reference Manual.

Section: 5.7.2

Specific Purpose: The specific purpose is to revise the section to include a way for the user to indicate that they are using control sequences from a certified ASHRAE Guideline 36 programming library.

Necessity: This change is necessary to have for the user to be able to indicate that they are complying with the requirement to use certified ASHRAE Guideline 36 libraries.

Sections 5.6.6, 5.7.2, 5.7.3

Specific Purpose: The specific purpose is to derate the proposed system energy performance in the performance approach Proposed design if the user indicates that they are not using ASHRAE Guideline 36, or not using control logic from a certified library.

Necessity: These changes are necessary so that if the user does not use certified ASHRAE Guideline 36 libraries, the proposed system energy performance is reduced through less efficient control sequences of operation.

3.3.3 Summary of Changes to the Nonresidential Compliance Manual

Chapter 4: Mechanical Systems of the Nonresidential Compliance Manual would need to be revised to incorporate changes to Section 4.6.2 Prescriptive Requirements.

- Section 4.6.2.1 Space Conditioning Zone Controls would need to be revised to include a Guideline 36 compliance requirement for space-conditioning zones with DDC.
- Section 4.6.2.2 Space Conditioning Zone Controls would need to be revised to include a Guideline 36 compliance requirement for economizers.
- Section 4.6.2.3 Space Conditioning Zone Controls would need to be revised to include a Guideline 36 compliance requirement for VAV system static pressure setpoint reset control.
- Section 4.6.2.4 Space Conditioning Zone Controls would need to be revised to include a Guideline 36 compliance requirement for supply air temperature setpoint reset.
- Section 4.6.2.8 DDC Controller Logic Using ASHRAE Guideline 36 would need to be added to include a requirement for HVAC systems with DDC to use ASHRAE Guideline 36 programming libraries. HVAC systems with DDC controllers that are capable of being programmed in the field and non-programmable controllers for zone terminal units shall use controller logic originating from a programming library based on sequences of operation from ASHRAE Guideline 36.

3.3.4 Summary of Changes to Compliance Forms

The proposed code change would modify the compliance documents listed below. Examples of the revised forms are presented in Section 0.

1. 2025-NRCC-MCH-E
2. 2025-NRCI-MCH-E
3. 2025-NRCA-MCH-18-A
4. 2025-NRCC-PRF-01-E

3.4 Regulatory Context

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

There are no relevant state or local laws or regulations.

3.4.2 Duplication or Conflicts with Federal Laws and Regulations

There are no relevant federal laws or regulations.

3.4.3 Difference From Existing Model Codes and Industry Standards

This proposal relies on ASHRAE Guideline 36. ASHRAE is recognized as an organization that sets industry standards. The proposal references the Guideline directly, requiring compliance with the sequences of operations in the Guideline. Other building energy efficiency model codes do not yet include requirements to follow Guideline 36. Addendum CN to ASHRAE Standard 90.1-2019 added informative references to Guideline 36 where there were existing and applicable controls requirements.

3.5 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:**
    - **Existing process:** In the design phase, the mechanical designer designs the HVAC system, including specifying and locating equipment. The controls designer, who is sometimes the mechanical designer or a subcontractor to the mechanical designer, designs HVAC controls, including specifying hardware, software, and sequences of operation. The design team submits plans, specifications, and Nonresidential Certificates of Compliance-Mechanical (NRCC-MCH) or Performance (NRCC-PRF) forms to the building department for plan check.
    - **Changes:** This measure would have moderate impact on the existing building design phase process. The controls designer would specify sequences of operation from Guideline 36 and would provide any required project design information. The controls drawings and specifications would clearly indicate references to Guideline 36.
- **Permit Application Phase:**
    - **Existing process:** In the permit application phase, the design team applies for a building permit with design drawings, specifications, and NRCC forms. The plans examiner reviews the NRCC-MCH forms and construction documents for compliance. The plans examiner reviews the equipment schedules and specifications at a high level to verify that HVAC controls documentation exists. The plans examiner does not typically verify compliance with individual controls requirements in Title 24, Part 6, and therefore, does not review the sequences of operation in detail. The plans examiner issues a permit once compliance is verified.
    - **Changes:** This measure would have moderate impact on the existing building permit application phase process. The compliance forms would have a field for designers to indicate whether Guideline 36 is being used based on the HVAC system type. The plans examiners would verify that there is a reference to Guideline 36 where applicable in the construction documents (mechanical plans, controls diagrams and/or, specifications). This process would be easier and more effective than the existing process because the plans examiner would only need to verify that Guideline 36 is referenced and would not have to verify individual controls requirements.
- **Construction Phase:**
    - **Existing process:** In the construction phase, the controls contractor selects and configures a BAS, selects hardware, and creates control programs. The BAS manufacturer provides software that the controls contractor uses to create the control program. In collaboration with the test and balance contractor, the controls contractor identifies any field-

determined project information, including the minimum fan speed, duct design maximum static pressure, and ventilation plenum pressures. The controls contractor and certified acceptance test technician (ATT) perform functional tests and acceptance tests and adjust the program in-field as needed. The commissioning agent reviews and tests the programming and witnesses functional tests. The ATT completes the NRCA-MCH forms and submits them to the inspector. The commissioning process may require significant coordination between the controls contractor and the commissioning agent to get all functional test results accepted.

    - **Changes:** This measure would have moderate impact on the existing building construction phase process. The BAS manufacturer would provide the controls contractors certified G36 programing libraries, from which the controls contractor would start controls programs. The controls contractor would make any selections required, customize the programming as needed for the project, and update program setpoints. The ATT would verify that the controls contractor used a certified Guideline 36 programming library. The Mechanical Systems Acceptance Tests would have added requirements to confirm use of a certified Guideline 36 programming library. The commissioning process would be more streamlined because the certified Guideline 36 programming library would have already been tested.

- **Inspection Phase:**
    - **Existing process:** In the inspection phase, the inspector verifies the NRCA-MCH forms in the field and issues a certificate of occupancy.
    - **Changes:** This measure would have minimal impact on the existing building inspection phase process. Language would be added to the NRCA-MCH form confirming use of elements from the certified library.

Overall, there would be moderate changes to the compliance and enforcement process of the proposed measure compared to the existing process. There would be revisions to the acceptable inputs to the compliance forms.

4. Market Analysis

4.1 Current Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology 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 about and outreach to 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 27, 2023 (Statewide CASE Team 2023).

The HVAC controls market actors include building owners, controls designers, HVAC designer, BAS manufacturers, controls contractors, mechanical contractor, plans examiner, commissioning agents, building inspector, ATT, ATT certification provider (ATTCP), and building operators. Each market actor is described below.

- **Building owner**: The building owner is responsible for indicating their building requirements. The HVAC controls process starts when the building owner puts out a request for proposals (RFP). Some building owners, particularly owners of portfolios and campuses, have specifications or performance expectations that they follow when issuing an RFP.
- **Controls designer**: The controls designer is responsible for designing HVAC controls, including specifying hardware, software, and sequences of operation. The controls designer develops a basis of design based on the RFP and writes the sequences of operation. Controls designers often start with specifications from a previous project.
- **HVAC designer**: The HVAC or mechanical designer of record sometimes designs the controls sequences and sometimes hires a controls designer. They are responsible for stamping mechanical drawings and signing certificates of compliance.
- **BAS manufacturer**: The BAS manufacturer is responsible for delivering hardware and software to the market through their controls contractors. They may provide tools, including factory application libraries and training to controls contractors using their products. Most manufacturers update their libraries regularly. Some manufacturers host a forum where controls contractors can share programming and other information.

- **Controls contractor**: The controls contractor is responsible for implementing controls in a building. The controls contractor interprets the sequences of operation written by the controls designer and develops or modifies control programming logic. Controls contractors design a BAS, select hardware, create control programs, and then adjust the program in-field if needed during commissioning.
- **Mechanical contractor**: The mechanical contractor sometimes hires a mechanical controls contractor whom they work with to deliver a functioning mechanical system. Mechanical contractors review construction documents to create project bids, order equipment, and install it during construction.
- **Plans examiners**: The plans examiner reviews construction documents at the time of permit application to verify compliance with building codes, including Part 6. Sometimes they specialize in mechanical systems but often they verify compliance for all building components. The plans examiner approves the project before a construction permit is issued.
- **Commissioning agent**: The commissioning agent is responsible for ensuring that the installed controls perform as designed. The commissioning agent reviews and tests the control installation and programming.
- **Building inspectors**: The building inspector reviews installations during field visits to verify compliance with building codes, including Part 6. Often inspectors specialize in mechanical systems, but sometimes they cover all building systems. They make multiple visits to jobsites during separate times in the construction process. Inspectors are responsible for verifying NRCA forms are completed before they issue a Certificate of Occupancy.
- **ATT**: The ATT is responsible for completing the acceptance tests during construction, which can be functional performance tests or visual field verifications. Mechanical ATTs are required to be certified and can be a third-party or the mechanical or controls contractor.
- **ATTCP**: The ATTCP is responsible for training and certifying mechanical ATTs. They maintain online systems to complete NRCA forms. Any changes to acceptance tests or forms must be coordinated with the ATTCPs.
- **Building operator**: The building operator is responsible for operating the building, including maintaining thermal comfort and responding to any thermal comfort complaints. The building operator interprets the intent of the controls and adjusts the controls to operate the building.

4.2 Technical Feasibility and Market Availability

4.2.1 Data Collection

The BIC research team (refer to Section 3.2.1) collected information on technical and market barriers through stakeholder interviews, a survey of controls contractors, and ongoing discussions with manufacturers. The BIC research team conducted interviews with a total of 17 stakeholders, which included 5 BAS manufacturers, 6 BAS controls contractors, 1 building engineer, 3 building owners, and 2 design engineers. The Statewide CASE Team interviewed the same five manufacturers as the BIC research team, as well as five commissioning providers, one building owner, one design engineer, and one controls contractor. The Statewide CASE Team incorporated the data collected during the interviews into the broader stakeholder engagement, described below. See Appendix F for more details on the stakeholder engagement.

The Statewide CASE Team conducted additional data collection, primarily through the Statewide CASE stakeholder meetings, the ASHRAE Guideline 36 Committee, informal interactions with stakeholders, and a drawing review. The Statewide CASE Team presented the proposed measure to the ASHRAE Guideline 36 Committee and facilitated a discussion around the proposal, after which the Committee Chair submitted a letter indicating the Committee's support for the measure. The committee is comprised of diverse industry stakeholders, including major BAS manufacturers, designers, building owners, and others.

The Statewide CASE Team determined that conducting individual interviews with stakeholders not already familiar with ASHRAE Guideline 36 and its uses would not be effective. It would take a significant effort to get someone acquainted with the guideline, the workflow, and the proposed measure, to collect any meaningful input. The Statewide CASE Team determined that it was more effective to encourage stakeholders to attend the utility-sponsored stakeholder meeting, and for the stakeholders to provide feedback during and after the meeting. Therefore, the Statewide CASE Team conducted outreach with six manufacturers and requested that they distribute information about the meeting to their controls contractors, encouraging them to attend. The Statewide CASE Team also distributed information about the stakeholder meeting and encouraged attendance through the ASHRAE Golden Gate Chapter, ASHRAE Southern California Chapter, and the ASHRAE Orange Empire Chapter.

The Statewide CASE Team includes members with significant design and commissioning experience that are active members of ASHRAE and other industry organizations. Throughout the proposal development, the Statewide CASE Team conducted numerous informal interactions with stakeholders including designers, manufacturers, commissioning agents, controls contractors, building owners, and building engineers. Through the informal interactions, the Statewide CASE Team disseminated information about the proposed code change and solicited input, which helped shape the proposed code change.

The BIC research team also worked with BAS manufacturers to develop and deploy a controls contractor survey. The survey included questions to better understand awareness of Guideline 36, interest in Guideline 36, implementation of Guideline 36, current controls contractor processes, and the types of retrofits the controls contractors typically encounter. There were 488 respondents to the survey, distributed by four different manufacturers. The survey results are presented in Sections 4.2.2 and 4.2.3.

The BIC research team held ongoing discussions with major BAS manufacturers regarding their efforts to implement Guideline 36, including Automated Logic Corporation, Siemens, Johnson Controls, Distech, Trane, Alerton, and Schneider Electric. Manufacturer commitment to this effort progressed significantly during the four-year span of the research project. Initially, only a few manufacturers expressed interest in creating programming libraries, while being noncommittal about developing them or a timeline for releasing them. Other manufacturers were noncommittal even with just their interest. By midway through the research project, most of the major manufacturers had expressed interest, but only a few had stated that the libraries were in development. By the end of the research project, all the manufacturers had expressed interest and had libraries in development, with multiple manufacturers having also released libraries. The research team tracked manufacturer progress, summarized in Figure 4 and updated through the Statewide CASE Team interviews, including the Guideline 36 libraries they had released to their controls contractors. The progress is self-reported by the manufacturers.

Manufacturer	Status of Application Libraries			Elements of Library Released							
				Sequence of Operation						FDD	Alarms
-	Interest expressed	In Development	Released	MZ AHUs	SZ AHUs	DFDD	VAV Terminal Units	Dual duct terminal unit	Fan powered terminal unit	-	-
Automated Logic / Carrier	✓	✓	◌	✓*	✓*	✓	✓*	–	✓	✓	✓
Trane	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Distech Controls	✓	✓	◌	◌	◌	–	✓**	–	–		
Johnson Controls	✓	✓	◌	✓	✓	✓	✓	✓	✓	✓	✓
Siemens	✓	✓	–	–	–	–	◌	–	–	–	–
Alerton	✓	✓	◌	✓	✓	–	✓	–	✓	✓	✓
Schneider Electric	✓	✓	◌	✓	✓	–	✓	–	✓	–	✓
Reliable Controls	✓	✓	◌	? →							

KEY

✓ Complete

◌ Partially Complete

– Not Started

*Third-party verified

** beta version

Based on available information September 2021

Figure 4: Manufacturer Guideline 36 library development status as of September 2021.

The Statewide CASE Team used the BIC stakeholder interview and controls contractor survey results to understand the current processes in the BAS industry, how Guideline 36 could improve upon those current processes, and what the barriers are and how to address them. The Statewide CASE Team used the BAS manufacturer tracking to verify that manufacturer libraries are sufficiently developed and available to be certified for use under Title 24-2025.

4.2.2 Awareness and Existing Guideline 36 Implementations

Guideline 36 is gaining market traction, with many market actors becoming aware of the guideline and numerous Guideline 36 implementations. The BIC research team successfully demonstrated Guideline 36 in several buildings. The BIC research team identified 28 other buildings that were early adopters of Guideline 36, either as new construction or retrofit projects.

The results of the BIC research team survey of controls contractors nationwide are presented below. The team analyzed the survey results by the BAS manufacturer with which the controls contractors work. Separating the results by manufacturer allowed the team to identify any differences among manufacturers. In general, results were consistent across manufacturers. The controls contractor survey responses showed that 68 percent of 488 respondents are aware of Guideline 36, the majority through communication from their manufacturer or from an industry publication, such as the ASHRAE Journal. Respondents who had heard of Guideline 36, approximately 330, indicated how many of their teams' projects had implemented Guideline 36, as shown in Figure 5.

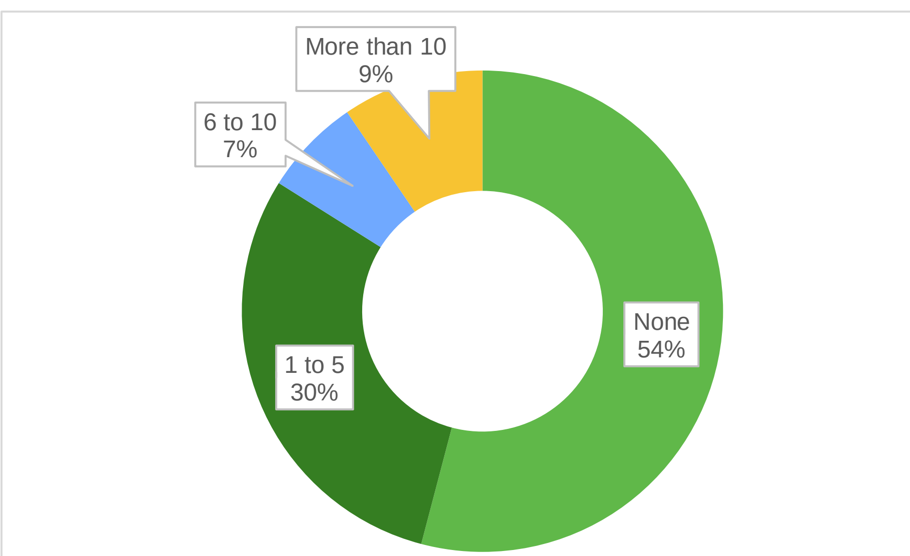

Figure 5: Survey responses to question: On how many projects has your team implemented ASHRAE Guideline 36?

The BIC research team estimated around 450 unique Guideline 36 implementations, either full or partial implementations. The survey asked respondents to rate their overall success of completed Guideline 36 projects on a five-point scale, without defining the criteria for success, by number of projects implemented, as shown in Figure 6. The results show that as a contractor implements more projects, the overall success rate increases.

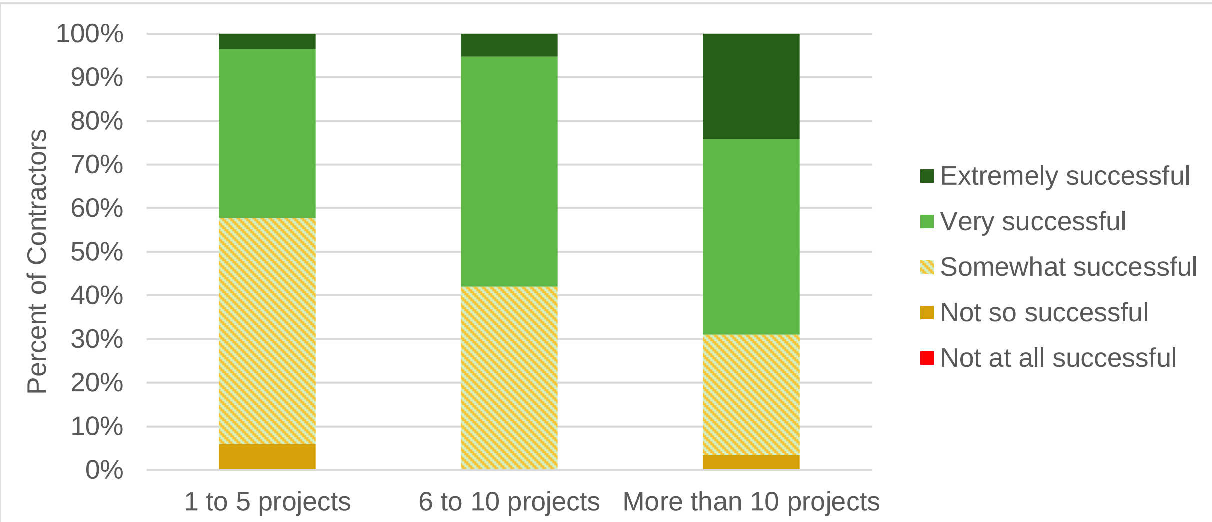

Figure 6: Overall success of the ASHRAE Guideline 36 projects based on number of projects implemented.

Design engineers are also starting to specify ASHRAE Guideline 36 as their in-office standard, and through their outreach, the Statewide CASE Team is aware of multiple organizations that already specify or are making efforts to specify ASHRAE Guideline 36 control sequences as part of their in-office standard. Building owners are also starting to include ASHRAE Guideline 36 in their master specifications. In 2021, the United States General Services Administration's Facilities Standards for the Public Buildings Service added a requirement that sequences of operation must follow ASHRAE Guideline 36. (U.S. General Services Administration 2021)

Figure 7 shows the feedback received during the utility-sponsored stakeholder meeting, which indicated that 84 percent of the stakeholders were familiar with ASHRAE Guideline 36, and 17 percent had significant experience with it.

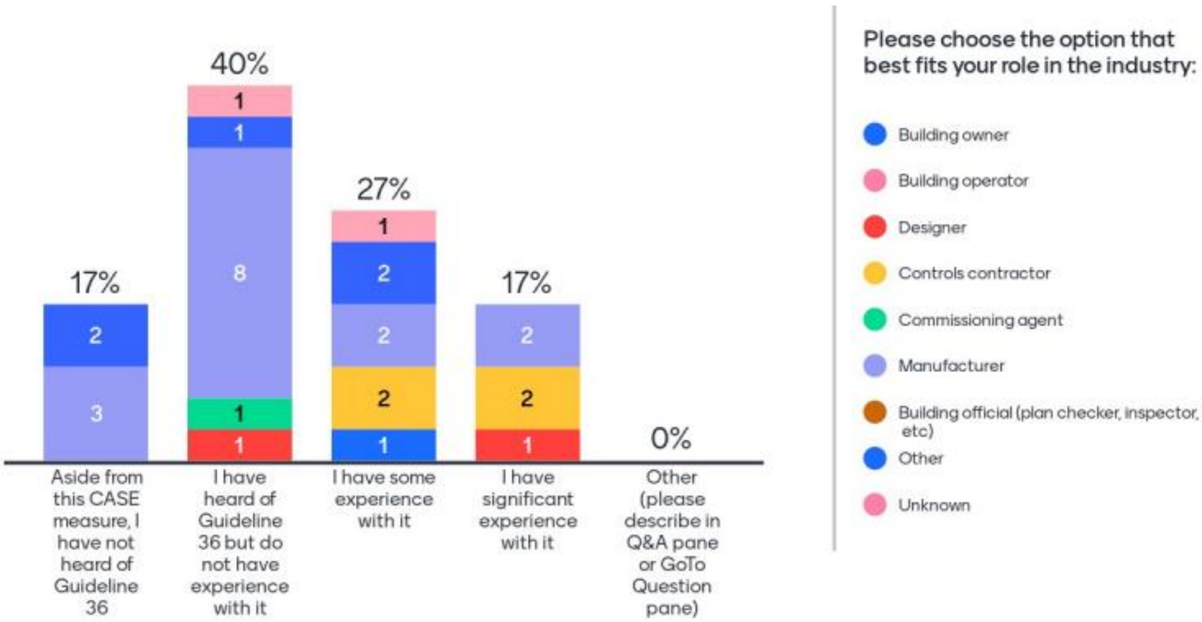

Figure 7: Stakeholder meeting poll response to 'Which option best describes your experience with ASHRAE Guideline 36.

4.2.3 Barriers and Solutions

The current industry delivery process for control logic is a high-risk process, meaning a process with potential for lost time and expense, lost energy savings, and occupant dissatisfaction. The process usually leads to suboptimal performance.

The status quo process has many steps that are manual and customized per project, and it is highly dependent on the expertise of individual engineers, controls technicians, and commissioning providers. The controls contractor survey asked how often contractors start programming for a new job. The results, shown in Figure 8, by manufacturer, show that dealers across manufacturers most often copy from previous jobs, followed by using their own dealer library.

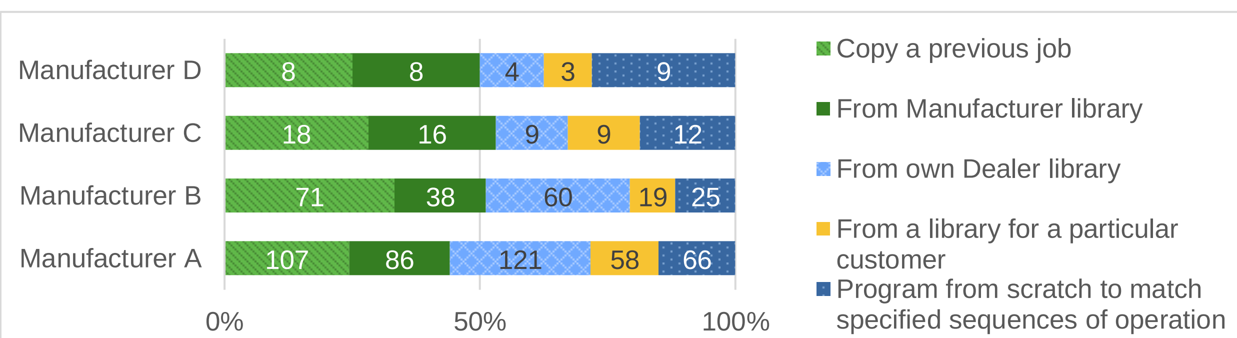

Figure 8: Survey responses to question: How do you most often start programming for a new job (select one or two options)?

The gray bars in the top section of Figure 9 below shows the controls project flow through the various stakeholders, with steps that are high-risk because they are manual, or error prone identified in the status quo process.

Standardization around Guideline 36 reduces many of these risks. The current Guideline 36 process with manufacturer libraries, represented by the blue bars in the lower section in Figure 9, represents best practice with reduced risks when project specifications use Guideline 36 and contractors follow the guideline. Overall, this process reduces effort, improves quality, and streamlines the overall product delivery chain.

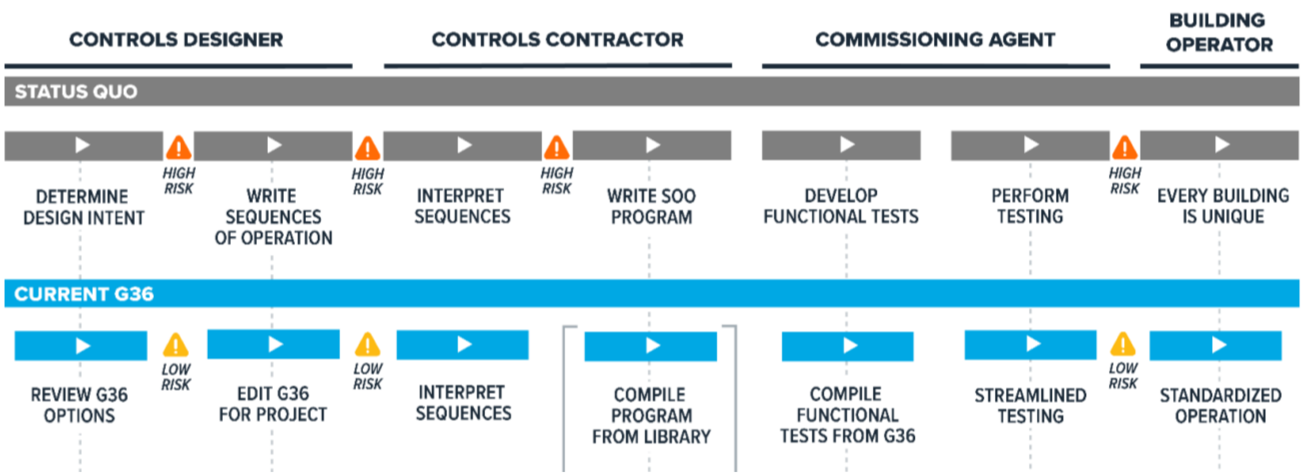

Figure 9: BAS controls industry workflow for the status quo and with Guideline 36.

Source: (Cheng, Eubanks and Singla 2022)

Use of Guideline 36 preprogrammed libraries is key to Guideline 36 standardization. Increasing the availability of preprogrammed Guideline 36 libraries and certifying them under Title 24, Part 6 would help drive this standardization. Figure 10 illustrates how this new process would look for controls contractors. The BAS manufacturer would create new factory application libraries for ASHRAE Guideline 36. The manufacturer would self-certify the library with the CEC per the new Joint Appendix JA15. Then for each project, the controls contractor would start programming from the certified ASHRAE Guideline 36 library. The contractor may need to customize the library, and they may also need to develop logic for systems that are not covered by ASHRAE Guideline 36.

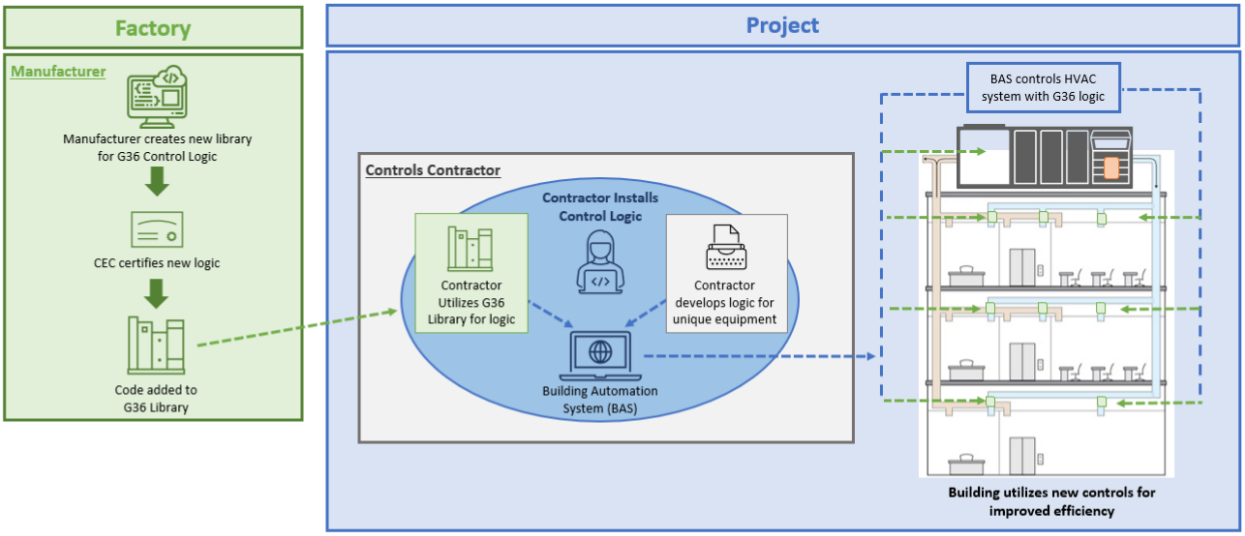

Figure 10: Process for controls contractors with certified Guideline 36 library.

Stakeholder interviews and other stakeholder outreach highlighted equipment limitations and hardware incompatibility as potential barriers to Guideline 36 implementation. These limitations are primarily only a concern in existing buildings. To address this potential barrier, the proposed measure only applies in existing buildings when control hardware is replaced.

The BIC research team identified lack of training materials and guidance for building operators as a potential barrier to advanced HVAC control sequences. In current processes, building operators make assumptions about controls system functionality and the level of interaction required to keep it working. Building operators often override setpoints when responding to occupant complaints or other problems as they arise, often due to lack of understanding of how the automatic controls should respond. Though the Guideline 36 control sequences are more complex than traditional sequences, standardization of control sequences would reduce this barrier, because the control strategies would become more familiar and used more consistently across different systems and buildings. Generic training on Guideline 36 could be used at scale, rather than operators needing to learn the specifics of how each individual building is controlled as per current practice.

During the Statewide CASE Team interview, one manufacturer noted that the Guideline 36 sequences are complex and would need more training, so the logic is understood by the building operators. One controls designer recommended pitching energy savings to building owners and operators to get them on board.

The BIC research team developed a best practice guide for a broad range of stakeholders including building owners, property managers, designers, installers, and building operators (Cheng, Eubanks and Singla 2022). This document serves as a key technical resource for industry users, compiling into a single document information from a wide range of existing resources and new data generated from the demonstration and market transformation activities.

4.3 Market Impacts and Economic Assessments

4.3.1 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 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 2). For 2022, total estimated payroll was 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, called the industrial sector.

Table 2: 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, and 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, and 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, and Other (Industrial+)	**All**	**4,206**	**101,002**	**11.4**
Industrial+	Building construction	288	3,995	0.4
Industrial+	Utility system construction	1,761	50,126	5.5
Industrial+	Land subdivision	907	6,550	1.0
Industrial+	Highway, street, and bridge construction	799	28,726	3.1
Industrial+	Other heavy construction	451	11,605	1.4

Source: (State of California n.d.)

The proposed change to the ASHRAE Guideline 36 Measure 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 3 shows the commercial building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report. HVAC contractors, including controls contractors, are responsible for installing HVAC controller hardware and software, programming the software, and performing startup and commissioning on the installed HVAC equipment. Controls contractors would need to program Guideline 36 sequences of operation, using a certified Guideline 36 library. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 4.4 Economic Impacts.

Table 3: 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 plumbing and HVAC contractors	2,346	55,572	5.5

Source: (State of California n.d.)

4.3.2 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 to remain compliant with changes to design practices and building codes.

Building designers and energy consultants would need to design the HVAC system and determine if the ASHRAE Guideline 36 sequences of operation apply. If the Guideline 36 sequences of operation apply, then the designers would have to specify sequences of operation that comply with Guideline 36. Guideline 36 training, including how to specify it, would help designers. New software created by the Lawrence Berkeley National Lab would automatically edit the Guideline 36 sequences based on a series of user selections, greatly simplifying the level of effort required by designers to use Guideline 36 (Berkeley Lab n.d.).

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 4 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 ASHRAE Guideline 36 Measure to affect firms that focus on nonresidential construction.

There is not a North American Industry Classification System (NAICS)[4] 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.[5] 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 4 provides an upper bound indication of the size of this sector in California.

Table 4: 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 and nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

[4] NAICS is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was development jointly by the U.S. Economic Classification Policy Committee (ECPC), Statistics Canada, and Mexico's Instituto Nacional de Estadistica y Geografia, to allow for a high level of comparability in business statistics among the North American countries. NAICS replaced the Standard Industrial Classification (SIC) system in 1997.

[5] Establishments in this sector include businesses primarily engaged in evaluating a building's structure and component systems and includes energy efficiency inspection services and home inspection services. This sector does not include establishments primarily engaged in providing inspections for pests, hazardous wastes or other environmental contaminates, nor does it include state and local government entities that focus on building or energy code compliance/enforcement of building codes and regulations.

4.3.3 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. 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.

4.3.4 Impact on Building Owners and Occupants

The commercial building sector includes a wide array of building types, including offices, restaurants and lodging, retail, mixed-use establishments, and warehouses, including those that are 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 4.4.1, when building occupants save on energy bills, they tend to spend it elsewhere in the economy, thereby creating jobs and economic growth for California. The Statewide CASE Team does not expect the proposed code change for the 2025 code cycle to impact building owners or occupants adversely.

4.3.5 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. In correspondence with three major BAS manufacturers, two manufacturers indicated that the development and testing of Guideline 36 programming libraries did not impact their control hardware products and would not increase costs for their products. The third manufacturer did not respond with any concerns when asked about the possibility of costs being passed on to customers. In general, the manufacturers indicated that their efforts in developing Guideline 36 programming libraries are primarily driven by market demand; this is consistent with the fact that most manufacturers have been developing their libraries well ahead of this CASE measure.

4.3.6 Impact on Building Inspectors

Table 5 shows employment and payroll information for state and local government agencies where many residential and commercial building inspectors 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 5: Employment in California State and Government Agencies with Building Inspectors in 2022 (Estimated)

Sector	Government	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.

4.3.7 Impact on Statewide Employment

As described in Sections 4.3.1 through 4.3.6, 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 4.4, the Statewide CASE Team estimated the proposed change in ASHRAE Guideline 36 Measure 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 ASHRAE Guideline 36 Measure would lead to modest ongoing financial savings for California residents, savings which would then be available for other economic activities.

4.4 Economic Impacts

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

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

4.4.1 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 4.4 would lead to modest changes in employment of existing jobs.

4.4.2 Creation or Elimination of Businesses in California

As stated in Section 4.4.1, 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 HVAC controls, 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.

4.4.3 Competitive Advantages or Disadvantages for Businesses in California

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

4.4.4 Increase or Decrease of Investments in the State of California

The Statewide CASE Team analyzed national data on corporate profits and capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[8] As Table 6 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

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

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

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 6: 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	**-**	**-**	**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 estimate of corporate profits, a portion of which we assume would be allocated to net business investment.[9]

4.4.5 Incentives for Innovation in Products, Materials, or Processes

The proposed measure would promote standardization for control requirements and sequences in the HVAC industry. The Statewide CASE Team does not anticipate an impact to innovation because of the proposed code change. The market is familiar with Guideline 36 control sequences.

4.4.6 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.

[9] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 6.

4.4.6.1 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. Since the proposed measure has been shown to be cost effective, the Statewide CASE Team does not expect any appreciable change to the state.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 3.5 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.

4.4.7 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 has not found any information showing that specific persons would be impacted by this proposal. Refer to Section 2 for more details addressing energy equity and environmental justice.

4.5 Fiscal Impacts

4.5.1 Mandates on Local Agencies or School Districts

There are no mandates for local agencies and school districts because the requirements would be specified at statewide through Title 24, Part 6.

4.5.2 Costs to Local Agencies or School Districts

There are no costs to local agencies and school districts, as the proposed measure does not result in any incremental costs or economic impacts. Please see Section 4.4 for economic impacts and Section 6.5 for incremental costs.

4.5.3 Costs or Savings to Any State Agency

There are no costs or savings to state agencies because they would not be involved in enforcement of the measure.

4.5.4 Other Nondiscretionary Cost or Savings Imposed on Local Agencies

There are no added nondiscretionary costs or savings to local agencies.

4.5.5 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state due to the measure. The state would not require federal funding to implement the proposed measure.

5. Energy Savings

The Statewide CASE Team based the assumptions for the energy savings analysis on literature review and stakeholder input. 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.

5.1 Energy Savings Methodology

The Statewide CASE Team focused the energy savings analysis on four specific energy-saving features of the Guideline 36 sequences. Although these features do not encompass all the operational or energy efficiency benefits of Guideline 36, the Statewide CASE Team determined these four features to be the most consequential for energy performance as well as being feasible to model. The four features are:

- **Dual maximum VAV logic**, which allows ventilation airflows below the heating setpoint when the zone is in dead band, saving fan energy and reducing reheat energy waste.
- **Duct static pressure reset by trim and respond logic**, which reduces fan power to that required by the most demanding zone.
- **Supply air temperature reset by trim and respond logic**, which makes the supply air temperature responsive to zone demand and ensures that the air being delivered is no colder than necessary.
- **Zone groups**, which facilitate independent scheduling of parts of the building with different occupancy patterns. This provides the building operator with greater flexibility and allows them to avoid the situation where an entire floor or building is being conditioned to serve one or a few spaces, such as an always-on computer room (runs continuously all day and year).

Although Title 24, Part 6 already requires many of these features, as discussed in Section 3.2, implementation often falls short, which is an issue that the proposed requirement to use certified Guideline 36 programming libraries helps address. The Statewide CASE Team determined the energy savings of these four features in Guideline 36 relative to a baseline that represents typical current practice in new and recently constructed buildings. Section 5.1.1 describes the baseline and how the Statewide CASE Team determined it. Section 5.1.2 describes how the Statewide CASE Team modeled the measure and the building prototypes in which they modeled it. Section 5.1.3 describes the statewide energy savings methodology.

5.1.1 Key Assumptions for Energy Savings Analysis

The Statewide CASE Team conducted interviews, a literature review, and a limited drawing review to determine reasonable assumptions for the baseline model. Based on the data collected and the Statewide CASE Team's professional judgement, the Statewide CASE Team defined the following baseline model features to reflect typical conditions in recently constructed nonresidential buildings in California:

- VAV boxes use historical and traditional single-maximum logic, with a ventilation minimum and heating maximum that is 30 percent of cooling maximum.
- Duct static pressure is reset by a control loop to maintain the most-open VAV damper at 90 percent open. There is no fault detection to identify rogue zones.
- Supply air temperature is reset over a limited range, based on demand[10].
- Zone groups are not used, so scheduled occupancy in any zone activates the HVAC system for the entire building.

The Statewide CASE Team reviewed published research, interviewed stakeholders, and reviewed HVAC drawings, all of which produced findings that support these baseline model features.

5.1.1.1 Literature Review

Based on as-found control logic in recent actual buildings, one study reported: (Rosenberg, et al. 2017):

- VAV airflow minimums of 30 percent were relatively common, but higher ratios were also found. No examples of lower ratios were reported.
- Supply air temperature reset was typically present and functional, but in many cases the reset spanned only 5°F, significantly less than the span recommended by Guideline 36.
- Duct static pressure reset based on demand was often implemented incorrectly or with too little range between minimum and maximum setpoints. A reset range of only 0.5 inches of water column (in. w.c.)—significantly less than that recommended by Guideline 36—was considered acceptable but even this modest threshold was often not achieved.

The Statewide CASE Team identified several other studies that relied upon professional experience to define baselines against which to determine the energy savings of control

[10] The literature would suggest that a linear reset based on outdoor air temperature is a common strategy. However, a baseline model using this method could result in underserved zones, resulting in an unequal comparison with the demand-based reset modeled for the proposed case. To avoid this issue, both baseline and proposed models reset supply air temperature based on demand, with the baseline case increasing airflow flow first, then temperature to reflect an inferior controls strategy.

strategies (Zuo and Wang 2022) (Pang, Piette and Zhou 2017) (Zhang, Blum, et al. 2022). The studies each defined an “average” baseline and a “poor” baseline. The Statewide CASE Team’s baseline is consistent with the “average” baseline in these studies.

5.1.1.2 Stakeholder Interviews

The Statewide CASE Team interviewed five commissioning providers and one large portfolio building owner (who is actively involved in the design, commissioning, and operation of their own buildings) to gather more information on the current industry practice for HVAC controls in new construction buildings in California. All interviewees had more than five years of experience and worked on building HVAC systems that are predominantly VAV reheat systems.

The Statewide CASE Team asked stakeholders about VAV box minimums in typical practice. The stakeholders generally observe VAV box minimums that meet code requirements. Several stakeholders noted that commissioning providers often catch non-compliance with this measure during design review, mitigating any potential non-compliance in implementation.

The Statewide CASE Team asked stakeholders about zone groups. The responses ranged, with three stakeholders stating that zone groups are not very common and three stakeholders stating that they are common. Like the VAV box minimums measure, several stakeholders noted that commissioning providers often recommend implementing this measure during design review, thereby increasing the rate at which it gets implemented.

The Statewide CASE Team asked stakeholders how often they observe that supply air temperature reset logic is implemented and that meets code. The responses ranged, with two stakeholders commenting that the logic always meets code (with one stakeholder noting that this is because they catch any non-compliance at design review). Three other stakeholders noted that compliance was low, with estimated compliance of 50 percent, below 50 percent, and under 10 percent. When asked about projects where the supply air temperature reset meets code but is not effective (i.e., the reset is stuck at minimum), three stakeholders commented that that occurred generally half of the time, and one stakeholder commented that it happened quite often, and another stakeholder commented that it did not occur very often.

The Statewide CASE Team asked stakeholders how often they observe that duct static pressure reset logic is implemented and that meets code. The responses ranged, with two stakeholders commenting that the logic very often meets code and two other stakeholders commenting that compliance was about half. When asked about projects where the duct static pressure reset meets code but is not effective (i.e., the reset is stuck at maximum), all stakeholders commented that that occurred at least half of the time.

The stakeholders that the Statewide CASE Team interviewed tend to work on high performance buildings. This means that they work with designers and contractors who design and implement buildings to exceed code and building owners who expect a code compliant building. Therefore, the stakeholders interviewed are not entirely representative of the market and tend to skew towards high performance buildings. Still, the interview results show that even these relatively high-performance buildings experience controls deficiencies.

5.1.1.3 HVAC Drawing Review

Dual maximum VAV box logic has been required by Title 24 since 2005, allowing a minimum airflow of no more than 30 percent in 2005, then allowing a minimum airflow of no more than 20 percent starting in 2008, before requiring a minimum airflow of no more than ventilation airflow starting in 2022 (though in all cases, higher airflow rates are permitted if required for ventilation).

To better understand current industry practice for VAV box minimum airflows, the Statewide CASE Team conducted a review of HVAC drawings. The Statewide CASE Team used drawing sets from the Dodge Construction Network database, which uses a mix of public and private sources to collect construction project data. The Statewide CASE Team filtered the database for new construction office building projects in California from the last three years and reviewed seven projects. Across the seven projects, the average VAV box minimum airflow in office spaces by building ranged from 15 to 50 percent, with an average of 34 percent.

Overall the findings from the literature review, interviews, and drawing review consistently showed that controls in recently constructed buildings were often not implemented correctly, consistent with the Statewide CASE Team's assumption of poorly implemented control strategies.

The Statewide CASE Team received mixed feedback during the utility-sponsored stakeholder meeting on the baseline assumptions. (Statewide CASE Team 2023). Some stakeholders agreed with the assumptions, while other stakeholders noted that the assumptions were extreme based on the current code compliance. The Statewide CASE Team welcomes data that may support adjustment of baseline assumptions.

The Statewide CASE Team simulated the energy impacts in each climate zone and applied a climate-zone specific Life Cycle Cost Hourly Factors when calculating energy and energy cost impacts.

5.1.2 Energy Savings Methodology per Prototypical Building

The Statewide CASE Team estimated per-unit energy savings expected from the proposed code changes 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 the CEC are strongly correlated with GHG emissions. Finally, the Statewide CASE Team calculated LSC savings, formerly known as Time Dependent Valuation (TDV) Energy Cost Savings. LSC savings are calculated using hourly LSC factors for both electricity and natural gas provided by the CEC. These LSC hourly factors are projected over the 30-year life of the building and incorporate the hourly cost of marginal generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO_2 emissions.

The CEC directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries for different types of buildings (California Energy Commission 2022). The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 7. Table 7 includes a description of each building type, including the number of stories, floor area, zoning, and window-to-wall ratio (WWR). The proposed measure impacts VAV systems with terminal reheat (i.e., VAV reheat systems). Therefore, only prototype building models that use VAV reheat systems are simulated to estimate statewide energy savings.

Table 7: 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. WWR-0.40.
OfficeMedium	3	53,628	3 story office building with 5 zones and a ceiling plenum on each floor. WWR-0.33.

The Statewide CASE Team estimated LSC savings, 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 CBECC software. The OfficeLarge and OfficeMedium prototype building models were simulated in CBECC 2025.0.4 RV (Research Version), (California Energy Commission n.d.). The CBECC simulations generate EnergyPlus input data files, which were used as the base case models. The base case models were then modified to represent the measures listed below and simulated using EnergyPlus.

This measure involves requirements that are already reflected in the 2022 code, but they currently have low rates of compliance. The base case models represent energy use in buildings with low compliance rates, as described in Section 5.1.1. The base case models assume the following:

- **Single-maximum VAV terminal unit logic:** VAV terminal units have a constant minimum flow fraction of 30 percent, which is the same as the heating flow fraction.
- **Less effective duct static pressure reset performance:** This is simulated by using the “GOOD-SP-RESET” fan curve coefficients (ACM Reference Manual Appendix 5.7). The “GOOD-SP-RESET” fan curve is the default fan curve defined in the ACM Reference manual that represents a duct static pressure reset (Figure 11). The “GOOD-SP-RESET” fan curve represents higher power consumption with respect to part-load ratio compared to the “PERFECT-SP-RESET” fan curve.

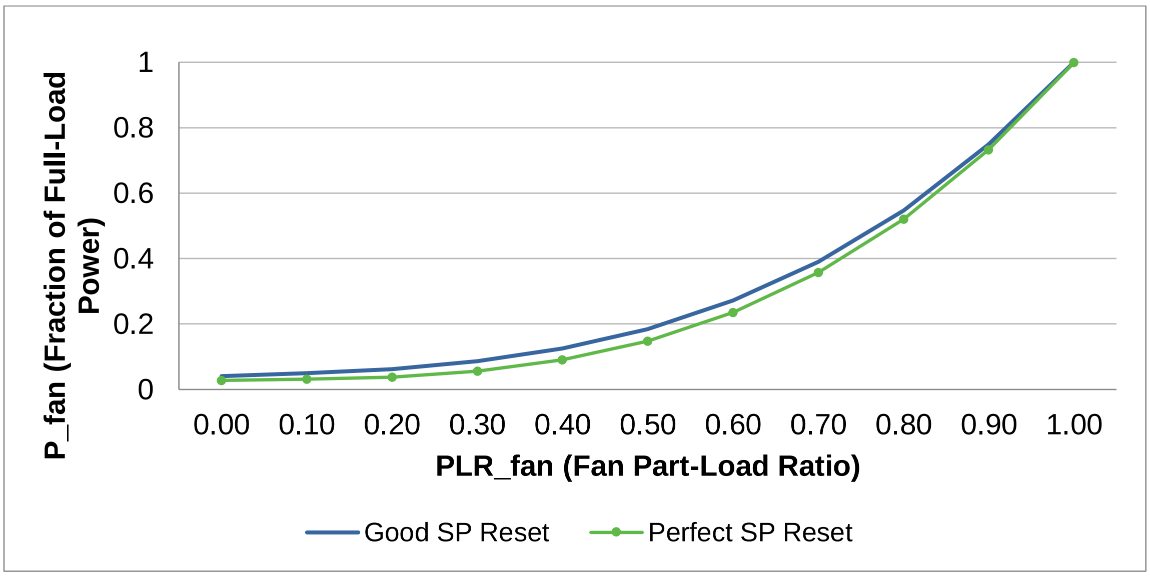

Figure 11: Duct static pressure reset fan curves.

- **Cooling supply air temperature reset:** This is based on the cooling demand of the warmest zone by increasing flow first, then temperature.
- **No zone groups**: The medium and large office prototype models normally use the Office Occupancy schedule profiles listed in the NRMF ACM Reference Manual Appendix 5.4B. To conservatively estimate savings from this measure, the first floor was assumed to be occupied one hour longer than the remaining floors. Since the base case model assumes no zone groups, HVAC systems serving all floors are scheduled to operate one hour longer.

The proposed case models represent compliance with 2022 code. The proposed case models assume the following:

- **Dual-maximum VAV terminal unit logic:** VAV terminal unit minimum flow is set to the required ventilation flow rate. Heating flow fraction is set to either the ventilation flow rate or 50 percent, whichever is greater.
- **Better duct static pressure reset performance**: This is simulated by using the "PERFECT-SP-RESET" fan curve coefficients The "PERFECT-SP-RESET" fan curve is defined in the Advanced Variable Air Volume System Design Guide published by PG&E (Pacific Gas and Electric Company 2007). The "PERFECT-SP-RESET" fan curve represents lower power consumption with respect to part-load ratio compared to the "GOOD-SP-RESET" fan curve.
- **Cooling supply air temperature reset:** This is based on the cooling demand of the warmest zone by increasing temperature while maintaining maximum supply air flow rate.
- **Zone groups:** The medium and large office prototype models use the Office Occupancy schedule profiles listed in the NRMF ACM Reference Manual Appendix 5.4B, except for the first floor, which is altered to operate one hour longer than the remaining floors. Only the first floor HVAC system operates the extra hour.

Table 8 presents precisely which parameters were modified and what values were used in the base case and proposed case models.

Table 8: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Submeasure	Objects Modified	Parameter Name	Baseline Design Parameter Value	Proposed Design Parameter Value
All Prototypes in Table 7, all climate zones	Dual Maximum VAV	AirTerminal: SingleDuct: VAV:Reheat	Zone Minimum Air Flow Method	Constant	FixedFlowRate
	Trim & Respond DSP Reset	Fan: Variable Volume	Fan Curve Coefficients	"GOOD-SP-RESET"	"PERFECT-SP-RESET"
	Trim & Respond SAT Reset	Setpoint Manager: Warmest	Entire object	Setpoint Manager: Warmest	SetpointManager: Warmest TemperatureFlow
	Zone Groups	Schedule: Compact	Operation Schedule	ACM Office Occupancy Schedule +1 hour each weekday	ACM Office Occupancy Schedule

CBECC calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/y) and therms per year (therms/y). It then applies the 2025 LSC hourly factors to calculate LSC in 2026 present value dollars (2026 PV$), Source Energy factors to calculate Source Energy use in kilo British thermal units per year (kBtu/y), and hourly GHG emissions factors to calculate annual GHG emissions in metric tons of carbon dioxide emissions equivalent (MT or “tonnes” CO_2e/y). CBECC also calculates annual peak electricity demand measured in kilowatts (kW).

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

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

5.1.3 Statewide Energy Savings Methodology

The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the CEC provided. 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 (California Energy Commission 2022). 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.

5.2 Per-unit Energy Impacts Results

Energy savings and peak demand reductions per unit are presented in Table 9 through Table 13. The energy savings and peak demand reductions are from new construction buildings only. 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 to 3.02 kWh/y and 0.84 to 2.57 kBtu/y, depending upon climate zone and building type. Demand reductions are expected to range between 0 and 0.06 kW, depending on climate zone and building type.

The Statewide CASE Team conservatively defined the base case for the VAV terminal unit logic, duct static pressure reset logic, supply air temperature reset logic, and zone group definitions. As described in Section 5.1, the Statewide CASE Team gathered data that suggested current practice could perform worse, but the team erred on the side of conservative savings, and it did not define the base case in a worse configuration. Additionally, there are some aspects of Guideline 36, such as optimal start, occupied standby, and automated fault detection and diagnosis, which are complex to model; therefore, the Statewide CASE Team did not model or show savings for these features.

The estimated savings for zone groups are especially conservative because the base case models assume only one additional hour of HVAC operation due to a lack of zone groups. Lack of effective zone groups and associated HVAC scheduling can often have a much greater impact on HVAC runtime when, for example, a single occupied zone causes the HVAC systems serving the whole building to run continuously, 24 hours a day, 7 days a week.

Table 9: First-Year Electricity Savings (kWh) Per Square Foot by Climate Zone (CZ) – ASHRAE Guideline 36

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
Large Office	0.34	0.65	0.49	0.87	0.59	0.82	0.73	1.03	0.98	1.14	0.99	0.79	1.10	1.11	1.64	0.65
Medium Office	0.20	0.26	0.19	0.33	0.22	0.35	0.30	0.39	0.39	0.43	0.31	0.28	0.31	0.48	0.38	0.39

Table 10: First-Year Peak Demand Reduction (W) Per Square Foot by Climate Zone (CZ) – ASHRAE Guideline 36

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
Large Office	0.70	0.73	0.75	0.80	0.86	0.65	0.51	0.65	0.61	0.67	0.64	0.69	0.66	0.68	0.61	0.56
Medium Office	0.23	0.42	0.33	0.54	0.44	0.38	0.25	0.48	0.47	0.52	0.46	0.37	0.39	0.67	0.67	0.52

Table 11: First-Year Natural Gas Savings (kBtu) Per Square Foot by Climate Zone (CZ) – ASHRAE Guideline 36

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
Large Office	1.28	1.36	1.38	1.48	1.57	1.19	0.93	1.19	1.10	1.23	1.19	1.29	1.24	1.22	1.13	1.02
Medium Office	0.43	0.78	0.58	1.03	0.79	0.64	0.42	0.81	0.81	0.91	0.88	0.69	0.72	1.26	1.20	1.01

Table 12: First-Year Source Energy Savings (kBtu) Per Square Foot by Climate Zone (CZ) – ASHRAE Guideline 36

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
Large Office	0.39	0.58	0.47	0.74	0.54	0.67	0.63	0.80	0.77	0.84	0.82	0.68	0.85	0.79	0.98	0.61
Medium Office	0.23	0.30	0.21	0.31	0.26	0.33	0.28	0.33	0.31	0.31	0.24	0.30	0.21	0.39	0.19	0.39

Table 13: First-Year LSC Savings (2026 PV$) Per Square Foot by Climate Zone (CZ) – Guideline 36 Controls

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	2.82	4.15	3.54	5.49	4.17	4.85	4.42	5.86	5.56	6.35	5.75	4.88	6.41	6.28	8.63	3.95
Medium Office	1.35	1.94	1.42	2.52	1.81	2.21	1.69	2.50	2.44	2.62	1.96	1.94	2.01	3.43	2.56	2.74

6. Cost and Cost Effectiveness

6.1 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 5.1. 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 30-year period of analysis.

The CEC requested LSC savings over the 30-year period of analysis in both 2026 PV$ and nominal dollars. The cost-effectiveness analysis uses LSC values in 2026 PV$. Costs and cost effectiveness using nominal and 2026 PV$ are presented in Section 6.5 of this report. The 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.

6.2 Energy Cost Savings Results

Per-unit energy cost savings for newly constructed buildings and alterations in terms of LSC savings realized over the 30-year period of analysis are presented as 2026 PV$ in Table 14 through Table 19. The LSC hourly factors methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Any time code changes impact cost, there is potential to disproportionately impact DIPs. Refer to Section 2 for more details addressing energy equity and environmental justice.

Table 14: 2026 PV Long-term Systemwide Cost Savings Over 30-Year Period of Analysis—Per Square Foot—New Construction and Additions—OfficeLarge

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	NA[a]	NA	NA
2	NA	NA	NA
3	1.24	2.30	3.54
4	1.34	4.16	5.49
5	NA	NA	NA
6	1.07	3.78	4.85
7	0.83	3.59	4.42
8	1.07	4.78	5.86
9	0.99	4.57	5.56
10	1.10	5.25	6.35
11	1.08	4.67	5.75
12	1.17	3.71	4.88
13	N/A	N/A	N/A
14	1.10	5.18	6.28
15	1.02	7.61	8.63
16	0.92	3.03	3.95

Appendix A: "N/A" refers to the fact that the CEC forecasts 0 square feet of construction activity in this climate zone for this building type in 2026.

Table 15: 2026 PV Long-term Systemwide Cost Savings Over 30-year Period of Analysis—Per Square Foot—New Construction and Additions—OfficeMedium

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	0.39	0.97	1.35
2	0.71	1.23	1.94
3	0.52	0.89	1.42
4	0.94	1.59	2.52
5	0.72	1.09	1.81
6	0.58	1.63	2.21
7	0.37	1.31	1.69
8	0.73	1.77	2.50
9	0.73	1.71	2.44
10	0.81	1.81	2.62
11	0.79	1.17	1.96
12	0.62	1.32	1.94
13	0.65	1.35	2.01
14	1.14	2.29	3.43
15	1.08	1.48	2.56
16	0.91	1.82	2.74

Table 16: 2026 PV Long-term Systemwide Cost Savings Over 30-Year Period of Analysis—Per Square Foot—Alterations—OfficeLarge

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	1.16	1.66	2.82
2	1.23	2.91	4.15
3	1.24	2.30	3.54
4	1.34	4.16	5.49
5	1.42	2.75	4.17
6	1.07	3.78	4.85
7	0.83	3.59	4.42
8	1.07	4.78	5.86
9	0.99	4.57	5.56
10	1.10	5.25	6.35
11	1.08	4.67	5.75
12	1.17	3.71	4.88
13	1.12	5.29	6.41
14	1.10	5.18	6.28
15	1.02	7.61	8.63
16	0.92	3.03	3.95

Table 17: 2026 PV Long-term Systemwide Cost Savings Over 30-year Period of Analysis—Per Square Foot—Alterations—OfficeMedium

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	0.39	0.97	1.35
2	0.71	1.23	1.94
3	0.52	0.89	1.42
4	0.94	1.59	2.52
5	0.72	1.09	1.81
6	0.58	1.63	2.21
7	0.37	1.31	1.69
8	0.73	1.77	2.50
9	0.73	1.71	2.44
10	0.81	1.81	2.62
11	0.79	1.17	1.96
12	0.62	1.32	1.94
13	0.65	1.35	2.01
14	1.14	2.29	3.43
15	1.08	1.48	2.56
16	0.91	1.82	2.74

Table 18: Average 2026 PV Long-term Systemwide Cost Savings Over 30-Year Period of Analysis—Per 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	0.39	0.97	1.35
2	0.71	1.23	1.94
3	1.03	1.88	2.91
4	1.21	3.33	4.54
5	0.72	1.09	1.81
6	0.84	2.80	3.64
7	0.61	2.47	3.07
8	0.93	3.52	4.45
9	0.88	3.33	4.21
10	0.89	2.67	3.56
11	0.87	2.18	3.05
12	0.72	1.72	2.44
13	0.65	1.35	2.01
14	1.12	3.35	4.47
15	1.07	1.77	2.85
16	0.91	2.22	3.14

Table 19: Average 2026 PV Long-term Systemwide Cost Savings Over 30-Year Period of Analysis—Per 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	0.41	0.99	1.41
2	0.75	1.38	2.14
3	0.98	1.79	2.78
4	1.19	3.21	4.40
5	0.80	1.29	2.09
6	0.91	3.08	3.99
7	0.66	2.73	3.39
8	0.98	3.98	4.96
9	0.93	3.94	4.87
10	0.95	3.42	4.37
11	0.83	1.64	2.47
12	0.86	2.36	3.22
13	0.78	2.41	3.19
14	1.12	4.03	5.15
15	1.06	3.33	4.39
16	0.92	2.47	3.39

6.3 Incremental First Cost

The Statewide CASE Team gathered data on the proposed measure cost impact from industry interviews, manufacturer marketing materials, and industry presentations. All sources provided qualitative data on the cost impact, with no quantitative information, and described that ASHRAE Guideline 36 reduces the level of effort to implement HVAC controls by reducing:

- Design time for engineers, who can use standard sequences of operation.
- Programming time for controls contractors, as standard applications provide consistent sequences of operation.
- Commissioning time for controls contractors and commissioning agents.

There are currently multiple efforts underway to further reduce the design and implementation cost of ASHRAE Guideline 36 compared to current practice:

- Lawrence Berkeley National Lab, funded by the U.S. Department of Energy, recently released open-source software that would significantly streamline the application of Guideline 36 sequences for project applications (Berkeley Lab n.d.). Users would be able to select from a set of equipment options and control configurations, relying on the software to edit the collection of sequences in the guideline to project needs. Use of the software would reduce designer effort by dozens of hours per project and would significantly improve quality, compared to manually editing the guideline in Microsoft® Word.
- Major BAS manufacturers are developing Guideline 36 programming libraries (Cheng, Paliaga and Singla 2022). The proposed measure requires using these programming libraries in Guideline 36 implementation. Some manufacturers have already published and released the Guideline 36 programming in the application libraries that they disseminate to their installers and controls contractors. Factory programming of Guideline 36 logic avoids the need for every local controls contractor and installer to interpret and program the Guideline 36 logic themselves, resulting in a significant reduction in programming effort on each project, with the potential for a substantial improvement in quality. Centralized testing and validation of the programming at the factory further reduces the level of effort required by contractors and commissioning providers on individual projects. Commissioning can instead focus on project implementation.

The Statewide CASE Team gathered qualitative data from multiple industry sources and used the information to assess the cost impact of the proposed measure. As part of the BIC research project (Cheng, Paliaga and Singla 2022), the research team interviewed several BAS manufacturers and controls contractors to investigate the cost impacts of implementing Guideline 36 measures in buildings. The interviews were all with early adopters that implemented ASHRAE Guideline 36 without programming libraries. The research team received mixed feedback on project and labor cost impacts. While two out of five contractors said that there would not be any project cost or time savings, the remaining three contractors and one of three manufacturers greed that Guideline 36 standardization would save time and labor. . One controls contractor mentioned that with more complex sequences of operation, there would be a higher level of commissioning effort, which would make it more expensive to implement the Guideline 36 measure. Most of these responses focused on system retrofits and not new construction. In correspondence with the Statewide CASE Team, two BAS manufacturers indicated that the development and testing of Guideline 36 programming libraries would not require any changes to control hardware products and would not lead to any increased costs passed on to customers. A third manufacturer did not raise any concerns when asked about the possibility of increased costs. In general, the manufacturers indicated that development efforts around Guideline 36 are driven by market demand and have already been well underway before this CASE measure was proposed.

The Statewide CASE Team reviewed resources on the manufacturer websites, including Trane, Alerton, ALC, Johnson Controls, Siemens, Schneider Electric, Distech, and Reliable Controls to get more data on the cost implications. Five out of the eight manufacturers indicated that standardizing Guideline 36 libraries (Department of Defense Environmental Security Technology Certification Program n.d.) would result in reduced engineering time, reduced programming, and commissioning time for contractors (Trane 2021) (Johnson Controls 2021) (Coogan n.d.) (Anonymous 2020). The project team was not able to find any information on cost impacts on the remaining three manufacturer websites. The team reviewed presentations on Guideline 36 delivered by nine distinct research groups during ASHRAE conferences and other webinars (Brian Russell 2015) (Interval Data Systems, Inc. 2018) (Taylor 2017) (Mark Hydeman 2015) (Wetter 2019) (Department of Defense Environmental Security Technology Certification Program n.d.) (TRC n.d.) (Jim Coogan 2021) (Stehmeyer 2018) (Xiaohui “Joe” Zhou 2015). Two out of ten presentations indicated the same trend as manufacturers suggesting reduced costs with Guideline 36 implementation (Taylor 2017) (Stehmeyer 2018). One of the ten presentations from the Iowa Energy Center (Xiaohui “Joe” Zhou 2015), stated that it took longer than current standard practices to program, debug, and commission the systems with Guideline 36 sequences. Figure 12 summarizes the data the Statewide CASE Team collected, as described above.

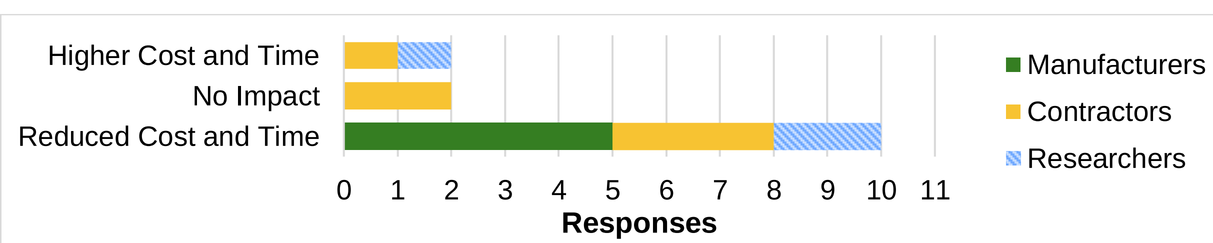

Figure 12: First-cost impacts response.

The Statewide CASE Team gathered qualitative cost data through stakeholder interviews. The interview feedback from four manufacturers and one controls designer supports the Statewide CASE Team assumption that Guideline 36 libraries reduced installation time and costs.

While it is challenging to quantify the cost reduction, as there are several variables impacting the install costs and the lack of quantitative data, the Statewide CASE Team expects the proposed measure would reduce first costs. After combining all this data, the Statewide CASE Team assumes a zero incremental cost for this measure.

The feedback received during the utility-sponsored stakeholder meeting supports the zero incremental cost assumption. Figure 13 shows the results to a poll during the stakeholder meeting, where the Statewide CASE Team asked attendees to indicate how the use of Guideline 36 would impact project costs. The results showed that on average, the costs would decrease slightly, with the biggest decrease being in the programming phase.

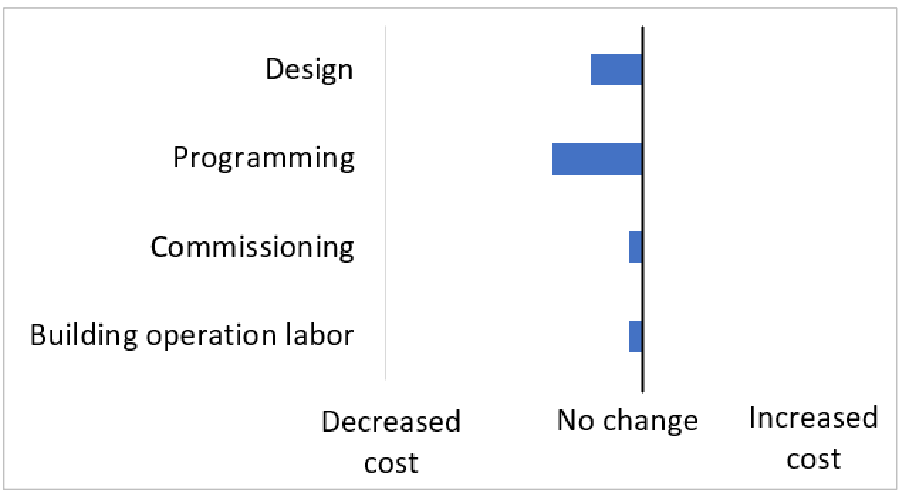

Figure 13: Stakeholder meeting poll response to 'How would the project costs be impacted with comprehensive and robust application libraries developed around Guideline 36 sequence of operation'.

6.4 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), consistent with the discount rate used when developing the 2025 lifecycle cost hourly factors. The present value of maintenance costs that occurs in the n^{th} year is calculated as follows:

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

Though the Guideline 36 sequences are more complex than typical control sequences, representing a challenge for building operators, standardization of Guideline 36 is expected to streamline building HVAC operation. Whereas operators currently need to learn how individual systems may be uniquely controlled depending on the designer or installer, Guideline 36 standardization would provide better consistency across HVAC systems and buildings, reducing the need for training and increasing the likelihood that systems are operated and maintained effectively.

The Statewide CASE Team assumes that the level of maintenance for the proposed case would be the same as the baseline, and the proposed measure would not contribute to any additional wear and tear on the equipment and systems. Despite the added complexity, standardization of the Guideline 36 sequences would reduce the level of effort and training required for maintaining the equipment and HVAC systems. Added FDD can also streamline the operator effort to resolve issues. Therefore, the Statewide CASE Team expects the proposed measure would reduce the maintenance cost. However, as described in Section 6.5, it is challenging to quantify the cost reduction. Therefore, to be conservative, the Statewide CASE Team assumed that the proposed measure has zero incremental maintenance cost.

6.5 Cost Effectiveness

This measure proposes prescriptive requirements. A cost analysis is required to demonstrate that the prescriptive requirements are cost effective over the 30-year period of analysis.

The CEC establishes the procedures for calculating cost effectiveness. 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 incremental cost to implement this measure is assumed to be zero as described in the Incremental First Cost and Incremental Maintenance and Replacement Costs sections. As a result of the zero incremental cost, the B/C ratio is infinite; therefore, it meets the 30-year threshold required by the CEC.

7. First-Year Statewide Impacts

This section provides first-year statewide impacts for energy, GHG emissions, materials use, and non-energy impacts.

7.1 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, presented in Section 5.2, by assumptions about the percentage of newly constructed buildings that would be impacted by the proposed code change. 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 by climate zone and building type that would be impacted by the proposal.

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.

Table 20 below presents the first-year statewide energy impacts and energy cost savings from newly constructed buildings and additions by climate zone. Table 21 presents first-year statewide savings from new construction, additions, and alterations.

The measure applies to buildings with VAV reheat systems, which the Statewide CASE Team estimates are in 50 percent of large office buildings and 50 percent of medium office buildings throughout the state. The 50 percent figure is derived from data in the Nonresidential Compliance Database, which stores data from NRCC-MCH prescriptive forms that have been submitted for compliance. Although this database only contains data from buildings that pursued prescriptive compliance, it is the best data source to which the Statewide CASE Team has access, and it could inform the proportion of office buildings that would be subjected to the proposed code change. These assumptions are conservative, because the assumed percentages of these building types affected by this measure are likely much higher based on stakeholder feedback. In addition, the measure would likely affect building types other than large and medium office, but these are the only prototype models that are served by systems that would be affected by this measure.

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 20: Statewide Energy and Energy Cost Impacts—New Construction and Additions

Climate Zone	Statewide New Construction and Additions Impacted by Proposed Change in 2026 (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	63,798	0.01	0.01	0.00	0.01	$0.09
2	233,289	0.06	0.10	0.00	0.07	$0.45
3	2,093,720	0.83	1.29	0.02	0.81	$5.99
4	1,058,236	0.72	0.75	0.01	0.63	$4.73
5	181,545	0.04	0.08	0.00	0.05	$0.33
6	1,213,502	0.72	0.63	0.01	0.62	$4.33
7	756,866	0.38	0.28	0.01	0.34	$2.27
8	1,812,185	1.35	1.04	0.02	1.07	$7.90
9	3,385,089	2.39	1.85	0.03	1.89	$13.97
10	747,380	0.44	0.41	0.01	0.32	$2.60
11	179,386	0.09	0.09	0.00	0.07	$0.53
12	1,624,108	0.58	0.68	0.01	0.58	$3.89
13	287,091	0.09	0.11	0.00	0.06	$0.58
14	258,612	0.18	0.17	0.00	0.14	$1.14
15	134,548	0.06	0.09	0.00	0.03	$0.38
16	71,935	0.03	0.04	0.00	0.03	$0.22
Total	**14,101,289**	**7.98**	**7.64**	**0.14**	**6.72**	**$49.40**

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

Table 21: Statewide Energy and Energy Cost Impacts from Alterations

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2026 (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	114,546	0.02	0.03	0.00	0.03	$0.16
2	1,113,672	0.33	0.50	0.01	0.36	$2.38
3	7,140,607	2.73	4.28	0.08	2.70	$19.82
4	3,744,580	2.51	2.64	0.05	2.19	$16.47
5	494,965	0.13	0.24	0.00	0.14	$1.04
6	4,813,433	3.20	2.71	0.05	2.71	$19.21
7	3,808,280	2.17	1.57	0.03	1.90	$12.92
8	7,242,527	6.22	4.38	0.08	4.88	$35.93
9	12,721,707	10.77	7.36	0.13	8.47	$61.98
10	4,088,887	3.11	2.41	0.04	2.28	$17.85
11	638,568	0.26	0.31	0.01	0.20	$1.57
12	5,890,127	2.96	3.01	0.06	2.74	$18.97
13	1,125,171	0.59	0.52	0.01	0.43	$3.59
14	1,097,600	0.95	0.74	0.01	0.69	$5.65
15	479,677	0.37	0.31	0.01	0.20	$2.11
16	285,049	0.15	0.15	0.00	0.15	$0.97
Total	**54,799,395**	**36.48**	**31.16**	**0.57**	**30.08**	**$220.62**

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

Table 22: Statewide Energy and Energy Cost Impacts—New Construction, Additions, and Alterations

Construction Type	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$)
New Construction and Additions	8.0	7.6	0.1	6.7	49
Alterations	36.5	31.2	0.6	30.1	221
Total	**44.5**	**38.8**	**0.7**	**36.8**	**270**

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

7.2 Statewide GHG Emissions Reductions

The Statewide CASE Team calculated avoided GHG emissions associated with energy consumption using the hourly GHG emissions factors that the CEC developed, along with the 2025 LSC hourly factors and an assumed cost of $123.15 per metric ton of carbon dioxide equivalent emissions (metric tons CO_2e).

The monetary value of avoided GHG emissions is based on a proxy for permit costs not social costs.[11] The cost-effectiveness analysis presented in Section 6 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 23 presents an estimated avoided 34,749 metric tons CO_2e during the first year due to the proposed code change.

Table 23: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/y)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO_2e)	Natural Gas Savings[a] (Million Therms/yr)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO_2e)	Total Reduced GHG Emissions[b] (Metric Ton CO_2e)	Total Monetary Value of Reduced GHG Emissions[c] ($)
ASHRAE Guideline 36	**44**	**782**	**0.70**	**1,947**	**2,729**	**336,106**

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

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

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

7.3 Statewide Water Use Impacts

The Statewide CASE Team estimated per-unit water savings expected from the proposed code changes. The proposed measure would not impact indoor water use. The proposed measure would impact outdoor water use where there is a cooling tower. The Statewide CASE Team modeled the water use impacts using the same prototype building models and modeling software used in the energy analysis, described in

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

Section 5.1. The OfficeLarge prototype has a chilled water plant, including water-cooled chillers and cooling towers for cooling, and therefore the proposed measure impacts outdoor water use as described below. The OfficeMedium prototype has packaged direct expansion units for cooling, and therefore the proposed measure does not impact outdoor water use.

The Statewide CASE Team modeled the total water usage for heat rejection in the OfficeLarge for the base case and the proposed case described in Section 5.1 and took the difference between the two to determine the outdoor water use impact. The proposed case would use less water at the cooling tower than the base case because the optimized control sequences, primarily the increased economizer operation and reduced simultaneous heating and cooling, would reduce the cooling loads.

Impacts on water use are presented in Table 24. It was assumed that all water savings occurred outdoors, and the embedded electricity value was 3,280 kWh/million gallons of water. The embedded electricity estimate was derived from a 2022 research analysis conducted under the auspices of California Public Utilities Commission (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 24: Impacts on Water Use and Embedded Electricity in Water

Impact	On-site Outdoor Water Savings (gallons/year)	Embedded Electricity Savings[a] (kWh/year)
Average Per Square Foot Impacts	0.72	0.0024
First-Year[b] Statewide Impacts for New Construction and Additions	7,630,722	25,029
First-Year[b] Statewide Impacts for Alterations	42,728,171	140,148
First-Year[b] Total Statewide Impacts	50,358,892	165,177

a. Assumes embedded energy factor of 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.

7.4 Statewide Material Impacts

The proposed code change would not result in material impacts.

7.5 Other Non-Energy Impacts

The proposed code change would likely improve or not change thermal comfort for the building occupants.

Occupant discomfort due to summertime overcooling is a widespread problem in commercial buildings with VAV reheat systems (Paliaga, et al. 2019). ASHRAE report RP-1515 (Arens, et al. 2015) showed that this negative thermal comfort impact is largely due to zone minimum airflows that are set unnecessarily high, often 20 to 50 percent of the cooling maximum. Reducing these minimums to minimum ventilation requirements as low as 10 percent of maximum achieved total HVAC savings of 10 to 30 percent, but it also achieved significantly reduced occupant dissatisfaction in the warm season (Arens, et al. 2015).

The BIC research project (Cheng, Paliaga and Singla 2022) evaluated the indoor environmental quality impact from control retrofits. Researchers expected that improved system resets and lower zone airflow minimums would result in decreased summer overcooling and improved occupant thermal comfort. However, results showed that space temperatures were relatively similar before and after the retrofits.

Figure 14 below shows box and whisker charts representing cooling season zone temperature data in office spaces, before and after control retrofits at four different demonstration sites. The x-axis shows the abbreviated names of each of the demonstration sites. The boxes show the range of temperatures in the interquartile, between the 25th and 75th percentiles. The whiskers represent the full range of temperatures recorded, and the median temperatures are shown by the white line. Where zone heating and cooling setpoint data are available, they are represented as diamonds and circles, respectively.

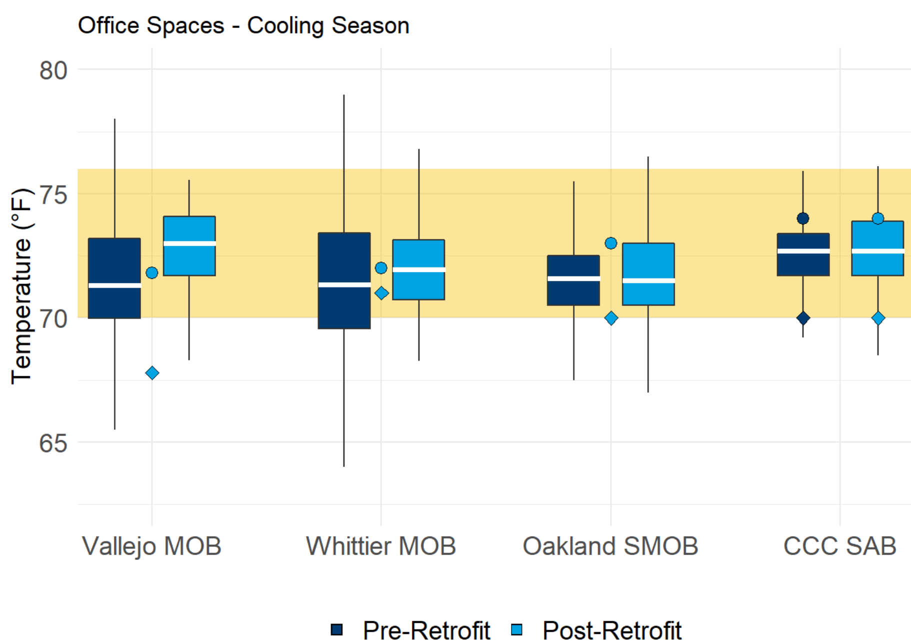

Figure 14: Thermal comfort zone temperatures before and after Guideline 36 retrofit.

Source: (Cheng, Paliaga and Singla 2022)

At three out of the four sites, thermostat setpoints were not available for the pre-retrofit period, so the setpoints depicted are between the pre- and post-retrofit bars, and they are based on the post-retrofit trends. At two sites, the zone temperatures were slightly warmer after the retrofit; at the other two sites, the zone temperatures were unchanged. The RP-1515 report (Arens, et al. 2015) project found that even an average space temperature increase of 0.4°F in the summer within the ASHRAE comfort region cut occupant cold discomfort in half, suggesting that the difference in average space temperatures seen at Kaiser Permanente (KP) Vallejo Medical Office Building (MOB) and KP Whittier MOB likely resulted in improved occupant thermal comfort in those areas.

At two other demonstration sites (Contra Costa College Student and Administration Building and KP Oakland Specialty Medical Office Building [MOB]), the average office space temperatures had only very slight changes from pre-retrofit to post-retrofit. For all demonstration sites evaluated as part of the project, the relative humidity and CO_2 typically remained within acceptable ranges in both the pre-retrofit and the post-retrofit periods.

Overall, indoor environmental quality conditions either improved or did not appear to vary considerably from the pre- to post-retrofit periods. Combined with the energy savings results, these case studies illustrate how energy savings can be achieved without decreasing thermal comfort.

8. Proposed Revisions to Code Language

8.1 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).

8.2 Standards

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

Section 100.1(b) – Definitions

ASHRAE Guideline 36 is the American Society of Heating, Refrigerating and Air-Conditioning Engineers document titled “High-Performance Sequences of Operation for HVAC Systems”. 2021 (ASHRAE Guideline 36-2021).

Programming Library is a collection of programming logic used for controlling HVAC equipment with direct digital control systems.

SECTION 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

A building complies with this section by being designed with and having constructed and installed a space- conditioning system that meets the applicable prescriptive requirements of Subsections (a) through (r~~q~~).

(c) Fan systems

2. Variable air volume (VAV) systems

B. Setpoint reset. For systems with direct digital control of individual zone boxes reporting to the central control panel:

i. static pressure setpoints shall be reset based on the zone requiring the most pressure~~; i.e., the setpoint is reset lower until one zone damper is nearly wide open~~.

ii. Control sequences of operation for static pressure setpoint reset shall be in accordance with ASHRAE Guideline 36.

(d) Space-conditioning zone controls. Each space-conditioning zone shall have controls designed in accordance with 1 or 2:

…

2. Zones served by variable air-volume systems that are designed and controlled to reduce, to a minimum, the volume of reheated, recooled, or mixed air are allowed only if the controls meet all the following requirements:

A. For each zone with direct digital controls (DDC):

i. The volume of primary air that is reheated, recooled or mixed air supply shall not exceed the larger of:

a. 50 percent of the peak primary airflow; or

b. The design zone outdoor airflow rate as specified by Section 120.1(c)3.

ii. The volume of primary air in the deadband shall not exceed the design zone outdoor airflow rate as specified by Section 120.1(c)3.

iii. The first stage of heating consists of modulating the zone supply air temperature setpoint up to a maximum setpoint while the airflow is maintained at the dead band flow rate, where the maximum setpoint is no higher than 20ºF above the space temperature setpoint.

iv. The second stage of heating consists of modulating the airflow rate from the dead band flow rate up to the heating maximum flow rate.

v. Control sequences of operation for reheat zones shall be in accordance with ASHRAE Guideline 36.

(e) Economizers.

2. If an economizer is required by Section 140.4(e)1, and an air economizer is used to meet the requirement, then it shall be:

A. Designed and equipped with controls so that economizer operation does not increase the building heating energy use during normal operation; and

Exception to Section 140.4(e)2A: Systems that provide 75 percent of the annual energy used for mechanical heating from site-recovered energy or a site-solar energy source.

B. Capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

C. Designed and equipped with a device type and high limit shut off complying with Table 140.4-G.

D. If controlled by a DDC system, configured with control sequences of operation in accordance with ASHRAE Guideline 36.

(f) Supply air temperature reset controls. Space-conditioning systems supplying heated or cooled air to multiple zones shall include controls that automatically reset supply air temperatures. Air distribution systems serving zones that are likely to have constant loads shall be designed for the air flows resulting from the fully reset supply air temperature. Supply air temperature reset controls shall be:

1. In response to representative building loads or to outdoor air temperature; and

2. At least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

3. Configured with control sequences of operation in accordance with ASHRAE Guideline 36.

(r) DDC Controller Logic Using ASHRAE Guideline 36. HVAC systems with DDC controllers shall use controller logic originating from a programming library based on sequences of operation from ASHRAE Guideline 36 in accordance with Subsections 140.4(r)1 through 140.4(r)3.

1. Requirement applies to all controllers that are capable of being programmed in the field.

2. Requirement applies to the entirety or all applicable portions of equipment control for configurations included in the programming library.

3. The programming library shall be certified by the Energy Commission as meeting the requirements of JA15.

Exception 1 to Section 140.4(r): Logic from the certified programming library may be modified to suit application-specific needs that are not supported by Guideline 36 sequences.

Exception 2 to Section 140.4(r): Systems serving healthcare facilities.

Exception 3 to Section 140.4(r): Non-programmable (configurable-only) controllers for zone terminal units shall follow applicable ASHRAE Guideline 36 zone sequences referenced in JA15 Table 15.3-1 but are not subject to programming library requirement in 140.4(r)3.

SECTION 141.0 – ADDITIONS, ALTERATIONS, AND REPAIRS TO EXISTING NONRESIDENTIAL, AND HOTEL/MOTEL BUILDINGS, TO EXISTING OUTDOOR LIGHTING, AND TO INTERNALLY AND EXTERNALLY ILLUMINATED SIGNS

(b) Alterations.

2. Prescriptive approach.

C. New or Replacement Space-Conditioning Systems or Components

Exception 6 to Section 141.0(b)2C: Requirements for the use of ASHRAE Guideline 36 in Sections 140.4(c)2C, 140.4(d)2Av, 140.4(e)2D, and 140.4(f)3, and 140.4(r) shall not apply to new or replacement components unless the space conditioning-systems are also new or replacements.

APPENDIX 1-A

STANDARDS AND DOCUMENTS REFERENCED IN THE ENERGY CODE

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (NATIONAL PUBLICATIONS)

ASHRAE GUIDELINE 36-2021 High-Performance Sequences of Operation for HVAC Systems (2021)

8.3 Reference Appendices

APPENDIX JA1 – Definitions

ASHRAE Guideline 36 is the American Society of Heating, Refrigerating and Air-Conditioning Engineers document titled "High-Performance Sequences of Operation for HVAC Systems". 2021 (ASHRAE Guideline 36-2021)

Programming Library is a collection of programming logic used for controlling HVAC equipment with direct digital control systems.

JA15 Guideline 36 Programming Library Certification

Title 24, Part 6, Section 140.4(r) requires that HVAC control systems with DDC use programming originating from a certified programming library based on control sequences of operation described in Guideline 36. This section describes the requirements of the Guideline 36 programming library.

JA15.1 Certification Submittal Requirements

Each company wishing to certify that their Guideline 36 programming library conforms to the Guideline 36 library requirements of Title 24, Part 6, may do so in a written declaration. This requires that a letter be sent to the California Energy Commission declaring that the Guideline 36 library is complete and conforms to the requirements listed in JA15.3. The declaration at the end of this section shall be used to submit to the California Energy Commission.

JA15.2 Information that shall be included with the Declaration

The certifying company shall provide evidence of compliance with these requirements, including the following at a minimum:

- Evidence: List of hardwired points and control points used in the library.
- Evidence: Documentation of test plan and results, including inputs and outputs for each test.
- Evidence: Documentation of programming, such as screenshots of programming function blocks or programming script.

JA15.3 Programming Library Requirements

The programming library to be certified shall include complete control logic for all sections from ASHRAE Guideline 36 listed in Table JA15.3-1, and shall meet the minimum validation requirements listed.

Table JA15.3-1 Required Guideline 36 Logic for Certified Programming Library

Guideline 36 Logic Section	**Minimum Validation Requirements**
Section 5.1 **General** Sections 5.1.14 and 5.1.17.3 only	Trim and Respond Setpoint Reset Logic, including Importance Multipliers, Request-Hours Accumulator, and Trim and Respond Variables per 5.1.14 Air Economizer High Limits based on device type and climate zone, per 5.1.17.3
Section 5.2 **Generic Ventilation Zones** (Section 5.2.1.3 is not required)	Zone minimum outdoor air setpoints and occupied minimum airflow calculations per 5.2.1.4 Time-averaged ventilation logic per 5.2.2

Guideline 36 Logic Section	Minimum Validation Requirements
Section 5.3 **Generic Thermal Zones**	Independently adjustable zone heating and cooling setpoints, demand limit setpoint adjustments, and setbacks per 5.3.2 Heating Loop and Cooling Loop are separate control loops per 5.3.4
Section 5.4 **Zone Groups**	Separate schedules for each Zone Group per 5.4.2 All zones in a Zone Group are in the same Operating Mode per 5.4.3 Zone Group Operating Modes per 5.4.6
Section 5.5 **VAV Terminal Unit—Cooling Only**	Airflow endpoints determined by Zone Group Mode per 5.5.4 Airflow setpoint is reset by Heating Loop or Cooling Loop signals per 5.5.5System Requests per 5.5.8
Section 5.6 **VAV Terminal Unit with Reheat**	Airflow endpoints determined by Zone Group Mode per 5.6.4 Airflow setpoint is reset by Heating Loop or Cooling Loop signals per 5.6.5System Requests per 5.6.8
Section 5.15 **Air-Handling Unit System Modes**	All Operating Modes defined for Zone Groups (see Section 6.4) are also defined for air-handling units per 5.15.1

Guideline 36 Logic Section	Minimum Validation Requirements
Section 5.16 **Multiple-Zone VAV Air-Handling Unit** (Sections 5.16.3.1, 5.16.4.1, 5.16.5.1, 5.16.6.1, and 5.16.11.2.a are not required)	Fan speed control and duct static pressure setpoint reset using trim and respond logic per 5.16.1 Supply air temperature control, temperature setpoint reset based on outdoor air temperature and trim and respond logic, and air economizer high limits per 5.16.2 System outdoor airflow requirements dynamically calculated for Zone Groups in Occupied Mode in accordance with Title 24 ventilation requirements, per 5.16.3.2 Minimum outdoor air control for multiple supported equipment configurations per 5.16.4, 5.16.5, and 5.16.6, using Title 24 ventilation logic Building relief per 5.16.8 and 5.16.9 Return fan control, per 5.16.10 and 5.16.11 Fan, filter, and pressure alarms per 5.16.13 Automatic FDD based on equipment operating state, including diagnostics based on fault conditions per 5.16.14 Plant Requests per 5.16.16

JA15.4 Declaration

Consistent with the requirements of Title 24, Part 6, Section 100.0(h), companies wishing to certify to the California Energy Commission shall execute a declaration under penalty of perjury attesting that all information provided is true, complete, accurate, and in compliance with the applicable provisions of Part 6. Companies may fulfill this requirement by providing the information, signing the declaration below and submitting to the California Energy Commission as specified by the instructions in JA15.5.

Company, Product Line, and Version Number of all libraries being certified

Company	Product Line	Guideline 36 Version	Library Version

When providing the information below, be sure to enter complete mailing addresses, including postal zip codes.

Certifying Company

Contact Person Name *	Phone 1
Certifying Company Name **	Phone 2
Address	Fax
(Address)	E-mail
(Address)	Company Website (URL)

* If the contact person named above is NOT the person whose signature is on the Declaration, then the full contact information for the person whose signature is on the Declaration must also be provided on a separate page.

** If the company named above is: A) a parent entity filing on behalf of a subsidiary entity; B) a subsidiary entity filing on behalf of a parent entity; or C) an affiliate entity filing on behalf of an affiliate entity, the above contact information must be provided for any additional entities on a separate page.

Company Responsible for Library Development if Different from Certifying Company

Contact Person Name	Phone 1
Company Name	Phone 2
Address	Fax
(Address)	E-mail
(Address)	Company Website (URL)

Declaration

I declare under penalty of perjury under the laws of the State of California that:

(1) All the information in this statement is true, complete, accurate, and in compliance with all applicable provisions of Joint Appendix JA15 of Title 24, Part 6 of the California Code of Regulations.

(2) [If the party submitting this statement is a corporation, partnership, or other business entity] I am authorized to make this declaration, and to file this statement, on behalf ofthe company named below.

Certifying Company Name	Date
Name/Title (please print)	Signature

JA15.5 Certification

Send declarations and evidence of functionality or test reports to the addresses below. Electronic submittals are preferred.

(1) Electronic submittal:
CertifiedtoCEC@energy.ca.gov
Attn: Guideline 36 Library Certification

(2) Mail:

Attn: Guideline 36 Library Certification

Building Standards Development Office

California Energy Commission

1516 Ninth St., MS 37

Sacramento, CA 95814

8.4 ACM Reference Manual

The purpose of this section is to present marked-up language for all relevant sections of the ACM Reference Manual, including describing how the software should treat the Proposed Design and the Standard Design. There are several changes needed to the Nonresidential and Multifamily ACM to account for the ASHRAE Guideline 36 measure. This section describes needed changes.

Section 5 Nonresidential Building Descriptors Reference

Section 5.6 HVAC Zone Level Systems

Section 5.6.6 Terminal Air Flow

TERMINAL MINIMUM AIRFLOW

Applicability: Systems that vary the volume of air at the zone level

Definition: The minimum airflow that will be delivered by a terminal unit.

Units: Unitless fraction of airflow

Input Restrictions: Input must be greater than or equal to the outside air ventilation rate. For systems 5 and 6, packaged VAV units and built-up VAV air handling units, where the Control System Type Certified Guideline 36 Libraries indicates that certified Guideline 36 libraries are not being used, the modeled minimum airflow shall be the maximum of 2 times the minimum airflow input or 2 times the minimum outside air ventilation rate.

Standard Design: For healthcare facilities, same as the Proposed Design. For systems 5 and 6, packaged VAV units and built-up VAV air handling units, set the minimum airflow to be the maximum of the minimum outside air ventilation rate or 10% of the design airflow.

For laboratories, the minimum airflow fraction shall be fixed at a value equivalent to the greater of the proposed design minimum exhaust requirements or the minimum ventilation rate.

Section 5.7 HVAC Secondary Systems

Section 5.7.2 System Controls

CERTIFIED GUIDELINE 36 LIBRARIES

Applicability: Systems 5 and 6, packaged VAV units and built-up VAV air handling units with Control Type DDC to the Zone.

Definition: Indicates whether certified ASHRAE Guideline 36 programming libraries are used in proposed HVAC control system design.

This input affects the proposed design system specification for zone level controls and fan static pressure part-load curves. See the following building descriptors:

- Terminal minimum airflow
- Fan part-load curve

Units: Boolean

Input Restrictions: None

Standard Design: Not applicable

Supply Air Temperature Control

SUPPLY AIR TEMPERATURE CONTROL

Applicability: All cooling or heating systems.

Definition: The method of controlling the supply air temperature. Choices are:

No control – for this scheme the coils are energized whenever there is a call for heating or cooling at the control zone.

Fixed (constant)

WarmestReset–the highest setpoint temperature that will satisfy all the zone cooling loads at the maximum zone supply air flow rate.

~~Reset by warmest zone, airflow first~~

~~Reset by warmest zone, temperature first~~

Reset by outside air dry-bulb temperature

Scheduled setpoint

Units: List (see above).

Input Restrictions: Warmest zone reset controls not applicable for single-zone systems.

Otherwise, as designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, for standard design systems 1 through 4 and 7 through 13, the SAT control is No Control. For systems 5 and 6, the SAT control shall be reset by warmest zone.~~, airflow first~~

Section 5.7.3 Fan and Duct Systems

FAN PART-FLOW POWER CURVE

Applicability: All variable flow fan systems.

Definition: A part-load power curve that represents the percentage full-load power draw of the supply fan as a function of the percentage full-load air flow.

The curve is typically represented as a quadratic equation with an absolute minimum power draw specified.

Units: Unitless ratio.

Input Restrictions: Prescribed, use curves in Appendix 5.7 based on fan control.

For systems 5 and 6, packaged VAV units and built-up VAV air handling units, where the Control System Type Certified Guideline 36 Libraries indicates that certified Guideline 36 libraries are not being used, the fan curve shall be FanVSDLimitedSpResetPwrRatio_fCFMRatio in Appendix 5.7. Otherwise, ~~T~~the default fan curve shall be selected from Appendix 5.7 for the type of fan specified in the proposed design.

$$PLR = (a) + (b \times FanRatio) + (c \times FanRatio^2) + (d \times FanRatio^3)$$

$$PLR = PowerMin$$

Where:

PLR - Ratio of fan power at part load conditions to full load fan power

PowerMin - Minimum fan power ratio

FanRatio - Ratio of cfm at part-load to full-load cfm

a, b, c, and d - Constants from the table below

Standard Design: For healthcare facilities with total system fan power less than 1 kW and system is not a DOAS, same as the Proposed Design. For all others, not applicable for standard design constant volume systems. The curve VSD with static pressure reset fans shall be used for variable volume systems. For exhaust fans, if a linear curve is used, the same fan curve, in the proposed design is used.

Appendix 5.7 Equipment Performance Curves

	Section	
	Page no.	
	Building Descriptor	
	SDD Object	Fan
	SDD Short Form	Pwr_fPLRCrvRef
	Curve Identifier	VSD with limited static pressure reset
	Curve ID Abv	VSDLimitedSpReset
	Unit System (if Applicable)	-
	Relevant To	DOE2, E+
	DOE-2.2 Keyword	FAN-EIR-FPLR
	E+ Object	Fan:VariableVolume
	E+ Field(s)	Fan Power Coefficient 1-5
	Curve Name (generated from fields)	FanVSDLimitedSpResetPwrRatio_fCFMRatio
	Curve Type	Cubic

Variables	Independents	**Dependent**	PwrRatio
		Var1	CFMRatio
		Var2	-
		Var3	-
		Var4	-
		Var5	-
	Coefficients	**a**	0.055594
		b	0.236688
		c	-0.266895
		d	0.976472
		e	-
		f	-
		g	-
		h	-
		i	-
		j	-
		Used to solve for MinVar1	0.180
	Boundaries	**MaxOut**	1.000
		MinOut	0.180
		MaxVar1	1.000
		MinVar1	0.420
		MaxVar2	
		MinVar2	
		Notes	

8.5 Compliance Forms

The following Compliance documents would need to be revised to include compliance of the systems with Guideline 36 control sequence of operations as required in Section 140.4 and 141.0.

8.5.1 Certificate of Compliance

2025-NRCC-MCH-E would need to be revised to document new prescriptive requirements specific to Guideline 36 control sequences, as described below.

[1]Table F—HVAC System Summary (Dry and Wet Systems)

a.Space Conditioning System Information—Add a column with a checkbox to indicate applicability of Guideline 36. The checkbox auto-populates based on the HVAC system type.

2 Table H—Fan Systems and Air Economizers

a.Add a new column in economizer section to indicate compliance with Guideline 36 control sequence of operations per 140.4(e).

b.Add a new column for compliance to indicate Guideline 36 control sequence of operations for static pressure reset 140.4(c).

3 Section I—System Controls

a.Add a new column for DDC controller logic to indicate use of Guideline 36 certified manufacturer library for control sequence of operations per 140.4(r).

4 Table K—Terminal Box Controls

a.Add a new column to indicate compliance with Guideline 36 control sequence of operations per 140.4(d).

NRCC-PRF-01-E would need to be revised to document new prescriptive requirements specific to Guideline 36 control sequences.

- Below Table O—Equipment Controls
    - Add a sentence to indicate applicability and use of Guideline 36 certified manufacturer programming library for control sequence of operations. Add a Yes/No check box.

8.5.2 Certificate of Installation

2025-NRCI-MCH-E would need to be revised to document new prescriptive requirements specific to Guideline 36 control sequences, as described below.

- Section F
    - Fans and Air Economizers—Add a column to indicate use of Guideline 36 sequence of operations for Fan Controls.
    - Fans and Air Economizers—For air-side economizers, add a column to indicate use of Guideline 36 sequence of operations for economizers.
- Section H
    - System Controls—For systems with DDC systems, add a column to indicate use of Guideline 36 certified manufacturer library for control sequence of operations.
    - System Controls—add a column to indicate use of Guideline 36 sequence of operations for supply air temperature reset.

  - Terminal Box Controls—add a column to indicate use of Guideline 36 sequence of operations for zone controls.

8.5.3 Certificate of Acceptance

2025-NRCA-MCH-18-A: EMCS SYSTEM ACCEPTANCE would need to be revised to document new prescriptive requirements specific to Guideline 36 control sequences, as described below:

- Table A – Construction Inspection: Add a row to check the programming with the contractor to look for a label, title, or version number in the programming to indicate that it came from a certified library.

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Appendix A: Statewide Savings Methodology

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide construction forecasts that the CEC provided (California Energy Commission 2022). The CEC provided the construction estimates on March 27, 2023, at the Staff Workshop on Triennial California Energy Code Measure Proposal Template.

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 25, and nonresidential existing statewide building stock is presented in Table 26. 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](https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency) on the CEC's website:https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

The construction forecast presents total floorspace of newly constructed buildings in 2026 by building type and climate zone. The building types included in the CEC's forecast are summarized in Table 25.

The Statewide CASE Team made assumptions about the percentage of newly constructed floorspace that would be impacted by the proposed code change.

Table 29 presents the assumed percentage of floorspace that would be impacted by the proposed code change by building type. If a proposed code change does not apply to a specific building type, it is assumed that zero percent of the floorspace would be impacted by the proposal. If the assumed percentage is non-zero, but less than 100 percent, it is an indication that some but not all buildings would be impacted by the proposal. The Statewide CASE Team assumed that 50 percent of medium and large offices would have HVAC system types that are covered by ASHRAE Guideline 36 and are not already complying with Title 24; therefore, these building types would be impacted by the proposed code change. The 50 percent figure is derived from data in the Nonresidential Compliance Database, which stores data from NRCC-MCH prescriptive forms that have been submitted for compliance. Although this database only contains data from buildings that pursued prescriptive compliance, it is the best data source to which the Statewide CASE Team has access that could inform the proportion of office buildings that would be subjected to the proposed code change. The Statewide CASE Team does not have data on how often the other building types would have HVAC systems covered by Guideline 36, and therefore conservatively assumed that zero percent of them would be impacted by the proposed code change. The Statewide CASE Team assumed that every 15 years the medium office and large office HVAC systems would be replaced. Because the replacement HVAC system would be impacted by the proposal, the Statewide CASE Team assumed that each year 50 percent of the existing medium and large office floor area would be impacted, which is consistent with impact assumption for New Construction offices.

Table 30 represents the percentage of floorspace assumed to be impacted by the proposed change by climate zone. The Statewide CASE Team assumes that the proposed code change impact does not vary by climate zone.

Table 25: Estimated New Nonresidential Construction by Climate Zone (CZ) 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 CZs
Large Office	-	-	2.90	1.42	-	1.28	0.74	2.05	3.72	0.35	0.10	0.52	-	0.18	0.01	0.04	13.31
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
TOTAL	0.13	0.48	4.27	2.16	0.37	2.48	1.54	3.70	6.91	1.53	0.37	3.31	0.59	0.53	0.27	0.15	28.78

Source: (California Energy Commission 2022)

Table 26: Estimated Existing Floorspace by Climate Zone (CZ) 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 CZs
Large Office	0.13	3.10	139.80	72.35	1.83	99.54	72.71	162.6	303.10	58.48	2.61	78.61	9.26	20.27	4.43	4.66	1033.49
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	644.04
TOTAL	3.51	34.09	218.59	114.63	15.15	147.35	116.58	221.7	389.44	125.17	19.55	180.31	34.44	33.60	14.68	8.73	1,677.53

Source: (California Energy Commission 2022)

Table 27: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (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 CZs
Large Office	0.00	0.00	1.39	0.68	0.00	0.61	0.36	0.99	1.79	0.17	0.05	0.25	0.00	0.09	0.01	0.02	6.39
Medium Office	0.06	0.23	0.66	0.36	0.18	0.58	0.39	0.79	1.53	0.56	0.13	1.34	0.28	0.17	0.13	0.05	7.43
TOTAL	0.06	0.23	2.05	1.04	0.18	1.19	0.74	1.78	3.32	0.73	0.18	1.59	0.28	0.25	0.13	0.07	13.81

Table 28: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (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 CZs
Large Office	0.06	1.55	69.90	36.18	0.92	49.77	36.36	81.30	151.55	29.24	1.30	39.31	4.63	10.14	2.22	2.33	516.7
Medium Office	1.69	15.50	39.40	21.14	6.66	23.91	21.94	29.56	43.17	33.35	8.47	50.85	12.59	6.67	5.13	2.03	322.0
TOTAL	1.75	17.05	109.30	57.32	7.58	73.68	58.29	110.86	194.72	62.59	9.77	90.16	17.22	16.80	7.34	4.36	838.8

Table 29: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Alterations Impacted (Percent Square Footage)
Large Office	50%	3.33%
Medium Office	50%	3.33%
Small Office	0%	0%
Large Retail	0%	0%
Medium Retail	0%	0%
Strip Mall	0%	0%
Mixed-use Retail	0%	0%
Large School	0%	0%
Small School	0%	0%
Unrefrigerated Warehouse	0%	0%
Hotel	0%	0%
Assembly	0%	0%
Hospital	0%	0%
Laboratory	0%	0%
Restaurant	0%	0%
Enclosed Parking Garage	0%	0%
Open Parking Garage	0%	0%
Grocery	0%	0%
Refrigerated Warehouse	0%	0%
Controlled-environment Horticulture	0%	0%
Vehicle Service	0%	0%
Manufacturing	0%	0%
Unassigned	0%	0%

Table 30: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone

Climate Zone	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
1	100%	100%
2	100%	100%
3	100%	100%
4	100%	100%
5	100%	100%
6	100%	100%
7	100%	100%
8	100%	100%
9	100%	100%
10	100%	100%
11	100%	100%
12	100%	100%
13	100%	100%
14	100%	100%
15	100%	100%
16	100%	100%

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. 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 5 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. This study resulted in the Water-Energy Calculator 1.0, which was updated in February 2022 to Version 2.0. 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 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

The California Energy Code already has a robust set of HVAC controls requirements in both the mandatory and prescriptive sections, but compliance with these requirements is often poor. The software currently assumes that HVAC controls get implemented and operate exactly as intended by the design. Most designs do not give enough detail, and industry workflow issues with design, implementation, commissioning, and operation prevent HVAC controls from performing as intended. See Section 3.2 for more details.

This proposed CASE measure would add requirements for the use of control sequences from ASHRAE Guideline 36. The purpose of ASHRAE Guideline 36 is to provide detailed, uniform sequences of operation for HVAC systems that are intended to maximize energy efficiency and performance, provide control stability, and allow for real-time fault detection and diagnostics. This proposed measure would address the performance issues described above by including a prescriptive requirement that controls programming for DDC systems use control logic from a CEC-certified Guideline 36 programming library, Certification would be based on requirements in a new joint appendix. The software needs to be updated to more accurately reflect performance of HVAC controls if the prescriptive requirement is not met.

The CASE study proposed changes to Alternative Calculation Method (ACM) modeling rules related to these technical areas. See Section 8.4 for details. CBECC needs to be updated according to the related changes to ACM Reference Manual.

Description of Software Change

Background Information for Software Change

The Statewide CASE Team proposes to require the use of ASHRAE Guideline 36. This measure aims to improve compliance with the existing controls requirements in Title 24 by requiring the use of CEC-certified programming libraries. The existing ACM modeling rules on HVAC controls model the controls based on the user inputs, which assumes perfect compliance and perfect performance.

The Statewide CASE Team recommends that CBECC be updated accordingly to the proposed changes to ACM modeling rules described in Section 8.4 for HVAC controls to support the implementation of the proposed prescriptive requirements.

The proposed changes apply to all nonresidential building types except healthcare, all space types, and all climate zones. The proposed changes only apply to VAV reheat systems, including both packaged VAV units and built-up VAV air handling units.

Existing CBECC Building Energy Modeling Capabilities

The existing ACM Reference Manual provides a comprehensive set of modeling rules for HVAC controls. These existing ACM modeling rules have been incorporated into CBECC. These rules and incorporation in CBECC assume perfect adherence to the design intention and perfect performance of HVAC controls.

The CASE Team found some discrepancies for the supply air temperature (SAT) reset strategies terminology among ACM, CBECC and EnergyPlus as shown in Table 31.

Table 31: SAT Reset Terminology – ACM, CBECC, EnergyPlus

ACM	CBECC	EnergyPlus
Fixed	Fixed	Scheduled, Constant setpoint
Scheduled setpoint	Scheduled	Scheduled, Scheduled setpoint
Reset by outside air dry-bulb temperature	OutsideAirReset	OutdoorAirReset
Reset by warmest zone, airflow first[a]	WarmestResetFlowFirst	WarmestTemperatureFlow, FlowFirst
Reset by warmest zone, temperature first	WarmestResetTemperatureFirst	WarmestTemperatureFlow, TemperatureFirst
NA[b]	WarmestReset	Warmest, Maximum Temperature

a. This option in CBECC triggers "Warmest, Maximum Temperature" in EnergyPlus, could be a mistake or an intentional override.

b. add to ACM as the standard model strategy, as described below.

Summary of Proposed Revisions to CBECC

The Statewide CASE Team recommends the following revisions to CBECC:

- Set the standard model Supply Air Temperature reset strategy to “WarmestReset”, since the WarmestResetFlowFirst strategy is not representative of real control practice and provides exceptionally high energy consumption compared to the other strategies. Of the available options, the “WarmestReset” strategy most closely represents common industry practice for resetting supply air temperature based on zone demand and is the best representation of the prescriptive requirement.

- Do not allow use of the WarmestResetTemperatureFirst or WarmestResetFlowFirst strategies for supply air temperature control. These are not representative of the actual control strategies implemented in the field, and in some cases not practically achievable except in a simulation model.
- Add a new user input to indicate if CEC-certified ASHRAE Guideline 36 programming libraries are used.
- When CEC-certified ASHRAE Guideline 36 programming libraries are not being used, replace the user-defined zone minimum flow in the proposed model with an adjusted value, which shall be the maximum of 2 times of the minimum airflow input or 2 times the minimum outside air ventilation rate.
- When CEC-certified ASHRAE Guideline 36 programming libraries are not being used, replace the default fan curve (FanVSDGoodSpResetPwrRatio_fCFMRatio) in the proposed model with a new fan curve (FanVSDLimitedSpResetPwrRatio_fCFMRatio).

User Inputs to CBECC

The Statewide CASE Team recommends that a user input be added to the CBECC software to indicate the use of certified Guideline 36 programming libraries. The user input would be available for VAV reheat, including either packaged VAV units or built-up VAV air handling unit systems.

Table 32 lists the proposed new CBECC user input for VAV reheat systems.

Table 32: Additional User Inputs Relevant to the Air System

Input Screen	Variable Name	Data Type	Units	User Editable	Recommended Label
Type = PVAV **Control Type = DDCToZone** **Reheat Control = DualMaximum**	G36_Certified_Libraries	Boolean	None	Yes	Certified ASHRAE Guideline 36 programming libraries

Simulation Engine Inputs

EnergyPlus/California Simulation Engine Inputs

The proposed ACM language describes the modeling assumptions to be used for the corresponding user input field.

EnergyPlus inputs for supply fans include the fan curve. CBECC would select a supply fan curve based on the HVAC system type, the control method, and the control type. If the supply fan is part of a multizone system, has a variable speed drive, and the system has DDC to the zone, then the ruleset selects the fan curve FanVSDGoodSpResetPwrRatio_fCFMRatio, which models a system with good static pressure reset.

These systems include a Fan:VariableVolume object, as shown in Figure 15. The Fan Power Coefficient 1, 2, 3, and 4 come from the Curve:Cubic, as shown in Figure 16.

```
Fan:VariableVolume,
  BaseAirSys5 Fan,                   !- Name
  OfficeHVACAvail,                   !- Availability Schedule Name
  0.6006,                            !- Fan Total Efficiency
  1004.383735247,                    !- Pressure Rise {Pa}
  6.31763005890816,                  !- Maximum Flow Rate {m3/s}
  FixedFlowRate,                     !- Fan Power Minimum Flow Rate Input Method
  0,                                 !- Fan Power Minimum Flow Fraction
  1.2657630426624,                   !- Fan Power Minimum Air Flow Rate {m3/s}
  0.924,                             !- Motor Efficiency
  1,                                 !- Motor In Airstream Fraction
  0.04076,                           !- Fan Power Coefficient 1
  0.088045,                          !- Fan Power Coefficient 2
  -0.072926,                         !- Fan Power Coefficient 3
  0.94374,                           !- Fan Power Coefficient 4
  0,                                 !- Fan Power Coefficient 5
  BaseAirSys5 CoilClg Outlet Node,   !- Air Inlet Node Name
  BaseAirSys5 Fan Outlet Node,       !- Air Outlet Node Name
  General;                           !- End-Use Subcategory
```

Figure 15: Example EnergyPlus input for Fan object

```
Curve:Cubic,
  FanVSDGoodSpResetPwrRatio_fCFMRatio,   !- Name
  0.04076,                               !- Coefficient1 Constant
  0.088045,                              !- Coefficient2 x
  -0.072926,                             !- Coefficient3 x**2
  0.94374,                               !- Coefficient4 x**3
  0.342,                                 !- Minimum Value of x {BasedOnField A2}
  1,                                     !- Maximum Value of x {BasedOnField A2}
  0.1,                                   !- Minimum Curve Output {BasedOnField A3}
  1;                                     !- Maximum Curve Output {BasedOnField A3}
```

Figure 16: Example EnergyPlus input for Curve object

Table 33 provides recommended translation information for generating EnergyPlus inputs from CBECC generated data.

Table 33: EnergyPlus Input Variables Relevant VAV Systems, Target EnergyPlus Object = Fan:VariableVolume

EnergyPlus Field	CBECC user input/specified value (if applicable)	Units
Name	created by OS	N/A
Availability Schedule Name	created by OS	N/A
Fan Total Efficiency	Calculated from Power Per Flow and Motor Information	N/A
Pressure Rise	Calculated from Power Per Flow and Motor Information	Pa
Maximum Flow Rate	Flow Capacity	m3/s
Fan Power Minimum Flow Rate Input Method	FixedFlowRate	N/A
Fan Power Minimum Flow Frac	Not Applicable	N/A
Fan Power Minimum Air Flow	Flow Minimum	N/A
Motor Efficiency	Motor Efficiency	N/A
Motor In Airstream Fraction	Default	N/A
Fan Power Coefficient 1	Determined from fan curve	N/A
Fan Power Coefficient 2	Determined from fan curve	N/A
Fan Power Coefficient 3	Determined from fan curve	N/A
Fan Power Coefficient 4	Determined from fan curve	N/A
Fan Power Coefficient 5	Determined from fan curve	N/A
Air Inlet Node Name	created by OS	N/A
Air Outlet Node Name	created by OS	N/A
End-Use Subcategory	created by OS	N/A

EnergyPlus inputs for air terminal units in single duct VAV reheat systems include the Fixed Minimum Air Flow Rate (m3/s), which is a user input in CBECC. An example is shown in Figure 17.

```
AirTerminal:SingleDuct:VAV:Reheat,
  BaseVAVBox TrmlUnit-8,                  !- Name
  Always On Discrete,                     !- Availability Schedule Name
  BaseVAVBox TrmlUnit-8 Damper Outlet,    !- Damper Air Outlet Node Name
  BaseAirSys5-2 Zone Splitter Outlet Node 3, !- Air Inlet Node Name
  3.5919778317719,                        !- Maximum Air Flow Rate {m3/s}
  FixedFlowRate,                          !- Zone Minimum Air Flow Input Method
  0.3,                                    !- Constant Minimum Air Flow Fraction
  0.7494525398016,                        !- Fixed Minimum Air Flow Rate {m3/s}
  ,                                       !- Minimum Air Flow Fraction Schedule Name
  Coil:Heating:Water,                     !- Reheat Coil Object Type
  BaseVAVBox TrmlUnit-8 CoilHtg,          !- Reheat Coil Name
  Autosize,                               !- Maximum Hot Water or Steam Flow Rate {m3/s}
  0,                                      !- Minimum Hot Water or Steam Flow Rate {m3/s}
  BaseVAVBox TrmlUnit-8 Outlet Node,      !- Air Outlet Node Name
  0.001,                                  !- Convergence Tolerance
  Reverse,                                !- Damper Heating Action
  ,                                       !- Maximum Flow per Zone Floor Area During Reheat {m3/s-m2}
  0.500000656946486,                      !- Maximum Flow Fraction During Reheat
  35;                                     !- Maximum Reheat Air Temperature {C}
```

Figure 17: Example EnergyPlus input for AirTerminal object

Table 34 provides recommended translation information for generating EnergyPlus inputs from CBECC generated data.

Table 34: EnergyPlus Input Variables Relevant VAV Terminal Units, Target EnergyPlus Object = AirTerminal:SingleDuct:VAV:Reheat

EnergyPlus Field	CBECC user input/specified value (if applicable)	Units
Name	Created by OS	N/A
Availability Schedule Name	Not applicable	N/A
Damper Air Outlet Node Name	Created by OS	N/A
Air Inlet Node Name	Created by OS	N/A
Maximum Air Flow Rate	Max. Primary Flow	m3/s
Zone Minimum Air Flow Input Method	FixedFlowRate	N/A
Constant Minimum Air Flow Fraction	Not Applicable	N/A
Fixed Minimum Air Flow Rate	Flow Minimum	m3/s
Minimum Air Flow Fraction Schedule Name	Not applicable	N/A
Reheat Coil Object Type	Created by OS	N/A
Reheat Coil Name	Created by OS	N/A
Maximum Hot Water or Steam Flow Rate	Max flow rate	m3/s
Minimum Hot Water or Steam Flow Rate	Min flow rate	m3/s
Air Outlet Node Name	Created by OS	N/A

EnergyPlus Field	CBECC user input/specified value (if applicable)	Units
Convergence Tolerance	Created by OS	N/A
Damper Heating Action	ReverseWithLimits	N/A
Maximum Flow per Zone Floor Area During Reheat	Max. Heating Flow	m3/s-m2
Maximum Flow Fraction During Reheat	Calculated from Max. Heating Flow and Max. Primary Flow	N/A
Maximum Reheat Air Temperature	Max reheat air temperature	C

Calculated Values, Fixed Values, and Limitations

See Section 8.4 for ACM Reference Manual for equations and assumption values for the proposed changes to the CBECC software.

Two changes must be calculated based on CBECC user inputs to configure EnergyPlus simulation inputs.

EnergyPlus inputs for supply fans include the fan curve. CBECC would select a supply fan curve based on the HVAC system type, the control method, and the control type. If the supply fan part of a multizone system, has a variable speed drive, and there is DDC to the zone control, then the Title 24 ruleset selects the fan curve FanVSDGoodSpResetPwrRatio_fCFMRatio, as depicted in Figure 18.

```
// For Proposed systems
else if( CtrlMthd = "VariableSpeedDrive" )
then
  if( Parent ( Type ) = "Relief" )
  then Rulelibrary(CrvCubic, "FanVSDPwrRatio_fCFMRatio")
  else if( SysType = "SZVAVAC" .OR. SysType = "SZVAVHP" )
  then Rulelibrary(CrvCubic, "FanVSDPerfSpResetPwrRatio_fCFMRatio")
  else if( AirSys:IsMultiZnSys = 1 )
    then
    if( AirSys:CtrlSysType = "DDCToZone" )
    then Rulelibrary(CrvCubic, "FanVSDGoodSpResetPwrRatio_fCFMRatio")
    else Rulelibrary(CrvCubic, "FanVSDPwrRatio_fCFMRatio")
    endif
  else Rulelibrary(CrvCubic, "FanVSDPwrRatio_fCFMRatio")
  endif endif endif
```

Figure 18: Section of CBECC ruleset HVACSecondary-Fan-Supply-T24N.rule

The proposed change is if the supply fan is part of a multizone system, has a variable speed drive, and there is DDC to the zone control, and the user indicates that a CEC-certified Guideline 36 programming library is not being used, then the curve FanVSDGoodSpResetPwrRatio_fCFMRatio should be replaced with the new

FanVSDLimitedSpResetPwrRatio_fCFMRatio fan curve, defined in the ACM, as described in Section 8.4.

EnergyPlus inputs for VAV terminal units include the Fixed Minimum Air Flow Rate, which is a user input in CBECC. The proposed change is if the supply fan is part of a multizone system, has a variable speed drive, and there is DDC to the zone control, and the user indicates that a CEC-certified Guideline 36 programming library is not being used, then the VAV terminal unit Fixed Minimum Air Flow Rate should be replaced with the maximum of 2 times the user-input value and 2 times the minimum outside air ventilation rate.

Changes to the standard supply air temperature reset strategy. The proposed change is to update the standard model supply air temperature reset strategy to “WarmestReset”, since the WarmestResetFlowFirst strategy is not representative of real control practice and provides exceptionally high energy consumption compared to the other strategies. The modeled “WarmestReset” strategy most closely matches the conventional supply air temperature reset used in common practice and the prescriptive requirement for supply air temperature reset control.

Alternate Configurations

There are no alternate configurations.

Simulation Engine Output Variables

No changes to simulation engine output variables are needed to support the implementation of measures proposed by this CASE study.

Compliance Report

CBECC generates a Title 24 Compliance Report that presents the results of the building’s compliance analysis. See Section 8.5.1 for details on changes needed to the compliance forms.

Compliance Verification

Authorities having jurisdiction would have to verify code compliance. See Section 3.5 and Appendix E for details on the impact on authorities having jurisdiction.

Testing and Confirming CBECC Building Energy Modeling

When CEC-certified ASHRAE Guideline 36 programming libraries are being used, the Proposed Design should be the same as the Standard Design. When the CEC-certified ASHRAE Guideline 36 programming libraries are not being used, then the energy use of the Proposed Design should be greater than that of the Standard Design. The user-input VAV terminal unit minimum airflow impacts the magnitude of the electricity and natural gas consumption difference. Table 35 shows the energy impacts of using certified libraries from the user-input VAV terminal unit minimum airflow.

Table 35: Energy Consumption Impacts from Using Certified Libraries and from VAV Terminal Unit Minimum Airflow

Prototype	CEC-certified ASHRAE Guideline 36 programming libraries Used	CZ12 Annual Electricity Use (kBtu)	CZ12 Annual Natural Gas Use (kBtu)
OfficeLarge	Yes	12,968,242	3,976,580
OfficeMedium	Yes	1,628,106	390,731

Description of Changes to ACM Reference Manual

Please see Section 8.4 for details on proposed changes to ACM Reference Manual.

Appendix D: Environmental Analysis

Potential Significant Environmental Effect of Proposal

The CEC is the lead agency under the California Environmental Quality Act 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 reduced air leakage and energy demand. The reduction in energy use would result in less GHG emissions and other pollutants. The energy and GHG emissions impacts are detailed in Section 7.1: Statewide Energy and Energy Cost Savings and Section 7.2: Statewide GHG Emissions Reductions.

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

Due to reduced cooling loads, the proposed code change would result in reduced outdoor water use at the cooling towers for large offices. There is no indoor water use impact for the proposed measure. The Statewide CASE Team estimated water use impacts due to the measure from the EnergyPlus models used for energy analysis, described in Section 5.1. The proposed code change would result in no significant impacts to water quality.

Embodied Carbon in Materials

Accounting for embodied carbon emissions is important for understanding the full environmental impact picture of a proposed code change. The embodied carbon in materials analysis accounts 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 proposed code change would not result in any materials impact. Therefore, the proposed code change would not result in embodied carbon impact.

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

This appendix discusses how the recommended compliance process, which is described in Section 3.5, could impact various market actors. Table 36 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 the ways negative impacts could be mitigated. The information contained in Table 36 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.

Overall, there would be moderate changes to the compliance and enforcement process of the proposed measure compared to the existing process, since the process for multiple market actors would be impacted, but the impact would simplify their process. The biggest impacts would be on the BAS manufacturers, controls designer, controls contractors, ATTs, and ATTCPs, who would benefit from resources and training that are already available and some that are in development. There would be revisions to the acceptable inputs to the compliance forms. Overall, the proposed approach would create a more streamlined and more effective compliance process because building officials could effectively check for compliance by checking for Guideline 36 rather than checking individual controls requirements.

Table 36 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 36: Roles of Market Actors in the Proposed Compliance Process

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Controls Designer	• Designs HVAC controls, including specifying controller hardware, software, and sequences of operation. The level of detail the designer provides the contractor, and what the designer leaves to the contractor to determine varies. • Design team submits plans, specifications, and NRCC forms to the building department for plan check.	• Would determine applicable sections of Guideline 36. • Would specify sequences of operation from Guideline 36. • Would specify any required project design information, including zones groups, schedules, and setpoints. • Would clearly indicate references to Guideline 36 on plans and specifications.	NRCC-MCH & NRCC-PRF forms would need to be updated with Guideline 36 requirements.	• Use Advanced Building Automation Systems Best Practices Guide (Cheng, Eubanks and Singla, Advanced Building Automation Systems Best Practices Guide 2022). • A software tool that allows designers to select applicable sections of Guideline 36, and that outputs the written sequences of operations. Lawrence Berkeley National Laboratory recently released such a tool. (Berkeley Lab n.d.) • Outreach and training to raise awareness and increase understanding of Guideline 36.
Plans Examiner	• Reviews the NRCC forms and construction documents for compliance. • High level reviews of equipment schedules and specifications to verify that HVAC controls documentation exists. • Issues a permit once compliance is verified.	• Would need to understand to what HVAC system types Guideline 36 is applicable. • Would verify there is a reference to Guideline 36 where applicable. • Would need to know where in the compliance form G36 is indicated.	• Plans examiner would need to check for Guideline 36 documentation in the construction documents. • Would be easier to verify compliance with Guideline 36 requirement compared to current process of verifying individual controls requirements.	Automation in the compliance forms on when the Guideline 36 requirement is applicable.
BAS Manufacturer	Provides software that the controls contractor uses to create the control program.	Would need to create Guideline 36 programming libraries.	BAS manufacturer would need to certify Guideline 36 programming libraries for use by their controls contractors.	Guidance on how to certify programming libraries.

Market Actor	Task(s) in current compliance process relating to the CASE measure	How will the proposed measure impact the current task(s) or workflow?	How will the proposed code change impact compliance and enforcement?	Opportunities to minimize negative impacts of compliance requirement
Controls Contractor and Controls Integrator	• Designs a BAS, selects hardware and creates control programs. • In collaboration with the test and balance contractor, determines and documents any field-determined project information. • Performs functional tests. • Adjusts the programming in-field if needed after commissioning or acceptance testing.	• Would start controls programs from a certified Guideline 36 programming library. • Would make any selections required, customize the library programming as needed, and program setpoints	• Mechanical Systems Acceptance Tests would need to be updated with requirements to confirm the use of a certified Guideline 36 library. • NRCA-MCH forms would need to be updated to confirm use of Guideline 36 programming library.	Training on options for customization from the Guideline 36 programming library, along with what should not be changed.
Commissioning Agent	• Reviews and tests the programming. Witnesses functional tests. • Coordinates with the controls contractor and iterates on witness tests as needed until all tests are accepted.	Because the certified Guideline 36 programming library would have already been tested, the commissioning process would involve fewer retests and less back-and-forth with the controls contractor, and it would therefore be more streamlined.	Would be easier because of the more streamlined commissioning process.	No significant impact.
ATT	• The ATT could be the controls contractor or a third-party. • Reviews acceptance tests NA Section 7.5. • Completes the NRCA-MCH forms and submits them to the inspector.	Would verify that the controls contractor used a certified Guideline 36 programming library.	Would review the language added to the NRCA-MCH forms to confirm use of a certified Guideline 36 programming library.	Training through ATTCPs on what to look for and when.
Inspector	Verifies the NRCA-MCH forms in the field and issues a certificate of occupancy.	No significant impact.	No significant impact.	No significant impact.

Appendix F: Summary of Stakeholder Engagement

Collaborating with stakeholders that might be impacted by proposed changes is a critical aspect of the Statewide CASE Team's efforts. The Statewide CASE Team aims to work with interested parties to identify and address issues associated with the proposed code changes, so the proposals presented to the CEC in this Draft CASE Report are generally supported. Public stakeholders provide valuable feedback on draft analyses and help identify and address challenges to adoption including cost effectiveness, market barriers, technical barriers, compliance and enforcement challenges, or potential impacts on human health or the environment. Some stakeholders also provide data that the Statewide CASE Team uses to support analyses.

This appendix summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the recommendations presented in this report.

Utility-Sponsored Stakeholder Meetings

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

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

The Statewide CASE Team hosted one stakeholder meetings for Nonresidential HVAC Controls via webinar described in Table 37. 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 37: Utility-Sponsored Stakeholder Meetings

Meeting Name	Meeting Date	Event Page from Title24stakeholders.com
First Round of Nonresidential HVAC Controls Utility-Sponsored Stakeholder Meeting	Monday. February 27, 2023	https://title24stakeholders.com/event/ hvac-controls-and-space-heating-utility-sponsored-stakeholder-meeting/

The first round of utility-sponsored stakeholder meetings occurred in February 2023, and they 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, early results of energy, cost effectiveness, incremental cost analyses, and code language for stakeholders to review.

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 it recorded outcomes of live attendee polls to evaluate stakeholder participation and support.

Stakeholder Comments to Draft CASE report

The Statewide CASE Team received several comments from stakeholders on the draft CASE report published in May 2023. Below is a summary of the comments received and the changes that the Statewide CASE Team made in response.

Siemens, Trane, and Automated Logic Controls, all BAS manufacturers, submitted comments. While all three manufacturers generally supported the proposal in the draft CASE report, the manufacturers recommended making changes to the proposal. Trane recommended changing the requirement applicability to be based on needs and performance rather than whether the controllers are configurable or programmable. Trane also recommended not having certified library requirements beyond the four prescriptive measures. Siemens recommended that compliance be based on the sequences being used and not require unused sequences to be certified. Siemens also recommended removing Time Based Suppression from the list of library requirements. Automated Logic Controls commented that cost with Guideline 36 would likely be the same as current practice and that initial implementations would likely cost more because of unfamiliarity with the G36 sequence.

Automated Controls, a controls contractor, commented that controller hardware that could handle ASHRAE Guideline 36 would cost 10% more than controller hardware used in current industry practice. They also commented that while they agree that Guideline 36 would save on labor costs in the long term, in the short term (6 –12 months), the labor costs would be higher than current practice.

The Natural Resources Defense Council, an advocate, commented in support of the proposal and recommended expanding the statewide impacts analysis to include other building types.

Altura, a consultant and commissioning provider, suggested that the proposed requirement should also apply to configurable controllers.

Red Car Analytics, a consultant and commissioning provider, commented on the energy savings assumptions, enforcement, and costs. They commented that in order to achieve energy savings over current practice, trim and respond variables would need to be set correctly in the Guideline 36 implementation. They also commented that Guideline 36 would incur costs beyond typical practice for training, design, monitoring, and commissioning. Lastly, Red Car Analytics commented that checking a box to indicate that the programming is from a certified library is inadequate to show compliance.

Interval Data Systems, a consultant, commented on the need for data from utility meters, energy models, and BAS's to connect in order to better control a building. The Statewide CASE Team recognizes the importance of connecting these data streams, but notes that it is outside the scope of the proposed measure.

Considering all the stakeholder input, the Statewide CASE Team made the following considerations and resulting changes:

The Statewide CASE Team carefully considered the input from the two manufacturers that commented that the programming library requirements in the draft CASE report Joint Appendix should be reduced. In response, the Statewide CASE Team reduced the programming library requirements in the Joint Appendix.

The Statewide CASE Team carefully considered the input from one manufacturer and one consultant who commented that the requirement should also apply to configurable controllers. In response, the Statewide CASE Team added language to the proposed code language to specifically include configurable zone controllers in the requirement.

Regarding costs, based on the interviews described in Section 6.3, hardware costs would not be more expensive for Guideline 36 than for complying with current Title 24 requirements. Design time and training time are not included in the CEC's cost-effectiveness analysis assumptions. Therefore, in this Final CASE report, the Statewide CASE Team continued to assume that the incremental measure cost was zero.

Regarding the trim and respond variables in the Guideline 36 implementation to realize energy savings, the Statewide CASE Team notes that Guideline 36 has default values for almost all the variables or instructions for how to determine them. Regarding expanding the analysis, the Statewide CASE Team chose to remain conservative in the statewide impact analysis. The statewide impact analysis does not affect the proposed change applicability.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email, phone, and Team meetings with numerous stakeholders when developing this report, listed in Table 38.

Table 38: Engaged Stakeholders

Organization or Individual Name	Market Role	Type of Outreach	Outcome	Mentioned in CASE Report Sections
75F / William McNeill	BAS Manufacturer	Interview Request and outreach to regional reps and local contractors	Outreach acknowledgement received	–
Automated Logic Controls/ Conrad Carino	BAS Manufacturer	Outreach to regional rep and local contractors	Outreach acknowledgement received	–
Automated Logic Controls / Multiple	BAS Manufacturer	Interview Request	Interview complete	Section 4.2.3
Alerton / Kevin Callahan	BAS Manufacturer	Interview Request	Interview complete	Section 4.2.1, 4.2.3
Distech / Eric Swiney	BAS Manufacturer	Interview Request	In-person meeting	–
Distech / Stefani Szczechowski	BAS Manufacturer	Outreach to regional rep and local contractors	Outreach acknowledgement received	–
Schneider Electric / Ann Patten, David Fisher, Wayne Stoppelmoor	BAS Manufacturer	Interview Request and outreach to regional reps and local contractors	Interview complete	Section 4.2.1, 4.2.3
Siemens / Jim Coogan	BAS Manufacturer	Interview Request and outreach to regional reps and local contractors	Interview complete and outreach acknowledgement received	Section 4.2.1
Trane / Tony Bruno	BAS Manufacturer	Interview Request and outreach to regional reps and local contractors	Interview complete	Section 4.2.1, 4.2.3
Automatic Controls Engineering / Wilson Lee	Controls Contractor	Outreach to regional rep and local contractors	Interview complete	–
JCI Folsom / Chris Gosline	Controls Contractor	Outreach to regional rep and local contractors	Outreach acknowledgement received	–
P2S / Cindy Callaway	Controls Designer	Interview Request	Interview complete	Section 4.2.1, 4.2.3

Organization or Individual Name	Market Role	Type of Outreach	Outcome	Mentioned in CASE Report Sections
Kaiser Permanent / Glen Kuromoto	Building Owner	Interview Request	Interview complete	Section 4.1.1
Veregy /Doug Chamberlin	Commissioning Provider	Interview Request	Interview complete	Section 4.1.1
Veregy / Robin Liu	Commissioning Provider	Interview Request	Interview complete	Section 4.1.1
KW Engineering / Eric Uribe	Commissioning Provider	Interview Request	Interview complete	Section 4.1.1
Altura / Jim Meacham	Commissioning Provider	Interview Request	Interview complete	Section 4.1.1
Facility Dynamics / Darren Goody	Commissioning Provider	Interview Request	Interview complete	Section 4.1.1
Veregy /Doug Chamberlin	Commissioning Provider	Interview Request	Interview complete	Section 4.1.1
University of California, Berkeley, Center for the Built Environment / Paul Raftery	Researcher	Outreach for comments on the proposal	Received statement of support	–
ASHRAE G36 Committee	Industry Organization	Outreach for announcement	Received statement of support	Section 4.2.1
ASHRAE Golden Gate Chapter	Industry Organization	Outreach for announcement	Proposed measure announced	Section 4.2.1
ASHRAE Southern California Chapter	Industry Organization	Outreach for announcement	Proposed measure announced	Section 4.2.1
ASHRAE Orange Empire Chapter	Industry Organization	Outreach for announcement	Proposed measure announced	Section 4.2.1

Engagement with DIPs

Stakeholder outreach did not specifically target DIPs.

Appendix G: Energy Cost Savings in Nominal Dollars

The CEC requested energy cost savings over the 30-year period of analysis in both 2026 PV$ and nominal dollars. The cost-effectiveness analysis uses energy cost values in 2026 PV$. Costs and cost effectiveness using 2026 PV$ are presented in Section 6.5 of this report. This appendix presents energy cost savings in nominal dollars. See Table 39 through Table 40 for cost savings results in nominal dollars.

Table 39: Nominal Life Cycle Energy Cost Savings Over 30-year Period of Analysis—Per Square Foot—New Construction, Additions and Alterations—OfficeLarge

Climate Zone	30-year Lifecycle Electricity Cost Savings (Nominal $)	30-year Lifecycle Natural Gas Cost Savings (Nominal $)	Total 30-year Lifecycle Energy Cost Savings (Nominal $)
1	$2.61	$4.17	$6.79
2	$2.78	$7.33	$10.12
3	$2.81	$5.79	$8.60
4	$3.02	$10.46	$13.49
5	$3.20	$6.92	$10.13
6	$2.41	$9.51	$11.92
7	$1.88	$9.02	$10.91
8	$2.42	$12.04	$14.46
9	$2.24	$11.51	$13.74
10	$2.49	$13.21	$15.70
11	$2.43	$11.76	$14.19
12	$2.63	$9.35	$11.99
13	$2.52	$13.32	$15.84
14	$2.48	$13.03	$15.52
15	$2.29	$19.15	$21.44
16	$2.07	$7.63	$9.71

Table 40: Nominal Life Cycle Energy Cost Savings Over 30-year Period of Analysis—Per Square Foot—New Construction, Additions and Alterations—OfficeMedium

Climate Zone	30-year Lifecycle Electricity Cost Savings (Nominal $)	30-year Lifecycle Natural Gas Cost Savings (Nominal $)	Total 30-year Lifecycle Energy Cost Savings (Nominal $)
1	$0.87	$2.43	$3.30
2	$1.59	$3.10	$4.69
3	$1.18	$2.25	$3.43
4	$2.11	$4.00	$6.11
5	$1.62	$2.75	$4.36
6	$1.30	$4.11	$5.41
7	$0.84	$3.30	$4.15
8	$1.64	$4.45	$6.10
9	$1.65	$4.31	$5.96
10	$1.84	$4.55	$6.39
11	$1.79	$2.94	$4.73
12	$1.41	$3.31	$4.72
13	$1.47	$3.41	$4.88
14	$2.57	$5.76	$8.33
15	$2.43	$3.73	$6.16
16	$2.05	$4.59	$6.65