Codes and Standards Enhancement (CASE) Initiative

2028 California Energy Code

Data Centers Efficiency Improvements

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Acronyms

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

Table 1: List of Acronyms

Acronym	Definition
ACM	Alternative Calculation Method
ADA	Americans with Disabilities Act
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
ATT	Acceptance Test Technician
BCR	Benefit-to-cost Ratio
BEM	Building Energy Modeling
Btu	British Thermal Units
CALGreen	California Green Building Standards Code
Cal/OSHA	California Division of Occupational Safety and Health
CARB	California Air Resources Board
CASE	Codes and Standards Enhancement
CBSC	California Building Standards Commission
CBECC	California Building Energy Code Compliance Software
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CBO	Community-Based Organization
CDU	Coolant Distribution Unit
CPUC	California Public Utilities Commission
CPU	Central Processing Unit
CSE	California Simulation Engine
CTF	Conduction Transfer Functions
CZ	Climate Zone
DAC	Disadvantaged Community
DFDD	Dual Fan Dual Duct
DGS	California Department of General Services
DOAS	Dedicated Outdoor Air System
DOSH	Division of Occupational Safety and Health
ECC	Energy Code Compliance
ECM	Electronically Commutated Motors
EIR	Environmental Impact Report

EPIC	Electric Program Investment Charge
ESJ	Environmental and Social Justice
FSOR	Final Statement of Reasons
GHG	Greenhouse Gas
GPU	Graphics Processing Unit
GWh	Gigawatt-Hour
HVAC	Heating, Ventilation, and Air Conditioning
IDF	Input Data File
IECC	International Energy Conservation Code
IOU	Investor-Owned Utility
ISOR	Initial Statement of Reasons
ITE	Information Technology Equipment
Kg/s	Kilograms per Second
kWh	Kilowatt-Hour
kWh/year	Kilowatt-Hour Per Year
LED	Light Emitting Diode
LPD	Lighting Power Density
LSC	Long-term System Cost
MeasureSET	CASE Measure Savings Estimation Template
MG	Million Gallons of Water
NAICS	North American Industry Classification System
NPDI	Net Private Domestic Investment
PEP	Public Engagement Plan
PUE	Power Usage Effectiveness
PV	Present Value
RDHx	Rear Door Heat Exchanger
SAT	Supply Air Temperature
SDD	Standards Data Dictionary
SOC	Standard Occupational Classification
SPMS	Saturation Pressure Measurement Sensors
SRIA	Standardized Regulatory Impact Assessment
UL	Underwriters Laboratories
W	Watt

1. Introduction

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

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

1. *For large new data centers, what percentage of the load is expected to be liquid-cooled ITE vs. air-cooled ITE?*
2. *What percentage of new computer room designs use heat recovery to heat other parts of the building heating or SHW load?*
3. *What is the frequency of ITE replacements?*

Email comments and suggestions to info@title24stakeholders.com *and Aniruddh Roy at* aroy@energy-solution.com*. Comments will either not be released for public review or will be anonymized if shared.*

1.1 Report Context

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

1.2 Proposal Sponsors

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

1.3 Stakeholder Engagement to Inform Proposal

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders including MEP firms, construction firms, building officials, appliance manufacturers, builders, utility incentive program managers, Title 24 energy analysts, state agencies, Lawrence Berkeley National Laboratory, and others involved in the code compliance process. In addition to those stakeholders, the Statewide CASE Team engaged market actors who manage data centers, design and engineering firms specializing in data centers and smaller computer rooms, manufacturers of cooling equipment, appliance standards associations, and national experts involved in data center projects across the country to provide updates on the proposed measure and invite their input and participation in the process. To understand the cost implications of this proposal to computer room builders and developers in California, the Statewide CASE Team engaged with two mechanical engineering and construction firms who were able to provide cost estimates of code compliant approaches.

The proposal also incorporates feedback received during a public stakeholder workshop that the Statewide CASE Team held on September 30, 2025 (California Energy Codes & Standards: A Statewide Utility Program 2025). Some of the specific feedback the Statewide CASE Team received during this workshop related to the complexity of the proposed code language and questions around specific compliant approaches. The Statewide CASE Team took that feedback and simplified the air-cooled and liquid-cooled ITE economizing requirements as shown in section 2.6.1 of this report. Members of the CASE Team are on AHRI's Datacom Standards Technical Committee, the committee overseeing revisions to AHRI Standard 1360, the performance rating standard of Computer and Data Processing Room Air Conditioners. On February 18, 2026, the CASE Team provided an overview of the measures in this CASE report to AHRI and ASHRAE members at a joint meeting of committees dealing with revisions to AHRI Standard 1360 and ASHRAE 127.

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

2. Computer Room Economizers

2.1 Computer Room Economizers - Measure Description

2.1.1 Proposed Code Change

This measure would expand definitions related to computer rooms and data centers, such as Liquid-cooled Information Technology Equipment (ITE), and increase the amount of time an economizer serves full or part load cooling in newly constructed computer rooms and existing computer room additions and alterations. These specific measures include:

Added to Definition Section 100.1

- **Liquid-cooled ITE** describes the cooling technology, common types of liquid cooling, and highlights that servers can be partially air-cooled and liquid-cooled.
- **Facility Water** describes the cooling fluid serving liquid-cooled ITE.
- **Computer Room Economizer** describes what a computer room economizer is and provides specific guidance on how to ensure it is fully integrated when the economizer is part of a cooling system that also includes a refrigerant compressor.

Section 140.9(a)1 – Covered Processes

This measure proposes modifying the computer room economizer requirements in the California Energy Code to expand the number of hours economizers must meet all or part of the computer room cooling load. Specific modifications are as follows and additional details about these changes are provided in Section 2.1.3.

A. Raise the 100 percent wet-bulb economizer threshold from 45°F wet-bulb to 60°F wet-bulb for air-cooled ITE.
B. Add new economizer thresholds at 75°F wet-bulb and 75°F dry-bulb for >2MW liquid-cooled ITE loads.
C. Impose minimum water and air temperature differentials and variable flow requirements to ensure integrated economizer savings.
D. Add economizer exception for computer rooms using a heat recovery system meeting specified minimum capacity thresholds.

Existing Building Economizers Section 141.1(b)1:

This code change would modify the requirement for additions and alterations so that they are subject to the New Construction requirements as stated in Section 140.9(a)1. This change would also modify Exception 1 and increase the ITE threshold to 10 Tons for when an economizer is not needed. The change would also delete Exception 2 and Exception 3. Lastly, a new exception would be added, allowing flexibility for existing buildings to comply with the Title 24, Part 6 economizer requirements that were in effect when the building was permitted. Table 2 summarizes the scope of the proposed code change.

Table 2: Scope of Proposed Code Change

A ☑ indicates the proposed code change is relevant.

Building Type(s)	Construction Type(s)	Type of Change
☐ Single Family	☑ New Construction	☐ Mandatory
☐ Multifamily	☑ Additions	☑ Prescriptive
☑ Nonresidential (Not Group R uses)	☑ Alterations	☑ Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	• Part 6, Sections 100.1, 140.9(a)1, 141.1(b)1	NRCC-PRC-E NRCI-PRC-E	Mandatory

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

2.1.2 Benefits of Proposed Change

To achieve California's ambitious climate action plan and hit carbon neutrality by 2045, addressing rising energy use in data centers is critical. With building emissions contributing to roughly 25 percent of California's GHG emissions, increased growth in a highly energy intensive industry such as data centers has the potential to increase overall emissions and negatively impact statewide climate goals (California Air Resources Board 2022). In addition to increased emissions, dramatic rise in energy load to the grid to support data centers could potentially result in increased costs for consumers in the state, if not appropriately managed. One cost-effective way to manage demand growth in data centers is to increase their overall efficiency through energy code measures and technological advancements.

Although projections vary, energy consumption in data centers is projected to increase significantly over the next few decades. According to a recent Lawrence Berkeley National Laboratory (LBNL) report, "data centers consumed about 4.4 percent of total U.S. electricity in 2023 and are expected to consume approximately 6.7 to 12 percent of total U.S. electricity by 2028 (Shehabi, et al. 2024)." During this same time, data centers have become increasingly efficient in computer processing and server cooling technologies, especially with the rise of liquid-cooling technologies. These technologies have improved energy-efficiency, characterized by power usage effectiveness (PUE), by as much as ten percent in some data centers (McKinsey & Company 2024).

While data center energy use roughly doubled from 2000 to 2010, energy use increases were modest from 2010 to 2020, which has largely been attributed to technological advancements in servers and cooling technologies. This rapid change in technologies means that current Title 24 requirements and definitions, which were last updated during the 2022 cycle, are falling behind current trends. The inclusion of new definitions such as liquid-cooled ITE and integrated computer room economizers would improve common understanding across the industry and code enforcement community.

In addition to myriad societal benefits, increasing the outdoor air temperature for when economizers operate would result in operational efficiencies at the individual computer room or data center level. These include, but are not limited to:

- **Energy and Operational Cost Savings:** Raising the server air or liquid inlet temperature in data centers has a direct effect on energy use. It is widely claimed that data centers can save 4-5 percent on energy costs for every 1°F increase in server air or liquid inlet temperature. Various mechanisms exist for saving energy by raising temperatures (Beaty et. al 2016).
- **Reduced Compressor Load:** Increasing the operating temperature and running equipment in economizing mode reduces the time when mechanical cooling is necessary and puts less strain on equipment to meet the load.

2.1.3 Background Information

2.1.3.1 Computer Room Economizer Requirements

Computer room economizer requirements were first introduced in Title 24, Part 6 during the 2013 cycle. During this cycle, 140.9(a) Prescriptive Requirements for Computer Rooms were established and included provisions regulating economizers, reheat, humidification, fan control, and air containment (California Energy Commission 2012). As it relates to this proposed measure, economizer requirements in the code were established in 2013 and updated in 2022 to reflect technological advancements and increased opportunity for cooling efficiencies.

- 2013 Requirements: When first introduced, cooling systems primarily serving computer rooms were required to include either an integrated dry-bulb or wet-bulb economizer, meeting 100 percent of the cooling load at 55°F dry-bulb or 35°F wet-bulb, respectively. Four exceptions applied.

- 2022 Requirements: These thresholds were updated in the 2022 standard to 65°F dry-bulb or 45°F wet-bulb for a dry-bulb and wet-bulb economizer, respectively. Exceptions were reduced and streamlined.

During and since the previous economizer requirements were implemented, recommended operating temperatures for ITE have steadily increased as technology has advanced. For example, in 2015, IBM's FlashSystem 900 had a recommended operating temperature of 50°F, where the FlashSystem 5200 can operate at 41-95°F (Hopwood 2025). Meanwhile NVIDIA's Grace Blackwell GB200 NVL72 GPU/CPUs use a liquid cooling system with a maximum liquid inlet temperature of 113°F.

ASHRAE's Technical Committee 9.9, which develops guidelines and standards for mission critical facilities, data centers, technology spaces, and electronic equipment/systems has also increased thermal guidelines for data centers over the years. The primary recommended temperature range for general data center equipment (all classes) has increased from 68-77°F in the 2004 edition to a wider range of 64-81°F in the 5th edition, with wider allowanced temperatures depending on the class and cooling approach (ASHRAE 2021).

Air-Cooled versus Liquid-Cooled ITE

Air-cooled ITE uses ambient air to help dissipate heat in computer rooms and data centers through established cooling technologies such as DX Air conditioners, chilled water air handlers, airside economizers, etc. Air-cooled technology has been the dominant approach to remove heat from ITE, and it has evolved and become more efficient over time through design approaches such as hot aisle containment. Liquid-cooling technology is typically employed in enterprise level data centers with high heat density workloads, such as artificial intelligence (AI), and high-performance computing (HPC) data centers. Liquid-cooled ITE uses a cooling liquid to provide cooling at the chip-level; two common liquid cooling systems are direct to chip (D2C) cold plates and immersion systems. According to a recent study from the Uptime Institute, there continues to be a trend toward rapid growth in rack densities, with colocation data centers – a data center where companies can rent space to locate their servers – seeing the strongest uptick in rack power (Donnellan, et al. 2024). As densities increase, traditional air-cooled ITE approaches may not effectively cool the servers, necessitating a switch to liquid-cooled ITE. Liquid cooling has a much higher heat rejection capacity than air-cooled technologies—roughly 1,000 times the cooling capacity of air—giving it the ability to handle heat loads exceeding 100 kW per rack (Lawrence Berkeley National Laboratory 2021). Liquid-cooled ITE can also operate at temperatures above 100°F entering water temperature; this allows for greater heat recovery potential than air-cooled ITE systems by rejecting heat directly to a hydronic heating system and meet space heating needs without the need to boost the temperature higher through a mechanical heating system for many, or all, hours of the year.

A primary goal of the proposed computer room definitions is to improve clarity and align the code language with common terminology within the industry and describe liquid-cooled ITE. As defined in the proposed definition:

> ***Liquid-cooled ITE***: components of ITE that are cooled by a fluid other than air and that do not use server fans to flow air across the components. Common liquid cooling fluids include water, glycol, and refrigerant. Individual servers can be partially liquid-cooled and partially air-cooled, with server fans serving the air-cooled components and pumps serving the liquid-cooled components.

The most common types of liquid-cooled ITE approaches include direct-to-chip (D2C) and immersion cooling. These technologies are described below:

- **Direct-to-chip:** D2C cools ITE by moving coolant (dielectric single-phase fluid) through server racks and directly connected to a cold plate that is connected to the central processing unit (CPU) or graphics processing unit (GPU). This enables heat to be removed directly from the chip, typically flowing through a coolant distribution unit and heat exchanger, and then rejected through a central chiller or cooling tower. Figure 1 is an image of a D2C cooling approach.
- **Immersion cooling:** This approach still uses a dielectric single-phase fluid for cooling, but instead of piping it through the servers, servers are directly submerged in fluid for cooling.
- **Rear door heat exchanger (RDHx):** This cooling approach offers precision cooling at the server cabinet level. A heat exchanger is attached directly to the door of the cabinet and heat generated by the servers is extracted through chilled water circulation. RDHx can either be passive—relying on server fans to drive airflow through the heat exchanger—or active with the use of additional auxiliary fans. This approach is often used in tandem with a building cooling system and airside economizer.

Figure 1 shows a server with air-cooled components on the left side and D2C liquid-cooled components on the right side.

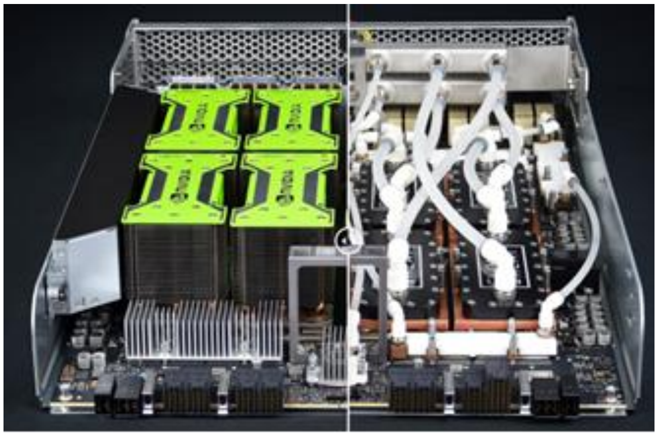

Figure 1: Air-cooled ITE (left) and D2C liquid-cooled ITE (right)

Figure 2: Immersion cooling at Sandia National Laboratories

Photo by Craig Fritz and published by Sandia National Laboratories 2024)

Figure 3: Passive RDHx devices at LBNL

Background on changes to 140.9(a)1

Additional context and design approaches for each of the proposed changes to 140.9(a)1 are described below:

1. Raise the 100 percent wet-bulb economizer threshold from 45°F wet-bulb to 60°F wet-bulb for air-cooled ITE.
    a. Unlike an airside economizer which has a direct cooling option, there is no direct option for waterside economizers. A typical waterside economizer serving air-cooled ITE is a water-cooled chilled water plant with plate heat exchangers. It has three approaches: 1) the cooling tower's leaving condenser water approach to the outdoor wet-bulb, 2) the heat exchanger approach from condenser water to chilled water, and 3) the air handler coil approach from chilled water to the supply air temperature. For the current 45°F threshold and a typical 75°F supply air temperature, the total of these three approaches must not exceed 30°F. Raising the full economizing threshold to 60°F outdoor wet-bulb means the three approaches must total no greater than 15°F. This would require larger equipment to reduce approach temperature: larger cooling towers, and/or larger heat exchangers, and/or larger cooling coils.
2. New economizer thresholds at 75°F wet-bulb and 75°F dry-bulb for >2MW liquid-cooled ITE loads.
    a. Air-cooled ITE can typically be satisfied with 60-65°F chilled water supply to the air handler. Liquid-cooled ITE can be satisfied with the same 60-65°F chilled water, but it can also be satisfied with higher entering fluid temperatures, like 80-105°F to the coolant distribution unit (CDU) which distributes liquid cooling to the chips and rejects the heat via a heat exchanger through a facility water loop connected to a chiller or cooling tower[1]. Most large data centers with liquid-cooled ITE also have a significant air-cooled ITE load, often in the same rack. It is common for these types of data centers to have a single chilled water distribution system serving both the air-cooled ITE and the liquid-cooled ITE with 60-65°F chilled water. It is also common for these types of data centers to include two sets of distribution piping: 60-65°F chilled water from chillers to the air-cooled ITE and 80-105°F chilled water to the liquid-cooled ITE. 80-105°F chilled water can be generated more efficiently than 60-65°F chilled water.
3. Impose minimum temperature differential and variable flow requirements.
    a. Currently Title 24, Part 6 simply states that a computer room economizer must be integrated, which means it is capable of partial economizer and partial mechanical cooling. This measure would also establish return air temperature and return water temperature requirements. In addition to the

[1] To cite manufacturer literature/Code Readiness lit review memo (publication pending).

proposed definition of an integrated economizer, this new requirement would be a way to further define computer room economizer integration and promote increased economizer utilization at part-load conditions through elevated return air and water temperatures.

Integrated Computer Room Economizers

There are many types of computer room economizers in use today. Many of these are not integrated and may not comply with the proposed prescriptive requirements in the measure.

Compliant Designs

The new definition would spell out several prescriptively compliant economizer types.[2] A description and diagram of potentially compliant dry-bulb and wet-bulb economizers for air-cooled and liquid-cooled ITE is outlined below.

1. Waterside economizer heat exchangers that are piped in series with chillers on the chilled water (evaporator) side. This allows the waterside economizer heat exchanger to cool the return chilled water before it reaches the chiller evaporator and reduces the load on the chiller from 1-99 percent during partial economizer operation. (see Figure 4).

[2] Note that just because an economizer meets the definition of integrated does not mean that it automatically complies. It must still meet the economizer temperature threshold requirements.

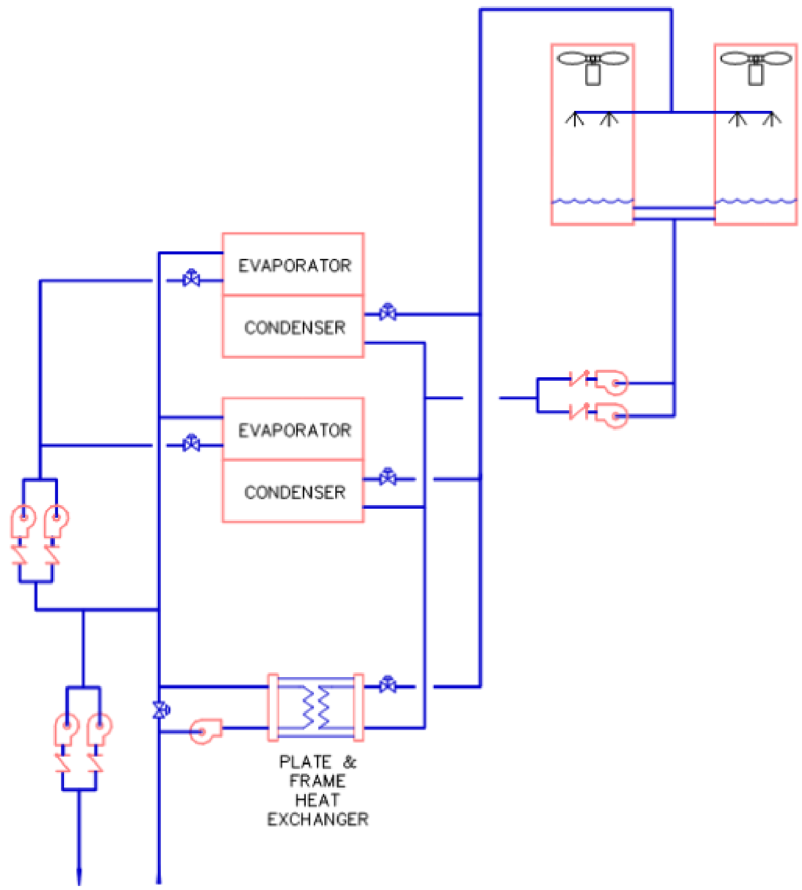

Figure 4: Compliant waterside economizer (piped in series with evaporator)

2. Air-cooled chillers with integrated economizer coils that are piped into the secondary circuit of a primary/secondary system. This allows the economizer to operate based on the return water temperature to the data center cooling coils, which is typically warmer, and therefore allows for more economizing hours, than the primary return water temperature which may be lower due to mixing with supply water to meet chiller minimum flow requirements. (see **Error! Reference source not found.**)
3. Air-cooled chillers with integrated economizer coils that are served by dedicated economizer fans and not by condenser fans that serve refrigerant condenser coils. This allows for the dry cooler condenser fans to operate independently from the chiller condenser fans and not be limited by the chiller head pressure control requirements. This also allows the dry cooler to make colder water at low outdoor temperatures and increase economizer cooling capacity (see Figure 5).

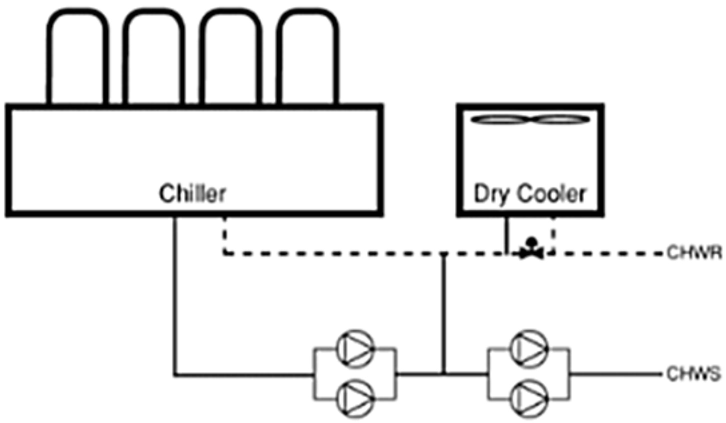

Figure 5: Potentially compliant air-cooled chiller with dry cooler piped into secondary circuit

4. Refrigerant economizer systems where 10-90 percent of the load on a refrigerant circuit could be met by a passive condenser or refrigerant pump, while the other 90 to ten percent of the load is met by an active condenser or refrigerant compressor.
5. In a scenario where a data center has both air-cooled and liquid-cooled ITE, separate plants for air-cooled and liquid-cooled ITE are more likely to comply. This enables the liquid-cooled ITE to be served at a high enough condenser water temperature to meet the liquid-cooled ITE economizer requirement and the other plant can operate at a lower temperature to meet the air-cooled ITE economizer requirement (see Figure 6).

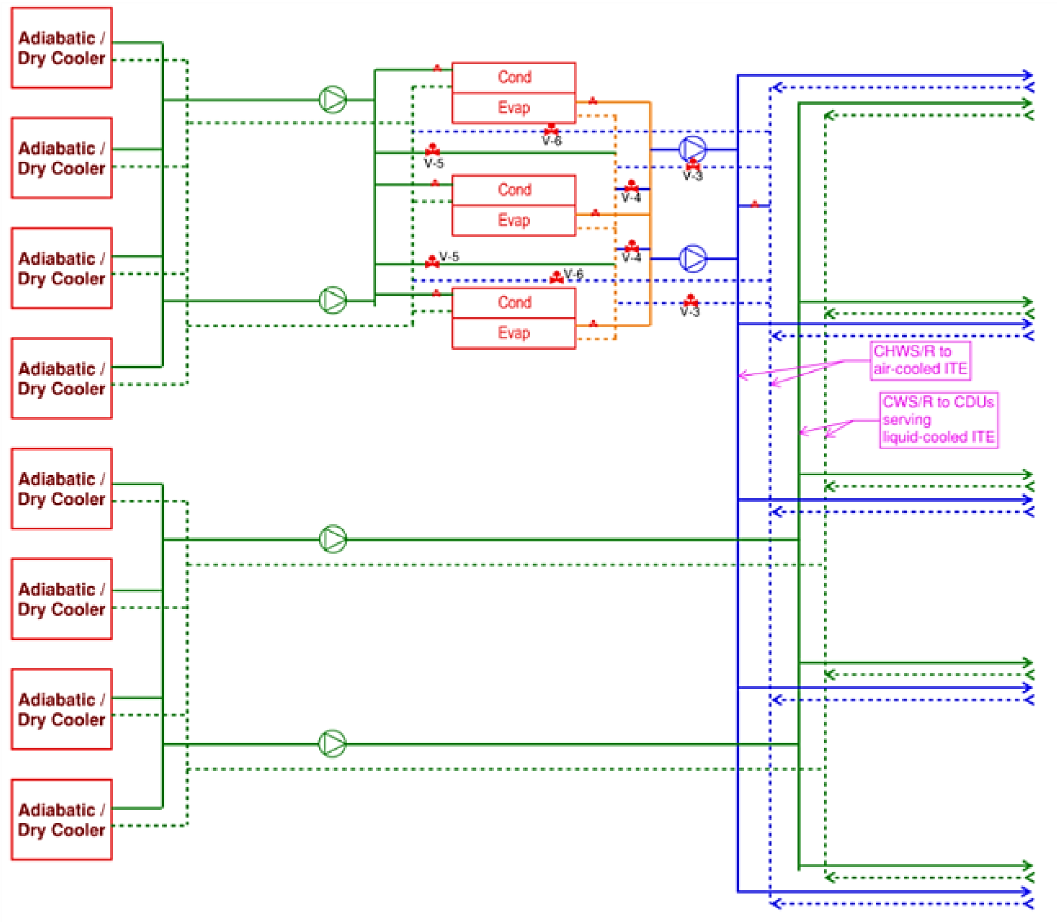

Figure 6: Potentially compliant liquid-cooled ITE economizer: chillers and wet-bulb economizer dedicated to air-cooled ITE and separate economizer-only plant dedicated to liquid-cooled ITE (note: CWS/R is same as FWS/R)

Error! Reference source not found. shows the Liquid-cooled ITE being served by dry coolers with adiabatic assist. Adiabatic assist refers to a system where water is sprayed into the airstream entering the dry cooler coil, thereby. evaporatively pre-cooling the entering air and allowing the dry cooler to achieve a lower leaving water temperature. This system has no mechanical cooling. This is just one of many possible systems that could meet the proposed liquid-cooled ITE economizer thresholds. Other possible systems include:

1. Cooling towers with heat exchangers (no mechanical cooling)
    - Typical approach from outdoor air wet-bulb (OAWB) to facility water supply temperature (FWST): 7°F-12°F
2. Dry-coolers with adiabatic assist (no mechanical cooling)
    - Typical approach from OADB to FWST: 10°F-15°F
    - Adiabatic assist typical effectiveness: 85%
3. Dry-coolers with air-cooled or water-cooled chillers (no evaporation)

    - Typical approach from OADB to FWST: 10°F-15°F
4. Refrigerant economizers with DX compressors, with optional adiabatic assist
    - Typical approach from OADB to TCS: 22°F (typically no CDU)

The design technology cooling system (TCS), which is a closed-loop liquid directly cooling ITE, supply temperature and the design CDU approach are the most critical factors in determining what cooling system will meet the requirement. Table 3 shows the required FWST for a range of possible TCS supply temperatures and CDU approaches. The table also shows the required approach of the cooling system to the FWST in order to meet the 75°F dry-bulb and 75°F wet-bulb threshold for >2MW liquid-cooled ITE loads.

Table 3: Technology Cooling System Supply Temperatures and Approaches

TCS Supply (C)	TCS Supply (F)	CDU approach (F)	FWST (F)	Required approach (F)
50	122	10	112	37
45	113	10	103	28
40	104	5	99	24
35	95	5	90	15
32	90	3	87	12

Non-compliant Designs

The new definition also would spell out several non-compliant economizer types. A description and diagram of potentially non-compliant dry-bulb and wet-bulb economizers for air-cooled and liquid-cooled ITE is outlined below.

1. Waterside economizer heat exchangers that are piped in parallel with chillers on the chilled water (evaporator) side. This prevents the economizer from providing partial economizing capacity; the waterside economizer heat exchanger only operates, and therefore only saves energy, when it can meet 100 percent of the cooling load (see **Error! Reference source not found.**).

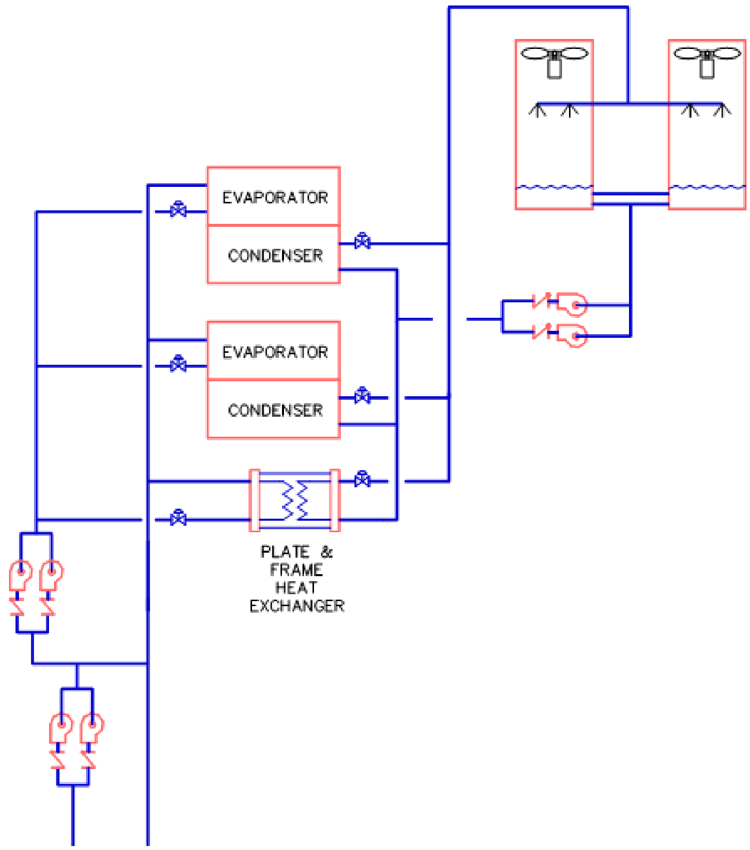

Figure 7: Non-compliant waterside economizer (piped in parallel with evaporator)

2. Air-cooled chillers with integrated economizer coils that are piped into the primary circuit of a primary/secondary system. The primary loop return chilled water temperature is typically lower than the secondary chilled water return temperature due to mixing with supply water through the minimum flow bypass pipe, which reduces the amount of economizer load that can be served by the dry cooler (see Figure 8).

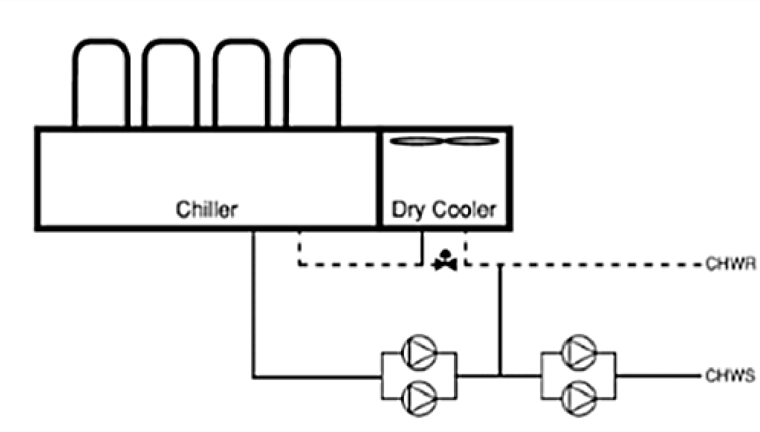

Figure 8: Non-compliant air-cooled chiller with dry cooler piped into primary circuit

3. Air-cooled chillers with integrated economizer coils that are served by the same condenser fans that serve refrigerant condenser coils. The refrigerant condenser fan speed is thus limited by the need to maintain a minimum refrigerant head pressure, which may reduce economizer heat rejection capacity at low outdoor temperatures (see Figure 9).

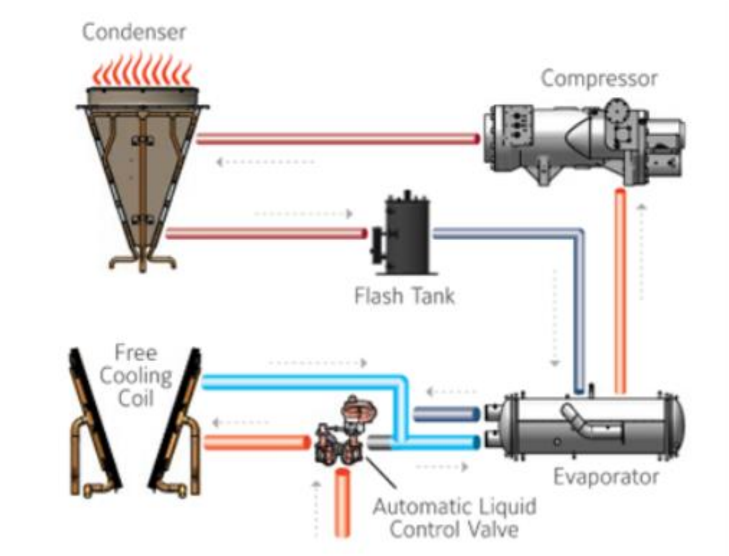

Figure 9: Likely non-compliant Air-cooled chillers with integrated economizer coils that are served by the same condenser fans that serve refrigerant condenser coils

4. Refrigerant economizer systems with one or more refrigerant circuits that must switch from full refrigerant compressor operation to full refrigerant pump condenser operation. This limits partial economizer capacity to the capacity of each circuit.

5. In a scenario where a data center has both air-cooled and liquid-cooled ITE, a single chilled water plant serving both air-cooled ITE and liquid-cooled ITE is unlikely to meet the liquid-cooled ITE economizer requirement. This is due to the fact that the chilled water required to serve the air-cooled ITE is too cold to meet the liquid-cooled ITE economizer requirement (see Figure 10),

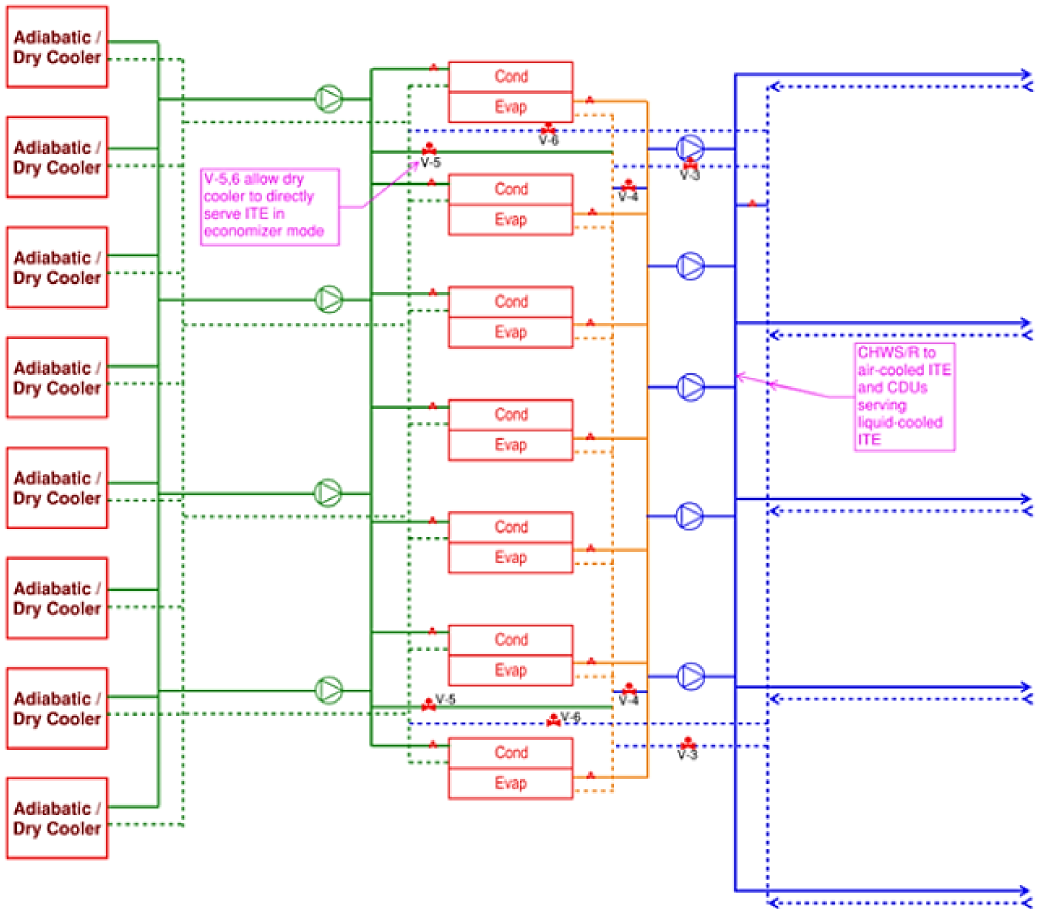

Figure 10: Likely non-compliant liquid-cooled ITE economizer: chiller plant with wet-bulb economizer that serves both air-cooled ITE and liquid-cooled ITE with chilled water

2.1.3.2 Humidity Considerations

Many data centers comply with the ASHRAE TC9.9 Guidelines on space humidity. Many data centers are also not limited to the TC 9.9 humidity constraints. It is important to understand if any of the proposed changes to Title 24 would hinder a data center's ability to meet the TC 9.9 humidity guidelines. As shown in Figure 11, TC 9.9 recommends a lower humidity limit of 15F dewpoint and an upper humidity limit of 70 percent RH and 59F dewpoint. Nothing in the proposed changes affects the lower dewpoint. The only proposed change that might impact the upper humidity limit is the change in the threshold for full airside economizing from 65°F DB / 50°F WB to 65°F DB

/ 60°F WB. It turns out, however, that 65°F DB / 60°F WB corresponds to a dewpoint of 57°F, which is safely below the recommendation of 59°F dewpoint. Thus, there are no proposed changes that would hinder a data center's ability to meet the TC 9.9 humidity guidelines.

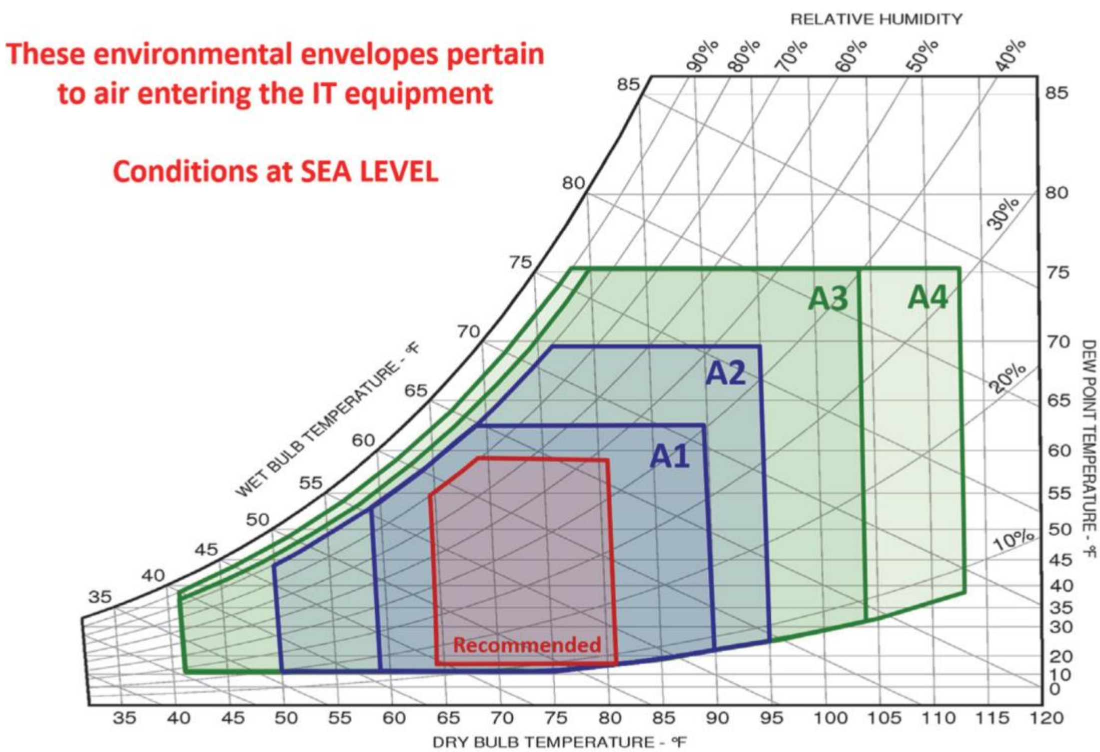

Figure 11: ASHRAE TC 9.9 Thermal Guidelines

2.1.3.3 Supply Air Temperature Rating Conditions

The current economizer requirement in Title 24 requires that the ambient threshold for 100percent economizing be achieved at a supply air temperature (SAT) range of 65°F to 80.6°F. 100 percent economizing can be onerous to achieve across all SATs within the specified range while limiting economizer choice. This SAT for rating the economizer was added to the 2022 edition of Title 24, Part 6, for a few reasons. First, the provisions in the code sought to ensure compliance by demonstrating that the economizer could meet 100 percent of the load at the SAT at which the system would actually operate and not at some unrealisticly high SAT like 100°F. If a system could only meet the criteria at 100F but actually operated at 70F SAT then it would lose most of the economizer benefit. Second, it illustrated that the Title 24 economizer requirement was not in conflict with the ASHRAE TC 9.9 Thermal Guidelines, which recommend SAT of 64.4°F to 80.6°F. Finally, it encouraged the use of a higher SAT. At the time it was still common to supply computer rooms with 55°F SAT and it was quite rare to supply over 75°F.

In this proposal the SAT rating range is changed from 65°F-80.6°F to 75°F. The primary reason for this change is to demonstrate compliance using a single SAT at which the economizer can be rated. For example, if Economizer A can barely meet 100 percent of the load at ambient conditions of 65°F OADB and 80°F SAT then it has an approach of 15°F. If Economizer B can barely meet 100 percent of the load at 65°F OAD and 75°F SAT then it has a 10°F approach. If both Economizers operate at SAT of 75°F then Economizer B will be in full economizer mode, but Economizer A will only be able to provide partial cooling. Economizer A will not be able to meet the entire load until the ambient DB falls below 60°F.

75°F is chosen for the rating range because that is the SAT used in all of the lifecycle cost analyses to justify the currently proposed thresholds, and the existing thresholds. This value was chosen because it is a common design SAT. Few data centers consistently operate over 75°F SAT (i.e., cold aisle temperature).

Using a rating condition of 75°F SAT does not mean that computer rooms must operate at exactly this SAT. It is simply a condition at which the economizer is rated. Computer rooms are free to operate at any SAT. There are many other examples of Title 24 requirements based on defined rating conditions. For example, the cooling tower GPM/HP efficiency requirements in 140.4(h)5 are based on the following rating conditions: 95°F entering water, 85°F leaving water, 75°F ambient air wb. This does not mean cooling towers must be selected at a 10°F approach or designed or operated at these entering and leaving water temperatures. It only means that they must meet the minimum GPM/HP at these rating conditions.

The SAT rating condition is changed from a range to a single value because it is a rating condition. Using a range of say 65°F to 75°F implies that the economizer must be capable of meeting 100 percent of the load at both 65°F SAT and 75°F SAT (and every SAT in between). This works fine for a direct airside economizer (which has 0F approach) but any other type of economizer has an approach and cannot necessarily provide 100 percent of the load at 65°F SAT, even if it can provide 100 percent at 75°F SAT. Using a single number removes any confusion about how to rate the economizer.

2.1.4 Modifications to Energy Code Documents

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

2.1.4.1 Energy Code Change Summary

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

This section would expand definitions pertaining to computer rooms and data centers to accommodate changes in technology and construction practices, especially as it relates to ways to efficiently cool ITE and computer room buildings. This expanded set of definitions would cover: Liquid-cooled ITE, Computer Room Economizer, Computer Room Wet-bulb Economizer, and Computer Room Dry-bulb Economizer. A primary goal of including the computer room economizer definition is to provide additional guidance on how to design a fully integrated computer room economizer.

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

Subsection 140.9(a)1: The proposed changes to this section would modify the computer room economizer requirements in several ways. Some of the proposed changes are more editorial, such as the removal of a wet-bulb temperature reference for dry-bulb economizer requirements, and dry-bulb temperature reference for wet-bulb economizers. The primary impact from the proposed changes, however, would increase the amount of time economizers must be capable of meeting all or part of the cooling load in computer rooms. Economizer temperature thresholds would be increased for wet-bulb economizers in computer rooms with air-cooled ITE. New economizing requirements are added for data centers with a liquid-cooled ITE load greater than 2MW. Additionally, minimum water and air temperature differentials and variable flow are required. Exception 2 is modified to raise the outdoor temperature for when an economizer must meet the design cooling load of the computer room. A third exception is proposed for computer rooms with a heat recovery system that can accept at least 50 percent and the design heating load of the system(s) to which the heat is transferred is at least five times greater than the computer room design cooling load.

SECTION 141.1 – REQUIREMENTS FOR COVERED PROCESSES IN ADDITIONS, ALTERATIONS TO EXISTING NONRESIDENTIAL, AND HOTEL/MOTEL BUILDINGS

Subsection 141.1(b)1: The proposed changes to the additions and alterations section would incorporate the expanded economizer requirements in 140.9(a)1 and apply those to new cooling systems serving computer rooms in an existing building. This change would also modify Exception 1 and increase the ITE threshold to 10 Tons for when an economizer is not needed. The change would also delete Exception 2 and Exception 3. Lastly, a new exception would be added, allowing flexibility for existing buildings to comply with the Title 24, Part 6 economizer requirements that were in effect when the building was permitted.

2.1.4.2 Reference Appendices Change Summary

The proposed changes would not impact the reference appendices as there is no acceptance testing for computer room requirements.

2.1.4.3 Compliance Manuals Change Summary

Section 10.4 of the Nonresidential Compliance Manual, which outlines Computer Room requirements in the code, would need to be updated. Specifically, section 10.4.1 would include proposed computer room economizing definitions. Section 10.4.3.1 – Economizers, would be updated to reflect economizing threshold changes for computer rooms with air-cooled and/or liquid-cooled ITE.

Additional guidance would also need to be included that describes a compliance scenario for data centers with part liquid-cooled ITE and part air-cooled ITE. Per proposed requirements as outlined in 140.9(a), the economizer serving liquid-cooled ITE must meet 140.9(a)B and, if applicable, a separate economizer serving air-cooled ITE must also meet 140.9(a)A temperature thresholds.

2.1.4.4 Alternative Calculation Method Reference Manual Change Summary

The following sections in the Nonresidential Alternative Calculation Method (ACM) would need to be updated based on the proposed change.

- Appendix 5.4B: Modify the cooling setpoint for data centers from 80F to 90F. Per ACM section 5.7.2.3 Supply Air Temperature Control, raising the cooling setpoint from 80F to 90F, will raise the SAT from 60F to 70F, which is more consistent with current standard practice.
- Section 5.7.4.2 Air Side Economizers: Revise the Economizer High Temperature Lockout standard design from a fixed dry-bulb high limit of 80F to 90F.

The Standard Computer Room Design (System 10 and System 11) includes a dry-bulb economizer. System 11 would be the baseline system to which a large liquid-cooled ITE data center is compared. A liquid-cooled ITE data center that meets the new prescriptive requirements in 140.9 should be at least as efficient as System 11. There is no need to add a new standard design for liquid-cooled ITE data centers.

2.1.4.5 Compliance Forms Change Summary

The existing nonresidential compliance form NRCC-PRC-E, NRCI-PRC-E, NRCC-PRF-E would need to be updated to reflect new economizer thresholds in Table M, column 2 for air-cooled and liquid cooled-ITE.

2.1.5 Measure Context

2.1.5.1 Comparable Model Codes or Standards

ASHRAE 90.1 – 2022 defines a computer room in the same way as Title 24, Part 6, specifying an equipment power density of 20 W/ft^2 of conditioned floor area. This standard does not, however, include additional definitions for computer room economizers and liquid-cooling ITE that are recommended as part of this measure. Section 6.5.1 requires computer room economizing in Climate Zones 2A or greater with specific exceptions. Exceptions are based on cooling load thresholds for new systems and alterations, or when the local water authority does not allow cooling towers. The primary exception for additions or alterations states that an economizer is not required if the added cooling equipment capacity is less than 600,000 Btu/hr.

Economizer high limit set points based on outdoor air temperature vary by climate zone and moisture regimes but are less stringent than what the Statewide CASE Team is proposing in this measure. ASHRAE 90.1 also does not require a minimum economizing load fraction based on temperature (ASHRAE 2022).

2024 IECC defines a computer room in the same way as Title 24, Part 6 but does not include additional definitions for computer room economizers and liquid-cooling ITE. Section C403.5 requires computer room economizing and specifies the same high-limit shutoff control table as ASHRAE 90.1-2022 for when economizing is no longer required based on outdoor air temperature and climate zone. This section does not include specific economizer exceptions for computer rooms.

As specified in Chapter 5—Existing Buildings, new cooling systems for computer rooms in existing buildings must comply with economizer requirements as described in C403.5 (International Code Council 2024).

ASHRAE 90.4 – 2022 serves as an optional compliance pathway for computer room or data centers with HVAC systems serving computer rooms with ITE load greater than 10kW. This standard provides more options for performance-based compliance of data center facilities (ASHRAE 2022).

2.1.5.2 Interactions with Other Regulations

There are no relevant local, state, or federal laws related to increased temperature thresholds for computer room economizers, but some of these laws do impact data center efficiency. These are described below:

Federal Laws: The Energy Independence and Security Act of 2007 required that a voluntary national information program be developed to address energy efficiency in data centers. This provision defined data center as “any facility that primary contains electronic equipment used to process, store and transmit digital information, which may be (A) a free-standing structure; or (B) a facility within a larger structure, that uses environmental control equipment to maintain the proper conditions for the operation of electronic equipment (Energy Independence and Security Act of 2007 2007).” The U.S. EPA and U.S. DOE established the National Data Center Energy Efficiency Information Program after this law and incorporated many of the requirements, such as developing specifications and benchmarks, coordinating with the industry, and an open data initiative, through existing programs like EPA’s ENERGY STAR® Program.

California State Laws: As outlined in section 1820.3 of the California State Administrative Manual, State-owned or leased data centers include additional requirements to measure and report PUE, and must reduce PUE by ten percent, annually, if it exceeds 1.5 (Services 2014). While there is no specific requirement related to economizing, existing state-owned or leased data centers that exceed 1.5 PUE, will likely consider increased economizing as a cost-effective strategy to reduce PUE and bring the data center into compliance with the state requirement. State owned and leased data centers are managed through the California Department of Technology.

Interactions with California Building Code: Appendix E: Sustainable Practices of the 2025 California Mechanical Code includes prescriptive requirements for computer room economizers in Section E 503.5. Exceptions (11) and (12) specify when economizer requirements apply to computer rooms. This appendix is provided for reference and is not mandatory in jurisdictions throughout California.

2.2 Computer Room Economizers - Compliance and Enforcement

2.2.1 Compliance Considerations

The proposed measure would build off the existing requirement for economizing in computer rooms by increasing minimum economizing temperature thresholds and requiring minimum water and air temperature differentials and variable flow provisions.

To help improve clarity and provide additional guidance in the code, the proposed measure would expand the definition of a computer room economizer to describe and provide examples of fully integrated economizers that are compliant and non-compliant. This additional information provided directly in the code would help address common confusion about integrated economizers in the marketplace and improve design efficiency and rates of compliance. Education and training would need to be developed and administered throughout the industry to ensure new economizer requirements, potential compliant design solutions, and ways to enforce and provide appropriate documentation for measures are fully understood.

The proposed measure would result in the following changes for market actors at each step of the design and construction process.

- **Design Phase:** The mechanical design engineering process would not change based on the proposed measure. A design engineer would still determine if an economizer requirement were triggered based on computer room ITE load. With the proposed ITE threshold change, more existing buildings would require an economizer and thus additional projects for a designer to support. Mechanical design engineers or energy consultants would complete Nonresidential Certificate of Compliance (NRCC) forms with the permit package. These activities are the same as current requirements; however, the mechanical design engineer would need to follow the new requirements.

- **Permit Application Phase:** The plans examiner would review mechanical permit drawings, specifications, and equipment schedules to confirm economizer type and newly proposed design temperatures are met, depending on if it is a dry-bulb or wet-bulb economizer, and if it is servicing air-cooled and/or liquid-cooled ITE.
- **Construction Phase:** The mechanical contractor reviews mechanical design documents to confirm new economizer requirements and then selects and installs an economizer that meets the design specification. The controls contractor installs controls to allow the economizer system to operate at the full or part load cooling design specifications.
- **Inspection Phase:** The mechanical contractor would complete the Nonresidential Certificate of Installation (NRCI) forms and the building inspector will need to verify compliance.

2.2.2 Impact on Market Actors

The increased temperature thresholds and additional requirements around integrated economizers would primarily impact HVAC contractors but are also expected to impact electrical and HVAC controls contractors.

Table 4 summarizes impacts on market actors and suggests outreach and education that would be helpful to support market actors as they prepare for the effective date of the requirements.

Table 4: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Builders [a]	Limited to no impact	Coordination with design professionals and the compliance improvement team to raise awareness.
Design Professionals [b]	Mechanical Engineers will need to be aware of increased temperature thresholds and design compliant systems with updated design temperatures on drawings	Provide outreach and training on new triggers and requirement thresholds through local ASHRAE chapters.
Construction Team [c]	HVAC Contractors will need to verify the installed system matches plans and meets temperature thresholds.	Provide outreach and training on new triggers and requirement thresholds.
Building Departments [d]	Plan examiners and inspectors confirm equipment achieves new economizer design temperatures on	Provide outreach through building official associations and conferences and provide CEUs for training

Market Actor	Impact(s)	Suggested Outreach and Education
	mechanical plans and in the field and learn how to appropriately review designs to ensure compliance is achieved.	provided online and in-person. Develop robust education and training outlining new requirements and compliant design solutions.
Verification Testers [e]	No impact.	No impact.
Building Owners, Managers, and Occupants	Reduced energy bills and incremental construction costs	Awareness of new economizing requirements, incremental construction costs, and how it will improve overall PUE through Energy Code ACE and building operator training.
Manufacturers and Distributors	Limited impact.	Awareness of new economizing requirements in data centers to ensure equipment that can serve compliant designs are readily available to the market.
Controls Contractor [f]	Install controls for system to economize and meet full and part cooling load based on design temperatures.	This is already part of their scope based on current economizer requirements. Limited training is needed on updated design thresholds.

a. Builders include builders and developers.

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

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

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

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

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

Builders. The proposed change would likely affect commercial builders; however, it would likely not impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers in the commercial building industry; instead, it would primarily affect specific subsectors within the industry. Table 5 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Table 5: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)

Construction Subsector	Establishments *	Employment	Annual Payroll (Billions $)
Commercial Building Construction	5,491	87,450	$10.6
Nonresidential Poured Foundation Contractors	497	15,884	$1.4
Nonresidential Structural Steel Contractors	365	11,899	$1.1
Nonresidential Framing Contractors	137	3,037	$0.2
Nonresidential Masonry Contractors	217	4,028	$0.3
Nonresidential Glass and Glazing Contractors	307	5,079	$0.5
Nonresidential Roofing Contractors	385	11,413	$1.0
Nonresidential Siding Contractors	32	735	$0.1
Other Nonresidential Exterior Contractors	234	2,259	$0.1
Nonresidential Electrical Contractors	3,245	72,794	$7.8
Nonresidential Plumbing & HVAC Contractors	2,270	55,182	$5.8
Other Nonresidential Equipment Contractors	580	9,749	$1.1
Nonresidential Drywall Contractors	593	19,328	$1.8
Nonresidential Painting Contractors	501	9,225	$0.7
Nonresidential Flooring Contractors	286	4,011	$0.4
Nonresidential Tile and Terrazzo Contractors	151	2,223	$0.2
Nonresidential Finish Carpentry Contractors	313	3,697	$0.3
Other Nonresidential Finishing Contractors	492	7,241	$0.6
Nonresidential Site Preparation Contractors	1,147	19,273	$1.9
All Other Nonresidential Trade Contractors	948	17,084	$1.7

Source: (State of California n.d.)

*An establishment is single economic unit, typically at one physical location, that engages in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Many businesses are composed of multiple establishments. US Bureau of Labor Statistics, Handbook of Methods. https://www.bls.gov/opub/hom/cew/concepts.htm

2.2.3 Compliance Software Updates

If the proposal is adopted, then the CBECC software will be modified based on the proposed changes to the ACM, as described in Section 2.6.6. Final recommendations will be provided in Summer 2026 based on the final proposal.

The CASE Team also considered CBECC's current lack of ability to model "Data Center" buildings. A calculation methodology was implemented to estimate savings for data center, and prototypes currently in CBECC were relied upon to estimate energy savings for computer rooms in Large Offices, Medium Offices, Small Offices, Large Schools, Small Schools and Hospitals.

The CASE Team is aware that in recent years LBNL has developed the following two new data center prototype models through OpenStudio and EnergyPlus™. For each of the following data center models, LBNL considered two levels of ITE load density, and covered wide ranging IT power density of data centers between 40 and 100 W/ft^2:

a. The small-size data center model represents a computer room in a building served by computer room air conditioners (CRACs).
b. The large-sized model represents stand-alone data centers served by computer room air handlers (CRAHs) with a central chiller plant.

Future CBECC enhancements could potentially build upon the approach taken by LBNL.

2.2.4 Cost of Enforcement

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

Given that the proposed change increases the temperature threshold and requires minimum water and air temperature differentials and variable flow provisions to existing computer room economizing requirements, the Statewide CASE Team anticipates that additional training will need to be provided to the enforcement community to fully understand and effectively implement the proposed changes. As part of the triennial process to update the California Energy Code, education, training and resources will need to be developed to highlight this proposed change.

2.3 Computer Room Economizers - Market and Economic Analysis

2.3.1 Market Structure and Availability

2.3.1.1 Current Market Structure and Availability

Requirements for computer room economizing have been in Title 24, Part 6 since the 2013 edition, and temperature thresholds were increased during the 2022 cycle. Since this time, economizing in computer rooms has become common practice for the industry in California, as building owners and operators are identifying cost-effective opportunities to reduce energy demand on the grid and overall energy costs to cool servers. As previously stated in section 2.1.3, with the growing demand for hyperscale data centers and higher computing CPUs and GPUs, the industry has embraced new cooling technologies such as liquid-cooled ITE systems, in addition to air-cooled ITE systems. The proposed measure would affect both air-cooled ITE and liquid-cooled ITE systems that utilize a dry-bulb or wet-bulb economizer. Given that computer room economizers have been required as industry standard since 2014, and energy efficient cooling technology and practices has only continued to advance, the market is well prepared to implement updated economizing requirements in the proposed measure.

Air-cooled ITE

For air-cooled ITE, many common economizer products could be used to achieve the proposed full economizing outdoor temperature thresholds of 65°F outdoor dry-bulb or 60°F outdoor wet-bulb. Examples of these systems include:

- Airside economizers
- Waterside economizer heat exchangers that are piped in series with chillers on the chilled water side.
- Air-cooled chillers with integrated economizer coils that are piped into the secondary circuit of a primary/secondary system.
- Air-cooled chillers with integrated economizer coils that are served by dedicated economizer fans and not by condenser fans that serve refrigerant condenser coils.
- Refrigerant economizer systems where 10-90 percent of the load on a refrigerant circuit can be met by a passive condenser or refrigerant pump.

Liquid-cooled ITE

For liquid-cooled ITE, the proposed outdoor temperature thresholds for full economizing are easily achievable by cooling products available on the market and supports manufacturer-stated liquid-cooled ITE product temperature requirements. A Code Readiness survey of liquid-cooled ITE cooling products and case studies revealed a typical advertised ITE inlet liquid temperature of 45°C (113°F), with some products advertising as high as 70°C (160°F)3.

Additionally, the CASE Team reviewed temperature requirements for NVIDIA liquid-cooled ITE products,[4] as summarized in Table 6. The maximum supply water temperature ranged from 30 to 50°C (86 to 122°F). At the January 2026 Consumer Electronics Show (CES), NVIDIA's Chief Executive Officer advertised that NVIDIA's newest product, Vera Rubin chips, can be cooled with water at 45°C (113°F) "with no chillers necessary."[5]

Table 6: Liquid-Cooled ITE Product Operating Temperatures

Product	Inlet Temperature Requirements (Operating)
NVIDIA H100 NVL GPU •NVIDIA H100 Tensor Core GPUs	0-50°C (32-122°F)
NVIDIA A2 Tensor Core GPUs (2022)	0-50°C (32-122°F)
NVIDIA Vera Rubin NVL72 • (72) Rubin GPUs, (36) Vera CPUs, ConnectX-9 SuperNICs, BlueField-4 DPUs • Rack-scale platform uses NVLink 6 Switch and scales out with NVIDIA Quantrum-X800 InfiniBand and Spectrum-X Ethernet	45°C (113°F)
NVIDIA GB200 NVL72 • Includes 72 Blackwell GPUs and 36 Grace CPUs	max 45°C
NVIDIA H200 NVL GPU	10C-45°C (50-113°F)
NVIDIA GB200 NL4 • Includes 4 Blackwell GPUs and 2 Grace CPUs	5–35°C (41–95°F)
NVIDIA DGX B200 • Includes 8 NVIDIA Blackwell GPUs	10-35°C (50-90°F)
NVIDIA DGX H100/H200 • NVIDIA Tensor Core GPUs	5-30°C (41-86°F)
NVIDIA DGX Spark • NVIDIA Grace Blackwell architecture with integrated GPU and CPU	5-30°C (41-86°F)

[3] Cite Code Readiness report (yet to be published, add citation once public).

[4] NVIDIA products were the focus of the product review because they represent about 90% of the US AI chip market (source: https://www.techpowerup.com/347125/nvidia-grabs-94-aib-gpu-market-share-amd-falls-to-5)

[5] https://www.datacenterdynamics.com/en/news/vera-rubin-hot-water-cooling-reveal-triggers-hvac-share-drop/

Alterations and Additions

Computer rooms that were built before 2013 Title 24, Part 6 went into effect, and computer rooms with an ITE design load below the cooling capacity thresholds in 141.1(b)1 exceptions, may not have economizers installed. Economizer requirements for existing computer rooms where new cooling systems are being installed were adopted during the 2022 Title 24, Part 6 code cycle, meaning the market has been subject to updating existing computer rooms to include economizers. While this proposed change will lower the ITE design load threshold for when an economizer must be installed, the equipment manufacturers and companies supporting computer room design and installation are well equipped to install an integrated economizer when updating a cooling system for these smaller ITE load computer rooms. Like new construction, computer rooms in existing buildings use a variety of economizer types listed above.

However, given some of the documented implementation challenges of economizers in existing buildings that were not initially designed for them, and the added cost and complexity of adding an economizer during an alteration, the CASE Team is proposing a new exception. This exception would allow new or modified systems that are smaller than 500 tons and less than 50% of the total computer room cooling capacity to comply with the Title 24, Part 6 economizing requirements that were in effect during the date of the initial building permit.

2.3.1.2 Market Challenges and Solutions

Although the industry is well equipped to install a fully integrated economizer in new computer room cooling systems, some commonly used cooling systems do not currently comply with this proposed code change and would require design adjustments to achieve compliance. However, it is noted that the proposed updates to the economizer definitions and requirements close a loophole in the existing code language and additional training on these changes will help the market adapt and modify their approaches. These cooling systems as well as the proposed solution to ensure compliance are described below and further outlined with diagrams in Section 2.1.3:

Waterside Economizer:

- **Non-compliant Approach**: Waterside economizer heat exchangers that are piped in parallel with chillers on the chilled water side.
    - **Solution:** This would require a simple design adjustment to pipe waterside economizer heat exchangers in series with chiller evaporators to allow for partial pre-cooling of return chilled water before it enters the chiller evaporators. Providing education and training through Energy Code Ace ASHRAE associations, and other venues can train the design

community on ways to make this approach more efficient and code compliant.

Air-cooled Chiller and Refrigerant Economizers:

- **Non-compliant Approach**: Air-cooled chillers with integrated economizer coils that are piped into the primary circuit of a primary/secondary system.
  - Solution: Install dry cooler economizer coils on the chilled water return secondary loop.
- **Non-compliant Approach**: Air-cooled chillers with integrated economizer coils that are served by the same condenser fans that serve refrigerant condenser coils whose speed control is limited by the need to maintain a minimum refrigerant head pressure.
  - **Solution:** Use separate dry coolers piped on the chilled water return pipe. This would allow for the dry cooler condenser fans to operate independently from the chiller condenser fans and not be limited by the chiller head pressure control requirements. This would also allow the dry cooler to make colder water at low outdoor temperatures and increase economizer cooling capacity.
- **Non-compliant Approach**: Refrigerant economizer systems with one or more refrigerant circuits that must switch between full circuit capacity in refrigerant compressor operation to full circuit capacity in refrigerant pump operation.
  - **Solution:** Use refrigerant economizers where equipment components are configured and controlled to provide continuous cooling capacity from at least 10-90 percent of full load through economizer or compressor cooling.

Liquid-cooled ITE

Liquid-cooled ITE is a new and rapidly-growing market, with many new ITE products and cooling solutions coming onto the market. One potential issue is that if liquid-cooled ITE is built for higher density, lower entering liquid temperatures may be required to provide adequate cooling. This would make it harder to comply with the increased economizer requirements.

- **Solution:** Size heat exchangers (cooling towers, waterside economizers, CDUs) for lower approach temperatures.
- **Solution:** Design system to use heat recovery to avoid the economizer requirement.

Alterations and Additions

When updating a cooling system in an existing computer room space, and adding an integrated economizer, additional challenges present themselves. Some of these challenges and potential solutions are described below:

- **Challenge:** Computer rooms in existing buildings typically have lower operating temperatures and are less efficient than new, larger data centers.[6]
    - **Solution:** Additional operator education on industry standard computer room temperatures would help understand how existing computer rooms can meet new requirements when undergoing an alteration or addition.
    - **Solution:** New, more efficient cooling equipment would help improve performance by providing energy efficiency features like variable fan speed control that can allow for higher operating temperatures by varying airflow with load. Paired with air containment, though not required by code, can further enhance capabilities to increase supply air temperatures.
- **Challenge:** There may be a perceived complexity and added expense of adding economizers to cooling systems serving computer rooms in existing buildings.
    - **Solution:** However, this has been a requirement since 2022 Title 24, Part 6, so the market has had time to develop cost-effective solutions to adding economizers in existing building computer rooms.
    - **Solution:** Economizer capacity and temperature thresholds proposed in the code change have been shown to be cost-effective. While including an economizer may increase first costs, those first costs are offset by operational cost savings and the system is cost-effective over its lifetime.
    - **Solution:** At the root of these perceived challenges are technical design and construction challenges; see section 2.3.2.3 for more information.
    - **Solution:** A newly proposed exception is available for existing buildings with a new or modified system that is less than 500 tons and serves less than 50 percent of the computer room cooling load.

See Section 2.2.2 for a description of workforce trainings that may be needed to ensure effective design, installation, and commissioning.

2.3.2 Design and Construction Practices

2.3.2.1 Current Design and Construction Practices

The proposed measure would affect dry-bulb and wet-bulb economizer designs for computer rooms with either or both air-cooled and liquid-cooled ITE. As such, there are many different code compliant designs that computer room mechanical designers can specify and install.

[6] Cite Code Readiness report (yet to be published, add citation once public).

Air-cooled ITE

For computer rooms with air-cooled ITE, the proposed measure would require computer rooms to be designed for a minimum 65-70°F server inlet air temperature (or higher), which aligns with ASHRAE Thermal Guidelines' Recommended range of 64.4-80.6°F.[7] Many of the same cooling systems and products that are used to comply with the economizer requirements as specified in 2025 Title 24, Part 6 could still be used.

For example, for a water-economizer to meet ten percent load fraction at 70°F outdoor air wet-bulb (OAWB), the system must be designed for a reasonably high return air temperature (e.g., 95°F) and a reasonably high return chilled water temperature (e.g., 82°F). The proposed new variable air and water flow requirements will encourage more efficient designs that leverage partial economizer performance during high ambient temperatures and periods of low load. For example, an AHU designed for 65°F SAT and 20°F airside differential temperature (i.e., 85°F return air temperature) means that even at 84°F outside air dry-bulb there is some economizer free cooling. For this same system, if the dT is only 10°F then there is no economizer free cooling even at 76°F ambient dry-bulb. Similarly, if system is designed for 65°F SAT and 20°F airside differential temperature (dT) and the airflow varies with the load then at low load the economizer is still providing partial cooling at 84°F OADB. But if the airflow does not vary with load then at low load the economizer might not be providing any free cooling even at 70°F OADB. Unnecessarily high minimum air handling fan speeds would not be able to maintain good dT at low load.

Similarly, varying the chilled water and facility water flow as a function of load ensures that economizer savings are captured at high ambient temperatures and low loads for both dry-bulb and wet-bulb economizer systems. For example, 3-way CHW valves at air handling coils would make it difficult or impossible to meet the variable flow requirement. To elaborate, if a system is designed for CHW supply temperature of 70F and return temperature of 85F (15F dT) with 100 percent water economizing at 60F OAWB, then it can do partial water economizing up to about 75F OAWB. If the CHW coils have 2-way control valves then the dT will stay constant at 15F at low load. But if the coils have 3-way valves then the dT will degrade at low load. At 50 percent load the dT will only be about 7F. So the return water temperature will be about 77F and there will be no economizing above about 67 OAWB.

Liquid-cooled ITE

For computer rooms with liquid-cooled ITE, the proposed measure would require computer rooms to be designed with a technology cooling system (TCS) that meets

[7] ASHRAE Thermal Guidelines for Data Processing Environments.

ASHRAE Thermal Guidelines class W27 or W32[8] (e.g., supply fluid temperature to ITE of 29°C/85°F) or higher. As shown in Figure 12, D2C and immersion cooling are typically cooled by a liquid cooling loop TCS connected to a CDU that includes a pump for the TCS loop. The CDU includes a heat exchanger that is connected to a facility chilled water loop (or in some cases a refrigerant loop).

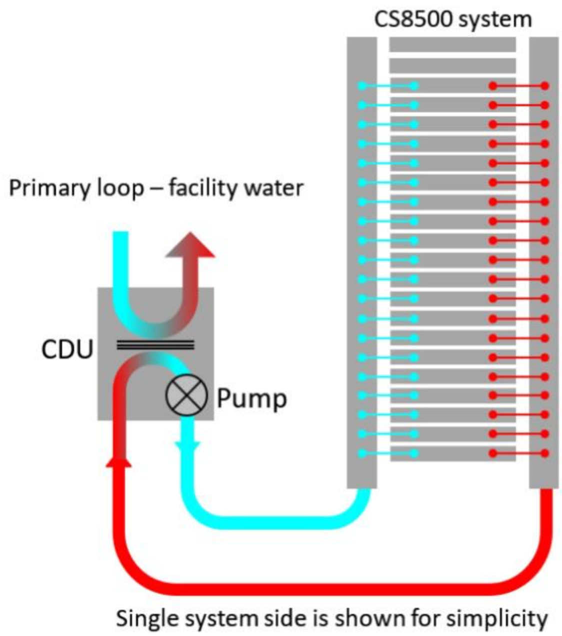

Figure 12: Diagram of CDU with TCS pump and heat exchanger connected to facility water loop[9]

A portion of the liquid-cooled ITE rejects heat to the air, so traditional cooling systems for air-cooled ITE, such as computer room air-conditioners (CRAC) and computer room air-handlers (CRAH), would still be required for a portion of the cooling load. Economizing could be provided by a computer room wet-bulb economizer or computer room dry-bulb economizer. Many different cooling system options could be used for heat rejection on the facility water side, including evaporative cooling towers, chillers (air-cooled or water-cooled with cooling tower), and dry coolers.

Additions and Alterations

The design process for computer rooms in additions/alterations projects is similar to new construction. Equipment is selected and laid out based on coordination and

[8] ASHRAE Thermal Guidelines for Data Processing Environments provides standardized operating environments and guidance for ITE. Classes W17, W27, W32, W40, and W45 represent environmental specifications for liquid cooling.

[9] NVIDIA Docs Hub: https://docs.nvidia.com/networking/display/cs8500sysum/system+cooling+design+overview

constraints imposed by other trades (electrical, structural, architectural, etc.). Design engineers perform computer room load calculations and determine if economizing is required or not. This process would remain unchanged; however, the economizer capacity sizing and setpoints would change.

2.3.2.2 Health and Safety Considerations

The proposed code change would not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health (DOSH). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building. In cases where airside economizing would be used to comply with this code requirement, indoor air quality for occupants (when present) would be improved by increasing the amount of outside air entering the computer room.

2.3.2.3 Design and Construction Challenges and Solutions

Liquid-cooled ITE cooling systems designed for facility water supply temperatures in temperature classes below W32 (e.g., W17 (62.6°F facility supply water temperature) and W27 (80.6°F facility supply water temperature)) would not be able to comply with the proposed economizer requirement. However, in the majority of cooling products and case studies reviewed in a recent study10, the products marketed design temperatures meeting ASHRAE Class W32 or higher. This indicates that many cooling products are available that can meet the proposed economizer temperature thresholds, so systems needing to meet the cooler temperatures of Class W17 or W27 would likely not be a widescale design and construction challenge.

Adding economizers to computer rooms in existing buildings may pose a range of design challenges. Fitting ducting for airside economizing in existing buildings may be challenging due to space constraints or may require structural upgrades. However, given that existing building economizer requirements already exist in the code, these would likely not be new challenges. Some potential solutions include:

- For very small computer rooms, the economizer capacity from the building's cooling system may be used rather than needing to install a dedicated economizer for the computer room.
- For larger computer rooms, heat recovery may be used instead of economizing to provide design flexibility.

[10] Cite Code Readiness report (yet to be published, add citation once public).

- Multiple economizer technologies may be used to comply with the proposed code change.
- For expansions to existing computer rooms, only projects with substantial increases in capacity would be required to meet the new economizer temperature thresholds.

Additionally, increased temperature thresholds for existing computer rooms would push cooling equipment to be designed for warmer indoor operating temperatures, which would require operators to adapt to different operating conditions than they might be used to. To overcome this challenge, operators may need additional training and offered ways to advance their expertise and be equipped for modern day practices.

See Table 4: Impacts on Market Actors and Suggested Training and Education Opportunities in Section 2.2.2 or a description of workforce trainings that could support effective design, installation, and commissioning.

2.3.3 Energy Equity and Environmental Justice

The Statewide CASE Team evaluated the potential impact on environmental and social justice (ESJ) communities,[11] including impacts related to race, class, and gender. With this proposal impacting data center design and efficiency, this proposal would likely not result in any negative impacts to ESJ communities. In fact, improving data center efficiency could provide secondary benefits to all communities, including ESJ. As data center efficiency increases, it will reduce energy and water usage, which will help alleviate strain on those resources.

The Statewide CASE Team identified potential impacts of the proposed code change via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement.

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

Please reach out to Aniruddh Roy (aroy@energy-solution.com) if you have input on how this proposal may impact ESJ communities or if you would like to offer your perspective.

2.3.4 Impacts on Jobs and Businesses

This section will be completed for the Final CASE Report.

2.3.5 Economic and Fiscal Impacts

This section will be completed for the Final CASE Report.

2.4 Computer Room Economizers - Cost Effectiveness

2.4.1 Cost Effectiveness Methodology

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

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

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

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

2.4.2 Energy and Energy Cost Savings Results

To assess the energy and energy cost savings of the proposed measure, the Statewide CASE Team conducted a custom spreadsheet-based analysis across three different data center scenarios. These scenarios were selected because they assess the impact of the proposed code change and are commonly found in the California marketplace. This approach, compared to an energy modeling (CBECC) based analysis, was used for the following reasons:

- Custom analysis can account for specific data center design efficiencies that would not be considered in CBECC.
- CBECC does not allow separate plants for air-cooled and liquid-cooled ITE as described in the analysis below.
- To represent real world data center scenarios that can help validate savings in the final report when energy modeling is used.

Proposed modifications would affect computer rooms with air-cooled ITE using wet-bulb economizers and computer rooms with liquid-cooled ITE using wet-bulb and/or dry-bulb economizers. To assess the impacts of the increased economizer thresholds and differential temperature and variable flow requirements, the Statewide CASE Team conducted three analyses: 1) a data center with air-cooled ITE and a wet-bulb economizer and 2a) a data center with liquid-cooled and air-cooled ITE with a wet-bulb economizer using a cooling tower, and 2b) a data center with liquid-cooled and air-cooled ITE with a dry-bulb economizer using a dry cooler. Detailed information about each scenario is described below:

1) **Air-Cooled ITE—Wet-bulb Economizer Scenario Modeling Assumptions:** This analysis demonstrates the energy, cost, and environmental impacts associated with updating the wet-bulb economizing threshold from 45°F to 60°F.

   Assumptions for this analysis include the following:

   - Standalone data center with Air-cooled ITE
   - Select climate zones (04, 07, 09, 12) representative of statewide impacts
   - Air-cooled ITE with 75°F design Supply Air Temperature (SAT) to the server
   - ITE Load at 300 W/ft^2
   - ITE Load profile: Title 24 ACM load profile (equal time at 25 percent, 50 percent, 75 percent, 100 percent load)
   - Chiller design kW/ton: 0.35
   - Cooling Tower Nominal Efficiency: 80 GPM/HP
   - Redundancy for heat exchanger (HX), chiller, cooling tower (CT), CRAH: 10 percent

   Base Case Design:

   - The approach from OAWB to SAT is 30°F for baseline design.
     - The approach is the sum of the approaches of the CT, the HX, and the CRAH coil
   - Fewer hours of full and partial economizer operation than proposed design

- CHW/CW pump and supply fan pressure drop is adjusted based on CT/HX/Coil selections

Proposed Design:

- The approach from OAWB to SAT is 15°F for proposed design.
- The proposed design has significantly greater hours of full and partial economizer operation
- CHW/CW pump and supply fan pressure drop is adjusted based on CT/HX/Coil selections

2) Separate Liquid-Cooled ITE Economizer Scenario Modeling Assumptions:

This analysis demonstrates the energy, cost, and environmental impacts associated with updating the economizing threshold to 75°F. Assumptions for these analyses include the following:

- Standalone data center with liquid-cooled and air-cooled ITE
- 80 percent Liquid-cooled ITE, 20 percent air-cooled ITE
- ITE Load at 300 W/ft^2
- Title 24 load profile (equal time at 25 percent, 50 percent, 75 percent, 100 percent load)
- Select climate zones (04, 07, 09, 12) representative of statewide impacts
- Dry cooler dT: 15°F
- TCS pump energy same for base case and proposed, so not modeled
- CRAH fan energy same for base case and proposed, so not modeled

While cost data was only provided for plants with cooling towers, two types of plants were simulated. The reason the Statewide CASE Team only derived costs for the cooling tower scenario is because it is the most common approach across the California market. Costs will be generated for the dry cooler scenario in the final report. The two scenarios include the following assumptions:

1. **Cooling Towers** – The baseline is a single chilled water plant with cooling towers, and the proposed case includes two chilled water plants and distribution piping for air-cooled ITE and liquid-cooled ITE. The primary reason the proposed design must have separate plants is because a single chilled water plant serving both air-cooled ITE and liquid-cooled ITE is unlikely to meet the proposed temperature threshold for a liquid-cooled ITE economizer. The two chilled water plants is the scenario that was costed.
2. **Dry Coolers** – In this scenario the baseline is a single chilled water plant with water-cooled chillers rejecting heat via dry coolers (rather than cooling towers). The proposed case includes two dry cooler plants and distribution

piping for air-cooled ITE and liquid-cooled ITE. The dry cooler plants use adiabatic spray assist if the dry coolers cannot achieve the required dry cooler leaving water temperature in a given hour.

Additional details describing the analytical approach and various assumptions used in the analysis is provided in Appendix A.

Results

Scenario 1. Air-Cooled ITE—Wet-bulb Economizer Scenario

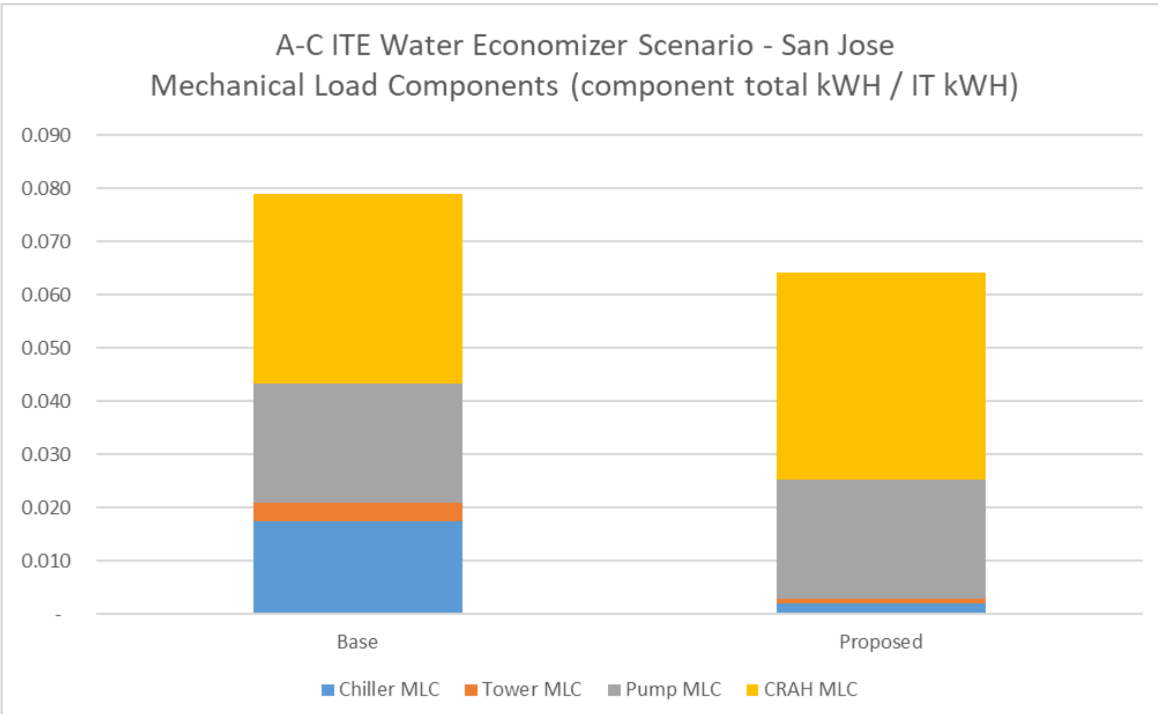

Figure 13: Summary results on the impacts of increased economizer thresholds, differential temperature and variable flow requirements on a data center with air-cooled ITE and a wet-bulb economizer.

Table 7: Percentage of Time Base vs. Proposed Design in Economizing Only Mode (Chillers Off)

Climate Zone (Location)	Base Case	Proposed Design
4 (San Jose)	23%	81%
7 (San Diego)	10%	59%
9 (Los Angeles)	11%	65%
12 (Sacramento)	25%	75%

Scenario 1 energy savings (electricity, natural gas, and source energy) and peak demand reductions per-unit are presented in Table 8 through Table 10. Per-unit savings for the first year are expected to range from 81 to 119 kWh/yr, depending upon climate zone. Demand reductions/increases are expected to be zero kW since there might not be any economizing when the peak load occurs.

Table 9 presents total energy cost savings per unit for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Table 9 presents a breakdown of total LSC savings from electricity and natural gas cost savings for the prototypical building.

Table 8: Scenario 1 Air-Cooled ITE—Wet-bulb Economizer - Energy and Energy Cost Savings – Per kW ITE – New Construction and Additions– Preliminary Analysis

Climate Zone	First Year Electricity Savings (kWh)	First Year Peak Demand Reduction (kW)	First Year Natural Gas Savings (kBtu)	First Year Source Energy Savings (kBtu)	Total 30-Year LSC Savings (2029 PV$)
4	81.21	0	-	TBD	$684
7	119.52	0	-	TBD	$1,045
9	110.09	0	-	TBD	$956
12	88.13	0	-	TBD	$741

Table 9: Scenario 1 Air-Cooled ITE—Wet-bulb Economizer 2029 PV LSC Savings Over 30-Year Period of Analysis – Per kW ITE – New Construction and Additions– Preliminary Analysis

Climate Zone	30-Year LSC Electricity Savings (2029 PV$)	30-Year LSC Natural Gas Savings (2029 PV$)	Total 30-Year LSC Savings (2029 PV$)
4	$684	-	$684
7	$1,045	-	$1,045
9	$956	-	$956
12	$741	-	$741

Table 10: Scenario 1 Air-Cooled ITE—Wet-bulb Economizer 2029 PV LSC Savings Over 30-Year Period of Analysis – Per kW ITE – Alterations – Preliminary Analysis

Climate Zone	30-Year LSC Electricity Savings (2029 PV$)	30-Year LSC Natural Gas Savings (2029 PV$)	Total 30-Year LSC Savings (2029 PV$)
4	$684	-	$684
7	$1,045	-	$1,045
9	$956	-	$956
12	$741	-	$741

Scenario 2. Separate Liquid-Cooled ITE Economizer Scenario

San Jose Results:

Table 11: Scenario 2.a - Partial PUE of Cooling Tower Scenario

Simulation #	Description	Partial PUE (chiller, tower, cooling tower, pump)
1A - Base Case	Combined Plant with low LWT for all	1.031
1B – Base Case	Combined Plant with high LWT, then Chillers cool to low LWT for RDHXs	1.043
2 - Proposed	Separate 1B (tower-only) Plant for CDUs Separate 1A Plant for RHDX	1.023

Table 12: Scenario 2.b - Partial PUE of Dry Cooler Scenario

Simulation #	Description	Partial PUE (chiller, tower, dry cooler, pump)
1A - Base Case	Combined Plant with low LWT for all	1.071
1B – Base Case	Combined Plant with high LWT, then Chillers cool to low LWT for RDHXs	1.045
2 - Proposed	Separate 1B (tower-only) Plant for CDUs Separate 1A Plant for RHDX	1.031

Scenario 2a energy savings (electricity, natural gas, and source energy) and peak demand reductions per-unit are presented in Table 13 through Table 14. Per-unit savings for the first year are expected to range from 57 to 104 kWh/yr, depending upon climate zone. Demand reductions/increases are expected to be zero kW since there might not be any economizing when the peak load occurs.

Table 14 presents total energy cost savings per unit for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Table 14 presents a breakdown of total LSC savings from electricity and natural gas cost savings for the prototypical building.

Table 13: Scenario 2a Liquid-Cooled ITE Wet-bulb Economizer-- Energy and Energy Cost Savings – Per kW ITE – New Construction and Additions– Preliminary Analysis

Climate Zone	First Year Electricity Savings (kWh)	First Year Peak Demand Reduction (kW)	First Year Natural Gas Savings (kBtu)	First Year Source Energy Savings (kBtu)	Total 30-Year LSC Savings (2029 PV$)
4	57.40	0	-	144.30	$474
7	104.27	0	-	262.14	$903
9	94.35	0	-	237.20	$817
12	66.06	0	-	166.08	$544

Table 14: Scenario 2a Liquid-Cooled ITE Wet-bulb Economizer- 2029 PV LSC Savings Over 30-Year Period of Analysis – Per kW ITE – New Construction and Additions– Preliminary Analysis

Climate Zone	30-Year LSC Electricity Savings (2029 PV$)	30-Year LSC Natural Gas Savings (2029 PV$)	Total 30-Year LSC Savings (2029 PV$)
4	$474	-	$ 474
7	$903	-	$903
9	$ 817	-	$ 817
12	$544	-	$544

Scenario 2b energy savings (electricity, natural gas, and source energy) and peak demand reductions per-unit are presented in Table 15 through Table 16. Per-unit savings for the first year are expected to range from 273 to 381 kWh/yr, depending upon climate zone. Demand reductions/increases are expected to be zero since there might not be any economizing when the peak load occurs.

Table 16 presents total energy cost savings per unit for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Table 16 presents a breakdown of total LSC savings from electricity and natural gas cost savings for the prototypical building.

Table 15: Scenario 2b Liquid-Cooled ITE Dry-bulb Economizer-- Energy and Energy Cost Savings – Per kW ITE – New Construction and Additions– Preliminary Analysis

Climate Zone	First Year Electricity Savings (kWh)	First Year Peak Demand Reduction (kW)	First Year Natural Gas Savings (kBtu)	First Year Source Energy Savings (kBtu)	Total 30-Year LSC Savings (2029 PV$)
4	272.72	0	-	685.63	$2,181
7	380.62	0	-	956.89	$3,209
9	342.92	0	-	862.12	$2,877
12	301.25	0	-	757.36	$2,463

Table 16: Scenario 2b Liquid-Cooled ITE Dry-bulb Economizer- 2029 PV LSC Savings Over 30-Year Period of Analysis – Per kW ITE – New Construction and Additions– Preliminary Analysis

Climate Zone	30-Year LSC Electricity Savings (2029 PV$)	30-Year LSC Natural Gas Savings (2029 PV$)	Total 30-Year LSC Savings (2029 PV$)
4	$2,181	-	$2,181
7	$3,209	-	$3,209
9	$2,877	-	$2,877
12	$2,463	-	$2,463

2.4.3 Incremental First Cost

Incremental first costs represent the overall cost to the building owner when constructing a data center to the proposed design, as compared to the baseline design. This does not represent the overall cost to build a data center, rather the additional cost needed to comply with the proposed code change.

To establish incremental costs for the two California data center scenarios (Scenario 1 and Scenario 2a) as described in 2.4.2, the Statewide CASE Team requested a detailed cost bid from equipment manufacturers and local mechanical contractors.

These detailed costs for baseline and proposed designs across each scenario are provided in the tables below:

Scenario 1: Air-Cooled ITE—Wet-bulb Economizer Scenario Incremental Costs

Incremental cost data for CRAH coils was provided by two Bay Area representatives for two of the largest packaged CRAH manufacturers. Each representative provided pricing for a standard CRAH unit with a 4 row coil selected for a design of 14,500 cfm. Pricing was also provided for the same unit with a 6 row coil. The 4 and 6 row units are the same size and have the same size motor so there are no impacts on other contractor prices (e.g., mechanical, structural, electrical.) The average incremental cost was $0.23/cfm, which translates to $35.68/kW of ITE capacity.

Incremental cost data for waterside economizer heat exchangers (WSE HX) was provided by a Bay Area representative for a large heat exchanger manufacturer. Cost data was provided for a range of HX approaches, as outlined in Table 17.

Table 17: Contractor Pricing Per Range of WSE HX Approaches

Approach	2	3	4	5	6	7	8	9
CHWST (hot leaving)	65	65	65	65	65	65	65	65
CHWRT (hot entering)	85	85	85	85	85	85	85	85
Hot GPM	1620	1620	1620	1620	1620	1620	1620	1620
Cold Entering	63	62	61	60	59	58	57	56
Cold Leaving	81	80	79	78	77	76	75	74
Cold GPM	1800	1800	1800	1800	1800	1800	1800	1800
Max Pressure Drop Either Side (psi)	10	10	10	10	10	10	10	10
Budget Price	$193,895	$154,377	$129,931	$114,487	$101,827	$94,391	$88,143	$83,567
$/KW	$40.85	$32.52	$27.37	$24.12	$21.45	$19.89	$18.57	$17.61

The lower the approach the larger and heavier the heat exchanger. To account for the cost impact on other trades (e.g., structural, rigging, etc.) a conservative installation multiplier of two is applied to the incremental cost for all approaches.

Incremental cost data for cooling towers was provided by a Bay Area representative for a large cooling tower manufacturer. Cost data was provided for a range of cooling tower approaches, as outlined in Table 18.

Table 18: Contractor Pricing Per Range of Cooling Tower Approaches

Approach	3	5	7	9	11
Tower gpm	1253	65	65	65	65
Tower Range	12	85	85	85	85
Tower Btu/hr	7518000	1620	1620	1620	1620
Tower Tons	626.5	62	61	60	59
Approximate Chiller Tons	537	80	79	78	77
Approximate kW	1880	1800	1800	1800	1800
Budget Price	$212,070	$200,010	$182,160	$160,460	$125,640
$/KW	$113	$106	$97	$85	$67

Like heat exchangers, the lower the cooling tower approach, the larger and heavier the cooling tower. To account for the cost impact on other trades (structural, rigging, etc.) a conservative installation multiplier of two is applied to the incremental cost. Note that a larger cooling lower tower approach does not require a larger motor, only a greater surface area (i.e., larger cooling tower).

Table 19. Wet-bulb Economizer Scenario: Cost and Performance Data, per kW of ITE Capacity

	CRAH Coil	WSE HX	Cooling Tower	Total	CRAH Total Static Pressure (" w.g.)
Base Case Design Approach (F)	8	11	11	30	2.25
Proposed Design Approach (F)	5	5	5	15	2.45
Incremental Cost / KW of capacity	$35.68	$6.98	$42.40	$85.06	-
Installation multiplier	1	2	2	1.58	-
Total incremental cost	$35.68	$13.96	$84.80	$134.44	-

Chiller Downsizing:

Please note that this incremental cost for the Wet-bulb Economizer Scenario is conservative because it does not take credit for chiller downsizing. In the base case the approach to the wet-bulb is 30°F, meaning that for a 75°F SAT the economizer provides 100 percent free cooling at 45°F OAWB and partial economizer free cooling at OAWB up to 65°F. Above 65°F there is no partial economizing and 100 percent of cooling is provided by chillers. Data center cooling systems are typically designed to meet the design loads at the ASHRAE 20 yr or 50 yr extreme dry-bulb/wet-bulb conditions. The extreme wet-bulbs are listed below. In all locations the extremes are above 65°F so the chillers must be sized for 100 percent of the load.

In the proposed case, however, the approach to wet-bulb is 15°F, meaning that the economizer will provide partial cooling up to about 80F OAWB. This is higher than all of the extreme OAWBs, meaning that the economizer should always provide at least partial free cooling and the chiller can be downsized. Table 20 shows the chillers can be downsized between 7 percent and 18 percent.

Table 20: Chiller Downsizing Percentage Based on Proposed Approach

Climate Zone	CZ04	CZ07	CZ09	CZ12
Weather file (TMY3)	San Jose	San Diego	Los Angeles	Sacramento
20yr extreme WB	75	76.8	77.3	77.3
50yr extreme WB	76.5	78.2	78.4	78.6
Baseline: WB Temp No Economizing	65	65	65	65
Proposed: WB Temp No Economizing	80	80	80	80
Chiller cap at 20 yr extreme	75%	84%	87%	87%
Chiller cap at 50 yr extreme	83%	91%	92%	93%
Percent chiller reduction at 50yr	18%	9%	8%	7%

Chiller downsizing will make the payback even better by reducing the net incremental cost. One reason this analysis does not take credit for downsizing is because downsizing requires the airside dT for the CRAH coil and the waterside dT for the CRAH coil to be at least 20°F (e.g., 75°F SAT, 95°F RAT, 70°F CHWST, 90°F CHWRT). Some engineers may not feel comfortable relying on this assumption. As such, this analysis uses conservative cost assumptions.

Scenario 2a: Separate Liquid-Cooled ITE Economizer Scenario Incremental Costs

Incremental costs were determined by starting with a real data center in the Bay Area that meets the proposed design and is currently under construction. The data center under construction was used in the proposed scenario of the analysis and has a total ITE load of 8.5 MW with 6.5 MW of liquid-cooled ITE and 2.0 MW of air-cooled ITE. The proposed data center uses separate cooling plants for the air-cooled and liquid-cooled ITE. The CASE Team engaged the mechanical and electrical contractors building this data center to determine the incremental cost to combine the separate plants into a single plant serving both the air-cooled and liquid-cooled ITE, reflecting the baseline case. The mechanical contractor was asked to estimate the cost increase when going from the baseline design vs. proposed design for the air-cooled ITE and liquid-cooled ITE scenarios. The mechanical contractor was selected based on significant experience designing and installing cooling equipment in data centers in California. Contractor pricing was for a fully complete system and includes equipment, labor, and acceptance testing.

- **Proposed case:** The existing (under construction) data center includes the following:
  - Water-cooled chilled water plant with waterside economizer serving chilled water (CHW) to air-cooled ITE via CRAH units.

- Separate tower condenser water plant serving tower water (TW) to liquid-cooled ITE via CDUs (cooling distribution units).
- Separate CHW and TW piping throughout each data hall.

- **Baseline case:** Contractors provided alternate pricing to combine the two plants into a single water-cooled chilled water plant serving both air and liquid cooled ITE. This is further described in Appendix A.

A summary of the incremental costs when going from the proposed case of two cooling plants to a single plant serving both air-cooled and liquid-cooled ITE is provided in Table 21. As shown in this table, it is less expensive to design and install the two cooling plant scenario serving air and liquid-cooled ITE separately, than a single system.

Table 21. Summary of Separate Liquid-Cooled ITE Economizer Scenario Incremental Costs

Proposed Case	Electrical	Mechanical	Total
Total Incremental first cost	$ (1,950,000)	$ (1,926,586)	$ (3,876,586)
Incremental first cost per kW of Liquid-Cooled ITE	$ (300)	$ (296)	$ (596)

2.4.4 Incremental Maintenance and Replacement Costs

Within the mechanical contractor incremental cost bid, costs associated with additional maintenance and replacement costs were established. While the maintenance costs are negligible between the two scenarios and system types, it is anticipated that certain components will wear out and need to be replaced over the 30-year analysis period.

Air-Cooled ITE—Wet-bulb Economizer Scenario: There is no incremental maintenance cost. The incremental replacement cost is calculated based on an expected life of 20 years for CRAH units, heat exchangers, and cooling towers.

Separate Liquid-Cooled ITE Economizer Scenario: The proposed case has 6 (smaller) cooling towers compared to 4 (larger) towers in the base case. The proposed case has 9 (smaller) pumps, compared to 6 (larger) pumps in the base case. The mechanical and electrical contractors estimate the incremental maintenance cost for the proposed case to be between $0 and $20,000/yr. To be conservative the worst case scenario of $20,000/yr is used in the analysis. For the 6.5 MW of liquid-cooled ITE capacity, this works out to $3.1/kW of ITE capacity.

Incremental Replacement cost is calculated based on a replacement period of 20 years for chillers, towers, and pumps.

2.4.5 Cost Effectiveness

Scenario 1 results of the per-unit cost-effectiveness analyses are presented in Table 22and Table 23 for new construction/additions and alterations, respectively.

Scenario 2a results of the per-unit cost-effectiveness analysis for new construction is presented in Table 24.

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

Table 22: Scenario 1 Air-Cooled ITE—Wet-bulb Economizer-30-Year Cost-Effectiveness Summary Per kW of ITE Capacity – New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
4	$684	$209	3.27
7	$1,045	$209	5.00
9	$956	$209	4.58
12	$741	$209	3.55

Table 23: Scenario 1 Air-Cooled ITE—Wet-bulb Economizer- 30-Year Cost-Effectiveness Summary Per kW of ITE Capacity – Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
4	$684	$209	3.27
7	$1,045	$209	5.00
9	$ 956	$209	4.58
12	$741	$209	3.55

Table 24: Scenario 2a Liquid-Cooled ITE Wet-bulb Economizer-30-Year Cost-Effectiveness Summary Per kW of ITE Capacity – New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
4	$474	$-618	Cost Effective
7	$903	$-618	Cost Effective
9	$ 817	$-618	Cost Effective
12	$544	$-618	Cost Effective

2.5 Computer Room Economizers - Statewide Impacts

2.5.1 Statewide Energy and Energy Cost Savings

See the 2028 CASE Methodology Report for details on how statewide savings are calculated. Appendix C presents the assumptions on the percentage of the total construction forecast that the proposed measure would impact.

For more details on the methodology and context about estimating the current market share rate, as well as statewide energy and energy cost savings, see the 2028 CASE Methodology Report.

To estimate statewide impacts of the proposed data center economizer changes, the Statewide CASE Team weighted potential savings across the three scenarios (1, 2a, and 2b) representing the likelihood of air-cooled and liquid-cooled ITE using either an airside or waterside economizer. To determine the breakdown of dry-bulb or wet-bulb economizers likely to be installed across the state, the Statewide CASE Team leveraged the market analysis conducted in the 2022 CASE Report *Nonresidential Computer Room Efficiency*. This assessment assumed 34.5 percent use a wet-bulb economizer while 65.5 percent use a dry-bulb economizer (Weitze, Bulger and Stein

2021). This analysis will be refined based on additional stakeholder engagement and updated for the final CASE Report.

Additionally, the Statewide CASE Team determined the likely ratio of new and existing data centers with air-cooled and liquid-cooled ITE. Two market assessments, one from Uptime Institute and another from Mordor Intelligence, which were conducted in 2024 and 2026, respectively, were used to generate a reasonable approximation of liquid-cooled and air-cooled ITE. The Uptime Institute Survey found that 22 percent of the global market currently uses liquid-cooled ITE, while another 61 percent would consider it. While the Mordor Intelligence Global Data Center Cooling Market Source found that 53.4 percent of the global data center market currently uses air-cooled ITE and 46.6 percent use liquid-cooled ITE. However, this assessment also shows that liquid cooled ITE is expected to grow by over 17 percent by 2032. Based on these assessments, the Statewide CASE Team conservatively estimates that 60 percent of the new data center market will be liquid-cooled ITE, with 40 percent air-cooled ITE.

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 25) and alterations (Table 26) by climate zone. Table 27 presents first-year statewide savings from new construction, additions, and alterations. It is assumed there is no demand savings for the economizer during the peak load condition.

Table 25: Statewide Energy and LSC Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (DC Capacity MW)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
4	4.7	0.61	0	-	1.54	4.93
7	3.7	0.70	0	-	1.75	5.92
9	11.2	1.90	0	-	4.78	16.07
12	6.6	0.95	0	-	2.40	7.83
Total	**26**	**4.17**	**0**	**-**	**10.47**	**34.74**

Table 26: Statewide Energy and LSC Impacts – Alterations

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2026 (DC Capacity MW)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
4	4.20	0.40	0	-	1.02	3.27
7	3.94	0.55	0	-	1.38	4.66
9	12.68	1.59	0	-	4.01	13.50
12	7.13	0.76	0	-	1.91	6.23
Total	**28**	**3.30**	**0**	**-**	**8.30**	**27.66**

Table 27: Statewide Energy and LSC Impacts – New Construction, Additions, and Alterations

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
New Construction & Additions	4.17	0	-	10.47	34.74
Alterations	3.30	0	-	8.30	27.66
Total	**7.47**	**0**	**-**	**18.78**	**62.40**

2.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 28 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 968.37 metric tons of carbon dioxide equivalent (CO_2e) emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

Table 28: First-Year Statewide GHG Emissions Impacts

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e)	Total Reduced GHG Emissions (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions ($)
New Construction & Additions	554	0	554	68,232
Alterations	439	0	439	54,110
Total	**993**	**0**	**993**	**122,343**

2.5.3 Statewide Water Use Impacts

While this proposed measure does not require an increase in water use, water use could increase in individual computer rooms if the requirements push designers to use certain cooling solutions over others. The 2022 CASE Report *Nonresidential Computer Room Efficiency*, which evaluated the impact of increased economizing thresholds, conducted a water use analysis based on an estimate statewide average for all economizer types (Weitze, Bulger and Stein 2021).

This analysis found that water use could increase or decrease based on the following scenarios:

1. **Design that increases water use:** A computer room design that changes from air-cooled cooling equipment under the current code requirement to an evaporative cooling tower for wet-bulb economizing based on the new temperature thresholds. The previous CASE Report estimated this increased annual water use at 1,000 – 2,500 gallons per kW of ITE design load depending on climate zone.
2. **Design that decreases water use:** A computer room design using dry-bulb economizers and evaporative-cooled chiller plant would result in reduced water use by decreasing the cooling load on the evaporative cooling towers. The previous CASE Report estimated this decreased water use at 100 – 900 gallons per kW of ITE design load depending on climate zone.

While the first scenario described above would increase water use, the Statewide CASE Team does not anticipate that the proposed change would result in more designers switching from air-cooled to water-cooled equipment. Because the proposed change would increase the temperature threshold and economizer stringency for wetbulb economizers and not dry-bulb economizers, the opposite effect may occur, and designers may opt for air-cooled equipment to avoid the new waterside requirements. Additionally, by increasing the threshold for wet-bulb economizers, more of the cooling load would be taken by the economizer, thus decreasing the cooling load on the evaporative cooling towers, which would reduce overall water use in those systems.

There are also other ways to reduce water consumption in evaporative systems, such as:

- Use recycled water in evaporatively-cooled systems.
- Design Hybrid air-cooled and (for peak days only) evaporatively-cooled systems.
- Design a closed loop heat recovery system where computer room heat can be rejected to a heating load instead of to the outdoors.

Considering these factors, the Statewide CASE Team does not anticipate this proposed change will result in increased water use and may in fact decrease overall water use if more designs use air-cooled cooling equipment.

2.5.4 Statewide Material Impacts

Material impacts related to this proposed measure would largely depend on how a cooling system is designed to comply with the proposed economizer requirements. Certain approaches may result in less materials, or different types of materials being used, while other approaches, such as the two analysis scenarios described in Section 2.4.2, would increase overall material use. While the Statewide CASE Team recognizes there are many other code compliant designs, as described in Sections 2.1.3 and 2.3.2, the material impacts defined in this section of the report are based on the two selected scenarios and described below.

Air-Cooled ITE—Wet-bulb Economizer Scenario:

Using a larger cooling tower and heat exchanger sized for lower approach temperatures to meet the increased wetbulb economizer threshold would result in an increase in steel use, as shown in Table 29.

Table 29: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per kW of ITE)	First-Year Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO2e)
Steel	**NC, Additions, Alterations**	**1.7**	**34,345**	**-18.9**

Liquid-Cooled ITE Economizer—Wet-bulb Economizer Scenario:

Using a separate waterside economizing plant for liquid-cooled ITE is expected to result in steel savings compared to a single cooling plant for all ITE. While using two cooling plants would result in a net increase in linear feet of piping, the piping required would be smaller in diameter, resulting in a net decrease in piping material of 2.5 pounds per kW of ITE load.

Table 30: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per kW of ITE)	First-Year Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO2e)
Steel	**NC, Additions, Alterations**	**-2.5**	**-70,093**	**38.6**

The estimated net impact in statewide material impacts for this measure is a reduction in steel use, as shown in Table 31. For more information on the Statewide CASE Team's methodology and assumptions used to calculate embodied GHG emissions, see the 2028 CASE Methodology Report.

Table 31: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per kW of ITE)	First-Year Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO2e)
Steel	**NC, Additions, Alterations**	**Varies depending on system type (see previous two tables)**	**-35,748**	**19.7**

2.5.5 Environmental Impacts

This measure is not expected to result in any environmental impacts. While certain cooling system designs do increase water use in computer rooms and data centers, the proposed changes are not expected to increase the use of those designs. As such, the code change will not directly impact water use or quality.

2.5.6 Other Non-Energy Impacts

This measure is not expected to result in any non-energy impacts.

2.6 Computer Room Economizers - Proposed Language Code

2.6.1 Guide to Markup Language

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

2.6.2 Administrative Code (Title 24, Part 1)

There are no proposed changes to Title 24, Part 1.

2.6.3 Energy Code (Title 24, Part 6)

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION*:*

LIQUID-COOLED INFORMATION TECHNOLOGY EQUIPMENT (ITE) are the components of ITE that are cooled by a fluid other than air and that do not use server fans to flow air across the components. Common liquid cooling fluids include water, glycol, and refrigerant. Individual servers can be partially liquid-cooled and partially air-cooled, with server fans serving the air-cooled components and pumps serving the liquid-cooled components.

AIR-COOLED ITE are the components of ITE that are cooled by the flow of air through the ITE equipment. Onboard server fans are typically used to move air through servers.

FACILITY WATER is the cooling fluid loop that carries heat away from liquid-cooled ITE (typically via a coolant distribution unit heat exchanger) toward plant-level heat rejection infrastructure (like chillers, cooling towers, and/or dry coolers).

COMPUTER ROOM ECONOMIZER is a system by which heat from ITE is rejected to the environment without the use of a refrigerant compressor. If a computer room economizer is part of a cooling system that also includes a refrigerant compressor, then the system shall be fully integrated, meaning it shall be capable of providing partial economizer cooling without limiting the capacity of compressor cooling and without limiting the capacity of compressor-less cooling.

(a) Systems that DO meet the fully integrated criteria of a computer room economizer, include the following:

1. Waterside economizer heat exchangers that are piped in series with chillers on the chilled water side.
2. Air-cooled chillers with integrated economizer coils that are piped into the secondary circuit of a primary/secondary system. The fans serving the integrated economizer coils must be able to modulate speed without being limited by the need to maintain a minimum refrigerant head pressure.
3. Air-cooled chillers with integrated economizer coils that are served by dedicated

economizer fans and not by condenser fans that serve refrigerant condenser coils.

4. Refrigerant economizer systems where 10-90% of the load on a refrigerant circuit can be met by a passive condenser or refrigerant pump, while the other 90% to 10% of the load is met by an active condenser or refrigerant compressor

(b) Systems that DO NOT meet the fully integrated criteria of a computer room economizer include the following:

1. Waterside economizer heat exchangers that are piped in parallel with chillers on the chilled water side.
2. Air-cooled chillers with integrated economizer coils that are piped into the primary circuit of a primary/secondary system, or on the chiller side of a chiller minimum flow bypass valve.
3. Air-cooled chillers with integrated economizer coils that are served by the same condenser fans that serve refrigerant condenser coils whose speed is limited by the need to maintain a minimum refrigerant head pressure.
4. Refrigerant economizer systems with one or more refrigerant circuits that must switch from refrigerant compressor operation to refrigerant pump operation.

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

a. **Prescriptive Requirements for Computer Rooms.** Computer rooms with a power density greater than 20 W/ft2 shall comply with this section.

~~1. **Economizers.** Each individual cooling system primarily serving computer rooms shall include either:~~

~~a. An integrated air economizer capable of providing partial cooling even when additional mechanical cooling is required and capable of providing 100 percent of the expected system cooling load at 65°F to 80.6°F supply air temperature at outside air temperatures of 65°F dry-bulb and below or 50°F wet-bulb and below, and be equipped with a fault detection and diagnostic system as specified by Section 120.2(i); or~~

~~b. An integrated water economizer capable of providing partial cooling even when additional mechanical cooling is required and capable of providing 100 percent of the expected system cooling load at 65°F to 80.6°F supply air temperature at outside air temperatures of 50°F dry-bulb and below or 45°F wet-bulb and below.~~

1. **Economizers.**

   A. Each individual cooling system primarily serving computer rooms shall include a computer room economizer, as defined in section 100.1, capable of providing 100 percent of the expected system design cooling load at the following ambient conditions and at 75°F supply air temperature for air-cooled ITE. Compliance shall be determined with redundant equipment operating if the redundant equipment is expected to operate in normal operation.

Type of ITE	Ambient Drybulb	Ambient Wetbulb
Air-Cooled ITE in a computer room with average air-cooled ITE design load > 25 kW/rack and served by a cooling system that does not evaporate water at these ambient conditions	≤ 55°F	any
All liquid-cooled ITE in buildings with a design liquid-cooled ITE load greater than 2 MW	≤ 75°F	≤ 75°F
All other ITE	≤ 65°F	≤ 60°F

B. The economizer shall be equipped with a fault detection and diagnostic system as specified by Section 120.2(i)

C. Differential Temperature (dT) and Variable Flow

  i. Air handling systems with a capacity exceeding 30,000 Btu/hr serving air-cooled ITE load shall be designed for a return to supply air dT of at least 20F. These systems shall be designed and controlled to vary airflow as a function of ITE load with a minimum airflow not to exceed 25% of design airflow, in order to maintain constant dT at ITE loads from 25% to 100%.

  ii. Chilled water and facility water systems serving air-cooled and liquid-cooled ITE shall be designed for a return to supply fluid dT of at least 15F. These systems shall be designed and controlled to vary fluid flow as a function of ITE load, in order to maintain constant dT at ITE loads from 25% to 100%.

EXCEPTION 1 to Section 140.9(a)1: Individual computer rooms with an ITE design load under 5 tons (18 kW) in a building that does not have any economizers.

EXCEPTION 2 to Section 140.9(a)1: A computer room with an ITE design load less than 20 tons (70 kW) may be served by a second fan system without an economizer if it is also served by a fan system with an economizer that also serves other spaces within the building, provided that all of the following are met:

i. The economizer system is sized to meet the design cooling load of the computer room when the other spaces within the building are at 50 percent of their design load at outside air temperatures of 65°F dry-bulb and below and ~~50°F~~ 60°F wet-bulb and below; and

ii. An economizer system that can stop service to other spaces in the building when those spaces are unoccupied and serve only the computer rooms.

EXCEPTION 3 to Section 140.9(a)1: Computer rooms that reject heat to a heat recovery system that is sized to accept at least 50% of the design computer room heat and that serves a qualifying heating load. Qualifying heating loads include:

i. Space heating systems and/or service water heating systems with design loads at least 5 times greater than the computer room design cooling load.

ii. Processes determined by the Executive Director to require more than 50% of the design computer room heat for more than 3,000 hours/year.

2. **Power Consumption of Fans.** The total fan power at design conditions of each fan system shall not exceed 27 W/kBtu·h of net sensible cooling capacity.

3. **Air Containment.** Computer rooms with air-cooled computers in racks and with a ITE design load exceeding ten kW (2.8 tons) per room shall include air barriers such that there is no significant air path for computer discharge air to recirculate back to computer inlets without passing through a cooling system.

EXCEPTION 1 to Section 140.9(a)3: Expansions of existing computer rooms.

EXCEPTION 2 to Section 140.9(a)3: Computer racks with a design load less than 1 kW (0.28 tons) per rack.

EXCEPTION 3 to Section 140.9(a)3: Equivalent energy performance based on computational fluid dynamics or other analysis.

SECTION 141.1 – REQUIREMENTS FOR COVERED PROCESSES IN ADDITIONS, ALTERATIONS TO EXISTING NONRESIDENTIAL, AND HOTEL/MOTEL BUILDINGS

Covered processes in additions or alterations to existing buildings that will be nonresidential, and hotel/motel occupancies shall comply with the applicable subsections of section 120.6 and 140.9.

a. **Lab and Process Facility Exhaust Systems.** All newly installed fan systems for a laboratory or process facility exhaust system greater than 10,000 cfm shall meet the requirements of Section 140.9(c).

b. **Computer Rooms.** All newly installed computer room cooling systems and uninterruptible power supply systems in additions/alterations shall meet the requirements of Sections 120.6(j), 140.9(a)2, and 140.9(a)4 and comply with item 1 below.

1. **Economizers.** Each individual cooling system primarily serving computer rooms in an existing building shall ~~include either~~: meet the requirements of Section 140.9(a)1

~~A. An integrated air economizer capable of partial cooling when additional mechanical cooling is required and capable of providing 100 percent of the expected system cooling load up to 80°F room supply air temperature at outside air temperatures of 55°F dry-bulb and below or 50°F wet-bulb and below, and be equipped with a fault detection and diagnostic system as specified by section 120.2(i); or~~

~~B. An integrated water economizer capable of partial cooling when additional mechanical cooling is required and capable of providing 100 percent of the expected system cooling load up to 80°F room supply air temperature at outside air temperatures of 40°F dry-bulb and below or 35°F wet-bulb and below.~~

EXCEPTION 1 to Section 141.1(b)1: Individual computer rooms with an ITE design load under ~~5 tons (18 kW)~~ 10 tons (35 kW) in a building that does not have any economizers or modulating DOAS.

~~**EXCEPTION 2 to Section 141.1.(b)1:** New cooling systems serving an existing computer room in an existing building with an ITE design load up to a total of 50 tons (176 kW).~~

~~**EXCEPTION 3 to Section 141.1(b)1:** New cooling systems serving a new computer room in an existing building with an ITE design load up to a total of 20 tons (70 kW).~~

EXCEPTION 2 to Section 141.1(b)1: new cooling systems serving an existing computer room where:

I. Total capacity of the new cooling system is less than 500 tons and less than 50% of the total computer room cooling system capacity, and

II. the new cooling system includes an integrated computer room economizer capable of providing 100 percent of the design cooling load at 75°F supply air temperature at the following outside air conditions:

Original Permit Date of Existing Computer Room	**Dry-bulb**	**Wet-bulb**
Before 1/1/2014	No economizer requirement	
1/1/2014 – 12/31/2022	55F	35F
1/1/2023 – 12/31/2028	65F	45F

2.6.4 Reference Appendices

There are no proposed changes to the Reference Appendices.

2.6.5 Compliance Manuals

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

2.6.6 ACM Reference Manual

The following sections in the Nonresidential Alternative Calculation Method (ACM) would need to be updated based on the proposed change.

- Appendix 5.4B: Modify the cooling setpoint for data centers from 80F to 90F. Per ACM section 5.7.2.3 Supply Air Temperature Control, raising the cooling setpoint from 80F to 90F, will raise the SAT from 60F to 70F, which is more consistent with current standard practice.
- Section 5.7.4.2 Air Side Economizers: Revise the Economizer High Temperature Lockout standard design from a fixed dry-bulb high limit of 80F to 90F.

Currently the ACM has two baseline systems for computer rooms:

System 10: Single zone VAV chilled water CRAH unit with airside economizer, served by water-cooled chillers served by cooling towers. This system is currently assigned to computer rooms with total process load > 800kW

System 11: Single zone VAV packaged DX with airside economizer. This system is currently assigned to computer rooms with total process load ≤ 800kW

These baselines were developed in 2012 and represented reasonable best practice for most computer rooms and data centers at that time. Much has changed since that time. One significant change is increased power density per rack. In 2012 typical racks were in the 2-10 kW/rack range. Now it is common for racks to have air-cooled ITE exceeding 25 kW/rack. Airside economizing is increasingly expensive and impractical at very high density. An airside economizer typically requires air handlers along an exterior wall of a data center for access to outside air, with long cold aisles perpendicular to the exterior wall to supply from the AHU to the racks. The airflow requirement for high density means the cold aisles can only be a couple racks deep. Any deeper and the aisle cross sectional area would be prohibitively large. High density air cooling typically requires close-couple cooling solutions, like rear door heat exchangers or in-row coolers (IRCs). Airside economizing with close-coupled airside cooling is not practical. Waterside economizers are common for high density air-cooling but unfortunately waterside economizers are not as energy efficient as air economizers. Thus a baseline system with an airside economizer is not a reasonable baseline for high density air-cooled ITE. As described below high density air-cooled ITE is now mapped to a new baseline system (12a) with a dry cooler economizer, which is in line with the new prescriptive economizer threshold for high density air-cooled ITE.

Another factor that must be considered is water scarcity. With the explosive growth of data centers there is real concern that water-cooled data centers will use an excessive quantity of water to the detriment of other critical uses such as agriculture and residential. Thus the data center industry is making great efforts to minimize or eliminate water use. Data centers that use water use less electricity and conversely data centers that don't use water require more electricity. In the Title 24 performance approach water is free but electricity is valued using the TDV/LSCC values. Currently, system 10 for large data centers uses water-cooled chillers. This makes it difficult or impossible for data centers striving to minimize water use to meet the baseline. Thus the performance approach is basically requiring water-cooled data centers. For these reasons System 10 is being changed from water-cooled chillers to air-cooled chillers. Obviously this does not prohibit a data center from using water-cooled chillers but it does not require it.

Another development is the growth of liquid cooling and the new proposed prescriptive requirement for large liquid cooled ITE loads. New System 12b is the new baseline corresponding to the new proposed prescriptive requirement for large liquid cooled ITE loads.

System 10 will be modified from water-cooled chillers to high efficiency air-cooled chillers. The CRAH units with airside economizers will be unchanged.

Three new baseline systems will be added:

System 12a: Air-cooled ITE served by CRAH units served by water-cooled chillers served by dry coolers that also function as fully integrated economizers. Some details of this system:

a. Dry coolers design approach to ambient drybulb: 15F (accounts for redundancy)
b. No waterside economizer heat exchanger. The dry cooler fluid is piped direct to the CRAH units in partial or full economizer mode.
c. CRAH unit SAT approach to facility water temperature: 5F (accounts for redundancy)
d. Dry coolers controlled to maintain SAT of 75F in full economizer mode.
e. Chillers controlled to maintain SAT of 80F, i.e., in cold weather the dry cooler will maintain SAT = 75F. As ambient temperature rises the SAT will drift up to 80F before the chillers are enabled. The plant will operate in integrated economizer mode until ambient drybulb exceeds 100F or higher (depending on IT load) at which point the chiller will meet the entire load.

System 12b: Liquid-cooled ITE served by CDUs, served by water-cooled chillers served by dry coolers that also function as fully integrated economizers. Some details of this system:

1. Dry coolers design approach to ambient drybulb: 15F
2. No waterside economizer heat exchanger. The dry cooler fluid (FWS) is piped direct to the CDUs in partial or full economizer mode.
3. CDU FWS to TCS approach: 5F
4. Dry coolers controlled to maintain TCS supply temperature of 95F in full economizer mode, i.e., 100% economoizer at ambient drybulb of 75F at full load.
5. Chillers controlled to maintain TCS supply temperature of 95F in partial economizer mode and non-economizer mode.

System 12c: Same as System 10 (A/C chillers / CRAHs) but no airside or waterside economizer. Note that this is only applied to systems that quality for the heat recovery economizer exception. As such, the load on the chillers is the current computer room load minus the lesser of:

1. The total current load of the heating systems used to qualify for the exception.
2. 50% of the design computer room load

New mapping is as follows:

System	**Serves…**
12a (W/C Chillers / Dry Cooler Econ)	Air-Cooled ITE in a computer room with total ITE load > 200 kW and with average Air-cooled ITE power density > 25 kW/rack and Liquid-Cooled ITE in buildings with a design liquid-cooled ITE load ≤ 2 MW
10 (A/C Chillers / Air Econ)	Air-Cooled ITE in a computer room with total ITE load > 800 kW and with average Air-cooled ITE power density ≤ 25 kW/rack
12b (High Temp W/C Chillers / Dry Cooler Econ)	All liquid-cooled ITE in buildings with a design liquid-cooled ITE load greater than 2 MW
12c (A/C Chillers / No Econ)	ITE in Computer rooms that meet EXCEPTION 3 to Section 140.9(a)1 or in buildings prescriptively required to have computer room heat recovery per Section 140.9(a)5

11 (PSZVAV / Air Econ)	All other ITE prescriptively required to have an economizer

2.6.7 Compliance Forms

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

3. Fan Control Requirements

3.1 Fan Control Requirements – Measure Description

3.1.1 Proposed Code Change

This measure proposes to modify mandatory requirements in section 120.6(j)3 by reducing the cooling capacity threshold for when variable supply airflow is required for direct expansion (DX) units in new and existing computer rooms. This would result in a greater number of air conditioners for computer rooms being installed with variable speed supply fans that modulate airflow based on cooling load. The threshold for when variable airflow fan control is required would be reduced from a 60,000 Btu/hr unit to a 30,000 Btu/hr unit. Table 32 summarizes the scope of the proposed code change.

Table 32: Scope of Proposed Code Change

A ☑ indicates the proposed code change is relevant.

Building Type(s)	Construction Type(s)	Type of Change
☐ Single Family	☑ New Construction	☑ Mandatory
☐ Multifamily	☑ Additions	☐ Prescriptive
☑ Nonresidential (Not Group R uses)	☑ Alterations	☐ Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	• Part 6, Section 120.6(j)3	NRCCPRC - update	None

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

3.1.2 Benefits of Proposed Change

In addition to the critical need to reduce energy, emissions, and water use in computer rooms and achieve statewide carbon reduction goals, as described in section 2.1.2, requiring variable airflow control for air conditioners in small computer rooms would reduce energy use and improve temperature control stability in those rooms.

Given that this measure is already required for systems that are greater than 60,000 Btu/hr (5 tons), this proposed change would extend the energy efficiency, cost savings, emissions reduction, and enhanced control benefits to smaller computer room systems down to 30,000 Btu/hr (2.5 tons). This measure can be implemented using cooling equipment that is widely available by many manufacturers with no incremental cost in many cases, as variable speed fans are often standard features.

This reduced capacity threshold for VAV control would enable all computer rooms down to 10 kW (34,120 Btu/hr)—which are already prescriptively required to have air containment under 140.9(a)3—to take full advantage of the energy savings potential of fan speeds varying in response to load. Additionally, the proposed capacity threshold change would expand the variable airflow requirement to many Intermediate Distribution Frame (IDF) rooms, which are present in nearly every nonresidential building type (e.g., typically one per floor or one per [12] square foot for offices[13]).

There are currently thousands of small computer rooms with dedicated DX cooling systems. Many of these systems are oversized and run at constant speed. When the cooling system is oversized, not only is energy wasted, but the compressor often cycles on and off in short time intervals, leading to unstable temperature control. Variable speed fans allow the fan airflow to vary with the load and help avoid over cooling the space.

3.1.3 Background Information

Title 24, Part 6 first began regulating computer rooms in 2013. The requirements focused on cooling system efficiency, particularly fan energy and cooling compressor energy. During the 2022 code cycle, three requirements were moved from prescriptive to mandatory, including fan control (120.6(j)3), and new and updated prescriptive requirements for new and existing computer rooms were added. Title 24, Part 6 requirements for computer rooms have not been substantially updated since that time.

Title 24, Part 6, 2025 has the following requirements related to computer room fan energy use:

- Section 120.6(j) has a mandatory requirement that fan airflow rate varies in response to computer room load for unitary air conditioners above 60,000 Btu/hr and all chilled water cooling units. Other than moving from prescriptive to mandatory, this requirement has not changed since its introduction to Title 24 in 2013.
- Section 140.9(a)2 prescriptively limits computer room total fan power to no greater than 27 W/kBtu·h of net sensible cooling capacity.
- Section 140.9(a)3 prescriptively requires air containment for computer rooms with air-cooled ITE load exceeding 10 kW (34,120 Btu/hr) per room. This

[13] Based on review of Code Readiness field site data.

requirement has a direct impact on computer room system fan energy by reducing airflow needed for cooling.

Common computer room cooling efficiency strategies have progressed beyond the minimum requirements in Title 24, Part 6. Efficient computer room products have become less expensive as they have become more widely adopted. In 2013, electronically commutated motors (ECMs), which allow for variable fan speed control, were still uncommon in the market, and there was not a cost-effective option for small variable speed fans for computer room cooling units at the time. Today, ECMs have become a common method of fan speed control for small computer room cooling units, with many products available to computer room owners (see section Fan Control Requirements - Market and Economic Analysis).

3.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 3.6:Fan Control Requirements - Proposed Language Code of this report for detailed revisions to code language.

3.1.4.1 Energy Code Change Summary

This proposed measure would impact section 120.6(j) – which regulates mandatory requirements for covered processes. Changes are described below.

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

Subsection 120.6(j)3: This proposed measure would adjust the design cooling load threshold for when fan speed and airflow is modulated based on load. The design cooling threshold is being adjusted from 60,000 Btu/hr to 30,000 Btu/hr. This would require that fans serving computer rooms have either variable-speed control or two-speed motors that provide for a reduction in fan motor power to ≤ 50 percent of power at design airflow when the airflow is at 66 percent of design airflow. This would apply to chilled water units of all sizes and DX units with a rated cooling capacity of ≥ 2.5 tons.

3.1.4.2 Reference Appendices Change Summary

The proposed changes would not impact the reference appendices as there is no acceptance testing for computer room requirements.

3.1.4.3 Compliance Manuals Change Summary

Section 10.4.2.3 of the Nonresidential Compliance Manual, which outlines mandatory requirements for computer room HVAC fan system efficiency, would be updated. This would need to be updated to reflect the cooling capacity threshold change from ≥ 5 tons to ≥ 2.5 tons.

3.1.4.4 Alternative Calculation Method Reference Manual Change Summary

The proposed modification to 120.6(j)3 would not require any updates to the Alternative Calculation Method (ACM) Reference.

3.1.4.5 Compliance Forms Change Summary

The proposed modification to 120.6(j)3 would likely require a minimal updates to NRCC-PRC-E and NRCI-PRC-E to reflect the threshold change from 60kBtuh to 30kBtuh.

3.1.5 Measure Context

3.1.5.1 Comparable Model Codes or Standards

ASHRAE 90.1 – 2022 While Standard 90.1 does not include a separate section for mandatory computer room requirements, like Title 24, Part 6, fan control requirements as specified in Section 6.5.3.2 are required on DX cooling systems with cooling capacity ≥65,000 Btu/h.

2024 IECC Per C403.8.6.1, the 2024 IECC also has similar requirements for fan airflow control that apply to computer rooms and data centers but are not called out specifically like Title 24, Part 6.

ASHRAE 90.4 – 2022 serves as an optional compliance pathway for computer room or data centers with HVAC systems serving computer rooms with ITE load greater than 10kW. This standard provides more options for performance-based compliance of data center facilities.

3.1.5.2 Interactions with Other Regulations

There are no direct federal or state laws and other requirements that conflict with this measure. Federal and state laws that address energy efficiency in computer rooms2.1.5.2￼.

There would be no additional interactions or changes with the California Building Code or local requirements as a result of this proposed change.

3.2 Fan Control Requirements - Compliance and Enforcement

3.2.1 Compliance Considerations

Extending fan control as a function of load to 2.5-to-5-ton cooling systems serving computer rooms will require the same process as is currently employed in larger systems. Despite the relatively straightforward change being proposed, education and training will be needed to ensure designers, installers, plan reviewers and inspectors fully understand and can implement the change. The impacts to the current compliance approach for this modified measure are described below:

- Design Phase: Designers would need to know how to specify cooling equipment with variable speed fans or ECM for 2.5-to-5-ton systems. As described in section 3.3.1, systems with this integrated technology are readily available and, for most equipment, come as a standard feature.
- Permit Application Phase: The current process to demonstrate compliance with this measure for systems 5-ton or greater would be applied to smaller systems.
- Construction Phase: The Statewide CASE Team does not anticipate any change during the construction phase as the only difference in approach would be the installation of a slightly more efficient cooling unit.
- Inspection Phase: Inspectors would need some additional training on which systems must now comply with this requirement. Aside from that, the inspection process remains the same.

3.2.2 Impact on Market Actors

Most market actors are already aware of the requirement and currently specify and install equipment capable of meeting the proposed code change.

Table 33 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements.

Table 33: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Builders [a]	Minimal impact	Increased awareness of code requirement.
Design Professionals [b]	MEP firms will need to specify 2.5-to-5-ton equipment with ECM or VFD fans. This equipment is readily available, so designers will need to be trained on the code change so they can specify the right equipment.	Use local ASHRAE chapters and CI team trainings to raise awareness and ensure capabilities are reflected in designs.
Construction Team [c]	Construction teams will potentially need to select different equipment than their standard practice.	Increased awareness of code requirement.
Building Departments [d]	Verify that smaller systems have VAV controls and ECMs on plans and in field.	Inform code officials about new requirements through newsletters and training sessions.

Verification Testers [e]	No impact	None required
Building Owners, Managers, and Occupants	Reduced energy bills and added first cost.	Awareness of new equipment capabilities will enable building owners to demand compliant products. Relevant trade associations could be contacted to spread awareness.
Manufacturers and Distributors	Manufacturers will need to be aware of the requirements for smaller systems and may need to increase availability of compliant products.	Systems with these capabilities are readily available. Additional outreach by the CI team could underscore the need to increase availability of equipment in time for the 2028 code cycle's enforcement period which would begin on 1/1/2029.

a. Builders include builders and developers.
b. Design professionals include architects, interior designers, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.
d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians and sustainability department staff.
e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

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

Builders. The proposed change would likely affect commercial builders; however, it would likely not impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers in the commercial building industry equally; instead, it would primarily affect specific subsectors within the industry. Table 33 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Table 34: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)

Construction Subsector	Establishments *	Employment	Annual Payroll (Billions $)
Commercial Building Construction	5,491	87,450	$10.6
Nonresidential Poured Foundation Contractors	497	15,884	$1.4
Nonresidential Structural Steel Contractors	365	11,899	$1.1
Nonresidential Framing Contractors	137	3,037	$0.2
Nonresidential Masonry Contractors	217	4,028	$0.3
Nonresidential Glass and Glazing Contractors	307	5,079	$0.5
Nonresidential Roofing Contractors	385	11,413	$1.0
Nonresidential Siding Contractors	32	735	$0.1
Other Nonresidential Exterior Contractors	234	2,259	$0.1
Nonresidential Electrical Contractors	3,245	72,794	$7.8
Nonresidential Plumbing & HVAC Contractors	2,270	55,182	$5.8
Other Nonresidential Equipment Contractors	580	9,749	$1.1

Nonresidential Drywall Contractors	593	19,328	$1.8
Nonresidential Painting Contractors	501	9,225	$0.7
Nonresidential Flooring Contractors	286	4,011	$0.4
Other Nonresidential Finishing Contractors	492	7,241	$0.6
Nonresidential Site Preparation Contractors	1,147	19,273	$1.9
All Other Nonresidential Trade Contractors	948	17,084	$1.7

Source: (State of California n.d.)

*An establishment is single economic unit, typically at one physical location, that engages in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Many businesses are composed of multiple establishments. US Bureau of Labor Statistics, Handbook of Methods. https://www.bls.gov/opub/hom/cew/concepts.htm

Manufacturers. As discussed in section 3.3.1, manufacturers are already producing 2.5-to-5-ton equipment with ECMs that can turn down as fan speed is decreased. Some manufacturers may need to increase compliant products in the California market to meet new demand.

3.2.3 Compliance Software Updates

The proposed modification to 120.6(j)3 would not require any compliance software updates.

3.2.4 Cost of Enforcement

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

The proposed change to this measure would not be expected to increase the cost of enforcement. Proposed changes to this measure would reduce the threshold for systems that must comply, but the approach to verifying compliance will remain the same. Education and training would need to be provided to ensure code officials fully understand the proposed changes, if adopted.

3.3 Fan Control Requirements - Market and Economic Analysis

3.3.1 Market Structure and Availability

3.3.1.1 Current Market Structure and Availability

This proposed measure would lower the threshold for when DX cooling systems are designed to vary the airflow rate as a function of cooling load. For computer rooms 30,000 – 60,000 Btu/hr, which would be impacted by this measure, the cooling load is typically provided by split system fan coils with an evaporator fan and cooling coil located in the computer room and connected to an outdoor condensing unit. For small cooling loads, using products marketed for computer room precision cooling or for standard commercial cooling applications are common practice.

A review of manufacturer literature and information provided by equipment vendors shows that supply fans with ECMs are a standard feature across most precision cooling and standard commercial cooling products. While there is theoretically an increased first cost of having ECM fans, for most products they are a standard feature leaving no option to select a less expensive option. Below is a summary of products reviewed[14]. Only three of the products do not come with ECM supply fans as a standard feature. All products are by major manufacturers with a large presence in the United States (U.S.) and are readily available.

[14] Product data includes research compiled by the CASE Team and (future Code Readiness published report citation).

Table 35: Summary of Cooling Products Fan Speed Control Market Survey

Capacity kBtu/hr	Manufacturer	Model	Unit type	Airflow Discharge	Supply Fan Motor Type and Control
12	Vertiv (Liebert)	VRC100KIT	Active in-row fan coil	Upflow	EC variable-speed
12	Vertiv (Liebert)	VRC100KIT split	Active in-row fan coil	Upflow	EC variable-speed
12-38	Vertiv (Liebert)	CoolPhase Wall	Wall-Mounted CRAC (R-32)	Horizontal flow	EC variable-speed
12-119	Stulz	CeilAir OHS	Split/packaged (R-407C)	Upflow/Downflow	Not listed
14-41	STULZ	MiniSpace EC (DX 4-12 kW family)	Floor-Mounted CRAC (R410A)	Upflow/Downflow	EC variable-speed
17-36	Vertiv (Liebert)	DataMate	Floor-Mounted CRAC	Upflow	2-speed Permanent Split Capacitor (PSC)
17-68	APC (Schneider)	Uniflair AM (5-20 kW family)	Floor-Mounted CRAC (R410A)	Upflow/Downflow	EC variable-speed
20-118	Stulz	CyberAir Mini	Floor-Mounted CRAC (R-513A)	Upflow/Downflow	EC variable-speed
21-51	APC (Schneider)	Uniflair Ceiling Mount UCF / MRA	Ceiling-Mounted CRAC	Horizontal flow	Not Listed
24-119	Stulz	CyberOne COS	Floor-Mounted CRAC (R-407C)	Upflow/Downflow	EC variable-speed
30	Vertiv (Liebert)	Mini-Mate2 MMD36E (8.3 kW)	Ceiling-Mounted CRAC (R410A)	Direct throw	Single-speed or EC (family-dependent)

Capacity kBtu/hr	Manufacturer	Model	Unit type	Airflow Discharge	Supply Fan Motor Type and Control
30	APC (Schneider)	Uniflair SP (Ceiling/wall split family)	Ceiling-Mounted CRAC	Ceiling/wall direct throw	EC variable-speed
30	Mitsubishi Electric	PKA-A30KA8	Wall-Mounted VRF Fan Coil	Direct throw wall unit	EC variable-speed
34	Vertiv (Liebert)	CRV CRD10	Active in-row fan coil (R410A)	Horizontal flow (in-row)	EC variable-speed
34-143	APC (Schneider)	Uniflair ACRD	Active in-row fan coil (R-32)	Horizontal flow (in-row)	EC variable-speed
36, 42, 48, 56	Mitsubishi Electric	PVA	Floor-Mounted CRAC (R-454B)	Upflow/Downflow/Horizontal flow	EC variable-speed
36-60	Vertiv (Liebert)	New Mini-Mate	Ceiling-Mounted CRAC (R410A)	Horizontal flow	EC variable-speed
36-99	Vertiv (Liebert)	PDX PX011 (11-29 kW family)	Floor-Mounted CRAC (R410A)	Upflow/Downflow/Horizontal flow	EC variable-speed
41-113	Stulz	CyberRow	Active in-row fan coil	Horizontal flow (in-row)	EC variable-speed
48, 54	Mitsubishi Electric	PEFY-P48NMAU-E4	VRF Fan Coil	Ceiling concealed (ducted)	EC variable-speed
60	Mitsubishi Electric	s-MEXT + high sensible config	Floor-Mounted CRAC (R410A)	Upflow/Downflow	EC variable-speed

As demonstrated in Table 35, because ECM motors are standard feature in many products, the increased first costs is minimal, and lack of available products in the California market is unlikely.

3.3.1.2 Market Challenges and Solutions

As previously described, this technology is standard in new cooling equipment in the marketplace, and this requirement has been in the code as a mandatory requirement since it took effect in 2012.[15] As such, no market challenges have been identified.

See Section 3.2.2 for a description of workforce trainings that may be needed to ensure effective design, installation, and commissioning.

3.3.2 Design and Construction Practices

3.3.2.1 Current Design and Construction Practices

Most cooling products in the impacted cooling system size category come standard with EC motors, which allow for variable speed control. ECMs enable continuously variable speed fan control; however, some manufacturers limit the control of the ECM to two, three, four, or more fan speeds. Varying fan speed based on load is a standard product feature and, as such, this code change should be common in the design and implementation of smaller cooling systems in computer rooms.

3.3.2.2 Health and Safety Considerations

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

3.3.2.3 Design and Construction Challenges and Solutions

No design and construction challenges have been identified.

See Table 33: Impacts on Market Actors and Suggested Training and Education Opportunities in Section 2.2.2 for a description of workforce trainings that could support effective design, installation, and commissioning.

3.3.3 Energy Equity and Environmental Justice

The Statewide CASE Team evaluated the potential impact on environmental and social justice (ESJ) communities, including impacts related to race, class, and gender. With this proposal impacting computer room design and efficiency, this proposal would likely not result in any negative impacts to ESJ communities. In fact, improving computer room efficiency could provide secondary benefits to all communities, including ESJ. As

[15] 2008 Title 24 specified VAV in single zone systems with an effective date of January 1, 2012 for mechanical cooling capacity greater than or equal to 110,000 Btu/hr.

computer room efficiency increases, it will reduce energy and water usage, which will help alleviate strain on those resources.

The Statewide CASE Team identified potential impacts of the proposed code change via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement. Please reach out to Aniruddh Roy (aroy@energy-solution.com) if you have input on how this proposal may impact ESJ communities or if you would like to offer your perspective.

3.3.4 Impacts on Jobs and Businesses

This section will be completed for the Final CASE Report.

3.3.5 Economic and Fiscal Impacts

This section will be completed for the Final CASE Report.

3.4 Fan Control Requirements - Cost Effectiveness

3.4.1 Cost Effectiveness Methodology

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

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

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

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

3.4.2 Energy and Energy Cost Savings Results

The Statewide CASE Team conducted a non-CBECC analysis to estimate energy, emissions, and cost savings, and cost-effectiveness of the proposed measure. A custom Excel file was used to calculate the unit energy consumption for fan energy consumption for a baseline and proposed case. The baseline case assumed a single speed fan while the proposed case assumed a variable speed fan, enabling fan speed to modulate based on cooling load.

Energy savings from the Excel based approach were applied to six building prototype models (Hospital, Large office, Medium Office, Small Office, Large School, Small School) to represent potential savings from smaller computer rooms within those buildings. These building types were selected because they often include a small computer room or IDF room where this proposed code change would be applicable. To estimate the total impact per building, the Statewide CASE Team assumed that computer rooms represent 1 percent of hospital floor area, and 0.5 percent of floor area for all other building types.

A more detailed description of the methodology employed, and specific assumptions used, is outlined in Appendix A: Assumptions for Cost-effectiveness Analysis.

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per-unit are presented in Table 36 through Table 39. Per-unit savings for the first year are expected to be 12.56 kWh/yr for all prototypes and climate zones. This proposed measure will only impact cooling systems and thus will not result in any natural gas savings. Demand reductions/increases are expected be 0.01 kW per square foot across all climate zones.

Table 40 presents total energy cost savings per unit for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Table 41 presents a breakdown of total LSC savings from electricity and natural gas cost savings for the prototypical building.

Table 36: First Year Electricity Savings (kWh) Per Square Foot – Fan Control

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	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56
Medium Office	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56
Small Office	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56
Large School	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56
Small School	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56
Hospital	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56

Table 37: First Year Peak Demand Reduction (kW) Per Square Foot – Fan Control

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	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Medium Office	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Small Office	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Large School	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Small School	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Hospital	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46

Table 38: First Year Natural Gas Savings (kBtu) Per Square Foot – Fan Control

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Medium Office	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small Office	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Large School	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small School	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hospital	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 39: First Year Source Energy Savings (kBtu) Per Square Foot – Fan Control

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	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01
Medium Office	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01
Small Office	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01
Large School	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01
Small School	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01
Hospital	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01	21.01

Table 40: Total 30-Year LSC Savings (2029 PV$) Per Square Foot – Fan Control

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	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Medium Office	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Small Office	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Large School	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Small School	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hospital	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 41: 2029 PV LSC Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction and Additions– Preliminary Analysis – All Prototypes

Climate Zone	30-Year LSC Electricity Savings (2029 PV$)	30-Year LSC Natural Gas Savings (2029 PV$)	Total 30-Year LSC Savings (2029 PV$)
1	109.50	0.00	109.50
2	109.32	0.00	109.32
3	109.27	0.00	109.27
4	109.27	0.00	109.27
5	108.98	0.00	108.98
6	109.95	0.00	109.95

Climate Zone	30-Year LSC Electricity Savings (2029 PV$)	30-Year LSC Natural Gas Savings (2029 PV$)	Total 30-Year LSC Savings (2029 PV$)
7	109.29	0.00	109.29
8	109.36	0.00	109.36
9	108.65	0.00	108.65
10	109.09	0.00	109.09
11	109.30	0.00	109.30
12	109.09	0.00	109.09
13	108.95	0.00	108.95
14	108.99	0.00	108.99
15	109.84	0.00	109.84
16	109.02	0.00	109.02

Table 42: 2029 PV LSC Savings Over 30-Year Period of Analysis – Per Square Foot – Alterations – Preliminary Analysis – All Prototypes

Climate Zone	30-Year LSC Electricity Savings (2029 PV$)	30-Year LSC Natural Gas Savings (2029 PV$)	Total 30-Year LSC Savings (2029 PV$)
1	109.50	0.00	109.50
2	109.32	0.00	109.32
3	109.27	0.00	109.27
4	109.27	0.00	109.27
5	108.98	0.00	108.98
6	109.95	0.00	109.95
7	109.29	0.00	109.29
8	109.36	0.00	109.36
9	108.65	0.00	108.65
10	109.09	0.00	109.09
11	109.30	0.00	109.30
12	109.09	0.00	109.09
13	108.95	0.00	108.95
14	108.99	0.00	108.99
15	109.84	0.00	109.84
16	109.02	0.00	109.02

3.4.3 Incremental First Cost

ECMs are anticipated to be the primary means of meeting the requirements of this measure. The example 45,000 Btu/hr unit modeled in the cost-effectiveness analysis uses a 1.22 hp fan motor. The incremental first cost for the 1.22 hp fan motor is summarized below.

Scenario	First Cost[16]
Baseline Design: 1.22-hp fan permanent split capacitor motor	$175
Proposed Design: 1.22-hp fan with electronically commutated motor	$450
Proposed Design minus Baseline Design Cost	$275

Although, through conversations with manufacturers, it was revealed that ECMs are standard practice in many cases of computer room air conditioners, and the incremental cost would be zero in those cases. However, for cases when ECMs are not standard and an upgrade from a split capacity motor to an ECM is required, an assumed incremental first cost of $275 is used in the cost-effectiveness analysis.

3.4.4 Incremental Maintenance and Replacement Costs

The estimated maintenance and replacement cost for this measure is zero or negative, meaning ECMs typically require lower maintenance and have a longer estimated useful life (EUL) than traditional constant or two-speed permanent split capacitor motors (PCMs). ECMs eliminate many of the components that require maintenance or replacement during the life of a PCM, such as belts, shafts, or greased bearings. An assumed incremental maintenance and replacement cost of $0 is used in the cost-effectiveness analysis.

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

3.4.5 Cost Effectiveness

Note to CEC - Conducting QC on cost-effectiveness results and will update them as soon as they are finalized. This measure is showing cost-effective.

[16] Source: Various sources from national manufacturers

Results of the per-unit cost-effectiveness analyses are presented in Table 43 and Table 33 for new construction/additions and alterations, respectively.

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

Table 43: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions – All Prototypes

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	109.50	64.4834	1.70
2	109.32	64.5374	1.69
3	109.27	63.9901	1.71
4	109.27	63.6682	1.72
5	108.98	64.6967	1.68
6	109.95	66.4192	1.66
7	109.29	61.5824	1.77
8	109.36	66.7577	1.64
9	108.65	66.8652	1.62
10	109.09	59.7266	1.83
11	109.30	63.1824	1.73
12	109.09	64.0661	1.70
13	108.95	63.8802	1.71
14	108.99	63.0228	1.73
15	109.84	60.7870	1.81
16	109.02	63.1270	1.73

Table 44: 30-Year Cost-Effectiveness Summary Per Square Foot – Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	109.50	62.6735	1.75
2	109.32	62.9441	1.74
3	109.27	63.2534	1.73
4	109.27	63.0844	1.73
5	108.98	63.1006	1.73
6	109.95	64.4981	1.70
7	109.29	62.9874	1.74
8	109.36	64.5474	1.69
9	108.65	64.5788	1.68
10	109.09	63.0294	1.73
11	109.30	61.4745	1.78
12	109.09	63.0133	1.73
13	108.95	61.2581	1.78
14	108.99	63.7665	1.71
15	109.84	63.5326	1.73
16	109.02	62.7247	1.74

3.5 Fan Control Requirements - Statewide Impacts

3.5.1 Statewide Energy and Energy Cost Savings

See the 2028 CASE Methodology Report for details on how statewide savings are calculated. Appendix C presents the assumptions on the percentage of the total construction forecast that the proposed measure would impact.

For more details on the methodology and context about estimating the current market share rate, as well as statewide energy and energy cost savings, see the 2028 CASE Methodology Report.

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 45) and alterations (Table 46) by climate zone. Table 47presents first-year statewide savings from new construction, additions, and alterations.

Table 45: Statewide Energy and LSC Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	48,752	0.00	0.00	-	0.01	$0.03
2	291,965	0.02	0.00	-	0.03	$0.18
3	1,300,044	0.09	0.01	-	0.15	$0.80
4	643,927	0.05	0.01	-	0.08	$0.40
5	136,552	0.01	0.00	-	0.02	$0.08
6	755,960	0.05	0.01	-	0.09	$0.45
7	627,519	0.05	0.01	-	0.08	$0.40
8	1,086,387	0.07	0.01	-	0.12	$0.64
9	1,987,660	0.13	0.02	-	0.22	$1.17
10	764,813	0.06	0.01	-	0.10	$0.50
11	202,147	0.01	0.00	-	0.02	$0.13
12	1,288,604	0.09	0.01	-	0.15	$0.79
13	415,140	0.03	0.00	-	0.05	$0.26
14	192,351	0.01	0.00	-	0.02	$0.12
15	120,546	0.01	0.00	-	0.01	$0.08
16	66,211	0.00	0.00	-	0.01	$0.04
Total	**9,928,578**	**0.70**	**0.08**	**-**	**1.17**	**$6.07**

Table 46: Statewide Energy and LSC Impacts – Alterations

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	250,788	0.02	0.00	-	0.03	$0.16
2	1,541,640	0.11	0.01	-	0.19	$0.97
3	6,990,200	0.50	0.06	-	0.84	$4.36
4	3,491,180	0.25	0.03	-	0.42	$2.18
5	716,840	0.05	0.01	-	0.09	$0.45
6	4,857,600	0.34	0.04	-	0.57	$2.97
7	3,794,920	0.27	0.03	-	0.46	$2.37
8	7,062,200	0.49	0.06	-	0.83	$4.31
9	12,161,800	0.85	0.10	-	1.42	$7.42
10	5,564,800	0.40	0.05	-	0.67	$3.48
11	1,297,760	0.10	0.01	-	0.16	$0.83
12	7,457,800	0.54	0.06	-	0.90	$4.67
13	2,565,080	0.19	0.02	-	0.32	$1.65
14	1,363,380	0.10	0.01	-	0.16	$0.84
15	755,420	0.05	0.01	-	0.09	$0.47
16	437,400	0.03	0.00	-	0.05	$0.27
Total	**60,308,808**	**4.29**	**0.50**	**-**	**7.18**	**$37.40**

Table 47: Statewide Energy and LSC Impacts – New Construction, Additions, and Alterations

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
New Construction & Additions	0.7	0.08	-	1.2	6
Alterations	4.3	0.5	-	7.2	37
Total	**5.0**	**0.58**	**-**	**8.3**	**43**

3.5.2 Statewide Greenhouse Gas Emissions Reductions

Note to CEC - Conducting QC on GHG emissions results and will update them as soon as they are finalized.

Table 48 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 665.09 metric tons of carbon dioxide equivalent (CO_2e) emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

Table 48: First-Year Statewide GHG Emissions Impacts

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e)	Total Reduced GHG Emissions (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions ($)
New Construction & Additions	61.66	0	61.66	7,592.93
Alterations	379.67	0	379.,67	46,755.69
Total	**441.33**	**0**	**441.33**	**54,347.62**

3.5.3 Statewide Water Use Impacts

The proposed code change would not result in water use impacts.

3.5.4 Statewide Material Impacts

The proposed code change would not result in impacts on material use.

3.5.5 Environmental Impacts

This measure would reduce energy use and overall emissions from computer rooms across California and would not result in any adverse environmental effects. Statewide emissions impacts from this change are summarized in Table 47.

3.5.6 Other Non-Energy Impacts

This measure is not expected to result in any non-energy impacts.

3.6 Fan Control Requirements - Proposed Language Code

3.6.1 Guide to Markup Language

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

3.6.2 Administrative Code (Title 24, Part 1)

There are no proposed changes to Title 24, Part 1.

3.6.3 Energy Code (Title 24, Part 6)

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

(j) Mandatory requirements for computer rooms. Space-conditioning systems serving a computer room shall meet the following requirements:

1. **Reheat.** Each computer room zone shall have controls that prevent reheating, recooling and simultaneous provisions of heating and cooling to the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by cooling equipment or by economizer systems.
2. **Humidification.** Humidification shall be adiabatic. Nonadiabatic humidification, including but not limited to steam and infrared, is prohibited.
3. **Fan control.** Each ~~unitary air conditioner~~ direct expansion system with mechanical cooling capacity exceeding ~~60,000~~ 30,000 Btu/hr and each chilled water fan system shall be designed to vary the airflow rate as a function of actual load. Fan motor demand shall not exceed 50 percent of design wattage at 66 percent of design fan speed.

3.6.4 Reference Appendices

There are no proposed changes to the Reference Appendices.

3.6.5 Compliance Manuals

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

3.6.6 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

3.6.7 Compliance Forms

As discussed in Section 3.1.4.5, the NRCC-PRC-E and NRCI-PRC-E compliance forms would be updated to reflect the proposed change. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

4. Computer Room Heat Recovery

4.1 Computer Room Heat Recovery - Measure Description

4.1.1 Proposed Code Change

This proposed measure would add prescriptive requirements to Section 140.9 to require new nonresidential buildings with both a computer room(s) and sizable heating loads to recover heat from the computer room(s) to serve other building heating loads. Computer room heat recovery is being defined as a mechanical system that transfers heat from a computer room(s) to provide heating to other zones or end-uses in the building that require heating. Heat recovery would be required in new buildings with computer rooms if the following conditions were met:

- Buildings with a design computer room(s) ITE load greater than 100 kW; and
- Buildings with non-computer room directly conditioned floor area greater than 35,000 square feet.

The required capacity of the heat recovery system would depend on the peak cooling capacity of the computer room and the combined total peak heating capacity of the space heating system and service water heating (i.e., domestic hot water) system. The heat recovery system's heat recovery capacity must be the lesser of the two values:

- 0.25 times the peak heat rejection capacity of the computer room system
- 0.25 times (the total capacity of the space heating system plus the SWH system)

Table 49 summarizes the scope of the proposed code change.

Table 49: Scope of Proposed Code Change

A ☑ indicates the proposed code change is relevant.

Building Type(s)	Construction Type(s)	Type of Change
☐ Single Family	☑ New Construction	☐ Mandatory
☐ Multifamily	☐ Additions	☑ Prescriptive
☑ Nonresidential (Not Group R uses)	☐ Alterations	☐ Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	Part 6, Section 140.9(a)5	NRCC-PRC-E and NRCI-PRC-E	Prescriptive

Third Party Verification)	Updates to Compliance Software

☑ No changes to third party verification	☐ No updates
☐ Update existing verification requirements	☑ Update existing feature
☐ Add new verification requirements	☐ Add new feature

4.1.2 Benefits of Proposed Change

In addition to the critical need to address increased energy, emissions, and water use from new computer rooms and achieve statewide carbon reduction goals, as described in section 2.1.2, requiring heat recovery in computer rooms would provide significant benefits at the building level. Computer rooms need constant cooling to remove heat from ITE and maintain optimal temperatures for ITE performance. When a computer room is in a facility that also requires heating, transferred heat from the computer room can be used to heat other parts of the building. Rejecting the computer room's heat to the heating system instead of the computer room's cooling system reduces the energy used by the computer room cooling system.

Traditionally, computer room waste heat is rejected through a mechanical cooling system consisting of cooling compressors and an economizer and separate heating equipment is used to meet building heating loads. Although economizers improve cooling system efficiency by reducing cooling loads on energy-intensive compressors, the computer room waste heat can be used more efficiently by being captured to serve concurrent building heating loads, such as space heating or service hot water loads, through a heat recovery system. Depending on the heat recovery system components and configuration, this can provide two key benefits – reduced load on the computer room cooling system leading to reduced cooling energy and reduced load on the heating system leading to reduced heating energy, with a net result of improved overall building heating and cooling efficiency. In buildings where natural gas is used for heating loads, the computer room heat recovery system reduces direct greenhouse gas (GHG) emissions from a combustion appliance (Scope 1 emissions).

While this proposal would only require heat recovery in buildings with both a computer room with an ITE load greater than 100 kW and a non-computer room conditioned space greater than 35,000 square feet, this could provide proof of concept and demonstrate cost-effectiveness to expand this approach to other applications, such as industrial or other processes heating loads.

For computer rooms using water-cooled mechanical cooling systems, rejecting heat to the heating system instead of to an evaporative condenser would reduce water use by reducing the load on the evaporative equipment.

4.1.3 Background Information

There are many forms of computer room heat recovery. One of the most efficient and economical forms of heat recovery is direct or indirect air transfer. Computer room hot aisle temperatures are typically 90-110°F. This air can be ducted directly to occupied spaces[17] and be used for space comfort heating without needing to increase the transferred air temperature higher.

Other common forms of heat recovery are heat recovery chillers or four-pipe heat pumps. With recent focus on building decarbonization through electrification of heating systems including the 2025 Title 24, Part 6 prescriptive requirement for nonresidential building heat recovery of simultaneous loads under 140.4(s), heat recovery chillers and heat pumps are becoming more common. Computer room heat recovery requirements were proposed for the Title 24, Part 6 2022 code cycle in the CASE Report *Nonresidential Computer Room Efficiency*; however, the proposed code change was not adopted due to lack of market readiness at the time, measure complexity, and enforcement challenges (Weitze, Bulger and Stein 2021). To address concerns with enforcement, this proposed computer room heat recovery requirement would use similar code language as structured in the 140.4 prescriptive heat recovery requirement in the 2025 code.

Another highly efficient form of heat recovery is direct water heat transfer from liquid-cooled ITE. As described in 2.1.3, liquid-cooled ITE could operate at temperatures above 100°F entering water temperature allowing for even warmer leaving water temperatures that can reject heat to a hydronic heating system, without the need to boost the temperature higher for many, or all, hours of the year.

Section 4.3 Computer Room Heat Recovery - Market and Economic Analysis provides additional detail on heat recovery systems that can be used to meet this proposed requirement.

Outside of the U.S., the European Union has established policies requiring data center heat recovery. This is outlined in their revised Energy Efficiency Directive (EU/2023/1791), which requires that data centers with greater than 1 MW ITE load must utilize their waste heat (European Union 2023). In Europe, it is increasingly common

[17] Section 120.1 states that computer room (not printing) spaces have an Air Class 1 designation per Table 120.1-A – Minimum Ventilation Rates, and therefore computer room air may be transferred to any space type per 120.1(g)1.

practice for large data centers to reject heat to district heating systems[18], and the same practices can be adopted in the U.S.

4.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 4.6: Computer Room Heat Recovery - Proposed Language Code of this report for detailed revisions to code language.

4.1.4.1 Energy Code Change Summary

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

Subsection 140.9(a)5: The proposed code change would require a heat recovery system, such as a heat recovery chiller or direct transfer of air through a dual fan dual duct system capable of transferring heat from the computer room cooling system to the space heating system and/or to the service water heating (SWH) system. This would need to be installed in a building with a computer room ITE load greater than 100 kW and a non-computer room with conditioned floor area greater than 35,000 square feet. This requirement cost-effectively would improve computer room efficiency and overall stringency of the Energy Code, thereby reducing its energy demand on the grid and more effectively using waste heat.

4.1.4.2 Reference Appendices Change Summary

The proposed changes would not impact the reference appendices there is no acceptance testing for computer room requirements.

4.1.4.3 Compliance Manuals Change Summary

Section 10.4 of the Nonresidential Compliance Manual, which outlines Computer Room requirements in the code, would need to be updated. Specifically, a new subsection would be added to 10.4.3 to include heat recovery requirements. Additionally, this change will need to be reflected in other chapters related to space conditioning and service water heating.

[18] "Europe is far ahead of the United States in seizing this opportunity with dozens of heat reuse projects across the region, including a Google project in Finland, a Microsoft project in Denmark, and, perhaps the most widely publicized, an Equinix project to heat the Olympic swimming pool in France." https://www.dgardiner.com/policies-support-data-center-heat-reuse/

4.1.4.4 Alternative Calculation Method Reference Manual Change Summary

A new subsection or modifications to existing sections would need to be added to the Nonresidential Alternative Calculation Method (ACM) Reference Manual to define computer room heat recovery systems.

4.1.4.5 Compliance Forms Change Summary

The existing nonresidential compliance forms NRCC-PRC-E, NRCI-PRC-E, NRCC-PRF-E would need to be updated to include computer room heat recovery with the following changes:

- New column should be added to Table M for Heat Recovery (140.9(a)5)
- New sub-table should be created to document computer room peak heat rejection capacity, combined capacity of space heating and service hot water systems, and heat recovery system capacity.

4.1.5 Measure Context

4.1.5.1 Comparable Model Codes or Standards

ASHRAE 90.1 – 2022 does not include specific requirements for heat recovery in computer rooms.

2024 IECC provides an exception for economizers if the system includes a heat recovery system in accordance with Section C403.11.5.

ASHRAE 90.4 – 2022 added guidance to encourage and calculate heat recovery savings in data center performance compliance. Language has been carefully included to avoid counting energy savings twice.

4.1.5.2 Interactions with Other Regulations

There are no direct federal or state laws and other requirements that conflict with this measure. Federal and state laws that address energy efficiency in computer rooms are described in Section 2.1.5.2.

Interactions with California Building Code

Section 140.4(s) – Mechanical Heat Recovery was adopted in the 2025 California Energy Code. This prescriptive measure requires the use of heat recovery for large buildings with significant simultaneous cooling and heating loads pursuing all-electric space heating. The heat recovery requirements proposed in 140.9(a)5 are identical to those in 140.4(s) with the only difference being what triggers the requirement. As such, 140.9(a)5 will effectively extend the current heat recovery requirement to more buildings.

4.2 Computer Room Heat Recovery - Compliance and Enforcement

4.2.1 Compliance Considerations

The proposed heat recovery requirement for nonresidential buildings with a computer room would build on the heat recovery requirement adopted in the 2025 California Energy Code for non-residential buildings. As such, heat recovery is not a new concept for typical market actors involved in its implementation, such as HVAC designers, installers, code officials, and controls contractors. Given that computer rooms provide 24/7 heat, heat recovery is common in computer room designs, so many designers will be familiar with various compliant approaches. The proposed impact at each step of the design and construction process is outlined below.

- Design Phase: The implementation of heat recovery would require new design strategies, such as directly or indirectly transferring air from the computer room to an adjacent office, as further described in section 4.3.2. Additional workforce education outlining various ways to design a heat recovery system that is suitable for computer rooms and meets the code requirement would be necessary.
- Permit Application Phase: The design phase changes would affect the plan reviewers and energy consultant's role and the permit application process. Plan reviewers and energy consultants would need training to understand the changes in energy code, as they typically guide the design team in interpreting and integrating these requirements. Documentation would need to be revised to ensure compliance.
- Construction Phase: The types of equipment will not change, but the configuration of equipment would. Most construction practices would remain consistent before and after this measure.
- Inspection Phase: While this would be a new requirement for computer rooms, heat recovery is not new to the code for nonresidential building types. This would be a new requirement for computer rooms, so inspectors would need to be trained on how to inspect and confirm a compliant heat recovery system has been installed, which would include checking the necessary equipment has been installed as indicated by the prescriptive heat recovery requirements included in this measure and per the project plans.

4.2.2 Impact on Market Actors

Table 50 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements.

Table 50: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Builders [a]	Awareness of requirement.	Increased awareness through Energy Code ACE and commercial building associations.
Design Professionals [b]	Designers will need to be aware of new requirements, and when they apply to nonresidential buildings. If applicable, they will need to factor in new heating and cooling approaches, including heat recovery.	Provide outreach through local ASHRAE chapters and training on new computer room heat recovery requirement.
Construction Team [c]	HVAC, plumbing, electrical contractors may have additional scope in applicable nonresidential buildings.	Provide training through local unions and skilled trade training facilities on new requirements.
Building Departments [d]	Understand when heat recovery threshold and verify system is capable of recovering computer room heat and supplementing heating load in applicable non-computer rooms. Ensure this system and space or water heating are appropriately designed to meet the overall heating loads.	Engage local code official chapters to improve awareness of new computer room heat recovery requirement.
Building Owners, Managers, and Occupants	Reduced energy bills, added cost, and improved understanding of system maintenance.	Increased awareness through Energy Code Ace and building operator training.
Manufacturers and Distributors	Ensuring equipment is available to support requirement in applicable building types	Increased awareness through Energy Code Ace and conversations to manufacturers through other utility programs.

a. Builders include builders and developers.
b. Design professionals include architects, interior designers, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.
d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians and sustainability department staff.
e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

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

Builders. The proposed change would likely affect commercial builders; however, it would likely not impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers in the commercial building industry equally; instead, it would primarily affect specific subsectors within the industry. Table 51 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report. This proposal includes requirements for heat recovery which will impact electrical and mechanical contractors.

Table 51: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)

Construction Subsector	Establishments *	Employment	Annual Payroll (Billions $)
Commercial Building Construction	5,491	87,450	$10.6
Nonresidential Poured Foundation Contractors	497	15,884	$1.4
Nonresidential Structural Steel Contractors	365	11,899	$1.1
Nonresidential Framing Contractors	137	3,037	$0.2
Nonresidential Masonry Contractors	217	4,028	$0.3
Nonresidential Glass and Glazing Contractors	307	5,079	$0.5

Construction Subsector	Establishments *	Employment	Annual Payroll (Billions $)
Nonresidential Roofing Contractors	385	11,413	$1.0
Nonresidential Siding Contractors	32	735	$0.1
Other Nonresidential Exterior Contractors	234	2,259	$0.1
Nonresidential Electrical Contractors	3,245	72,794	$7.8
Nonresidential Plumbing & HVAC Contractors	2,270	55,182	$5.8
Other Nonresidential Equipment Contractors	580	9,749	$1.1
Nonresidential Drywall Contractors	593	19,328	$1.8
Nonresidential Painting Contractors	501	9,225	$0.7
Nonresidential Flooring Contractors	286	4,011	$0.4
Other Nonresidential Finishing Contractors	492	7,241	$0.6
Nonresidential Site Preparation Contractors	1,147	19,273	$1.9
All Other Nonresidential Trade Contractors	948	17,084	$1.7

Source: (State of California n.d.)

*An establishment is single economic unit, typically at one physical location, that engages in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Many businesses are composed of multiple establishments. US Bureau of Labor Statistics, Handbook of Methods. https://www.bls.gov/opub/hom/cew/concepts.htm

Manufacturers. The Statewide CASE Team anticipates the proposed change would have minimal material impact on California component retailers. This proposed requirement for heat recovery in computer rooms would be achievable with existing commercially available equipment. As described in 4.3.2, virtually all major manufacturers produce heat recovery chillers or heat pumps capable of meeting this requirement, which are some of the most common approaches in nonresidential buildings.

4.2.3 Compliance Software Updates

If the proposal is adopted, then the CBECC software will be modified based on the proposed changes to the ACM, as described in Section 4.6.6. Final recommendations will be provided in Summer 2026 based on the final proposal.

The CASE Team also considered CBECC's current lack of ability to model "Data Center" buildings. A calculation methodology was implemented to estimate savings for data center, the Medium Office prototype in CBECC was relied upon to estimate energy savings for computer rooms in those buildings.

The CASE Team is aware that in recent years LBNL has developed the following two new data center prototype models through OpenStudio and EnergyPlus^{TM}. For each of the following data center models, LBNL considered two levels of ITE load density, and covered wide ranging IT power density of data centers between 40 and 100 W/ft^2:

a. The small-size data center model represents a computer room in a building served by computer room air conditioners (CRACs).

b. The large-sized model represents stand-alone data centers served by computer room air handlers (CRAHs) with a central chiller plant.

Future CBECC enhancements could potentially build upon the approach taken by LBNL.

4.2.4 Cost of Enforcement

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

The Statewide CASE Team anticipates this proposed measure would require additional training, through Energy Code Ace, and other venues. This will be provided as part of the 2028 Title 24, Part 6 code update, and this measure would be included and need to be emphasized in that training. Additionally, local building departments would have had recent training and awareness of heat recovery systems in nonresidential building types due to the adoption and implementation of section 140.4(s) – Mechanical Heat Recovery in the 2025 California Energy Code.

4.3 Computer Room Heat Recovery - Market and Economic Analysis

4.3.1 Market Structure and Availability

4.3.1.1 Current Market Structure and Availability

With the introduction of 140.4(s) mechanical heat recovery in 2025 Title 24 and recent focus on building decarbonization and electrification[19], heat recovery has become increasingly common for computer rooms located in nonresidential buildings with high simultaneous cooling and heating loads.

Successful implementation of heat recovery requires planning by the mechanical engineer, to incorporate heat recovery systems into the design. Heat recovery systems are designed and specified by the mechanical engineer using off-the-shelf products. A heat recovery system may consist of multiple mechanical system components specified together or packaged products such as heat recovery chillers. In either case, there are many manufacturers that make and sell these products in California, ranging from a few tons to greater than 1,000 tons of cooling capacity.

4.3.1.2 Market Challenges and Solutions

For the proposed code requirement, a computer room heat recovery system would be any mechanical system that transfers heat from computer room return air to provide heating to other zones in the building demanding heating. Examples of heat recovery systems include: computer room return air transferred directly to air systems providing heating, heat recovery chillers, air-source or water-source heat pumps providing simultaneous heating and cooling, and variable refrigerant flow systems with heat recovery.

Although heat recovery has become a common practice in nonresidential buildings with computer rooms, there is a first-cost increase for heat recovery equipment which may

[19] One of the predominate methods of buildings reducing their scope 1 carbon emissions is by using electric heating (https://www.ashrae.org/about/cebd-building-decarb-101, https://www.csemag.com/four-strategies-for-decarbonization-electrification-in-commercial-buildings/), including heat pumps and heat pumps with heat recovery for space heating.

pose a perceived challenge for the market. In order to comply with the proposed measure, there are many relatively simple and economical designs.

- One approach is to directly or indirectly transfer hot air from a computer room to a non-computer room with a heating load. Computer room hot aisle temperatures are typically 90-110°F. This air could be directly ducted to occupied spaces and would not require the temperature to be boosted or tempered.
- Another common approach is using water-to-water heat pumps or heat recovery chillers. Heat recovery chillers/heat pumps combine heating and cooling into single equipment, which helps reduce first cost and space requirements.

While the design and installation of a heat recovery system, as described above, does modestly increase the overall construction cost, the system is cost-effective over its useful life and makes optimal use of computer room heat instead of dumping it to the outside. This approach would reduce the cooling load of computer rooms and heating load of the adjacent non-computer room space in a non-residential building.

See Section 4.2.2 for a description of workforce trainings that may be needed to ensure effective design, installation, and commissioning.

4.3.2 Design and Construction Practices

4.3.2.1 Current Design and Construction Practices

Heat recovery chillers / heat pumps are one of the simplest ways to implement heat recovery. These products are offered by virtually all major chiller manufacturers in the U.S., in capacities ranging from a few tons to thousands of tons.

Other common examples of heat recovery systems include:

- Heat exchangers on the chilled water loop that transfer computer room waste heat directly to another hydronic loop that needs slightly warmer water (e.g., certain process cooling applications, preheating for space heating or domestic hot water, low-temperature radiant heating systems)
- Direct transfer of warm computer room return air to another space that requires heating (e.g., via dual duct dual fan system).
- Heat exchanger or heat recovery coil located in the computer room return airstream used to transfer computer room waste heat to another space that requires heating.

4.3.2.2 Health and Safety Considerations

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

4.3.2.3 Design and Construction Challenges and Solutions

Some of the approaches to implement heat recovery, such as the use of hydronic loops, would require both the cooling and heating system to use water. This can limit cooling and heating system options. However, this is not anticipated to be a significant design challenge to complying with this measure as hydronic heating and cooling systems are already standard practice in system sizes that are required to have heat recovery under this measure.

Another possible design challenge is that the additional controls required to operate heat recovery systems effectively may increase overall design complexity and designers and building operators may lack familiarity with heat recovery systems in computer rooms. To overcome this challenge, additional education, training, and resources would be provided to the market through Energy Code ACE and other training venues. Fortunately, with the inclusion of a new heat recovery requirement (140.4(s)) for large buildings with significant simultaneous heating and cooling loads in 2025 Title 24, Part 6, many of these training materials would have already been developed and distributed to the market. By the time this proposed 2028 measure would go into effect in 2029, many designers and building operators in the market would already have had time to adapt to this new technology and approach.

See Table 50 in Section 4.2.2 for a description of workforce trainings that could support effective design, installation, and commissioning.

4.3.3 Energy Equity and Environmental Justice

The Statewide CASE Team evaluated the potential impact on environmental and social justice (ESJ) communities, including impacts related to race, class, and gender. With this proposal impacting computer room design and efficiency, this proposal would likely not result in any negative impacts to ESJ communities. In fact, improving computer room efficiency could provide secondary benefits to all communities, including ESJ. As computer room efficiency increases, it will reduce energy and water usage, which will help alleviate strain on those resources.

The Statewide CASE Team identified potential impacts of the proposed code change via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement.

Please reach out to Aniruddh Roy (aroy@energy-solution.com) if you have input on how this proposal may impact ESJ communities or if you would like to offer your perspective.

4.3.4 Impacts on Jobs and Businesses

This section will be completed for the Final CASE Report.

4.3.5 Economic and Fiscal Impacts

This section will be completed for the Final CASE Report.

4.4 Computer Room Heat Recovery - Cost Effectiveness

4.4.1 Cost Effectiveness Methodology

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

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

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

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

4.4.2 Energy and Energy Cost Savings Results

Analysis Approach

To assess energy, economic and environmental impacts of this proposed change, the Statewide CASE Team used a hybrid analytical approach. This hybrid approach involved energy modeling to determine the heat load for a prototype building and a custom Excel tool to calculate the impact of a heat recovery system and a post-processing analysis to evaluate computer room size and load profile in terms of btuh/ft2 (e.g., 100 kW computer room at 100 percent load for a 35,000 square feet building is

9.75 btuh/ft2). The analysis was completed for four climate zones (CZ 03, 04, 09 & 12) and one office building type. The final report will include results for all climate zones and additional building types, such as large office and other larger building prototypes.

A CBECC Medium Office baseline was used with changes to occupancy, lighting, plug density and schedules in the baseline model; the medium office baseline model includes an air-to-water (AWHP) heat pump for space heating. To establish baseline energy use of a medium office without heat recovery, the Statewide CASE Team simulated a medium office with VAV reheat and without heat recovery. The hourly heating load (btuh/ft2), AWHP heating energy (kW/ft2), and electricity costs were exported from CBECC. These outputs were used in an annual hourly post processing analysis to determine the hourly and annual heating energy savings from computer room heat recovery.

In this analysis, a medium office building with a 100-kW data center is used to represent the potential impact of this change. In the base case and proposed case, the Statewide CASE Team assumed the following:

- **Base Case (BEM Model):** medium office building 53,628 sq. ft. with a 100-kW computer room
    - Air-to-water heat pump (AWHP) serves as a backup to the HW coil in hot deck (sized for full capacity)
    - No heat recovery system is assumed - dual fan dual duct (DFDD) with air handling unit (AHU) mixing section not included
- **Proposed Case (Custom Excel Tool):** medium office building 53,628 sq. ft. with a 100-kW computer room
    - Air-to-water heat pump (AWHP) serves as a backup to the HW coil in hot deck (sized for full capacity)
    - DFDD system
    - Computer room return air ducted to hot deck AHU mixing section to supply heat to office

Energy and Energy Cost Savings

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per-unit for the four analyzed climate zones are presented in Table 52. Per-unit savings for the first year are expected to range from 0.16 to 0.58 kWh/yr, depending upon climate zone. Demand reductions/increases are expected to range between 0.07 kW and 0.22 kW, depending on climate zone. There are no natural gas savings because the medium office prototype uses a heat pump to serve the heating load.

Table 53 presents total energy cost savings per unit for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Table 53 presents a breakdown of total LSC savings from electricity and natural gas cost savings for the prototypical building.

Table 52: Energy and Energy Cost Savings – Per Square Foot – New Construction– Medium Office with Computer Room

Climate Zone	First Year Electricity Savings (kWh)	First Year Peak Demand Reduction (kW)	First Year Natural Gas Savings (kBtu)	First Year Source Energy Savings (kBtu)	Total 30-Year LSC Savings (2029 PV$)
3	0.33	0.12	0.00	1.08	3.94
4	0.58	0.22	0.00	2.06	6.41
9	0.16	0.07	0.00	0.65	1.81
12	0.49	0.19	0.00	1.81	5.22

Table 53: 2029 PV LSC Savings Over 30-Year Period of Analysis – Per Square Foot – New Construction – Medium Office with Computer Room

Climate Zone	30-Year LSC Electricity Savings (2029 PV$)	30-Year LSC Natural Gas Savings (2029 PV$)	Total 30-Year LSC Savings (2029 PV$)
3	3.94	0.00	3.94
4	6.41	0.00	6.41
9	1.81	0.00	1.81
12	5.22	0.00	5.22

4.4.3 Incremental First Cost

Incremental first costs represent the overall cost to the building owner when constructing a computer room to the proposed design, as compared to the baseline design. This does not represent the overall cost to build a computer room, rather the additional cost needed to comply with the proposed code change.

To establish incremental costs when adding computer room heat recovery as described in 4.4.2, the Statewide CASE Team requested a detailed cost bid from a local mechanical contractor. The mechanical contractor included all additional costs associated with the design and installation of a DFDD system with return air ducted to hot deck AHU mixing section to supply heat from the data center to the office. The mechanical contractor was selected based on significant experience designing and installing cooling equipment in data centers in California.

It should be noted that the DFDD with hot deck AHU mixing is one of many ways to comply with this proposed code change. Additional compliant designs are described in 4.3.2. The additional design components and materials for the proposed heat recovery design, and the cost to install them are provided below.

Table 54: Computer Room Heat Recovery Incremental Costs

Design Component	Proposed Costs (2029 PV$)
Fire Smoke Damper (FSD)	$10,000
Duct from FSD to AHU Transfer Air opening	$7,000
Additional Controls	$20,000
Economizer mixing section to hot deck AHU	$7,250
Total First Cost	$44,250
Total First Cost (psf)	$1.26

Total first costs were derived based on a 35,000 square foot office building which yields a $1.26 per square foot cost based on the proposed approach in the analysis.

4.4.4 Incremental Maintenance and Replacement Costs

Description of the incremental maintenance and replacement costs, as well as estimation of present value of maintenance and replacement costs, are provided in the 2028 CASE Methodology Report. It is assumed that with proper maintenance, as described below, additional equipment required for this measure will last at least 30 years so replacement costs were not considered in this analysis.

Maintenance Costs: The mechanical contractor that provided the cost bid to design and install a heat recovery system as described in this analysis, is assuming that the system should be tested every four years to ensure it is working properly. The assumed maintenance cost for this system is $2,940.

4.4.5 Cost Effectiveness

Results of the per-unit cost-effectiveness analyses are presented in Table 55 for new construction and additions.

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

Table 55: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
3	3.94	1.34	2.94
4	6.41	1.34	4.80
9	1.81	1.34	1.36
12	5.22	1.34	3.91

4.5 Computer Room Heat Recovery - Statewide Impacts

4.5.1 Statewide Energy and Energy Cost Savings

See the 2028 CASE Methodology Report for details on how statewide savings are calculated. Appendix C presents the assumptions on the percentage of the total construction forecast that the proposed measure would impact.

For more details on the methodology and context about estimating the current market share rate, as well as statewide energy and energy cost savings, see the 2028 CASE Methodology Report.

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings (Table 56) by climate zone. Table 56 presents first-year statewide savings from new construction.

Table 56: Statewide Energy and LSC Impacts – New Construction

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
3	1,049,580	0.35	0.13	-	1.14	$4.13
4	569,313	0.33	0.12	-	1.17	$3.65
9	2,435,760	0.39	0.18	-	1.59	$4.42
12	2,141,235	1.05	0.41	-	3.87	$11.18
Total	**6,195,888**	**2.12**	**0.84**	**-**	**7.77**	**$23.37**

4.5.2 Statewide Greenhouse Gas Emissions Reductions

Note to CEC - Conducting QC on GHG emissions results and will update them as soon as they are finalized.

Table 57 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 441 metric tons of carbon dioxide equivalent (CO_2e) emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

Table 57: First-Year Statewide GHG Emissions Impacts

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e)	Total Reduced GHG Emissions (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions ($)
New Construction	411	NA	411	50595
Total	**-**	**-**	**-**	**-**

4.5.3 Statewide Water Use Impacts

The proposed code change would not result in water use impacts.

4.5.4 Statewide Material Impacts

The proposed code change would result in additional materials being used to design a heat recovery system capable of transferring heat from a computer room to an adjacent space with a heating demand. The type and extent of additional materials would depend on the type of heat recovery design selected, but for the analysis described in 4.4.2, which ducts air from hot aisles to the hot deck of a DFDD HVAC system, the additional materials largely include metal ductwork. The additional materials for a heat recovery system serving a 100kW computer room and a 35,000 sq. ft. office are outlined in Table 58. The analysis assumes 25 percent of impacted floor area will utilize a DFDD system to meet the heat recovery requirement

For more information on the Statewide CASE Team's methodology and assumptions used to calculate embodied GHG emissions, see the 2028 CASE Methodology Report.

Table 58: First-Year Statewide Impacts on Material Use

Material	Impact	Per-Unit Impacts (Pounds per Square Foot)	First-Year Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO2e)
Steel	New Construction	0.06	4,100	-2.3

4.5.5 Environmental Impacts

This measure would reduce energy use and overall emissions from computer rooms across California and does not result in any adverse environmental effects. Statewide emissions impacts from this change are summarized in Table 47.

4.5.6 Other Non-Energy Impacts

This measure is not expected to result in any non-energy impacts.

4.6 Computer Room Heat Recovery - Proposed Language Code

4.6.1 Guide to Markup Language

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

4.6.2 Administrative Code (Title 24, Part 1)

There are no proposed changes to Title 24, Part 1.

4.6.3 Energy Code (Title 24, Part 6)

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

a. Prescriptive Requirements for Computer Rooms.

5. Computer Room Heat Recovery. Buildings with a design computer room ITE load greater than 100 KW and a non-computer room conditioned floor area greater than 35,000 square feet shall include a heat recovery system, such as ducting hot aisles to the hot deck of a dual fan dual duct system, or a heat recovery chiller, capable of transferring the lesser of the following from the computer room cooling system to the space heating system and/or to the service water heating (SWH) system:

A. 0.25 times the peak heat rejection capacity of the computer room system

B. 0.25 x (capacity of space heating system + capacity of SWH system)

4.6.4 Reference Appendices

There are no proposed changes to the Reference Appendices.

4.6.5 Compliance Manuals

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

4.6.6 ACM Reference Manual

The following is the proposed procedure for implementing computer room heat recovery in the baseline model. It only applies to new construction with a design computer room ITE load greater than 100 KW and a non-computer room conditioned floor area greater than 35,000 square feet.

Appendix 5.4B includes the following computer room fractional load schedules.

JanMaySep	0.25
FebJunOct	0.50
MarJulNov	0.75
AprAugDec	1.00

The total computer room design load is then multiplied by these fractions to determine the current hourly computer room load for every hour that month (CR-LOAD).

HR-PEAK-CAP = The peak capacity of the computer room heat recovery system. HR-PEAK-CAP is the smaller of the following:

1. 0.25 times design computer room ITE load of all computer rooms in the building
2. 0.25 x (capacity of all space heating systems + capacity of SWH systems)

HR-CAP = The current hour computer room heat recovery capacity = the smaller of the following:

1. HR-PEAK-CAP
2. CR-LOAD

HEAT-LOAD = The sum of the following:

1. total hourly space heating load for all systems in the building
2. total hourly space heating load for zones in the building
3. total hourly service water heating load in the building

If HEAT-LOAD < = HR-CAP then the baseline model has zero heating load in that hour.

If HEAT-LOAD > HR-CAP then each heating load is multiplied by HR-CAP/HEAT-LOAD. For example, if HR-CAP = 1000 Btuh and HEAT-LOAD = 2000 Btuh and Zone

1’s reheat heating load is 200 Btuh then Zone 1’s reheating load in that hour is reduced to 200 *(1000/2000) = 100 Btuh.

4.6.7 Compliance Forms

As discussed in Section 4.1.4.5, the NRCC-PRC-E, NRCI-PRC-E, NRCC-PRF-E compliance forms would be updated to reflect the proposed change. The Statewide CASE Team would support the CEC in implementing these updates if the proposed change is adopted.

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Appendix A: Assumptions for Cost-effectiveness Analysis

140.9(a)1 – Computer Room Economizers

Key Assumptions for Energy Savings Analysis

The Statewide CASE Team conducted a non-CBECC analysis to estimate energy, emissions, and cost savings, and cost-effectiveness of the proposed measure for two scenarios representing standalone data centers with air-cooled and liquid-cooled ITE.

- The Statewide CASE Team assessed the energy impacts in representative climate zones (CZ 4, 7, 9, 12) and applied the climate-zone-specific LSC hourly factors when calculating energy and energy cost impacts.
- A custom spreadsheet was developed based on previous energy and cost-saving analysis generated for data centers with integrated wet-bulb economizers for air-cooled and liquid-cooled ITE data centers.
- Three scenarios were analyzed: 1) a data center with air-cooled ITE and a wet-bulb economizer and 2a) a data center with liquid-cooled and air-cooled ITE with a wet-bulb economizer and 2b) a data center with liquid-cooled and air-cooled ITE with a dry-bulb economizer.

Energy Savings Methodology

Detailed information about each scenario is described below:

1) **Air-Cooled ITE—Wet-bulb Economizer Scenario Modeling Assumptions:** This analysis demonstrates the energy, cost, and environmental impacts associated with updating the wet-bulb economizing threshold from 45°F to 60°F.

   Assumptions for this analysis include the following:

   - Standalone data center with Air-cooled ITE
   - Select climate zones (04, 07, 09, 12) representative of statewide impacts
   - Air-cooled ITE with 75°F design Supply Air Temperature (SAT) to the server
   - ITE Load at 300 W/ft^2
   - ITE Load profile: Title 24 ACM load profile (equal time at 25%, 50%, 75%, 100% load)
   - Chiller design kW/ton: 0.35
   - Cooling Tower Nominal Efficiency: 80 GPM/HP

- Redundancy for heat exchanger (HX), chiller, cooling tower (CT), CRAH: 10%

Base Case Design:

- The approach from OAWB to SAT is 30°F for baseline design.
  - The approach is the sum of the approaches of the CT, the HX, and the CRAH coil
- Fewer hours of full and partial economizer operation than proposed design
- CHW/CW pump and supply fan pressure drop is adjusted based on CT/HX/Coil selections

Proposed Design:

- The approach from OAWB to SAT is 15°F for proposed design.
- The proposed design has significantly greater hours of full and partial economizer operation
- CHW/CW pump and supply fan pressure drop is adjusted based on CT/HX/Coil selections

Table 59: Base Case vs. Proposed Design Approach

	CRAH Coil	Water Side Economizer HX	Cooling Tower	Total	CRAH Total Static Pressure (" w.g.)
Base Case Design Approach (F)	8	11	11	30	2.25
Proposed Design Approach (F)	5	5	5	15	2.45

2) Separate Liquid-Cooled ITE Economizer Scenario Modeling Assumptions:

This analysis demonstrates the energy, cost, and environmental impacts associated with updating the economizing threshold to 85°F. Assumptions for these analyses include the following:

- Standalone data center with liquid-cooled and air-cooled ITE
- 80% Liquid-cooled ITE, 20% air-cooled ITE
- ITE Load at 300 W/ft^2
- Title 24 load profile (equal time at 25%, 50%, 75%, 100% load)
- Select climate zones (04, 07, 09, 12) representative of statewide impacts
- Dry cooler dT: 15F
- TCS pump energy same for base case and proposed, so not modeled
- CRAH fan energy same for base case and proposed, so not modeled

While cost data was only provided for plants with cooling towers, two types of plants were simulated with the following assumptions:

> **2a - Cooling Towers** – The baseline is a single chilled water plant with cooling towers, and the proposed case includes two chilled water plants – one serving the liquid-cooled ITE. The proposed case is a data center designed with separate plants and distribution piping for air-cooled ITE and liquid-cooled ITE. The primary reason the proposed design must have separate plants is because a single chilled water plant serving both air-cooled ITE and liquid-cooled ITE is unlikely to meet the proposed temperature threshold for a liquid-cooled ITE economizer. This is the scenario that was costed.

2b - Dry Coolers – In this scenario the baseline is a single chilled water plant with water-cooled chillers rejecting heat via dry coolers (rather than cooling towers). The proposed case includes two dry cooler plants – one serving the liquid-cooled ITE. The dry cooler plants use adiabatic spray assist if the dry coolers cannot achieve the required dry cooler leaving water temperature in a given hour.

Parametric analysis was performed with different sequences of operation to achieve the lowest electricity consumption.

Table 60: Sequence of Operation Description for Cooling Towers

Base Case 1A	CHWST Setpoint = 60F. When possible, tower fan speed modulates to meet constant CWST = CHWST Setpoint - WSE HX approach to handle all loads via the waterside economizer and the chiller is off. If the tower fan is at max speed and WSE isn't fully maintaining CHWST at setpoint, the chiller runs to cool the remaining load.
Base Case 1B	Towers maintain 85 CWST Setpoint to handle CDUs via WSE HX. Chiller then runs 24/7 at high lift (i.e., no WSE) to bring RDHX water down to low LWT for just the RDHXs loads that need low LWT
Proposed Case 2	Separate tower plants and operate under two temperature setpoints: The chiller + tower plant supply low LWT (per base case 1A SOO) and separate tower plant supplies high LWT (per base case 1B SOO).

Table 61: Sequence of Operation Description for Dry Coolers

Base Case 1A	**The dry coolers are controlled to maintain 60F LWT for both dry coolers and chillers in dry mode. If the dry coolers cannot make dry LWT setpoint then fans run full speed. If dry CWST exceeds the Adiabatic Assist LWT Setpoint, then run spray and modulate fan speed to maintain the Adiabatic Assist LWT Setpoint. Chiller load (via WSE) and lift is reduced when low temperature LWT is provided.**
Base Case 1B	The dry coolers run with a high temperature LWT setpoint for CDUs and Chillers. Chiller then runs 24/7 at high lift (i.e., no WSE) to bring RDHX water down to low LWT for just the RDHXs loads that need low LWT
Proposed Case 2	Dry coolers are separated and operate under two temperature setpoints: The chiller dry coolers supply low LWT (per base case 1A SOO) and the CDU dry coolers supply high LWT (per base case 1B SOO).

	Base Case 1A	Base Case 1B	Proposed
Dry Cooler Leaving Water Temperature Setpoint (LWT) for CDUs	60	88	88
Dry Cooler Entering Water Temp (EWT) for CDUs	75	103	103
Dry Cooler LWT for Chillers	60	88	60
Dry Cooler EWT for Chillers	75	103	75
Adiabatic Assist LWT Setpoint	88	88	88
Chilled Water Delta T @ 100% Load	25	15	-
Chilled Water Delta T @ 75% Load	20	12	-
Chilled Water Delta T @ 50% Load	15	10	-
Chilled Water Delta T @ 25% Load	10	7	-

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

Scenario 2a - Incremental Cost Assumptions

Instructions to the contractors for pricing the cost difference between the proposed scenario 2a, which uses separate cooling plants for air-cooled and liquid-cooled ITE, and the baseline scenario, using a single plant. The proposed scenario is a data center currently under construction, so the contractor was asked to adjust pricing to reflect a baseline scenario. These instructions are outlined below:

Mechanical Revisions

1. Delete from base design:

a. Three York YZ 225-ton water-cooled variable speed centrifugal chillers (CH-1, CH-2, CH-3) piped in parallel with 4” chilled water piping and 6” condenser water piping
b. One B&G AP 585 GPM waterside economizer plate and frame heat exchanger with 2°F approach, 316 stainless steel plates, and 6” chilled water piping and 6” condenser water piping
c. Four Marley NC 475 GPM crossflow cooling towers (TWCT-1, TWCT-2, TWCT-3, TWCT-4) with 304 stainless steel basins, ultra quiet fans, PVC fill, drift eliminators, and 5’ fan cylinder extensions with 6” condenser water piping, 4” CPVC sweeper piping and 8” common equalizer
d. Two Marley NC 610 GPM crossflow cooling towers (CWCT-1, CWCT-2) with 304 stainless steel basins, ultra quiet fans, PVC fill, drift eliminators, and 5’ fan cylinder extensions with 6” condenser water piping, 4” CPVC sweeper piping and 8” common equalizer
e. Three headered 340 GPM 20 HP variable speed chilled water pumps (CHWP-1, CHWP-2, CHWP-3) with 6” chilled water piping
f. Three headered 600 GPM 15 HP variable speed condenser water pumps (CWP-1, CWP-2, CWP-3) with 6” condenser water piping
g. Three headered 950 GPM 40 HP variable speed tower water pumps (TWP-1, TWP-2, TWP-3) with 8” condenser water piping
h. Two Hellan FB 1900 GPM carbon steel basket strainers with 1/8” holes, 200 mesh liner, and 10” condenser water piping
i. Two Cary Company 1900 GPM carbon steel bag filters with 35 micron filter bags and 10” condenser water piping
j. Schedule 40 carbon steel piping of the following diameters and lengths
    i. 30 ft of uninsulated 4” piping
    ii. 560 ft of uninsulated 6” piping
    iii. 610 ft of uninsulated 8” piping
    iv. 395 ft of uninsulated 10” piping
    v. 25 ft of 1” insulated 3” piping
    vi. 50 ft of 1” insulated 6” piping
    vii. 100 ft of 1” insulated 8” piping

2. Add for alternative design:
    a. Three York YZ 875-ton water-cooled variable speed centrifugal chillers (CH-1, CH-2, CH-3) piped in parallel with 8” chilled water piping and 10” condenser water piping
    b. One B&G AP 2540 GPM waterside economizer plate and frame heat exchanger with 2°F approach, 316 stainless steel plates, and 12” chilled water piping and 12” condenser water piping

c. Four Marley NC 1190 GPM crossflow cooling towers (CWCT-1, CWCT-2, CWCT-3, CWCT-4) with 304 stainless steel basins, ultra quiet fans, PVC fill, drift eliminators, and 5’ fan cylinder extensions with 10” condenser water piping, 5” CPVC sweeper piping and 12” common equalizer
d. Three headered 1320 GPM 60 HP variable speed chilled water pumps (CHWP-1, CHWP-2, CHWP-3) with 10” chilled water piping
e. Three headered 2375 GPM 60 HP variable speed condenser water pumps (CWP-1, CWP-2, CWP-3) with 12” condenser water piping
f. Two Hellan BS 4750 GPM basket strainers with 1/8” holes, 200 mesh liner, and 16” condenser water piping
g. Two Cary Company 4750 GPM carbon steel bag filters with 35 micron filter bags and 16” condenser water piping
h. Schedule 40 carbon steel piping of the following diameters and lengths
    i. 55 ft of uninsulated 12” piping
    ii. 355 ft of uninsulated 16” piping
    iii. 30 ft of 1” insulated 4” piping
    iv. 585 ft of 1” insulated 10” piping
    v. 315 ft of 1” insulated 12” piping

Electrical Revisions

1. Delete from base design:
    a. CH-1, CH-2, and CH-3: 115 kW each (all on s-power)
    b. CWCT-1 and CWCT-2, 10 HP each (all on s-power)
    c. TWCT-1, TWCT-2, TWCT-3, and TWCT-4, 10 HP each (three on s-power)
    d. CHWP-1, CHWP-2, and CHWP-3: 20 HP each (all on s-power)
    e. CWP-1, CWP-2, and CWP-3: 15 HP each (all on s-power)
    f. TWP-1, TWP-2, and TWP-3: 40 HP each (two on s-power)
2. Add for alternative design:
    a. CH-1, CH-2, and CH-3: 450 kW each (all on s-power)
    b. CWCT-1, CWCT-2, CWCT-3, and CWCT-4, 15 HP each (all on s-power)
    c. CHWP-1, CHWP-2, and CHWP-3: 60 HP each (all on s-power)
    d. CWP-1, CWP-2, and CWP-3: 60 HP each (all on s-power)

Add Alternate Pricing Details – Mechanical

A breakdown of costs for mechanical and electrical modifications when going from the proposed two-plant (proposed scenario) to a baseline scenario off a single plant is detailed in the following tables.

EQUIPMENT DESCRIPTION	# of Trips			HRS (ST)	HRS (OT)	HRS (DT)	HRS (SHIFT)	LABOR RATE	LABOR $	MATERIAL $	TOTAL $
See attached sheet: Equipment										$ 1,555,803.16	$ 1,555,803.16
Equipment Totals:				0.0	0.0	0.0	0.0		$ -	$ 1,555,803.16	**$ 1,555,803.16**
PIPING - FIELD INSTALL				HRS (ST)	HRS (OT)	HRS (DT)	HRS (SHIFT)	LABOR RATE	LABOR $	MATERIAL $	TOTAL $
Material Handling	8%			-59.0				$ 161.10	$ (9,504.90)		$ (9,504.90)
Credited Pipe - CHW (1,141) LF	(1,470.2)	80%		(1,176.2)				$ 161.10	$ (189,479.38)	$ (167,363.84)	$ (356,843.22)
Added Pipe - CHW (1,827) LF	2,795.5	80%		2,236.4				$ 161.10	$ 360,284.04	$ 517,565.80	$ 877,849.84
Credited Pipe - CW (2,899) LF	(4,023.3)	80%		(3,218.6)				$ 161.10	$ (518,522.90)	$ (513,845.35)	$ (1,032,368.25)
Added Pipe - CW (703) LF	1,821.4	80%		1,457.1				$ 161.10	$ 234,742.03	$ 492,098.62	$ 726,840.65
Tagging & Labeling	2%			-14.0				$ 161.10	$ (2,259.52)	$ -	$ (2,259.52)
Field Detailing	3%			-21.0				$ 161.10	$ (3,389.29)	$ -	$ (3,389.29)
QA/QC Inspection/Testing	2%			-14.0				$ 161.10	$ (2,259.52)		$ (2,259.52)
Clean-up for added work	2%			-16.0	0.0	0.0	0.0	$ 161.10	$ (2,577.60)		$ (2,577.60)
Field Consumables	2%									$ 4,926.83	$ 4,926.83
Field General Foreperson Time	12%			-100.0	0.0	0.0	0.0	$ 176.86	$ (17,686.00)		$ (17,686.00)
Piping Field Totals:				-925.4	0.0	0.0	0.0		$ (150,653.04)	$ 333,382.06	**$ 182,729.02**
RIGGING				HRS (ST)	HRS (OT)	HRS (DT)	HRS (SHIFT)	LABOR RATE	LABOR $	MATERIAL $	TOTAL $
HVACPF - Anchorage/Seismic (See attached Breakdown)				-12.0	0.0	0.0	0.0	$ 161.10	$ (1,933.20)	$ -	$ (1,933.20)
Rigging Totals:				-44.0	0.0	0.0	0.0		$ (7,088.40)	$ -	**$ (7,088.40)**
SYSTEMS OPERATIONS				HRS (ST)	HRS (OT)	HRS (DT)	HRS (SHIFT)	LABOR RATE	LABOR $	MATERIAL $	TOTAL $
HVAC Startup Equip (See attached breakdown)				-52.0	0.0	0.0	0.0	$ 179.97	$ (9,358.44)	$ -	$ (9,358.44)
Systems Operation Totals:				-52.0	0.0	0.0	0.0		$ (9,358.44)	$ -	**$ (9,358.44)**
SUBCONTRACTS											TOTAL $
Mechanical Insulation - Net Add/Credit											$ 93,312.85
DDC Controls - Net add/credits											$ (60,000.00)
Subcontract Totals:											**$ 33,312.85**
Jobsite Expenses							# PAGES			RENTAL $	TOTAL $
Truck Charge											$ (1,200.00)
Jobsite Expense Totals:										$ -	**$ (1,200.00)**

EQUIPMENT																			
						Equipment		Install Labor Hrs						SU Labor Hrs					
Tag	Vendor	Description	Equip Scope	Equip Type	Quantity	Unit	Total	ST Unit	OT Unit	DT Unit	Shift Unit	Subtotal Units	Total	ST Unit	OT Unit	DT Unit	Shift Unit	Subtotal Units	Total
CH	USACD	York YZ 225-ton Chillers	HVAC	Chillers (H20 Cooled)	(3)	$277,469.50	($832,408.50)	0.0				0.0	0.0	0.0				0.0	0.0
HX	CHC	B&G AP Waterside Economizer	HVAC	Heat Exchangers - HVAC	(1)	$86,546.25	($86,546.25)	0.0				0.0	0.0	0.0				0.0	0.0
TWCT	NSW	Marley NC crossflow cooling towers	HVAC	Cooling Towers	(4)	$122,088.75	($488,355.00)	0.0				0.0	0.0	0.0				0.0	0.0
CWCT	NSW	Marley NC crossflow cooling towers	HVAC	Cooling Towers	(2)	$122,088.75	($244,177.50)	16.0				16.0	-32.0	20.0				20.0	-40.0
CHWP	CHC	20HP Chilled Water pumps	HVAC	Pumps - HVAC	(3)	$9,393.30	($28,179.90)	0.0				0.0	0.0	0.0				0.0	0.0
CWP	CHC	15HP Condenser Water pumps	HVAC	Pumps - HVAC	(3)	$9,938.25	($29,814.75)	0.0				0.0	0.0	0.0				0.0	0.0
TWP	CHC	40 HP Tower Water pumps	HVAC	Pumps - HVAC	(3)	$9,938.25	($29,814.75)	4.0				4.0	-12.0	4.0				4.0	-12.0
BS	Hellan	Carbon Steel Basket Strainers	HVAC	Filters	(2)	$19,356.75	($38,713.50)	0.0				0.0	0.0	0.0				0.0	0.0
BF	CaryCo	Carbon Steel Bag Filter Vessels	HVAC	Filters	(2)	$43,027.43	($86,054.85)	0.0				0.0	0.0	0.0				0.0	0.0
VFD	NSW	Net Removed VFDs	HVAC	Variable Speed Drives - HV/	(3)	$8,766.67	($26,300.00)	0.0				0.0	0.0	0.0				0.0	0.0
CH	USACD	York YZ 875-ton Chillers	HVAC	Chillers (H20 Cooled)	3	$623,333.33	$1,870,000.00	0.0				0.0	0.0	0.0				0.0	0.0
HX	CHC	B&G AP Waterside Economizer	HVAC	Heat Exchangers - HVAC	1	$175,193.00	$175,193.00	0.0				0.0	0.0	0.0				0.0	0.0
CWCT	NSW	Marley NC crossflow cooling towers	HVAC	Cooling Towers	4	$247,500.00	$990,000.00	0.0				0.0	0.0	0.0				0.0	0.0
CHWP	CHC	60HP Chilled Water pumps	HVAC	Pumps - HVAC	3	$14,459.00	$43,377.00	0.0				0.0	0.0	0.0				0.0	0.0
CWP	CHC	60HP Condenser Water pumps	HVAC	Pumps - HVAC	3	$18,113.00	$54,339.00	0.0				0.0	0.0	0.0				0.0	0.0
BS	Hellan	Carbon Steel Basket Strainers	HVAC	Filters	2	$19,590.00	$39,180.00	0.0				0.0	0.0	0.0				0.0	0.0
BF	CaryCo	Carbon Steel Bag Filter Vessels	HVAC	Filters	2	$137,039.58	$274,079.16	0.0				0.0	0.0	0.0				0.0	0.0
							$0.00					0.0	0.0					0.0	0.0
			Totals		(8)		$1,555,803.16						-44.0						-52.0

Add Alternate Pricing Details - Electrical

Pricing:

	Total	#	Per unit
Old mech connections	-$87,368	18	-$4,854
New mechanical connections	$116,442	13	$8,957
Connection change pricing	**$29,074**		

1250kW/1563kVA - NEW	**$1,950,000**

Recommended based on new loads. Pricing includes genereator/ATS/feeders/switchboard

Labor and material breakdown

	System	DB Material	Total Material	Direct Hrs	Direct Labor $	Total Hrs	Total Labor $	Markup	Defined Adj.	Total	Area	Db Mtl $ /Area	Total Mtl $	Labor $ /Area	Total $ /Area	Direct Hrs /Area	Total Hrs /Area
1	| | OLD CHILLERS 115KW	-19,894.69	-19,894.69	-77.51	-11,765.94	-77.51	-11,765.94	-4,749.09	-728.19	-37,137.91	3	-6,631.56	-6,631.56	-3,921.98	-12,379.30	-25.8367	-25.8367
2	| | NEW CHILLERS 450KW	36,335.21	36,335.21	165.69	25,151.98	165.69	25,151.98	9,223.06	1,414.21	72,124.46	3	12,111.74	12,111.74	8,383.99	24,041.49	55.23	55.23
3	| | OLD CWCT - 10HP	-714.85	-714.85	-20.5	-3,112.68	-20.5	-3,112.68	-574.13	-88.03	-4,489.69	2	-357.425	-357.425	-1,556.34	-2,244.85	-10.25	-10.25
4	| | NEW CWCT - 15 HP	2,098.58	2,098.58	53.15	8,068.68	53.15	8,068.68	1,525.09	233.85	11,926.20	4	524.645	524.645	2,017.17	2,981.55	13.2875	13.2875
5	| | OLD TWCT - 10 HP	-2,054.70	-2,054.70	-67.53	-10,252.11	-67.53	-10,252.11	-1,846.02	-283.06	-14,435.89	4	-513.675	-513.675	-2,563.03	-3,608.97	-16.8825	-16.8825
6	| | OLD CHWP - 20HP	-1,942.39	-1,942.39	-32.57	-4,943.85	-32.57	-4,943.85	-1,032.94	-158.38	-8,077.56	3	-647.4633	-647.463	-1,647.95	-2,692.52	-10.8567	-10.8567
7	| | NEW CHWP - 60HP	5,336.15	5,336.15	59.64	9,054.11	59.64	9,054.11	2,158.54	330.98	16,879.78	3	1,778.72	1,778.72	3,018.04	5,626.59	19.88	19.88
8	| | OLD CWP - 15HP	-1,681.36	-1,681.36	-36.68	-5,567.90	-36.68	-5,567.90	-1,087.38	-166.73	-8,503.37	3	-560.4533	-560.453	-1,855.97	-2,834.46	-12.2267	-12.2267
9	| | NEW CWP - 60HP	4,958.00	4,958.00	54.45	8,266.07	54.45	8,266.07	1,983.61	304.15	15,511.83	3	1,652.67	1,652.67	2,755.36	5,170.61	18.15	18.15
10	| | OLD TWP - 40HP	-4,867.69	-4,867.69	-50.62	-7,684.53	-50.62	-7,684.53	-1,882.83	-288.7	-14,723.75	3	-1,622.56	-1,622.56	-2,561.51	-4,907.92	-16.8733	-16.8733

Tag	OLD - NORMAL	OLD GENERATOR	NEW - NORMAL	NEW GENERATOR KVA	NORMAL SOURCE	Length	DISC
CH1 - old	143.75				HMD-A	-100	250
CH2 - old		143.75				-100	250
CH3 - old		143.75				-110	250
CH1 - new				562.5		100	600
CH2 - new				562.5		100	600
CH3 - new				562.5		110	600
CWCT1 - 10 HP		11.64				-60	30
CWCT2 - 10 HP		11.64				-80	30
TWCT1 - 10HP		11.64				-110	30
TWCT2 - 10HP		11.64				-120	30
TWCT3 - 10HP		11.64				-140	30
TWCT4 - 10HP		11.64				-150	30
CHWP1 - 20 HP	22.45				HMD-A	-70	60
CHWP2 - 20 HP		22.45				-80	60
CHWP3 - 20 HP		22.45				-90	60
CWP1 - 15 HP	17.46				HMD-A	-80	40
CWP2 - 15 HP		17.46				-60	40
CWP3 - 15 HP		17.46				-70	40
TWP1 - 40 HP		43.23				-110	100
TWP2 - 40 HP		43.23				-100	100
TWP3 - 40 HP		43.23				-90	100
CWCT1 - 15 HP				17.46		60	40
CWCT2 - 15 HP				17.46		80	40
CWCT3 - 15 HP				17.46		100	40
CWCT4 - 15 HP				17.46		100	40
CHWP1 - 60 HP - new				64.02		70	125
CHWP2 - 60 HP - new				64.02		80	125
CHWP3 - 60 HP - new				64.02		90	125
CWP1 - 60 HP - new				64.02		80	125
CWP2 - 60 HP - new				64.02		60	125
CWP3 - 60 HP - new				64.02		70	125
TOTALS	**183.66**	**566.85**	**-**	**2,141.44**			

NORMAL DELTA - KVA	(183.66)
GENERATOR DELTA - KVA	1,574.59
Delta KVA	1,390.93
Delta KW	1,112.75

120.6(j)3 – Fan Control Requirements

Key Assumptions for Energy Savings Analysis

- The Statewide CASE Team evaluated the energy impacts in every climate zone and applied the climate-zone-specific LSC hourly factors when calculating energy and energy cost impacts.
- A custom Excel file was used to calculate the unit energy consumption for fan energy consumption, assuming a single speed motor for the baseline case and variable speed fan control for the proposed case.
- Applied fan energy savings to the following building prototype models (Hospital, Large office, Medium Office, Small Office, Large School, Small School) which often include a small computer room or IDF to demonstrate proposed code change impacts.

Energy Savings Methodology per Prototypical Building

The 2028 CASE Methodology Report provides details on estimating energy savings per prototypical building and unit. The CEC directed the Statewide CASE Team to model energy impacts using specific prototypical building models that represent typical building geometries for different building types. Table 62 presents the prototype buildings where fan energy savings were applied to derive computer room savings within each building type. To estimate the total impact per building, the Statewide CASE Team assumed that computer rooms represent 1 percent of hospital floor area, and 0.5 percent of floor area for all other building types.

Table 62: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Hospital	5	241,501	5-story hospital plus basement. Assume computer room represents 1% of floor area.
OfficeLarge	12	498,589	12-story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR–40%. Assume computer room represents .5% of floor area.
OfficeMedium	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%. Assume computer room represents .5% of floor area.
OfficeSmall	1	5,502	1-story, 5-zone office building with pitched roof and unconditioned attic. WWR–24%. Assume computer room represents .5% of floor area.

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
SchoolLarge	2	210,866	High school with WWR–35% and SRR–1.4%
SchoolSmall	1	24,413	Elementary school with WWR–36%. Assume computer room represents .5% of floor area.

There is an existing Title 24, Part 6 requirement that covers the building system in question and applies to both new construction/additions and alterations, so the Standard Design is minimally compliant with the 2025 Title 24 requirements. The baseline case assumes a single speed fan using a fan curve per Appendix 5.7 from CBECC.

Table 63: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Hospital	All	HVAC System	Fan Control	Fan riding the fan curve	VSD
OfficeLarge	All	HVAC System	Fan Control	Fan riding the fan curve	VSD
OfficeMedium	All	HVAC System	Fan Control	Fan riding the fan curve	VSD
OfficeSmall	All	HVAC System	Fan Control	Fan riding the fan curve	VSD
SchoolLarge	All	HVAC System	Fan Control	Fan riding the fan curve	VSD
SchoolSmall	All	HVAC System	Fan Control	Fan riding the fan curve	VSD

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 63 presents the parameters modified and the values used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume a variable speed fan control.

Table 64: Assumptions used for Simplified Hourly Savings Analysis

Parameter	Description	Value	Notes
A	Full load capacity Btuh	45,000	Assumption (avg of 30 and 60 kBtu)
B	Sizing Factor	1.15	ACM
C	ITE 100% Load Watts	11468	A/(B*3.412)
D	Temp difference Deg F across the coil F	20	ACM
E	Fan air Flow @ full load in cfm	2,184	A/(1.08*D)
F	Maximum Fan Power W/kBtuh	27	T24 2025 Part 6
G	Fan Power @ Full load in kW	1.215	F*A/1000/1000
H	Assumed IT Load Density W/sq.ft	30	Average of T24 and LBNL minimum IT load densities[20]
I	Computer room CFA sq.ft	382	C/H
J	Baseline Fan	AF or BI Riding the Curve	Assumption (Appendix 5.7 from CBECC)
K	Measure Fan	VFD or ECM	Proposal (Appendix 5.7 from CBECC)
L	Load profile	CBECC Ruleset	-
M	Fan Performance Curve	Appendix 7 Performance Curves	-
N	Prototype considered for analysis	Hospital, Large office, Medium Office, Small Office, Large School, Small School	-
O	T24 2028 CEC Metrics	Emission factor, source factor, LSC	-
P	Conditioned Floor Area		Value from CEC 2026 Forecast

The energy impacts of the proposed code change do not vary by climate zone. Since savings do not vary by climate zone, the Statewide CASE Team used the statewide LSC hourly factors when calculating energy and LSC impacts.

140.9(a)5 – Computer Room Heat Recovery

Key Assumptions for Energy Savings Analysis

- The Statewide CASE Team simulated the energy impacts in four climate zones (CZ 3, 4, 9, 12) and applied the climate-zone-specific LSC hourly factors when calculating energy and energy cost impacts.
- A hybrid energy cost analysis was conducted, including energy modeling to determine the heat load for a medium office building and a custom Excel tool to calculate the impact of a heat recovery system and a post-processing analysis to evaluate computer room size and load profile in terms of btuh/ft2.
- Heat recovery is assessed based on a 100-kW computer room and 53,628 sq. ft. office space in the same building.

Energy Savings Methodology per Prototypical Building

The 2028 CASE Methodology Report provides details on estimating energy savings per prototypical building and unit. The CEC directed the Statewide CASE Team to model energy impacts using specific prototypical building models that represent typical building geometries for different building types. Table 65 presents the prototype buildings used in the analysis.

Table 65: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
OfficeMedium	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%

There are no existing requirements in Title 24, Part 6 that require heat recovery for a computer room and non- computer room floor area of this size. The Statewide CASE Team modified the Standard Design so that it calculated energy impacts based on a building with a computer room and office without heat recovery. Base Case assumptions are provided below:

Base Case (BEM Model): medium office building 53,628 sq. ft. with a 100-kW computer room

- Air-to-water heat pump (AWHP) serves backup HW coil in hot deck (sized for full capacity)
- No heat recovery system is assumed (DFDD with AHU mixing section not included)

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 66 presents the parameters modified and the values used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume:

Proposed Case (Custom Excel Tool): medium office building 53,628 sq. ft. with a 100-kW computer room

- Air-to-water heat pump (AWHP) serves backup HW coil in hot deck (sized for full capacity)
- DFDD (dual fan dual duct) system
- Computer room return air ducted to hot deck AHU mixing section to supply heat to office

A CBECC Medium Office baseline was used with changes to occupancy, lighting, plug density and schedules in the baseline model. To establish baseline energy use of a medium office without heat recovery, the Statewide CASE Team simulated a medium office with VAV reheat and without heat recovery. The hourly heating load (btuh/ft2), AWHP heating energy (kW/ft2), and electricity costs were exported and used in a post processing analysis to determine the hourly heating load to computer room heating capacity and hourly and annual energy savings.

Table 66: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zones	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
OfficeMedium	3, 4, 9, 12	NA	NA	NA	NA

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

Appendix B: Purpose and Necessity of Proposed Code Changes

Introduction

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

See Sections 2.6.3, 3.6.3, and 4.6.3 of this report for marked-up code language.

140.9(a)1 – Computer Room Economizers

Purpose and Necessity of Changes to Title 24, Part 1

There are no proposed changes to Title 24, Part 1.

Purpose and Necessity of Changes to Title 24, Part 6

Section: Section 100.1

Purpose: The purpose of this change is to expand definitions pertaining to computer rooms and data centers to accommodate changes in technology and construction practices, especially as it relates to different ways to efficiently cool ITE and computer room buildings. This expanded set of definitions covers: Liquid-cooled ITE, Computer Room Economizer, Wet-bulb Computer Room Economizer, and Dry-bulb Computer Room Economizer.

Necessity: This change is necessary to ensure computer room definitions remain updated as cooling technologies and practices evolve. This change also provides additional guidance on how to design a fully integrated computer room economizer.

Section: Section 140.9(a)1

Purpose: The purpose of this change is to increase the amount of time economizers must be capable of meeting all or part of the cooling load in computer rooms. The proposed change provides specific guidance to the industry for the maximum outdoor air temperature threshold for when a dry-bulb or wet-bulb economizing system must meet all or some of the cooling load. Exception 2 is modified to raise the outdoor temperature for when an economizer must meet the design cooling load of the computer room. A third exception is proposed for computer rooms with a heat recovery system that can accept at least 50 percent of the design heat and recover at least 25 percent of the annual computer room heat.

Necessity: This change is necessary to continually improve data center operational efficiency and maximize economizer cooling when conditions are advantageous to do so. In addition to the energy and economic savings established in this report, the proposed change will also reduce data center cooling load and thus limit the rising electricity demand on the grid from data centers.

Section: Section 141.1(b)1

Purpose: The purpose of this change is to incorporate the expanded economizer requirements in 140.9(a)1 and apply those to new cooling systems serving computer rooms in an existing building. This change also covers existing computer rooms with new cooling systems serving smaller ITE loads by removing exception 3 and modifying exception 2.

Necessity: This change is necessary to reduce cooling load in existing computer rooms when it is most cost effective to do so—when a new cooling system is being installed. Small computer rooms are ubiquitous in nonresidential buildings across California and require significant cooling load to shed heat, so applying this requirement to smaller computer rooms will make a significant impact on the grid as these facilities are updated.

Purpose and Necessity of Changes to the Reference Appendices

There are no proposed changes to reference appendices.

120.6(j)3 – Fan Control Requirements

Purpose and Necessity of Changes to Title 24, Part 1

There are no proposed changes to Title 24, Part 1.

Purpose and Necessity of Changes to Title 24, Part 6

Section: Section 120.6(j)3

Purpose: The purpose of this change is to reduce the design cooling load threshold for when cooling equipment serving computer rooms must have an integrated ECM motor and VAV capable of modulating fan speed and airflow based on load. This change now includes DX units with a rated cooling capacity of ≥ 2.5 tons to 5 tons.

Necessity: This change is necessary to align standard practice with minimum code requirements. There are thousands of computer rooms with a cooling load between 2.5 – 5 tons and available cooling equipment with ECMs to meet this requirement. This change codifies standard practice and aligns the industry.

Purpose and Necessity of Changes to the Reference Appendices

There are no proposed changes to reference appendices.

140.9(a)5 – Computer Room Heat Recovery

Purpose and Necessity of Changes to Title 24, Part 1

There are no proposed changes to Title 24, Part 1.

Purpose and Necessity of Changes to Title 24, Part 6

Section: 140.9(a)5

Purpose: The purpose of this change is to require a heat recovery system be installed in a building with a computer room ITE load greater than 100 KW and a non-computer room with conditioned floor area greater than 35,000 square feet. This change requires efficient use of heat from a computer room in other spaces inside the building instead of wasting that heat to the outside.

Necessity: This change is necessary to manage waste heat from computer rooms in an efficient manner. Computer rooms produce heat 24/7 and by using that heat to supplement the heating load in another space, it will reduce energy use and overall demand on the grid.

Purpose and Necessity of Changes to the Reference Appendices

There are no proposed changes to reference appendices.

Appendix C: Assumptions for Statewide Savings Estimates

The Statewide CASE Team is anticipating updated construction forecasts to be released by the California Energy Commission in February 2026. This will impact statewide energy savings but not the cost effectiveness of the proposal. The final CASE Report will present the updated savings based on the new forecasts.

The assumptions described in this Appendix are being refined based on ongoing research and stakeholder feedback and will be finalized in the Final CASE Report.

Computer Room Economizers

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide data center capacity for new and existing buildings. The Statewide CASE Team leveraged the approach used in the 2022 CASE Report *Nonresidential Computer Room Efficiency* to generate statewide data center capacity assumptions impacted by the proposal, which are assumed to be 26 MW of ITE capacity for new data centers, and 28 MW of ITE capacity in existing buildings. The following approach was used to estimate new and existing statewide ITE capacity:

Table 67: Estimated Statewide Data Center Capacity – New Construction and Additions Impacted

Parameter Letter	Parameter Name	Unit	New Construction	Source/Notes
A	Total CA statewide building electricity consumption 2024	GWh/yr	282,783	(California Energy Commission 2025)
B	Total computer room energy (IT + support systems) as a percent of existing building energy	%	2.6	(Yu, et al. 2024)
C	Existing statewide computer room total (IT + support systems energy consumption)	GWh/yr	7,352	A * B
D	New Construction computer room PUE	No Dimension	1.2	(Harms and Chen 2024)
E	Annual percent increase in computer room energy	%	5	(EPRI 2024)

Parameter Letter	Parameter Name	Unit	New Construction	Source/Notes
F	New statewide computer room total (IT + support systems) energy consumption	GWh/yr	368	C*E
G	New statewide computer room IT energy consumption	GWh/yr	306	F/D
H	New average statewide IT load	MW	35	G*10^3/8760
I	Estimated Percent of New IT Load Impacted (Non-Market Share/Alterations)	%	75	Estimate.
J	New impacted statewide IT load	MW	26	H*I

Table 68: Estimated Statewide Data Center Capacity – Alterations Impacted

Parameter Letter	Parameter Name	Unit	New Construction	Source
A	Existing statewide computer room total (IT + support systems energy consumption)	GWh/yr	7,352	Parameter C from Table 67
B	Existing computer room PUE	No Dimension	1.8	(National Laboratory of the Rockies 2025)
C	Existing statewide computer room ITE energy consumption	GWh/yr	4,085	A/B
D	Existing average statewide IT load	MW	466	C *10^3/8760
E	Estimated Percent of New IT Load Impacted (Non-Market Share)	%	90	Estimate.
F	Estimated HVAC Replacement Rate	%	6.7	Assumes 15 yr HVAC EUL.
G	Impacted statewide IT load	MW	28	D*E*F

The statewide savings and cost estimates take the current market share rate into account. The Statewide CASE Team estimated that the current market share rate for the proposed code change is 25 percent for the new construction market and ten percent for the retrofit market. The current market share rate is estimated based on the Statewide CASE Team's professional judgment and data from the evaluation of past

Title 24 code cycles. This is reflected in the statewide savings estimates as presented in 2.5.1.

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

Fan Control Requirements

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide construction forecasts provided by the CEC. The 2028 CASE Methodology Report includes additional information about the methodology and assumptions used to calculate statewide energy impacts.

The statewide savings and cost estimates take the current market share rate into account. The Statewide CASE Team estimated that the current market share rate for the proposed code change is 80 percent for the new construction market and 20 percent for the retrofit market. The current market share rate is estimated based on the Statewide CASE Team's professional judgment and data from the evaluation of past Title 24 code cycles.

Table 69 presents the projected nonresidential new construction that the proposed code change will impact in 2026. Table 70 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2026. The Statewide CASE Team developed these estimates using the methods described in this section.

The Statewide CASE Team estimated the percentage of newly constructed floorspace that the proposed code change would impact. Table 71 shows the assumed percentage of affected floorspace by building type. If a proposed code change does not apply to a specific building type, the Statewide CASE Team assumes that zero percent of the floorspace would be impacted. If the assumed percentage is non-zero, but less than 100 percent, the proposal is expected to affect some—but not all—buildings. Table 72 represents the assumed percentage of affected floorspace by climate zone.

Table 69: 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
Large Office	0.0000	0.0000	0.0029	0.0014	0.0000	0.0013	0.0007	0.0021	0.0037	0.0004	0.0001	0.0005	0.0000	0.0002	0.0000	0.0000	0.0133
Medium Office	0.0001	0.0005	0.0014	0.0007	0.0004	0.0012	0.0008	0.0016	0.0032	0.0012	0.0003	0.0028	0.0006	0.0003	0.0003	0.0001	0.0155
Small Office	0.0000	0.0004	0.0002	0.0000	0.0001	0.0001	0.0002	0.0002	0.0004	0.0004	0.0001	0.0005	0.0004	0.0000	0.0001	0.0000	0.0032
Large School	0.0000	0.0001	0.0008	0.0004	0.0000	0.0005	0.0005	0.0008	0.0013	0.0008	0.0003	0.0010	0.0005	0.0001	0.0001	0.0001	0.0073
Small School	0.0001	0.0003	0.0005	0.0002	0.0001	0.0003	0.0003	0.0004	0.0007	0.0003	0.0001	0.0008	0.0003	0.0001	0.0000	0.0000	0.0045
Hospital	0.0001	0.0003	0.0016	0.0008	0.0002	0.0006	0.0011	0.0009	0.0015	0.0016	0.0003	0.0016	0.0005	0.0003	0.0002	0.0001	0.0117
TOTAL	**0.0003**	**0.0016**	**0.0073**	**0.0036**	**0.0008**	**0.0041**	**0.0037**	**0.0059**	**0.0107**	**0.0046**	**0.0012**	**0.0072**	**0.0023**	**0.0011**	**0.0007**	**0.0004**	**0.0555**

Table 70: 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
Large Office	0.000	0.000	0.007	0.004	0.000	0.005	0.004	0.008	0.015	0.003	0.000	0.004	0.000	0.001	0.000	0.000	0.052
Medium Office	0.000	0.002	0.004	0.002	0.001	0.002	0.002	0.003	0.004	0.003	0.001	0.005	0.001	0.001	0.001	0.000	0.032
Small Office	0.000	0.001	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.002	0.001	0.000	0.000	0.000	0.011
Large School	0.000	0.000	0.002	0.001	0.000	0.001	0.001	0.002	0.004	0.003	0.001	0.003	0.001	0.001	0.000	0.000	0.020
Small School	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Hospital	0.000	0.001	0.005	0.002	0.001	0.003	0.003	0.004	0.007	0.004	0.001	0.005	0.002	0.001	0.001	0.000	0.040
TOTAL	**0.001**	**0.004**	**0.019**	**0.010**	**0.002**	**0.013**	**0.010**	**0.018**	**0.032**	**0.015**	**0.003**	**0.020**	**0.007**	**0.003**	**0.002**	**0.001**	**0.158**

Table 71: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
Large Office	0.50%	0.1%
Medium Office	0.50%	0.1%
Small Office	0.50%	0.1%
Large Retail	0.00%	0%
Medium Retail	0.00%	0%
Strip Mall	0.00%	0%
Mixed-Use Retail	0.00%	0%
Large School	0.50%	0.1%
Small School	0.50%	0.1%
Non-refrigerated Warehouse	0.00%	0%
Hotel	0.00%	0%
Assembly	0.00%	0%
Hospital	1.00%	0.2%
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 72: 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	0.05%	0.010%
2	0.05%	0.010%
3	0.05%	0.010%
4	0.00%	0.000%
5	0.00%	0.000%
6	0.00%	0.000%
7	0.00%	0.000%
8	0.05%	0.010%
9	0.01%	0.002%
10	0.00%	0.000%
11	0.00%	0.000%
12	0.00%	0.000%
13	0.10%	0.020%
14	0%	0.000%
15	0%	0%
16	0%	0%

Computer Room Heat Recovery

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide construction forecasts provided by the CEC. The statewide construction forecasts for new construction include the impact of additions. The current analysis is based on a medium office building prototype. Additional building types may be considered in the Final CASE Report. This measure only applies to new construction, so the Statewide CASE Team discounted the construction forecast for medium office by 15% to account for the impact of additions. While the actual percentage of adding computer rooms to medium office buildings is difficult to quantify, the estimated percentage of affected buildings is intended to capture statewide savings from other building types that will be impacted by this measure until those building types are modeled separately. The 2028 CASE Methodology Report includes additional information about the methodology and assumptions used to calculate statewide energy impacts.

The statewide savings and cost estimates take the current market share rate into account. The Statewide CASE Team estimated that the current market share rate for the proposed code change is ten percent for the new construction market. The current market share rate is estimated based on the Statewide CASE Team's professional judgment and data from the evaluation of past Title 24 code cycles.

Table 73 presents the projected nonresidential new construction that the proposed code change will impact in 2026. The Statewide CASE Team developed these estimates using the methods described in this section.

The Statewide CASE Team estimated the percentage of newly constructed floorspace that the proposed code change would impact. Table 74 shows the assumed percentage of affected floorspace by building type. If a proposed code change does not apply to a specific building type, the Statewide CASE Team assumes that zero percent of the floorspace would be impacted. If the assumed percentage is non-zero, but less than 100 percent, the proposal is expected to affect some—but not all—buildings. Table 75 represents the assumed percentage of affected floorspace by climate zone.

Table 73: 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
Medium Office	0.10	0.36	1.05	0.57	0.28	0.92	0.62	1.26	2.44	0.90	0.21	2.14	0.45	0.27	0.20	0.08	11.83
TOTAL	**0.10**	**0.36**	**1.05**	**0.57**	**0.28**	**0.92**	**0.62**	**1.26**	**2.44**	**0.90**	**0.21**	**2.14**	**0.45**	**0.27**	**0.20**	**0.08**	**11.83**

Table 74: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
Large Office	0%	0%
Medium Office	77%	0%
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%
Non-refrigerated 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 75: 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	0%	0%
2	0%	0%
3	100%	0%
4	100%	0%
5	0%	0%
6	0%	0%
7	0%	0%
8	0%	0%
9	100%	0%
10	0%	0%
11	0%	0%
12	100%	0%
13	0%	0%
14	0%	0%
15	0%	0%
16	0%	0%

Appendix D: Environmental Analysis

140.9(a)1 – Computer Room Economizers

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

Direct Environmental Impacts

Direct Environmental Benefits

This measure is expected to result in energy savings and GHG emissions reductions by requiring higher thresholds for when economizers need to meet the cooling load when serving air-cooled and/or liquid-cooled ITE. The estimated impact of these benefits has been quantified in this report.

Direct Adverse Environmental Impacts

This measure is not expected to result in any direct adverse environmental impacts.

Indirect Environmental Impacts

Indirect Environmental Benefits

This measure is not expected to result in any indirect environmental benefits.

Indirect Adverse Environmental Impacts

This measure is not expected to result in any indirect adverse environmental impacts.

Mitigation Measures

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

Reasonable Alternatives to Proposal

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternative would achieve its purpose with less environmental effect.

Water Use and Water Quality Impacts Methodology

While certain cooling system designs do increase water use in computer rooms and data centers, the proposed changes are not expected to increase the use of those designs. As such, the code change will not directly impact water use or quality.

120.6(j)3 – Fan Control Requirements

Potential Significant Environmental Effect of Proposal

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

Direct Environmental Impacts

Direct Environmental Benefits

This measure is expected to result in energy savings and GHG emissions reductions by requiring VAV fans capable of adjusting indoor airflow as a function of load and ECMs in 2.5-to-5-ton cooling systems serving computer rooms. The estimated impact of these benefits has been quantified in this report.

Direct Adverse Environmental Impacts

This measure is not expected to result in any direct adverse environmental impacts.

Indirect Environmental Impacts

Indirect Environmental Benefits

This measure is not expected to result in any indirect environmental benefits.

Indirect Adverse Environmental Impacts

This measure is not expected to result in any indirect adverse environmental impacts.

Mitigation Measures

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

Reasonable Alternatives to Proposal

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternative would achieve its purpose with less environmental effect.

Water Use and Water Quality Impacts Methodology

There are no impacts on water quality or water use.

140.9(a)5 – Computer Room Heat Recovery

Potential Significant Environmental Effect of Proposal

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

Direct Environmental Impacts

Direct Environmental Benefits

This measure is expected to result in energy savings and GHG emissions reductions by requiring computer rooms to optimize waste heat through a heat recovery system that serves other spaces in the building with a heating load. The estimated impact of these benefits has been quantified in this report.

Direct Adverse Environmental Impacts

This measure is not expected to result in any direct adverse environmental impacts.

Indirect Environmental Impacts

Indirect Environmental Benefits

This measure is not expected to result in any indirect environmental benefits.

Indirect Adverse Environmental Impacts

This measure is not expected to result in any indirect adverse environmental impacts.

Mitigation Measures

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

Reasonable Alternatives to Proposal

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternative would achieve its purpose with less environmental effect.

Water Use and Water Quality Impacts Methodology

There are no impacts on water quality or water use.

Appendix E: Summary of Stakeholder Engagement

Introduction to Stakeholder Engagement

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

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

All Measures

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 2028 code cycle. The goal of these meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To promote transparency in the development of code change proposals, the Statewide CASE Team uses stakeholder meetings to solicit feedback on:

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

The Statewide CASE Team hosted one stakeholder meetings for the proposed computer room measures via webinar, as described in Table 76. The Statewide CASE Team will host a second stakeholder meeting on the proposed measure to gather feedback on this draft report. 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 76: Utility-Sponsored Stakeholder Meetings

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of Nonresidential Covered Processes, Envelope, Utility-Sponsored Stakeholder Meeting	Tuesday, September 30, 2025	• Proposed code change measures impacting new construction and alterations • Descriptions of compliant vs. non-compliant integrated economizer designs • Market and technical barriers • Compliance changes and challenges

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

The objectives of the first round of stakeholder meetings were to solicit input on the scope of the 2025 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers. The Statewide CASE Team also presented the initial draft code language for stakeholders to review.

The Statewide CASE Team received the following feedback from stakeholders during this meeting and modified the proposal accordingly.

- Proposed part-load economizing requirements outlined in Table A and Table B were too complicated.
    - In response to this feedback, the Statewide CASE Team removed these tables and simplified the requirements.

The second utility-sponsored stakeholder meeting will occur on March 17, 2026 to provide updated details on proposed code changes and engage additional stakeholders impacted by the proposed measures. This meeting will introduce early results of energy, cost effectiveness, and incremental cost analyses, and solicit additional feedback on refined draft code language.

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

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

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders when developing this report. The organizations listed in Table 77 provided input on the proposed measures and content in the report. In addition to those stakeholders, the Statewide CASE Team engaged market actors who manage data centers, design and engineering firms specializing in data centers and smaller computer rooms, manufacturers of cooling equipment, appliance standards associations, and national experts involved in data center projects across the country to provide updates on the proposed measure and invite their input and participation in the process.

Table 77: Engaged Stakeholders

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections
Air Conditioning Contractors of America	Trade Association for Contractors	-
ACCO	Mechanical contractor	Sections 2.4, 4.4
Air-Conditioning, Heating, and Refrigeration Institute	Trade Association of Appliance Manufacturers	Section 1.2.1
AAON, Inc.	Appliance Manufacturer	-
APC by Schneider Electric	Appliance Manufacturer	-
California Energy Commission	Regulator	-
Carrier Corporation	Appliance Manufacturer	-
Daikin U.S. Corporation, Daikin Applied, and Daikin Comfort Technologies	Appliance Manufacturer	-

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections
Heating, Air-conditioning & Refrigeration Distributors International	Trade Association for Distributors	-
Lawrence Berkeley National Laboratory	National Laboratory	Sections 2.2.3, 2.4, 3.4, 4.2.3 and 4.4
LG Air Conditioning Technologies	Appliance Manufacturer	-
Midea America Research Center and North America Technical Service Center	Appliance Manufacturer	-
Mitsubishi Electric US, Inc	Appliance Manufacturer	-
Rheem Manufacturing Company	Appliance Manufacturer	-
Trane	Appliance Manufacturer	-
Western Allied Mechanical	Mechanical contractor	Sections 2.4, 4.4
Vertiv	Appliance Manufacturer	-