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Filer:	Michael Shewmaker
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SUMMARY OF AIR-COOLED CHILLER LIMITATION ANALYSIS IN THE COOLING TOWERS CASE STUDY FROM THE 2025 CYCLE

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California Energy Commission

Docket No. 25-BSTD-03

The California Statewide Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (CEC's) efforts to update California's Energy Code (Title 24, Part 6), including revisions to simplify and clarify existing code requirements. Three California Investor-Owned Utilities (IOUs) — Pacific Gas & Electric Company, San Diego Gas & Electric, and Southern California Edison sponsored this effort as a group.

This letter provides background to the CEC from a past Statewide CASE team effort regarding the water-energy tradeoffs of water-cooled vs. air-cooled heat rejection approaches in commercial HVAC systems. The information provided in this letter stems from 2025 Title 24 Part 6 code cycle research that the Statewide CASE Team undertook in early 2023. Information provided in this letter is intended to assist CEC with its work to better understand the tradeoffs between air-cooled and water-cooled HVAC options. The Statewide CASE Team is eager to continue to work with CEC as the process unfolds

1. Background

In March 2026, CEC approached the Statewide CASE Team raising concerns with the 300 ton ACC limit in light of data center projects in water stressed regions of the state.

For many years, there has been a known tradeoff between water and energy efficiency in regard to heat rejection in HVAC systems. Water-cooled chillers (WCC), while more energy efficient, will consume significantly more water due to the evaporative nature of cooling towers. Air cooled chillers (ACC) are typically less energy efficient but have the advantage of rejecting heat without using any water.

During the 2025 code cycle, the Statewide CASE Team conducted an analysis comparing the water and energy performance of a WCC plant with a high efficiency

ACC plant to see if they could achieve parity with WCCs on an energy basis. This measure was explored as part of the Cooling Towers CASE report but was dropped after the draft stage due to unfavorable cost effectiveness[1]. This memorandum summarizes that analysis.

2. Summary of 2025 Code Cycle Proposal

2.1 Air-Cooled Chiller Threshold

The draft 2025 ACC measure proposed adding a new exception to the prescriptive requirement in Title 24 Part 6 Section 140.4(j) which currently limits air-cooled chillers to providing no more than 300 tons of cooling capacity per building. The exception would allow for air-cooled chillers in excess of this 300-ton capacity for high efficiency air-cooled chillers that meet or exceed the proposed efficiency threshold of 10.72 EER and 20.10 IPLV. EER and IPLV would be required to be rated to AHRI Standard 550/590. The exception was expected to generally be used in new construction and addition projects, though alterations were not explicitly prevented from using the exception in the proposal.

The current prescriptive requirement includes three exceptions: 1) projects are exempted from the current requirement at sites where the water quality fails to meet manufacturer's requirements for the use of water-cooled chillers, 2) for chillers that are used to charge a thermal storage system with a design temperature of less than 40°F, and 3) for systems serving healthcare facilities.

2.2 Energy and Water Savings Methodology

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

The energy and water savings analysis of the air-cooled threshold measure assesses the impacts of increasing the prescriptive 300-ton cooling capacity limitation for air-cooled chillers. To determine the impacts, comparisons between buildings compliant

[1] https://title24stakeholders.com/wp-content/uploads/2023/05/2025_T24_CASE-Report-DRAFT_Cooling-Tower-Efficiency-1.pdf.

with the existing 2022 Title 24, Part 6 Standards and buildings compliant with the proposed measure were examined. In practice, this took the form of comparing the water and energy used by a building with baseline minimally code-compliant water-cooled chillers and cooling towers to the same building with proposed air-cooled chillers. Performance of this method requires assumptions for water-cooled chiller performance, cooling tower performance, air-cooled chiller performance, and all related subsystems.

2.2.1 Energy Savings Methodology Detail

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

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

For the Proposed Design air-cooled chiller systems, several iterations of chiller design were modeled to identify the efficiency and capacity for which the measure is cost effective. Path B compliance was assumed for the Proposed Design air-cooled chillers to align with the prescriptive requirement in 2022 Tile 24, Part 6 140.4(i). Ultimately, the air-cooled chiller performance curves were updated to reflect a high efficiency chiller of 10.72 EER and 20.1 IPLV. All additional components and conditions were assumed to comply with the 2022 Title 24, Part 6 building code.

Additional detail regarding the energy savings methodology can be found in the 2025 Draft Cooling Towers CASE Report.

2.2.2 Water Cost Savings Methodology Detail

Water cost savings were calculated by applying water service charges ($/kgal) and sewer service charges ($/kgal) to the water savings estimates. Water and sewer service charges for the analysis were determined by collecting current rates from websites for water utilities serving the ten most populated cities in California and determining the population weighted average. Utility flat fees such as monthly meter charges were excluded from the survey as they will not be impacted by measure savings. Table 1 provides a summary of the water costs collected for each city and the population weighted averages used for the water cost savings in this report, $8.13/kgal for water service and $6.11/kgal for sewer service. Note that utilities typically provide volumetric service rates in dollars per hundred cubic feet of water ($/hcf or $/ccf) which were converted to dollars per kilogallon (kgal) to align with building model water savings outputs.[2]

Table 1: 2022-2023 Water utility service charges

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

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

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

savings, and to align with the 30-year life cycle energy cost methodology, a 3 percent discount rate was applied.

The Statewide CASE Team is aware of a CPUC Water-Energy Nexus calculator that could be further investigated and used in a future analysis.

2.3 Per-Unit Energy and Water Impacts Results

Prototypes for this measure were selected as those for which the Standard Design central plant consists of water-cooled chillers. The prototype buildings to be used in the Statewide CASE Team analysis are presented in Table 2. For the installation of an air-cooled chiller of 10.72 EER and 20.1 IPLV in OfficeLarge prototype, an energy penalty (i.e., negative electricity savings) was observed in all zones when compared to a water-cooled chiller plant. The Large Office prototype was chosen because it matches the building most likely to be impacted by this new exception, since 300 ton or less ACC systems are already prescriptively allowed in the Energy Code. Additional building types such as Medium Office, Large School, and Data Centers could be included in a future analysis. Per-unit savings for the first year are expected to range from negative 1.31 kWh/yr to negative 0.04 kWh/yr, depending upon climate zone. The analysis was conducted in 2023 using the 2025 Title 24 weather files. Demand reductions/increases are expected to range between -3.98 kW and 9.88 kW depending on climate zone.

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

Table 2: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

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

Per-unit energy and water savings and peak demand reductions are presented in Table 3.

Table 3: Large Office First Year Savings Per Square Foot by Climate Zone (CZ) – Air-Cooled Chiller Threshold

Climate Zone	Electricity Savings (kWh/sf)	Peak Demand Reduction (kW/sf)	Natural Gas Savings (kBtu/sf)	Source Energy Savings (kBtu/sf)	Long-term Systemwide Cost Savings (2026 PV$/sf)	Water Savings (gallons/sf)
CZ 1	-0.04	0	-0.01	-0.01	-0.2	0.27
CZ 2	-0.32	0	-0.02	-0.02	-1.26	2.49
CZ 3	-0.15	0	0	0	-0.6	1.23
CZ 4	-0.53	0	-0.02	-0.02	-2.34	3.78
CZ 5	-0.21	0	-0.01	-0.01	-0.86	1.59
CZ 6	-0.31	0	0	0	-1.39	2.89
CZ 7	-0.32	0	0	0	-1.5	3.11
CZ 8	-0.51	-0.01	0	0	-2.29	4.67
CZ 9	-0.52	-0.01	0	0	-2.38	4.47
CZ 10	-0.66	-0.01	0	0	-2.93	5.25
CZ 11	-0.68	-0.01	-0.01	-0.01	-3.01	5.17
CZ 12	-0.45	0	-0.04	-0.03	-1.94	3.68
CZ 13	-0.68	-0.01	-0.01	-0.01	-3.15	5.43
CZ 14	-0.73	0	-0.03	-0.02	-3.26	4.85
CZ 15	-1.31	-0.02	0	0	-6.12	9.85
CZ 16	-0.23	-0.01	-0.04	-0.04	-1.03	1.82

2.4 Energy and Water Cost Savings Results

Per-unit energy cost savings for newly constructed buildings and additions that are realized over the 30-year period of analysis are presented in 2026 present value dollars (2026 PV$) in Table 7 for the OfficeLarge prototype.

Table 4: 2026 PV Long-term Systemwide Cost Savings Over 30-Year Period of Analysis – Per Prototype Square Foot – New Construction – OfficeLarge Prototype

Climate Zone	30-Year LSC Electricity Savings (2026 PV$)	30-Year LSC Natural Gas Savings (2026 PV$)	Electricity and Natural Gas Total 30-Year LSC Savings (2026 PV$)	30-Year Lifecycle Water Cost Savings (PV$)
1	-0.19	-0.01	-0.20	0.18
2	-1.25	-0.01	-1.26	1.64
3	-0.60	0.00	-0.60	0.81
4	-2.33	-0.01	-2.34	2.49
5	-0.85	-0.01	-0.86	1.05
6	-1.39	0.00	-1.39	1.90
7	-1.51	0.00	-1.50	2.04
8	-2.29	0.00	-2.29	3.07
9	-2.38	0.00	-2.38	2.94
10	-2.93	0.00	-2.93	3.46
11	-3.01	-0.01	-3.01	3.40
12	-1.92	-0.02	-1.94	2.42
13	-3.14	-0.01	-3.15	3.57
14	-3.24	-0.02	-3.26	3.19
15	-6.12	0.00	-6.12	6.48
16	-1.01	-0.02	-1.03	1.20

2.5 Cost Effectiveness

Results of the per-unit cost-effectiveness analyses are presented in Table 5 for new construction/additions. The proposed measure saves money over the 30-year period of analysis relative to the existing conditions. The proposed code change is cost effective in every climate zone. Note that this measure is cost effective due to factoring in water cost savings to the benefits column, as well as the lower initial and ongoing maintenance costs for ACCs relative to WCCs and cooling towers. Additional detail regarding this aspect of the analysis was present in the draft 2025 Cooling Towers CASE report.

Table 5: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction/Additions

Climate Zone	Benefits - 30-Year Life Cycle Water Savings + Other PV Savings (2026 PV$)	Costs - LSC Savings +Total Incremental PV Costs (2026 PV$)	Benefit-to-Cost Ratio
1	$1.37	$0.24	5.60
2	$3.15	$1.28	2.45
3	$2.20	$0.65	3.41
4	$4.07	$2.39	1.70
5	$2.32	$0.87	2.66
6	$3.36	$1.43	2.34
7	$3.62	$1.55	2.33
8	$4.65	$2.34	1.99
9	$4.53	$2.43	1.87
10	$4.96	$2.97	1.67
11	$5.09	$3.06	1.66
12	$3.98	$1.99	2.00
13	$5.25	$3.17	1.66
14	$4.75	$3.30	1.44
15	$8.31	$6.16	1.35
16	$2.44	$1.08	2.26