Proposal Summary

2022 California Energy Code (Title 24, Part 6)

Nonresidential Data Center Efficiency

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Introduction

The document summarizes proposed revisions to the California Energy Code (Title 24, Part 6) that will be discussed during a utility-sponsored stakeholder meeting on October 15, 2019. The Statewide Utility Codes and Standards Enhancement (CASE) Team is seeking input and feedback. To provide your comments, email info@title24stakeholders.com by October 29, 2019.

Measure Description

The data center efficiency CASE Report will improve energy performance of data center mechanical and electrical systems by including the following submeasures:

- **Uninterruptible Power Supply (UPS) Efficiency**
  This submeasure proposes adding minimum UPS prescriptive efficiency requirements for Ac-output UPS units used in computer rooms to match EnergyStar minimum efficiency requirements. The minimum average UPS efficiency takes into account UPS efficiency at 100%, 75%, 50%, and 25% load factor.
- **Computer Room Heat Recovery**
  Computer rooms with airflow containment that are controlled to ASHRAE's allowable upper limit for server inlet temperature (80.6°F)[1] can see high return air temperatures, in many cases in excess of 95°F to 100°F. This high air temperature can be used for direct heating in forced air systems, ventilation preheating, or process load heating. This submeasure proposes a prescriptive requirement to recover computer room return air heat for heating other building heating loads. Analysis will determine the building system constraints and computer room cooling loads for which this measure is cost effective.
- **Monitoring**
  This submeasure proposes a prescriptive requirement for computer rooms of a minimum size to have metering installed to calculate Power Usage Effectiveness (PUE) and server utilization rates and provide this data to the building operator in an accessible manner. This measure will be evaluated to determine metering, network, and data dashboard display requirements.
- **Increased Temperatures**

[1] ASHRAE. *Thermal Guidelines for Data Processing Environments, Fourth Edition*, 2015.

- Title 24-2019 prescriptively requires computer rooms to economize 100% of the cooling load with an air economizer at outside air temperatures of 55°F drybulb/50°F wetbulb and below, or to economize 100% of the cooling load with a water economizer at outside air temperatures of 40°F drybulb/35°F wetbulb and below. This submeasure proposes increasing the minimum drybulb temperature for 100% economizing and simplifying the economizer requirement to a single outside air temperature condition of 65°F drybulb/50°F wetbulb for any economizer type.
- Title 24-2019 prescriptively requires airflow containment for air-cooled computer racks for rooms exceeding 175 kW/room. Airflow containment is widely implemented in data centers, and there are many containment products on the market that make containment viable and cost-effective even for small computer rooms. This submeasure proposes reducing the IT load threshold where containment is required to 35 kW/room.
- This submeasure proposes raising the supply air temperature (SAT)/ return air temperature (RAT) from 60°F/80°F to 70°F/90°F in the baseline compliance modeling software model to better match industry standard practice. Many data centers are designing for a server inlet temperature of nearly 80°F per ASHRAE *Thermal Guidelines for Data Processing Environments*, *Fourth Edition*, 2015.

- **Generator Crankcase Heating**
  This submeasure prescriptively requires generators serving computer rooms to be located in an indirectly conditioned space. Generators must have dampers on both intake and exhaust. The goal of this measure is to reduce generator crankcase heating energy through reduced heat loss to the outdoors and more efficient heating sources. There are many options for reducing crankcase heater energy including transferring data center relief air into the generator room before exhausting it to the outdoors or using heat pumps for heating. The ACM will include a baseline heater heating load (Btu/hr) and heater efficiency based on this prescriptive requirement and multiple design options ranging from heating via computer room heat recovery to a worst-case heater efficiency for generators located outdoors without an enclosure using electric resistance heating. Heater runtime will vary depending on the generator location (outdoors vs. enclosed) and climate.
- **Liquid Cooling Credit in Compliance Software**
  This submeasure proposes adding a compliance credit in the compliance modeling software for data centers that use liquid cooling at the server chip level. Using liquid cooling instead of the air-cooled server cooling reduces energy use by eliminating server fan energy and computer room air handler fan energy.
- **Mandatory Measures**
  The following Prescriptive Requirements in Title 24-2019 will become Mandatory Requirements:
  - 140.9(a)2: Reheat
  - 140.9(a)3: Humidification
  - 140.9(a)5: Fan Control.

Draft Code Language

The proposed changes to the Standards and Reference Appendices are provided below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions). Expected sections or tables of the proposed code (but not specific changes at this time) are highlighted in yellow.

Standards

10-102 – DEFINITIONS

ALTERNATING CURRENT-OUTPUT UNINTERRUPTIBLE POWER SUPPLY (UPS): An ac-output UPS is a UPS that supplies power with a continuous flow of electric charge that periodically reverses direction.

MODULAR UNINTERRUPTIBLE POWER SUPPLY (UPS): A Modular UPS is a UPS comprised of two or more single UPS units, sharing one or more common frames and a common energy storage system, whose outputs, in Normal Mode of operation, are connected to a common output bus contained entirely within the frame(s). The total quantity of single UPS units in a modular UPS equals "n + r" where n is the quantity of single UPS units required to support load; r is the quantity of redundant UPS units. Modular UPSs may be used to provide redundancy, to scale capacity, or both.

UNINTERRUPTIBLE POWER SUPPLY (UPS): Combination of convertors, switches, and energy storage devices (such as batteries) constituting a power system for maintaining continuity of load power in case of input power failure. Input power failure occurs when voltage and frequency are outside rated steady-state and transient tolerance bands or when distortion or interruptions are outside the limits specified for the UPS.

UNINTERRUPTIBLE POWER SUPPLY (UPS) NORMAL MODE: Stable mode of operation that the UPS attains under the following conditions:

a) Alternating current input power is within required tolerances and supplies of the UPS.
b) The energy storage system remains charged or is under recharge.
c) The load is within the specified rating of the UPS.
d) They Bypass is available and within specified tolerances (if applicable).

VOLTAGE AND FREQUENCY DEPENDENT (VFD) UNINTERRUPTIBLE POWER SUPPLY (UPS): A UPS that produces an Ac-output where the output voltage and frequency are dependent on the input voltage and frequency.

VOLTAGE AND FREQUENCY INDEPENDENT (VFD) UNINTERRUPTIBLE POWER SUPPLY (UPS): A UPS where the device remains in normal mode producing and ac-output voltage and frequency that is independent of input voltage and frequency variations and protects the load against adverse effects from such variations without depleting the stored energy source.

VOLTAGE INDEPENDENT (VI) INTERRUPTIBLE POWER SUPPLY (UPS): A UPS capable of protecting the load as required for a Variable Frequency Dependent UPS and from under-voltage applied continuously to the input and over-voltage applied continuously to the input.

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

(a) Prescriptive Space Conditioning Requirements for Computer Rooms. Space conditioning systems serving a computer room with a power density greater than 20 W/ft^2 shall comply with this section by being designed with and having constructed and installed a cooling system that meets the requirements of Subsections 1 through ~~6~~5. Energy use from prescriptive computer room requirements can only be traded off among other computer room requirements.

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

A. An integrated ~~air~~ economizer capable of providing 100 percent of the expected system cooling load as calculated in accordance with a method approved by the Commission, at outside air temperatures of ~~56~~5°F dry-bulb/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 100 percent of the expected system cooling load as calculated in accordance with a method approved by the Commission, at outside air temperatures of 40°F dry-bulb/35°F wet-bulb and below.~~

EXCEPTION 1 to Section 140.9(a)1: Individual computer rooms under 5 tons in a building that does not have any economizers.

EXCEPTION 2 to Section 140.9(a)1: New cooling systems serving an existing computer room in an existing building up to a total of 50 tons of total cooling equipment capacity serving the computer room of new cooling equipment per building.

EXCEPTION 3 to Section 140.9(a)1: New cooling systems serving a new computer room in an existing building up to a total of 20 tons of total cooling equipment capacity serving the computer room of new cooling equipment per building.

EXCEPTION 4 to Section 140.9(a)1: A computer room with a design cooling load less than 50 tons may be served by a 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; and~~

~~i~~i. The economizer system has the ability to serve only the computer room, e.g. shut off flow to other spaces within the building when unoccupied; and

ii. The economizer system can deliver either (a) the design computer room load, or (b) the available economizer capacity, to the computer room at all times. Available economizer capacity is the total cooling capacity of the economizer system on the same floor as the computer room and within 30 ft of the computer room minus the current cooling load of other spaces on that floor.

iii. The economizer system can deliver either (a) the design computer room load, or (b) at least 5 tons, to the computer room when there is no cooling load in other spaces on the floor.

~~iii. The noneconomizer system does not operate when the outside air drybulb temperatures is below 605°F and, the cooling load of other spaces within the building served by the economizer system is less than 50 percent of design load.~~

EXCEPTION 5 to Section 140.9(a)1: Computer rooms where at least 80% of annual computer room heat output is recovered by a heat recovery system with a heating COP at design conditions of at least 4.0. This includes recovering heat from the computer room for use by industrial processes outside of the building.

~~2. **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.~~

~~3. **Humidification.** Nonadiabatic humidification (e.g. steam, infrared) is prohibited. Only adiabatic humidification (e.g. direct evaporative, ultrasonic) is permitted.~~

42. **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.

~~5. **Fan Control.** Each unitary air conditioner with mechanical cooling capacity exceeding 60,000 Btu/hr and each chilled water fan system shall be designed to continuously vary the airflow rate as a function of actual load and shall have controls and/or devices (such as two-speed or variable speed control) that will result in fan motor demand of no more than 50 percent of design wattage at 66 percent of design fan speed.~~

63. **Air Containment.** Computer rooms with air-cooled computers in racks and with a design load exceeding ~~175~~ 35 kW/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)~~6~~3: Expansions of existing computer rooms.

EXCEPTION 2 to Section 140.9(a)~~6~~3: Computer racks with a design load less than 1 kW/rack.

EXCEPTION 3 to Section 140.9(a)~~6~~3: Equivalent energy performance based on computational fluid dynamics or other analysis.

4. **Heat Recovery.** A computer room with a total design IT load exceeding 500 kW located in a building with a design comfort or process heating load of over 500 kW shall have a heat recovery system capable of transferring at least 50% of the design IT load or at least 50% of the design heating load from the computer room to the space or process requiring heating.

   The heat recovery system shall have a heating coefficient of performance (COP) of at least 4.0 at design conditions. The heat recovery system consists of the energy consuming mechanical equipment (pumps, fans, etc.) which has a dedicated function of transferring heat from the computer room to a heating load. Heating COP = heat transfer in kW divided by total power of dedicated heat recovery equipment input power in kW.

   EXCEPTION 1 to Section 140.9(a)4: Buildings that use heating equipment with a design COP of 3.5 or greater, where COP equals design heating load in kW divided by the total input power of the heating equipment.

5. **Generator Crankcase Heating**. Generators serving computer rooms are required to be located in enclosures with a wall insulation U-value no greater than that for Heavy Mass Walls in Section 120.7(b). Generators must have dampers on both radiator intake and radiator exhaust. Generator crankcase heaters are required to be thermostatically controlled.

   EXCEPTION 1 to Section 140.9(a)5: Thermostatic controls are not required for generator heating provided by recovered heat.

(b) Prescriptive Uninterruptible Power Supply (UPS) Requirements for Computer Rooms. Alternating Current (Ac)-output uninterruptible power supply systems serving a computer room shall comply with Subsections 1 and 2 below. Energy use from prescriptive computer room requirements can only be traded off among other computer room requirements.

1. Uninterruptible Power Supply Efficiency. Ac-output UPS units must meet or exceed the efficiencies in Table 140.9-XX.

***Table 140.9 – XX** Minimum Average UPS Efficiency (Eff_{ave}):*

Rated Output Power ("P")	Voltage and Frequency Dependent (VFD)	Voltage Independent (VI)	Voltage and Frequency Independent (VFI)
P ≤ 350W	$5.71 * 10^{-5} * P + 0.962$	$5.71 * 10^{-5} * P + 0.964$	$0.011 * LN(P) + 0.824$

350W < P ≤ 1500W	0.982	0.984	
1,500W < P ≤ 10,000W	0.981 - E_{MOD}	0.980 - E_{MOD}	0.0145 * LN(P) + 0.800 - E_{MOD}
P > 10,000W	0.970	0.940	0.0058 * LN(P) + 0.886

Where $Eff_{ave} = t_{25\%}*Eff_{25\%} + t_{50\%}*Eff_{50\%} + t_{75\%}*Eff_{75\%} + t_{100\%}*Eff_{100\%}$

$Eff_{xx\%}$ = UPS efficiency at *xx*% load
$t_{xx\%}$ = proportion of time spent at *xx*% load
E_{MOD} = allowance of 0.004 for Modular UPSs applicable in the 1500–10,000W range.
LN = natural log

Inputs for $t_{xx\%}$ follow the table below.

Rated Output Power ("P"), Watts	**Input Dependency Characteristic**	**25% Load**	**50% Load**	**75% Load**	**100% Load**
P ≤ 1,500W	VFD	0.2	0.2	0.3	0.3
	VI or VFI	0.0	0.3	0.4	0.3
1,500W < P ≤ 10,000W	VFD, VI, or VFI	0.0	0.3	0.4	0.3
P > 10,000W	VFD, VI, or VFI	0.25	0.5	0.25	0.0

2. Testing. UPS efficiency shall be tested and calculated in accordance with ENERGY STAR Program Requirements for Uninterruptible Power Supplies (UPSs) - Eligibility Criteria Version 2.0.

(c) Prescriptive Monitoring Requirements for Computer Rooms. Computer rooms shall have monitoring systems that comply with Subsections 1 and 2 below. Energy use from prescriptive computer room requirements can only be traded off among other computer room requirements.

1. **Power Usage Effectiveness (PUE) Monitoring.** Computer rooms exceeding 200 kW/room of design IT load and where at least 50% of the total building cooling capacity serves computer rooms shall include a power usage effectiveness monitoring system with the following minimum requirements:

    a. True root mean square (RMS) power measurements of total computer room IT power demand and total building power demand. IT power shall be measured immediately downstream of any UPS, such that UPS losses are not included in IT energy.

    b. Data transfer on a server capable of trending and storing data for a minimum of 18 months, with data collected at 15-minute intervals or less.

    c. Time series plots of hourly, daily, and monthly cumulative PUE are displayed on a visual dashboard visible to the building operator. Cumulative PUE is equal to total building cumulative kWh in the time period divided by total cumulative IT kWh in that time period.

2. **Server Utilization Monitoring.** Computer rooms exceeding 200 kW/room of design IT load shall include a server utilization monitoring system with the following minimum requirements:

    a. [Data measurement requirements]

    b. [Data storage requirements]

    c. [Data display requirements]

EXCEPTION to Section 140.9(a-c): Computer rooms located in healthcare facilities.

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

Nonresidential, high-rise residential, and hotel/motel buildings shall comply with the applicable requirements of Sections 120.6(a) through 120.6(~~g~~h).

(h) **Mandatory Requirements for Computer Rooms**
Space conditioning systems serving a computer room with a power density greater than 20 W/ft2 shall comply with this section by being designed with and having constructed and installed a cooling system that meets the requirements of Subsections 1 through 3:

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.** Nonadiabatic humidification (e.g. steam, infrared) is prohibited. Only adiabatic humidification (e.g. direct evaporative, ultrasonic) is permitted.

3. **Fan Control.** Each unitary air conditioner with mechanical cooling capacity exceeding 60,000 Btu/hr and each chilled water fan system shall be designed to continuously vary the airflow rate as a function of actual load and shall have controls and/or devices (such as variable frequency drives or electronically commutated motors) that will result in fan motor demand of no more than 50 percent of design wattage at 66 percent of design fan speed.

Reference Appendices

The following Reference Appendices will be modified:

- JA1: new sections added for PUE Monitoring Acceptance Test and Server Utilization Acceptance Test
- NA7.5: modifications made for data center heat recovery and containment