TITLE 24, PART 6 | 2028 CODE CYCLE

Welcome to the Statewide CASE Team's Utility Sponsored Stakeholder Meeting

Topic: Data Center Efficiency Improvements

Presenters:

Hillary Weitze, Red Car Analytics

Jeff Stein, Taylor Engineers

March 17, 2026

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Summary of Proposed Code Changes for Computer Rooms

1. **Mandatory Requirements: Revised Threshold for Variable-Speed Fan Control (120.6)**

2. **Prescriptive Requirements: Economizer Requirement Updates (100.1, 140.9, 141.1)**
   - 2.1 New Computer Room Integrated Economizer Definition
   - 2.2 Revised Drybulb / Wetbulb Econ Thresholds
   - 2.3 New Liquid-Cooled ITE Economizer Threshold
   - 2.4 New Differential Temperature and Variable Flow Requirements
   - 2.5 New Economizer Exception for Heat Recovery
   - 2.6 Revised Additions/Alterations Economizers

3. **Prescriptive Requirements: New Heat Recovery Requirement (140.9)**

4. **Revised ACM Modeling Rules**

See Title24stakeholders.com
for proposal description, justification, draft code language, and requested data
https://title24stakeholders.com/wp-content/uploads/2025/09/2028-T24-Measure-Summary_Data-Centers-Efficiency-Improvements-HVAC.pdf

1. Revised Computer Room Fan Control Measure Summary

Existing Code Language

- **2025 120.6(j)3:** Unitary air conditioners exceeding 60,000 Btu/hr cooling capacity shall vary airflow as a function of load

Proposed Code Language

- **2028 120.6(j)3:** Direct Expansion air conditioners exceeding 30,000 Btu/hr cooling capacity shall vary airflow as a function of load

Background/Justification

- Since 60,000 Btu/hr threshold was introduced in 2013, variable-speed fans have become much more common and cost-effective in smaller capacity cooling units, especially through the use of electronically commutated motor (ECM) fans.
- Proposed change would expand variable airflow requirement to many small IT rooms, such as IDF rooms.

1. Energy and Cost Analysis – Revised Computer Room Fan Control

- **Analysis Assumptions:**
  - **Climate Zones:** All
  - **Building Types:** Hospital, Large office, Medium Office, Small Office, Large School, Small School
  - **Computer Rooms (% of Prototype ft^2):** Hospital – 1%, Other Building Types - 0.5%
  - **System Type:** 45,000 Btu/hr direct expansion cooling unit
  - **ITE Load Density:** 30 W/ft^2; load changes between 25%, 50%, 75%, and 100% monthly

- **Base Case:** Single-Speed Fan (AF or BI Riding the Curve, Appendix 5.7 from CBEC-Com)
- **Proposed Case:** Variable-Speed Fan (VFD OR ECM, Appendix 5.7 from CBEC-Com)

1. Cost Effectiveness – Revised Computer Room Fan Control

- Electronically commutated motors (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.
- This is anticipated to be a conservative estimate as ECMs are standard practice in many cases for computer room air conditioners, and the incremental cost would be $0 in those cases. **Does audience agree with these assumptions?**
- Incremental maintenance costs: $0

Incremental First Cost for 1.22 hp Fan Motor

Scenario	First Cost
Baseline Design: 1.22-hp fan permanent split capacitor motor (single speed)	$175
Proposed Design: 1.22-hp fan with ECM (variable speed)	$450
Incremental Cost: Proposed Design minus Baseline Design	$275

Benefit-to-Cost Ratio: > 1.0

Sources: Various national manufacturers and product cost sheets

2.1 Computer Room Economizer Definition

Current T24-2025 Computer Room Economizer:

- air econ capable of 100% cooling at 65°F DB / 50°F WB (at SAT 65°F to 80.6°F), or
- water econ capable of 100% cooling at 50°F DB / 45°F WB (at SAT 65°F to 80.6°F)

ECONOMIZER, AIR, is a ducting arrangement, including dampers, linkages, and an automatic control system that allows a cooling supply fan system outside air to reduce or eliminate the need for mechanical cooling.

ECONOMIZER, WATER, is a system by which the supply air of a cooling system is cooled directly or indirectly by evaporation of water in order to reduce or eliminate the need for mechanical cooling.

Current code not clear:

- Is an air-cooled chiller with econo-coil an air econ or water econ or neither?
- Dry cooler?
- Refrigerant economizer?
- Liquid cooling?

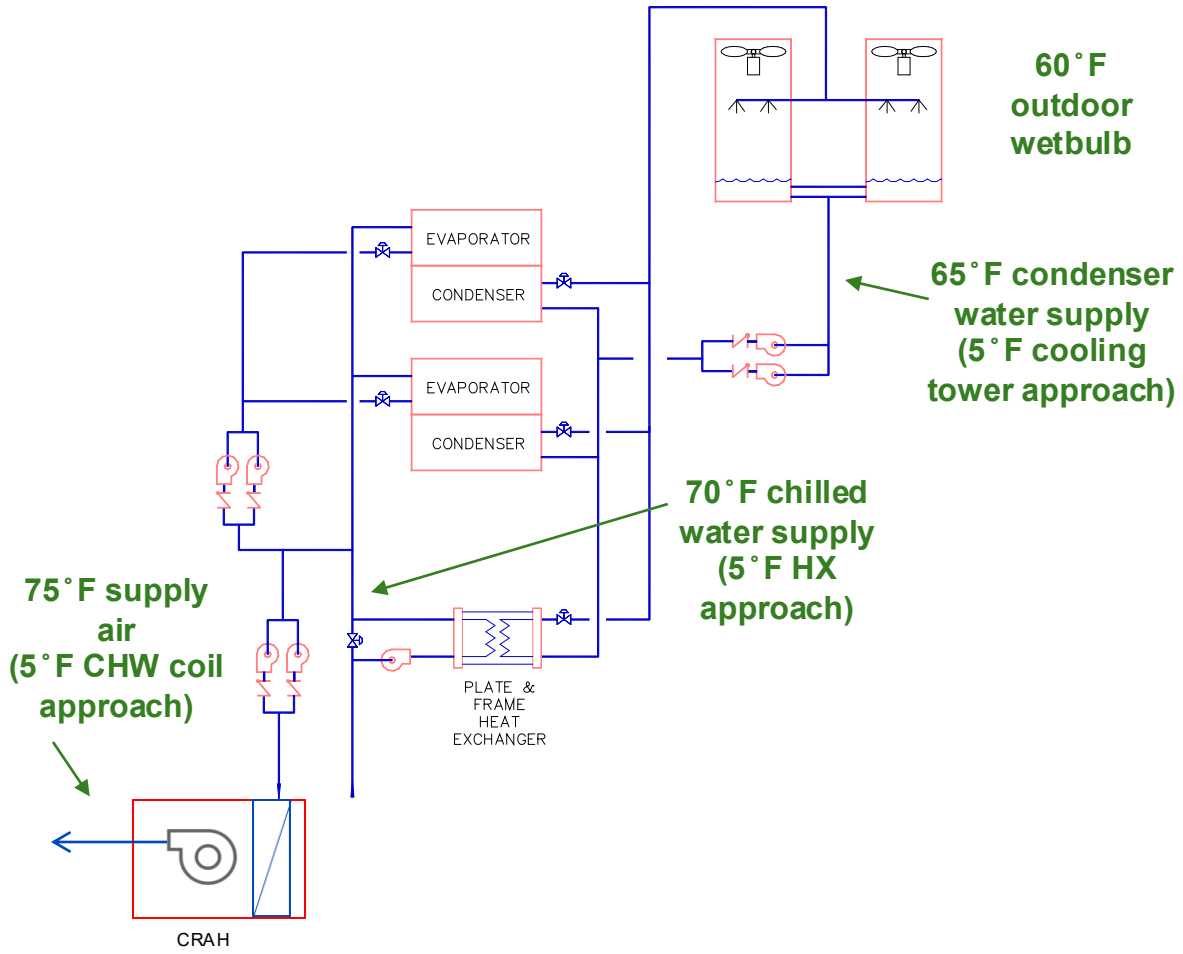
2.1 New Computer Room Economizer Definition

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.

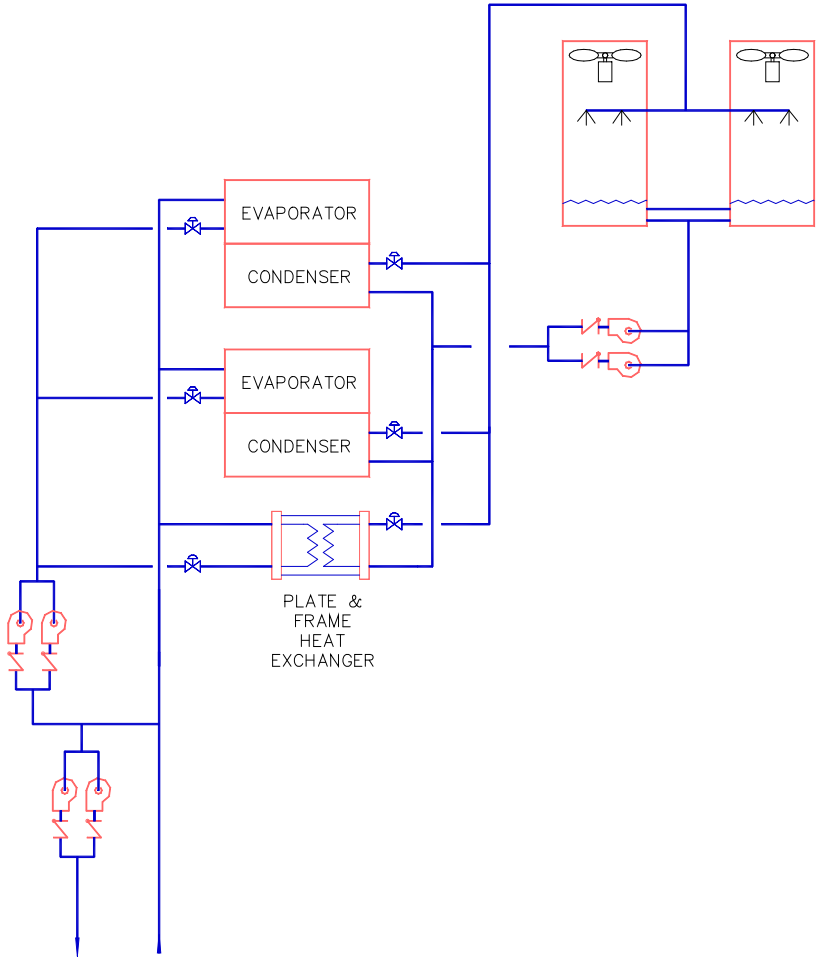
1. DO meet the criteria:
   - Waterside economizer heat exchangers piped in series with chillers on the chilled water side.
   - Air-cooled chillers with integrated economizer coils that are piped into the secondary circuit of a primary/secondary system. The fans serving the integrated economizer coils must be able to modulate speed without being limited by the need to maintain a minimum refrigerant head pressure.
   - 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% 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.
2. DO NOT meet the criteria:
   - Waterside economizer heat exchangers piped in parallel with chillers on the chilled water side.
   - 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.
   - 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.
   - Refrigerant economizer systems with one or more refrigerant circuits that must switch from refrigerant compressor operation to refrigerant pump operation.

2.1 Integrated Economizer: Waterside Economizer Examples for Air-Cooled ITE

Compliant configuration (waterside economizer HX piped in series with evaporator); meets proposed 60F outdoor wetbulb threshold for full economizing

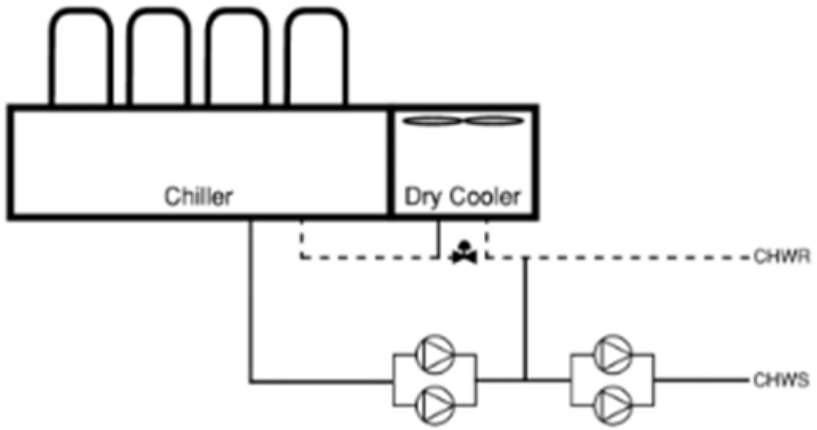


Non-compliant configuration (waterside economizer HX piped in parallel with evaporator)

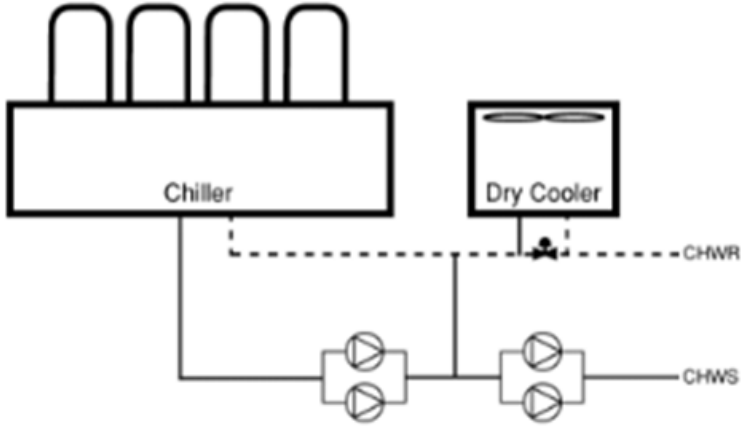


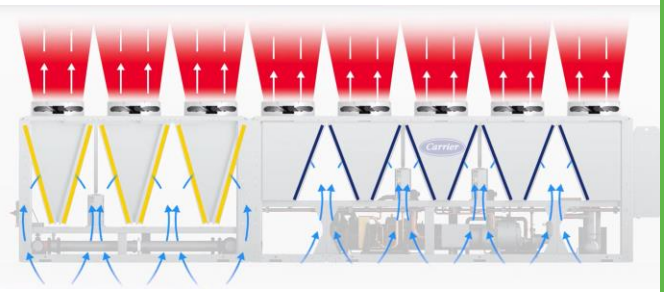
2.1 Integrated Economizer: Air-Cooled Chillers

Non-compliant (air-cooled chiller with dry cooler piped into primary circuit)

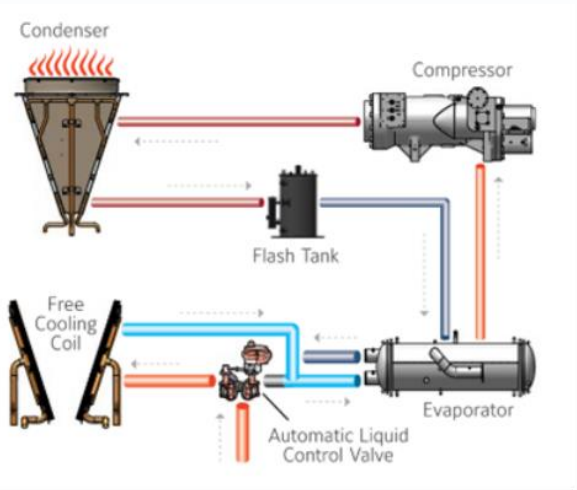


Potentially **compliant** (air-cooled chiller with dry cooler piped into secondary circuit)





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



2.2 Revised Economizer Thresholds

Current T24-2025:

- air econ capable of 100% cooling at 65°F DB / 50°F WB (at SAT 65°F - 80.6°F), or
- water econ capable of 100% cooling at 50°F DB / 45°F WB (at SAT 65°F - 80.6°F)

Proposed T24-2028:

- computer room econ capable of 100% cooling at following ambient (at SAT of 75°F)

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

2.2 Lifecycle Cost Analysis (LCCA) for Revised Wetbulb Econ Threshold

- Modeled standalone data center with CHW CRAHs with waterside economizer
- Approach from OAWB to SAT = CT approach + HX approach + CRAH coil approach
- Base Case approach from OAWB to SAT = 30°F (45°F OAWB to 75°F SAT)
- Proposed approach = 15°F (60°F OAWB to 75°F)
- Worked with equipment suppliers and contractors to determine total incremental cost

Description	CRAH Coil	WSE HX	Cooling Tower	Total	CRAH Total Static
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		
Total incremental cost / kW of capacity	$35.68	$13.96	$84.80	$134.44	

Percentage of Time in Economizing Only Mode by Climate Zone

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

2.2 Lifecycle Cost Analysis (LCCA) for Revised Wetbulb Econ Threshold (Summary Per kW of ITE)

Without chiller downsizing…

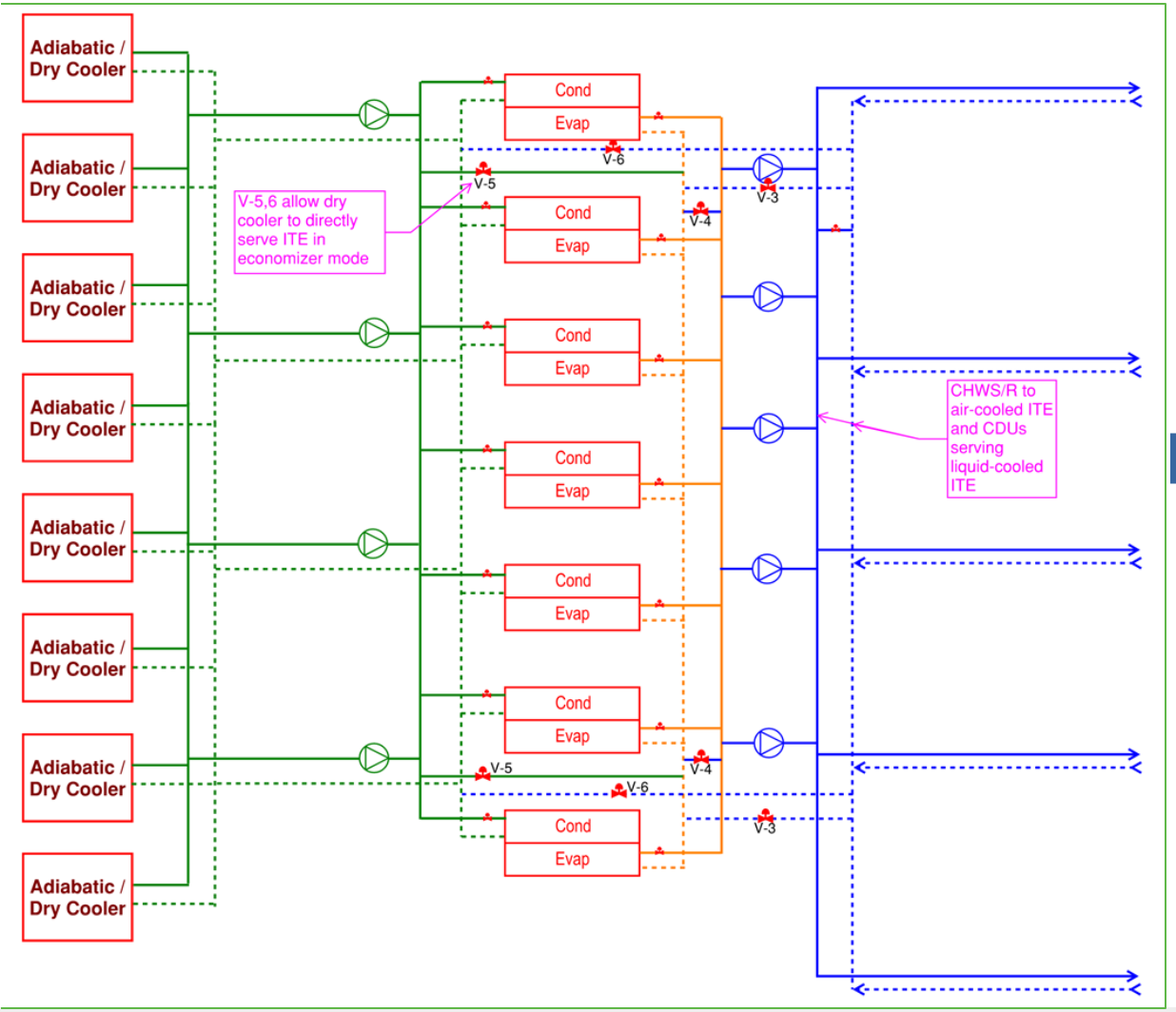
Climate Zone	CZ09	CZ12	CZ07	CZ04
Weather file	Los Angeles	Sacramento	San Diego	San Jose
Base Case (30F Approach) energy cost	$3,065	$2,780	$3,189	$2,670
Proposed (15F Approach) energy cost	$2,109	$2,039	$2,144	$1,987
Lifecycle Energy Cost Savings	$956	$741	$1,045	$684
Incremental first cost	$134	$134	$134	$134
NPV of Incr. Maint and Replacement	$74	$74	$74	$74
B/C ratio	4.6	3.5	5.0	3.3

With chiller downsizing…

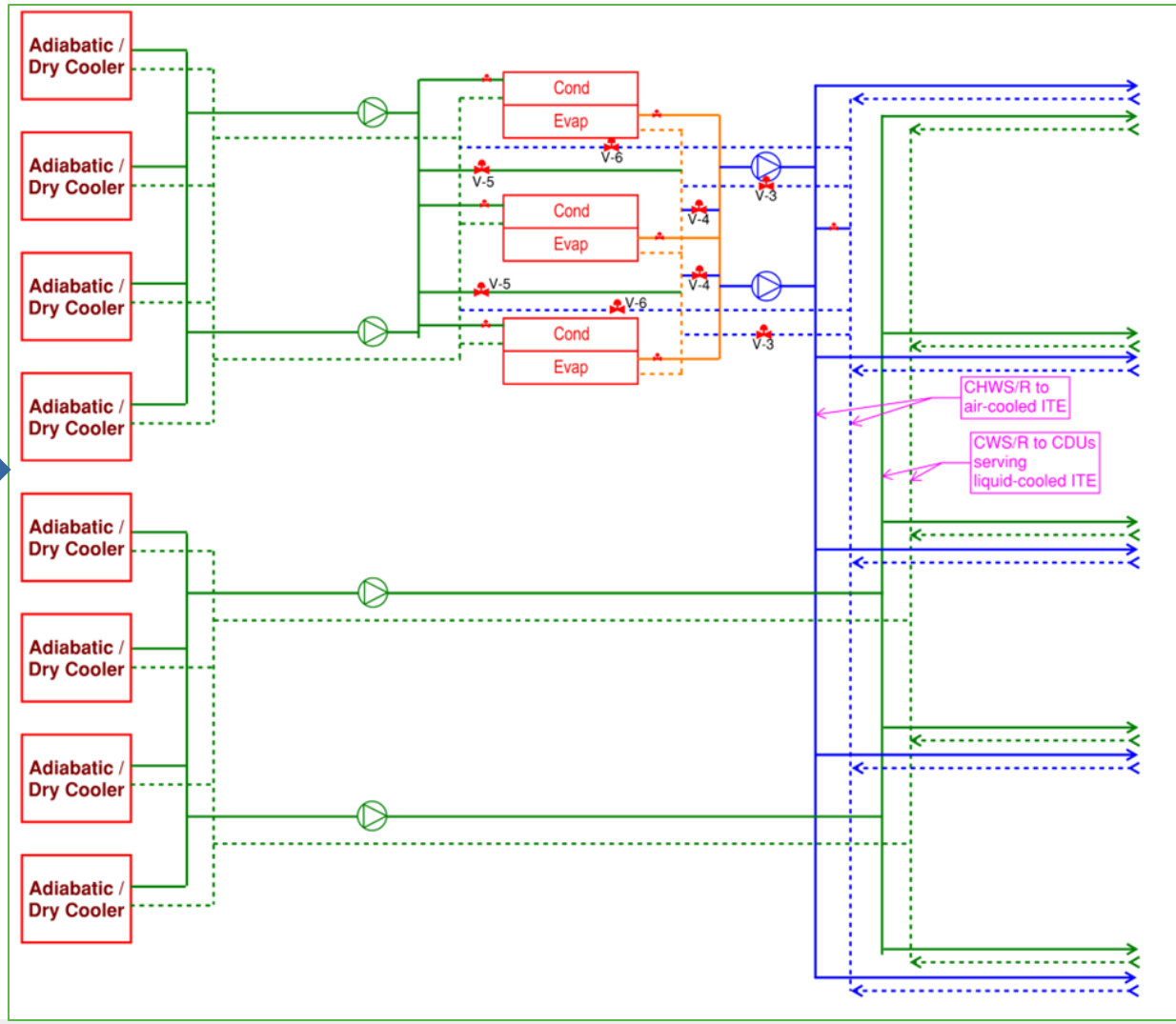
Climate Zone	CZ09	CZ12	CZ07	CZ04
Weather file	Los Angeles	Sacramento	San Diego	San Jose
20yr extreme WB	77.3	77.3	76.8	75
50yr extreme WB	78.4	78.6	78.2	76.5
baseline 0% free cooling at WB of	65	65	65	65
proposed 0% free at WB of	80	80	80	80
chiller cap at 20 yr extreme	87%	87%	84%	75%
chiller cap at 50 yr extreme	92%	93%	91%	83%
percent chiller reduction at 50yr	8%	7%	9%	18%
first cost savings for chiller	$45.30	$39.64	$50.97	$99.10
net first cost	$89.14	$94.80	$83.47	$35.34
B/C with chiller cost savings	5.8	4.4	6.6	6.2

2.3 New Liquid-Cooled ITE Economizer Threshold – Practical Implication

Non-compliant: single plant sending 70°F FWS to CRAHs and CDUs



Compliant: Separate LC plant: 75°F OADB→90°F FWS to CDU → 95F TCS to LC ITE



2.3 LCCA for New Liquid-Cooled ITE Economizer Threshold - Cost

- Started with actual 8.5 MW data center in Bay Area with two plants:
  - Cooling towers → Bag Filters → CW → CDUs (6.5 MW)
  - Cooling towers → Chillers / HXs → CHW → CRAHs (2.0 MW)
- Redesigned the data center for single plant (baseline):
  - Cooling towers → Chillers / HXs → CHW → CDUs + CRAHs
- Had mechanical and electrical contractors price the redesign.
- Baseline (single plant) higher costs for:
  - Chillers, CTs, HX, basket strainers, bag filters
  - Generators
- Proposed (separate plants) higher costs for:
  - CW and CHW distribution piping
- Net incremental cost is negative (separate plants costs less)

Proposed Case vs. Baseline Case Incremental Cost Savings: Cooling Tower Scenario

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)

2.3 LCCA for New Liquid-Cooled ITE Economizer Threshold - Energy

Analysis Assumptions:

- 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: 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

Partial PUE of Cooling Tower Scenario (San Jose)

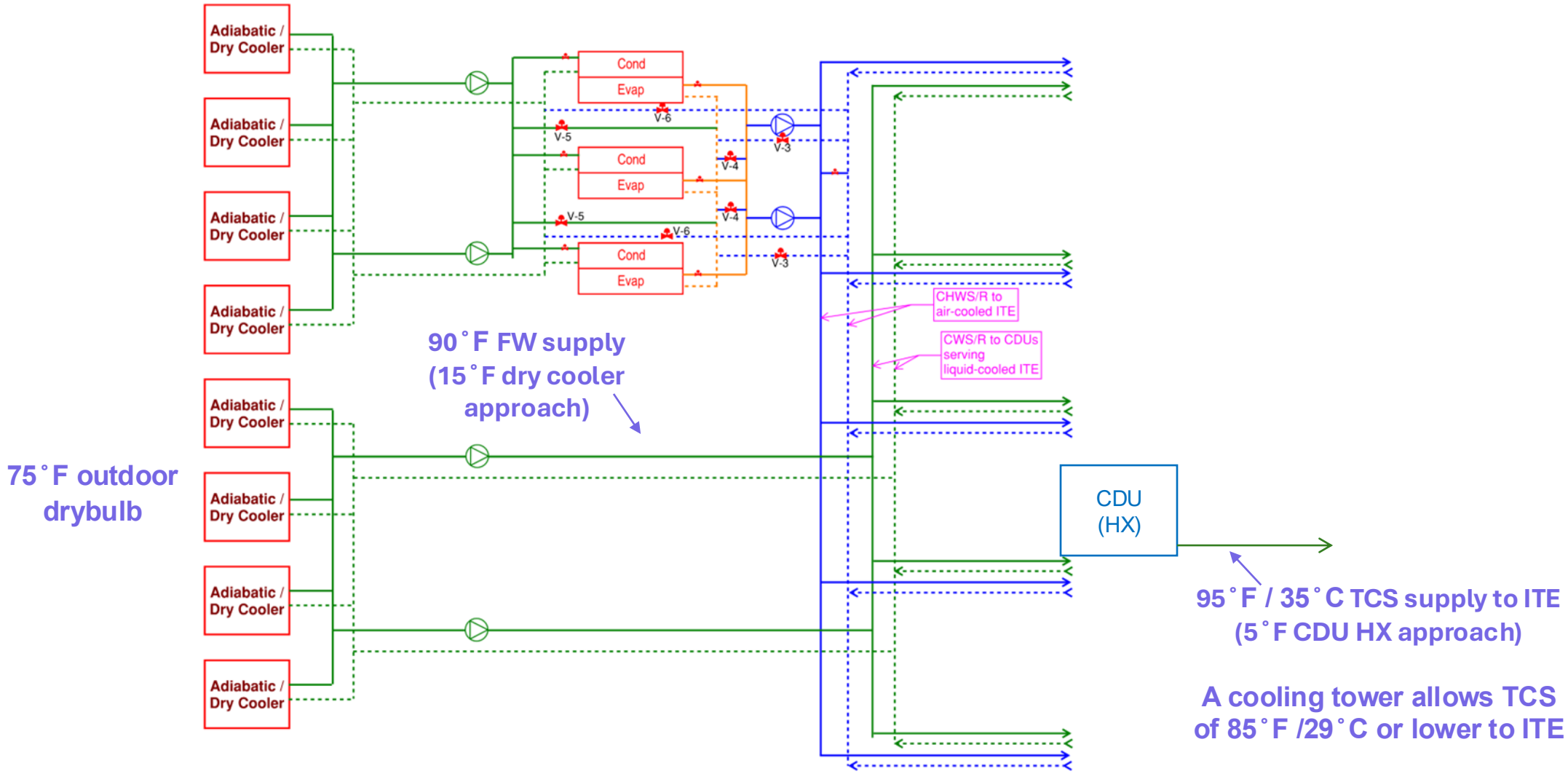
Simulation #	Description	Partial PUE (Chiller, Cooling Tower, Pump)
1A – Base Case	Combined Plant with low LWT for all	1.031
1B – Base Case	Combined Plant with high LWT, then Chillers cool to low LWT for RDHXs	1.043
2 – Proposed	Separate 1B (tower-only) Plant for CDUs; Separate 1A Plant for RHDX	1.023

Partial PUE of Dry Cooler Scenario (San Jose)

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 (dry cooler only) Plant for CDUs; Separate 1A Plant for RHDX	1.031

2.3 Liquid-Cooled ITE Economizer Schematic Example

Proposed for buildings with >2 MW of liquid-cooled ITE



2.4 New Differential Temperature (dT) and Variable Flow Requirement

- Air handling systems > 30,000 Btu/h
  - Return to supply air dT of at least 20F
  - Vary airflow as a function of ITE load
  - Minimum airflow ≤25% of design airflow
  - Constant dT at ITE loads from 25% to 100%
- Chilled water and facility water systems
  - Return to supply fluid dT of at least 15F
  - Vary fluid flow as a function of ITE load
  - Constant dT at ITE loads from 25% to 100%

2.5 New Economizer Exception for Heat Recovery

- **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:
  - 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
  - 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 the design heating load of the space heating system and/or service water heating system to which the heat is transferred is at least 5 times greater than the computer room design cooling load.

2.6 Revised Additions/Alterations Economizers (141.1(b)1)

- ~~Air econ capable of 100% cooling at 55°F DB / 50°F WB, or~~
- ~~Water econ capable of 100% cooling at 40°F DB / 35°F WB~~
- Meet 140.9(a)1 (e.g. 65°F DB / 60°F WB for low density air-cooled ITE)
  - Exception 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
  - ~~Exception 2: New systems serving existing computer room ≤ 50 tons~~
  - ~~Exception 3: New systems serving new computer room in existing building ≤ 20 tons~~
  - Exception 2: New systems serving existing computer room where:
    - 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
    - New cooling system includes economizer capable of 100% cooling at the following:

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

3. New Computer Room Heat Recovery Measure (140.9(a)5)

Prescriptively require heat recovery for new buildings with:

- Total computer room ITE load > 100 kW; and
- Non-computer room floor area > 35,000 ft^2.

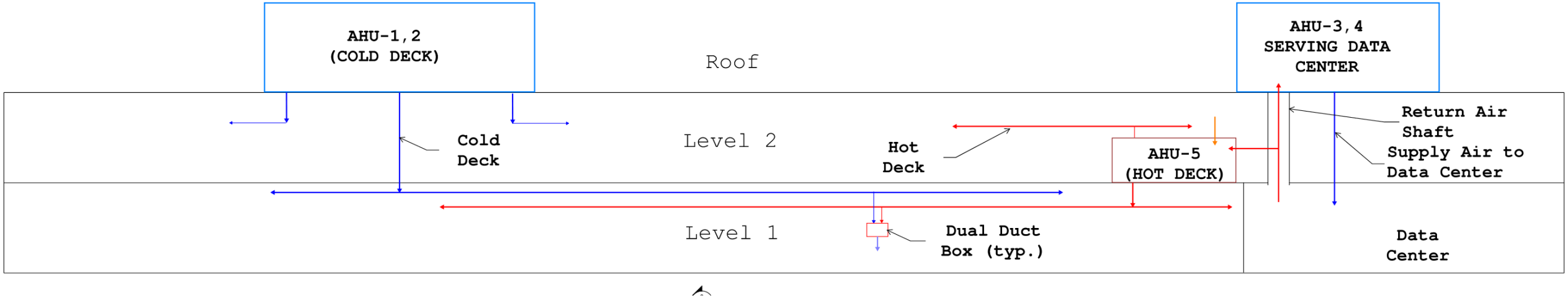
Heat recovery system capacity must be lesser of:

- 0.25 x peak heat rejection of computer room cooling system
- 0.25 x (space heating system capacity + SWH system capacity)

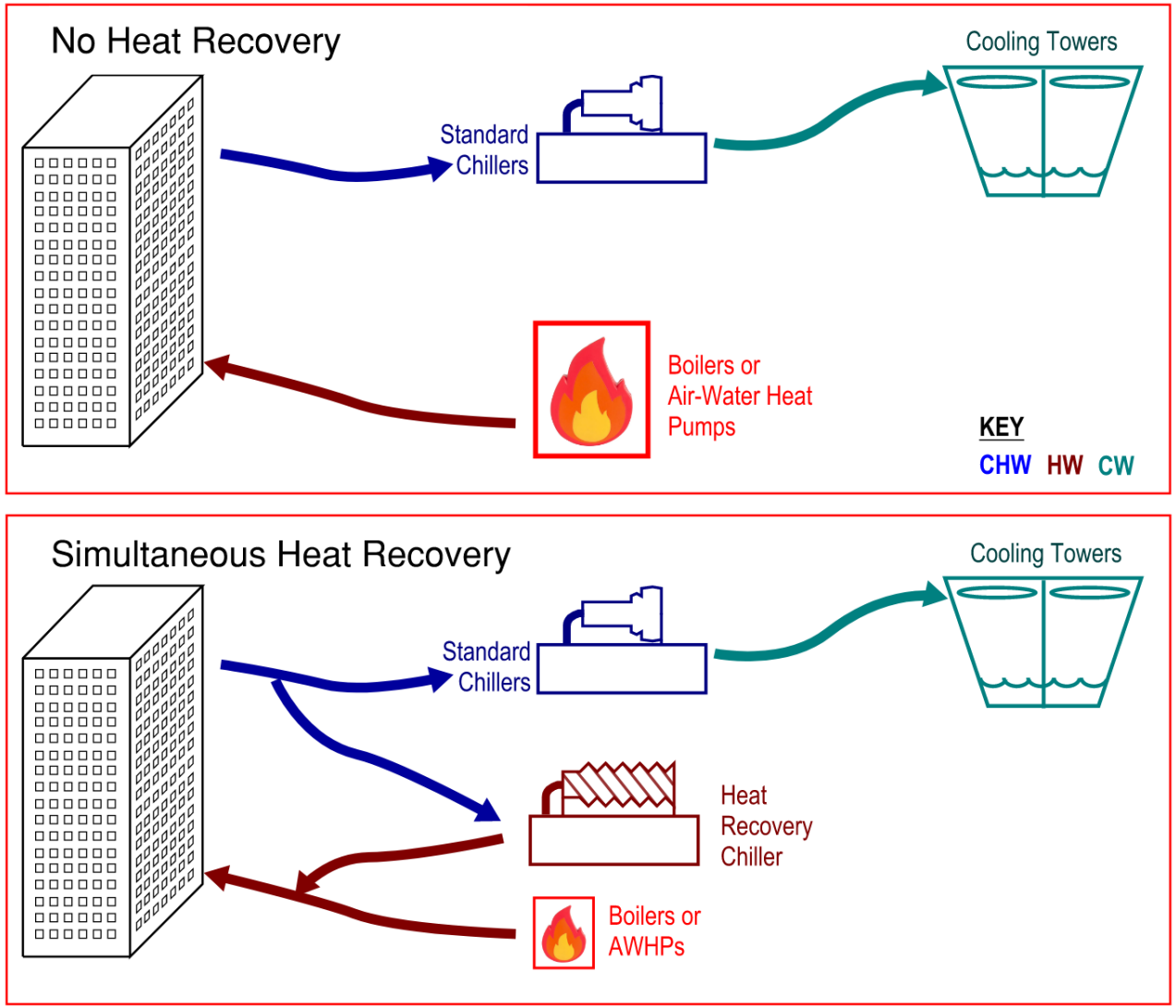
Background/Justification

- Computer rooms can provide consistent sources of efficient, low carbon heating for building heating loads
- There are many system options to comply including:
  - Heat recovery water-to-water chillers
  - 4-pipe (heat recovery) air-source heat pumps
  - Dual-Fan-Dual-Duct air transfer to hot deck
  - Water-source heat pumps

3. Computer Room Heat Recovery Example: Dual Fan / Dual Duct



3. Computer Room Heat Recovery Example: HR Chiller



3. Energy and Cost Analysis - Computer Room Heat Recovery

Analysis Assumptions:

- **Climate Zones:** 3,4,9,12
- **Building Type:** Medium office building 53,628 sq.ft. with a 100-kW computer room
- **Base Case:**
  - Dual Fan Dual Duct (DFDD) system
  - Air-to-water heat pump (AWHP) serves as primary heating source to HW coil in hot deck (sized for full capacity)
  - No heat recovery system is assumed - DFDD air handling unit (AHU) mixing section not included
- **Proposed Case:**
  - Dual Fan Dual Duct (DFDD) system
  - Air-to-water heat pump (AWHP) serves as backup heating source to HW coil in hot deck (sized for full capacity)
  - Computer room return air ducted to hot deck AHU mixing section to supply heat to office as primary heating source

3. Incremental Costs – Computer Room Heat Recovery

- A local mechanical contractor provided a quote to install heat recovery per the scope described in the heat recovery analysis (previous slide).
- Pricing includes 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.

Heat Recovery Incremental First 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	$44,250
Total First Cost ($/ft2)	$1.26

Sources: Local Bay Area mechanical contractor

4. Revised ACM Modeling Rules – Heat Recovery in Baseline

For non-residential buildings that trigger the prescriptive computer room heat recovery requirement:

- Hourly heating load in every zone/system is reduced by the available heat recovery capacity which is smallest of:
  - 0.25 x total design ITE load
  - 0.25 x capacity of space heating and SWH systems

4. Revised ACM Modeling Rules – New System Map for Computer Rooms

Current T24-2025:

- Comp Rooms > 800 kW → System 10 = CHW CRAHs with air econ, chillers, cooling towers
- Comp Rooms ≤ 800kW → System 11 = SZVAV packaged DX with air econ

Proposed T24-2028:

System	Serves…	Design / Controls
11a (W/C Chillers / Dry Cooler Econ)	Air-Cooled ITE in computer room with total ITE load > 200 kW and with average air-cooled ITE power density > 25 kW/rack Liquid-Cooled ITE in buildings with a design liquid-cooled ITE load ≤ 2 MW	• 100% econ at 55°F OADB (15°F dry cooler approach, 5°F CRAH approach, includes redundancy) • No WSE HX (dry coolers can serve CRAHs) • Dry cooler maintains SAT of 75°F • Chillers maintain SAT of 80°F
11b (High Temp W/C Chillers / Dry Cooler Econ)	All liquid-cooled ITE in buildings with a design liquid-cooled ITE load > 2 MW	• 100% econ at 75F OADB (15°F dry cooler approach, 5°F CDU approach, includes redundancy) • No WSE HX (dry coolers can serve CRAHs) • Dry cooler and chillers maintain TCS = 95°F
11c (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	• Same as System 10 but no economizer
10 (A/C Chillers / Air Econ)	All other ITE prescriptively required to have an economizer	• SAT: 70°F • RAT: 90°F • Differential drybulb economizer

Aniruddh Roy
Energy Solutions
aroy@energy-solution.com

Jeff Stein
Taylor Engineers
jstein@taylor-engineering.com

Hillary Weitze
Red Car Analytics
hillary@redcaranalytics.com

Please copy: info@title24stakeholders.com

More information on
CEC's 2028 proceeding website.

We want to hear from you!

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM