Welcome to the California Statewide Codes and Standards Enhancement (CASE) Team's Stakeholder Meeting on

Nonresidential HVAC Part 1.

We'll get started shortly.

In the meantime, please fill out the polls below.

Welcome: Connect Your Audio

Audio – there are **three** options for connecting to the meeting audio:

To view options, click on the icon on the top ribbon, then select *Connect My Audio.*

1. **Dial-out:** receive a call from the meeting. *Please note this feature **requires a direct line.***

2. **Dial-in:** dial-in to the conference via phone. Conference phone number and room number code provided. *Please then **identify your line** by entering your unique user ID on your phone.*

3. Use the **microphone** from your computer/device.

Above: audio conference settings pop-up box

2022 TITLE 24 CODE CYCLE, PART 6

First Utility-Sponsored Stakeholder Meeting

Nonresidential HVAC Part 1

Statewide CASE Team
October 15, 2019

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Meeting Guidelines

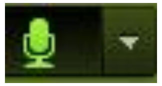
Muting Guidelines

Once you turn on your preferred audio connection, please **MUTE** your microphone.

- Please keep yourself **MUTED.**
- Wait for instructions and/or permission to unmute yourself during designated Q&A periods.

Phone users – please mute your phone line.

Computer/device users – please mute your microphone by clicking on the microphone icon on your top ribbon.



NOT MUTED

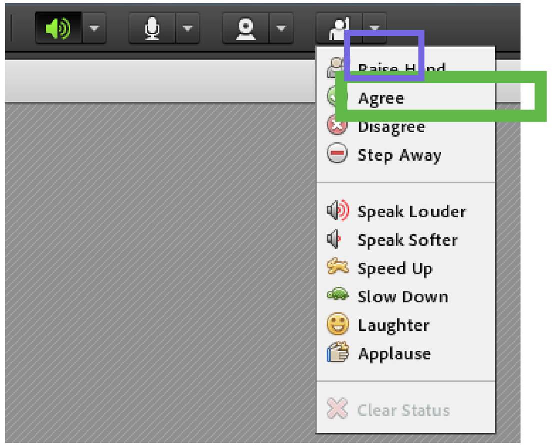
MUTED

Meeting Guidelines

Participation Guidelines

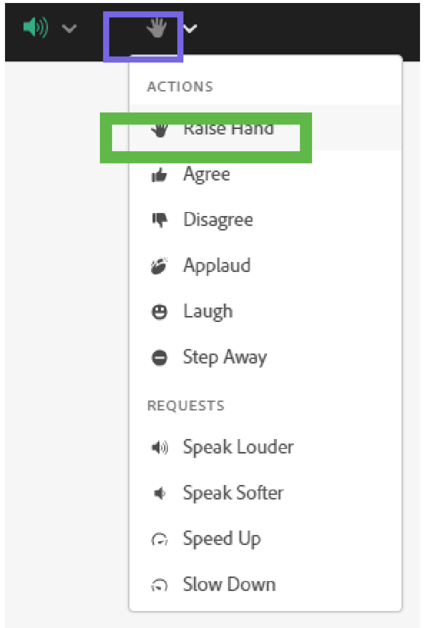
- **Questions & Comments**
  - Click **"*Raise Hand*"** if you would like to speak. Those with a hand raised will be called on by the speaker.
  - All questions and comments are also welcome via the chat window.

- **Other Meeting Feedback**
  - Provide live meeting feedback from the **top toolbar drop-down**.



Above: *feedback view for Adobe Connect app users.*

Below: *feedback view for HTML users.*



Meeting Ground Rules

- **We want to hear your thoughts**
  - Supporting and opposing viewpoints are welcome
- **When making comments**
  - Unmute yourself
  - Clearly state your name and affiliation prior to speaking
  - Speak loudly for phone audio
  - Place yourself back on mute
- **Calls are recorded** for note development, recordings will not be publicized
- Notes and presentation material will be posted on Title24Stakeholders.com

Agenda

1	**Meeting Guidelines**	*8:30 am*
2	**Opening Remarks** from the California Energy Commission	*8:35 am*
3	**Overview & Welcome** from the Statewide Utility Team	*8:40 am*
4	**Presentation I:** Data Center Efficiency	*8:45 am*
5	***10 Minute Break***	*10:05 am*
6	**Presentation II:** HVAC Controls (Part 1)	*10:15 am*
7	**Presentation III:** High-Capacity Boiler Service Water Heating Systems	*11:00 am*
8	**Wrap Up and Action Items**	*12:00 pm*
9	**Closing**	*12:00 pm*

Opening Remarks: California Energy Commission

Policy Drivers: Building Standards

The following policy documents establish the goal for new building standards:

- **2008 CPUC/CEC Energy Action Plan** – ZNE for Residential buildings by 2020 and nonresidential buildings by 2030
- **SB 100** – Clean electricity by 2045
- **B-55-18** – Governor Jerry Brown’s Executive Order to achieve carbon neutrality
- **AB 3232** – Assess the potential for the state to reduce the emissions of greenhouse gases from the state’s residential and commercial building stock by at least 40% below 1990 levels by January 1, 2030

9

2022 Standards Schedule

Estimated Date	Activity or Milestone
November 2018 - April 2019	Updated Weather Data Files
November 2018 - July 2019	Measures Identified and Approved (Internal at the Energy Commission)
November 2018 - July 2019	Compliance Metrics Development
April 24, 2019	Efficiency Measure Proposal Template for public to submit measures
October 17, 2019	Compliance Metrics and Climate Data workshop
November, 2019	Final Metrics Workshop
November, 2019	Research Version of CBECC Available with new weather data files and updated Metrics
July 2019 - March 2020	Utility-Sponsored Stakeholder Workshops
March, 2020	All Initial CASE/PUBLIC Reports Submitted to Commission
March - August 2020	Commission-Sponsored Workshops
July, 2020	All Final CASE/PUBLIC Reports Submitted to the Commission
July - September 2020	Express Terms Developed
January, 2021	45-Day Language posted and set to list serve, Start of 45-Day review/comment period
January, 2021	Lead Commissioner Hearing
April, 2021	Adoption of 2022 Standards at Business Meeting
May - November 2021	Staff work on Software, Compliance Manuals, Electronic Documents
May - November 2021	Final Statement of Reasons Drafted and Approved
October, 2021	Adoption CALGreen (energy provisions) - Business Meeting
December, 2021	CBSC Approval Hearing
January, 2022	Software, Compliance Manuals, Electronic Documents Available to Industry
January - December 2022	Standards Training (provided by 3rd parties)
June 1, 2022	6 Month Statutory Wait Period Deadline
January 1, 2023	Effective Date

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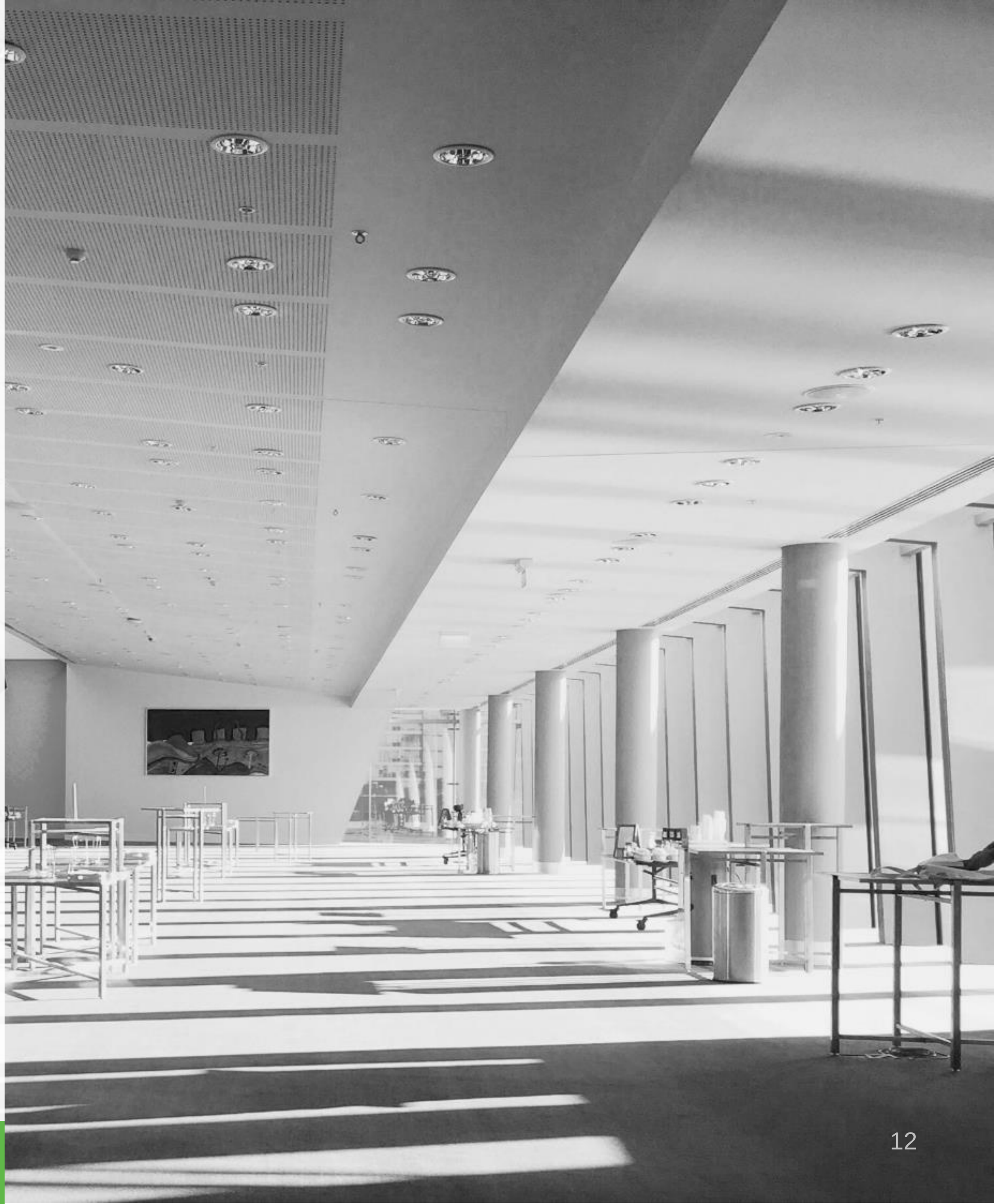
More information on pre-rulemaking for the 2022 Energy Code at:
https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Title 24, Part 6 Overview

Kelly Cunningham
Codes and Standards
Pacific Gas & Electric



Statewide Utility Codes and Standards Team

- **Actively supporting the California Energy Commission** in developing proposed changes to the California Energy Code (Title 24, Part 6)
- Achieve significant energy savings through the development of **feasible**, **enforceable**, **cost-effective, and non-proprietary** code change proposals for the 2022 code update, and beyond

Requirements for a Successful Code Change Proposal

The utilities support the California Energy Commission by proposing changes to the Energy Code that are:

Feasible | Cost effective | Enforceable | Non-proprietary

Utility-Sponsored Stakeholder Meetings

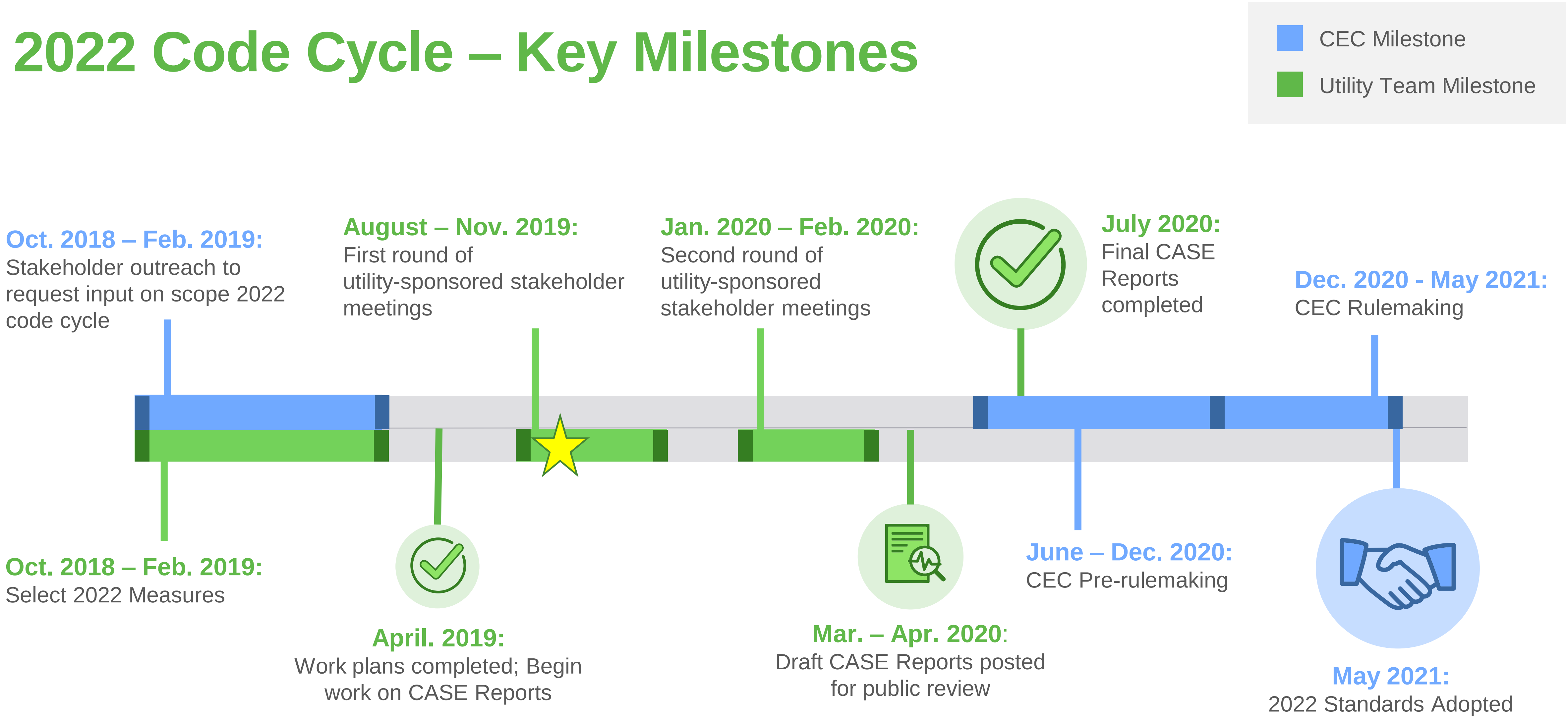
- All meetings can be attended **remotely**
- Check Title24Stakeholders.com/events for information about meetings and topic updates
- Sign up to receive email notifications

First Round Utility-Sponsored Stakeholder Meetings

Meeting Topic	Building Type	Date
Multifamily HVAC and Envelope	MF, NR	Thursday August 22, 2019
Outdoor Lighting and Daylighting	MF, NR	Thursday September 5, 2019
Indoor Lighting	NR	Thursday September 12, 2019
Covered Processes Part 1: Controlled Environment Horticulture	NR	Thursday, September 19, 2019
Multifamily & Nonresidential Water Heating	MF/NR	Thursday, October 3, 2019
Single Family HVAC	SF	Thursday, October 10, 2019
Nonresidential HVAC Part 1: Data Centers, Boilers, & Controls	NR	Tuesday, October 15, 2019
Nonresidential Envelope Part 1	NR	Thursday, October 24, 2019
Nonresidential HVAC and Envelope Part 2: Air Distribution, & Controls	NR	Tuesday, November 5, 2019
Covered Processes Part 2: Compressed Air, Steam Traps, & Refrigeration	NR	Thursday, November 7, 2019
Single Family Whole Building	SF	Tuesday, November 12, 2019
Nonresidential Software Improvements	NR	Tuesday, November 12, 2019

Sign up for all meetings at title24stakeholders.com/events/

2022 Code Cycle – Key Milestones



Comply With Me

Learn how to comply with California's building and appliance energy efficiency standards

www.EnergyCodeAce.com

offers **No-Cost**

Tools ♠ Training ♠ Resources

to help you decode Title 24, Part 6 and Title 20

SDGE A Sempra Energy utility® | SoCalGas A Sempra Energy utility® | Southern California EDISON An EDISON INTERNATIONAL® Company | PG&E Pacific Gas and Electric Company®

This program is funded by California utility customers and administered by Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E®), Southern California Edison Company (SCE), and Southern California Gas Company (SoCalGas®) under the auspices of the California Public Utilities Commission.

EnergyCode Ace™
Helping you play your cards right

The **Codes and Standards Reach Codes Program** provides technical support to local jurisdictions considering adopting a local energy efficiency ordinance.

www.LocalEnergyCodes.com

This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Data Center Efficiency

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | Covered Processes

Hillary Weitze, *Red Car Analytics*
Jeff Stein, *Taylor Engineering*

October 15, 2019

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Agenda

1	Background	*20 min*
2	Market Overview and Analysis	*5 min*
3	Technical Feasibility	*10 min*
4	Cost and Energy Methodology	*10 min*
5	Compliance and Enforcement	*5 min*
6	Proposed Code Changes	*10 min*
7	Discussion and Next Steps	*15 min*

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

Building Types	System Type (Submeasure)	Type of Change	Software Updates Required	Description of Change
Computer Rooms	Uninterruptible Power Supply (UPS) Efficiency	Prescriptive	Yes	New requirement for minimum UPS efficiency to match EnergyStar
Computer Rooms	Heat Recovery	Prescriptive	Yes	New requirement to recover computer room heat for comfort or process heating for computer rooms of a minimum size
Computer Rooms	Monitoring	Prescriptive	Yes	New requirement to monitor PUE and server utilization for computer rooms of a minimum size
Computer Rooms	Generator Crankcase Heating	Prescriptive	Yes	New requirement to house generators in insulated enclosures or use a more efficient heating source

PUE = Power Usage Effectiveness

Code Change Proposal – Summary

Building Types	System Type (Submeasure)	Type of Change	Software Updates Required	Description of Change
Computer Rooms	Economizers, Containment (Increased Temperatures)	Prescriptive	Yes	Updated requirement: 100% economizing at 65°F dry-bulb/50°F wet-bulb outside air temperature for any economizer; Reduce IT load threshold for air containment
Computer Rooms	Reheat	Mandatory	No	Change no reheat, recool, or simultaneous heating/ cooling requirement from prescriptive to mandatory
Computer Rooms	Humidification	Mandatory	No	Change no nonadiabatic humidification requir ement from prescriptive to mandatory
Computer Rooms	CRAC/CRAH Fan Control	Mandatory	No	Change variable speed fan requirement from prescriptive to mandatory
Computer Rooms	Liquid Cooling	Performance Credit	Yes	Add compliance credit for liquid cooling

CRAC = computer room air conditioner
CRAH = computer room air handler

Context and History: Uninterruptible Power Supply (UPS)

- All computer room critical loads are supplied through UPSs
- UPS efficiency increases **as load factor increases**. **Higher UPS efficiency results in less waste heat from the UPS and less cooling load** on the air conditioning system.
- UPSs are currently unregulated by Title 24. Updating Title 24 to use EnergyStar's UPS standard will help save energy in data centers.

ENERGY STAR

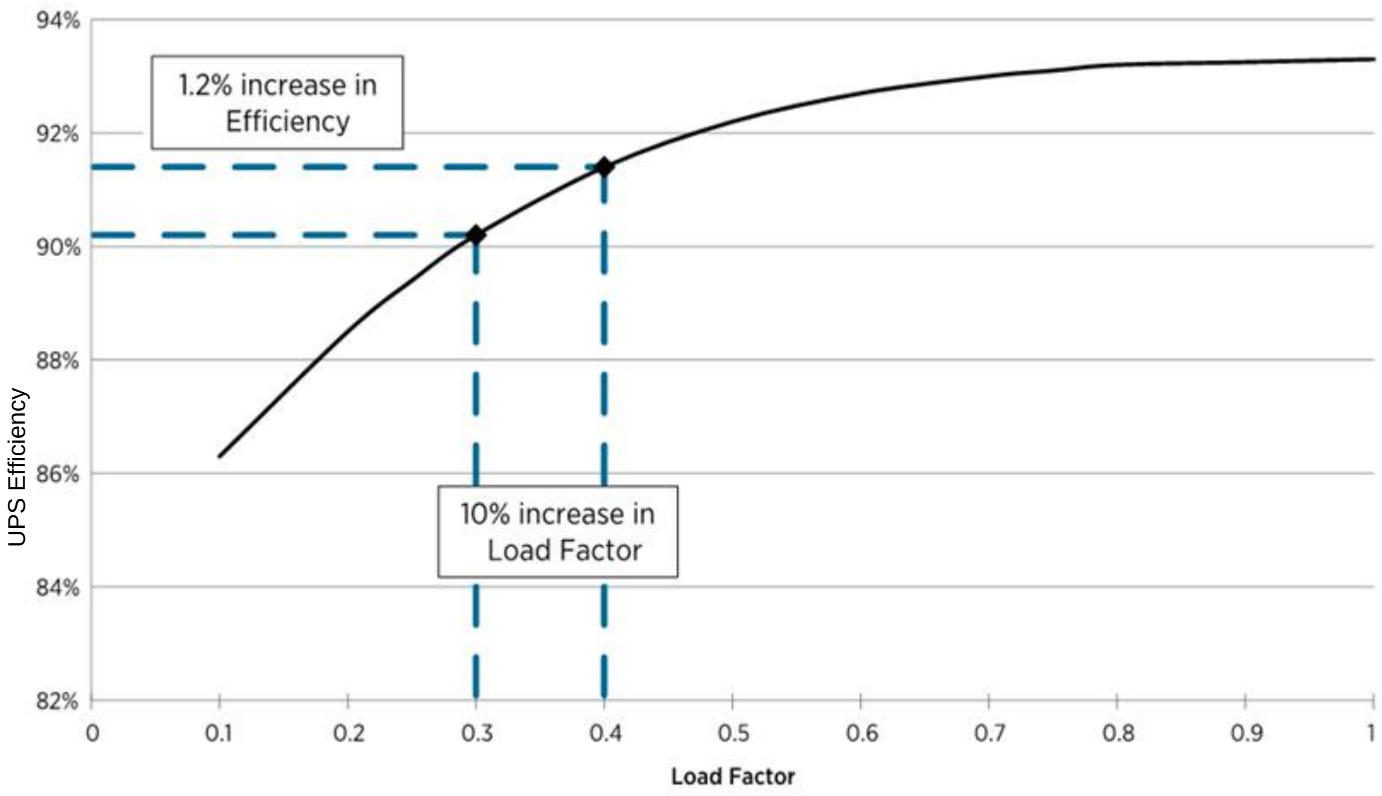


Figure 6. Typical UPS efficiency curve for 100 kVA capacity and greater

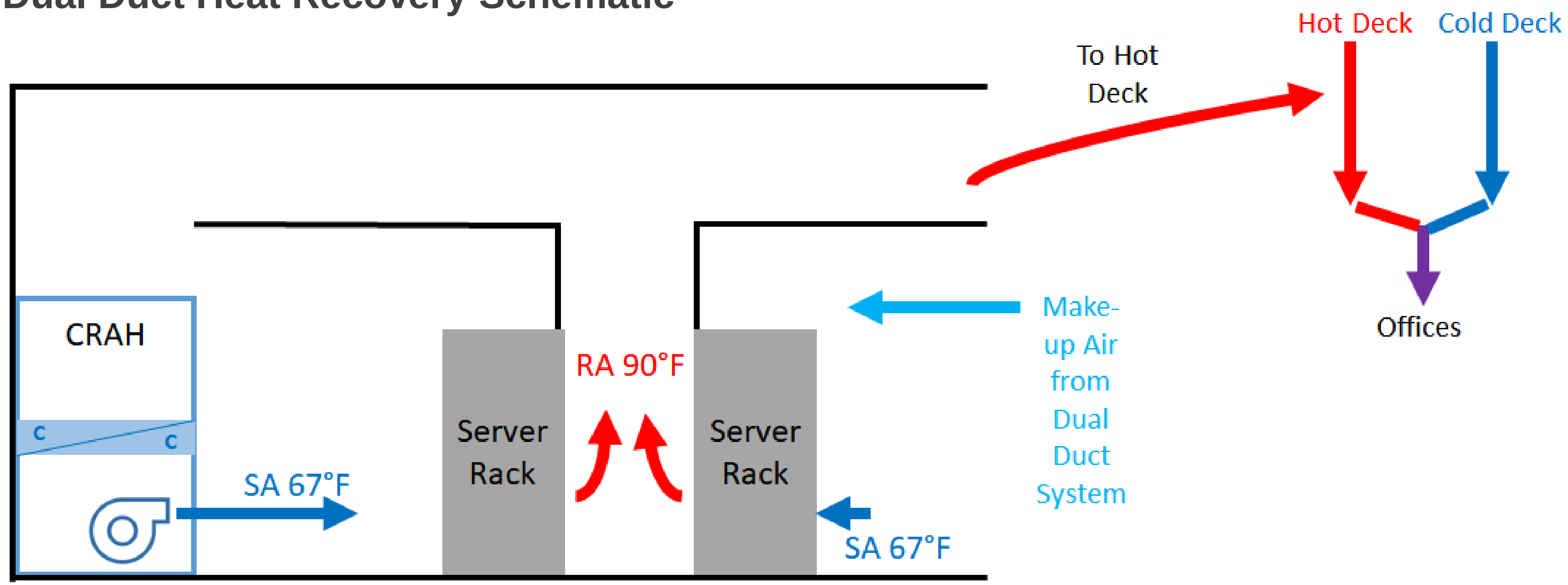
Image source: US DOE. *Best Practices Guide for Energy-Efficient Data Center Design*. 2011.

Context and History: Computer Room Heat Recovery

Recovering heat from computer room return air:

- Reduces cooling load on the CRAH cooling coil
- Reduces heating load on comfort heating system

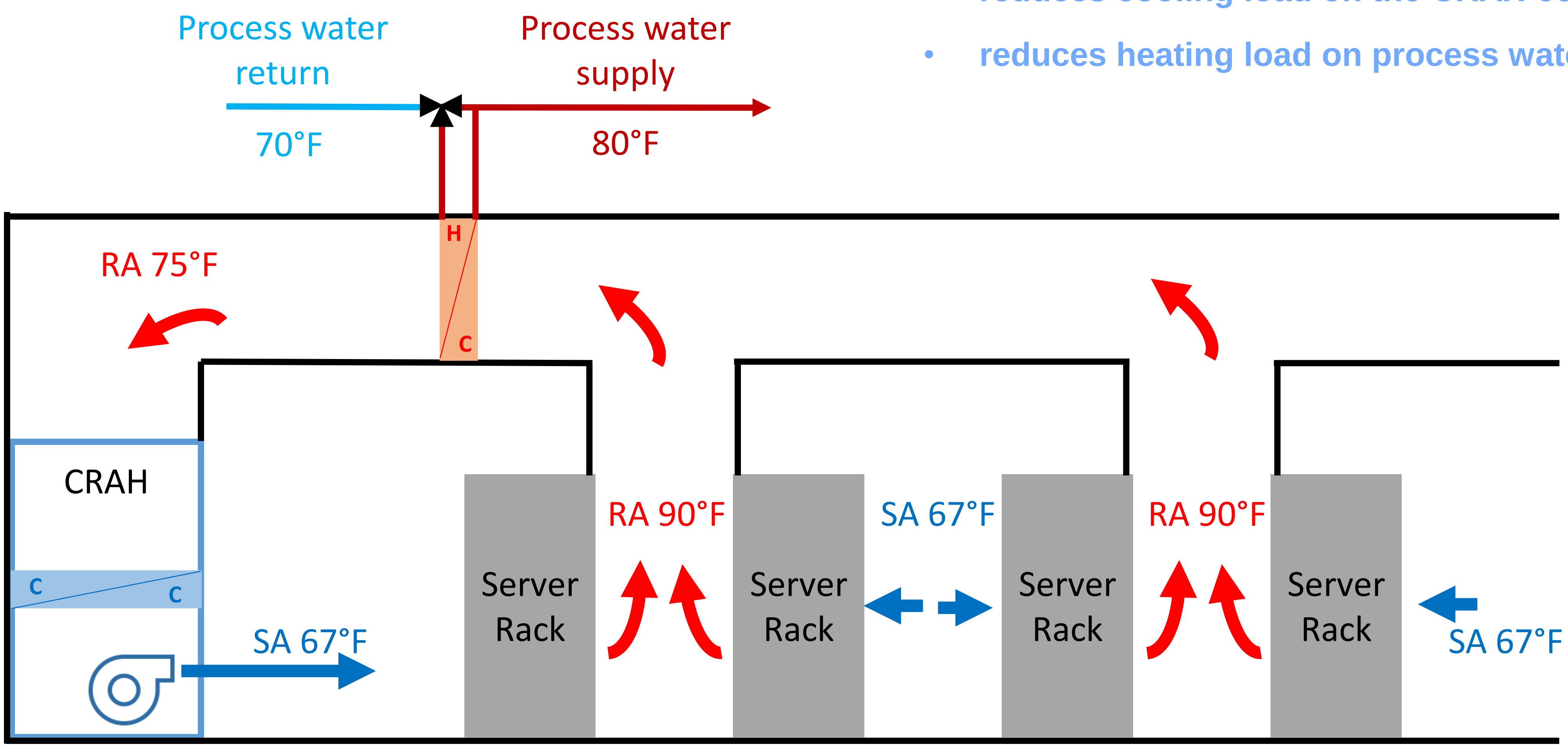
Dual Duct Heat Recovery Schematic



CRAH = Computer Room Air Handler
SA = Supply Air RA = Return Air

Context and History: Computer Room Heat Recovery

Process Heat Recovery Schematic Example



Recovering heat from computer room return air:

- **reduces cooling load on the CRAH cooling coil**
- **reduces heating load on process water system**

CRAH = Computer Room Air Handler
SA = Supply Air RA = Return Air

Context and History: Monitoring

Power Usage Effectiveness (PUE) Monitoring provides information to computer room operators to assess the performance and opportunity for energy savings in their computer rooms.

$$PUE = \frac{\text{IT load + HVAC load + electrical load + lighting load}}{\text{IT load}}$$

Standard	Good	Better
2.0	1.4	1.1

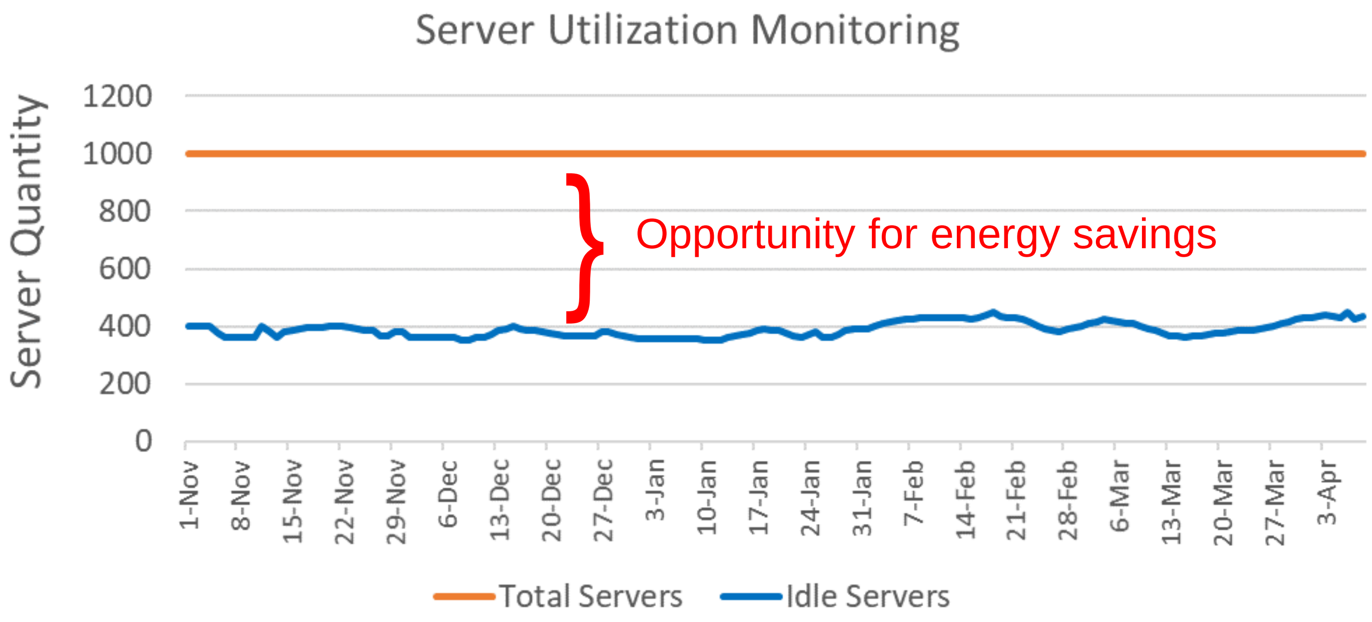
PUE Benchmarks[1]

1 Source: Lawrence Berkeley National Laboratory. *Self-benchmarking Guide for Data Center Infrastructure: Metrics, Benchmarks, Actions*. 2010. https://datacenters.lbl.gov/sites/default/files/datacenter-benchmarking-guide.pdf

Context and History: Monitoring

Server Utilization Monitoring:

- Servers use electricity even when not being actively used.
- Identifies idle (zombie) or underutilized servers, which are candidates for energy savings strategies:
  - server virtualization
  - decommissioning



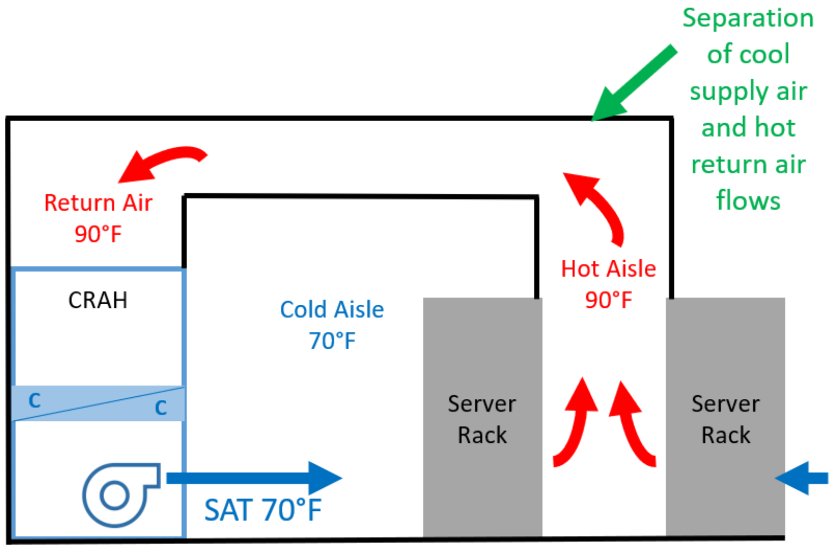
Context and History: Increased Temperatures

- Better alignment with ASHRAE guidelines allows for more hours of economizing
- Air containment helps achieve warmer server inlet temperatures by reducing mixing of supply and return air

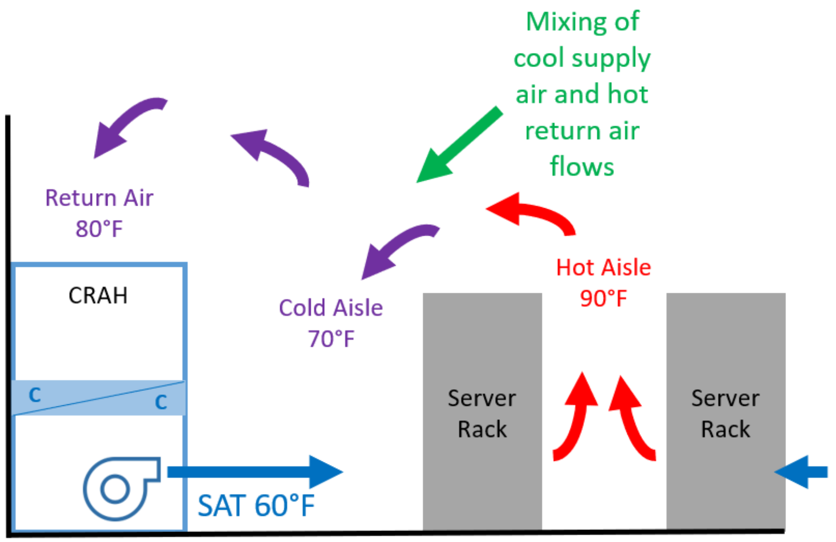
Server Inlet Environment Specifications for Air Cooling [1]

Class [1]	Dry-Bulb Temperature	Humidity Range
A1 to A4	64.4 to 80.6°F	15.8°F DP to 59°F DP and 60% RH

Computer Room with Air Containment



Computer Room without Air Containment

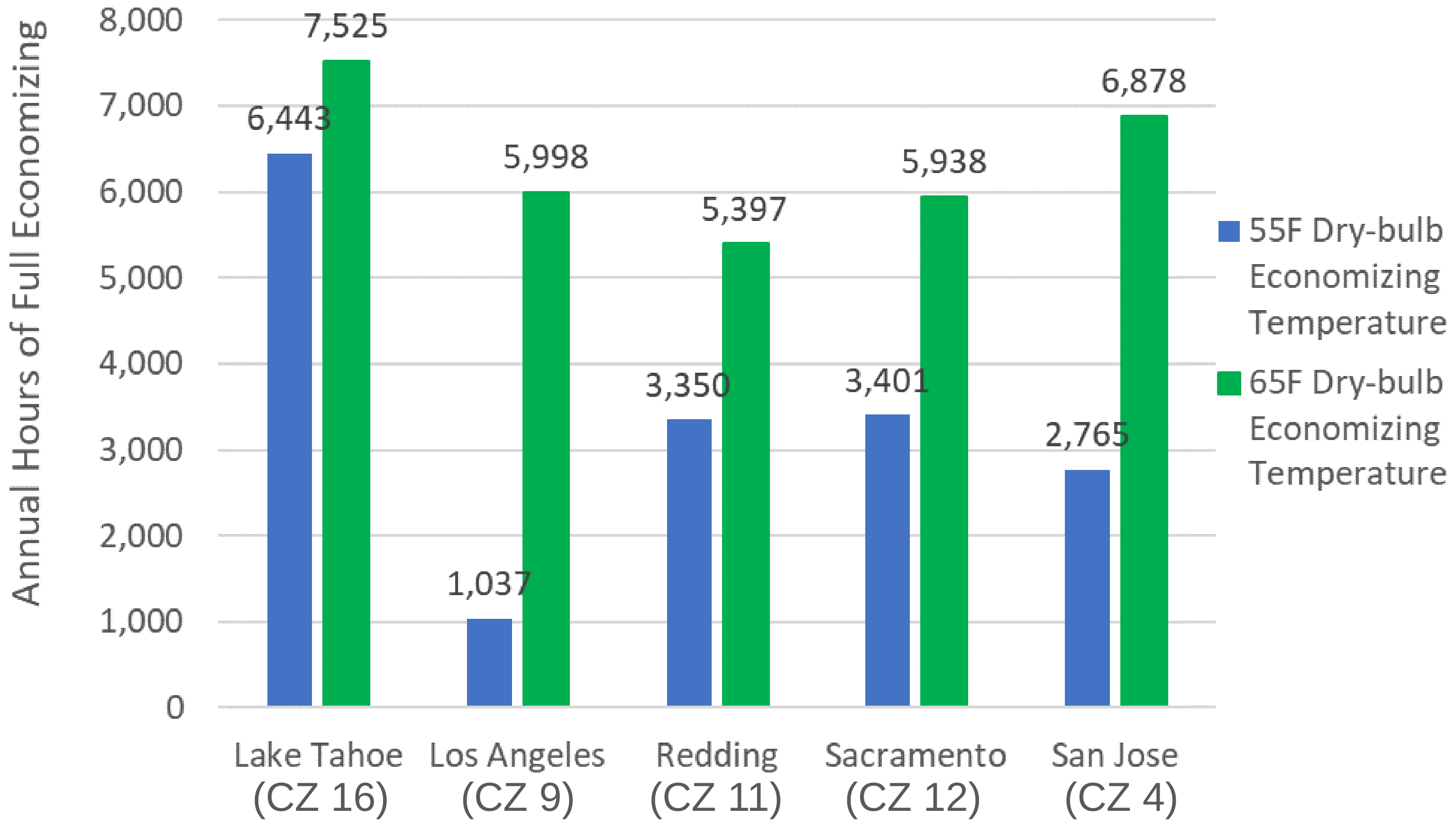


1 ASHRAE. *Thermal Guidelines for Data Processing Environments, Fourth Edition*, Table B.1. 2015.

DP = dew-point temperature RH = relative humidity CRAH = Computer room air handler SAT = supply air temperature

Context and History: Increased Temperatures

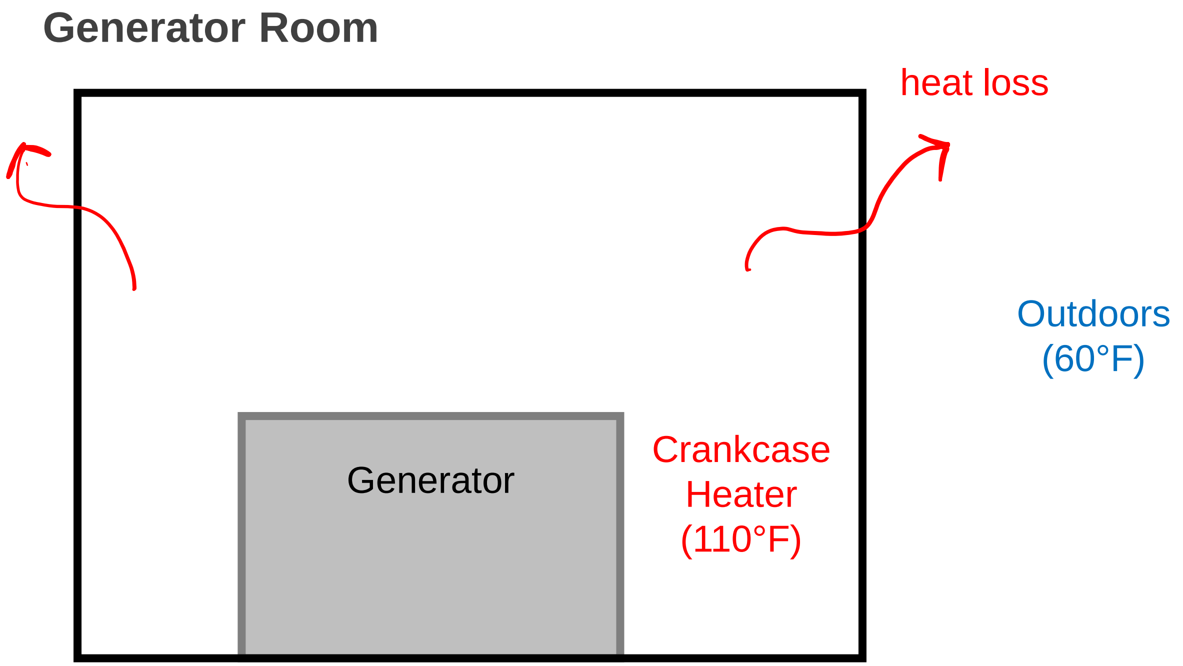
Increasing the outdoor air threshold for full air economizing leads to significantly more economizer hours and energy savings.



Context and History: Generator Crankcase Heating

- Generator crankcases must be kept warm at all times.
- Using more efficient heating sources such as recovered data center return air or heat pumps are other ways to save crankcase heating energy.

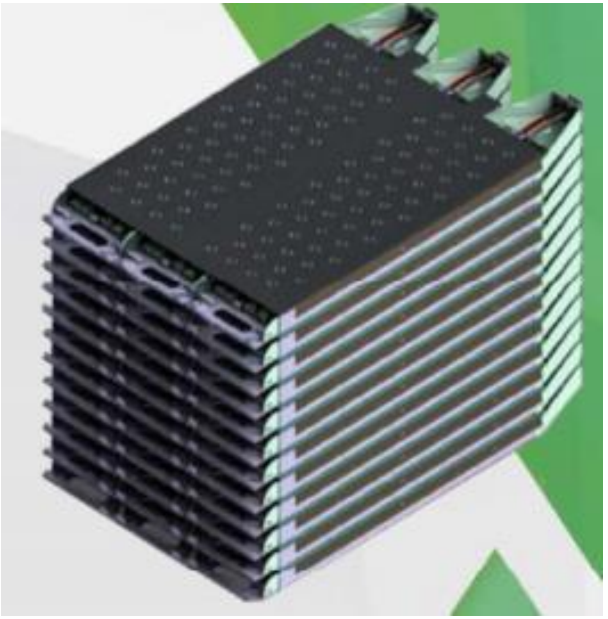
Installing generators in insulated spaces reduces heat loss to the outdoors to reduce heating energy.



Context and History: Liquid Cooling

Using liquid cooling instead of air-cooled server cooling saves energy by eliminating CRAH/CRAC fan energy and server fan energy.

Example Liquid Cooling Technologies



Fixed Cold Plate Liquid Cooling [1]

Direct Immersion Liquid Cooling [2]

1 NREL. “Liquid in the Rack: Liquid Cooling Your Data Center” Better Buildings Summit, 2018.
2 LBNL. “Electronics Take a Bath.” 2014.

CRAH = computer room air handler
CRAC = computer room air conditioner

2019 Code Requirements

- Existing relevant Prescriptive Requirements in Title 24, Part 6, Section 140.9(a)
  - **Economizers**: 100% of cooling load must be served by either an integrated air economizer at outside air temperatures of 55°F dry-bulb/50°F wet-bulb and below or by an integrated water economizer at outside air temperatures of 40°F dry-bulb/35°F wet-bulb.
  - **Air Containment**: Air barrier containment is required for new air-cooled computer rooms with a design cooling load exceeding 175 kW/room.
  - **Air Temperature Assumptions**: Baseline computer room air temperatures are 60°F supply air temperature and 80°F return air temperature.
  - **Reheat**: Reheating, recooling, and simultaneous heating/cooling to same zone is prohibited.
  - **Humidification**: Nonadiabatic humidification is prohibited.
  - **Fan Control**: Supply airflow from cooling equipment must vary with load and have a fan power demand of no more than 50% of design wattage at 66% of design fan speed.

Proposed Code Change Overview

- See the proposal summary and mark-up language in resources tab

System Type (Submeasure)	Type of Requirement	Description of Change
Uninterruptible Power Supply (UPS)	New	New requirement for minimum UPS efficiency to match EnergyStar
Heat Recovery	New	New requirement to recover computer room heat for comfort or process heating for computer rooms of a minimum size
Monitoring	New	New requirement to monitor PUE and server utilization for computer rooms of a minimum size
Generator Crankcase Heating	New	New requirement to house generators in insulated enclosures or use a more efficient heating source

PUE = power usage effectiveness

Proposed Code Change Overview

- See the proposal summary and mark-up language in resources tab

System Type (Submeasure)	Type of Requirement	Description of Change
Economizers, Containment (Increased Temperatures)	Prescriptive	Updated requirement: 100% economizing at 65°F dry-bulb/50°F wet-bulb outside air temperature for any economizer; Reduce IT load threshold for air containment
Reheat	Mandatory	Change no reheat, recool, or simultaneous heating/ cooling requirement from prescriptive to mandatory
Humidification	Mandatory	Change no nonadiabatic humidification requirement from prescriptive to mandatory
CRAC/CRAH Fan Control	Mandatory	Change variable speed fan requirement from prescriptive to mandatory
Liquid Cooling	Performance Credit	Add compliance credit for liquid cooling

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis: Current Market

Submeasure	Level of Adoption	Market Maturity	Applicable Incentive Programs
UPS Efficiency	High	Mature	PG&E, EnergyStar
Heat Recovery	Low	Emerging	PG&E, SCE
PUE Monitoring	Medium	Mature	n/a
Server Utilization Monitoring	Low	Emerging	n/a
Increased Air Temperatures Economizer, Air Containment	High	Economizer: Mature Containment: Mature but evolving	PG&E, SCE, SMUD
Generator Crankcase Heating	Medium	Mature	PG&E
Increased Baseline Air Temperatures	Medium	Mature	PG&E, SCE, SMUD
Liquid Cooling	Low	Mature but evolving	PG&E, SCE

Market Trends

- **Uninterruptible Power Supplies**: As of September 2019, Energy Star has dozens of unique qualified UPS products from less than 1 kW to greater than 200 kW.

EnergyStar UPS Search Options:

Active Output Power Rating (W)

- ☐ < 1,000 W (99)
- ☐ 1,000 - 9,999 W (168)
- ☐ 10,000 - 49,999 W (61)
- ☐ 50,000 - 99,999 W (9)
- ☐ 100,000 - 199,999 W (22)
- ☐ ≥ 200,000 (15)

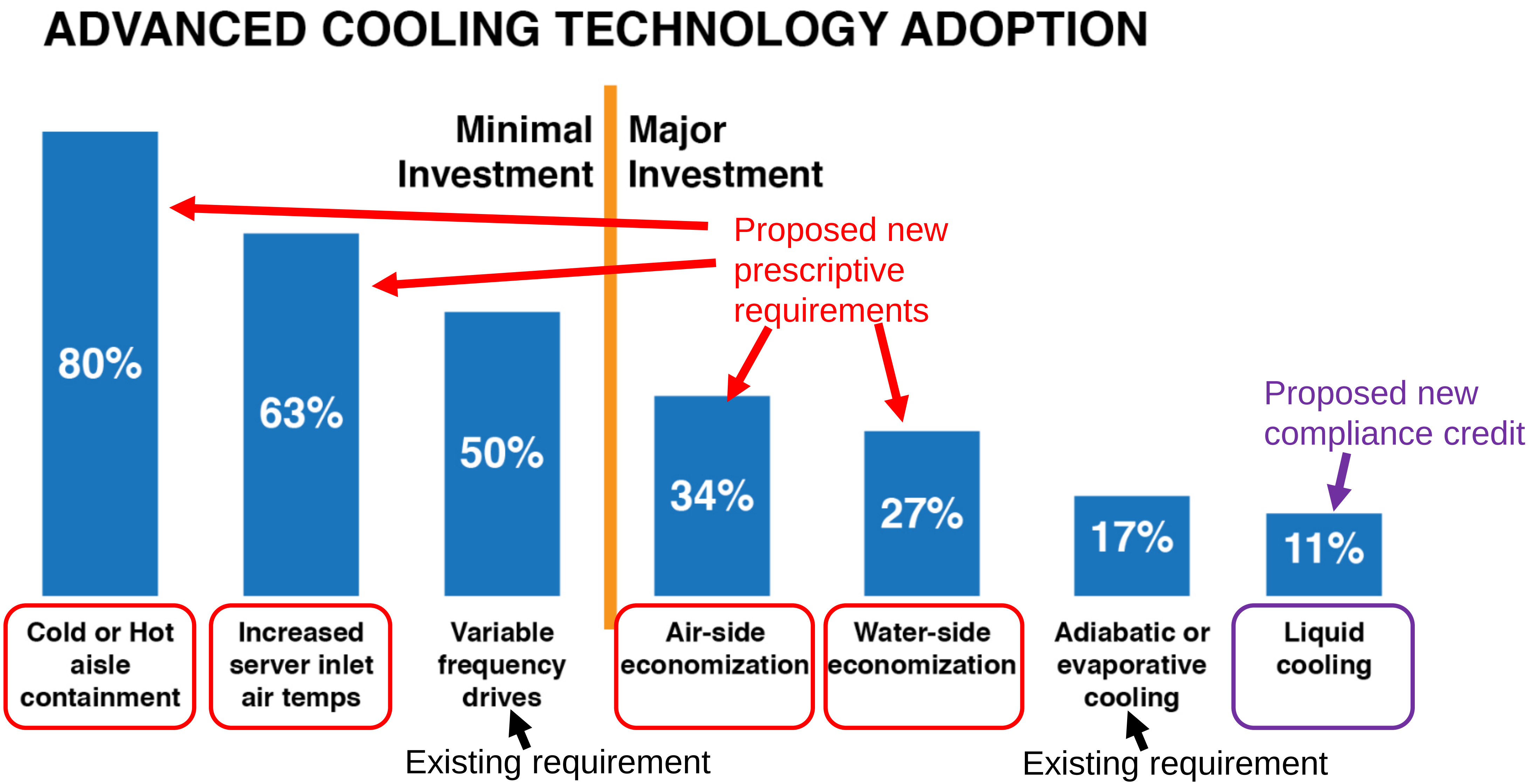
Topology and Product Type Combined

- ☐ ac - Double Conversion (VFI) (86)
- ☐ ac - Other (167)
- ☐ ac Line Interactive (VI) (62)
- ☐ Alternating Current (ac) - Offline (VFD) (47)

- **Monitoring**: 42% of data center stakeholders indicate their customers are deploying server utilization and energy monitoring and management[1]

1 Uptime Institute. "DCIM: Effective Selection and Deployment Trends." 2019.

Market Trends



Source: Uptime Institute. "2014 Data Center Industry Survey." https://journal.uptimeinstitute.com/2014-data-center-industry-survey/

Market Barriers

Submeasure	Barrier	Potential Solution	Next Step
UPS Efficiency	Increased first cost	Demonstrate cost effectiveness with data	Discuss UPS sales figures with manufacturers; develop analysis
Heat Recovery	More complex design	Provide design resources and case studies	Engage mechanical design engineers to find case studies and design examples for documentation
Monitoring	Additional cost when “do nothing” is option	Demonstrate cost effectiveness with data	Find case studies on energy savings due to PUE monitoring, server virtualization monitoring

Market Barriers (continued)

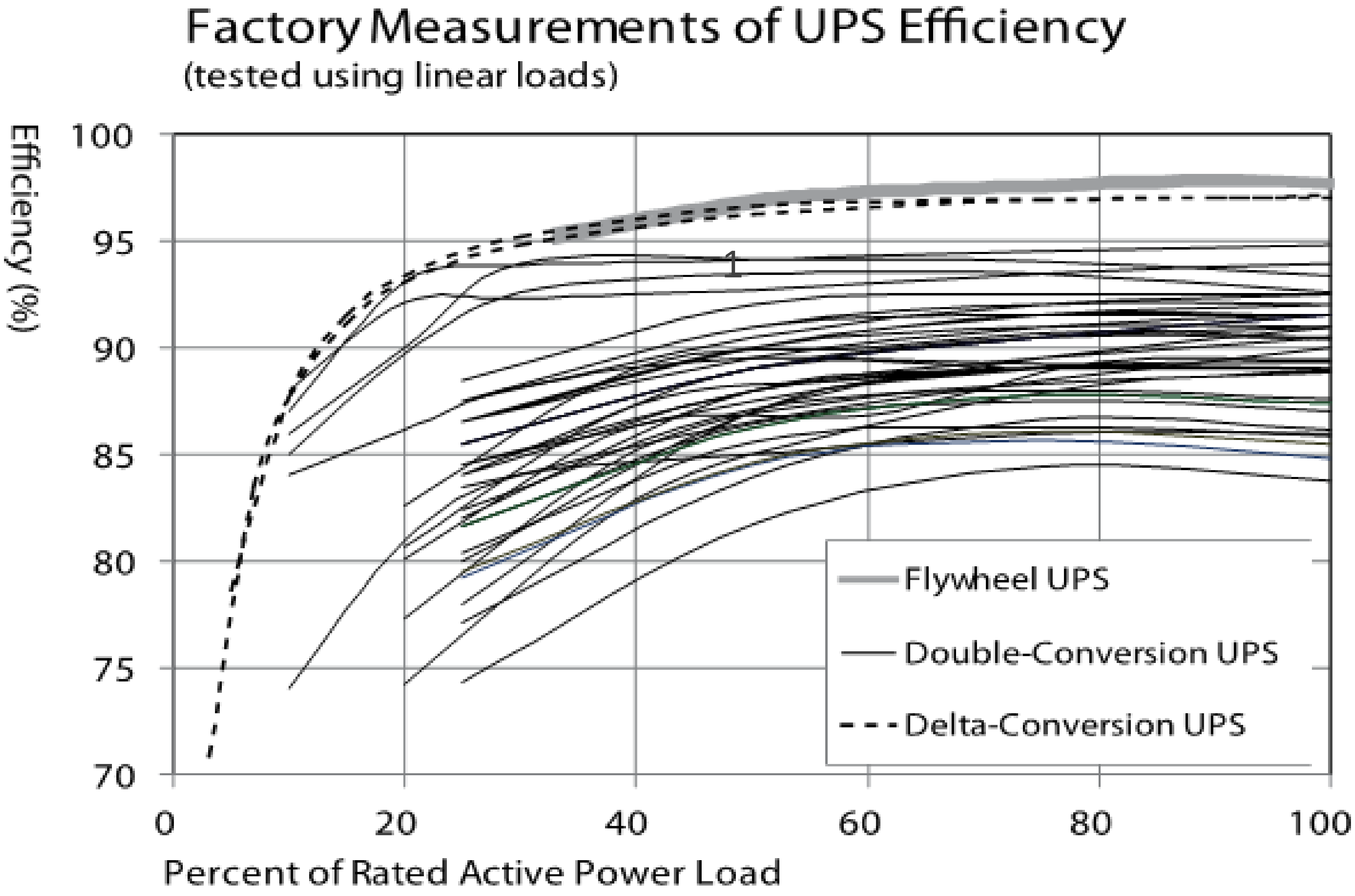
Submeasure	Barrier	Potential Solution	Next Step
Increased Tem peratures	Historical reluctance of data center operators to adopt warmer air temperatures; Central plants serving multiple spaces for smaller data centers; increased first cost for containment	Provide education to operators; demonstrate cost effectiveness with data	Cite research supporting warmer temperatures; get pricing from manufacturers; develop analysis
Generator Crankcase Heating	Need to allocate physical space for generator room or add enclosure	If generator must be located outdoors, build insulated enclosure	n/a
Liquid Cooling	Lack of industry familiarity with technology	Provide resources/ education to mech. designers and data center operators	Research case studies and design best practices

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations: UPS

- UPSs are sized for design IT load.
  - Installed IT load is often lower or takes time to reach design load
  - High part-load UPS efficiency results in energy savings
- Operate in bypass mode for increased efficiency.



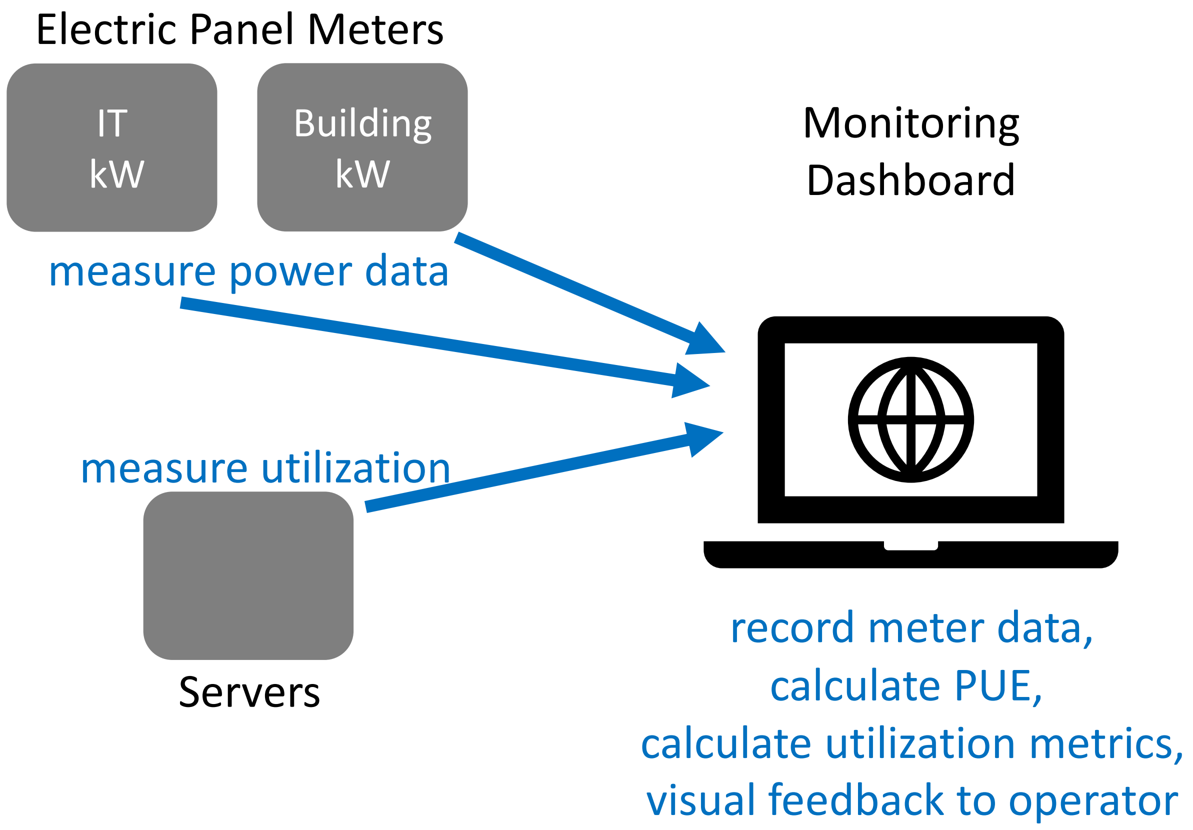
Source: PG&E. "Data Center Best Practices Guide". 2012.

Technical Considerations: Heat Recovery

- Design considerations:
  - This measure is most cost effective when computer room return air path is near supply ducting to other building heat loads.
  - Recovered heat is "low-grade" at around 90°F; heating load must be no greater than this temperature or requires additional booster heater
  - Heat recovery system should avoid recovering heat from computer room when it exceeds heating load in other spaces.

Technical Considerations: Monitoring

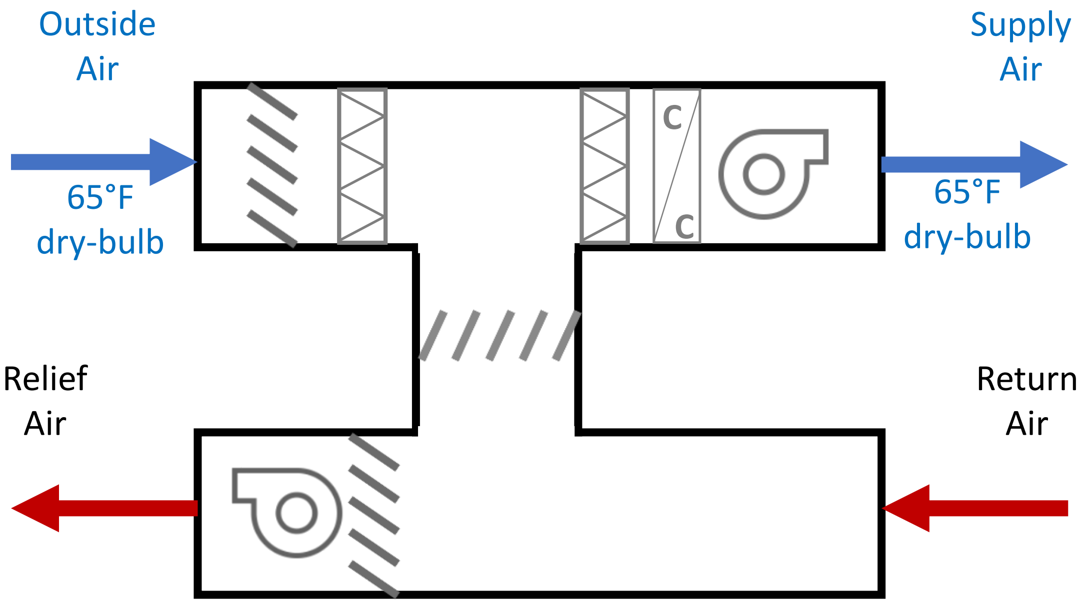
- Requires infrastructure involving multiple contractors: electrical, controls/IT
- Requires commissioning to confirm equipment is installed correctly
  - Initial installation review
  - Trend review with IT, electrical, and mechanical loads installed



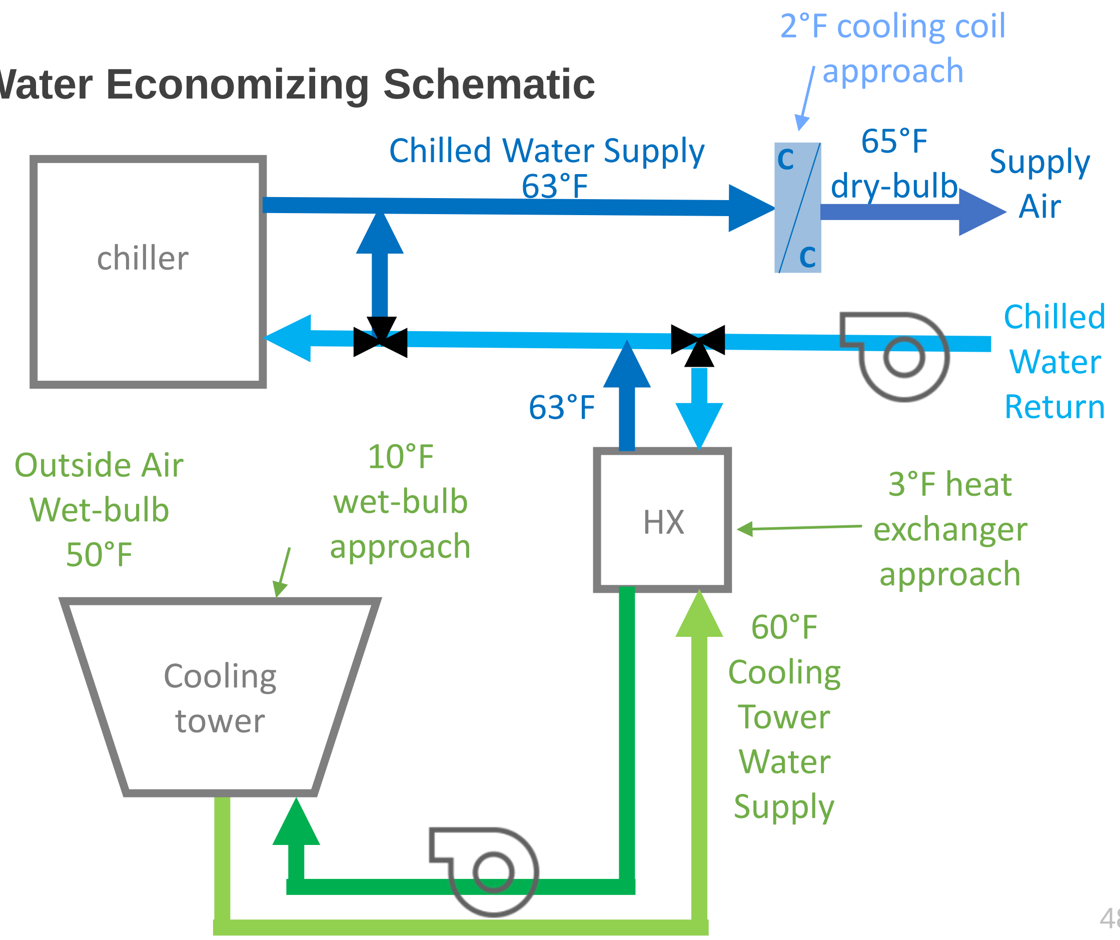
Technical Considerations: Increased Temperatures

Cooling coils must be sized for and data center must be operated at 65°F dry-bulb supply air temperature or greater.

Air Economizing Schematic



Water Economizing Schematic



Technical Considerations: Increased Temperatures

- Servers should be arranged in “hot” and “cold” aisles (server inlets face each other in a common aisle)
- Containment creates physical barriers in computer room
  - Installing smoke detection for all sections and fusible links on containment so fire suppression system can reach all areas addresses fire protection requirements without increasing risk to health and safety.

Technical Considerations: Generator Crankcase Heating

- Generator crankcases must be kept warm (approx. 100-110°F) at all times to allow the generator to turn on quickly at any time.
- Typically heating is done through a generator-mounted electric resistance heater.
- Locating the generator in an enclosed, insulated space reduces the heat loss from the generator and reduces the runtime of the heater.
- More efficient options than electric resistance heating exist, including recovering heat from the data center and using electric heat pumps.

Technical Considerations: Audience Feedback

Do you have additional technical considerations to add to any of the submeasures?

Energy and Cost Impacts
Methodology and Assumptions

- Energy Impacts Methodology
- Cost Impacts Methodology
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

Submeasure	Per Unit Savings	Modeling Tool	Savings Vary by Climate Zone?	Scenarios
UPS Efficiency	kW IT load	Spreadsheet	Yes, for cooling energy	• All climate zones • IT loads: 200 kW, 1,000 kW
Heat Recovery	kW IT load	EnergyPlus (OpenStudio)	Yes	• All climate zones • Built-up VAV for office • Heat recovery HW coil for process hot water • IT load: 500 kW • Office heating load: peak 500 kW • Process heating load: 500 kW

Methodology for Energy Impacts Analysis

Submeasure	Per Unit Savings	Modeling Tool	Savings Vary by Climate Zone?	Scenarios
Monitoring	kW IT load	EnergyPlus (OpenStudio)	Yes	• All climate zones • CRAC (200 kW IT load) • CRAH (1,000 kW IT load)
Increased Temperatures: Economizer	kW IT load	Spreadsheet	Yes	• All climate zones • IT loads: 50 kW, 1,000 kW
Increased Temperatures: Air Containment	kW IT load	Spreadsheet	Yes	• All climate zones • IT loads: 50 kW
Generator Crankcase Heating	kW IT load	Spreadsheet	Yes	• All climate zones • IT loads: 1,000 kW

2023 Construction Forecast

Update pending

Submeasure	Applicable Market (Statewide Total)	Percent of Market Affected	Statewide Impact	Assumptions
UPS Efficiency				
Heat Recovery				
Monitoring				
Increased Temperatures				
Generator Crankcase Heating				

Definition of Baseline and Proposed Conditions: UPS Efficiency Submeasure

Baseline Conditions

- UPS efficiency = survey of manufacturer products
- 8,760 hrs/yr operation
- Cooling system type (CRAC or CRAH w/ CHW plant) and capacity are based computer room load
- Cooling system efficiency = Title 24 2019
- UPS capacity = design IT load

Proposed Conditions

- UPS efficiency = proposed new code
- 8,760 hrs/yr operation
- Cooling system type (CRAC or CRAH w/ CHW plant) and capacity are based computer room load
- Cooling system efficiency = Title 24 2019
- UPS capacity = design IT load

Green text = differences in Baseline and Proposed conditions.

Definition of Baseline and Proposed Conditions: Heat Recovery Submeasure

Baseline Conditions

- No heat recovery
- 8,760 hrs/yr operation
- Cooling/heating system efficiency = Title 24 2019
- Computer room system type (CRAH w/ CHW plant) and capacity are based building cooling load

Proposed Conditions

- Reduced cooling load on data center cooling coil, reduced heating load on comfort/ process heating source, energy from heat recovery system
- 8,760 hrs/yr operation
- Cooling/heating system efficiency = Title 24 2019
- Computer room system type (CRAH w/ CHW plant) and capacity are based building cooling load

Green text = differences in Baseline and Proposed conditions.

Definition of Baseline and Proposed Conditions: PUE Monitoring Submeasure

Baseline Conditions

- 8,760 hrs/yr operation
- Cooling/heating system efficiency = Title 24 2019
- Computer room system type (CRAC or CRAH w/ CHW plant) and capacity are based building cooling load

Proposed Conditions

- 1% decrease in HVAC energy from Baseline
- 8,760 hrs/yr operation
- Cooling/heating system efficiency = Title 24 2019
- Computer room system type (CRAC or CRAH w/ CHW plant) and capacity are based building cooling load

Green text = differences in Baseline and Proposed conditions.

Definition of Baseline and Proposed Conditions: Server Utilization Monitoring Submeasure

Baseline Conditions

- 8,760 hrs/yr operation
- Cooling/heating system efficiency = Title 24 2019
- Computer room system type (CRAC or CRAH w/ CHW plant) and capacity are based building cooling load

Proposed Conditions

- 2% decrease in IT load from Baseline
- 8,760 hrs/yr operation
- Cooling/heating system efficiency = Title 24 2019
- Computer room system type (CRAC or CRAH w/ CHW plant) and capacity are based building cooling load

Green text = differences in Baseline and Proposed conditions.

Definition of Baseline and Proposed Conditions: Increased Temperatures Submeasure

Baseline Conditions

- Title 24, Part 6 2019: full air economizing at 55°F dry-bulb/50°F wet-bulb OAT and below
- SAT = 60°F / RAT = 80°F
- 8,760 hrs/yr operation
- Cooling system type (CRAC or CRAH w/ CHW plant) and capacity are based computer room load
- Cooling system efficiency = Title 24 2019

Proposed Conditions

- Full economizing at 65°F dry-bulb/50°F wet-bulb OAT and below
- SAT = 70°F / RAT = 90°F
- 8,760 hrs/yr operation
- Cooling system type (CRAC or CRAH w/ CHW plant) and capacity are based computer room load
- Cooling system efficiency = Title 24 2019

Green text = differences in Baseline and Proposed conditions. CHW = chilled water OAT = outside air temperature
CRAC = computer room air conditioner CRAH = computer room air handler

Definition of Baseline and Proposed Conditions: Generator Crankcase Heating

Baseline Conditions

- Generator located outdoors
- 8,760 hrs/yr operation
- Generator crankcase temperature setpoint: 110°F
- Generator capacity = design IT load
- Thermostatically-controlled electric resistance generator crankcase heater (COP = 1)

Proposed Conditions

- Enclosure insulation U-value: 1.4
- 8,760 hrs/yr operation
- Generator crankcase temperature setpoint: 110°F
- Generator capacity = design IT load
- Thermostatically-controlled electric resistance generator crankcase heater (COP = 1)

Green text = differences in Baseline and Proposed conditions.

Definition of Baseline and Proposed Conditions: Audience Feedback

Are there any key energy considerations missing from any of the submeasures?

Incremental Cost Information

Submeasure	Incremental Cost Items	Cost Sources
UPS Efficiency	• Higher efficiency equipment	• Manufacturers
Heat Recovery	• Additional mechanical equipment material & labor (ducting or heat recovery coil, etc.) • Additional design/ commissioning time	• Cost estimators • Mechanical contractors • Design engineers • Commissioning engineers
Monitoring	• Additional equipment material & labor (meters, network & dashboard infrastructure) • Additional design/ commissioning time	• Cost estimators • Electrical contractors • Design engineers • Commissioning engineers

Incremental Cost Information (continued)

Submeasure	Incremental Cost Items	Cost Sources
Economizer Temperatures	• $0	
Containment	• Additional material & labor for containment installation	• Manufacturers • Installing contractors
Generator Crankcase	• Room enclosure	• RS Means

Incremental Cost Information: Audience Feedback

- **Are there any key cost considerations missing from any of the submeasures?**
- **Do you have implementation cost data you are willing to provide for any of the submeasures?**

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- **Project Team:**
  - Identify if project triggers new/updated requirements.
    - Computer rooms > 35 kW require air containment
    - Computer rooms > 200 kW require PUE and server utilization monitoring
    - Computer rooms > 500 kW in buildings with > 500 kW design heating load require heat recovery
  - If applicable, confirm design includes necessary equipment to meet triggered requirements.

PUE = power usage effectiveness

Compliance Verification Process

2. Permit Application Phase

- **Project Team:**
  - Submits design documents including specs that identify equipment that meet new requirements such as:
    - **UPS Efficiency**: UPS with Energy Star certification
    - **Heat Recovery**: heat recovery system on mechanical drawings (ducts, heat recovery coil, etc.)
    - **Monitoring**: system monitoring capabilities
    - **Increased Temperatures**: economizer system design approach and setpoint temperatures, design supply air temperature, air containment
    - **Generator Crankcase Heating**: generator room envelope information, generator crankcase heater type
    - **Liquid Cooling** (if compliance credit is pursued)**:** Server specifications showing liquid cooling compatibility

UPS = uninterruptible power supply

Compliance Verification Process

3. Construction phase

- **Construction Team:**
  - Confirms that equipment indicated in compliance docs and design docs has been installed.
    - **UPS Efficiency**: UPS
    - **Heat Recovery**: heat recovery system; Acceptance Tests
    - **Monitoring**: power and server utilization monitoring equipment; Acceptance Tests
    - **Increased Temperatures**: air containment / economizer
    - **Generator Crankcase Heating**: generator enclosure, generator crankcase heater
    - **Liquid Cooling** (if compliance credit is pursued): cooling system equipment and servers

Compliance Verification Process

4. Inspection Phase

- **Building Official:**
  - Visually verifies that equipment is installed per permit documents.
    - **UPS Efficiency:** UPS nameplate matches permit drawings
    - **Heat Recovery**: heat recovery system matches permit drawings
    - **Monitoring**: monitoring equipment matches permit drawings
    - **Increased Temperatures**: economizer and containment configuration matches permit drawings
    - **Generator Crankcase Heating**: generator enclosure and generator crankcase heater match permit drawings
    - **Liquid Cooling** (if compliance credit is pursued): cooling system equipment and servers match permit drawings

Market Actors

Market Actor	Role
Building Owners	Coordinate with design team to provide liquid cooling servers (if compliance credit is pursued)
Electrical Designers/ Installing Contractors	Understand applicable requirements and include in design docs. Coordinate with architect and mechanical designer on UPS, monitoring, and generator equirement.
Mechanical Designers/ Installing Contractors	Understand applicable requirements and include in design documents
Architect	Identifies applicable requirements, includes in design documents
Plans Examiners/ Building Inspectors	Confirm and verify compliance documents are supported in design documents and equipment is installed per design

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**.
- **Are any details missing from language?**
- **Are there additional major mechanical system options to consider in the heat recovery cost effectiveness analysis?**
- **Are there any exceptions that should be considered?**

Software Updates

Submeasure	Current Modeling Capabilities	Proposed Modeling Capabilities
UPS Efficiency	N/a	• UPS capacity and UPS 4-point part-load curve (25%, 50%, 75%, 100% load factor) • Dedicated room for UPS cooling using CRAC/CRAH cooling
Heat Recovery	N/a	• Reduction in computer room cooling coil load • If heat recovery used for covered process load, reduction in heating system load • If heat recovery used for non-covered process load, design heating load, annual hourly schedule, and heating system efficiency • Heat recovery equipment energy (e.g., fans, pumps)
Monitoring	N/a	• 1% increase in proposed annual HVAC energy if no PUE monitoring installed • 2% increase for proposed design IT load if no server virtualization monitoring installed

Software Updates

Submeasure	Current Modeling Capabilities	Proposed Modeling Capabilities
Increased Temperatures	• Full air economizing at outside 55°F dry-bulb/50°F wet-bulb and below or by water economizing at outside air temperatures of 40°F dry-bulb/35°F wet-bulb and below • Adjustable supply air temperature	No change in capabilities; update of temperatures.

Software Updates

Submeasure	Current Modeling Capabilities	Proposed Modeling Capabilities

Generator Crankcase Heating	N/a	• Model generator heating load and heater runtime based on enclosure type and climate.
		• Provide options for different generator heating sources, each with a different efficiency:
		    • Heat recovery from data center: 0 heater energy
		    • Enclosed structure (baseline) with electric resistance heating: COP = 1
		    • Enclosed structure with heat pump heating: COP = 3
		    • Unenclosed outdoor generator with electric resistance heating: COP = 1

Software Updates

Submeasure	Current Modeling Capabilities	Proposed Modeling Capabilities
Liquid Cooling	N/a	• Remove CRAC/CRAH supply fan energy • Pump energy for liquid cooling

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2022 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Comments on this measure are due by October 29, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Break – 10 minutes

Please take a minute to review materials in ‘Resources’

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 TITLE 24 CODE CYCLE, PART 6

First Utility-Sponsored Stakeholder Meeting

Nonresidential HVAC Topics

Tim Minezaki, *Energy Solutions*

Shaojie Wang, *Energy Solutions*

Neil Bulger, *Red Car Analytics*

Jeff Stein, *Taylor Engineering*

October 15, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

1	Dedicated Outside Air Systems (DOAS)	*30 min*
2	Variable Air Volume Minimum Airflow Rate Change	*15 min*

Interested in reviewing the proposed changes for additional NR HVAC measures (Air Efficiency and Guest Rooms Controls) in the 2022 California Energy Code?

Attend the Nonresidential HVAC and Envelope 2 Meeting on November 5th

RSVP at title24stakeholders.com/events/

2022 TITLE 24 CODE CYCLE, PART 6

HVAC Control: Dedicated Outside Air System

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | HVAC

Neil Bulger, *Red Car Analytics*

October 15, 2019

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Agenda

1. Background
2. Market Overview and Analysis
3. Technical Feasibility
4. Cost and Energy Methodology
5. Compliance and Enforcement
6. Proposed Code Changes
7. Discussion and Next Steps

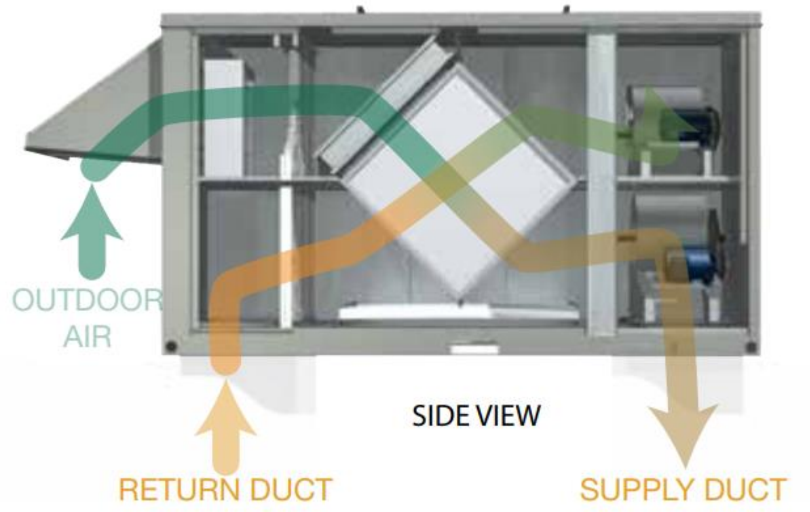
Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Common Definition for Dedicated Outside Air System

Dedicated Outside Air Systems (DOAS) are systems which delivers 100 percent outdoor air without requiring operation of the heating and cooling system fans for ventilation air delivery.

Energy Recovery Ventilators



Heat Recovery Ventilators

DX-DOAS

Code Change Proposal – Summary

Add prescriptive requirements for Dedicated Outside Air Systems (DOAS) when used as the primary source of ventilation.

Submeasure	Type of Change	Software Updates Required	Section(s) of Code Updated
Ventilation heat recovery with integrated bypass control	Prescriptive	Yes	140.4 new section
Maximum fan power & modulating capabilities	Prescriptive	Yes	140.4 new section
Space heating and cooling fans able to shut-off when satisfied	Prescriptive	Yes	140.4 new section
Capable of increased ventilation for economizing	Prescriptive	Yes	140.4 new section
Modify maximum supply air temperatures when systems have reheat	Prescriptive	Yes	140.4 new section

Key Points

- DOAS not required, but if one chooses to install DOAS they would need to meet prescriptive requirements
- Size thresholds (measured in CFM) will exist.

Code Change Proposed – Summary

Add general **exhaust air heat recovery** requirements for any system in the same format as ASHRAE 90.1:

- By climate zone.
- By minimum equipment size (cfm).
- Requiring same type of integrated bypass control capabilities as DOAS.
- Re-investigating where effective.

Submeasure	Type of Change	Software Updates Required	Section(s) of Code Updated
Exhaust air heat recovery	Prescriptive	Yes	140.4 new section

2019

BUILDING ENERGY EFFICIENCY STANDARDS FOR RESIDENTIAL AND NONRESIDENTIAL BUILDINGS

Proposed Code Change Overview

- See the proposal summary and mark-up language in **resources tab**

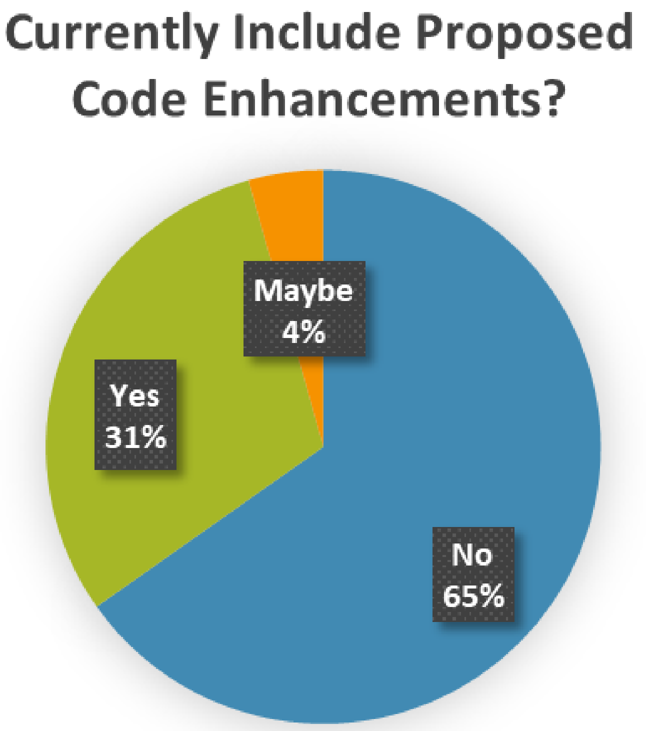
Section 140.4 (p) for DOAS

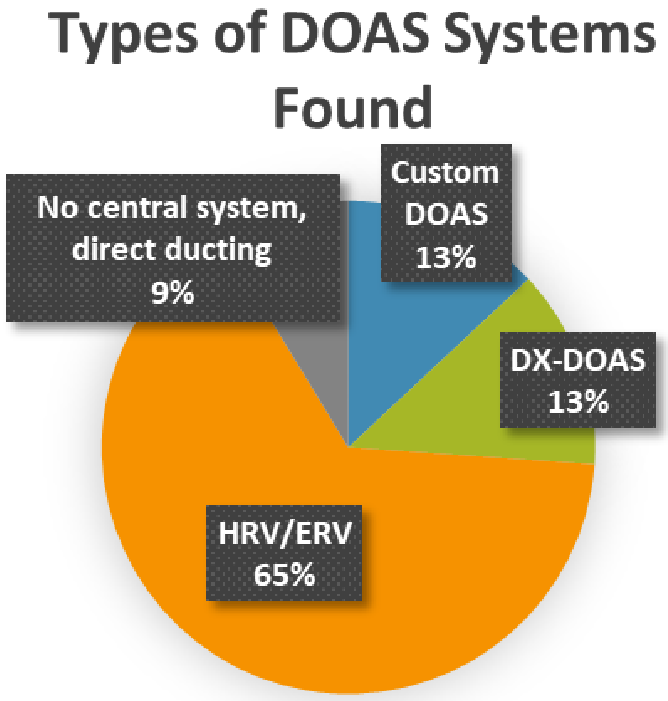
- For systems above a design size, capabilities to include
  - Heat recovery with bypass control
  - A maximum fan power and modulating capabilities
  - Space heating and cooling systems to shut off when not required
  - Capable of increased ventilation if using DOAS
  - Maximum supply air temperature criteria on systems with reheat

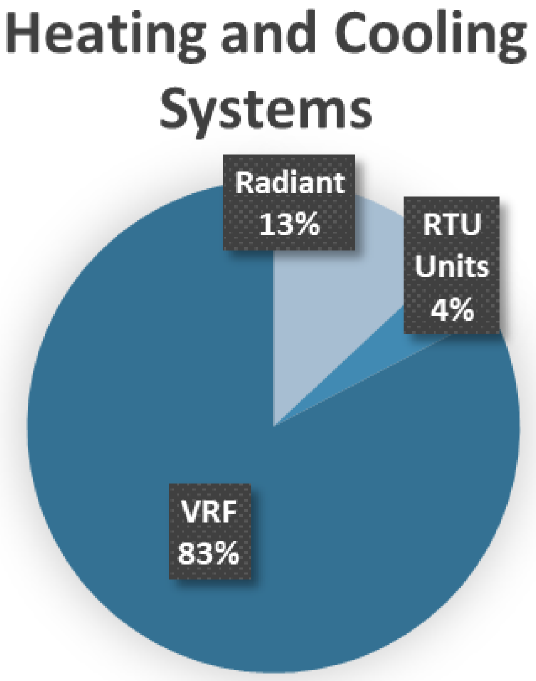
Section 140.4 (q) Exhaust Air Heat Recovery

- New criteria for when exhaust air heat recovery is required on all systems, based on ASHRAE 90.1

Context and History







23 projects in California surveyed, primarily office, both new and major renovation. System construction between 2012-current.

Context and History

- **Review of Title 24, Part 6 finds:**
  - No criteria on ventilation conditioning capabilities if using DOAS.
  - 140.4 (e) Economizers, Exception 6
  - Fan Power Limitations 140.4 (c) only regulates the fan system above 5 hp, often DOAS less than 5 hp.

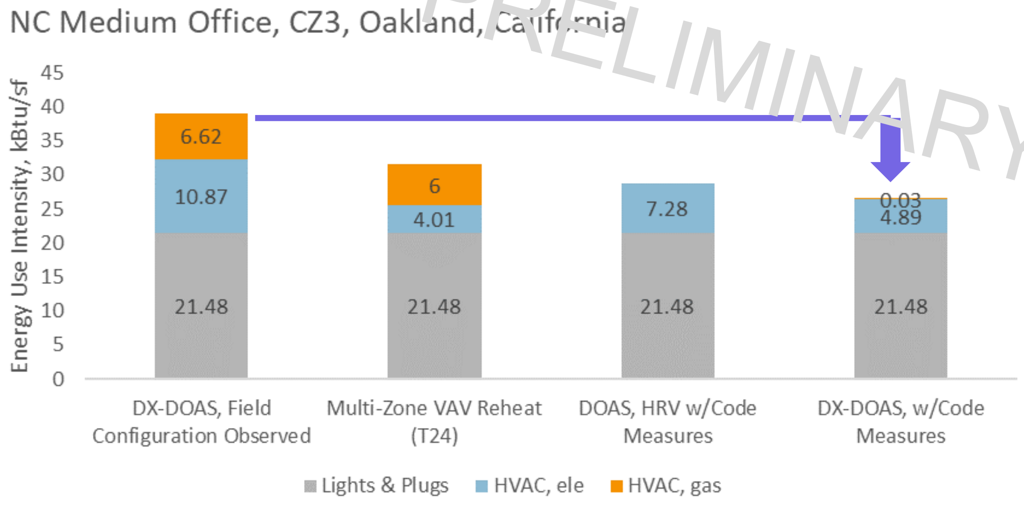
DOAS in small office building in California.

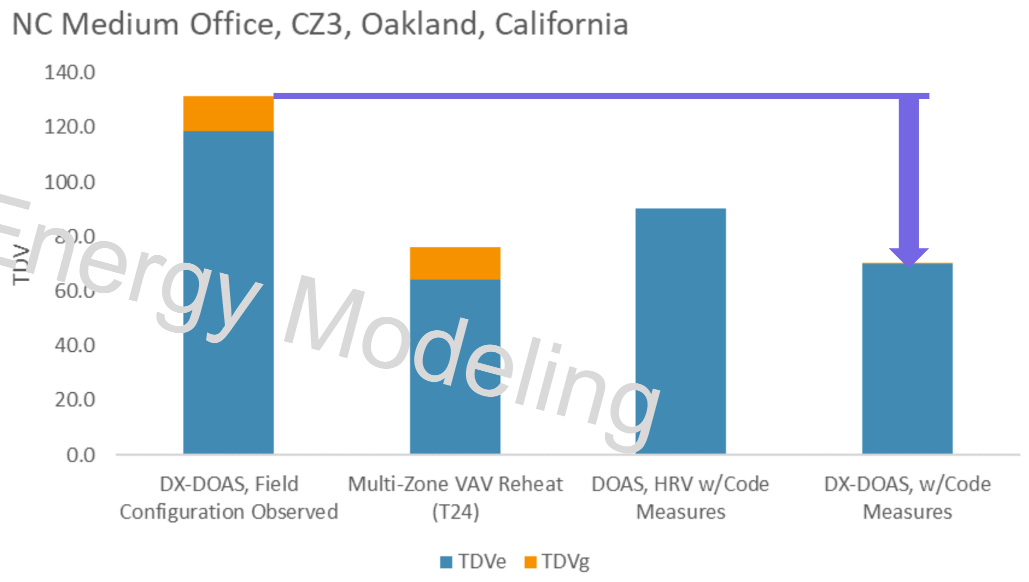
Proposed Code Change Overview

- **How it saves energy**
  - **Heat Recovery**: Ventilation will be required to have heat recovery and dampening peak thermal loads resulting in saving cooling and heating energy
  - **Bypass/Economize**: Systems must be capable of heat recovery bypass control to allow for ventilation economizing
  - **Fan Control:** System fans will have to meet a minimum level of efficiency and be capable of variable speed control to allow for multiple configurations
  - **Zone Fans Cycle Off:** When thermostats are meet, zone heating cooling fans cycle off.
  - **Ventilation Capabilities:** DOAS to be capable of providing an increased level of ventilation to increase partial economizing energy savings
  - **Minimize DX-DOAS reheat:** Sets a maximum supply air temperature limit on air if the building is in cooling mode.

Methodology for Energy Impacts Analysis

- PRELIMINARY Energy Modeling, CZ3, Medium Office Building





Reduced HVAC electric from DX-DOAS without measures by 55%.

Reduced TDV 2019 8% compared to a code minimum coupled air system (VAV) and 50% from DOAS without measures.

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

- Current Market
  - DOAS in combination with, VRF/VRV, HP, Radiant is a growing market
  - Indirect market indicator: VRF/VRV global market expected to reach $24 billion by 2022 from $11 billion in 2015

Market Overview

PERKINS+WILL
Research

2013 / VOL 05.01

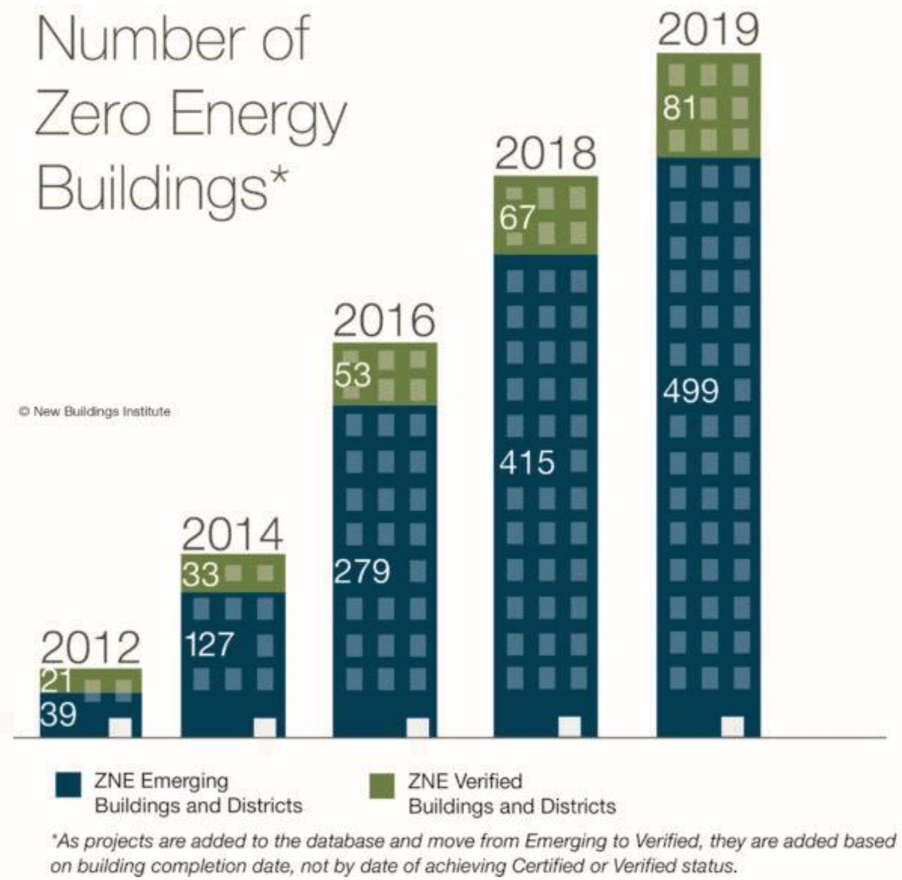
2nd largest architect in US
(2018, ENR Top 500 Design Firms)

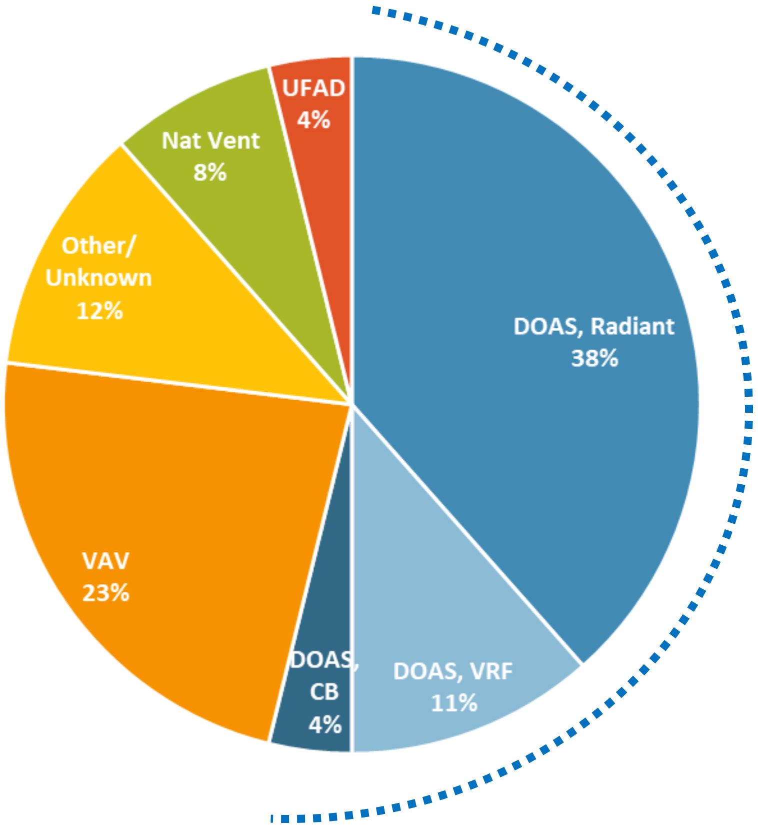
Current industry trends are moving **HVAC design away from VAV systems, which provide both ventilation and heating and cooling, to decoupled systems** which either partially or completely separate the ventilation air from the cooling and heating functions. The primary cost savings associated with decoupled systems is the result of a reduction in fan energy….

Market Overview

ZNE Building Trends of DOAS

26 buildings evaluated for HVAC, from 2017





54% Used a DOAS System

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

1. Ventilation air delivery configuration matters to achieve the recommended controls.

Solution: develop example problems in reference manuals and point to design guides.

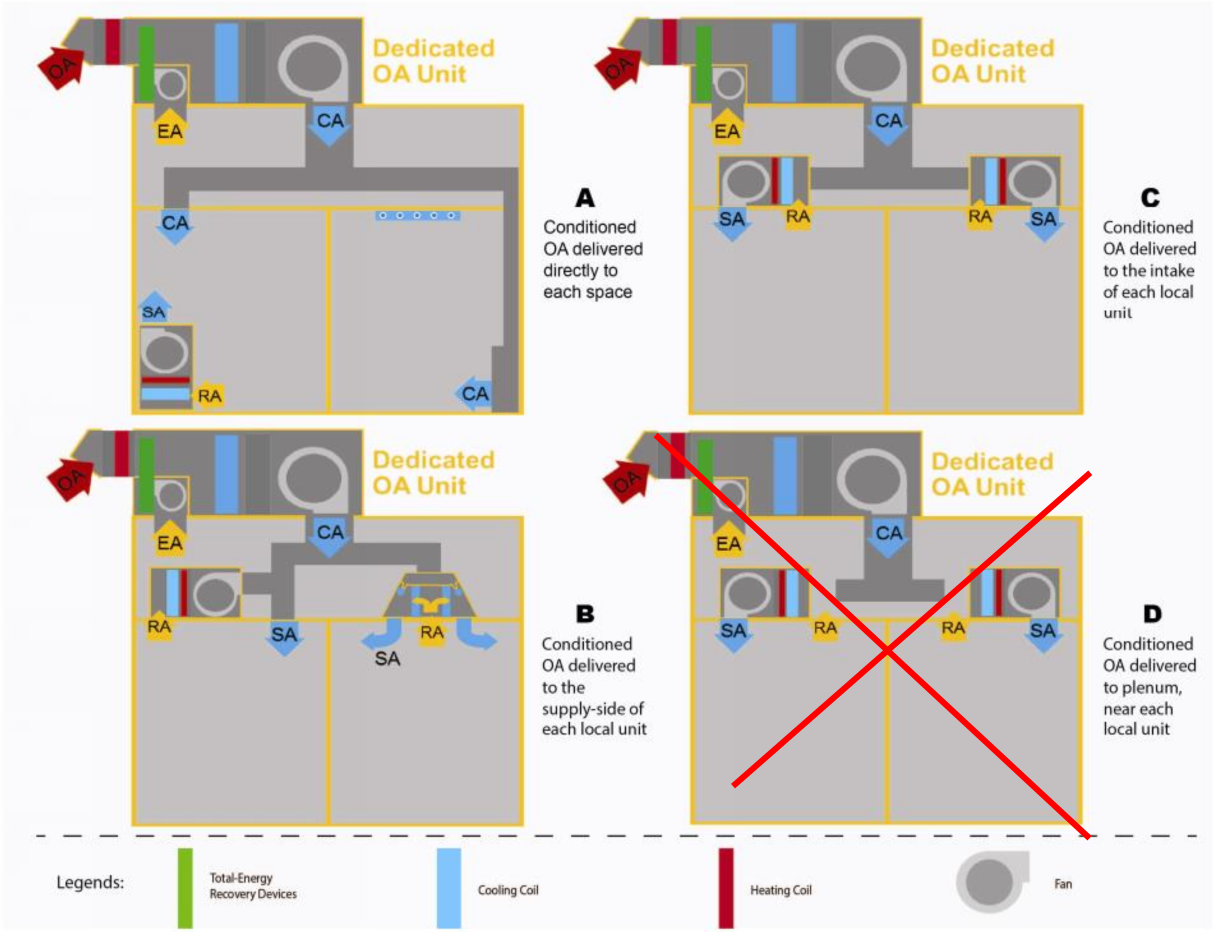


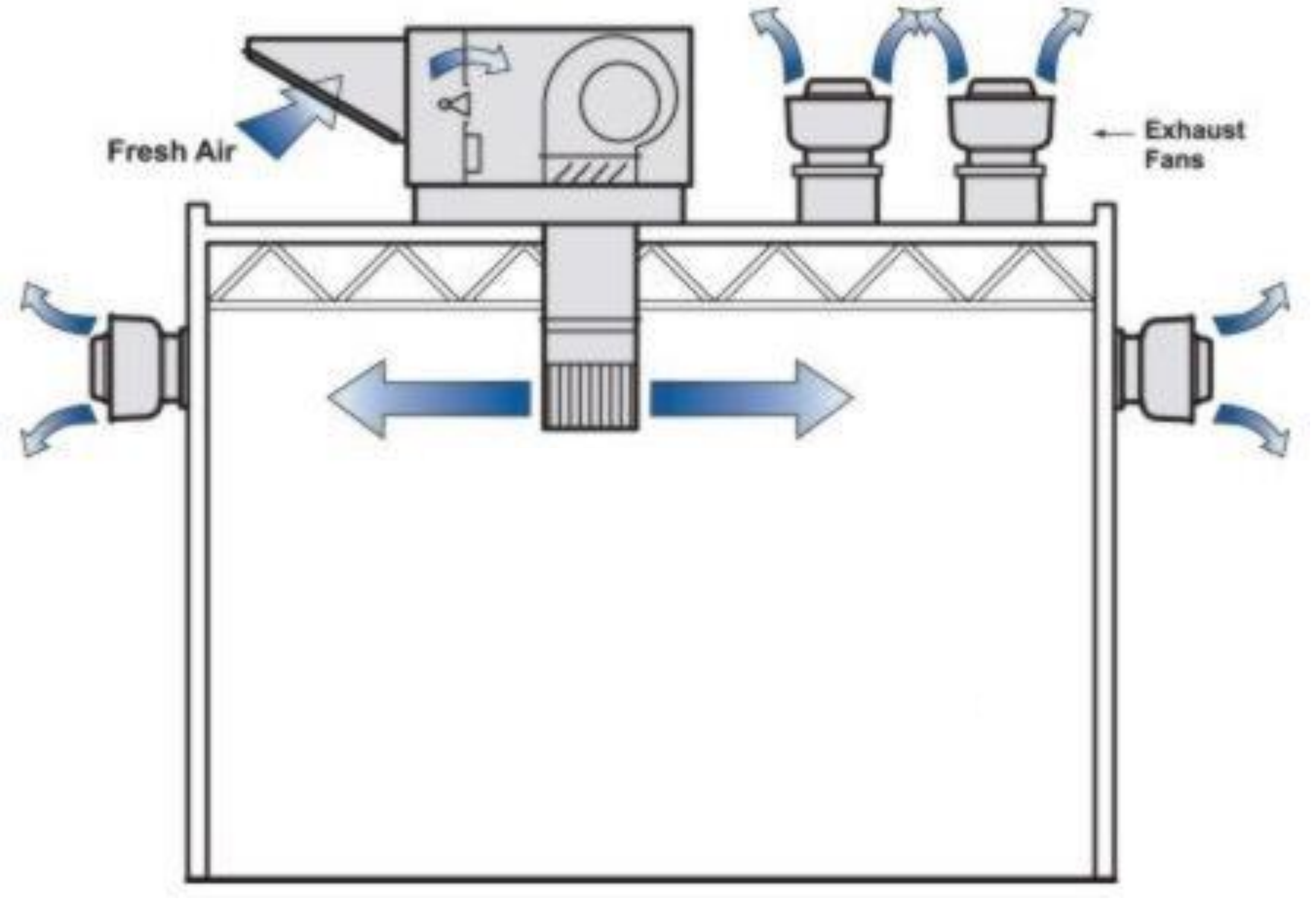
Figure 2-1: DOAS with total-energy recovery delivering OA (ASHRAE 2012).

2014 - ENERGY BENEFITS OF DIFFERENT DEDICATED OUTDOOR AIR SYSTEMS CONFIGURTIONS IN VARIOUS CLIMATES, Shihan Deng

Technical Considerations

2. Directly ducted outside air or once-through ventilation configurations may constitute a DOAS ventilation or exhaust system.

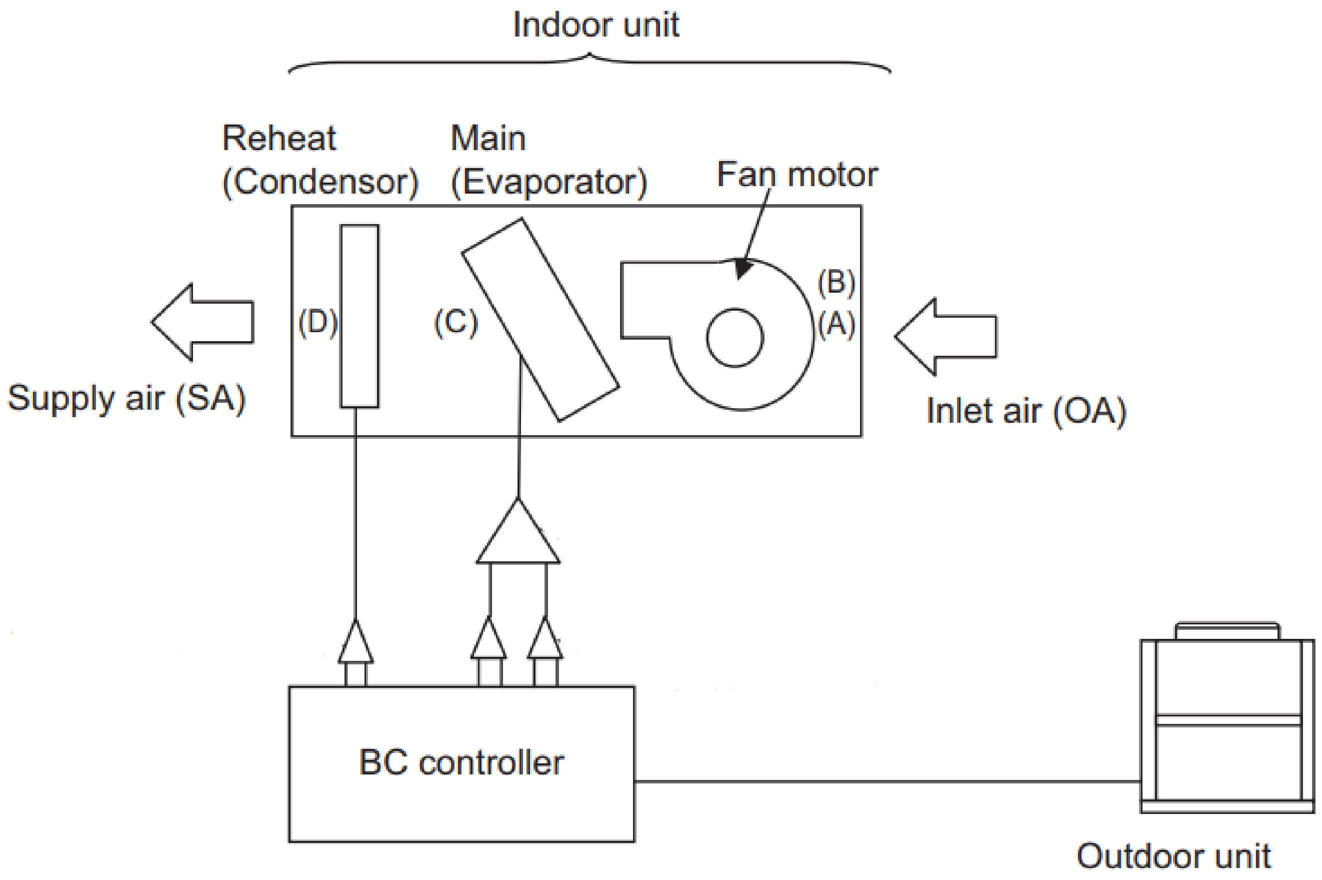
Solution: Stipulate if multiple exhaust outlets located within a set distance (x ft radius) from supply air unit shall be considered a single source.



Technical Considerations

3. DX DOAS Systems with integrated VRF coils do not typically include ventilation heat recovery.

Solution: Only allowed under a performance pathway for compliance.



Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts Methodology
- Cost Impacts Methodology
  - Incremental costs
  - Energy cost savings

Initial Research

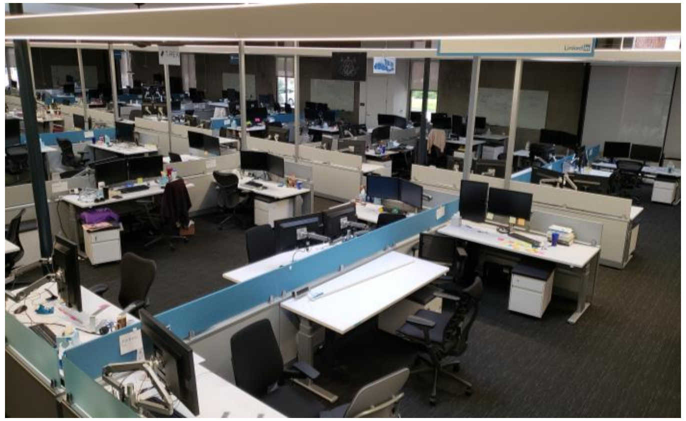
1. Additional DOAS field sites and technology demonstration sites from **PG&E Code Readiness** currently under review. 5 field sites, 3 demonstration sites

2. 2014 ASHRAE Article on multiple configurations of DOAS and benefit analysis. (JOSEPHINE LAU 2014)

3. NEEA DOAS Case Studies, 6 in total, Airport Terminal example (Better Bricks 2019)

Site: Sunnyvale Office

38,900 sf Retrofit



DOAS (HRVs)

Solid Core Heat Recovery
No Heat Recovery Bypass
No Active Cooling/Heating
MERV 13 Filters

VRF Air Cooled

Refrigerant Heat Recovery

Methodology for Energy Impacts Analysis

- Baseline of DOAS system being installed now (field research) versus Code DOAS criteria
- EnergyPlus for control and configuration capabilities
- Estimate of the market of nonresidential building types are DOAS
  - Buildings considered: Small, Medium Office, Small School, Primary School, Retail
- Results will be evaluated across all climate zones
- 2023 Construction Forecast: Literature review on the percentage of newly constructed and existing buildings is currently still being conducted
- Incremental Costs to be based on standard DOAS without controls and capabilities vs one with (seeking information now)

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 Code
- DOAS with heat recovery and no bypass
- DX-DOAS without heat recovery
- DOAS total fan power W/cfm (field data)
- Space conditioning fans do not cycle
- **Alt Baseline to be compared:** Current prototype HVAC ‘non-DOAS System’

Proposed Conditions

- Minimally compliant with 2019 Code
- DOAS with heat recovery and integrated bypass
- DX-DOAS w/ heat recovery and integrated bypass
- DOAS total fan power at a max W/cfm
- Space conditioning fans cycle off when no call for heating or cooling in the zone

Compliance Verification Process

1. Design Phase

- System configuration on ducting
- DOAS equipment selection capability

2. Permit Application Phase

- Check of DOAS criteria satisfied, either on drawings
- **<u>or</u>**
- in new system documentation form for Part 6

Compliance Verification Process

3. Construction phase

- System controls configured for DOAS.

4. Inspection Phase

- Acceptance testing of controls
- **Or**
- Site inspection check of installed equipment matches design

Market Actors

Market actors involved in implementing this measure include:

- Mechanical Designers
- Equipment Representatives
- Manufacturers
- Installers
- Plans Examiners
- Controls Contractors
- Inspectors

Are you interested in participating in a survey? Please reach out to info@title24stakeholders.com **and include which group you most closely identify with.**

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
  - *NOTE: Exhaust Air Heat Recovery to be developed in more detail for second stakeholder meeting in January/February 2020*
- **Are there concise and clear existing definitions of DOAS and DX-DOAS people are familiar with?**
- **Is there any sources of information to help inform what size systems (in nominal cfm) would be capable of implementing these controls?**

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2022 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Comments on this measure are due by October 29, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

Neil Bulger, *Red Car Analytics*
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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

HVAC Controls: VAV Minimum Airflow Rates

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | HVAC

Shaojie Wang, *Energy Solutions*

Tim Minezaki, *Energy Solutions*

Jeff Stein, *Taylor Engineering*

October 15, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

1. Background
2. Market Overview and Analysis
3. Technical Feasibility
4. Cost and Energy Impacts
5. Compliance and Enforcement
6. Proposed Code Changes
7. Discussion and Next Steps

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

Remove existing 20 percent flowrate deadband requirements

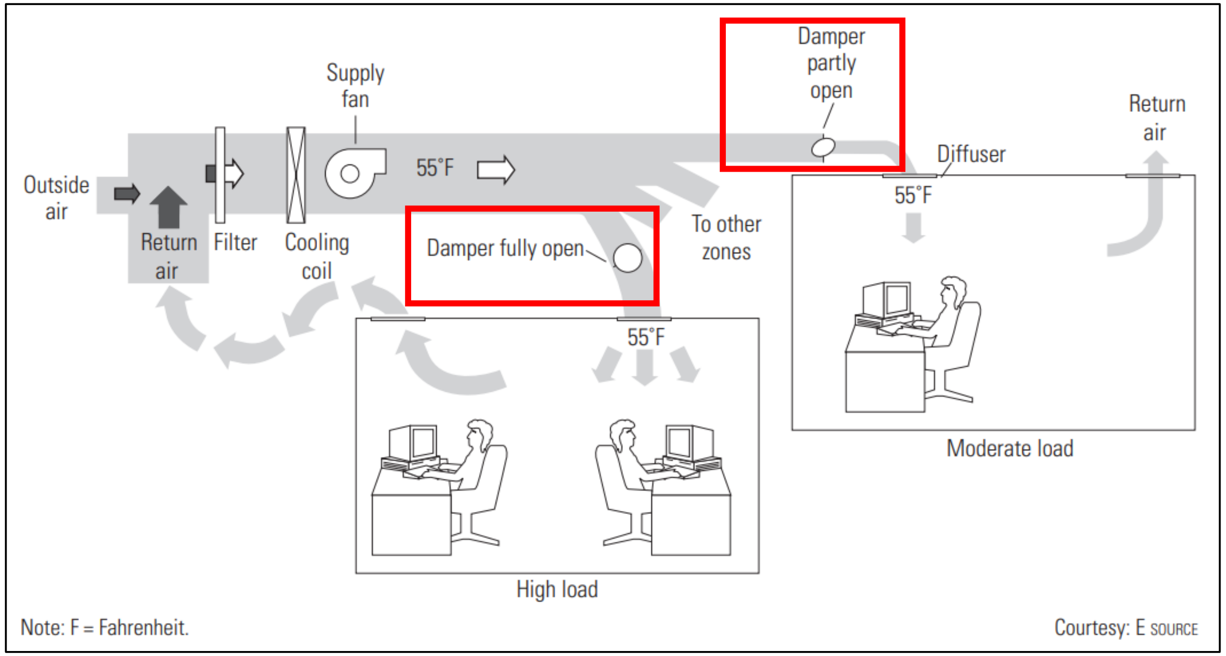
Measure Name	Type of Change	Software Updates Required	Section of Code Updated
VAV Minimum Flowrate	Prescriptive	Yes	140.4(d)3 NA7.5.12.4

Buildings Impacted

- All nonresidential buildings with VAV HVAC Systems

Context and History

- **What are VAV boxes?**
  - Variable Air Volume (VAV) boxes are a major component of variable airflow systems and are common in California
  - VAV boxes are controlled by a thermostat to control the amount of airflow (for cooling) or to open a heating valve (for heating) depending on the conditions in a room

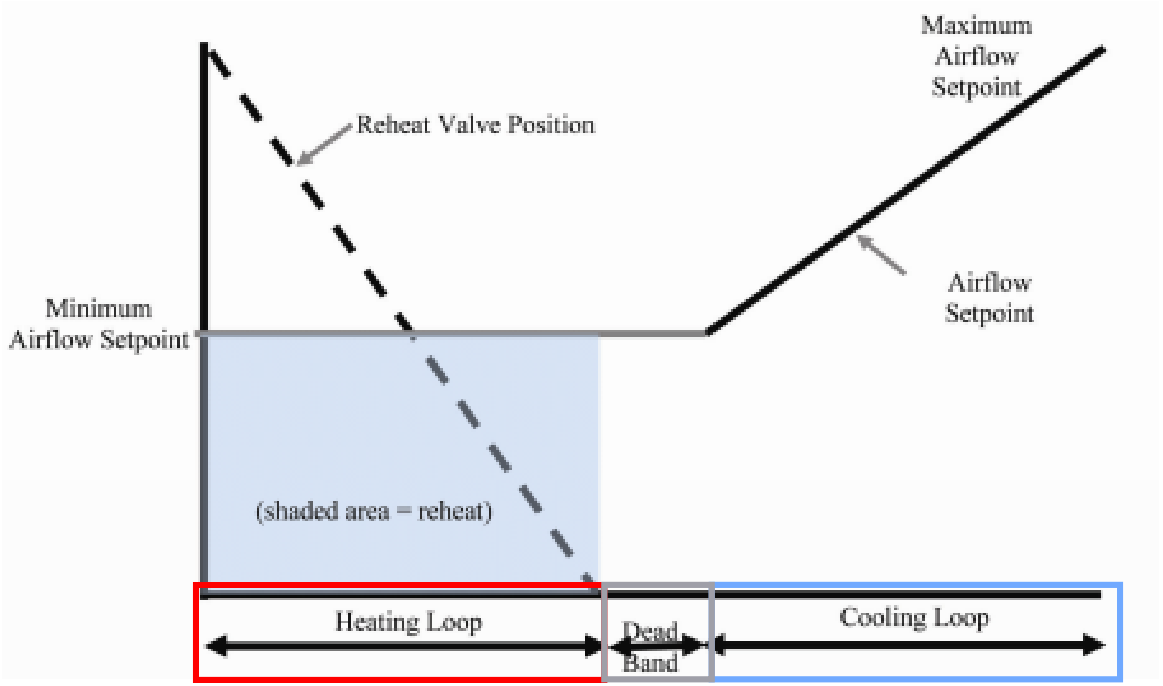


Typical VAV Distribution System – VAV boxes highlighted
(Source: Energy Star, 2008)

Image Source: Energy Star Building Upgrade Manual (Energy Star 2008): https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/comprehensive-approach/energy-star

Context and History

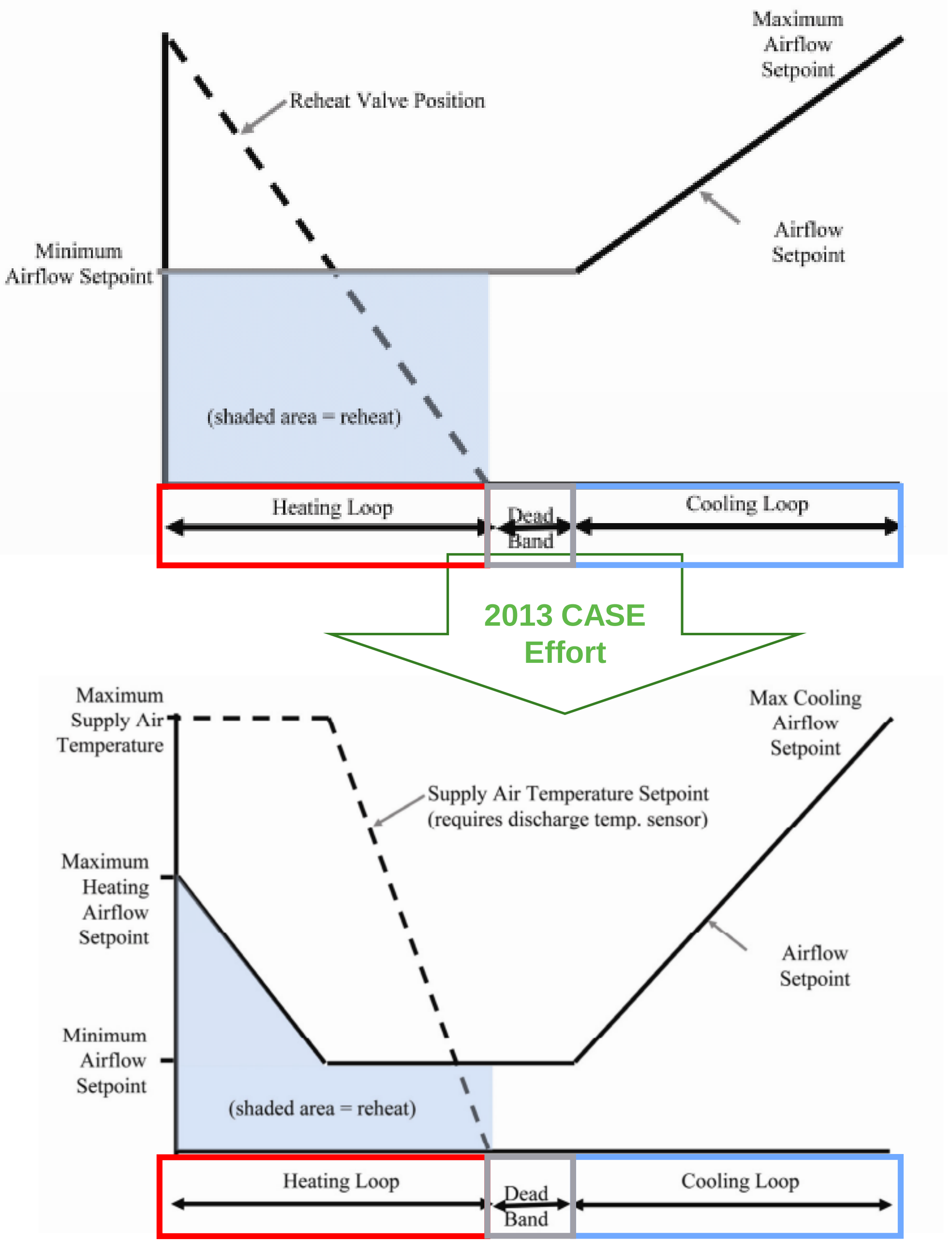
- **VAV Boxes: before 2013**
  - Prior to 2013, VAV systems had very simple controls:
    - Cooling mode: damper opens to allow more air to meet the thermostat setpoint
    - Deadband operation: airflow is operated at a minimum flowrate and HVAC system is neither calling for heating or cooling
    - Heating mode: heating valve modulates to reheat the air to meet the thermostat setpoint



Conventional "Single Maximum" Reheat Box Control
(Source: Advanced VAV System Design Guide, Energy Design Resources March 2007)

Context and History

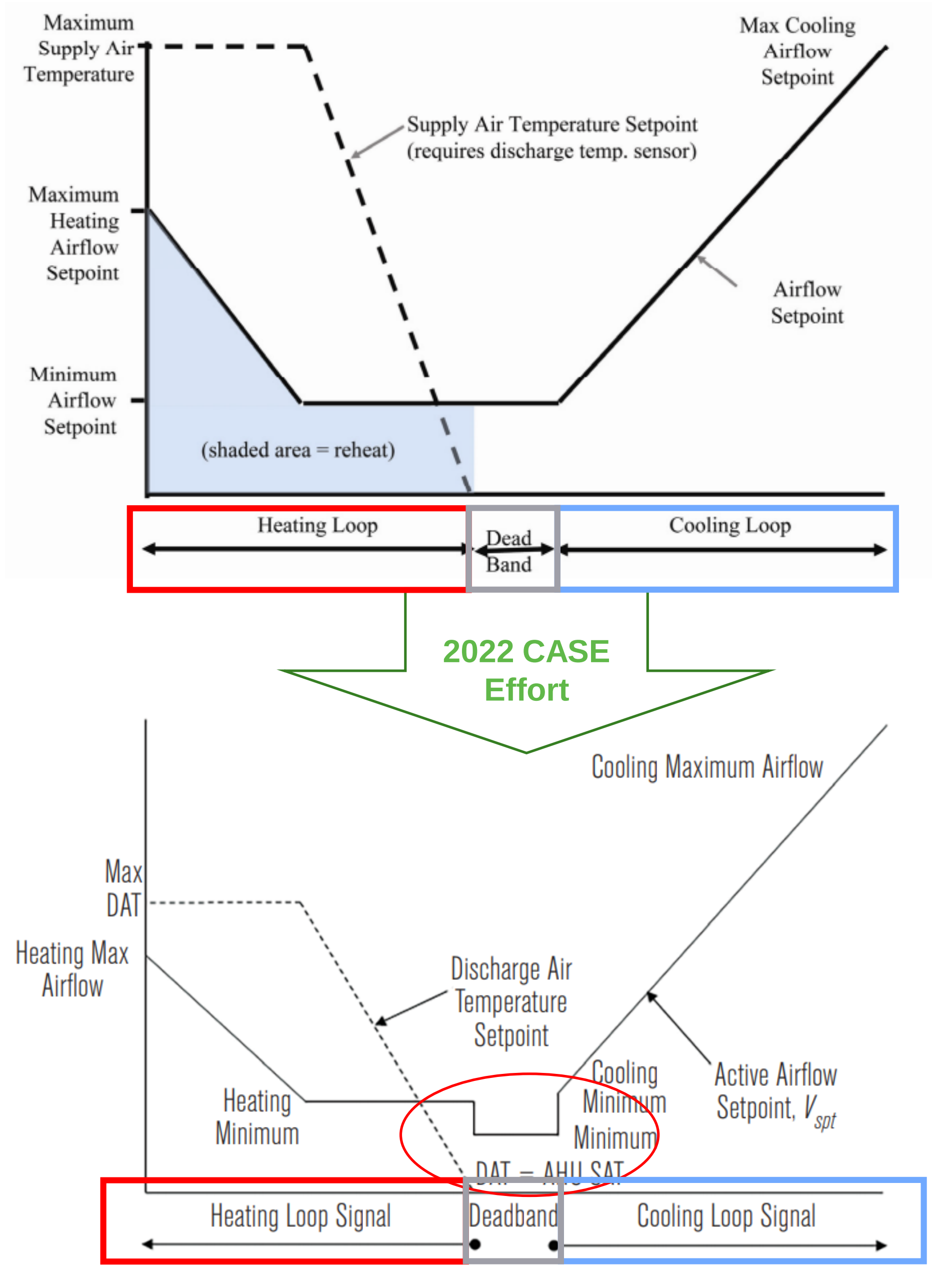
- **VAV Boxes after 2013**
  - A 2013 CASE effort implemented "Dual Maximum" controls into Section 140.4 (d)
  - This control strategy significantly reduced the amount of energy spent on reheat by significantly reducing the amount of airflow during heating mode.



(Source: Advanced VAV System Design Guide, Energy Design Resources March 2007)

Context and History

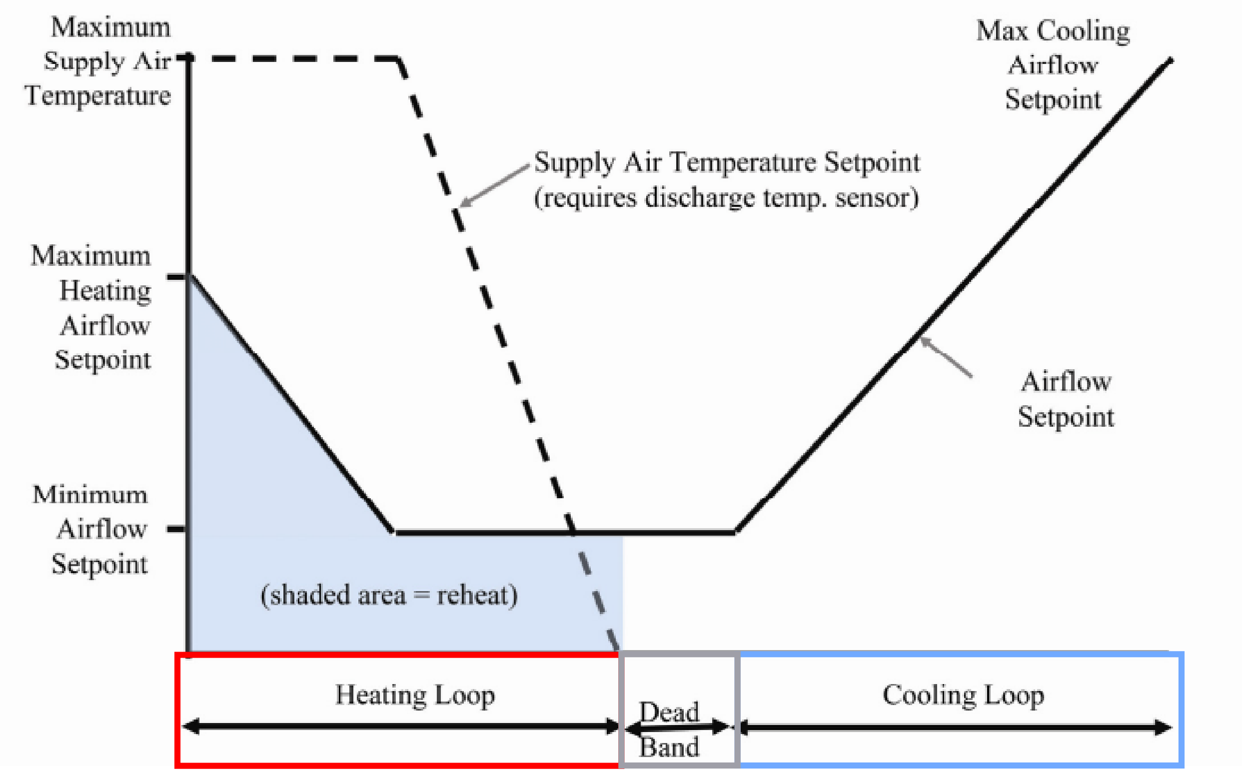
- **Additional VAV Energy Savings**
  - Studies from the Center for the Built Environment (CBE) and Taylor Engineering found that the minimum airflow setpoint could be safely lowered beyond the current Title 24 code requirements (ASHRAE RP-1515)
  - The lower deadband airflow requirements should save significant energy and increase comfort



Source: Making VAV Great Again (Taylor Engineering): http://www.taylor-engineering.com/Websites/taylorengineering/articles/ASHRAE_Journal_-_Making_VAV_Great_Again.pdf

2019 Code Requirements

- Section 140.4 (d): Current code requirements require "dual maximum" VAV box controls.
  - Cooling Max: 100% of design cooling load
  - Heating Max: 50% of design cooling level
  - Minimum Flow: **20%** or minimum flow calculation from 120.1(c)3



2019 Code Requirements

Title 24, Part 6 Prescriptive Requirements	ASHRAE 90.1 (2016) Prescriptive Requirements
Section 140.4 (d) • Primary airflow rate in the deadband • Design zone outdoor airflow rate will be used in the deadband	Section 6.5.2.1 • Primary airflow rate in the deadband

Proposed Code Change

- See the proposal summary and mark-up language in **resources tab**
- Remove 20 percent VAV box minimum airflow requirements from 140.4(d) to allow flow rate to be based on outdoor flow rate requirements (section 120.1(c)3)

SECTION 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

(d) **Space-conditioning Zone Controls**

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

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

ii. The volume of primary air in the deadband shall ~~not exceed the larger of~~:

~~a. 20 percent of the peak primary airflow; or~~

~~b. T~~ be the design zone outdoor airflow rate as specified by Section 120.1(c)3.

- **Do you agree with this proposed code change? Tell us if you have other suggestions**

Market Overview

- Current Market
- Trends
- Barriers

Market Overview and Analysis

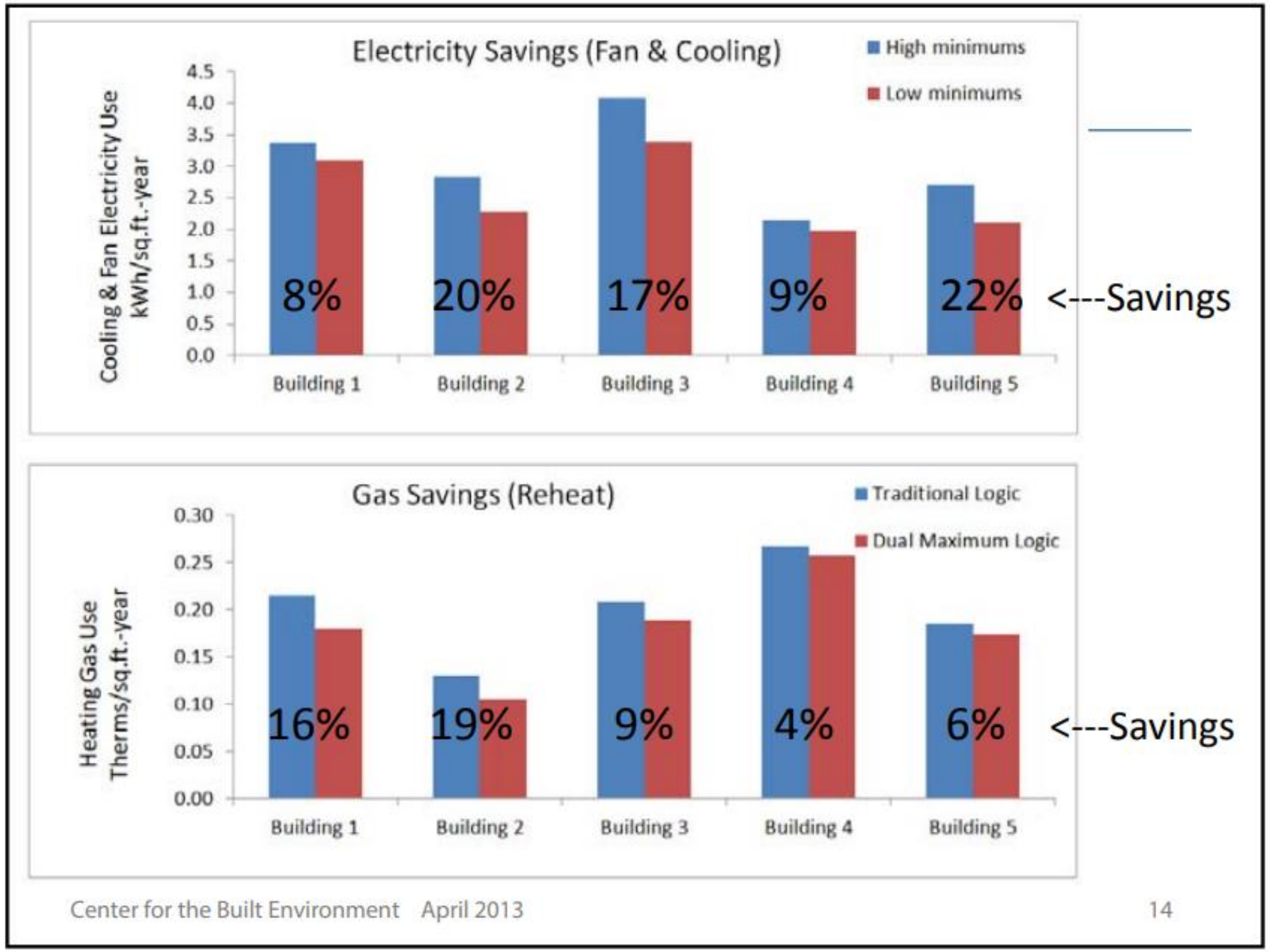
- **Current Market**
  - Designers understand VAV terminal box measure well
  - Manufacturers likely already have control settings for VAV minimum in their existing products
  - Building Automation System (BAS) can easily integrate this measure in the control software
- **Market Trends**
  - Energy Service Companies (ESCOs) already integrate this measure in retrofit projects
- **Market barriers**
  - Designers may want the simplicity of setting terminal box minimums to 20% of the design air flow.
- **Do you agree with this description? What else should we know?**

Energy and Cost Impacts
Methodology and Assumptions

- Energy Impacts
- Cost Impacts
  - Incremental Costs
  - Energy Cost savings

Energy Savings – Initial Research

- ASHRAE study (RP-1515) found that reducing minimum air flows reduced pre-existing cold complaints while saving energy
- HVAC energy use was reduced by 10% to 30% with very small changes to pre-existing control settings. Subsequent studies confirmed the same findings
- While this effort will do limited reduction within the deadband, these graphs can illuminate what type of savings and magnitude



Source: Control Strategies that Reduce Minimum Airflow to Save Energy and Maintain Comfort (https://cbe.berkeley.edu/project/minimum-airflow/)

Incremental Per Unit Cost

Over 15/30 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Equipment	$0	Equipment Replacement	$0
Installation	$0	Annual Maintenance	$0
Commissioning	$0		
Other	$0		
Total	**$0**	**Total**	**$0**

- **Do you agree with our understanding of costs?**
- **Are there components of costs we left out?**
- **Do you find these costs to be reasonable?**

Poll

Do you agree with our incremental cost assessment?

A. Yes, Incremental Cost are $0 or near zero
B. No, costs are low
C. No, costs are significant

Methodology for Energy Impacts Analysis

Submeasure	Per Unit Savings	Modeling Tool	Savings Vary by Climate Zone?	Scenarios
VAV Minimum Airflow Rate	-	EnergyPlus	Yes	• All climate zones • All prototype buildings

2023 Construction Forecast

Building Prototype	Percent of New Construction Impacted by Proposed Requirement*	Million Square footage of New Construction Impacted by Proposed Requirement
Small office	< 100%	476.52
Large office	< 100%	1665.45
Restaurant	< 100%	238.92
Retail	< 100%	1490.53
Grocery store	< 100%	394.19
Schools	< 100%	724.95
Colleges	< 100%	379.99
Hotel/motels	< 100%	451.77

*Variable airflow systems have wide applicability but are likely to have reduced market share due to the rise of Variable Refrigerate Volume (VRV) systems. We will investigate the latest industry trends to adjust our forecasted energy usage.

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 Code
- Period of evaluation:15 years
- Minimum VAV terminal box airflow: 20% of peak airflow rate

Proposed Conditions

- Minimally compliant with 2019 Code
- Period of evaluation:15 years
- Minimum VAV terminal box airflow: zone outdoor airflow rate

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Mechanical Designer utility space-by-space ventilation requirements to set VAV box minimum airflow rates in mechanical schedule table and call out utilization in sequence of operation (SOO)

2. Permit Application Phase

- Plans examiner to verify design is supported by the compliance documents

Are there any other phases that would improve compliance?

Compliance Verification Process

3. Construction phase

- Controls contractors provide new inputs to reflect lower flow during deadband operation

4. Inspection Phase

- Commissioning will functionally test that new sequences of operation were appropriately implemented (small change to NA7.5.12)

Are there any other phases that would improve compliance?

Market Actors

Market actors involved in implementing this measure include:

- VAV box manufacturers – Johnson Controls, Honeywell, Carrier, Dakin, Trane
- VAV box trade associations – The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), American Heating Refrigeration Institute (AHRI), Heating, Air Conditioning & Refrigeration Distributors International (HARDI)
- Local contractors, builders and designers and architects – Including representatives from Air Conditioning Contractors of America (ACCA) and Plumbing, Heating and Cooling Contractors (PHCC)
- Efficiency advocates – Alliance to Save Energy, American Council for an Energy-Efficient Economy (ACEEE), National Resource Defense Council (NRDC), California Energy Alliance, Appliance Standards Awareness Project

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to open the draft language from the **resources tab**
- **Are there specific concerns about meeting the VAV box minimum airflow design requirements?**
- **How often are you designing VAV box minimum airflow based on outdoor airflow rate?**

Poll

How do you design and specify VAV box minimum airflow?

A. Design zone outdoor airflow rate
B. 20% of peak primary airflow
C. Other

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2022 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Comments on this measure are due by October 29, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

High Efficiency Boilers and Service Water Heating Systems

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | HVAC

George M. Chapman, *Energy Solutions*

October 15, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

1. Background
2. Market Overview and Analysis
3. Technical Feasibility
4. Cost and Energy Impacts
5. Compliance and Enforcement
6. Proposed Code Changes
7. Discussion and Next Steps

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Proposed Code Change Overview

- Draft code language for this submeasure is available in the **resources tab**
- Description of changes
  - Harmonize with ASHRAE 90.1 7.5.3 and Addendum BC
  - Require weighted boiler system efficiency for systems 1,000,000 – 10,000,000 Btu/hr to a weighted-thermal efficiency of 90 percent
    - Hot water return entering the boiler(s) be 120°F or less
    - Establish flow rate requirements to ensure condensing operation
  - Require weighted service water heating system efficiency for systems 1,000,000 – 10,000,000 Btu/hr to a weighted-thermal efficiency of 90 percent
  - Expand scope and requirements for combustion controls from 5% to 3% excess oxygen for systems 5-10 MMBtu/hour using O2 trim control

Code Change Proposal – Summary

Submeasure	Building Types	System Type	Type of Change	Software Updates Required
Boiler System Efficiency	Nonresidential Highrise Residential	HVAC	Prescriptive	Yes
Hot Water Distribution System Design – return and supply water temps	Nonresidential Highrise Residential	HVAC	Prescriptive	Yes
Hot Water Distribution System Design – supply water flow rates	Nonresidential Highrise Residential	HVAC	Prescriptive	Yes
Service Water Heating System Efficiency	Nonresidential Highrise Residential	Water Heating	Prescriptive	Yes
Oxygen Trim Control	Nonresidential Highrise Residential	HVAC	Mandatory	Yes

- The first three requirements are all aspects of a single submeasure
- Service water heating is closely related
- O2 trim control addresses the combustion of these boiler systems

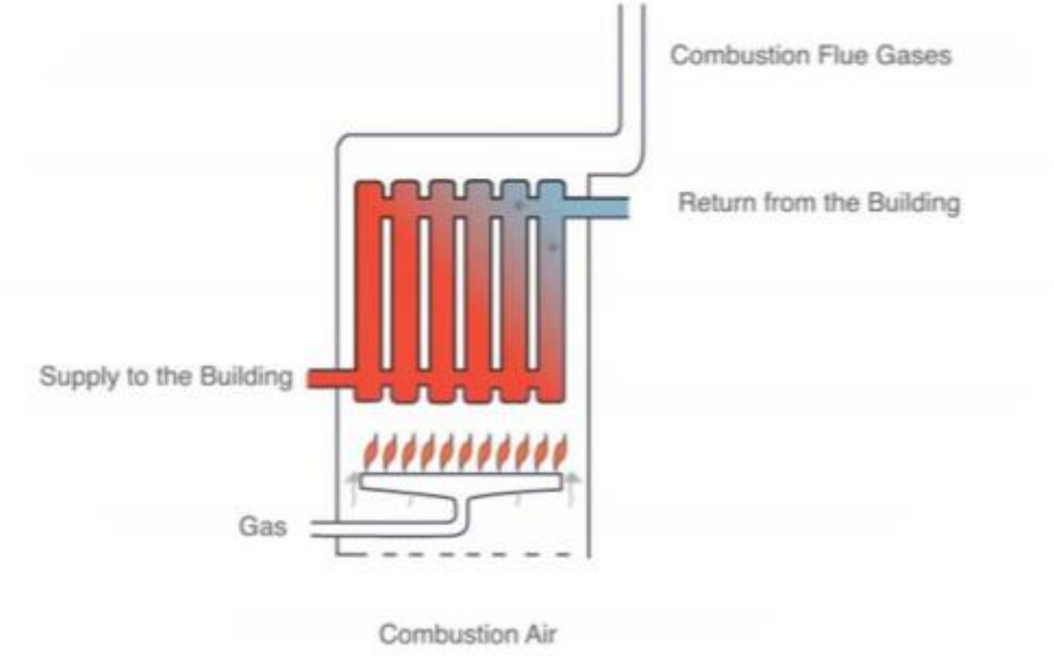
Context and History

- Primary drivers
  - Condensing technology has achieved market maturity and represents significant energy savings
    - Approximately 10% savings over baseline efficient products
  - ASHRAE 90.1 requirements have been revised to adopt this technology and there is a desire to harmonize to capture these savings
  - Savings from combustion controls measures has been demonstrated in previous code cycles
    - Capturing an opportunity to expand this savings opportunity to a broader scope of systems

Would require **condensing system technology** for boiler systems and service water heating

Context – Conventional Boilers

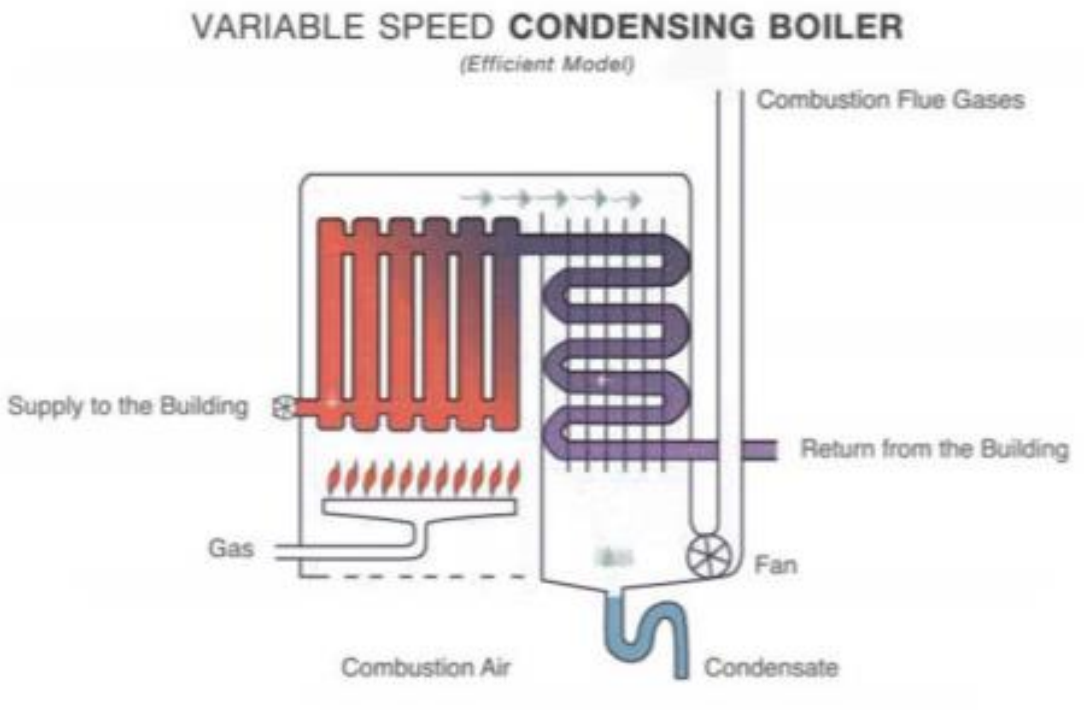
- Boilers and water heaters burn gas to produce heat
  - The hot flue gases then pass through a heat exchanger which heats up the water
  - Traditional boilers and water heaters have a single heat exchanger
    - The hot flue gases then rise up a chimney stack for safe ventilation



http://mn.gov/commerce-stat/pdfs/card-cee-slides.pdf

Context – Condensing Boilers

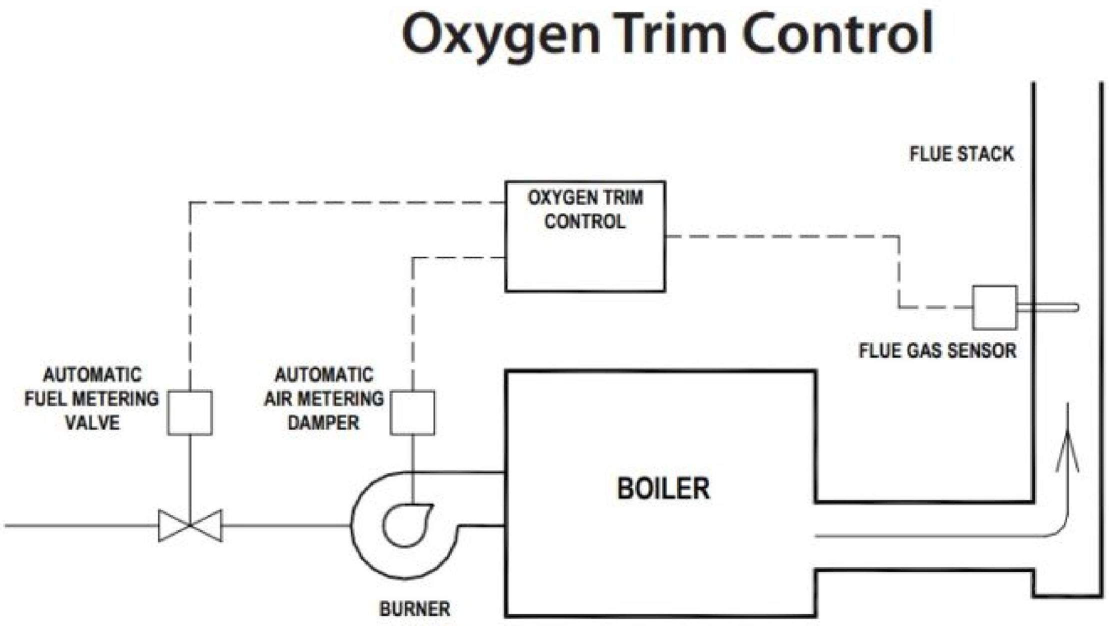
- Condensing boilers contain a stainless steel heat exchanger
  - This exchanger captures additional heat which traditionally would be lost up the chimney
  - Some of this cooler exhaust gas condenses and becomes a liquid, providing additional heat through phase change
  - The resulting liquid condensate is acidic due to combustion byproducts
  - The remaining exhaust may not be hot enough to safely ventilate through a traditional chimney



http://mn.gov/commerce-stat/pdfs/card-cee-slides.pdf

Context and History – O2 Trim Control

- Would require improved combustion controls
- Fire requires oxygen to burn
  - Too much or too little oxygen impacts how efficiently a fire burns, and thus how efficiently a natural gas or other combustion product produces heat
  - Combustion controls help balance and optimize the most efficient oxygen ratios to ensure efficient performance
  - O2 trim control systems continuously monitor the flue gases and adjust the burner air supply to ensure efficient operation



2019 Code Requirements

Title 24, Part 6	ASHRAE 90.1 (2016)
Section 110.2 • Minimum product efficiencies for boilers and water heaters • Unchanged by these proposals for individual products but the average weighted system efficiency will be higher	**Section 7.5.3** • Thermal efficiency requirements for gas service heating systems
Section 120.9 • Requirements for commercial boilers including excess oxygen levels of 5% for boilers 5 MMBtu/h and over using firing rate or measured flue gas oxygen concentration	**Addendum BC (2019)** • Thermal efficiency requirements for gas hot water boilers between 1 MMBtu/h and 10 MMBtu/h • Hot water distribution design specifications

Proposed Scope: Preemption

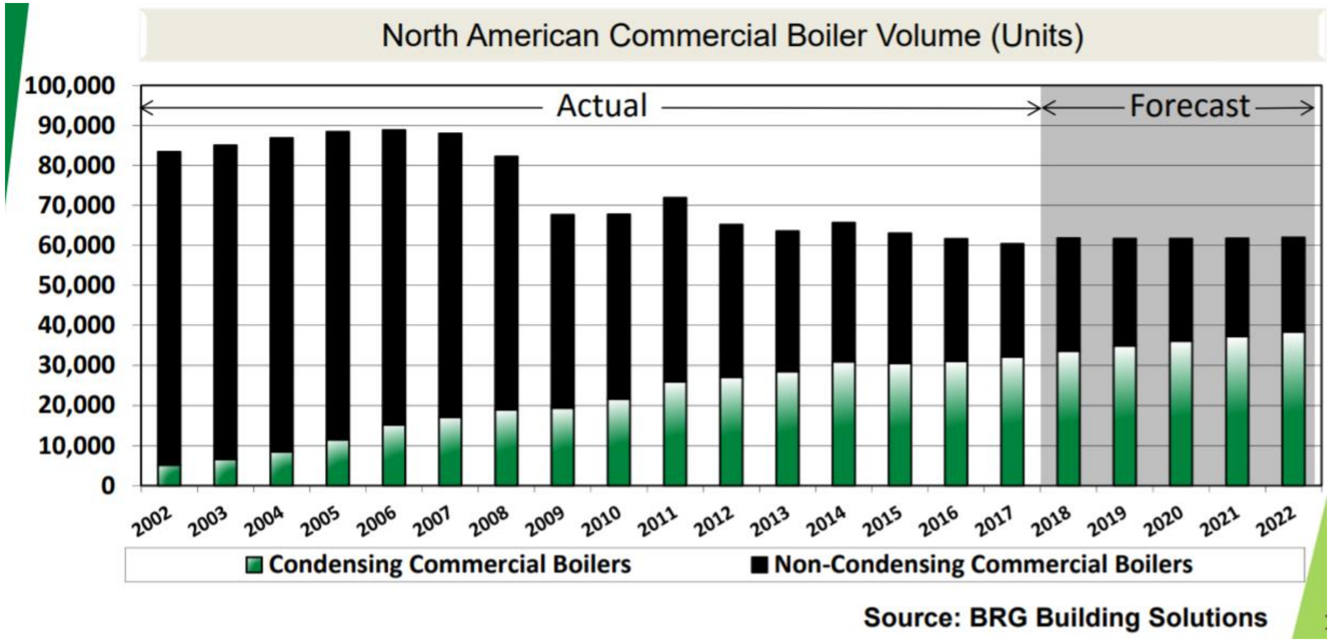
- Preemption considerations
  - Boilers and water heaters are covered products and thus subject to preemption
  - There is a limited exception for alignment with ASHRAE for new construction, this proposal seeks to utilize this exception

Market Overview

- Current Market
- Trends
- Barriers

Market Overview and Analysis - Boilers

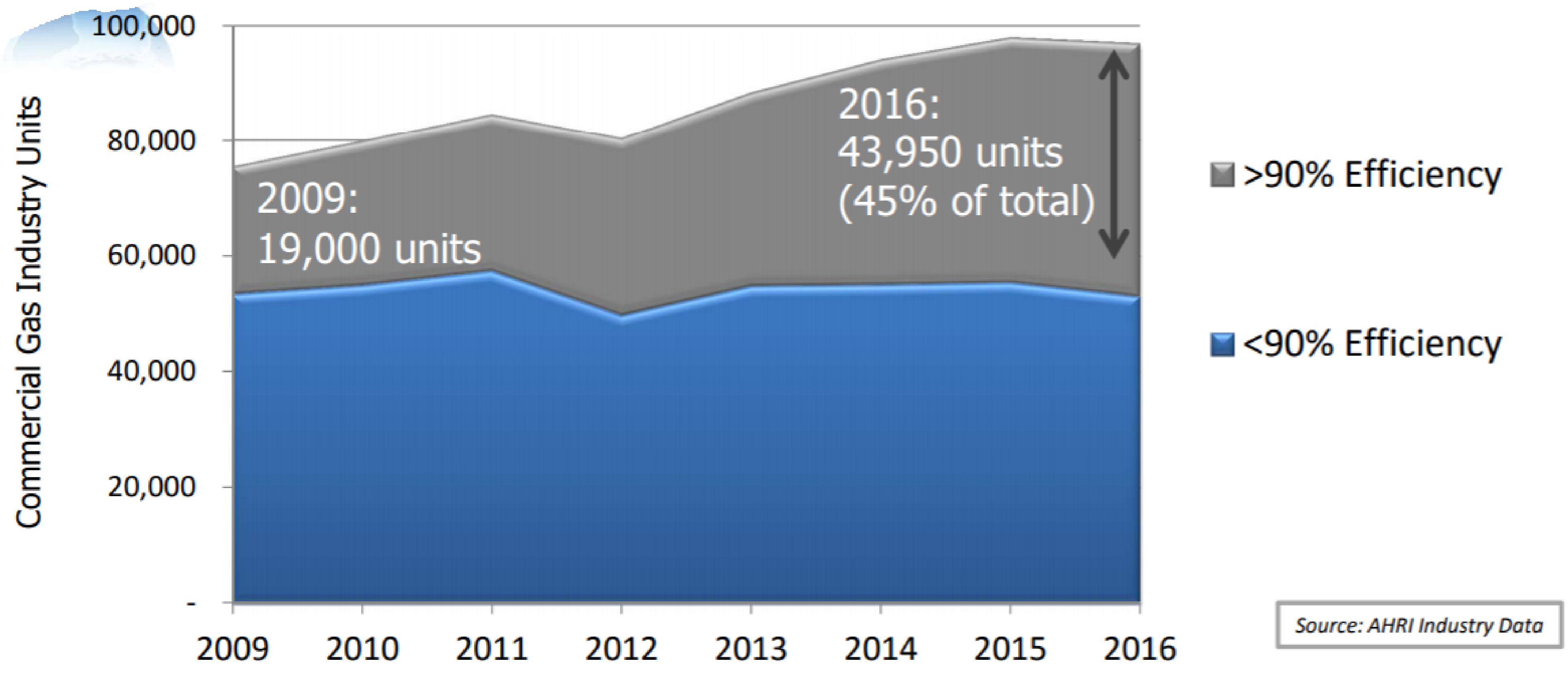
- Current Market
  - Condensing boilers have been on the market since the late 1990s
  - Global trend towards condensing
  - ENERGY STAR certified commercial boilers must have thermal efficiency of at least 94%
  - Condensing products now make up close to 50% of sales in the US
  - For new construction in 2019, DOES estimates 2 small and .4 large gas-fired hot water boilers per every million square feet of new commercial buildings



https://www.regulations.gov/document?D=EERE-2013-BT-STD-0030-0044 ; https://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2018/2018%20Unit%20Shipment%20Data%20Summary%20Report%20.pdf?b177-515e ; https://www.regulations.gov/document?D=EERE-2013-BT-STD-0030-0044; http://investor.aosmith.com/static-files/7dd9851f-b6eb-4e86-88eb-9f88c6600328

Market Trends – Commercial Water Heaters

- In 2018, 56% of commercial water heater sales met ENERGY STAR standards of 94% thermal efficiency



http://investor.aosmith.com/static-files/8b84da9c-ab86-4f5b-afe9-183acb60b34b;
https://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2018/2018%20Unit%20Shipment%20Data%20Summary%20Report%20.pdf?f755-aaea

Boiler and Water Heater rebates

- Efficiency programs across California provide incentives for efficient commercial boilers and water heaters, and custom incentives for systems
  - Improved combustion controls are also offered
  - These systems may be eligible for PACE financing and other measures
- ENERGY STAR offers product recognition for both commercial boilers and commercial water heaters

https://www.energystar.gov/about/federal_tax_credits/gas_propane_oil_hot_water_boiler ; http://www.ahrinet.org/Homeowners/Federal-Energy-Efficiency-Tax-Credits ; https://programs.dsireusa.org/system/program?fromSir=0&state=CA ; https://www.thepress.net/living/pace-financing-makes-going-green-easy/article_2b63443e-d3df-11e4-b850-8f3762dcbb76.html

Market Barriers

Potential Barrier	Proposed Solution
Building and facility owners may resist to put in an expensive, unfamiliar, and more complex hot water system	Provide information on the benefits of the high-efficiency system, how it can and should be designed and operated, and its life cycle cost
Mechanical engineers may be skeptical of whether such high-efficiency can be achieved reliably in the field	Provide case studies and potentially design guides to demonstrate that in-field efficiency can match rated performance when requirements for return water temperature and recirculation are met

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

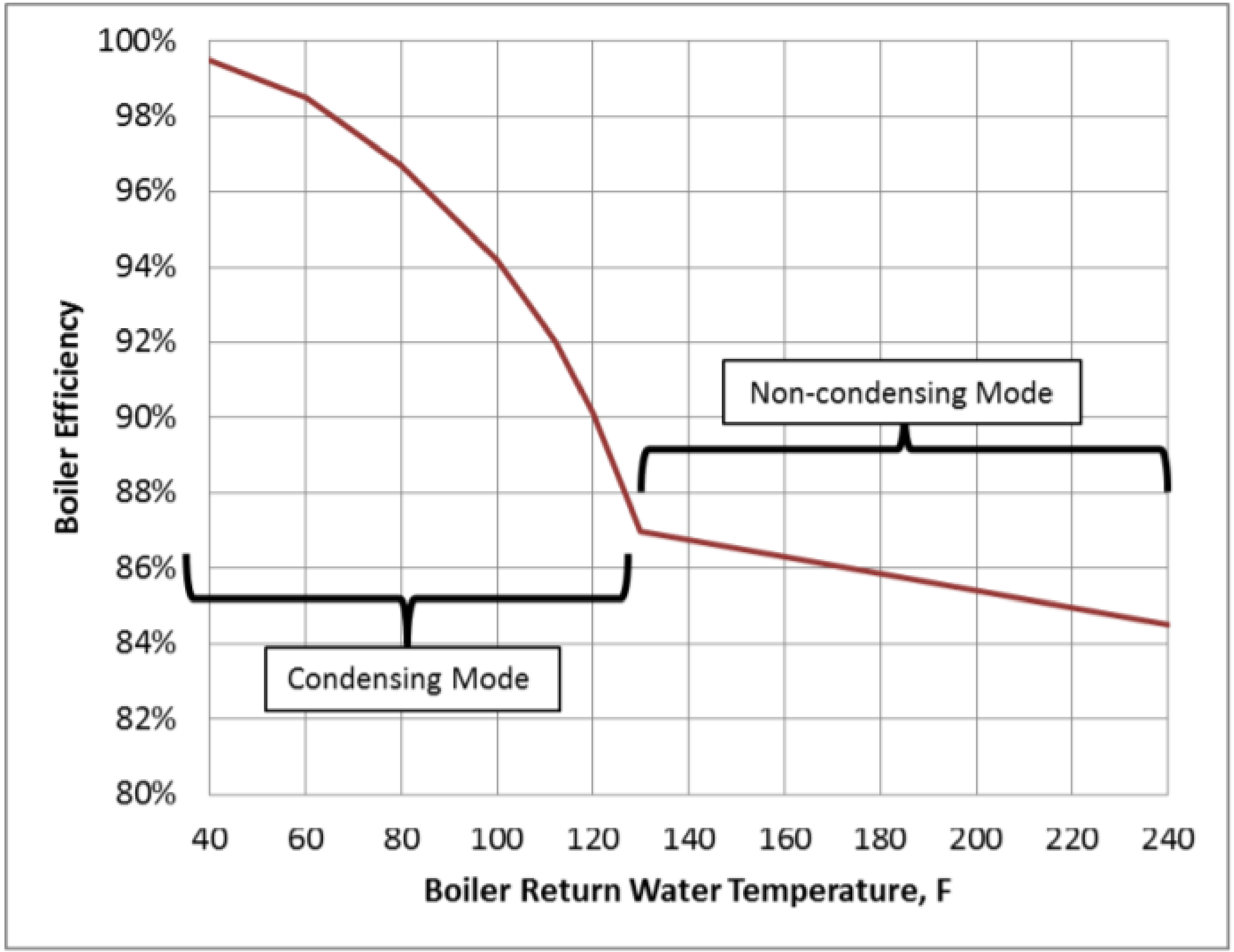
Technical Overview

- Condensing technologies require additional installation considerations
  - Acidic condensate must be treated and disposed of
  - Atmospheric venting may not be appropriate for condensing products due to the lower flue gas temperatures
- These requirements are different from a traditional system, but as these products become more common place the strategies to address them are well known and understood
- These challenges are mitigated by the proposed measure only applying in new construction applications
  - Often the installation challenges are exacerbated by existing conditions in retrofit

Technical Overview

- Condensing technologies have different requirements in order to perform at their rated efficiencies, such as requiring:
  - Return water temperature requirements to ensure this performance
  - Minimum flow rates to ensure this performance
- These design requirements may not be typical for traditional systems

Figure 1: Relationship of boiler performance to return water temperature



http://mn.gov/commerce-stat/pdfs/card-condensing-boilers.pdf

Technical Barriers

Potential Barrier	Proposed Solution
Building and facility owners may have concerns with condensate drainage	Document methods of proper acidic condensate removal
Building and facility owners may have concern with venting	Document methods of proper ventilation
Manufacturers and other stakeholders challenge the measure as being more stringent than the federal standards	Clarify that this is an alignment with ASHRAE Standard 90.1 for new construction, and that the efficiency is required at the system level not at the component or equipment level

Energy and Cost Impacts
Methodology and Assumptions

- Energy Impacts
- Cost Impacts
    - Incremental Costs
    - Energy Cost savings

Incremental Cost Information – Boilers and Water Heaters

- **How we collected costs of base case technology and proposed technology**
  - Use of DOE Technical Support Document from most recent standards
  - Use of 2013 O2 trim control CASE Report
  - Use of materials used by ASHRAE to support development of Addendum BC
    - Including General Services Administration study, Federal Energy Management Program cost calculator, Energy Information Administration building systems costs
- How we will further collect information
  - Data from manufacturers and stakeholders
  - RSMeans and RECS to calculate California adjustments for materials and labor
- **What other sources of costs did we leave out?**

https://www.gsa.gov/governmentwide-initiatives/sustainability/emerging-building-technologies/published-findings/hvac/condensing-boilers; https://www.regulations.gov/document?D=EERE-2013-BT-STD-0030-0083; https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf

Poll

Boiler Type	Input Capacity (MBH)	Rated Efficiency	Installed Cost ($/MBH)
Standard	2500	80%	$35.40
Near-condensing	2500	84%	$38.50
Condensing	2500	95%	$42.60

Are these costs reasonable?

A. Yes – These estimates appear reasonable to me
B. No – The estimated costs for condensing products seems too high
C. No – The estimated costs for condensing products seems too low
D. I am not sure – I need further time to evaluate these estimates

Energy Cost Savings Assumptions – O2 Trim Controls

- Annual operation hours: 2920 hrs
- Fuel for natural gas: $.887 per therm
- Annual statewide installed boiler capacity: 4709 MMBtu/h
- Percentage of boilers with O2 trim control: 29%
- Cutoff boiler capacity: 10 MMBtu/h
- Incremental Installed Cost: $27,000
- Annual Maintenance Cost: $800
- Discount rate: 3%
- Effective useful life (EUL): 15 years
- Payback period threshold: 11.94 years

http://title24stakeholders.com/wp-content/uploads/2017/10/2013_CASE-Report_Process-Boilers.pdf; https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SCA_m.htm

Lifecycle Cost Effectiveness Results – O2 Trim Control

Summary of Results from 2013 CASE Initiative

- Cost effective for boilers 5.5 MMBtuh and larger.
- Benefit / Cost ratio of 1.0 for 5.5MMBtu – just met the Energy Commission's lifecycle cost effectiveness threshold

Boiler Input, MMBtuh	2.0	5.0	5.5	10.0	20.0	50.0
Savings, therms/yr:	914	2,284	2,509	4,569	9,138	22,845
Savings, $/yr @ $1.22/therm:	$1,115	$2,787	$3,061	$5,574	$11,148	$27,870
PV of energy savings over 11.94 yrs:	$13,311	$33,277	$36,550	$66,554	$133,109	$332,772
Total incremental cost:	$36,550	$36,550	$36,550	$36,550	$36,550	$36,550
Benefit/Cost ratio:	**0.4**	**0.9**	**1.0**	**1.8**	**3.6**	**9.1**
Simple payback, yrs	32.8	13.1	11.9	6.6	3.3	1.3

http://title24stakeholders.com/wp-content/uploads/2017/10/2013_CASE-Report_Process-Boilers.pdf

Methodology for Energy Impacts Analysis

Submeasure	Per Unit Savings	Modeling Tool	Savings Vary by Climate Zone?	Scenarios
High Efficiency Boilers	-	EnergyPlus and Spreadsheet	Yes	• All climate zones • Prototype buildings meeting size thresholds
Oxygen Trim Control	-	EnergyPlus and Spreadsheet	Yes	• All climate zones • Prototype buildings meeting size thresholds
Service Water Heating Systems	-	EnergyPlus and Spreadsheet	Yes	• All climate zones • Prototype buildings meeting size thresholds

Definition of Baseline and Proposed Conditions: High Efficiency Boilers

Baseline Conditions

- Boiler efficiency minimally compliant with 2019 Code: 80.5% thermal efficiency
- 8,760 hrs/yr simulation
- Period of evaluation:15 years
- Boiler capacity: 1 MMBtu/h

Proposed Conditions

- Boiler efficiency 90% thermal efficiency
- 8,760 hrs/yr simulation
- Period of evaluation: 15 years
- Boiler capacity: 1 MMBtu/h
- Return hot water temperature 120 F or less
- Bypass hot water flow rate: 20% of design hot water flow

Definition of Baseline and Proposed Conditions: Oxygen Trim Control

Baseline Conditions

- Boiler efficiency minimally compliant with 2019 Code: 80.5% thermal efficiency
- 8,760 hrs/yr simulation
- Period of evaluation:15 years
- Boiler capacity: 1 MMBtu/h
- Excess oxygen concentration: 5%

Proposed Conditions

- Boiler efficiency: 80.5% thermal efficiency
- 8,760 hrs/yr simulation
- Period of evaluation:15 years
- Boiler capacity: 1 MMBtu/h
- Excess oxygen concentration: 3%

Definition of Baseline and Proposed Conditions: Service Water Heating Systems

Baseline Conditions

- Boiler efficiency minimally compliant with 2019 Code: 80.5% thermal efficiency
- 8,760 hrs/yr simulation
- Period of evaluation:15 years
- Boiler capacity: 1 MMBtu/h

Proposed Conditions

- Boiler efficiency: 90% thermal efficiency
- 8,760 hrs/yr simulation
- Period of evaluation:15 years
- Boiler capacity: 1 MMBtu/h

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Project Team:
  - Identifies if project triggers requirements based on system size (BTU/hr)
    - weighted TE
    - flow rate and return water temp
    - oxygen trim control
  - If applicable, selects design equipment that meets the requirements

2. Permit Application Phase

- Project Team
  - Submits design documents that include:
    - Individual boiler/water heater specs
    - *Weighted TE for all high capacity boilers/water heaters*
    - *Boilers flow rates and temperatures*
    - 02 trim control specs

Compliance Verification Process

3. Construction phase

- Project team installs compliant equipment in accordance with compliance and design documentation. Documents installation on compliance documentation.

4. Inspection Phase

- Code official verifies compliance documents are submitted and meet requirements
- Temp and flow rate verified through commissioning process
  - No acceptance tests or field verification

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to open the draft language from the **resources tab**
- **Are there specific concerns about meeting the return water and flow rate design requirements?**
- **How often are you installing boilers with O2 trim control?**
    - **What percent excess oxygen do you design to?**

Poll

How often are you installing boilers with O_2 trim control when you install a new boiler or perform a major retrofit?

A. <25%
B. 25-50%
C. 50-75%
D. >75%

Poll

What percent excess oxygen do you design to?

A. <3%
B. 3-5%
C. >5%

Discussion and Next Steps

Feedback Requested

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- More information on pre-rulemaking for the 2022 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

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Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Thank you for your participation today

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George Chapman, *Energy Solutions*
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Please complete the closing polls below

Upcoming Meetings

Meeting Topic	Building Type	Date
Nonresidential Envelope Part 1	NR	Thursday, October 24, 2019
Nonresidential HVAC and Envelope Part 2: Air Distribution, & Controls	NR	Tuesday, November 5, 2019
Covered Processes Part 2: Compressed Air, Steam Traps, & Refrigeration	NR	Thursday, November 7, 2019
Single Family Whole Building	SF	Tuesday, November 12, 2019
Nonresidential Software Improvements	NR	Tuesday, November 12, 2019

Appendix A: Data Center Efficiency

CALIFORNIA ENERGY CODES & STANDARDS
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Appendix

Acronyms

- **ACM** = Alternative Calculation Method
- **ASHRAE** = American Society of Heating, Refrigerating, and Air-Conditioning Engineers
- **HX** = heat exchanger
- **IT** = information technology
- **kW** = kilowatt
- **OAT** = outside air temperature
- **PUE** = Power Usage Effectiveness
- **RAT** = return air temperature
- **SAT** = supply air temperature
- **UPS** = Uninterruptible Power Supply

ASHRAE ASHRAE Thermal Guidelines for Data Processing Environments IT Class Definitions

A1: datacenter with tight temperature & moisture control; mission critical (e.g., enterprise servers and storage products)

A2, A3, A4: IT space with some control of temperature and moisture (e.g., volume servers, storage products, personal computers)

Source: ASHRAE. *Thermal Guidelines for Data Processing Environments, Fourth Edition*, 2015.

Current Code Requirements

- Existing Model Code Requirements
  - Washington state is anticipated to adopt the following efficiency requirements for UPS in November 2019:

Battery Charger Product Class	Rated Output Power	Minimum Efficiency
10a (VFD UPSs)	$0\ W < P_{rated} \leq 300\ W$	-1.20E-06 * P_{rated}^2 + 7.17E-04 * P_{rated} + 0.862
	$300\ W < P_{rated} \leq 700\ W$	-7.85E-08 * P_{rated}^2 + 1.01E-04 * P_{rated} + 0.946
	$P_{rated} > 700\ W$	-7.23E-09 * P_{rated}^2 + 7.52E-06 * P_{rated} + 0.977
10b (VI UPSs)	$0\ W < P_{rated} \leq 300\ W$	-1.20E-06 * P_{rated}^2 + 7.19E-04 * P_{rated} + 0.863
	$300\ W < P_{rated} \leq 700\ W$	-7.67E-08 * P_{rated}^2 + 1.05E-04 * P_{rated} + 0.947
	$P_{rated} > 700\ W$	-4.62E-09 * P_{rated}^2 + 8.54E-06 * P_{rated} + 0.979
10c (VFI UPSs)	$0\ W < P_{rated} \leq 300\ W$	-3.13E-06 * P_{rated}^2 + 1.96E-03 * P_{rated} + 0.543
	$300\ W < P_{rated} \leq 700\ W$	-2.60E-07 * P_{rated}^2 + 3.65E-04 * P_{rated} + 0.764
	$P_{rated} > 700\ W$	-1.70E-08 * P_{rated}^2 + 3.85E-05 * P_{rated} + 0.876

These translate to slightly lower efficiency requirements than EnergyStar.

Incentive Programs

Submeasure	PG&E	SCE	SDG&E	SMUD	LADWP	EnergyStar
	Provides Incentive?					
UPS	Yes	No[1]	No[1]	No[1]	No[1]	Yes
Heat Recovery	?[1]	?[1]	?[1]	?[1]	?[1]	No
PUE Monitoring	No	No	No	No	No	No
Server Utilization Monitoring	No	No	No	No	No	No
Economizer Temperatures	Yes	Yes[1]	?[1]	Yes	No[1]	No
Air Containment	Yes	Yes[1]	?[1]	Yes	No[1]	No
Increased Baseline Air Temperatures	Yes	Yes[1]	?[1]	Yes	No[1]	No
Liquid Cooling	?[1]	?[1]	?[1]	?[1]	No[1]	No
Generator Crankcase Heating	No[1]	No[1]	No[1]	No[1]	No[1]	No

1 Not explicitly listed in website literature.

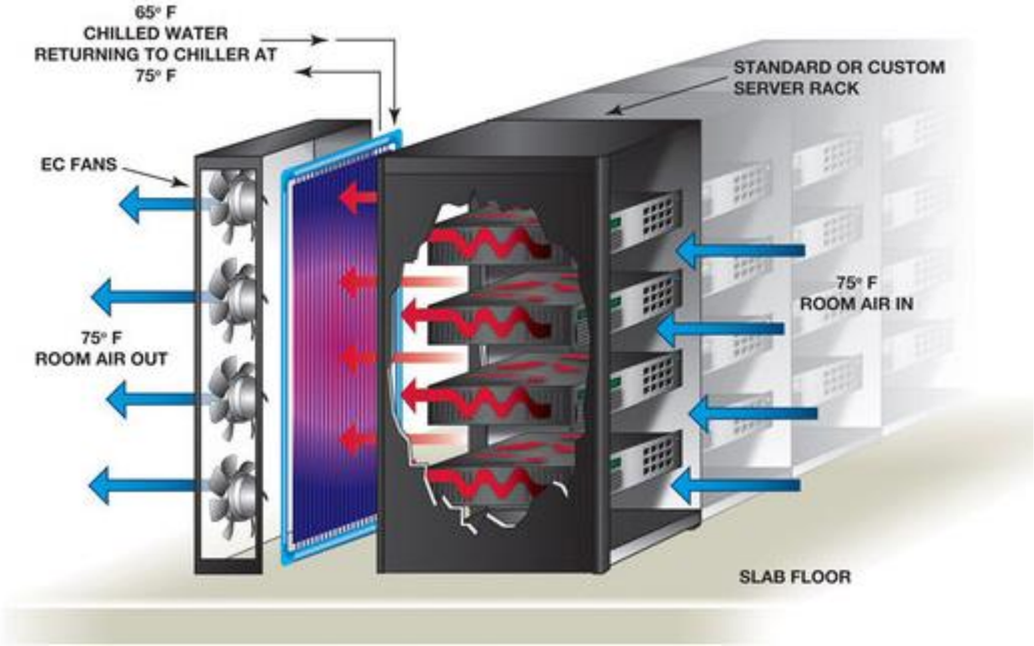
Technical Considerations: Air Containment

- Example products:
  - Blanking panels [1]

  - Hot (or cold) aisle containment doors/panels [2]

- Return air chimneys / ducted return air [3]

- In-row cooling [4]



1 http://blankingpanels.com/
2 https://datacenterresources.com/product/aisle-containment-wall/
3 http://powerquality.eaton.in/products-services/airflow-management/heat-containment-system.asp?cx=36
4 https://www.energystar.gov/products/install_in_rack_or_in_row_cooling

Definition of Baseline and Proposed Conditions: Increased Baseline Air Temperatures Submeasure

Baseline Conditions

- SAT = 60°F / RAT = 80°F
- Full economizing temperature (SAT) = 55°F; partial economizing temperature (RAT) = 75°F
- 8,760 hrs/yr operation
- Cooling system type (CRAC or CRAH w/ CHW plant) and capacity are based computer room load
- Cooling system efficiency = Title 24 2019
- Fan efficiency = 0.81 W/cfm (Title 24 2019)

Proposed Conditions

- SAT = 70°F / RAT = 90°F
- Full economizing temperature (SAT) = 65°F; partial economizing temperature (RAT) = 85°F
- 8,760 hrs/yr operation
- Cooling system type (CRAC or CRAH w/ CHW plant) and capacity are based computer room load
- Cooling system efficiency = Title 24 2019
- Fan efficiency = 0.81 W/cfm (Title 24 2019)

Green text = differences in Baseline and Proposed conditions.

Appendix B: HVAC Controls

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM