DOCKETED	
Docket Number:	19-BSTD-03
Project Title:	2022 Energy Code Pre-Rulemaking
TN #:	234890
Document Title:	September 23rd Staff Presentation on proposed 2022 Energy Code
Description:	Pre-rulemaking Presentation on: Nonresidential Computer Room Efficiency, Integrated Pumped Refrigerant Economizer Proposal, Pipe Sizing, Monitoring, and Leak testing for Compressed Air Systems, and Two new Mandatory requirements for covered Processes.
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Organization:	California Energy Commission
Submitter Role:	Commission Staff
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Docketed Date:	9/24/2020

2022 Pre-Rulemaking for Building Energy Efficiency Standards

Payam Bozorgchami, P.E.

September 23, 2020

Start Time: 9:00 AM

What We Will Cover Today

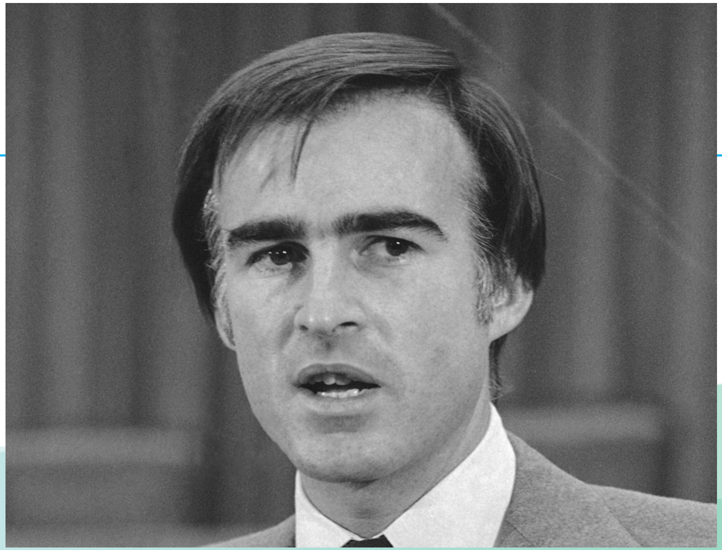
- Some Basic, Background
- How Title 24, Part 6 is Developed
- **Haile Bucaneg**
  - Nonresidential Computer Room Efficiency
- **Ronald Balneg**
  - Nonresidential Integrated Pumped Refrigerant Economizer Proposal
- **Haile Bucaneg**
  - Pipe Sizing, Monitoring, and Leak testing for Compressed Air Systems
- **Cheng Moua, P.E.**
  - Two new Mandatory requirements for covered Processes

Authority & Process

•**Public Resources Code (PRC 25402):** Reduction of wasteful, uneconomic, inefficient, or unnecessary consumption of energy

- (a)(1) Prescribe, by regulation, lighting, insulation, climate control system, and other building design and construction standards that increase the efficiency in the use of energy and water…

- Warren Alquist Act Signed into law in 1974 by Governor Ronald Reagan and launched by Governor Jerry Brown in 1975 which mandates updates Building Efficiency Standards and requires the building departments to enforce them through the permit process.



Goals of the California Energy Code

1. Increase building energy efficiency cost-effectively
2. Contribute to the state's GHG reduction goals
3. Enable pathways for all-electric buildings
4. Reduce residential building impacts on the electricity grid
5. Promote demand flexibility and self-utilization of PV generation
6. Provide tools for local government reach codes

Process Used to Updated Energy Codes

CEC staff, with input from utility partners and industry stakeholders, develop the triennial standards update

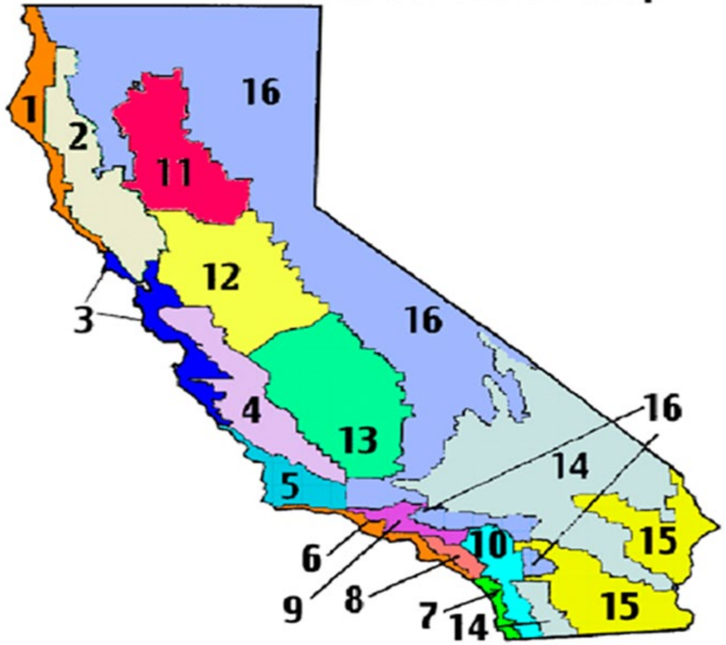
Opportunities for participation

- Utility-Sponsored Stakeholder Meetings
- CEC-Sponsored Workshops

Standards must be cost-effective

- Life-Cycle Costing Methodology
- Time Dependent Valuation (TDV)

California Climate Zone Map



2022 Standards Process

2022 STANDARDS UPDATE SCHEDULE	
DATE	**MILESTONES**
November 2018 - November 2019	Updated Weather Files
November 2018-December 2019	Metric Development
November 2018-July 2019	Measures Identified and approval
August 2019 to October 2020	Stakeholder meeting/workshop & final staff workshop
August 2020-October 2020	CASE Reports submitted to the CEC
February 2021	45-day Language Hearings
July 2021	Adoption of 2022 Standards at a Business Meeting
July 2021 to November 2021	Staff work on Software, Compliance Manuals, Electronic Documents Available to Industry
December of 2021	Approval of the Manuals
January 2022	Software, Compliance Manuals, Electronic Documents Available to Industry
January 1, 2023	Effective Date

Tentative Pre-Rulemaking Schedule

- **September 1**
  - Energy Savings and Process Improvements for Alterations and Additions
    - Roof deck insulation for low-slope roofs
    - Prescriptive attic insulation for alterations
    - Prescriptive duct sealing
    - Electric resistance water heating
    - Electric resistance space heating
    - 40-ft trigger for prescriptive duct requirements
    - Cool roof for steep-slope roofs
    - Cool roof for low-slope roof
- **September 9**
  - Nonresidential Grid Integration
  - Controlled Receptacle, CEA Proposal
- **September 10**
  - Verification Testing
- **September 22**
  - Outdoor lighting
  - Daylighting
- **September 23**
  - Computer Room Efficiencies
  - Pipe Sizing and Leak Testing for Compressed Air Systems
  - Refrigeration System Operation

Tentative Pre-Rulemaking Schedule (Cont.)

- **September 30**
  - Indoor Air Quality Roundtable discussion with the outside world
- **October 6 and November 17**
  - Solar Photo Voltaic and Electrification
  - Multifamily All Electric
- **October 7**
  - Nonresidential Indoor Lighting
  - Air Distribution
  - Nonresidential HVAC Controls
- **October 13**
  - Multifamily Domestic Hot Water
  - Multifamily Restructuring
- **October 20**
  - Nonresidential High Performance Envelope
- **October 27**
  - Control Environmental Horticulture
  - New Construction Steam Trap
- **October 29 Place holder (May get pushed backed based on the Roundtable results from the September 30**
  - Indoor Air Quality Roundtable discussion with the outside world

Key Web-Link

2022 Title 24 Utility-Sponsored Stakeholder
http://title24stakeholders.com/

Building Energy Efficiency Program
http://www.energy.ca.gov/title24/

Comments to be submitted to:
https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-BSTD-03

NOTE: For this workshop comments To Be Submitted By October 7, 2020

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STATE OF CALIFORNIA
ENERGY COMMISSION

Comments For Todays Workshop

Due Date October 7, 2020 By 5:00 PM

Comments to be submitted to:
https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-BSTD-03

Questions?

Thank You!

Nonresidential Computer Room Efficiency Proposals for 2022

Staff Pre-Rulemaking Workshop

Presenter: Haile Bucaneg, Senior Mechanical Engineer

Date: September 23, 2020

Proposal Summary

Submeasures pertaining to Nonresidential Computer Room Efficiency.

- 2022 Code Update
    - Increased Temperature Thresholds for Economizers
    - Uninterruptible Power Supply (UPS) Efficiency
    - Move Reheat, Humidification, Fan Controls to Mandatory Requirements

2022 Code Update Sections Affected

Building Energy Efficiency Standards for Residential and Nonresidential Buildings:

- Section 110.1(b)
- Section 140.9(a)
- Section 141.1(b)

Reference Appendices:

- No changes

Increased Temperature Threshold for Economizers

Increased Temperature Threshold for Economizers

Existing required minimum outdoor air temperature where full economizing occurs.

- Air economizers, 55° F dry bulb and 50° F wet bulb.
- Water economizers, 40° F dry bulb and 35° F wet bulb.

Existing air containment requirement.

- 175 kW per room design load.

Increased Temperature Threshold for Economizers

Proposed required minimum outdoor air temperature where full economizing occurs.

- All economizers 65° F dry bulb and 50° F wet bulb.

Proposed air containment requirement.

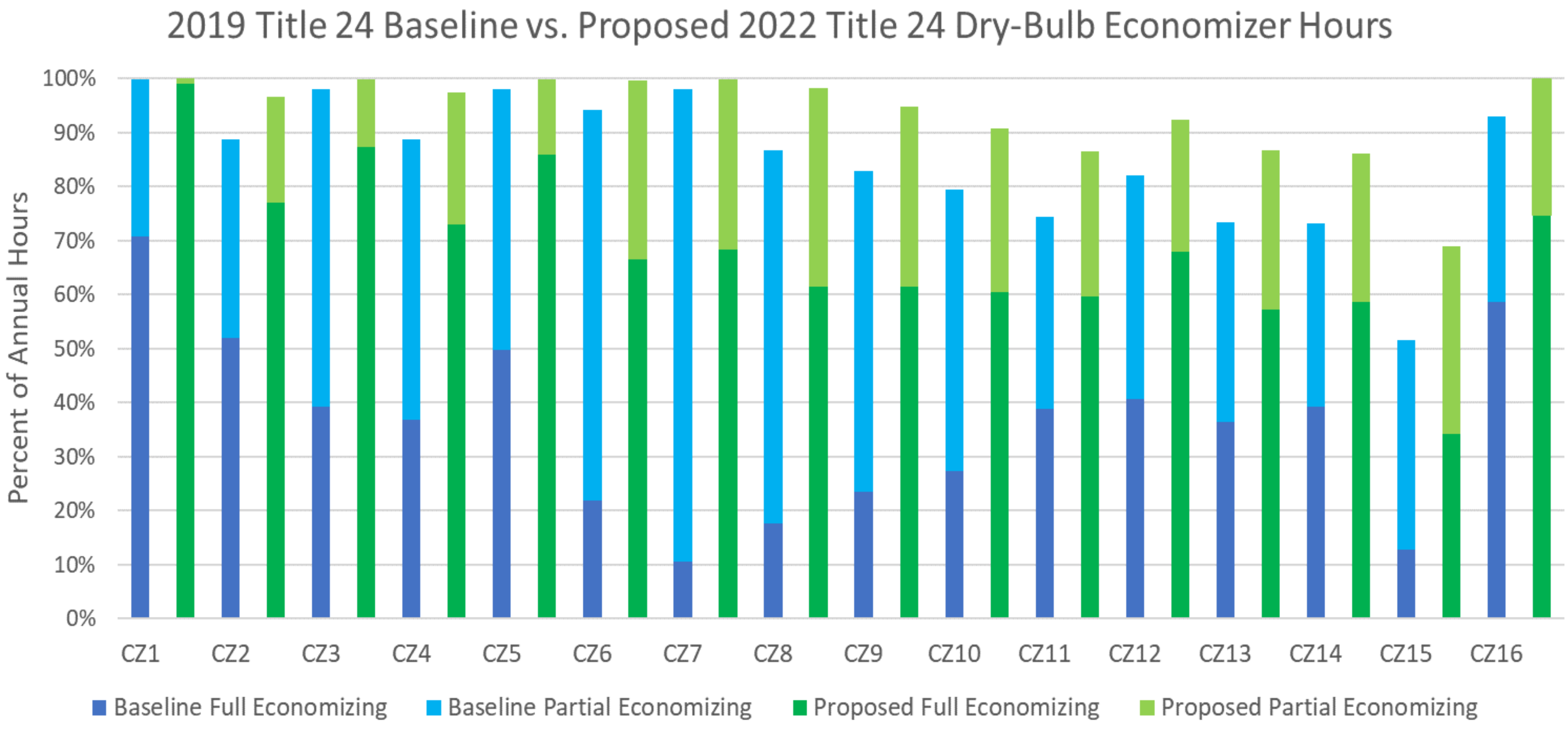
- 10 kW per room ITE design load.

Increased Temperature Threshold for Economizers

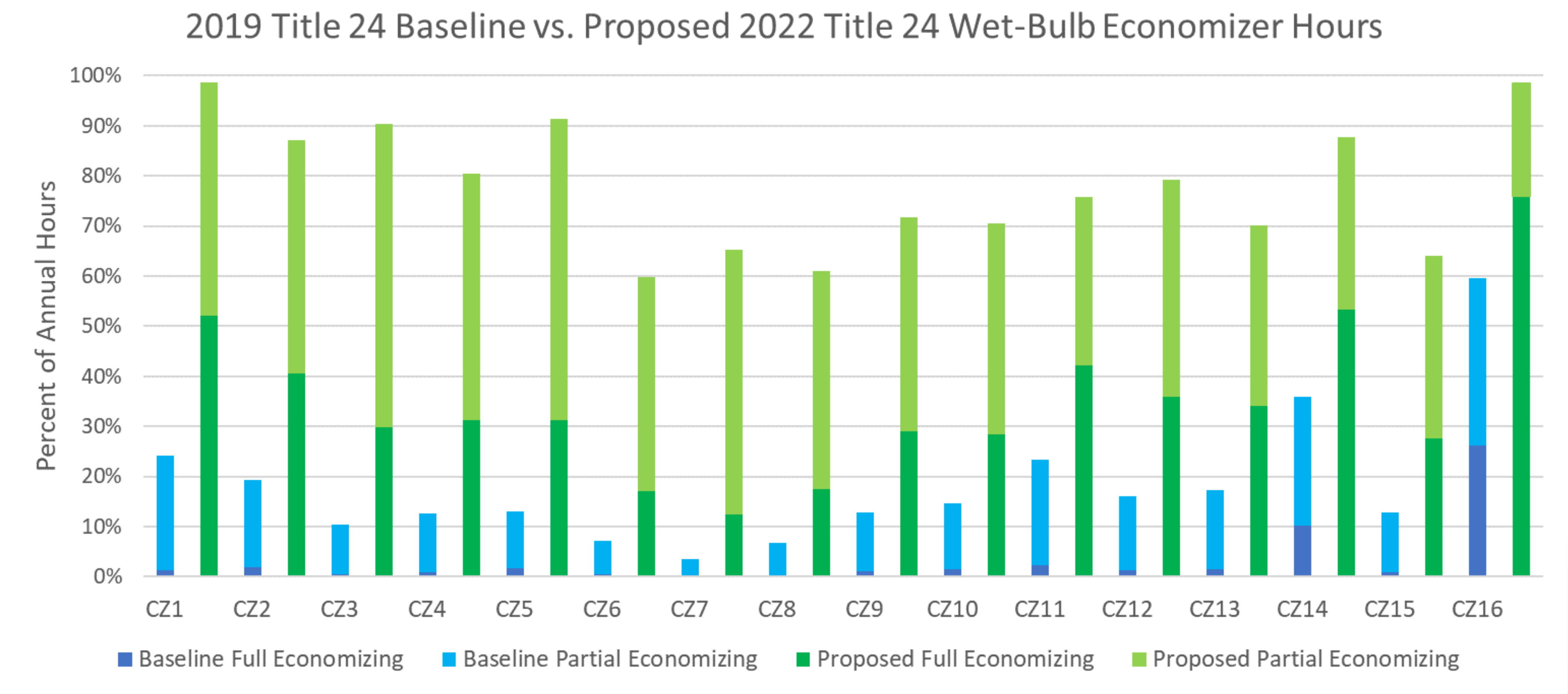
Existing facility with newly installed computer room cooling systems proposed required minimum outdoor air temperature where full economizing occurs.

- Air economizers, 55° F dry bulb and 50° F wet bulb.
- Water economizers, 40° F dry bulb and 35° F wet bulb.
- Refrigerant economizers, 40° F dry bulb or 35° F wet bulb in climate zones 1-9, 11-14, or 16.

Increased Temperature Thresholds for Economizing



Increased Temperature Thresholds for Economizing



Increased Temperature Threshold for Economizers

Direct expansion computer room air conditioner.

- Baseline system.
  - Air economizer.
- Proposed system.
  - Air economizer.
  - Air containment.

Cost Item	Incremental First Cost ($ per ITE design load kW)
Return air rack chimneys with ducted return air	$280
Labor	$70
Total	$350

Increased Temperature Threshold for Economizers

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reduction (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	331	0.0	0	8,753
2	452	0.0	0	11,776
3	596	0.0	0	18,060
4	574	0.0	0	15,469
5	534	0.0	0	14,211
6	788	0.0	0	22,148
7	955	0.0	0	26,937
8	758	0.0	0	20,066
9	644	0.0	0	16,830
10	577	0.0	0	14,942
11	439	0.1	0	11,931
12	493	0.0	0	12,597
13	446	0.0	0	11,357
14	420	0.0	0	10,591
15	464	0.1	0	11,918
16	440	0.0	0	11,616

Increased Temperature Threshold for Economizers

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$779	$350	2.2
2	$1,048	$350	3.0
3	$1,607	$350	4.6
4	$1,377	$350	3.9
5	$1,265	$350	3.6
6	$1,971	$350	5.6
7	$2,397	$350	6.9
8	$1,786	$350	5.1
9	$1,498	$350	4.3
10	$1,330	$350	3.8
11	$1,062	$350	3.0
12	$1,121	$350	3.2
13	$1,011	$350	2.9
14	$943	$350	2.7
15	$1,061	$350	3.0
16	$1,034	$350	3.0

Increased Temperature Threshold for Economizers

Chilled water computer room air handler.

- Baseline system.
  - Air economizer.
- Proposed system (no change).
  - Air economizer.

Cost Item	Incremental First Cost ($ per ITE design load kW)
Air containment equipment	$0
Air containment labor	$0
Controls	$0
Commissioning	$0
Total	$0

Increased Temperature Threshold for Economizers

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reduction (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	181	0.0	0	4,499
2	200	0.0	0	4,989
3	331	0.0	0	9.271
4	281	0.0	0	7,592
5	260	0.0	0	7,360
6	361	0.0	0	9,701
7	440	0.0	0	11,858
8	361	0.0	0	9,472
9	315	0.0	0	8,209
10	275	0.0	0	7,056
11	186	0.0	0	4,728
12	222	0.0	0	5,663
13	189	0.0	0	4,637
14	175	0.0	0	4,374
15	202	0.0	0	5,202
16	161	0.0	0	4,159

Increased Temperature Threshold for Economizers

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$400	$0	infinite
2	$444	$0	infinite
3	$825	$0	infinite
4	$676	$0	infinite
5	$655	$0	infinite
6	$863	$0	infinite
7	$1,055	$0	infinite
8	$843	$0	infinite
9	$731	$0	infinite
10	$628	$0	infinite
11	$421	$0	infinite
12	$504	$0	infinite
13	$413	$0	infinite
14	$389	$0	infinite
15	$463	$0	infinite
16	$370	$0	infinite

Increased Temperature Threshold for Economizers

Chilled water computer room air handler.

- Baseline system.
  - Water-cooled chiller.
  - Heat exchanger.
  - Evaporative cooling tower.
- Proposed system.
  - Water-cooled chiller.
  - Larger heat exchanger.
  - Evaporative cooling tower.

Cost Item	Incremental First Cost ($ per ITE design load kW)
Heat exchanger	$23
Labor	$7
Total	$30

Increased Temperature Threshold for Economizers

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reduction (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	748	0.0	0	21,632
2	585	0.0	0	15,399
3	521	0.0	0	13,844
4	476	0.0	0	12,656
5	510	0.0	0	14,281
6	284	0.0	0	7,969
7	258	0.0	0	7,093
8	308	0.0	0	8,560
9	429	0.0	0	11,458
10	405	0.0	0	10,897
11	542	0.0	0	14,160
12	506	0.0	0	13,441
13	469	0.0	0	12,440
14	548	0.0	0	13,723
15	412	0.0	0	11,097
16	565	0.0	0	14,593

Increased Temperature Threshold for Economizers

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$1,925	$30	63
2	$1,371	$30	45
3	$1,232	$30	41
4	$1,126	$30	37
5	$1,271	$30	42
6	$709	$30	23
7	$631	$30	21
8	$762	$30	25
9	$1,020	$30	34
10	$970	$30	32
11	$1,260	$30	41
12	$1,196	$30	39
13	$1,107	$30	36
14	$1,221	$30	40
15	$988	$30	33
16	$1,299	$30	43

Increased Temperature Threshold for Economizers

Chilled water computer room air handler.

- Baseline system.
  - Air-cooled chiller with dry cooler economizer
- Proposed system.
  - Non-economizing air-cooled chiller.
  - Heat exchanger.
  - Evaporative cooling tower.

Cost Item	Incremental First Cost ($ per ITE design load kW)
Air-cooled chiller	-$86
Cooling tower	$37
Heat exchanger	$39
Cooling tower water pump	$4
Miscellaneous equipment (CW piping, water treatment, etc.)	$503
Total	$497

Increased Temperature Threshold for Economizers

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reduction (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	607	0.2	0	17,168
2	573	0.3	0	15,264
3	539	0.2	0	14,309
4	505	0.2	0	13,476
5	524	0.2	0	14,391
6	385	0.2	0	10,502
7	412	0.2	0	11,181
8	424	0.2	0	11,501
9	525	0.3	0	13,849
10	503	0.3	0	13,331
11	582	0.3	0	15,472
12	534	0.3	0	14,280
13	512	0.3	0	13,614
14	667	0.3	0	17,388
15	602	0.3	0	16,022
16	683	0.3	0	18,499

Increased Temperature Threshold for Economizers

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$1,278	$540	2.4
2	$1,153	$540	2.1
3	$1,084	$540	2.0
4	$1,029	$540	1.9
5	$1,088	$540	2.0
6	$823	$540	1.5
7	$886	$540	1.6
8	$906	$540	1.7
9	$1,080	$540	2.0
10	$1,037	$540	1.9
11	$1,192	$540	2.2
12	$1,093	$540	2.0
13	$1,049	$540	1.9
14	$1,333	$540	2.5
15	$1,283	$540	2.4
16	$1,376	$540	2.5

Increased Temperature Threshold for Economizers

Exceptions to proposed requirements.

- Small computer rooms.
  - Buildings that do not have an economizer .
  - ITE design load under 18 kW.
- Computer rooms with a second fan system with an economizer.
  - ITE design load under 70 kW.
  - Economizer on second fan system can serve the fan room when the building is unoccupied.
  - Economizer can meet the computer room ITE design load or 5 tons plus 25% of economizer capacity at design conditions.

Increased Temperature Threshold for Economizers

Exception to proposed requirements.

- Local water authority does not allow cooling towers.
  - Air economizers, full economizing at 55° F dry bulb or 50° F wet bulb.
  - Water economizers, full economizing at 40° F dry bulb or 35° F wet bulb.
  - Refrigerant economizers, full economizing at 40° F dry bulb or 35° F wet bulb in climate zones 1-9, 11-14, or 16.

Increased Temperature Threshold for Economizers

Exception to proposed requirements.

- Computer room fan system does not exceed 0.35 W/cfm, and
- Supply air/return air temperature differential at least 25° F, and
- Cooling system efficiency is 20 percent better than required efficiencies identified in Table 110.2-A through 110.2 K or Title 20, Table C-7.
  - Air economizers – full economizing at 55° F dry bulb or 50° F wet bulb.
  - Water economizers – full economizing at 40° F dry bulb or 35° F wet bulb.
  - Refrigerant economizers – full economizing at 40° F dry bulb or 35° F wet bulb in climate zones 1-9, 11-14, or 16.

Increased Temperature Threshold for Economizers

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (million therms)	15-Year Present Valued Energy Cost Savings (PV$ million in 2023)
New Construction	215	27	0	$514
Additions and Alterations	0	0	0	0
Total	215	27	0	$514

Increased Temperature Threshold for Economizers

Measure	Electricity Savings (GWh/yr)	Reduced GHG Emissions from Electricity Savings (Metric Ton CO2e)	Natural Gas Savings (million therms/yr)	Reduced GHG Emissions from Natural Gas Savings (Metric Ton CO2e)	Total Reduced CO2e Emissions (Metric Ton CO2e)
Increased Temperature Threshold for Economizers	215	51,623	0.0	0	51,623

Increased Temperature Threshold for Economizers

Technical Feasibility

- Exceptions to provide flexibility based on various scenarios.
- Allows for flexibility in economizing technology.
    - Not limited to air or water economizing

Cost Effectiveness

- Cost effective in all climate zones.

QUESTION?

Uninterruptible Power Supply (UPS) Efficiency

UPS Efficiency

Uninterruptible Power Supply (UPS) minimum efficiency.

- Weighted average of part-load efficiencies.
- Dependent on UPS type and size.
- Testing procedures are based on ENERGY STAR Program Requirements for Uninterruptible Power Supplies (UPSs) – Eligibility Criteria Version 2.0.
- Exception for UPS that utilize standardized NEMA 1-15P or NEMA 5-15P input plug as specified in ANSI/NEMA WD-6-2016.

UPS Efficiency

AC-output UPS Minimum Average Efficiency Requirement from ENERGY STAR.

Minimum Average Efficiency Requirement ($Eff_{AVG\ MIN}$), Where:
- **P is the Rated Output Power in watts (W),**
- **E_{MOD} is an allowance of 0.004 for Modular UPSs applicable in the commercial 1500–10,000 W range,**
- **ln is the natural logarithm; and**
- **The requirement shall be rounded to the third decimal place for certification and reporting.**

<table>
<tr><th rowspan="2">Rated Output Power</th><th colspan="3">Input Dependency Characteristic</th></tr>
<tr><th>VFD</th><th>VI</th><th>VFI</th></tr>
<tr><td>$P \leq 350$ W</td><td>$5.71 \times 10^{-5} \times P + 0.962$</td><td>$5.71 \times 10^{-5} \times P + 0.964$</td><td rowspan="2">$0.011 \times \ln(P) + 0.824$</td></tr>
<tr><td>350 W < $P \leq 1500$ W</td><td>0.982</td><td>0.984</td></tr>
<tr><td>1500 W < $P \leq 10{,}000$ W</td><td>0.981 - E_{MOD}</td><td>0.980 - E_{MOD}</td><td>$0.0145 \times \ln(P) + 0.800 - E_{MOD}$</td></tr>
<tr><td>$P > 10{,}000$ W</td><td>0.970</td><td>0.940</td><td>$0.0058 \times \ln(P) + 0.886$</td></tr>
</table>

UPS Efficiency

	DX CRAC Prototype	Chilled Water CRAH Prototype
Incremental Equipment Costs ($ per ITE design load kW)	$112	$91
Labor	$0	$0
Controls	$0	$0
Commissioning	$0	$0

UPS Efficiency

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reduction (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	54.4	0.0	0	1,533
2	54.6	0.0	0	1,538
3	54.7	0.0	0	1,542
4	54.8	0.0	0	1,532
5	54.6	0.0	0	1,560
6	54.8	0.0	0	1,574
7	54.9	0.0	0	1,552
8	54.9	0.0	0	1,577
9	54.9	0.0	0	1,591
10	54.9	0.0	0	1,573
11	54.9	0.0	0	1,538
12	54.8	0.0	0	1,539
13	54.9	0.0	0	1,554
14	54.9	0.0	0	1,524
15	55.3	0.0	0	1,557
16	54.5	0.0	0	1,591

*200 kW ITE load
*Direct-expansion computer room air conditioner

UPS Efficiency

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reduction (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	52.9	0.0	0	1,436
2	55.0	0.0	0	1,459
3	61.9	0.0	0	1,671
4	59.8	0.0	0	1,630
5	57.9	0.0	0	1,581
6	64.5	0.0	0	1,746
7	68.8	0.0	0	1,857
8	64.7	0.0	0	1,754
9	62.2	0.0	0	1,683
10	60.0	0.0	0	1,625
11	55.1	0.0	0	1,392
12	56.7	0.0	0	1,427
13	55.4	0.0	0	1,402
14	54.6	0.0	0	1,395
15	57.4	0.0	0	1,498
16	52.7	0.0	0	1,410

*1,000 kW ITE load
*Chilled water computer room air handlers cooling

UPS Efficiency

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$136	$112	1.2
2	$137	$112	1.2
3	$137	$112	1.2
4	$136	$112	1.2
5	$139	$112	1.2
6	$140	$112	1.3
7	$138	$112	1.2
8	$140	$112	1.3
9	$142	$112	1.3
10	$140	$112	1.3
11	$137	$112	1.2
12	$137	$112	1.2
13	$138	$112	1.2
14	$136	$112	1.2
15	$139	$112	1.2
16	$142	$112	1.3

*Direct-expansion computer room air conditioner

UPS Efficiency

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
1	$128	$91	1.4
2	$130	$91	1.4
3	$149	$91	1.6
4	$145	$91	1.6
5	$141	$91	1.5
6	$155	$91	1.7
7	$165	$91	1.8
8	$156	$91	1.7
9	$150	$91	1.6
10	$145	$91	1.6
11	$124	$91	1.4
12	$127	$91	1.4
13	$125	$91	1.4
14	$124	$91	1.4
15	$133	$91	1.5
16	$126	$91	1.4

*Chilled water computer room air handler

UPS Efficiency

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (million therms)	15-Year Present Valued Energy Cost Savings (PV$ million in 2023)
New Construction	23	0.8	0	$57
Additions and Alterations	114	3.8	0	$278
TOTAL	137	4.6	0	$335

UPS Efficiency

Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings (Metric Ton CO2e)	Natural Gas Savings (million therms/yr)	Reduced GHG Emissions from Natural Gas Savings (Metric Ton CO2e)	Total Reduced CO2e Emissions (Metric Ton CO2e)
UPS Efficiency	137	32,871	0.0	0	32,871

UPS Efficiency

Technical Feasibility

- Exception based on UPS devices under federal requirements.
- Reduces energy usage over 24 hours.
- Reduces cooling load to computer room.

Cost Effectiveness

- Cost effective in all climate zones.

QUESTION?

Mandatory Requirements for Computer Rooms

Mandatory Requirements for Computer Rooms

Reheating mandatory requirement.

- Prevent reheating, recooling and simultaneous provisions of heating and cooling to the same zone.

Humidification mandatory requirement.

- Only adiabatic humidification is permitted.

Fan control mandatory requirement.

- Air conditioner exceeding 60,000 btu/hr and each chilled water fan system, vary air flow rate as a function of actual load and have controls or devices that will result in fan power demands of no more than 50% of design wattage at 66% of design fan speed.

Staff Questions

Increased temperature thresholds for economizers:

- Q1: can various economizer technologies work under revised thresholds?

QUESTION?

Comments for Todays Workshop

Due Date: October 7, 2020 By 5:00 PM

Comments to be submitted to:
https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-BSTD-03

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Thank You!

Nonresidential Integrated Pumped Refrigerant Economizer Proposals for 2022

Staff Pre-Rulemaking Workshop

Presenter: Ronald Balneg, Mechanical Engineer

Date: September 23, 2020

Proposal Summary

Staff received proposals pertaining to Nonresidential Computer Rooms.

- 2022 Code Update
  - Addition of Integrated Pumped Refrigerant Economizers

2022 Code Update Sections Affected

Building Energy Efficiency Standards for Residential and Nonresidential Buildings:

- Section 100.1
- Section 140.9 (a)1

Reference Appendices:

- No changes

Alternative Calculation Method:

- Modeled equivalent to airside and waterside economizers

Addition of Integrated Pumped Refrigerant Economizers

Existing Data Center Requirements

Existing required economizer included air and water economizers in section 140.9(a)1

- Air economizers, 55° F dry bulb and 50° F wet bulb.
- Water economizers, 40° F dry bulb and 35° F wet bulb.

Pumped Refrigerant Economizers are currently used as an alternative compliance option to 140.9(a)1

Addition of Integrated Pumped Refrigerant Economizers

Proposed addition of Pumped Refrigerant Economizer definition and as an equivalent option to meet compliance with 140.4(a)1.

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

- **Economizer, Pumped Refrigerant,** is a system by which the supply air of a cooling system is cooled directly by refrigerant pumped between indoor and outdoor units during cooler ambient temperatures in order to reduce or eliminate the need for mechanical cooling, without using any water.

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

- **Subsection 140.9 (a) 1C:** An integrated pumped refrigerant economizer capable of providing 100 percent of the expected system cooling load as calculated in accordance with a method approved by the Commission, at outside air temperatures of 40°F dry-bulb and below.

Pumped Refrigerant

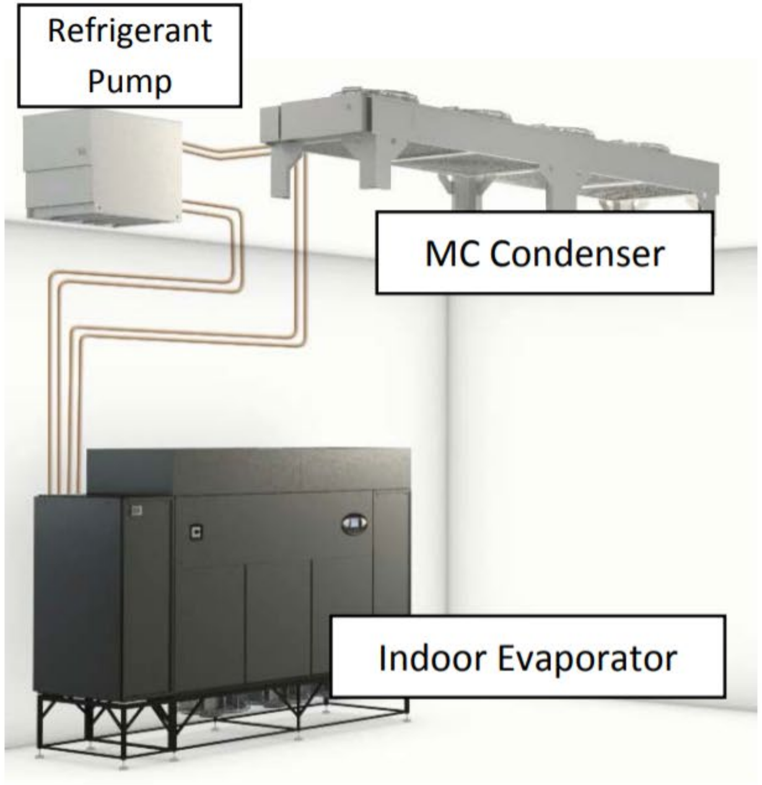


Fig 1 - System Component Layout

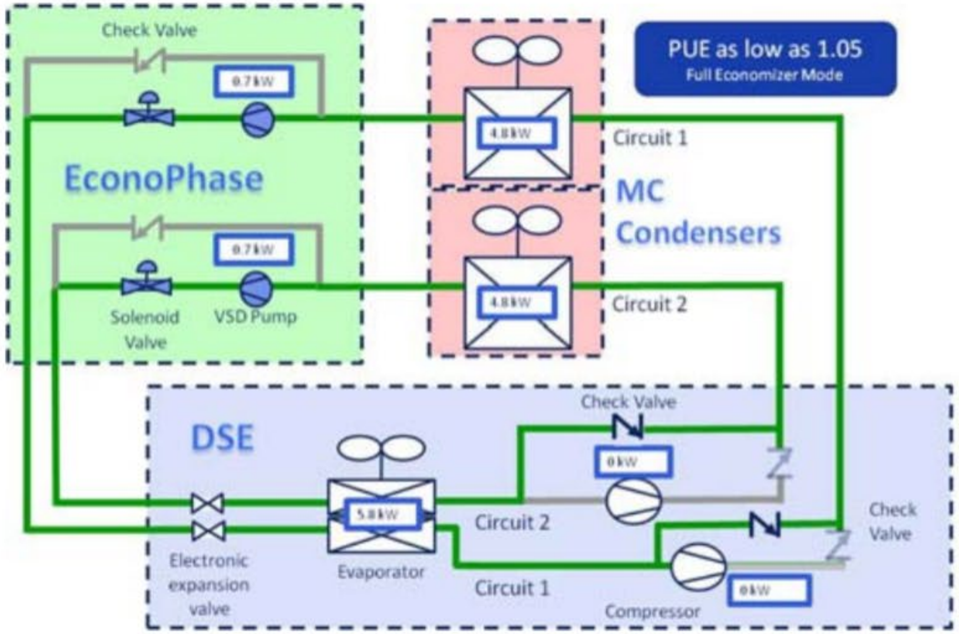
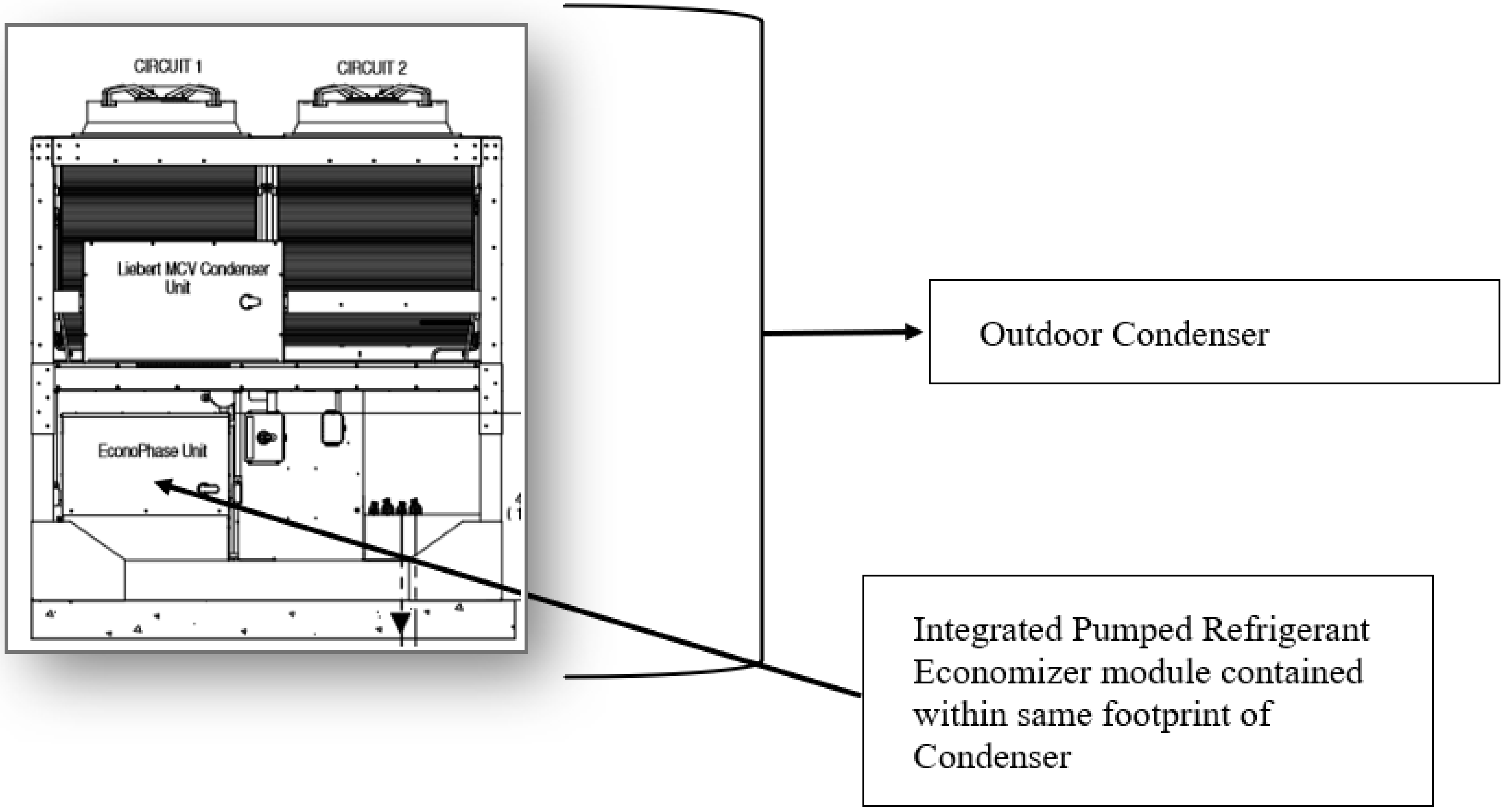


Fig 2 - System Flow Diagram

Integrated Pumped Refrigerant



Modelling Assumptions

Prototype ID	Occupancy Type (Residential, Retail, Office, etc.)	Area (Square Feet)	Number of Stories	Statewide Area (million square feet)
Large Data Center	Data Computer Room	14,000	1	1.598(assuming data centers are 5% of Misc New Construction)

- 85 Watt/sqft
- Same load profile applied to all climate zones
- Savings compared to a baseline water-side economizer

Energy Savings

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Energy Savings (TDVkBTU/yr)
1	26	0.004	0	368
2	17	0	0	1,496
3	5	0.001	0	1,840
4	6	0.001	0	1,177
5	33	0.005	0	1,234
6	5	0.001	0	1,308
7	4	0.001	0	802
8	2	0.001	0	872
9	2	0	0	1,000
10	4	0.001	0	1,307
11	22	0.003	0	1,603
12	4	0.001	0	1,350
13	11	0.001	0	1,617
14	30	0.003	0	2,412
15	35	0.007	0	1,679
16	101	0.010	0	2,719

Incremental First Cost

- Incremental cost - $0
- One real world example of cost figures from an independent mechanical contractor for 200 tons of cooling

Cost Item	Cost	Maintenance
Pumped Refrigerant System	$850,000	$7,200
Chilled Water	$1,400,000	$51,800

Cost Benefit Ratio

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[1] (2023 PV $)	Costs Total Incremental Present Valued (PV) Costs[2] (2023 PV $)	Benefit-to-Cost Ratio
1	$ 33	0	infinite
2	$ 133	0	infinite
3	$ 164	0	infinite
4	$ 105	0	infinite
5	$ 110	0	infinite
6	$ 116	0	infinite
7	$ 71	0	infinite
8	$ 78	0	infinite
9	$ 89	0	infinite
10	$ 116	0	infinite
11	$ 143	0	infinite
12	$120	0	infinite
13	$ 144	0	infinite
14	$ 215	0	infinite
15	$ 149	0	infinite
16	$242	0	infinite

Addition of Integrated Pump Economizers

Technical Feasibility

- Pumped refrigerant economizers have been installed and operating for the past 6 years

Other Benefits

- Estimated to save 4.3 million gallons of water annually assuming a data center IT load of 1.2 MW in California

Cost Effectiveness

- Cost effective in all climate zones

Staff Questions

- Are the incremental cost assumptions compared to waterside economizers accurate to assume a $0 incremental cost?
- Should the term ‘Integrated’ be included in the prescriptive requirement? The term integrated is used differently in other sections of the code, and would this limit other methods of this style of economizer?
- Other stakeholders pushed to change the term ‘refrigerant’ to ‘fluid’ for another proposal regarding refrigerant economizers. Should the term ‘without using any water’ be removed from the definition?
- Should pumped fluid economizers be modeled equivalent to airside and waterside economizers?

Comments for Todays Workshop

Due Date: October 7, 2020 By 5:00 PM

Comments to be submitted to:
https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-BSTD-03

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Thank You!

Pipe Sizing, Monitoring, and Leak Testing for Compressed Air Systems

Staff Pre-Rulemaking Workshop

Presenter: Haile Bucaneg, Senior Mechanical Engineer

Date: September 23, 2020

Proposal Summary

Measures pertaining to Pipe Sizing, Monitoring, And Leak Testing for Compressed Air Systems.

- 2022 Code Update.
  - Pipe sizing for compressed air systems.
  - Leak testing for compressed air piping.
  - Compressed air system monitoring.

2022 Code Update Sections Affected

Building Energy Efficiency Standards for Residential and Nonresidential Buildings:

- Section 120.6(e)

Reference Appendices:

- NA7.13

Pipe Sizing for Compressed Air Systems

Pipe Sizing for Compressed Air Systems

Compressed air piping greater than 50 adjoining feet in length must meet the following.

- Service line piping.
    - Inner diameter greater than or equal to ¾ inch.

Pipe Sizing for Compressed Air Systems

Compressed air piping greater than 50 adjoining feet in length must meeting one of the following.

- Piping section velocity design.
  - Maximum air velocity of 20 ft/sec in compressor room interconnection and main header piping.
  - Average velocity of 30 ft/sec or less in each segment of distribution and service piping.
- Piping total pressure drop design.
  - Frictional pressure loss is less than 5 percent of operating pressure between the compressor and end use or end use regulator.

Pipe Sizing for Compressed Air Systems

	Prototype 1	Prototype 2	Prototype 3	Prototype 4
Rated Flow (cfm)	579	966	2,181	4,666
Nominal Operating Base Load (cfm)	342	729	1,417	3,138
Nominal Trim Load (cfm)	237	237	764	1,528
Primary Receiver Size (ft^3)	474	474	1,528	3,050
Compressor 1	75 hp, load/unload, single stage, lubricant injected, reciprocating	150 hp, load/unload, single stage, lubricant injected, reciprocating	300 hp, load/unload, single stage, lubricant injected, reciprocating	500 hp, inlet vane, multiple stage, centrifugal
Compressor 2	50 hp, VSD, single stage, lubricant injected, rotary screw	50 hp, VSD, single stage, lubricant injected, rotary screw	150 hp, VSD, single stage, lubricant injected, rotary screw	150 hp, VSD, single stage, lubricant injected, rotary screw
Compressor 3	N/A	N/A	N/A	150 hp, VSD, single stage, lubricant injected, rotary screw

Pipe Sizing for Compressed Air Systems

Savings Summary	Prototype 1	Prototype 2	Prototype 3	Prototype 4
Total Pressure Loss (psig) Baseline	14.17	22.97	13.75	10.64
Total Pressure Loss (psig) Proposed	1.72	2.84	2.99	2.19
Reduced Pressure Loss (psig) Baseline to Proposed	12.45	20.13	10.77	8.45

- Pressure drop at design condition of 100 psig.

Pipe Sizing for Compressed Air Systems

Prototype	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)	Total 15-Year TDV Energy Cost Savings (2023 PV $)
Prototype 1	59,150.5	5.68	N/A	1,662,648	$147,976
Prototype 2	164,774.8	15.09	N/A	4,615,495	$410,779
Prototype 3	201,556.6	18.47	N/A	5,660,805	$503,812
Prototype 4	210,147.0	18.28	N/A	5,977,719	$532,017

Pipe Sizing for Compressed Air Systems

Component	Prototype 1 Cost	Prototype 2 Cost	Prototype 3 Cost	Prototype 4 Cost
Interconnection Piping	$1,275	$1,677	$1,677	$2,078
Loop Piping	$2,731	$4,685	$13,127	$73,438
Service Line Piping	$4,352	$7,261	$16,393	$35,071
Labor	$16,925	$27,587	$45,771	$162,394
Total	$25,284	$41,210	$76,968	$272,982

Pipe Sizing for Compressed Air Systems

	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
Prototype 1	$147,976	$25,284	5.85
Prototype 2	$410,779	$41,210	9.97
Prototype 3	$503,812	$76,968	6.55
Prototype 4	$532,017	$272,982	1.95

Pipe Sizing for Compressed Air Systems

First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (million therms)	15-Year Present Valued Energy Cost Savings (PV$ million in 2023)	Total Reduced CO_2e Emissions (Metric Tons CO_2e)
13.6	1.25	N/A	34.0	3,275

Pipe Sizing for Compressed Air Systems

Technical Feasibility

- Standardize best practices for compressed air pipe design.
- Flexibility in meeting code requirements.
  - Design to velocity, or
  - Design to pressure drop.

Cost Effectiveness

- Cost effective in all climate zones.

Questions?

Leak Testing for Compressed Air Piping

Leak Testing for Compressed Air Piping

New compressed air piping greater than 50 adjoining feet.

- Required pressure testing at design pressure.
  - If necessary isolate compressed air piping from supply air and end uses.
  - Hold pressure for length of time (no less than 30 minutes) identified by authority having jurisdiction.

Leak Testing for Compressed Air Piping

New compressed air piping 50 adjoining feet or less.

- Required leak testing.
  - Pressurize system.
  - Test connections using noncorrosive leak-detecting fluid or other leak-detecting methods at the discretion of the authority having jurisdiction.

Leak Testing for Compressed Air Piping

Prototype	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)	Total 15-Year TDV Energy Cost Savings (2023 PV $)
Prototype 1	10,168.8	1.11	N/A	279,025	$24,833
Prototype 2	3,027.9	0.66	N/A	89,030	$7,924
Prototype 3	6,548.2	1.58	N/A	178,391	$15,877
Prototype 4	76,763.1	7.84	N/A	2,128,716	$189,456

Leak Testing for Compressed Air Piping

Component	Prototype 1 Cost	Prototype 2 Cost	Prototype 3 Cost	Prototype 4 Cost
Pressure Gauge	$171	$171	$171	$171
Temperature Gauge	$30	$30	$30	$30
Leak Detecting Fluid	$15	$30	$90	$120
Test Labor	$787	$1,378	$3,051	$6,398
Total	$1,003	$1,609	$3,342	$6,719

Leak Testing for Compressed Air Piping

	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
Prototype 1	$24,833	$1,003	24.76
Prototype 2	$7,924	$1,609	4.92
Prototype 3	$15,877	$3,342	4.75
Prototype 4	$189,456	$6,719	28.20

Leak Testing for Compressed Air Piping

First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (million therms)	15-Year Present Valued Energy Cost Savings (PV$ million in 2023)	Total Reduced CO_2e Emissions (Metric Tons CO_2e)
1.4	0.19	N/A	3.5	339

Leak Testing for Compressed Air Piping

Technical Feasibility

- Standardize best practices for compressed air leak testing.
- Testing procedures for compressed air leaks is based on testing procedures for natural gas systems.

Cost Effectiveness

- Cost effective in all climate zones.

Questions?

Compressed Air System Monitoring

Compressed Air System Monitoring

New compressed air systems and additions with capacities 100 hp or greater.

- Compressed air system monitoring requirements.
  - System pressure.
  - Amps or power of each compressor.
  - Airflow of each compressor.
  - Data logging of pressure, power, airflow and compressed air specific efficiency at intervals of 5 minutes or less.
  - Maintained data storage of at least 24 months.
  - Visual trending display of each recorded point, load, and specific efficiency.

Compressed Air System Monitoring

Testing requirements for compressed air systems monitoring.

- Construction inspection.
  - Measurement of header or compressor discharge pressure.
  - Measurement of amps or power of each compressor.
  - Measurement of determination of airflow in cfm.
  - Data logging of pressure, power, airflow, and calculated compressed air system specific efficiency at intervals of 5 minutes or less.
  - Maintained data storage of at least 24 months.
  - Visual trending display of each recorded point, load and specific efficiency.

Compressed Air System Monitoring

Testing requirements for compressed air systems monitoring.

- Functional testing.
  - Data observed during testing is being recorded to a log file that can be opened and viewed to see trend of airflow, power, and specific efficiency in intervals of 5 minutes or less.
  - Airflow and compressor power data vary with loading and unloading of the compressor within typical performance expectations. Measurements should be observed across various loading, whether manually varied or in response to actual operational loads.

Compressed Air System Monitoring

Prototype	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)	Total 15-Year TDV Energy Cost Savings (2023 PV $)
Prototype 1	42,058.5	4.55	N/A	1,177,764	$104,821
Prototype 2	60,170.3	6.38	N/A	1,666,918	$148,356
Prototype 3	137,378.9	14.25	N/A	3,844,830	$342,190
Prototype 4	290,292.7	30.46	N/A	8,045,256	$716,028

Compressed Air System Monitoring

Component	Cost
Flowmeter (<2 inch pipe)	$617
Flowmeter (>2 inch pipe)	$3,104
Power Metering	$1,250
Visual Display	$4,000
Data Services Cost ($/yr)	$150 per compressor
Labor	8 hours per compressor

Compressed Air System Monitoring

	Benefits TDV Energy Cost Savings + Other PV Savings (2023 PV$)	Costs Total Incremental PV Costs (2023 PV$)	Benefit-to-Cost Ratio
Prototype 1	$104,821	$45,349	2.31
Prototype 2	$148,356	$54,749	2.71
Prototype 3	$342,190	$64,150	5.33
Prototype 4	$716,028	$78,572	9.11

Compressed Air System Monitoring

First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (million therms)	15-Year Present Valued Energy Cost Savings (PV$ million in 2023)	Total Reduced CO_2e Emissions (Metric Tons CO_2e)
29.3	3.11	N/A	3.5	7,049

Compressed Air System Monitoring

Technical Feasibility

- Standardize best practices for compressed air system monitoring.
- Number of monitoring system options currently available.

Cost Effectiveness

- Cost effective in all climate zones.

Staff Questions

Pipe sizing for compressed air systems questions:

- Q1: is verification of compressed air piping required to ensure appropriate piping was installed?

Compressed air system monitoring:

- Q1: are the identified monitoring points and procedures adequate to identify compressed air system issues?
- Q2: is an 80% realization rate for compressed air monitoring adequate?

Questions?

Comments for Todays Workshop

Due Date: October 7, 2020 By 5:00 PM

Comments to be submitted to:
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Thank You!

Refrigeration System Opportunities Proposal for 2022 Nonresidential Covered Processes

Staff Pre-Rulemaking Workshop

Presenters: Cheng Moua, PE, Mechanical Engineer

Date: September 23, 2020

Proposal Summary

Staff is considering two measure proposals relating to refrigeration systems. These are new mandatory requirements for covered processes.

- Design and Control Requirements for Transcritical CO_2 Systems
- Automatic Door Closers

Sections Affected By These Two Measures

Energy Standards

- Section 120.6(a) – Mandatory Requirements for Refrigerated Warehouses
- Section 120.6(b) - Mandatory Requirements for Commercial Refrigeration Systems

Reference Appendices

- Nonresidential Appendix NA7

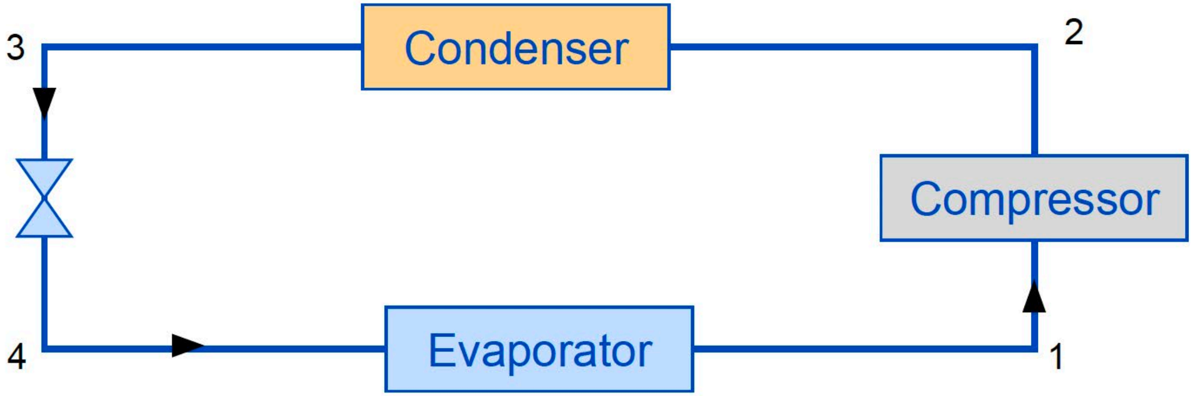
Design and Control Requirements for Transcritical CO_2 Systems

Transcritical CO_2 Systems

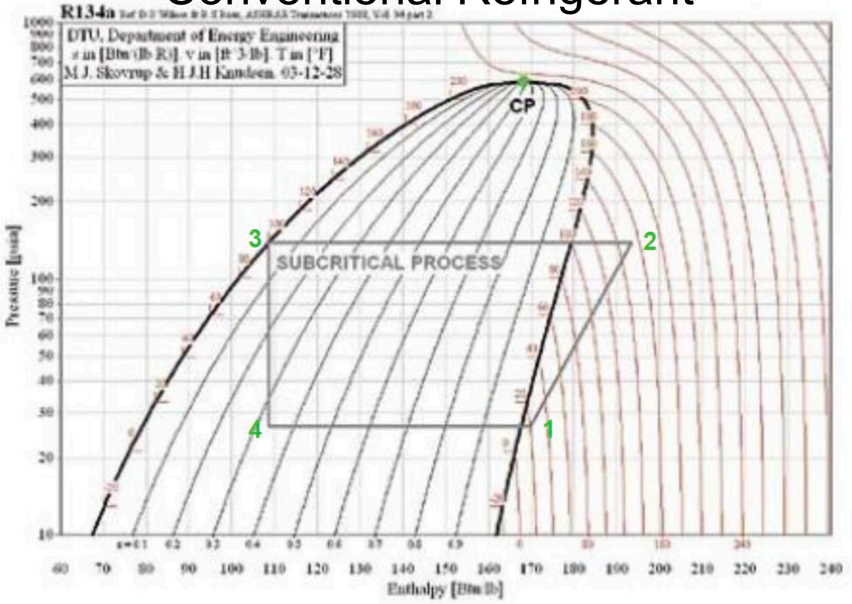
What are Transcritical CO_2 Systems?

- Uses CO_2 as working fluid
- Operate at much higher pressures (~1200 psi)
- Operates above critical point after the vapor compression stage during higher ambient temperatures typically above approximately 75 deg F (supercritical operation)
- System efficiency decreases during supercritical operation
- Operates below critical point during lower ambient temperatures similarly to common refrigerant systems (subcritical operation)

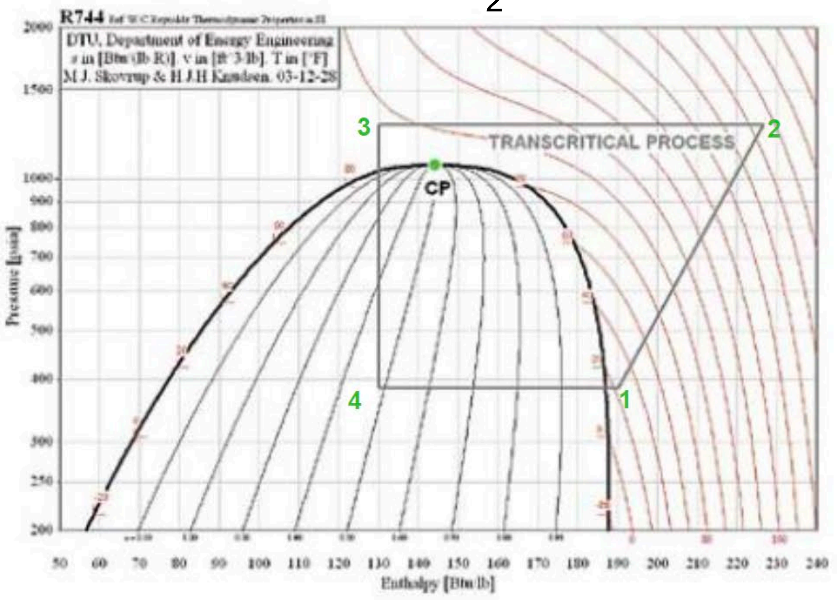
Transcritical CO_2 Systems



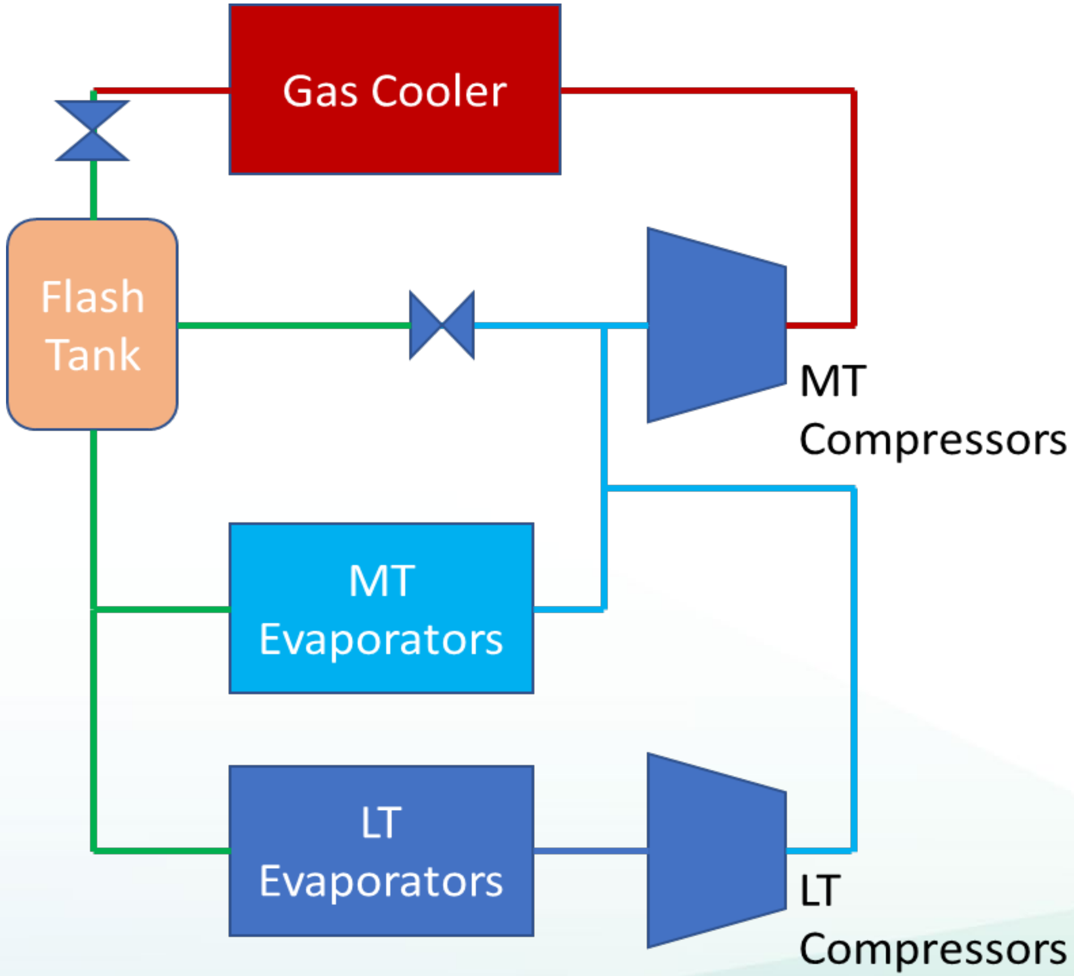
Conventional Refrigerant



CO_2



Transcritical CO_2 Systems



Transcritical CO_2 Booster Refrigeration System Diagram

Transcritical CO_2 Systems

Why are requirements being proposed?

- Transcritical CO_2 Systems has been increasing with technology innovation.
- Phase out of halocarbon refrigerants that have high global warming potential (GWP).
- Title 24 Part 6 currently does not include Transcritical CO_2 Systems.
- Design and control requirements can have significant energy savings.
- Provide clarity to individuals for the design practice as we transition to low GWP.

Transcritical CO_2 Systems

Applicable to…

- Refrigerated warehouses that are greater than or equal to 3,000 square feet.
- Refrigerated spaces with a sum total of 3,000 square feet or more that are served by the same refrigeration system.
- Retail food stores with 8,000 square feet or more conditioned area.
- New construction, additions, and alterations where there is a newly installed refrigeration system.

Transcritical CO_2 Systems

New Construction Forecast

Building Type	Total Statewide New Construction Permitted in 2023 (million square feet)	Percent of Statewide New Construction Impacted by Proposal	Statewide New Construction Impacted by Proposal in 2023 (million square feet)
Refrigerated Warehouse	1.638	10%	0.16
Commercial Refrigeration	8.39	30%	2.51

Transcritical CO_2 Systems

Negligible impact on existing building stock

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent of SF Impacted by Proposal	Statewide SF Impacted by Proposal in 2023 (million square feet)
Small Office	476.52	0%	0
Large Office	1,665.45	0%	0
Restaurant	238.92	0%	0
Retail	1,490.53	0%	0
Grocery Store	394.19	0%	0
Non-refrigerated Warehouse	1,402.32	0%	0
Refrigerated Warehouse	75.65	0%	0
Schools	724.95	0%	0
Colleges	379.99	0%	0
Hospitals	488.66	0%	0
Hotel / Motel	451.77	0%	0
Total	**7,788.95**	**0%**	**0**

Transcritical CO_2 Systems

What requirements are being proposed?

- Does not mandate the use of Transcritical CO_2 Systems.
- Establishes mandatory design and control requirements for Transcritical CO_2 Systems utilized in commercial refrigeration and refrigeration warehouse. These include:
  - Air-cooled gas cooler restriction
  - Gas cooler sizing and specific efficiency
  - Supercritical optimized head pressure control
  - Subcritical ambient temperature reset control strategy
  - Minimum saturated condensing temperature setpoint of 60 deg F
  - Heat recovery

Transcritical CO_2 Systems

Air-cooled gas cooler restriction

- Restricts the use of air-cooled gas coolers in high ambient temperature climate zones in order to reduce the number of supercritical operating hours.
- Restricted Climate Zones for Refrigerated Warehouses: Climate Zone 9, 10, 11, 12, 13, 14, and 15
- Restricted Climate Zones for Commercial Refrigeration: Climate Zone 10, 11, 12, 13, 14, and 15
- Available options include water-cooled condensers connected to a cooling tower, adiabatic gas coolers, and evaporative gas coolers

Transcritical CO_2 Systems

Gas cooler sizing and specific efficiency

- Ensure cost-effective design of the refrigeration system’s heat rejection equipment, balancing first cost of the equipment and the additional energy savings that are achieved with larger heat exchanger surfaces.

Transcritical CO_2 Systems

Supercritical optimized head pressure control

- Allows for the head pressure setpoint to be reset in response to ambient conditions.

Subcritical ambient temperature reset control strategy

- Aligns the head pressure control strategy of CO_2 systems during subcritical operation with existing code language.

Minimum saturated condensing temperature setpoint of 60 deg F

- Applies to systems with design saturated suction temperatures of less than 30 deg F (otherwise 70 deg F).

Transcritical CO_2 Systems

Heat recovery in supermarkets

- Refrigeration equipment in supermarkets creates a heating load to maintain comfortable space temperatures for shoppers. As a result, supermarkets require heating for more hours than most occupancies.
- In most climate zones, waste heat from the refrigeration system can be recovered to provide it more efficiently.

Proposed Language for Refrigerated Warehouse

Section 120.6(a)5. Transcritical CO2 Gas Coolers. New fan-powered gas coolers on all new transcritical CO2 refrigeration systems shall conform to the following:

A. Air cooled gas coolers are prohibited in Climate Zones 9 through 15.

B. Design leaving gas temperature for air-cooled gas coolers shall be less than or equal to the design dry bulb temperature plus 6°F.

   EXCEPTION to Section 120.6(a)5B: Design leaving gas temperature for air-cooled gas coolers in Climate Zone 2, 4, and 8 shall be less than or equal to the design dry bulb temperature plus 8°F.

C. Design leaving gas temperature for adiabatic gas coolers necessary to reject the design total heat of rejection of a refrigeration system assuming dry mode performance shall be less than or equal to the design dry bulb temperature plus 15°F.

D. All gas cooler fans shall be continuously variable speed, with the speed of all fans serving a common condenser high side controlled in unison.

Proposed Language for Refrigerated Warehouse (continue)

E. While operating below the critical point, the gas cooler pressure shall be controlled in accordance to 120.6(a)4F.

F. While operating above the critical point, the gas cooler pressure setpoint shall be reset based on ambient conditions such that the system efficiency is maximized.

G. The minimum condensing temperature setpoint shall be less than or equal to 60°F for air-cooled gas coolers, evaporative-cooled gas coolers, adiabatic gas coolers, air or water-cooled fluid coolers or cooling towers.

   EXCEPTION to Section 120.6(a)5G: Transcritical CO_2 systems with a design intermediate saturated suction temperature greater than or equal to 30°F shall have a minimum condensing temperature setpoint of 70°F or less.

H. Fan-powered gas coolers shall meet the gas cooler efficiency requirements listed in TABLE 120.6-F. Gas cooler efficiency is defined as the Total Heat of Rejection (THR) capacity divided by all electrical input power (fan power at 100 percent fan speed).

Proposed Language for Refrigerated Warehouse

TABLE 120.6-F TRANSCRITICAL CO_2 FAN-POWERED GAS COOLERS – MINIMUM EFFICIENCY REQUIREMENTS

CONDENSER TYPE	REFRIGERANT TYPE	MINIMUM EFFICIENCY	RATING CONDITION
Outdoor Air-Cooled	Transcritical CO_2	160 Btuh/W	1400 psig, 100°F Outlet Gas Temperature, 90°F Outdoor Dry bulb Temperature
Adiabatic Dry Mode	Transcritical CO_2	90 Btuh/W	1100 psig, 100°F Outlet Gas Temperature, 90°F Outdoor Dry bulb Temperature

Proposed Language for Commercial Refrigeration

Section 120.6(b)2. Transcritical CO2 Gas Coolers . New fan-powered gas coolers on all new transcritical CO2 refrigeration systems shall conform to the following:

A. Air cooled gas coolers are prohibited in Climate Zones 10 through 15.
B. Design leaving gas temperature for air-cooled gas coolers shall be less than or equal to the design dry bulb temperature plus 6°F
C. Design leaving gas temperature for adiabatic gas coolers necessary to reject the design total heat of rejection of a refrigeration system assuming dry mode performance shall be less than or equal to the design dry bulb temperature plus 15°F.
D. All gas coolers fans shall be continuously variable speed, with the speed of all fans serving a common condenser high side controlled in unison.
E. While operating below the critical point, the gas cooler pressure shall be controlled in accordance to 120.6(b)1A.

Proposed Language for Commercial Refrigeration (Continue)

F. While operating above the critical point, the gas cooler pressure setpoint shall be reset based on ambient conditions such that the system efficiency is maximized.

G. The minimum condensing temperature setpoint shall be less than or equal to 60°F for air-cooled gas coolers, evaporative-cooled gas coolers, adiabatic gas coolers, air or water-cooled fluid coolers or cooling towers.

   EXCEPTION to Section 120.6(b)2G: Transcritical CO_2 systems with a design intermediate saturated suction temperature greater than or equal to 30°F shall have a minimum condensing temperature setpoint of 70°F or less.

H. Fan-powered gas coolers shall meet the condenser efficiency requirements listed in TABLE 120.6-H. Gas cooler efficiency is defined as the Total Heat of Rejection (THR) capacity divided by all electrical input power (fan power at 100 percent fan speed).

Proposed Language for Refrigerated Warehouse

TABLE 120.6-H TRANSCRITICAL CO2 FAN-POWERED GAS COOLERS – MINIMUM EFFICIENCY REQUIREMENTS

CONDENSER TYPE	REFRIGERANT TYPE	MINIMUM EFFICIENCY	RATING CONDITION
Outdoor Air-Cooled	Transcritical CO2	160 Btuh/W	1400 psig, 100°F Outlet Gas Temperature, 90°F Outdoor Dry bulb Temperature
Adiabatic Dry Mode	Transcritical CO2	90 Btuh/W	1100 psig, 100°F Outlet Gas Temperature, 90°F Outdoor Dry bulb Temperature

Transcritical CO_2 Systems

Energy Savings Method

Prototype Buildings Used For Savings

Prototype Name	Number of Stories	Floor Area (square feet)
Large Refrigerated Warehouse (LRWH)	1	92,000
Large Supermarket (LSM)	1	60,000

- Detailed layouts can be found in the CASE Report

Transcritical CO_2 Systems

- Used DOE2.2R simulation software to estimate energy and demand impacts
- Per-unit energy impacts were calculated for each submeasure

Prototype ID	Climate Zone	Submeasure Name	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
LRWH and LSM	All	Air Cooled Gas Cooler Restriction	Gas Cooler Type	Air Cooled	Adiabatic
LRWH and LSM	All	Minimum Air-Cooled Gas Cooler Sizing and Specific Efficiency	Gas Cooler Size (Rated approach temperature)	8F	Multiple, parametric analysis (4F, 5F, 6F and 7F)

- For heat recovery submeasure, additional spreadsheet analysis was performed.
- Supercritical optimized head pressure control, subcritical ambient temperature reset control strategy, and minimum saturated condensing temperature setpoint is considered standard practice.

Transcritical CO_2 Systems

First-Year Energy Impacts Per Square Foot – Large Refrigerated Warehouse Prototype Building – Air-Cooled Gas Cooler Restriction

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)[a]	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(1.22)	0.00	0.00	(34.05)
2	0.73	0.00	0.00	32.26
3	(0.75)	0.00	0.00	6.40
4	0.81	0.00	0.00	27.41
5	(0.42)	0.00	0.00	(15.67)
6	0.90	0.00	0.00	23.17
7	(0.18)	0.00	0.00	(9.36)
8	1.49	0.00	0.00	32.99
9	1.67	0.00	0.00	51.60
10	2.17	0.00	0.00	62.58
11	2.60	0.00	0.00	125.17
12	1.72	0.00	0.00	62.25
13	1.86	0.00	0.00	73.55
14	2.16	0.00	0.00	73.81
15	4.74	0.00	0.00	167.70
16	0.42	0.00	0.00	9.76

Transcritical CO_2 Systems

First-Year Energy Impacts Per Square Foot – Large Refrigerated Warehouse Prototype Building – Air-Cooled Gas Cooler Sizing

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)[a]	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)[b]
1	0.15	0.00	0.00	3.99
2	0.07	0.00	0.00	0.46
3	0.09	0.00	0.00	2.64
4	0.10	0.00	0.00	0.96
5	0.11	0.00	0.00	3.11
6	0.16	0.00	0.00	3.61
7	0.15	0.00	0.00	3.65
8	0.08	0.00	0.00	0.77
9	0.06	0.00	0.00	0.35
10	0.06	0.00	0.00	0.36
11	(0.00)	(0.00)	0.00	(1.28)
12	0.05	0.00	0.00	(0.02)
13	(0.01)	0.00	0.00	(1.49)
14	(0.02)	0.00	0.00	(1.71)
15	(0.09)	0.00	0.00	(3.04)
16	0.06	0.00	0.00	1.53

Transcritical CO_2 Systems

First-Year Energy Impacts Per Square Foot – Large Supermarket Prototype Building – Air-Cooled Gas Cooler Restriction

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)[a]	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)[b]
1	(1.94)	0.00	0.00	(53.84)
2	(0.42)	0.00	0.00	5.24
3	(1.20)	0.00	0.00	(24.86)
4	(0.39)	0.00	0.00	12.43
5	(1.03)	0.00	0.00	(30.69)
6	(0.33)	0.00	0.00	(5.02)
7	(0.78)	0.00	0.00	(22.64)
8	0.16	0.00	0.00	17.71
9	0.32	0.00	0.00	26.47
10	0.83	0.00	0.00	41.34
11	1.42	0.00	0.00	67.01
12	0.45	0.00	0.00	36.42
13	1.42	0.00	0.00	67.64
14	1.38	0.00	0.00	54.21
15	4.58	0.00	0.00	170.72
16	(0.36)	0.00	0.00	(9.33)

Transcritical CO_2 Systems

First-Year Energy Impacts Per Square Foot – Large Supermarket Prototype Building – Air-Cooled Gas Cooler Sizing

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)[a]	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	0.27	(0.00)	0.00	7.06
2	0.14	0.00	0.00	3.76
3	0.19	(0.00)	0.00	5.11
4	0.22	(0.00)	0.00	5.39
5	0.21	(0.00)	0.00	6.03
6	0.27	0.00	0.00	7.18
7	0.24	(0.00)	0.00	6.66
8	0.17	(0.00)	0.00	5.10
9	0.17	0.00	0.00	4.33
10	0.16	(0.00)	0.00	4.64
11	0.08	(0.00)	0.00	1.63
12	0.15	(0.00)	0.00	3.78
13	0.13	(0.00)	0.00	2.89
14	0.07	(0.00)	0.00	1.36
15	0.03	0.00	0.00	0.82
16	0.11	(0.00)	0.00	2.81

Transcritical CO_2 Systems

First-Year Energy Impacts Per Square Foot – Large Supermarket Prototype Building – Heat Recovery

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)[a]	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	(0.35)	0.00	0.18	2.52
2	(0.33)	0.00	0.14	1.71
3	(0.35)	0.00	0.16	2.18
4	(0.33)	0.00	0.13	1.64
5	(0.34)	0.00	0.17	2.19
6	(0.33)	0.00	0.13	1.65
7	(0.34)	0.00	0.12	1.43
8	(0.33)	0.00	0.11	1.16
9	(0.32)	0.00	0.11	1.18
10	(0.32)	0.00	0.10	1.08
11	(0.31)	0.00	0.10	1.14
12	(0.32)	0.00	0.11	1.20
13	(0.31)	0.00	0.10	1.03
14	(0.31)	0.00	0.10	1.13
15	(0.29)	0.00	0.05	0.27
16	(0.33)	0.00	0.14	1.71

Transcritical CO_2 Systems

<u>**Incremental first cost**</u>

Air-cooled gas cooler restriction

- The price difference between the air cooled and adiabatic gas coolers was used to determine a percent cost increase that was then applied to each climate zone simulation for each prototype
- Pricing data from multiple manufacturers collected
- Approximately 30 percent more for equipment
- Estimated $3,000 difference for labor
- Total $83,000 for large refrigerated warehouse prototype
- Total $34,000 for large supermarket prototype

Transcritical CO_2 Systems

<u>**Incremental first cost**</u>

Minimum gas cooler sizing and specific efficiency

- Established an average cost per unit of heat rejection capacity ($/MBH).
- Incremental size increase associated with change in the rated temperature difference between gas cooler outlet temperature and ambient air temperature was converted.
- $5,000 per degree approach temperature difference for large refrigerated warehouse.
- $2,500 per degree approach temperature difference for supermarkets.

Transcritical CO_2 Systems

Incremental first cost

Heat Recovery

- Equipment (brazed plate glycol/CO_2 HX, glycol air coil, recirc pump) estimated at $13,195
- Materials (piping, ductwork, additional refrigerant, etc.) estimated at $10,563
- Labor for installation and commission estimated at $13,350
- Taxes, permits, contingency and others estimated at $13,915
- Total $51,023 for supermarket prototype

Transcritical CO_2 Systems

<u>Incremental maintenance and replacement cost (15-year analysis period)</u>

Air-cooled gas cooler restriction measure

- Maintenance needed for pre-cooling pads and control strategy estimated at $64,000 for LRWH and $32,000 for LSM
- Three replacement costs (over 15 years) for pre-cooling pads estimated at $120,000 for LRWH and $60,000 for LSM
- Water usage and sewer costs were included

Transcritical CO_2 Systems

<u>**Incremental maintenance and replacement cost (15-year analysis period)**</u>

Minimum gas cooler sizing and specific efficiency

- No incremental maintenance or replacement cost

Transcritical CO_2 Systems

Incremental maintenance and replacement cost (15-year analysis period)

Heat Recovery

- Estimated incremental maintenance at $800 per year
- Total estimated $9,550 for LSM

Transcritical CO_2 Systems

15-Year Cost-Effectiveness Summary Per Square Foot – New Construction – Large Refrigerated Warehouse – Air-Cooled Gas Cooler Restriction

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	($3.03)	$2.98	(1.02)
2	$2.87	$3.57	0.80
3	$0.57	$3.25	0.18
4	$2.44	$3.42	0.71
5	($1.39)	$3.26	(0.43)
6	$2.06	$4.17	0.49
7	($0.83)	$3.62	(0.23)
8	$2.94	$4.24	0.69
9	$4.59	$4.12	1.11
10	$5.57	$4.13	1.35
11	$11.14	$3.92	2.84
12	$5.54	$3.84	1.44
13	$6.55	$4.08	1.60
14	$6.57	$3.93	1.67
15	$14.92	$4.54	3.29
16	$0.87	$3.19	0.27

Transcritical CO_2 Systems

15-Year Cost-Effectiveness Summary Per Square Foot – New Construction – Large Refrigerated Warehouse – Gas Cooler Sizing

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	$0.36	$0.10	3.49
2	$0.04	$0.15	0.27
3	$0.23	$0.14	1.74
4	$0.09	$0.15	0.58
5	$0.28	$0.14	2.00
6	$0.32	$0.15	2.21
7	$0.32	$0.14	2.33
8	$0.07	$0.16	0.44
9	$0.03	$0.16	0.20
10	$0.03	$0.17	0.19
11	($0.11)	$0.17	(0.68)
12	($0.00)	$0.16	(0.01)
13	($0.13)	$0.16	(0.81)
14	($0.15)	$0.17	(0.92)
15	($0.27)	$0.19	(1.45)
16	$0.14	$0.13	1.02

Transcritical CO_2 Systems

15-Year Cost-Effectiveness Summary Per Square Foot – New Construction – Large Supermarket – Air-Cooled Gas Cooler Restriction

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	($4.79)	$2.18	(2.20)
2	$0.47	$2.64	0.18
3	($2.21)	$2.40	(0.92)
4	$1.11	$2.53	0.44
5	($2.73)	$2.41	(1.13)
6	($0.45)	$3.16	(0.14)
7	($2.01)	$2.71	(0.74)
8	$1.58	$3.18	0.50
9	$2.36	$3.08	0.76
10	$3.68	$3.07	1.20
11	$5.96	$2.91	2.05
12	$3.24	$2.85	1.14
13	$6.02	$3.00	2.00
14	$4.83	$2.90	1.66
15	$15.19	$3.26	4.66
16	($0.83)	$2.37	(0.35)

Transcritical CO_2 Systems

15-Year Cost-Effectiveness Summary Per Square Foot – New Construction – Large Supermarket – Gas Cooler Sizing

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	$0.63	$0.07	9.27
2	$0.33	$0.07	4.52
3	$0.46	$0.07	6.60
4	$0.48	$0.07	6.77
5	$0.54	$0.07	7.85
6	$0.64	$0.07	9.10
7	$0.59	$0.07	8.79
8	$0.45	$0.07	6.08
9	$0.39	$0.08	5.11
10	$0.41	$0.08	5.24
11	$0.15	$0.08	1.82
12	$0.34	$0.08	4.34
13	$0.26	$0.08	3.32
14	$0.12	$0.08	1.52
15	$0.07	$0.09	0.83
16	$0.25	$0.07	3.72

Transcritical CO_2 Systems

15-Year Cost-Effectiveness Summary Per Square Foot – New Construction – Large Supermarket – Heat Recovery

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	$2.52	$1.01	2.50
2	$1.71	$1.01	1.69
3	$2.18	$1.01	2.16
4	$1.64	$1.01	1.62
5	$2.19	$1.01	2.17
6	$1.65	$1.01	1.63
7	$1.43	$1.01	1.42
8	$1.16	$1.01	1.15
9	$1.18	$1.01	1.17
10	$1.08	$1.01	1.07
11	$1.14	$1.01	1.13
12	$1.20	$1.01	1.19
13	$1.03	$1.01	1.02
14	$1.13	$1.01	1.12
15	$0.27	$1.01	(0.27)
16	$1.71	$1.01	1.69

Transcritical CO_2 Systems

First-year Statewide Energy and Impacts

Measure	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (MMtherms/yr)	TDV Energy Savings (TDV kBtu/yr)
Design and Control Requirements for Transcritical CO_2 Systems (Total)	1.51	1.13	0	7,019,545

Transcritical CO_2 Systems

First-Year Statewide GHG Emissions Impacts

Measure	Avoided GHG Emissions (Metric Tons CO_2e/yr)	Monetary Value of Avoided GHG Emissions ($2023)
Design and Control Requirements for Transcritical CO_2 Systems	140	$14,848

Questions?

Automatic Door Closers

Automatic Door Closers

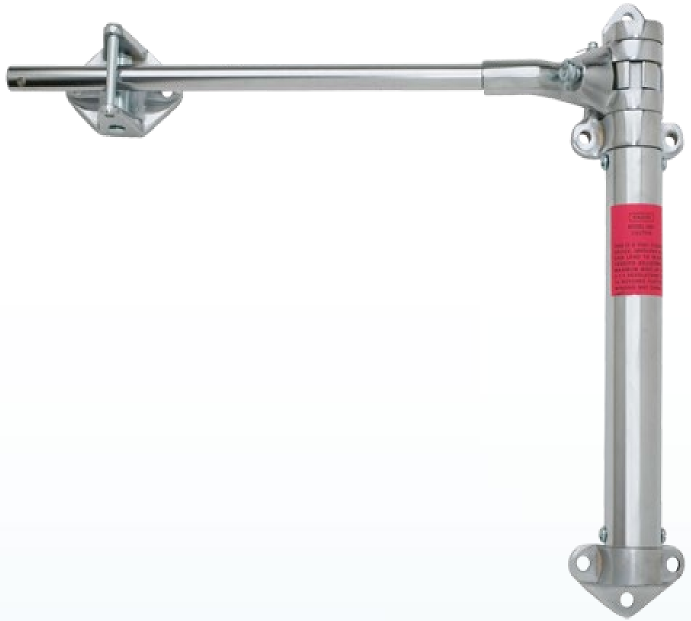
What are Automatic Door Closers?

- Two types of automatic door closers
  1. Mechanism that closes door from standing-open position
     - cam hinge
     - spring hinge

  2. Mechanism that tightly seals the door to the frame to eliminate air leakage
     - snap type door closers
     - magnetic gaskets

Automatic Door Closers

Examples



Spring Hinge

Cam Hinge

Snap Type

Automatic Door Closers

What requirement is being proposed?

- Require automatic door closers for refrigerated spaces 3,000 square feet (SF) and over
- Aligns with Title 20 and federal requirements for smaller refrigerated spaces (<3,000 SF)
- Applies to new construction, additions, and alterations

Automatic Door Closers

Size	Federal	CA Title 20	CA Title 24, Part 6 existing	CA Title 24, Part 6 proposed
Less than 3,000ft^2	Automatic Door Closers required	Automatic Door Closers required	Title 24, Part 6 does not apply, references federal standards	No additional Title 24, Part 6 code proposals
3,000ft^2 and over	No federal standards	Does not apply	Option for automatic door closer, air curtain or strip curtains	Required automatic door closers for personnel doors

Automatic Door Closers

Why is the requirement is being proposed?

- People forget to close doors behind them or close them without achieving tight seal
- Infiltration barriers reduce cooling loads by preventing warmer air from entering refrigerated spaces
- One of the most cost-effective ways to save energy in grocery stores and refrigerated warehouses

Automatic Door Closers

Technical Feasibility and Market Availability

- Door closers market is well established with multiple manufacturers producing different types of automatic door closers
- Many supermarkets already use automatic door closers
- Cost-effective in all climate zones except for 16

Automatic Door Closers

Energy Savings Method

Prototype Buildings Used for Savings

Prototype Name	Number of Stories	Floor Area (ft^2)
Large Refrigerated Warehouse	1	92,000
Small Refrigerated Warehouse	1	26,000

Breakdown of Refrigerated Space

Prototype	35°F Cooler (ft^2)	-10°F Freezer (ft^2)	40°F Dock (ft^2)	Total (ft^2)
Large Refrigerated Warehouse	40,000	40,000	12,000	**92,000**
Small Refrigerated Warehouse	**10,000**	**10,000**	**6,000**	**26,000**

Automatic Door Closers

- Used DOE2.2R simulation software to estimate energy and demand impacts

Prototype ID	Climate Zone	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Large Refrigerated Warehouse, Small Refrigerated Warehouse	All	Infiltration for each exterior door	50 CFM	40 CFM
Large Refrigerated Warehouse, Small Refrigerated Warehouse	All	Passage time per door opening	5 seconds	4 seconds
Large Refrigerated Warehouse, Small Refrigerated Warehouse	All	Stand-open time per hour for each interior door	60 seconds	0 seconds
Large Refrigerated Warehouse, Small Refrigerated Warehouse	All	Leakage when door is closed	5% of the maximum flow through the door	0% of the maximum flow through the door

Automatic Door Closers

First-Year Energy Impacts Per Square Foot – Large Refrigerated Warehouse Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	0.07	0.00	0	1.87
2	0.07	0.00	0	1.91
3	0.07	0.00	0	2.02
4	0.07	0.00	0	2.04
5	0.07	0.00	0	1.97
6	0.08	0.00	0	2.19
7	0.07	0.00	0	2.05
8	0.07	0.00	0	2.00
9	0.07	0.00	0	1.94
10	0.07	0.00	0	1.89
11	0.06	0.00	0	1.84
12	0.07	0.00	0	1.88
13	0.06	0.00	0	1.89
14	0.06	0.00	0	1.71
15	0.07	0.00	0	1.97
16	0.04	0.00	0	1.10

Automatic Door Closers

Incremental First Cost per Door

Cost Component	Cost ($)	Notes
Snap Closer Mechanism	$103	Online retail suppliers for walk in coolers and freezers
Spring/Cam Hinge Mechanism	$448	Online retail suppliers for walk in coolers and freezers
Installation Labor	$60	Assumes $60/hr
Taxes, Permits and Contingency Costs	$96	7.5% for taxes and permits 10% for contingency
Total	$707	

Automatic Door Closers

Incremental First Cost per Square Foot

	Description	Value	Notes
1	# of Doors per Prototype	10	
2	Incremental Cost per Door	$707	
3	Incremental Cost per Prototype	$7,070	[3] = [1] * [2]
4	Prototype Square Footage	92,000	
5	Incremental Cost Per Square Footage	$0.077	[5] = [3] / [4]

Automatic Door Closers

15-Year Cost-Effectiveness Summary Per Square Foot – New Construction, Additions, Alterations

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	$0.17	$0.12	1.37
2	$0.17	$0.12	1.40
3	$0.18	$0.12	1.48
4	$0.18	$0.12	1.50
5	$0.18	$0.12	1.45
6	$0.19	$0.12	1.61
7	$0.18	$0.12	1.51
8	$0.18	$0.12	1.47
9	$0.17	$0.12	1.43
10	$0.17	$0.12	1.39
11	$0.16	$0.12	1.35
12	$0.17	$0.12	1.38
13	$0.17	$0.12	1.39
14	$0.15	$0.12	1.26
15	$0.18	$0.12	1.45
16	$0.10	$0.12	0.80

Automatic Door Closers

Statewide Energy and Energy Cost Impacts – New Construction

Climate Zone	Statewide New Construction Impacted by Proposed Change in 2023 (nonres: million ft^2)	First-Year[a] Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (MMtherms)	15-Year Present Valued Energy Cost Savings (million 2023 PV$)
1	0.008	532	0	0	$1,312
2	0.047	3,127	0	0	$7,970
3	0.238	17,128	0	0	$42,718
4	0.121	8,484	0	0	$21,904
5	0.024	1,712	0	0	$4,283
6	0.081	6,206	0	0	$15,838
7	0.015	1,115	0	0	$2,813
8	0.118	8,129	0	0	$20,943
9	0.172	11,512	0	0	$29,725
10	0.108	7,077	0	0	$18,172
11	0.090	5,741	0	0	$14,706
12	0.298	19,508	0	0	$49,959
13	0.235	15,244	0	0	$39,485
14	0.037	2,214	0	0	$5,714
15	0.021	1,465	0	0	$3,767
16	0.000	0	0	0	$0
TOTAL	1.614	109,194	0	0	$279,309

Automatic Door Closers

Statewide Energy and Energy Cost Impacts – New Construction, Alterations, and Additions

Construction Type	First-Year Electricity Savings[a] (kWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (MMtherms)	15-Year Present Valued Energy Cost Savings (million 2023 PV$)
New Construction	109,194	0	0	$279,309
Additions and Alterations	252,107	0	0	$645,183
TOTAL	361,301	0	0	$924,491

- Additions and alterations was estimated to be 5 percent of the square footage of the current building stock

Automatic Door Closers

First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (kWh/yr)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO2e)	Natural Gas Savings[a] (MMtherms/yr)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO2e)	Total Reduced CO_2e Emissions[a,b] (Metric Tons CO2e)
New Construction	108,646	26	0	0	26
Additions and Alterations	250,983	60	0	0	60
Total	**359,629**	**86**	**0**	**0**	**86**

Closing

- Copy of the CASE Report found here:
  https://efiling.energy.ca.gov/GetDocument.aspx?tn=234658&DocumentContentId=67508
- How to submit comments:
  1. Submit E-Comment here:
     https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumbr=19-BSTD-03
  2. By Email: docket@energy.ca.gov
     - Include docket number **19-BSTD-03** and **2022 Building Energy Efficiency Standards** in the subject line.

Comments are due October 7, 2020 by 5:00 PM

Questions?

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Thank You!