DOCKETED	
Docket Number:	21-BSTD-01
Project Title:	2022 Energy Code Update Rulemaking
TN #:	239071
Document Title:	Statewide Utility Codes and Standards Enhancement Team Comments - Response to Comments on Computer Room Pumped Refrigerant Econo
Description:	Statewide Utility Codes and Standards Enhancement Team - Response to Comments on Computer Room Pumped Refrigerant Economizer Analysis
Filer:	System
Organization:	Statewide Utility Codes and Standards Enhancement Team
Submitter Role:	Public
Submission Date:	7/28/2021 5:26:37 PM
Docketed Date:	7/29/2021

Comment Received From: Statewide Utility Codes and Standards Enhancement Team
Submitted On: 7/28/2021
Docket Number: 21-BSTD-01

Response to Comments on Computer Room Pumped Refrigerant Economizer Analysis

Additional submitted attachment is included below.

Response to Comments on Computer Room Pumped Refrigerant Economizer Analysis

CALIFORNIA STATEWIDE UTILITY CODES AND STANDARDS TEAM

July 28, 2021

1. Introduction

The California Statewide Utility Codes and Standards Enhancement Team (Statewide CASE Team) appreciates the opportunity to participate in the review of the July 14, 2021 15-Day Express Terms 2022 Energy Code, Title 24 Parts 1 and 6 (15-Day Express Terms)[1] and respond to the comments presented in *Vertiv Response to TN238233 - Nonresidential Computer Room Efficiency Code Change Recommendations*[2].

The Statewide CASE Team actively supports code-setting bodies in developing and revising building energy codes and standards. The program's objective is to achieve significant energy savings and assist in meeting other energy-related state policy goals through the development of reasonable, responsible, and cost-effective code changes. Three California Investor Owned Utilities – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities – Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – sponsored this effort. The Statewide CASE Team is actively supporting the California Energy Commission (Energy Commission) in updating the California Energy Code (Title 24, Part 6) for the 2022 code update cycle. Through CASE Reports, the Statewide CASE Team has provided the Energy Commission with the technical and cost-effectiveness information to assist in making informed judgments on proposed standards for promising energy efficiency design practices and technologies. The Statewide CASE Team encourages the Energy Commission to consider the recommendations presented in this document.

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[1] CEC Docket #21-BSTD-01, TN #238848
https://efiling.energy.ca.gov/GetDocument.aspx?tn=238848&DocumentContentId=72256

[2] CEC Docket #21-BSTD-01, TN # 238362
https://efiling.energy.ca.gov/GetDocument.aspx?tn=238362&DocumentContentId=71667

2. Statewide CASE Team Responses to Vertiv's Comments

Excerpts from Comment Letter TN#238362[3] are pasted below with our responses.

2.1 Issue 1

> As important context, the Comment continually and mistakenly states that Vertiv's proposal showed the pumped refrigerant economizer to be energy equivalent to a water economizer. Rather, Vertiv's proposal showed the pumped refrigerant economizer to be *more* efficient than a baseline water economizer system. As such, the basis for the Comment's additional metric of minimum equipment efficiency values is flawed because federally-minimum compliant equipment could still show energy savings versus a baseline water economizer.

Response: While Vertiv's proposal may have shown a pumped refrigerant economizer to be more efficient than a baseline water economizer system, there were flaws in the simulation, including the baseline CRAH fan operation. Therefore, the results shown in Vertiv's proposal are not valid to justify a pumped refrigerant economizer being equivalent or better in energy performance to a baseline water economizer system, and additional analysis was needed.

The economizer type's hours of operation difference (pumped refrigerant vs. evaporative cooling tower water economizer) is not the only factor impacting energy savings. The pumped refrigerant economizer system utilizes an air-cooled CRAC cooling system which is an entirely different system from a water-cooled chiller with evaporative cooling towers system. A water-cooled chiller system with evaporative cooling towers has efficiency values about twice the COP of an air-cooled CRAC. This inherent system efficiency difference is a major factor impacting the overall energy comparison between these two economizer system types.

2.2 Issue 2

> 1) First, the Comment seeks to isolate the proposed refrigerant cooling system's economizer-only performance to equalize the overall system performance during non-economizer mode operating hours throughout the year. This is contrary to the Commission's preferred method of documenting a proposed submeasure's cost-effectiveness and energy efficiency by using CBECC-Com (California Building Energy Code Compliance), or another approved software method to "perform the annual energy analysis comparing its energy efficiency relative to the 2016/2019 Standards." *See* http://bees.archenergy.com/index.html.

[3] CEC Docket #21-BSTD-01, TN # 238362 https://efiling.energy.ca.gov/GetDocument.aspx?tn=238362&DocumentContentId=71667

Response: The energy modeling that supported the Statewide CASE Team's analysis utilized annual hourly simulations using EnergyPlus (the same engine used by Title 24 compliance software CBECC-Com). The full-load COPs reported are done to establish an efficiency metric that is reported by manufacturers, in order to reflect the modeled energy use. The simulations used the 10%-incremental part-load curves and part-load COPs provided by Vertiv. Supply fan energy inputs in the model were changed to be equal in the baseline and proposed cases (and to match 140.9(a) minimum requirements) in order to isolate the energy savings of the economizer for the cooling system.

2.3 Issue 3

2) Next, the Comment includes a request to "equalize" the performance of one component, the evaporator fan, between the baseline water economizer system and the proposed pumped refrigerant economizer system to negate the inherent performance advantage of the entire proposed refrigerant cooling system. This approach is impossible to justify because the evaporator fan is an integral part of the overall system. Further, this approach is wholly inappropriate because the refrigerant economizer can only be used with the

modeled evaporator fan and cannot be installed with any other cooling system. As such, the proposed metric does not "level the playing field" with respect to other technologies but instead creates negative impacts to artificially disadvantage the proposed pumped refrigerant technology. This runs counter to Title 24's technology-neutral intent.

Response: We disagree that the supply fan energy should be included in the energy equivalence comparison. The code change proposal for refrigerant economizers included them as an economizer option under 140.9(a)1, not as a packaged standalone product (which could be permitted via the performance pathway). Title 24, Part 6 has separate supply fan requirements in 140.9(a)2 and 120.6 which are not being changed as part of adding refrigerant economizers to 140.9(a)1 and 141.1(b).

2.4 Issue 4

3) Additionally, the Comment's analysis only uses the annualized energy savings data provided with Vertiv's proposal, which includes a 40°F economizer threshold for an equivalent water economizer, as taken from 2019 Title 24 Energy Code. The Comment's use of this data compared to a baseline water economizer with a 50°F economizer threshold used in the CASE proposal for 2022 Title 24 generates a grossly misleading bar chart in Figure 1 because the data sets shown by that chart do not compare performance at the same economizer temperature threshold. The Comment does not clarify this discrepancy. As a result, Vertiv's proposal reflects a lower number of hours in 100% economizer mode (because it is capped at 40°F), whereas the compared baseline water economizer data captures more hours in 100% economizer mode up to 50°F. To generate this data, the Comment had to have made

Response: The commentor appears to misunderstand this chart (Figure 1 in the comment letter TN238233). The chart shows the percent annual energy savings of a pumped refrigerant economizer as proposed in the 2022 Title 24, Part 6 15-Day Language (which includes a 50F outdoor dry-bulb full economizer threshold for refrigerant economizers), compared to the 2022 Title 24, Part 6 15-Day Language minimally-compliant baseline water economizer system (which includes a 45F outdoor wet-bulb full economizer threshold). The pumped refrigerant economizer code change proposal only compared a refrigerant economizer to the 2019 Title 24, Part 6 water economizer baseline (35F outdoor wet-bulb full economizer threshold), but since the water economizer baseline in 2022 is anticipated to decrease in energy use (per 15-Day language which increases the outdoor wet-bulb temperature for full water economizing), this chart is needed to demonstrate how the proposed 15-Day Language for refrigerant economizers did not result in energy equivalence to other economizer systems, specifically a baseline water economizer with water-cooled chillers.

2.5 Issue 5

100% economizer mode up to 50°F. To generate this data, the Comment had to have made unsubstantiated assumptions regarding the performance of Vertiv's equipment at outside temperatures between 40°F and 50°F. The Comment incorrectly assumed, without consulting Vertiv, that Vertiv's energy model reflected energy consumption at 100% economizer mode up to 50°F. Thus, the pumped refrigerant economizer appears substantially less efficient in this skewed misrepresentation of the data.

Response: We did not assume the Vertiv energy model reflected 100% economizer mode up to 50F dry-bulb; the model shows full economizing at 40F dry-bulb and partial economizing up to around 60F dry-bulb. However, since the 15-Day Language includes a 50F dry-bulb full economizing requirement for pumped refrigerant economizers, the Vertiv pumped refrigerant economizer is required to meet that threshold to be permitted prescriptively, and an analysis using 50F dry-bulb full economizing temperature to calculate pumped refrigerant economizer energy was needed. This resulted in reduced energy use by the pumped refrigerant economizer. Reasonable engineering adjustments were used based on the 40F full economizer part-load curves provided by Vertiv to adjust the pumped refrigerant economizer annual energy performance for a 50F dry-bulb full economizing temperature and estimated 70F maximum partial economizing temperature, using CEC weather data for each climate zone. To make energy adjustments, a percent cooling energy reduction was applied to the model results based on the percent difference in economizer hours using CEC annual hourly weather data. This included both a percent increase in full economizing hours and a percent increase in partial-economizing hours.

2.6 **Issue 6**

4) Most importantly, the Comment proposes to add an efficiency metric to the refrigerant economizer prescriptive requirement: the AHRI design point representative only of one, single test point in 100% compressor cooling mode at one summer outdoor air condition. However, this AHRI metric is intended as an equalizer for manufacturers to certify their products under the AHRI Datacom Cooling Certification Program and does not account *in any way* for the cooling equipment's annualized performance. *See* https://www.ahrinet.org/App_Content/ahri/files/Certification/ResourcesForms/WHY_CERTIFY_FLYER-2020.pdf. Additionally, this AHRI metric, when applied as intended, does not indicate whether an economizer is included in the product to which the metric is applied, which directly conflicts with the Commenter's original desire to divorce the economizer mode performance from the cooling mode performance.

Response: While a full-load COP was reported in the analysis, part-load efficiency data (at 10% increments provided by Vertiv) was used in an annual hourly model to demonstrate equivalence. All part-load efficiency data was scaled linearly with the full load COP during simulation to demonstrate energy equivalence.

We are not proposing that full load COP is the only factor being used to show energy equivalence. It is important to recognize that the COP is for a pumped refrigerant economizer system with air-cooled DX cooling, and this combination of economizer operation and cooling equipment efficiency provides energy equivalence. In contrast, an air-cooled CRAC without a refrigerant economizer but with the COP listed in the tables presented would not show energy equivalence to a baseline water economizer system.

2.7 **Issue 7**

The values in the proposed "Minimum Pumped Refrigerant Economizer CRAC Net Sensible COP by Climate Zone" table reference the AHRI 1360, 2017 Standard for Performance Rating of Computer and Data Processing Room Air Conditioners, which identifies the test inputs including an External Static Pressure (ESP) = 0.2" for Downflow units and MERV8 filters. By contrast, the energy model included in Vertiv's proposal was run with an elevated ESP = 0.75" to account for additional simulated ductwork for air distribution or containment, and it included higher efficiency MERV13 filters in compliance with 2019 California Green Building Standards Code Section 5.504.5.3 Filters, 2019 Title 24 Section 120.1(c) 1.B., and 2019 California Mechanical Code Chapter 4 Section 401.2. These inputs used in Vertiv's proposal are more conservative than what AHRI 1360 requires. This means that the

Commenter built a table of values that inaccurately assumes the inputs to the Vertiv data set were taken from the Test Method described within AHRI 1360. This inaccuracy makes invalid any attempt to establish a tie between the Commenter's proposed minimum efficiency values and AHRI Standard 1360.

Response: This comment makes incorrect assertions to the modeling process. Since 140.9(a)2 has requirements for computer room supply fan power, that was used to adjust fan power. Title 24, Part 6's maximum fan power at design conditions applies to all conditions, such as external static pressure or filtration levels. An assumption had to be made to calculate Net Sensible COP (AHRI rating) from cooling COP. Alternatively, 140.9(a)1 could require a minimum cooling COP for refrigerant economizers, but that would be more difficult to enforce since manufacturers do not typically list cooling COP for CRACs.

2.8 Issue 8

The values in the proposed table also assume an 85°F Return Air temperature, which is the input from AHRI Standard 1360; however, the report attempts to justify an elevated economizer temperature for refrigerant economizers by increasing the Return Air temperature to 95°F. The Commenter changes their expectation of an appropriate design Return Air temperature from 85°F when making the argument for AHRI 1360-based minimum efficiency levels and then moves up to 95°F when arguing that pumped refrigerant economizers should have an economizer threshold up at 65°F. This change is inappropriate and results in a metric target that contains more than one value for the same input, with which no product can comply.

Response: The 95F return air temperature was only meant to be an illustrative example of refrigerant economizer full economizing temperature capabilities. It was not used in any of the energy analysis.

2.9 Issue 9

Because the Comment's proposed minimum efficiency values only take Full Load operation into account, the Comment completely throws out any annual energy performance that has been provided to the Commission for a true evaluation of the pumped refrigerant economizer proposal and ignores the process that the Commission employs to evaluate submeasure proposals. The Comment's calculated NSenCOP values eliminate any recognition of the proposed pumped refrigerant economizer's performance in economizer mode.

Response: The statement that our minimum efficiency values only account for full-load operation is incorrect. Annual hourly energy simulations were done using the part-load pumped refrigerant economizer efficiency data provided from Vertiv. Part-load efficiency and economizing conditions were incorporated into the analysis, and each part-load COP was assumed to be scaled linearly with the full-load COP in the energy simulation. This is a similar methodology that is used to establish exceptions to nonresidential (non-computer room) economizer use under 2019 Exception 4 to 140.4(e)1.

As noted above, it is important to recognize that the COPs presented are for a pumped refrigerant economizer system, and the combination of cooling equipment (air-cooled DX CRAC) efficiency and economizer operation provides energy equivalence. In contrast, an air-cooled CRAC without a refrigerant economizer but with the COP listed in the tables we presented would <u>not</u> show energy equivalence to a baseline water economizer system.

2.10 Issue 10

The proposed acceptable minimum efficiency level for Climate Zone 1 is more than double the ASHRAE 90.1-2019 minimum NSenCOP efficiency value = 2.36 for this size of unit, which has been well-reported and is widely expected to be adopted by the DOE later this year, as noted in the Federal Register entry linked above. Imposing such an elevated minimum value discourages manufacturers from developing innovative, emergent technologies. The minimum efficiency values within ASHRAE 90.1 are evaluated with each 3-year cycle and generated with input from industry experts to set aggressive targets for manufacturers to develop new and increasingly efficient technologies. Increasing these minimums by a factor of 200% moves that already intentionally aggressive target and creates an unnecessarily heavy burden on innovators. Further, this disrupts ASHRAE's carefully developed and well-documented industry guidance that is specifically established to balance aggressive targets with flexibility for new and promising technologies.

Response: The intent of our comment letter was to provide analysis results for minimum energy efficiency requirements for refrigerant economizers to be energy equivalent to Title 24 baseline economizer systems (specifically a water economizer with evaporative cooling towers and water-cooled chillers). California is not governed by ASHRAE 90.1, and there are many instances where Title 24 sets higher efficiency standards than ASHRAE 90.1, including computer room economizer requirements.

2.11 Issue 11

If the metrics proposed in this table are approved, they will continue to push data center designers to favor the use of one of the two currently listed prescriptive economizer options, which are not ideal technologies for all data centers. For example, air economizers provide optimum payback only when outdoor air conditions are pollutant and smog-free so as to not degrade the performance of the servers within the data centers utilizing them,

which has been a genuine concern for residents of California in the past several years. *See, e.g.,* ASHRAE RP-1755, February 2020 Controlling Data Centers' Air Pollution, Environmental Control to Ensure Equipment, Systems Reliability. Additionally, data centers that use water-cooled systems are gaining attention for the impacts of that use. For example, such systems have been described as an "irresponsible use of our water" in Arizona, negative environmental impacts have been reportedly observed in other states, and Microsoft has set water consumption metrics as part of their corporate conservation goals, including for their data centers. *See* https://www.nbcnews.com/tech/internet/drought-stricken-communities-push-back-against-data-centers-n1271344. By contrast, pumped refrigerant economizers are not subject to these constraints or concerns because they do not depend on air quality and also do not consume water.

Response: While the 2019 computer room economizer system types in 140.9(a)1 may not be ideal for all data centers, they establish California's minimum prescriptive efficiency requirements. It is not in California's best interest to allow less efficient economizer technologies simply for the sake of flexibility. Other technology types not listed prescriptively may be permitted via the performance path if they can show energy equivalence.

3. Recommended Revisions to 15-Day Language

The 15-Day Language added Table 141.1-A Net Sensible COP By Climate Zone for Alterations. However, values shown in Table 141.1-A in the 15-Day Language are based on an energy-equivalent refrigerant economizer analysis using a 50F outdoor dry-bulb full economizing temperature (matching 140.9(a)1). However, 141.1 only requires 40F dry-bulb for full refrigerant economizing, so the values in Table 141.1-A should reflect a 40F dry-bulb full economizing temperature.

The results of this energy-equivalence analysis are in the table below; the COPs required for energy equivalence are a little higher than what is in the 15-Day Language due to there being fewer refrigerant economizer hours with a 40F vs. 50F outdoor dry-bulb full economizing threshold.

See below for a marked up version of the 15-Day Express Terms with our suggested revisions. Our recommended language insertions are double underlined in purple and recommended language deletions are ~~struck in purple~~.

3.1.1.1.1.1.1 Table 141.1-A: Net Sensible COP By Climate Zone For Alterations

Climate Zone	Net Sensible COP
Climate Zone 1	~~2.9~~3.1
Climate Zone 2	~~2.8~~3.2
Climate Zone 3	~~2.5~~3.2
Climate Zone 4	~~2.6~~3.2
Climate Zone 5	~~2.6~~3.2
Climate Zone 6	~~2.1~~3.2
Climate Zone 7	~~1.7~~3.2
Climate Zone 8	~~2.1~~3.2
Climate Zone 9	~~2.3~~3.2
Climate Zone 10	~~2.5~~3.2
Climate Zone 11	~~2.8~~3.2
Climate Zone 12	~~2.7~~3.2
Climate Zone 13	~~2.7~~3.2
Climate Zone 14	~~2.7~~3.1
Climate Zone 15	~~2.7~~3.2
Climate Zone 16	~~2.3~~2.7