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BUILDING ENERGY EFFICIENCY MEASURE PROPOSAL TO THE

CALIFORNIA ENERGY COMMISSION

FOR THE 2022 UPDATE TO THE

CALIFORNIA ENERGY CODE, TITLE 24, PART 6

BUILDING ENERGY EFFICIENCY STANDARDS

INTEGRATED PUMPED REFRIGERANT ECONOMIZER FOR COMPUTER ROOMS

NONRESIDENTIAL HVAC

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EXECUTIVE SUMMARY

Introduction

This proposal presents recommendations to support California Energy Commission's (Energy Commission) efforts to update the Title 24 Standards to include or upgrade requirements for various technologies in California's Building Energy Efficiency Standards. Vertiv, formerly Emerson Network Power, sponsored this effort. The goal of this proposal is to create new measures that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the Energy Commission effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficient design practices and technologies.

Scope of Code Change Proposal

Integrated Pumped Refrigerant Economizer for Computer Rooms will affect the following code documents listed in Table 1.

Table 1: Scope of Code Change Proposal

Standards Requirements (see note below)	Compliance Option	Appendix	Modeling Algorithms	Simulation Engine	Forms
Ps Section 140.9(a)1.	Yes	N/A	Yes	Yes	N/A

Note: An (M) indicates mandatory requirements, (Ps) Prescriptive, (Pm) Performance.

List of other areas affected including changes to trade-offs:

- None

Measure Description

"California's *Building Energy Efficiency Standards* require the mechanical cooling equipment serving a computer room to be equipped with either an integrated air-side economizer or an integrated water-side economizer. A mechanical cooling system integrated with one of these features can provide cool air to the space without operating the mechanical cooling system when the outside conditions are cool enough to provide sufficient cooling to the space. This results in energy savings due to not having to operate a compressor to cool the air or water mechanically.

Pumped refrigerant economizing uses the same concept for energy savings, in that it bypasses the compressor for mechanical cooling by using a pump to move the refrigerant through the evaporator and condenser. The energy savings is achieved by the difference in energy consumption between the pump and compressor." [Alatorre, M. 2015. Staff Paper "Pumped Refrigerant Economizers for Use in Computer Rooms" CEC-400-2015-029. August.]

The addition of the integrated pumped refrigerant economizer as a prescriptive measurement alongside integrated airside and integrated waterside economizers provides an additional compliant prescriptive option for engineers designing computer rooms that results in substantial energy savings and uses no water.

Market Analysis and Regulatory Impact Assessment

The addition of the integrated pumped refrigerant economizer as a prescriptive measurement offers the computer room market one more compliant option to meet the prescriptive economizer requirement.

The integrated pumped refrigerant economizer technology has been deployed in hundreds of computer room installations globally and is available as an integrated feature to standard manufactured equipment without custom modifications. Since the integrated pumped refrigerant economizer is an integrated pump and associated controls with the standard equipment's existing refrigeration cycle, there is no extraneous maintenance added with the addition of integrated pumped refrigerant economizer other than basic pump maintenance.

This proposal is cost effective over the period of analysis. Overall this proposal increases the wealth of the State of California. California consumers and businesses save more money on energy than they do for financing the efficiency measure. As a result this leaves more money available for discretionary and investment purposes.

Statewide Energy Impacts

Table 2 shows the estimated energy savings over the first twelve months of implementation of the integrated pumped refrigerant economizer for computer rooms.

Table 2: Statewide Estimated First Year Energy Savings

	First Year Statewide Savings			First Year Statewide TDV Savings	
	Electricity Savings (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Electricity Savings (Million kBTU)	TDV Natural Gas Savings (Million kBTU)
Integrated Pumped Refrigerant Economizer	11.64	1.67	0	2,099	0

Section 4.2 discusses the methodology and Section 4.3 shows the results for the per unit energy impact analysis.

Compliance and Enforcement

The proposed compliance and enforcement process to ensure the success of the measure is described in Section 2.5. The impacts the proposed measure will have on various market actors is described in Section 2.5. The key issues and challenges related to compliance and enforcement are summarized below:

- Confirming integrated pumped refrigerant economizer is truly integrated to standard refrigeration cycle and controls of standard equipment

Cost-effectiveness

Results per unit Cost-effectiveness Analyses are presented in

Table 3. The TDV Energy Costs Savings are the present valued energy cost savings over the 15 year period of analysis using Energy Commission's TDV methodology. The Total Incremental Cost represents the incremental initial construction and maintenance costs of the proposed measure relative to existing conditions (current minimally compliant construction practice when there are existing Title 24 Standards). Costs incurred in the future (such as periodic maintenance costs or replacement costs) are discounted by a 3 percent real discount rate, per Energy Commission's LCC Methodology. The Benefit to Cost (B/C) Ratio is the incremental TDV Energy Costs Savings divided by the Total Incremental Costs. When the B/C ratio is greater than 1.0, the added cost of the measure is more than offset by the discounted energy cost savings and the measure is deemed to be cost effective. For a detailed description of the Cost-effectiveness Methodology see Section 5.1of this report.

An independent full-service Mechanical, Plumbing, Electrical, Fire Protection, Energy Engineering and Commissioning firm, with California offices located in Anaheim, Emeryville, and San Marcos, serving the western United States, Optimum Energy Design (OED), modeled the proposed alternative integrated pumped refrigerant economizer versus a baseline of waterside economizer using the following software:

- Energypro 8.1.1 / CBECC-Com 2019.1.2 (Build 1132)
- Energy Plus Version 9.2

The independent engineer concluded that the integrated pumped refrigerant economizer is more efficient than a waterside economizer in all 16 of the California Climate Zones.

Table 3: Cost-effectiveness Summary

Climate Zone	Benefit: TDV Energy Cost Savings (2023 PV$)	Cost: Total Incremental First Cost and Maintenance Cost (2023 PV$)	Change in Lifecycle Cost (2023 PV$)	Planned Benefit to Cost (B/C) Ratio
Climate Zone 1	$ 33	0	0	infinite
Climate Zone 2	$ 133	0	0	Infinite
Climate Zone 3	$ 164	0	0	infinite
Climate Zone 4	$ 105	0	0	Infinite
Climate Zone 5	$ 110	0	0	infinite
Climate Zone 6	$ 116	0	0	Infinite
Climate Zone 7	$ 71	0	0	infinite
Climate Zone 8	$ 78	0	0	Infinite
Climate Zone 9	$ 89	0	0	infinite
Climate Zone 10	$ 116	0	0	Infinite
Climate Zone 11	$ 143	0	0	infinite
Climate Zone 12	$ 120	0	0	Infinite
Climate Zone 13	$ 144	0	0	infinite
Climate Zone 14	$ 215	0	0	Infinite
Climate Zone 15	$ 149	0	0	infinite
Climate Zone 16	$ 242	0	0	Infinite

Section 5.1discusses the methodology and Section 5.2 shows the results of the Cost Effectiveness Analysis

Greenhouse Gas and Water Related Impacts

For more a detailed and extensive analysis of the possible environmental impacts from the implementation of the proposed measure, please refer to Section 6.2 through 6.5 and Appendix B and C of this report.

Greenhouse Gas Impacts

Table 4 presents the estimated avoided greenhouse gas (GHG) emissions of the proposed code change for the first year the standards are in effect. Assumptions used in developing the GHG savings are provided in Section 6.2 and Appendix C of this report.

The monetary value of avoided GHG emissions is included in TDV cost factors (TDV $) and is thus included in the Cost-effectiveness Analysis prepared for this report.

Table 4: Estimated Statewide Greenhouse Gas Emissions Impacts

	First Year Statewide	
	Avoided GHG Emissions ($MTCO_2e$/yr)	**Monetary Value of Avoided GHG Emissions ($2023)**
Integrated Pumped Refrigerant Economizer	2,619	$277,614

Section 6.2 discusses the methodology and Table 11 shows the results of the greenhouse gas emission impacts analysis.

Water Use and Water Quality Impacts

The addition of integrated pumped refrigerant economizer will not have any impact on water quality but does provide substantial water use reduction. When compared to an integrated waterside economizer, an integrated pumped refrigerant economizer does not use any water at all. Based on an independent engineer's model, a waterside economizer on a data center in the state of California with an IT load of 1.2MW uses on average 4.0 million gallons of water annually. Use of an integrated pumped refrigerant economizer would completely eliminate this excessive water use.

Impacts on water use and water quality are presented in Table 5. The water impacts presented below do not include impacts that occur at power plants. The methodology used to derive water use and water quality impacts is presented in Section 6.3.

Table 5: Impacts on Water Use and Water Quality (2017)

	On-Site Water Savings (gallons/yr)	Impact on Water Quality Material Increase (I), Decrease (D), or No Change (NC) compared to existing conditions			
		Mineralization (calcium, boron, and salts)	Algae or Bacterial Buildup	Corrosives as a Result of PH Change	Others
Impact (I, D, or NC)	D – decrease water use	NC	NC	NC	NC
Per Unit Impacts	4.0 million per data center site compared to waterside economizer	NC	NC	NC	NC
Statewide Impacts (first year)	452 million gallons (converting per unit impact to gal/ sq ft)	NC	NC	NC	NC

Section 6.3 and Appendix B discusses the methodology and Section 6.3 shows the results of the water use and water quality analysis.

Acceptance Testing

Acceptance testing of an integrated pumped refrigerant economizer is similar to established acceptance testing processes of other commonly-used economizers. The commissioning agent must perform similar controls checks and verification to ensure that the integrated pumped refrigerant economizer is in fact integrated to both the standard equipment's refrigeration circuit and the controls operation of the unit. The integrated pumped refrigerant economizer manufacturer must prove that economization mode of the integrated pumped refrigerant economizer operates to the conditions of the standard and is not just an immaterial add on option to the unit construction.

1. INTRODUCTION

Vertiv sponsored this effort. The goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficiency design practices and technologies.

The overall goal of this Report is to propose a code change proposal for Integrated Pumped Refrigerant Economizers. The report contains pertinent information that justifies the code change.

Section 2 of this Report provides a description of the measure, how the measure came about, and how the measure helps achieve the state's zero net energy (ZNE) goals. This section presents how the proposed code change would be enforced and the expected compliance rates.

Section 3 presents the market analysis, including a review of the current market structure, a discussion of product availability, and the useful life and persistence of the proposed measure. This section offers an overview of how the proposed standard will impact various stakeholders including builders, building designers, building occupants, equipment retailers (including manufacturers and distributors), energy consultants, and building inspectors. Finally, this section presents estimates of how the proposed change will impact statewide employment.

Section 4 describes the key assumptions used in the energy savings analysis, the energy savings methodology and provides the per-unit energy impacts and energy savings results.

Results from the energy, demand, costs, and environmental impacts analysis are presented in Sections 5 and 6. The authors calculated energy, demand, and environmental impacts using three metrics: (1) per unit, (2) statewide impacts during the first year buildings complying with the 2016 Title 24 Standards are in operation, and (3) the cumulative statewide impacts for all buildings built during the 15 year period of analysis. Time Dependent Valuation (TDV) energy impacts, which accounts for the higher value of peak savings, are presented per unit, first year statewide and cumulative statewide. The incremental costs, relative to existing conditions are presented as are present value of year TDV energy cost savings and the overall cost impacts over the year period of analysis.

Section 7 of the report concludes with specific recommendations for language for the Standards, Appendices, Alternate Calculation Manual (ACM) Reference Manual and Compliance Forms.

2. MEASURE DESCRIPTION

2.1 Measure Overview

The addition of the integrated pumped refrigerant economizer as a prescriptive measurement alongside integrated airside and integrated waterside economizers provides an additional compliant prescriptive option for engineers designing computer rooms that results in substantial energy savings and zero additional water use for the state of California.

The integrated pumped refrigerant economizer is an available technology on currently-regulated computer room air conditioning (CRAC) units that has hundreds of installations worldwide. If inserted into the 2022 code, the integrated pumped refrigerant economizer would require the same treatment in the Commission-approved software as airside and waterside economizers.

2.2 Measure History

The proposal of integrated pumped refrigerant economizer into the 2022 Code solidifies its historical approval as a compliant option for economization in computer rooms confirmed by the California Energy Commission in 2015. In 2015, the Commission has issued the following three documents approving the integrated pumped refrigerant economizer as a new compliance option for economizers in computer rooms:

- Issue 111, September-October 2015 Blueprint
- Resolution No. 15-0909-10, Docket No. 15-MISC-03
- Pumped Refrigerant Economizers for Use in Computer Rooms, Staff Paper CEC-400-2015-029

At some point, the Commission added the integrated pumped refrigerant economizer into the 2019 draft code language as follows:

"EXCEPTION 5 to Section 140.9(a)1: A computer room located in Climate Zones 1-9. 11, 14 and 16 may be served by an integrated pumped refrigerant economizer certified by AHRI using AHRI 1360."

One comment, TN# 222480, filed in Docket# 17-BSTD-02 on 2/8/2018 requested this Exception 5 not be added to the 2019 code and this resulted in this Exception 5 being removed from the proposed 2019 code language. Vertiv submitted a rebuttal to these comments in TN# 223851, filed in the same Docket# 17-BSTD-02 on 6/18/2018 requesting the Commission's reconsideration of this exception to be returned to the proposed 2019 code language.

Ideally, the integrated pumped refrigerant economizer would be an additional section C. under Section 140.9 (a) 1. inserted on an equal plane to the integrated airside and waterside economizer prescriptive requirements.

Modeling the integrated pumped refrigerant economizer will involve determining the energy savings in economization mode as seen in the energy consumption of a refrigerant pump versus an operating compressor.

2.3 Summary of Proposed Changes to Code Documents

The sections below provide a summary of how each Title 24 documents will be modified by the proposed change.

2.3.1 Standards Change Summary

This proposal would modify the following sections of the Building Energy Efficiency standards as shown below. See *Section 7.1 Standards* of this report for the detailed proposed revisions to the standards language.

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

Economizer, Pumped Refrigerant to be added.

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

Integrated pumped refrigerant economizer would be added as 140.9 (a) 1.C.

2.3.2 Reference Appendices Change Summary

The addition of integrated pumped refrigerant economizer will not modify the appendices of the Standards.

2.3.3 Alternative Calculation Method (ACM) Reference Manual Change Summary

This proposal would modify the following sections of the Alternative Calculation Method (ACM) Reference Manual as shown below. See *Section 7.3 ACM Reference Manual* of this report for the detailed proposed revisions to the text of the Alternative Calculation Method (ACM) Reference Manual. Tables with details included.

The integrated pumped refrigerant economizer is to be handled similar to the waterside economizer as an optional economizer type to the baseline airside economizer.

2.3.4 Compliance Manual Change Summary

The addition of integrated pumped refrigerant economizer will require modification to section 10.4.3 Prescriptive Measures of the Title 24 Compliance

Manual. The pumped refrigerant economizer would need to be added as an additional option the air or water side economizers.

2.3.5 Compliance Forms Change Summary

The addition of integrated pumped refrigerant economizer will not modify any of the Compliance Forms. Only applicable form is NRCC-PRC-04-E where the form is completed by only providing reference to the plans where an economizer is specified. The form does not currently differentiate between air or water side economizers so the proposed addition of a refrigerant economizer would not require any modification to this form, unless deemed necessary at this time.

2.4 Regulatory Context

2.4.1 Existing Standards

The integrated pumped refrigerant economizer is not mentioned in any existing standards.

2.4.2 Relationship to Other Title 24 Requirements

This integrated pumped refrigerant economizer proposal does overlap with a CASE initiative Proposal Summary for Computer Room Efficiency. The current version updated March 16, 2020 proposes one single outdoor air temperature condition common to any economizer type and would generate a re-analysis of any economizer type and its performance at the agreed-upon revised temperature.

2.4.3 Relationship to Federal Laws

The integrated pumped refrigerant economizer is not mentioned in any federal regulatory requirements.

2.4.4 Relationship to Industry Standards

The integrated pumped refrigerant economizer is defined in AHRI 1360-2017 in Section 3 "Definitions" as follows:

3.8 *Fluid Economizer.* An option available with a CRAC or CRAH system in which a cold fluid is circulated by a pump through an indoor heat exchanger to provide cooling during lower outdoor ambient conditions, in order to reduce or eliminate compressor operation. The fluid could be chilled water, water/glycol solution, or refrigerant. An external fluid cooler such as a drycooler, cooling tower, or condenser is utilized for heat rejection. This is sometimes referred to as a free cooling coil, econ-o-coil, or economizer.

2.5 Compliance and Enforcement

The presence of an integrated pumped refrigerant economizer would be apparent from the model number of the CRAC equipment and reflected in the serial tag of the equipment. Such indicators would reliably reflect the presence of an integrated pumped refrigerant economizer, and would add no additional burden to the building inspection officials for verification of installation as this is similar to current checks of any other required equipment option.

3. MARKET ANALYSIS

The authors performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The authors considered how the proposed standard may impact the market in general and individual market players. The authors gathered information about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with key stakeholders, Energy Commission, and a wide range of industry players who were invited to participate in stakeholder meetings held in 2019.

3.1 Market Structure

Vertiv is the major supplier of integrated pumped refrigerant economizer technology in the CRAC market. Vertiv is not the only manufacturer of this type of proven technology that has been installations spanning the last six years.

3.2 Technical Feasibility, Market Availability and Current Practices

Since Vertiv has been the major supplier of integrated pumped refrigerant economizer units for six years, it is anticipated that other manufacturers are designing their own type of integrated pumped refrigerant economizer to directly compete with this product offering.

The integrated pumped refrigerant economizer is an integrated refrigerant pump as part of a standard cooling unit. There is additional weight and footprint of the integrated pumped refrigerant economizer module to be designed for.

There is no change in design practices; the integrated pumped refrigerant economizer is substantially simpler to design for in comparison to a waterside economizer since it is truly integrated to the refrigeration cycle of a split system.

The same refrigerant piping design guidelines would apply to a split system designed with or without the proposed integrated pumped refrigerant economizer. Since this technology is integrated into a split system offering, there are no design practice changes necessary, only application of proper refrigerant charge and footprint of the pumped refrigerant economizer where it is not already fully integrated into the footprint of the condenser.

Certain aspects of the integrated pumped refrigerant economizer offered by Vertiv are patented, mostly attributed to the controls operation.

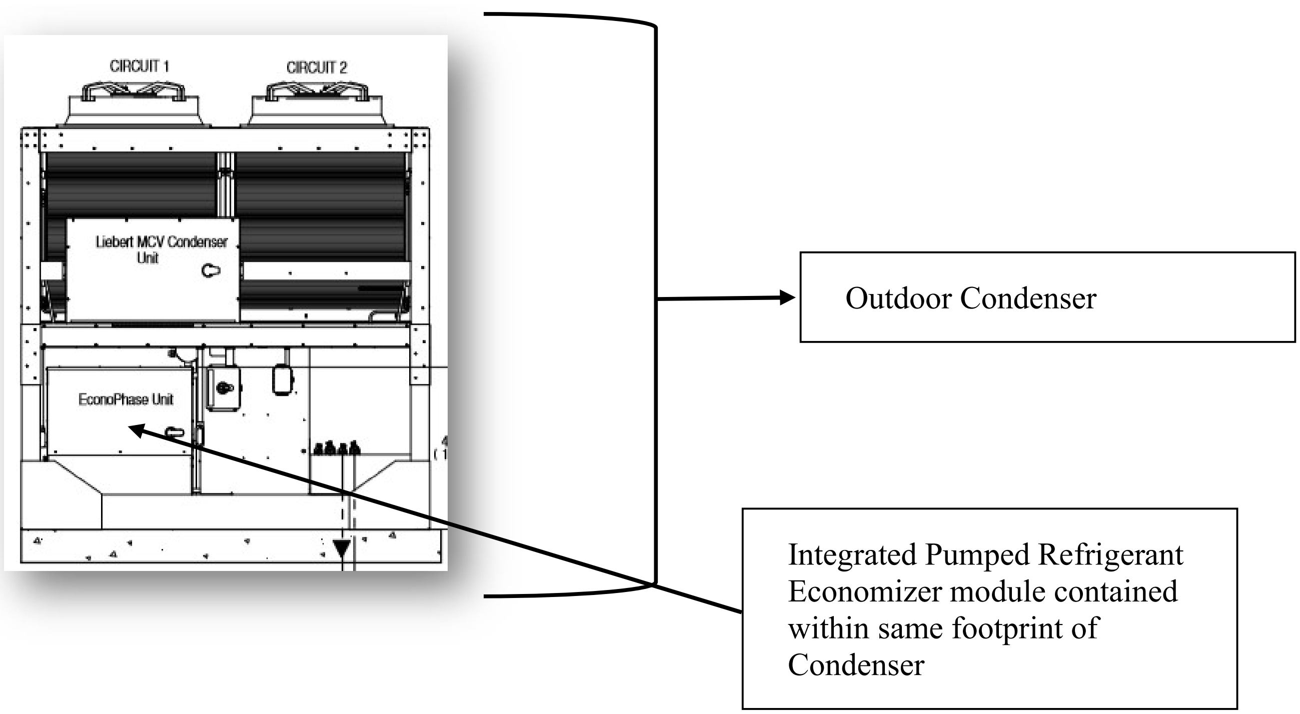
3.3 Market Impacts and Economic Assessments

3.3.1 Impact on Builders

The integrated pumped refrigerant economizer is even easier to install than a waterside economizer, in part because it does not require any utility water connections. As compared to an airside economizer, the integrated pumped refrigerant economizer does not require any larger building penetrations, and thus does not require additional insulation and sealing that could further compromise the thermal properties of the building and/or the security of the computer room it is serving.

3.3.2 Impact on Building Designers and Energy Consultants

The integrated pumped refrigerant economizer as a prescriptive requirement offers building designers and energy consultants an opportunity to focus their efforts and talents toward other more critical parts of the mechanical design without needing to spend time providing extra justification for this type of economizer as an existing compliance option. Building designers would need to ensure the weight of the economizer can be supported. Though some installations do exist where the integrated pumped refrigerant economizer is mounted separately and piped to both the indoor and the outdoor units in the field, the typical integrated pumped refrigerant economizer (EconoPhase Unit) is housed within the same footprint of the outdoor air-cooled condenser (Liebert MCV Condenser Unit) as shown below extracted from the Vertiv EconoPhase Installer/User Guide:



3.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Department of Occupational Safety and Health (Cal/OSHA). All existing health and safety rules will remain in place. Complying with the proposed code change is not anticipated to have any impact on the safety or health occupants or those involved with the construction, commissioning, and ongoing maintenance of the building.

This proposed measure would not have any adverse affects on occupational safety and health outside of those that exist for typical split systems. A typical split system without an integral pumped refrigerant economizer would require approximately 170 lbs of refrigerant, assuming a 100 foot distance between the indoor and outdoor units. There is a minimal amount of additional refrigerant charge to accommodate the integrated pumped refrigerant economizer as shown in example table below extracted from the Vertiv EconoPhase Installer/User Guide:

Table 6.4 EconoPhase refrigerant charge

Model	R410A Charge per Circuit, lb (kg)
PR050	5.4 (2.5)
PR085	5.4 (2.5)
PR125	5.4 (2.5)
PR250	9.2 (4.2)

3.3.4 Impact on Building Owners and Occupants (including homeowners and potential first-time homeowners)

The addition of integrated pumped refrigerant economizer will add a highly efficient economizer compliant option allowing owners more flexibility in equipment selection for their computer rooms.

3.3.5 Impact on Building Component Retailers (including manufacturers and distributors)

The addition of integrated pumped refrigerant economizer will not affect Building Component Retailers.

3.3.6 Impact on Building Inspectors

The addition of integrated pumped refrigerant economizer will not adversely affect Building Inspectors as the compliance check for an integrated pumped refrigerant economizer is similar to established acceptance testing processes of other required equipment options. The presence of an integrated pumped refrigerant economizer would be apparent from the model number of the CRAC equipment and reflected in the serial tag of the equipment. Such indicators would reliably reflect the presence of an integrated pumped refrigerant economizer and would add no additional burden to the Building Inspectors for verification of installation.

3.3.7 Impact on Statewide Employment

The addition of integrated pumped refrigerant economizer will not alter the employment status in the state of California.

3.4 Economic Impacts

The estimated impacts that the proposed code change will have on California's economy are discussed below.

3.4.1 Creation or Elimination of Jobs

The addition of integrated pumped refrigerant economizer as a prescriptive requirement will not create or eliminate jobs in the state of California. The installation of a pumped refrigerant economizer still requires a staff of knowledgeable and trained mechanical contractors to install the system refrigerant lines.

3.4.2 Creation or Elimination of Businesses within California

The addition of integrated pumped refrigerant economizer as a prescriptive requirement will not create or eliminate businesses in the state of California.

3.4.3 Competitive Advantages or Disadvantages for Businesses within California

The addition of integrated pumped refrigerant economizer as a prescriptive requirement will not create any immediate competitive advantages or disadvantages for businesses in California. This proposal could potentially actually create more of a market demand for an integrated pumped refrigerant economizer and create more competition amongst CRAC manufacturers.

3.4.4 Increase or Decrease of Investments in the State of California

The addition of integrated pumped refrigerant economizer allows computer room owners to have flexibility in their HVAC system design allowing more than just an airside of waterside economizer for compliance with Code. Allowing an additional prescriptive requirement may potentially appeal to more data center owners to build their facilities in the state of California.

3.4.5 Effects on Innovation in Products, Materials, or Processes

The addition of integrated pumped refrigerant economizer to the Code will drive other CRAC manufacturers to develop and release their own directly competing offering, promoting competition in the marketplace in a sector that has substantial energy efficiency and water-saving benefits. In addition, any pumped refrigerant manufacturer would still be expected to comply with CARB regulations mandating maximum GWP levels in the state of California.

3.4.6 Effects on the State General Fund, State Special Funds and Local Governments

The addition of integrated pumped refrigerant economizer will not require any government funding to implement.

3.4.6.1 Cost of Enforcement

Cost to the State

The addition of integrated pumped refrigerant economizer will not require any state government funding to implement.

Cost to Local Governments

The addition of integrated pumped refrigerant economizer will not require any local government funding to implement.

3.4.6.2 Impacts on Specific Persons

The addition of integrated pumped refrigerant economizer will not impact any specific group of persons in the state of California to implement.

4. ENERGY SAVINGS

4.1 Key Assumptions for Energy Savings Analysis

The energy model provided modeled a 14,000 square foot data center with 85 Watts/square foot. The total assumed load was 1.2 Megawatts. This same model was placed in each of the 16 climate zones and the same load profile was used across all the climate zones. The data contained within this proposal uses the most current CBECC modeling software.

The energy and cost analysis presented in this report uses the 2019 TDV factors as the final 2022 TDV factors have not been released as of the date of final preparation of this proposal. If necessary, the energy analysis can be updated to reflect inclusion of the final 2022 TDV factors if necessary, provided the difference in the 2022 and 2019 TDV factors have changed drastically enough with relevance to this proposal.

The proposed integrated pumped refrigerant economizer was modeled against a baseline integrated waterside economizer as the inherent fluid-based system design is more closely related to a waterside economizer versus an airside economizer.

4.2 Energy Savings Methodology

To assess the energy, demand, and energy cost impacts, Vertiv compared current design practices to design practices that would comply with the proposed requirements. There is an existing Title 24 standard that covers the building system in question, so the existing conditions assume a building minimally complies with the 2019 Title 24 Standards.

The proposed conditions are defined as the design conditions that will comply with the proposed code change. Specifically, the proposed code change will vary with the load profile of each applicable climate zone.

Energy Commission provided guidance on the type of prototype buildings that must be modeled.

Table 6 presents the details of the prototype building used in the analysis.

Table 6: Prototype Buildings used for Energy, Demand, Cost, and Environmental Impacts Analysis

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)

Energy savings, energy cost savings and peak demand savings were calculated on an hourly basis using a Time Dependent Valuation methodology.

4.3 Per Unit Energy Impacts and Energy Savings Results

Energy savings, peak demand savings and per unit energy and demand impacts of the proposed measure are presented in Table 7.

Table 7: First Year Energy Impacts per square foot

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

The per unit TDV energy cost savings over the 15 year period of analysis are presented in Table 9. These are presented as the discounted present value of the energy cost savings over the analysis period.

5. Life Cycle Cost and Cost-Effectiveness

5.1 Energy Cost Savings Methodology

Time Dependent Value (TDV) energy is a normalized format for comparing electricity and natural gas savings that takes into account the cost of electricity and natural gas consumed during each hour of the year. The TDV values are based on long term discounted costs (30 years for all residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 15 years. The TDV cost impacts are presented in 2023 present valued dollars. The TDV energy estimates are based on present-valued cost savings but are normalized in terms of "TDVkBTUs". Peak demand savings are presented in peak power reductions (kW). Energy Commission derived the 2023 TDV values that were used in the analyses for this report (Energy Commission 2019).

5.2 Energy Cost Savings Results

The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Table 8: TDV Energy Cost Savings Over 15 Year Period of Analysis - Per square foot

Climate Zone	15 Year TDV Electricity Cost Savings (2023 PV $)	15 Year TDV Natural Gas Cost Savings (2023 PV $)	Total 15 Year TDV Energy Cost Savings (2023 PV $)
1	$ 33	0	$ 33
2	$ 133	0	$ 133
3	$ 164	0	$ 164
4	$ 105	0	$ 105
5	$ 110	0	$ 110
6	$ 116	0	$ 116
7	$ 71	0	$ 71
8	$ 78	0	$ 78
9	$ 89	0	$ 89
10	$ 116	0	$ 116
11	$ 143	0	$ 143
12	$120	0	$120
13	$ 144	0	$ 144
14	$ 215	0	$ 215
15	$ 149	0	$ 149
16	$242	0	$242

5.3 Incremental First Cost

There is no difference in incremental cost of this proposed code change versus a standard split system manufactured without an integrated pumped refrigerant economizer. Any incremental maintenance costs are equal to a standard split system since the integrated pumped refrigerant system is integral to the closed refrigerant system. A split system with or without the integrated pumped refrigerant economizer has as expected life of about 15 years and does not warrant any expected replacement costs incurred within the 15 year analysis.

Vertiv estimated the Current Incremental Construction Costs and Post-adoption Incremental Construction Costs. The Current Incremental Construction Cost represents the incremental cost of the measure if a building meeting the proposed standard were built today. The Post-adoption Incremental Construction Cost represents the anticipated cost assuming full market penetration of the measure as a result of the new Standards, resulting in possible reduction in unit costs as manufacturing practices improve over time and with increased production volume of qualifying products the year the Standard becomes effective.

Per Energy Commission's guidance, design costs are not included in the incremental first cost.

5.4 Lifetime Incremental Maintenance Costs

Incremental maintenance cost is the incremental cost of replacing the equipment or parts of the equipment, as well as periodic maintenance required to keep the equipment operating relative to current practices over the period of analysis. The present value of equipment and maintenance costs (savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2019 TDV. The present value of maintenance costs that occurs in the nth year is calculated as follows (where d is the discount rate of 3 percent):

$$\text{Present Value of Maintenance Cost} = \text{Maintenance Cost} \times \left\lfloor \frac{1}{1+\text{d}} \right\rfloor^{\text{n}}$$

This proposed measure would have the same maintenance costs as are associated with a standard split system design. Maintenance of a proposed split system with integrated refrigerant pump is composed of main components being an indoor air handler, an outdoor air-cooled condenser, and a refrigerant pump. This proposed system is much simpler and far less expensive than a chiller system with a waterside economizer to maintain since there is no water treatment necessary required with a chiller and a cooling tower. The indoor units' maintenance comparing the proposed system to the baseline is comparable (i.e. filter changes and evaporator coil cleaning). Additionally, the lifespan of the proposed equipment does not require any planned replacement during the 15-year analysis period.

5.5 Lifecycle Cost-Effectiveness

This measure proposes a prescriptive requirement. As such, a lifecycle cost analysis is required to demonstrate that the measure is cost-effective over the 15 year period of analysis.

Energy Commission's procedures for calculating lifecycle cost-effectiveness are documented in LCC Methodology (placeholder of reference). Vertiv followed these guidelines when developing the cost-effectiveness analysis for this measure. Energy Commission's guidance dictated which costs were included in the analysis. Incremental first cost and incremental maintenance costs over the 15 year period of analysis were included. The TDV energy cost savings from electricity and natural gas savings were also considered.

Design costs were not included nor was the incremental cost of code compliance verification.

According to Energy Commission's definitions, a measure is cost-effective if the Benefit-to-Cost (B/C) Ratio is greater than 1.0. The B/C Ratio is calculated by dividing the total present lifecycle cost benefits by the present value of the total incremental costs.

Results per unit lifecycle Cost-effectiveness Analyses are presented in Table 9.

An independent mechanical contractor in Irvine, California presented cost figures from a recently-priced project for this analysis. The project where the following costs were extracted from was a data center sized for 200 tons of total cooling with full redundancy.

Pumped refrigerant economizer equipment to meet the cooling needs of this date center costs $850,000 including installation, commissioning and start-up. All controls are integral to the equipment purchased and part of the manufacturer's responsibility to program at the factory. The annual maintenance costs for the pumped refrigerant economizer system is $7,200.

Chilled water equipment inclusive of water-cooled chillers, cooling towers, associated pumps and heat exchangers to meet the cooling needs of this data center costs $1,400,000 including installation, commissioning and start-up. An estimated $125,000 is included in this figure to cover the coordination of the complicated controls required to ensure this type of system is controlling all the various pumps, valves, and equipment correctly. Annual maintenance of this water-cooled chiller system is $51,800 including tower cleaning and water treatment.

The installation and maintenance costs of a system with a pumped refrigerant economizer are only 60% and 14% of the costs compared to a baseline chilled water system with a waterside economizer, respectively.

Table 98: Life Cycle Cost-effectiveness Summary Per square foot

If the savings vary by climate zone, use the following table and repeat the table for each sub-measure. All climate zones must be represented.

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

1. **TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (see http://docketpublic.energy.ca.gov/PublicDocuments/16-BSTD-06/TN212524_20160801T120224_2019_TDV_Methodology_Report_7222016.pdf, Chapter 5 pages 51-53). Other savings are discounted at a real 3% rate. Includes incremental first cost savings if proposed first cost is less than current first cost. Includes present value maintenance cost savings if PV of proposed maintenance costs is less than the PV of current maintenance costs.
2. **Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement and maintenance costs over the period of analysis. Present value cost = Current cost x (1/(1.03)^n. Costs are discounted by 3% real rate. Includes incremental first cost if proposed first cost is greater than current first cost. Includes present value of maintenance incremental cost if PV of proposed maintenance costs is greater than the PV of current maintenance costs. If incremental maintenance cost is negative it is treated as a positive benefit. If there are no Total Incremental Present Valued Costs, the Benefit/Cost Ratio is Infinite.

6. First Year Statewide Impacts

6.1 Statewide Energy Savings and Lifecycle Energy Cost Savings

Vertiv calculated the first year statewide savings by multiplying the per unit savings, which are presented in Section 4.3 Per Unit Energy Impacts and Energy Savings Results, by the statewide new construction forecast for 2023, which is presented in more detail in Appendix A: Statewide Savings Methodology. The first year energy impacts represent the first year annual savings from all buildings that were completed in 2023. The lifecycle energy cost savings represents the energy cost savings over the entire 15-year period of analysis. Results are presented in Table 11.

Given data regarding the new construction forecast for 2023, Vertiv estimates that the proposed code change will reduce annual statewide electricity use by 11.64 GWh with an associated demand reduction of 1.67 MW. Natural gas use is expected to be reduced by 0 million therms. The energy savings for buildings constructed in 2023 are associated with a present valued energy cost savings of approximately PV$186.8 million in (discounted) energy costs over the 15- year period of analysis.

The data contained within the following table conservatively assumes that data centers account for 5% of the Miscellaneous New Construction Type of Nonresidential Space. Data centers can be located within office buildings, school, and colleges, but for this proposal they have been accounted for only within Miscellaneous.

Table 90: Statewide Energy and Energy Cost Impacts

Climate Zone	Statewide Construction in 2023 (nonre: million sf)	First Year[1] Electricity Savings (GWh)	First Year[1] Peak Electrical Demand Reduction (MW)	First Year[1] Natural Gas Savings (million therms)	First Year[1] Source Energy Savings (kBtu/sq ft)	Lifecycle[2] Present Valued Energy Cost Savings (PV$ million)
1	0.007	0.18	0.03	0	368	$ 0.2
2	0.043	0.75	0.01	0	1,496	$ 5.7
3	0.200	0.94	0.13	0	1,840	$ 32.8
4	0.103	0.62	0.08	0	1,177	$10.8
5	0.020	0.65	0.10	0	1,234	$ 2.2
6	0.130	0.69	0.12	0	1,308	$ 15.1
7	0.094	0.40	0.12	0	802	$ 6.7
8	0.175	0.43	0.09	0	872	$ 13.6
9	0.256	0.50	0.11	0	1,000	$ 22.8
10	0.181	0.66	0.11	0	1,307	$ 21.0
11	0.037	0.83	0.11	0	1,603	$ 5.3
12	0.195	0.70	0.11	0	1,350	$ 23.4
13	0.079	0.84	0.10	0	1,617	$ 11.4
14	0.041	1.22	0.14	0	2,412	$ 8.8
15	0.024	0.84	0.17	0	1,679	$ 3.6
16	0.014	1.41	0.14	0	2,719	$3.4
TOTAL	**1.598**	**11.64**	**1.67**	**0**		**$ 186.8**

1. First year savings from all buildings completed statewide in 2023.
2. Energy cost savings from all buildings completed statewide in 2023 accrued during 15-year period of analysis.

6.2 Statewide Greenhouse Gas Emissions Reductions

Vertiv calculated avoided greenhouse gas (GHG) emissions assuming the emissions factors specified in the USEPA Emissions & Generation Resource Integrated Database (eGRID) for the WECC California (CAMX) subregion. The electricity emission factor represents savings from avoided electricity generation and accounts for the GHG impacts if the state meets the Renewable Portfolio Standard (RPS) goal of 33 percent renewable electricity generation by 2020. [1] Avoided GHG emissions from natural gas savings

[1] When evaluating the impact of increasing the Renewable Portfolio Standard (RPS) from 20 percent renewables by 2020 to 33 percent renewables by 2020, California Air Resources Board (CARB) published data on expected air pollution emissions for various future electricity generation scenarios (CARB 2010). The incremental emissions were calculated by dividing the

attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in USEPA's Compilation of Air Pollutant Emissions Factors (AP-42).

Table 12 presents the estimated first year avoided GHG emissions of the proposed code change. During the first year greenhouse gas emissions of 2,619 metric tons of carbon dioxide equivalents ($MTCO_2e$).

Table 101: First Year[1] Statewide Greenhouse Gas Emissions Impacts

Electricity Savings (GWH/yr)	Reduced GHG Emissions from Electricity Savings (MT CO_2e)	Natural Gas Savings (Therm/yr)	Reduced GHG Emissions form Natural Gas Savings (MT CO_2e)	Total Reduced CO2e Emissions[2] (MT CO_2e)
11.64	2,619	0	0	2,619

First year savings from all buildings completed statewide in 2023.

1. Assumes the following emission factor: 225 MTCO2e/GWh. Extracted from eGRID Summary Tables 2018, Table 1, $C0_2$ for CAMX Subregion Output Emission Rate.

6.3 Statewide Water Use Impacts

This proposal for an integrated pumped refrigerant economizer uses no water compared to the comparison baseline waterside economizer which uses an estimated average 4.3 million gallons of water annually assuming a data center in the state of California with an IT load of 1.2MW.

difference between California emissions in the CARB high and low generation forecasts by the difference between total electricity generated in those two scenarios.

Table 112: Annual Water Savings

Climate Zone	Waterside Economizer Estimated Water Usage (Gallons/ Year)
1	3,007,889
2	3,745,391
3	3,694,075
4	3,765,235
5	3,465,347
6	3,825,134
7	3,674,818
8	3,916,532
9	3,825,134
10	4,267,553
11	4,343,252
12	4,034,111
13	4,463,738
14	4,619,242
15	5,480,521
16	3,975,873
Average	4,006,490

Table 12: Impacts on Water Use

	On-Site Indoor Water Savings (gallons/yr)	On-site Outdoor Water Savings (gallons/yr)	Embedded Electricity Savings[1] (kWh/yr)
Per Square Foot Impacts	N/A	N/A	N/A
First Year[2] Statewide Impacts	N/A	N/A	N/A

1. Assumes embedded energy factor of 4,848/3,565 kWh per million gallons of water (CPUC 2015).
2. First year savings from all buildings completed statewide in 2023.

6.4 Statewide Material Impacts

There are no material impacts associated with this proposal.

Table 13: Impacts of Material Use

	Impact on Material Use Material Increase (I), Decrease (D), or No Change (NC) compared to base case (lbs/year)					
	Mercury	**Lead**	**Copper**	**Steel**	**Plastic**	**Others (Identify)**
Impact (I, D, or NC)	NC	NC	NC	NC	NC	NC
Per Unit Impacts	NC	NC	NC	NC	NC	NC
First Year[1] Statewide Impacts	NC	NC	NC	NC	NC	NC

1. First year savings from all buildings completed statewide in 2023.

6.5 Other Non-Energy Impacts

Because this proposed measure for integrated pumped refrigerant economizer does not use any water, as compared to the baseline waterside economizer, this measure results in substantial water savings for the state of California. Compared to an airside economizer, this proposal does not require any introduction of outside air directly into the space increasing data center security, reducing humidity concerns, and eliminating any need for duct penetrations through the building. Include any impacts not already identified that would need to be included in the Energy Commission’s CEQA analysis for the rulemaking action.

7. Proposed Revisions to Code Language

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2019 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

7.1 Standards

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) 1.C.: 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.

7.2 Reference Appendices

There are no proposed changes to the Reference Appendices.

7.3 ACM Reference Manual

The addition of integrated pumped refrigerant economizer will require an addition of a section titled "Pumped Refrigerant Economizers" similar to 5.7.4.2. Air Side Economizers and 5.8.4. Water-side Economizers which details the definitions and attributes for this new economizer option.

SECTION 5.8 HVAC Primary Systems

Since the integrated pumped refrigerant economizer is integrated into the standard equipment refrigerant cycle, we propose to insert an integrated pumped refrigerant economizer section into 5.8, similar and adjacent to the Water-side Economizers provision.

7.4 Compliance Manuals

The pumped refrigerant economizer would need to be added as an additional option the air or water side economizers.

7.5 Compliance Forms

There are no proposed changes to the Compliance Forms, unless the addition of another economizer option makes it deemed necessary to add to the form the description of the economizer type installed. This modification to the compliance form is not necessary to this proposal.

8. REFERENCES

[CA DWR] California Department of Water Resources. 2016. "California Counties by Hydrologic Regions". http://www.water.ca.gov/landwateruse/images/maps/California-County.pdf. Accessed April 3, 2016.

[CPUC] California Public Utilities Commission. 2015a. "Water/Energy Cost-Effectiveness Analysis: Revised Final Report." Prepared by Navigant Consulting, Inc. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5360.

[CPUC] California Public Utilities Commission. 2015b. "Water/Energy Cost-Effectiveness Analysis: Errata to the Revised Final Report." Prepared by Navigant Consulting, Inc. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5350

[CARB] California Air Resources Board. 2010. "Proposed Regulation for a California Renewable Electricity Standard Staff Report: Initial Statement of Reasons Appendix D." http://www.arb.ca.gov/regact/2010/res2010/res10d.pdf. Accessed November 12, 2013.

[Energy Commission] California Energy Commission. 2016 {placeholder for Energy Commission 2019 Lifecycle Cost Methodology Report}.

U.S. Census Bureau. 2014. Population Division. "Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2014." http://factfinder2.census.gov/bkmk/table/1.0/en/PEP/2014/PEPANNRES/0400000US06.05000.

[U.S. EPA] United States Environmental Protection Agency. 2011. "Emission Factors for Greenhouse Gas Inventories." http://www.epa.gov/climateleadership/documents/emission-factors.pdf. Accessed December 2, 2013.

Reference Guide

8.1 Text Reference Citations

8.2 Reference List

(Alatorre, Mark August 2015) Pumped Refrigerant Economizers for Use in Computer Rooms, Staff Paper CEC-400-2015-029

(Dolcich, et al. June 2018) Request for Reconsideration to CEC for PRE June 2018, letter

(Efficiency Division, California Energy Commission) Issue 111, September-October 2015 Blueprint CEC400-2015-031

- (Energy Resources Conservation and Development Commission) Resolution No. 15-0909-10, Docket No. 15-MISC-03, Resolution of the Energy Commission Approving Recommendation by the Executive Director to Approve Refrigerant Economizers as an Alternative Component Package for Use in Computer Rooms in Certain Climate Zones

Appendices

Appendix A: Statewide Savings Methodology

Example Language for Nonresidential Buildings

The Energy Commission Demand Analysis Office provided the Vertiv with the residential and nonresidential new construction forecast for 2023, broken out by building type and forecast climate zones (FCZ). Table 145: provides a more complete definition of the various space types used in the forecast. Table 18 provides a mapping of the various space types used in the forecast to the nonresidential prototypes. The Vertiv translated this data to building climate zones (BCZ) using the weighting provided by the Energy Commission as presented in Table 18: . The projected nonresidential new construction forecast by BCZ is presented in Table 21. Table 156: Mapping Factors for Construction Building Types to Nonresidential Prototypes

Building Type *Building sub-type*	**Composition of Building Type by Sub-types**
Small Office	
Restaurant	
Retail	
Stand-Alone Retail	10%
Large Retail	75%
Strip Mall	5%
Mixed-Use Retail	10%
Food	
Non-Refrigerated Warehouse	
Refrigerated Warehouse	
Schools	
Small School	60%
Large School	40%
College	
Small Office	5%
Medium Office	15%
Medium Office/LKab	20%
Public Assembly	5%
Large School	30%

High-Rise Apartment	25%
Hospital	
Hotel/Motel	
Large Offices	
Medium Office	50%
Large Office	50%

Table 167: presents the assumed percent of new construction that would be impacted by the proposed code change.

Vertiv used the mid scenario of forecasted residential new construction for statewide savings estimates. The projected new residential construction forecast, presented by BCZ is presented below in **Error! Reference source not found.**21. This measure only applies to high-rise residential buildings. Low-rise residential and single family residential construction is not impacted. It was assumed that 50% of the multi-family buildings indicated in the Residential New Construction Forecast, are high-rise residential.

Table 145: Description of Space Types used in the Nonresidential New Construction Forecast

OFF-SMALL	Offices less than 30,000 ft^2
OFF-LRG	Offices larger than 30,000 ft^2
REST	Any facility that serves food
RETAIL	Retail stores and shopping centers
FOOD	Any service facility that sells food and or liquor
NWHSE	Nonrefrigerated warehouses
RWHSE	Refrigerated Warehouses
SCHOOL	Schools K-12, not including colleges
COLLEGE	Colleges, universities, community colleges
HOSP	Hospitals and other health-related facilities
HOTEL	Hotels and motels
MISC	All other space types that do not fit another category

Table 156: Mapping Factors for Construction Building Types to Nonresidential Prototypes

Building Type *Building sub-type*	**Composition of Building Type by Sub-types**

Small Office	
Restaurant	
Retail	
Stand-Alone Retail	10%
Large Retail	75%
Strip Mall	5%
Mixed-Use Retail	10%
Food	
Non-Refrigerated Warehouse	
Refrigerated Warehouse	
Schools	
Small School	60%
Large School	40%
College	
Small Office	5%
Medium Office	15%
Medium Office/LKab	20%
Public Assembly	5%
Large School	30%
High-Rise Apartment	25%
Hospital	
Hotel/Motel	
Large Offices	
Medium Office	50%
Large Office	50%

Table 167: Percent of New Construction Impacted by the Proposed Measure

Type of Nonresidential Space	Integrated Pumped Refrigerant Economizer
Office-Small	N/A
Restaurant	N/A
Retail	N/A
Food	N/A
Non-refrigerated Warehouse	N/A
Refrigerated Warehouse	N/A
School	N/A
College	N/A
Hospital	N/A
Miscellaneous	5%
Office-Large	N/A
High-rise Residential Buildings	N/A

Table 18: Translation from FCZ to BCZ.

Table B: To be used for converting from New Forecast Zones to Standards Zone (Using 2010 Census Population Data)

Source:CECCFM/Weather/ClimateZoneAnalysis 12-06-16.xlsx

	New Forecast Zones																				
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	17.90%	0.00%	13.51%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	0.00%	0.00%	80.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.19%	0.00%	0.00%	0.00%	0.00%	0.00%
3	0.00%	52.43%	6.28%	0.00%	3.64%	0.00%	52.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
4	0.00%	30.39%	0.00%	0.00%	0.00%	0.00%	15.39%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	32.33%	0.00%	0.18%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	18.89%	61.19%	0.00%	0.00%	0.00%	6.60%	0.00%	0.00%	0.00%	17.18%	0.00%	0.00%	0.00%	0.00%
7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	62.81%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	43.99%	0.00%	0.00%	0.00%	0.00%	1.94%	0.00%	0.00%	0.00%	27.90%	0.00%	0.00%	0.00%	0.00%
9	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	32.29%	37.22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	54.92%	99.35%	100.00%	0.00%	0.00%
10	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	71.19%	86.11%	27.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11	0.42%	0.00%	0.00%	84.77%	22.07%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%	0.00%	44.55%	0.00%	0.00%	0.00%	0.00%	0.00%
12	0.00%	17.18%	0.00%	0.00%	72.61%	4.55%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	99.58%	100.00%	52.65%	0.00%	0.00%	0.00%	0.00%	0.00%
13	0.00%	0.00%	0.00%	0.00%	0.00%	94.81%	0.00%	0.00%	0.00%	78.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
14	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.51%	0.00%	12.10%	24.17%	0.00%	0.66%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%
15	3.18%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	13.33%	0.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	99.98%	0.00%
16	78.50%	0.00%	0.01%	15.23%	1.68%	0.64%	0.00%	0.33%	1.41%	9.41%	4.55%	0.56%	0.00%	0.00%	0.00%	2.61%	0.00%	0.65%	0.00%	0.00%	100.00%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Table 19: Estimated New Nonresidential Construction in 2023 by Climate Zone and Building Type (Million Square Feet)

Source: Energy Commission Demand Analysis Office

	2023 Nonresidetial Newly Constructed (in millions of square feet)											
	Small Office	Large Office	Restaurant	Retail	Grocery Store	Non-Refridgerated Warehouse	Refridgerated Warehouse	Schools	Colleges	Hospitals	Hotel/Motels	Miscellaneous
CZ 1	0.036309085	0.113935156	0.015393766	0.106956066	0.028734626	0.079446531	0.006258985	0.049238632	0.026864003	0.03622387	0.043438516	0.145452813
CZ 2	0.215756963	0.676513303	0.091446832	0.635351731	0.170729149	0.472156439	0.037219886	0.292559557	0.159573582	0.215204145	0.257968417	0.863990545
CZ 3	0.76957464	3.842010967	0.37546166	2.903421279	0.714798171	2.425735381	0.189103696	1.183093044	0.691738398	0.918416406	1.181236859	3.990895063
CZ 4	0.385408429	2.019037538	0.191759169	1.489201166	0.362945205	1.245608741	0.096109342	0.60065487	0.354742749	0.467702439	0.610832729	2.051580107
CZ 5	0.084420563	0.348479448	0.039090422	0.302460309	0.076679052	0.23322355	0.019371953	0.124667122	0.071283101	0.09907117	0.117677844	0.408418463
CZ 6	0.633506635	3.21228155	0.429754562	2.348828234	0.591099103	2.205411741	0.074759413	0.729544163	0.432102744	0.564325156	0.805184599	2.599385191
CZ 7	0.81122609	1.734636669	0.267210913	1.608552446	0.476784413	1.289543236	0.016120182	0.753590503	0.348834306	0.568060419	0.813651197	1.877578864
CZ 8	0.77926511	4.549803874	0.576704008	3.117904265	0.771664337	2.928309563	0.098829353	0.926796631	0.58164492	0.785444018	1.03955066	3.509440504
CZ 9	1.119971232	7.241827312	0.855286383	4.460693864	1.09589153	4.264893197	0.134854771	1.222324081	0.95725273	1.242153846	1.475858875	5.129028093
CZ 10	1.005295137	1.623993332	0.639399117	2.841000359	0.797111529	3.558889773	0.082515015	1.284280156	0.506758057	0.712421536	0.868713532	3.617332726
CZ 11	0.269787042	0.322575757	0.086244095	0.574757032	0.190237125	0.653034974	0.069831186	0.330266042	0.137607766	0.215433769	0.167611303	0.742227211
CZ 12	1.456587203	3.301112629	0.416288406	3.21944025	0.838886802	3.35962163	0.230559107	1.422833731	0.656643201	1.045324574	1.019604095	3.893479698
CZ 13	0.587863556	0.505642868	0.191538452	1.233100347	0.41452439	1.126349913	0.189102902	0.736953486	0.278099926	0.461673596	0.319731573	1.571735437
CZ 14	0.196627408	0.540611839	0.140400402	0.663921751	0.177421572	0.760576717	0.029859823	0.263004484	0.111303535	0.155070119	0.187045636	0.8186977
CZ 15	0.190906496	0.163452561	0.069802362	0.377393237	0.128244254	0.55650027	0.017075163	0.185008237	0.049282812	0.084570239	0.138499868	0.476348523
CZ 16	0.080363258	0.133633021	0.040716048	0.213633478	0.063105242	0.233483827	0.019407313	0.102838441	0.040666479	0.060454187	0.057684537	0.270738733
Total	8.622868847	30.32954783	4.426496596	26.09661581	6.898856499	25.39278548	1.310978089	10.20765318	5.404398308	7.631549487	9.104290241	31.96632967

Appendix B: Embedded Electricity in Water Methodology

As defined, there are no on-site customer-consumed water savings associated with this proposed code change. This proposal for an integrated pumped refrigerant economizer uses no water compared to the comparison baseline waterside economizer which uses an estimated average 4.3 million gallons of water annually.

Appendix C: Environmental Impacts Methodology

Greenhouse Gas Emissions Impacts Methodology

Avoided GHG emissions are calculated assuming the emissions factors specified in the USEPA Emissions & Generation Resource Integrated Database (eGRID) for the WECC California (CAMX) subregion[2]. This ensures consistency between state and federal estimations of potential environmental impacts.

To be conservative, the authors calculated the emissions factors of the incremental electricity between the low and high load scenarios. These emission factors are intended to provide a benchmark of emission reductions attributable to energy efficiency measures that could help achieve the low load scenario. The incremental emissions were calculated by dividing the difference between California emissions in the high and low generation forecasts by the difference between total electricity generated in those two scenarios.

Avoided GHG emissions from natural gas savings attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in USEPA's Compilation of Air Pollutant Emissions Factors (AP-42)[3].

Greenhouse Gas Emissions Monetization Methodology

The 2022 TDV cost values used in the LCC Methodology includes the monetary value of avoided GHG emissions based on a proxy for permit costs (not social costs) and the Cost-effectiveness Analysis presented in Section 5 of this report does include the cost savings from avoided GHG emissions. To demonstrate the cost savings of avoided GHG emissions, the authors disaggregated value of avoided GHG emissions from the other economic impacts. The authors used the same monetary values that are used in the TDV factors – \$106/MTCO_2e.

Water Use and Water Quality Impacts Methodology

This proposed code change uses no water in comparison to the baseline waterside economizer that uses an estimated average 4.3 million gallons of water annually. This proposed code change also has no impacts to water quality.

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[2] https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

[3] https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

Appendix D: California Building Energy Code Compliance (CBECC) Software Specification

This proposed addition of the integrated pumped refrigerant economizer would be modelled similarly in the CBECC Software to a comparable integrated airside or waterside economizer. This specification should include but may not be limited to:

- Operation during applicable outside air temperature ranges.