CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Nonresidential Economizer Modifications

Measure Number: 2016-NR-HVAC1-F

Nonresidential HVAC

2016 CALIFORNIA BUILDING ENERGY EFFICIENCY STANDARDS

California Utilities Statewide Codes and Standards Team

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EXECUTIVE SUMMARY

Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (CEC) efforts to update California's Building Energy Efficiency Standards (Title 24) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and Southern California Gas Company – and Los Angeles Department of Water and Power (LADWP) sponsored this effort. The program 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 efficient design practices and technologies.

The overall goal of this CASE Report is to propose a code change for Nonresidential Economizer Modifications. The report contains pertinent information that justifies the code change including:

- Description of the code change proposal, the measure history, and existing standards (Section 2);
- Market analysis, including a description of the market structure for specific technologies, market availability, and how the proposed standard will impact building owners and occupants, builders, and equipment manufacturers, distributers, and sellers (Section 3);
- Methodology for the stakeholder outreach process (Section 4);
- Results of the stakeholder outreach process (Section 5); and
- Proposed code change language (Section 6).

Scope of Code Change Proposal

Nonresidential Economizer Modifications 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
M, Ps	N/A	JA6, NA7	N/A	N/A	MECH-5

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

Measure Description

The 2013 Title 24 prescriptively requires that economizers be installed on air-cooled unitary direct-expansion units with cooling capacity equal to or greater than 54,000 Btu/h. A

mandatory control requirement for these economizers is a Fault Detection and Diagnostic (FDD) system that meets a list of requirements in section 120.2(i). Manufacturer FDD systems that meet these requirements are approved and listed by the CEC. In response to stakeholder concerns, the 2016 Nonresidential Economizer Modifications CASE proposal intends to clarify language passed as part of the 2013 code cycle, and modify economizer airflow and leakage requirements.

Section 2 of this report provides detailed information about the code change proposal including: Section 2.2 Summary of Changes to Code Documents (page 4) provides a section-by-section description of the proposed changes to the standards, appendices, alternative compliance manual and other documents that will be modified by the proposed code change. See the following tables for an inventory of sections of each document that will be modified:

- Table 2: Scope of Code Change Proposal (page 5)
- Table 3: Sections of Standards Impacted by Proposed Code Change (page 5)
- Table 4: Appendices Impacted by Proposed Code Change (page 5)

Detailed proposed changes to the text of the building efficiency standards, the reference appendices, and are given in Section 6 Proposed Language of this report. This section proposes modifications to language with additions identified with underlined text and deletions identified with ~~struck-out~~ text.

Market Analysis and Regulatory Impact Assessment

The economizer and economizer FDD markets are comprised of economizer manufacturers, FDD manufacturers, and commercial HVAC contractors. The Statewide CASE Team has been working with the Western HVAC Performance Alliance (WHPA) to ensure that the perspectives of manufacturers and contractors are understood. The proposed measures will not affect the availability of the manufacturers listed above to supply the market with products, because the measures do not change the scope of the products involved. The measures that clarify outdoor air damper operation, fault reporting, and damper leakage certification to the CEC are the only measures that may mildly affect manufacturer practices, but not their products.

The expected impacts of the proposed code change on various stakeholders are summarized below:

- **Impact on builders:** There should be minimal to no impact on builders.
- **Impact on building designers:** Mechanical, electrical, and controls designers will need to coordinate slightly more to ensure proper power and wiring is supplied for fault reporting purposes.
- **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 California Division of Occupational Safety and Health. All existing health and safety rules will remain in place. Complying with the proposed code changes 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. The

proposed code change is not expected to have an impact on occupational safety and health.

- **Impact on building owners and occupants:** Building owners and occupants will have the ability to report faults prior to failure.
- **Impact on equipment retailers (including manufacturers and distributors):** Thermostat and economizer control manufacturers must ensure that their devices are capable of keeping outdoor air dampers closed during unoccupied periods (except pre-occupancy purges or when economizing conditions are favorable). Economizer damper manufacturers will be required to certify damper leakage performance to the CEC using a declaration under penalty of perjury, if they are not already certified with a third party certification program referencing ANSI/AMCA Standard 500-D that is accredited by A2LA, or ICC-ES, or the Federal EPA to be in compliance with ISO 17065.
- **Impact on energy consultants:** Energy consultants will not be impacted by this measure.
- **Impact on building inspectors:** As compared to the overall code enforcement effort, this measure has negligible impact on the effort required to enforce the building codes.
- **Statewide Employment Impacts:** The Statewide CASE Team expects no impact on statewide employment, as manufacturing and building practices will remain essentially the same. The economizer and economizer FDD products being manufactured should not change significantly, if at all.
- **Impacts on migrant workers; persons by age group, race, or religion:** This proposal and all measures adopted by CEC into Title 24, Part 6 do not advantage or discriminate in regards to race, religion or age group.
- **Impact on Homeowners (including potential first time home owners):** The proposal does not impact residential buildings. There is no expected impact on homeowners.
- **Impact on Renters:** There is no expected impact from this proposal on renters.
- **Impact on Commuters:** This proposal and all measures adopted by CEC into Title 24, Part 6 are not expected to have an impact on commuters.

Statewide Energy Impacts

The proposed language intends to clarify and modify existing language to improve compliance, as opposed to making the standards more stringent. Thus, energy savings are not calculated nor claimed.

Cost-effectiveness

The proposed language intends to clarify and modify existing language to improve compliance, as opposed to making the standards more stringent. Thus, cost-effectiveness is not calculated nor claimed.

Greenhouse Gas and Water Related Impacts

This proposal will have little to no impacts on greenhouse gas emission, water use, or water quality.

Acceptance Testing

Changes in acceptance testing will be very minimal. Most measures will not affect the current language of acceptance tests, and when they do, the changes will not result in increased time or resources required.

As with the 2013 Title 24 Standards, local code enforcement entities will likely need to reference the product specifications of economizer dampers to ensure compliance with leakage performance. Minor additions to current acceptance tests will require that economizer damper product specifications show that the product has been certified to the CEC.

The certification of approval process for Economizer FDD, facilitated by the CEC, is already being utilized. One proposed measure formalizes the process by inserting required submittal documents into the Joint Appendices. As a result, more comprehensive documentation will be reviewed by the CEC.

1. INTRODUCTION

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (CEC) efforts to update California's Building Energy Efficiency Standards (Title 24) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and Southern California Gas Company – and Los Angeles Department of Water and Power (LADWP) sponsored this effort. The program 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 efficient design practices and technologies.

The overall goal of this CASE Report is to propose modifications for nonresidential economizer and economizer fault detection and diagnostics (FDD) requirements. The report contains pertinent information that justifies the code change.

Section 2 of this CASE 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 Statewide CASE Team envisions the proposed code change would be enforced and the expected compliance rates. This section also summarized key issues that the Statewide CASE Team addressed during the CASE development process, including issues discussed during a public stakeholder meeting that the Statewide CASE Team hosted in May 2014.

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 methodology and approach the Statewide CASE Team used to develop the code change proposal, primarily stakeholder outreach. Results from the stakeholder outreach are presented in Section 5. Due to the nature of the measures proposed, the Statewide CASE Team did not need to calculate energy, demand, and environmental impacts.

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

2.1.1 Measure Description

The 2013 Title 24 prescriptively requires that economizers be installed on cooling fan systems with cooling capacity equal to or greater than 54,000 Btu/h. A mandatory control requirement for economizers on air-cooled unitary direct expansion systems is a Fault Detection and Diagnostic (FDD) system that meets a list of requirements in section 120.2(i). Manufacturers certify these FDD systems to the CEC, and the CEC lists the FDD systems online.[1]

In response to stakeholder concerns a set of modifications and additions to the 2013 code are proposed:

1. Clarify in mandatory Section 120.2(f) that outdoor air supply and exhaust dampers shall open with fan operation only during a pre-occupancy purge cycle, occupied periods, or when economizing conditions are favorable.
2. Clarify in mandatory Section 120.2(i) that controls for the economizer FDD can be either stand-alone or integrated with the system controller.
3. Delete refrigerant pressure sensor requirements for economizer FDD in mandatory Section 120.2(i)3 and refrigerant diagnostics requirements in NA7.5.11.
4. Clarify that heating-related requirements for economizer FDD in mandatory Section 120.2(i)5 and 6 are only applicable for systems that have heating capabilities.
5. Clarify in mandatory Section 120.2(i)7 how faults are reported.
6. Modify prescriptive Section 140.4(e) and Appendix NA7.5.4 to specify economizer and return air damper open and closed positions, rather than percent of design airflow.
7. Modify prescriptive Section 140.4(e) and Appendix NA7.5.4 to require damper leakage testing be certified to the CEC.
8. Clarify prescriptive Section 140.4(e) to require damper reliability for 60,000 damper opening and closing cycles.
9. Integrate the Economizer FDD Testing document and System Declaration into the Joint Appendices.[2]

The proposed measures do not expand the scope of the Standards, but rather modify and clarify existing code language. In addition to clarifying 2013 code language, the Statewide CASE

[1] Currently available at: http://www.energy.ca.gov/title24/equipment_cert/fdd/

[2] Currently available at: http://www.energy.ca.gov/title24/equipment_cert/fdd/FDD_Certification_Guidance.pdf

Team developed a list of longer term code changes and associated research needs necessary for the 2019 Title 24 update cycle.

The Statewide CASE Team worked closely with the WHPA, an advisory group comprised of manufacturers, consultants, researchers, distributors, and contractors, to ensure that industry perspectives were understood. The WHPA was created by the California Utilities and California Public Utilities Commission.

2.1.2 Measure History

Fault detection and diagnostics are regulated by Title 24 Standards. For nonresidential buildings, FDD was included in 2008 Title 24 as a compliance option, and in 2013 Title 24 as a mandatory requirement in Section 120.2(i). Performance requirements for economizers were also added in the 2013 Title 24 as prescriptive requirements in Section 140.4(e). Nonresidential Appendices NA7.5.4 and NA7.5.11, and the MECH-5, MECH-12, and MECH-13 acceptance testing forms, were also modified to reflect these code changes.

The code changes as a result of the 2013 CASE report titled HVAC Controls and Economizers (also called Light Commercial Unitary HVAC) were adopted in June 2012. Detection of the following faults was made mandatory for all newly installed air-cooled unitary direct-expansion units with mechanical cooling capacity at AHRI conditions greater than or equal to 54,000 Btu/h, and equipped with an economizer.

- Air temperature sensor failure/fault
- Not economizing when it should
- Economizing when it should not
- Damper not modulating
- Excess outdoor air

Requirements for sensors and controller capabilities for economizer FDD were also made mandatory. Prescriptive economizer performance requirements covered the economizer warranty, drive mechanism, reliability testing, leakage, adjustable setpoint, control sensor location, sensor accuracy, sensor calibration, and relief air pressurization. High limit shut off control requirements were also specified. The 2016 Nonresidential Economizer Modifications CASE proposal intends to clarify language passed as part of the 2013 code cycle, and modify economizer airflow and leakage requirements.

At the time of the 2013 CASE study, FDD installation levels were very low, but due to the new mandatory requirement for FDD and the increasing number of commercially available FDD tools, it is reasonable to assume that FDD installation levels will increase after the 2013 Title 24 Standards take effect on July 1, 2014. The 2013 CASE report approximated that 30% of the market share of air-cooled unitary direct-expansion units would be affected by the code proposal.

There are no preemption concerns with this measure, as economizers and economizer FDD are not federally regulated.

2.1.3 Existing Standards

Economizers and economizer FDD are currently regulated by Title 24. ASHRAE 90.1-2013 standards also prescriptively require economizers for units greater than or equal to 54,000 Btu/h, and have similar requirements for sensor accuracy, damper leakage, and relief of excess outdoor air.

Similar economizer performance measures to those passed in 2013 are included in the 2012 International Energy Conservation Code (IECC).[3] In the IECC code, cooling systems with capacities greater than or equal to 33,000 Btu/h are prescriptively required to have economizers.

2.1.4 Alignment with Zero Net Energy Goals

The Statewide CASE Team and the California Energy Commission (CEC) are committed to achieving California's zero-net-energy (ZNE) goal. While this measure will not directly result in energy savings, it will help achieve ZNE goals by clarifying existing language to improve compliance in nonresidential new construction. This measure will also set the foundation for future code changes that will help ensure ZNE goals are achieved. In particular, this measure has developed suggestions to attain adequate data that will support significant changes in the 2019 and 2022 code cycles.

2.1.5 Relationship to Other Title 24 Measures

Refrigerant charging of residential air conditioning systems are addressed in the Residential HVAC Field Verification and Diagnostics CASE measure. In Section 5.2, the Statewide CASE Team references the Direct Digital Controller CASE Proposals. However, there are no significant overlaps with these CASE measures or the other Title 24 code change proposals for the 2016 cycle.

2.2 Summary of Changes to Code Documents

The sections below provide a summary of how Title 24 documents will be modified by the proposed change. See Section 6 of this report for detailed proposed revisions to code language.

2.2.1 Catalogue of Proposed Changes

Scope

Table 2 identifies the scope of the code change proposal. This measure will impact the following areas (marked by a "Yes").

[3] Under section C403.3 Simple HVAC systems and equipment (Prescriptive). IECC 2012 available at: http://publicecodes.cyberregs.com/icod/iecc/2012/

Table 2: Scope of Code Change Proposal

Mandatory	Prescriptive	Performance	Compliance Option	Trade-Off	Modeling Algorithms	Forms
Yes	Yes	-	-	-	-	Yes

Standards

The proposed code change will modify the sections of the California Building Energy Efficiency Standards (Title 24, Part 6) identified in Table 3.

Table 3: Sections of Standards Impacted by Proposed Code Change

Title 24, Part 6 Section Number	Section Title	Mandatory (M) Prescriptive (Ps) Performance (Pm)	Modify Existing (E) New Section (N)
120.2(f)	Required Controls for Space-Conditioning Systems -- (f) Dampers for Air Supply and Exhaust Equipment	M	E
120.2(i)	Required Controls for Space-Conditioning Systems -- (i) Economizer Fault Detection and Diagnostics (FDD)	M	E
140.4(e)	Prescriptive Requirements for Space Conditioning Systems	Ps	E

Appendices

The proposed code change will modify the sections of the indicated appendices, and add a new section JA6.3, presented in Table 4. If an appendix is not listed, then the proposed code change is not expected to have an effect on that appendix.

Table 4: Appendices Impacted by Proposed Code Change

NONRESIDENTIAL APPENDICES		
Section Number	**Section Title**	**Modify Existing (E) New Section (N)**
NA7.5.4	Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes – Air Economizer Controls	E
NA7.5.11	Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units	E
JOINT APPENDICES		
Section Number	**Section Title**	**Modify Existing (E) New Section (N)**
JA6.3	Economizers Fault Detection and Diagnostics Certification Submittal Requirements	N

Simulation Engine Adaptations

Economizer operation and performance are modeled using the current simulation engine. Changes to the simulation engine relating to the proposed code changes are not necessary. Improvements to the simulation engine and modeling assumptions will be investigated by the CASE team for the 2019 Title 24 update cycle.

2.2.2 Standards Change Summary

This proposal would modify the following sections of the Building Energy Efficiency standards as shown below. See Section 6.1 Standards of this report for the detailed proposed revisions to the standards language.

Changes in Scope

- There are no changes in scope.

Changes in Mandatory Requirements

- In Section 120.2(f), the proposed measure clarifies that outdoor air dampers should only open with fan operation during periods of occupancy or pre-occupancy purge, or when economizing conditions are favorable.
- In Section 120.2(i), the proposed measure clarifies that economizers can be either stand-alone or integrated into the system controller, removes refrigerant sensor pressure requirements, clarifies that heating-related control requirements are applicable for systems that have heating elements, and clarifies how economizer FDD devices shall report faults.

Changes in Prescriptive Requirements

- In Section 140.4(e), the proposed measure modifies standards to specify economizer and return air damper open and closed positions rather than percent of design airflow, to require that damper leakage testing be certified to the California Energy Commission.

2.2.3 Standards Reference Appendices Change Summary

This proposal would modify the following sections of the Standards Appendices as shown below. See Section 6.2 Reference Appendices of this report for the detailed proposed revisions to the text of the reference appendices.

JOINT APPENDICES

JA6.3: Testing and submittal requirements for Economizer FDD certification is added into the Joint Appendices, as well as a declaration carrying a penalty of perjury.

NONRESIDENTIAL APPENDICES

NA7.5.4 Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes – Air Economizer Controls: Acceptance Test inspection procedures and functional testing are modified to indicate damper positions rather than airflow, and damper leakage testing be conducted by a third party laboratory.

NA7.5.11 Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units: Acceptance Test construction inspection procedures and functional testing are modified to remove refrigerant diagnostic sensor testing.

2.2.4 Nonresidential Alternative Calculation Method (ACM) Reference Manual Change Summary

The proposed code change will not modify the ACM Reference Manuals.

2.2.5 Compliance Forms Change Summary

The proposed code change will modify only one compliance form listed below. An example of the revised form is presented in 6.5 Compliance Forms.

- **NRCA-MCH-05-A** – Air Economizer Controls Acceptance. Language will be revised to ensure that damper leakage testing is certified to the CEC.

Further changes to NRCA-MCH-05 are unnecessary, as the current function testing language already references economizer damper modulation rather than design airflow. NRCA-MCH-12 and NRCA-MCH-13 forms are also related to economizer FDD, but do not require changes as they are related only to the functional testing of the unit-mounted FDD device, and do not mention refrigerant diagnostic testing.

2.2.6 Simulation Engine Adaptations

Because the measures presented in this CASE report are primarily clarifications and minor adjustments to existing code language to improve compliance, simulation engines cannot and do not need to model the measures.

2.3 Code Implementation

2.3.1 Verifying Code Compliance

The measures will have the following affects, at a minimum, on code compliance:

- **Remove refrigerant pressure sensor requirements:** This measure will reduce the amount of compliance verification required.
- **Economizer FDD heating requirements:** This measure will require that only systems with heating capabilities comply with the economizer FDD heating-related requirements.
- **Fault reporting:** Local code enforcement entities will likely need to reference the product specifications of the thermostat or energy management control system to ensure compliance. Thermostats and Energy Management Control Systems (EMCSs) must be able to communicate with the FDD systems. However, acceptance tests will not be affected by this requirement.
- **Economizer position:** Current acceptance tests already refer to economizer and return air damper open and closed positions, rather than percent of design airflow. Thus, this

measure will not affect compliance practices. The previous wording which reference '100 percent of the design supply air quantity' was not included in the acceptance tests, and is very difficult to verify.

- **Damper leakage:** As with the 2013 Standards, local code enforcement entities will likely need to reference the product specifications of economizer dampers to ensure compliance with leakage performance. Minor additions to current acceptance tests will require that economizer damper product specifications show that the product has been certified to the CEC.
- **Damper reliability:** This measure will not have an effect on compliance verification, as current acceptance test language is clear that the damper must demonstrate reliability for at least 60,000 cycles.
- **Economizer FDD Certification:** The California Energy Commission is already reviewing and approving economizer FDD system declarations. As of June 2014 the CEC has approved four (4) devices. This process will not significantly change, but inserting the Economizer FDD Testing document into the Joint Appendices will require manufacturers to submit the evidence alongside the declaration document, resulting in more comprehensive documentation for the CEC to review.

2.3.2 Code Implementation

The building industry will not be required to do more than that which is required by the 2013 Title 24, as the measures are clarifications of requirements and do not add significant expenses, and the building industry is accustomed to complying with Title 24.

- Thermostats and/or economizer controls can be reprogrammed to ensure that outdoor air dampers only open when ventilation is needed: when the building is occupied or during pre-occupancy purges, or economizing conditions are favorable.
- To meet the clarified fault reporting requirements, mechanical contractors will not necessarily need to specify different thermostats or EMCSs, or locate them differently from common practice.
- Damper manufacturers who perform damper leakage testing internally will not need to change testing procedures, but will need to certify to the CEC, under a penalty of perjury, that the damper leakage information that they provide is true.

2.4 Issues Addressed During CASE Development Process

The Statewide CASE Team solicited feedback from a variety of stakeholders when developing the code change proposal presented in this report. In addition to personal outreach to many members of the WHPA subcommittee and working group, the Statewide CASE Team conducted a public stakeholder meeting to discuss the proposals. The issues that were addressed during development of the code change proposal are summarized below.

- **Fault reporting:** During the stakeholder webinar, manufacturers expressed concerns that economizer FDD devices and thermostats developed to comply with the 2013

Standards would no longer comply with the 2016 proposed language. The Statewide CASE Team indicated this was not the intention, and adjusted language to incorporate more elements from the 2013 language.

- **Economizer damper capabilities:** During meetings with the Western HVAC Performance Alliance (WHPA) FDD committee, a member of the Air Movement and Control Association (AMCA) indicated that the proposed language regarding economizer damper opening and closing position increases the opportunity for insufficiently sized dampers to be installed. AMCA recommended proposed language be added to the Statewide CASE Team proposal, discussed in Section 5.1.6.
- **Damper leakage testing:** The Statewide CASE Team initially proposed that damper leakage be certified according to AMCA Publication 511, as was briefly considered for the 2013 Standards. Stakeholders indicated that certification would entail costs to manufacturers, at which point the Statewide CASE Team suggested that certification was not necessary, but that damper leakage be tested by an independent third party. During stakeholder outreach, damper manufacturers and AMCA indicated that there would be additional costs associated with third party testing as well. The Statewide CASE Team confirmed the extra costs through outreach with representatives of Underwriters Laboratory (UL). Ultimately, the Statewide CASE Team removed the proposal for third party damper leakage testing, instead adding a requirement that manufacturers certify damper leakage performance to the CEC.

3. MARKET ANALYSIS

The Statewide CASE Team performed a market analysis with the goal of identifying current technology availability, current product availability, and market trends. The Statewide CASE Team considered how the proposed standard may impact the market in general and individual market players. The Statewide CASE Team gathered information about the market size and measure applicability through research and outreach with key stakeholders including utility program staff, the CEC, and a wide range of industry players who were invited to the WHPA FDD committee meetings and a public stakeholder meeting that the Statewide CASE Team hosted in May 2014.

3.1 Market Structure

The economizer and economizer FDD markets are comprised of economizer manufacturers, FDD manufacturers, and commercial HVAC contractors. The Statewide CASE Team has been working with the WHPA to ensure that the perspectives of manufacturers and contractors are understood. Stakeholders engaged during WHPA meetings and/or the stakeholder meeting included members of:

- **Damper Manufacturers:** Ruskin, Greenheck, MicroMetl
- **HVAC Manufacturers:** Trane, Lennox, Daikin McQuay, Emerson, Rheem, Carrier

- **FDD Manufacturers:** Field Diagnostics, EcoFactor, Honeywell, Johnson Controls, Belimo
- **Industry Representatives:** Air Movement and Control Association (AMCA), Air Conditioning Heating and Refrigeration Institute (AHRI)
- **Research Organizations and Consultants:** Western HVAC Performance Alliance, Purdue University, Proctor Engineering, DNV GL, National Institute of Standards and Technology, UC Davis Western Cooling Efficiency Center (WCEC)

For a complete list of stakeholders contacted, please review Section 4.1 Stakeholder Outreach.

3.2 Market Availability and Current Practices

The proposed measures will not affect the ability of the manufacturers listed above to supply the market with products, because the measures do not change the scope of the products involved. The measures that clarify outdoor air damper operation, fault reporting, and damper leakage certification are the only measures that may mildly affect manufacturer practices and products:

- Stakeholders indicated that most thermostats and economizer controls should have the capability to be programmed to ensure that outdoor air dampers do not open during unoccupied periods (except during pre-occupancy purges, or when outdoor temperatures are favorable for indoor conditioning). Some products may need to have added functionality, such as additional dry contacts at thermostats, to ensure this capability.
- Economizer FDD devices currently approved by the CEC are manufactured by Honeywell, Lennox, or Belimo. Their products have been designed to conform to the 2013 Title 24 requirements, which require reporting faults to a fault management application or zone thermostat. These modes of reporting faults are still included in the proposed fault language, but the revised code language clarifies how and to whom the faults should be reported. The added proposed clarifications allow one or more thermostats per air-cooled unit to annunciate the faults, or for another indicator device within five feet of a thermostat to annunciate the fault. Display of steps to contact a technician could either be reported on the thermostat, another device, or on an adjacent label.[4]
- Economizer damper manufacturers will be required to certify damper leakage performance to the CEC using a declaration under penalty of perjury. Damper manufacturers will not need to certify their product to the CEC if their products are already certified with a third party certification program referencing ANSI/AMCA Standard 500-D that is accredited by A2LA, or ICC-ES, or the Federal EPA to be in compliance with ISO 17065, where:

[4] This will be clarified in the compliance manual.

- A2LA is the American Association for Laboratory Accreditation, an accreditation body that offers a full range of comprehensive laboratory and laboratory-related accreditation services and training.[5]
- ICC-ES is ICC Evaluation Service, a nonprofit that does technical evaluations of building products, components, methods, and materials[6]
- The Federal EPA is Federal Environmental Protection Agency
- ISO 17065 is the International Organization for Standardization requirements for bodies certifying products, processes and services

Many damper manufacturers are certified according to AMCA Publication 511, which complies with the above requirements. Requiring manufacturers to certify to the CEC that dampers meet the leakage performance requirements should not affect their products. Manufacturers may be more careful about testing and reporting procedures, thereby improving the compliance rate of meeting the 2013 Title 24 code requirements.

3.3 Useful Life, Persistence, and Maintenance

The proposed measures are not necessarily expected to improve the life of the systems. Reduced maintenance of economizer dampers may result due to improved compliance with reliability and leakage requirements, but may be offset by the increased maintenance caused by enhanced fault reporting. Economizer useful life will likely increase due to the proposed measures, but this is extremely difficult to estimate as the 2013 Standards have just recently taken effect.

The proposed language intends to clarify and modify existing language to improve compliance, as opposed to making the standards more stringent. Thus, energy savings related to useful life or maintenance are not calculated nor claimed.

3.4 Market Impacts and Economic Assessments

3.4.1 Impact on Builders

The potential effect of all proposed changes to Title 24 on builders will be small. Assuming that builders pass compliance costs on to consumers, demand for construction could decrease slightly if all other factors remaining the same. For instance, a 1% increase in the first cost of buildings could decrease long-term demand for buildings by 0.1% (UC Berkeley 2010, Appendix p.33 estimate a long-term price elasticity for buildings at -0.1%). On the other hand, the proposed standards will lead to greater new building affordability and economic growth due to reduce energy expenditures as noted below in Section 3.5, which likely would increase demand for construction.

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[5] More information on the A2LA is available at: https://www.a2la.org/

[6] More information on ICC-ES is available at: http://www.icc-es.org/

This particular code change proposal will have a minimal impact on builders. Much of the coordination will need to occur among HVAC, electrical, and controls contractors.

3.4.2 Impact on Building Designers

Title 24 is updated on a three-year revision cycle, so adjusting to changes to Title 24 is routine practice for building designers. Adjusting design practices to comply with changing code practices is within the normal practices of building designers. This particular revision to Title 24 will not require changes in design practices that are abnormally onerous for building designers.

As a whole, the measures being considered for the 2016 code change cycle aim to provide designers with plentiful options on how to comply with the building efficiency standards. The proposed standards do not aim to limit building aesthetics or any particular type of building equipment.

For this particular measure, beyond what is already required by the 2013 Title 24 Standards, building designers will need to ensure that specified dampers have been certified to the CEC, and that specifications for economizer FDD and thermostats are updated to comply with the more detailed fault reporting requirements. When designing office buildings, shopping malls, or other types of buildings with multiple tenants, designers will need to ensure that faults are annunciated in property management offices or common spaces accessible by the property or building manager. Coordination will be needed among the mechanical, electrical, and controls designers to ensure the appropriate power supply and wiring are available for the faults to be reported as necessary.

3.4.3 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.

3.4.4 Impact on Building Owners and Occupants

Building owners and occupants will have increased opportunity to report faults to appropriate HVAC technicians when a fault is annunciated indoors. HVAC technicians will need to be able to correctly maintain economizers for the proposed fault reporting measure to be effective.

3.4.5 Impact on Retailers (including manufacturers and distributors)

Thermostat and economizer control manufacturers must ensure that their devices are capable of keeping outdoor air dampers closed during unoccupied periods (except pre-occupancy purges and under outdoor air conditions that are favorable for economizer operation).

Manufacturers will have to continue applying for economizer FDD certification through the CEC, but now with evidence required in Joint Appendices 6.3.

Economizer damper manufacturers will be required to certify damper leakage performance to the CEC using a declaration under penalty of perjury, which requires manufacturers to complete and sign a form. If a manufacturer is already certified with a third party certification program referencing ANSI/AMCA Standard 500-D that is accredited by A2LA, or ICC-ES, or the Federal EPA to be in compliance with ISO 17065, they will not need to certify damper leakage performance to the CEC. Many damper manufacturers are already certified according to AMCA Publication 511, which is an example of a certification program that meets these requirements.

3.4.6 Impact on Energy Consultants

Energy consultants will not be impacted by this measure. All of the measures affect product quality and installation practices.

3.4.7 Impact on Building Inspectors

Building inspectors will need to ensure that the fault reporting methods are met: that the economizer FDD system reports faults on or within five feet from a thermostat, at eye level, in appropriate locations in multiple tenant buildings, and capable of reporting faults to an HVAC technician.

3.4.8 Impact on Statewide Employment

The proposed changes to Title 24 are expected to result in positive job growth as noted below in Section 3.5. However, the Statewide CASE Team expects no impact on statewide employment from this particular measure, as manufacturing and building practices will remain essentially the same. The economizer and economizer FDD products being manufactured should not change significantly, if at all.

3.5 Economic Impacts

The proposed Title 24 code changes, including this measure, are expected to increase job creation, income, and investment in California. As a result of the proposed code changes, it is anticipated that less money will be sent out of state to fund energy imports, and local spending is expected to increase due to higher disposable incomes due to reduced energy costs.[7]

These economic impacts of energy efficiency are documented in several resources including the California Air Resources Board's (CARB) Updated Economic Analysis of California's

[7] Energy efficiency measures may result in reduced power plant construction, both in-state and out-of-state. These plants tend to be highly capital-intensive and often rely on equipment produced out of state, thus we expect that displaced power plant spending will be more than off-set from job growth in other sectors in California.

Climate Change Scoping Plan, which compares the economic impacts of several scenario cases (CARB, 2010b). CARB include one case (Case 1) with a 33% renewable portfolio standard (RPS) and higher levels of energy efficiency compared to an alternative case (Case 4) with a 20% RPS and lower levels of energy efficiency. Gross state production (GSP)[8], personal income, and labor demand were between 0.6% and 1.1% higher in the case with the higher RPS and more energy efficiency ((CARB 2010b, Table 26). While CARB's analysis does not report the benefits of energy efficiency and the RPS separately, we expect that the benefits of the package of measures are primarily due to energy efficiency. Energy efficiency measures are expected to reduce costs by $2,133 million annually (CARB 2008, pC-117) whereas the RPS implementation is expected to cost $1,782 million annually, not including the benefits of GHG and air pollution reduction (CARB 2008, pC-130).

Macro-economic analysis of past energy efficiency programs and forward-looking analysis of energy efficiency policies and investments similarly show the benefits to California's economy of investments in energy efficiency (Roland-Holst 2008; UC Berkeley 2011).

For these particular measures, the Statewide CASE Team expects the impacts on California's economy to be minimal to none, because no energy impacts are anticipated.

3.5.1 Creation or Elimination of Jobs

CARB's economic analysis of higher levels of energy efficiency and 33% RPS implementation estimates that this scenario would result in a 1.1% increase in statewide labor demand in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b, Tables 26 and 27). CARB's economic analysis also estimates a 1.3% increase in small business employment levels in 2020 (CARB 2010b, Table 32).

For these particular measures, the Statewide CASE Team does not expect an impact on the creation or elimination of jobs, because no energy impacts are anticipated.

3.5.2 Creation or Elimination of Businesses within California

CARB's economic analysis of higher levels of energy efficiency and 33% RPS implementation (as described above) estimates that this scenario would result in 0.6% additional GSP in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b, Table ES-2). We expect that higher GSP will drive additional business creation in California. In particular, local small businesses that spend a much larger proportion of revenue on energy than other businesses (CARB 2010b, Figures 13 and 14) should disproportionately benefit from lower energy costs due to energy efficiency standards. Increased labor demand, as noted earlier, is another indication of business creation.

Table 5 below shows California industries that are expected to receive the economic benefit of the proposed Title 24 code changes. It is anticipated that these industries will expand due to an

[8] GSP is the sum of all value added by industries within the state plus taxes on production and imports.

increase in funding as a result of energy efficiency improvements. The list of industries is based on the industries that the University of California, Berkeley identified as being impacted by energy efficiency programs (UC Berkeley 2011 Table 3.8).[9] This list provided below is not specific to one individual code change proposal; rather it is an approximation of the industries that may receive benefit from the 2016 Title 24 code changes. A table listing total expected job creation by industry that is expected in 2015 and 2020 from all investments in California energy efficiency and renewable energy is presented in Appendix A: Job Creation by Industry.

For these particular measures, the Statewide CASE Team does not expect an impact on the creation or elimination of businesses, because no energy impacts are anticipated.

Table 5: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) Code

Industry	NAICS Code
Residential Building Construction	2361
Nonresidential Building Construction	2362
Roofing Contractors	238160
Electrical Contractors	23821
Plumbing, Heating, and Air-Conditioning Contractors	23822
Boiler and Pipe Insulation Installation	23829
Insulation Contractors	23831
Window and Door Installation	23835
Asphalt Paving, Roofing, and Saturated Materials	32412
Manufacturing	32412
Other Nonmetallic Mineral Product Manufacturing	3279
Industrial Machinery Manufacturing	3332
Ventilation, Heating, Air-Conditioning, & Commercial Refrigeration Equip. Manf.	3334
Computer and Peripheral Equipment Manufacturing	3341
Communications Equipment Manufacturing	3342
Electric Lighting Equipment Manufacturing	3351
Household Appliance Manufacturing	3352
Other Major Household Appliance Manufacturing	335228
Used Household and Office Goods Moving	484210

[9] Table 3.8 of the UC Berkeley report includes industries that will receive benefits of a wide variety of efficiency interventions, including Title 24 standards and efficiency programs. The authors of the UC Berkeley report did not know in 2011 which Title 24 measures would be considered for the 2016 adoption cycle, so the UC Berkeley report was likely conservative in their approximations of industries impacted by Title 24. Statewide CASE Team believes that industries impacted by utilities efficiency programs is a more realistic and reasonable proxy for industries potentially affected by upcoming Title 24 standards. Therefore, the table provided in this CASE Report includes the industries that are listed as benefiting from Title 24 and utility energy efficiency programs.

Engineering Services	541330
Building Inspection Services	541350
Environmental Consulting Services	541620
Other Scientific and Technical Consulting Services	541690
Advertising and Related Services	5418
Corporate, Subsidiary, and Regional Managing Offices	551114
Office Administrative Services	5611
Commercial & Industrial Machinery & Equip. (exc. Auto. & Electronic) Repair & Maint.	811310

3.5.3 Competitive Advantages or Disadvantages for Businesses within California

California businesses would benefit from an overall reduction in energy costs. This could help California businesses gain competitive advantage over businesses operating in other states or countries and an increase in investment in California, as noted below.

For these particular measures, the Statewide CASE Team does not expect an impact because no energy impacts are anticipated.

3.5.4 Increase or Decrease of Investments in the State of California

CARB's economic analysis indicate that higher levels of energy efficiency and 33% RPS will increase investment in California by about 3% in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b Figures 7a and 10a).

For these particular measures, the Statewide CASE Team does not expect an impact because no energy impacts are anticipated.

3.5.5 Incentives for Innovation in Products, Materials, or Processes

Updating Title 24 standards will encourage innovation through the adoption of new technologies to better manage energy usage and achieve energy savings. Significant impact on product innovation is not expected through these proposed changes, as they are primarily clarifications to improve compliance.

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

The Statewide CASE Team expects positive overall impacts on state and local government revenues due to higher GSP and personal income resulting in higher tax revenues, as noted earlier. Higher property valuations due to energy efficiency enhancements may also result in positive local property tax revenues. The Statewide CASE Team has not obtained specific data to quantify potential revenue benefits for this measure.

3.5.6.1 Cost of Enforcement

There are no projected impediments to, or incentives for, innovation that would result from the proposed measures. Economizer and economizer FDD functionality requirements remain the

same. Likewise, training or additional time spent on enforcement, which may lead to increased enforcement costs for the state or local government, are very minimal. With the 2013 Standards, the CEC was already approving economizer FDD devices, and local government already enforcing economizer FDD fault reporting requirements.

Cost to the State

State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24 standards, including updating education and compliance materials and responding to questions about the revised standards, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals.

Cost to Local Governments

All revisions to Title 24 will result in changes to Title 24 compliance determinations. Local governments will need to train permitting staff on the revised Title 24 standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2016 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining. For example, utilities offer compliance training such as “Decoding” talks to provide training and materials to local permitting departments. As noted earlier, although retraining is a cost of the revised standards, Title 24 energy efficiency standards are expected to increase economic growth and income with positive impacts on local revenue.

These proposed changes would revise an existing measure without significantly affecting the complexity of this measure. Therefore, on-going costs are not expected to change significantly.

3.5.6.2 Impacts on Specific Persons

The proposed changes to Title 24 are not expected to have a differential impact on any of the following groups relative to the state population as a whole:

- Migrant Workers
- Persons by age
- Persons by race
- Persons by religion
- Commuters

4. METHODOLOGY

This section describes the methodology and approach the Statewide CASE Team used. Because the proposed measures were clarifications and minor modifications, the Statewide CASE Team did not need to estimate energy savings or cost-effectiveness for the proposed measures. Instead, we reached out to stakeholders for feedback on the proposed measures, impacts on market actors, and suggestions for improvement.

4.1 Stakeholder Outreach

Since October 2013, the Statewide CASE Team coordinated closely with the WHPA and their associated committees and working groups. The WHPA Meetings that the Statewide CASE Team participated in are listed in Table 6. Committee meetings and working group meetings often contained approximately 15-30 industry stakeholders, including members of the utilities and the CEC. Smaller meetings with WHPA staff members Mark Cherniack and Dr. Kristin Heinemeier of the UC Davis WCEC were scheduled ahead of presentations to the wider committee to ensure that the goals of the Statewide CASE Team and WHPA could be aligned. After committee wide meetings, the Statewide CASE Team often interviewed individual members for their expertise on a particular measure.

Table 6: WHPA Meeting Dates

Date	Meeting	Description
10/21/13	FDD Committee	Introduction of 2016 Title 24 process
11/4/13	FDD Working Group	Faults, detection, and diagnostics research
11/11/13	FDD Working Group	Current state of FDD tools
12/2/13	FDD Working Group	Consensus on recommendation for nonresidential and residential HVAC performance degradation device
2/21/14	Statewide CASE Team and Mark Cherniack, Kristin Heinemeier	Scope revision based on CEC approval of HVAC measures
3/17/14	FDD Committee	Status update of residential and nonresidential measures
4/3/14	Statewide CASE Team and Mark Cherniack, Kristin Heinemeier	Coordination of proposed measures
4/14/14	FDD Committee	Nonresidential proposed measures
4/28/14	FDD Committee	Nonresidential and residential proposed measures
6/9/14	FDD Committee	Status update of nonresidential and residential measures

The stakeholder meeting for the nonresidential HVAC economizer and FDD measure was held via webinar on May 21st, 2014. The Statewide CASE Team also presented this measure at the CEC Staff Workshop on June 12th, 2014. Through the WHPA meetings, related interviews, and the stakeholder webinar, the Statewide CASE Team engaged the following list of stakeholders regarding the measures.

Table 7: Stakeholders Contacted

Name	Organization	Organization Role
Beth Braddy	Trane	Manufacturer
Dane Carey	TAMCO	Manufacturer
Mark Cherniack	Western HVAC Performance Alliance	Efficiency Advocate
Abram Conant	Proctor Engineering	Engineering Consultant
Darryl DeAngelis	Belimo	Manufacturer
Jon Douglas	Lennox International	HVAC Manufacturer
Shane Easter	EcoFactor	Manufacturer
Skip Ernst	Daikin McQuay	Manufacturer
Martin Gissel	Greenheck	Manufacturer
Wayne Guelfo	Johnson Controls	Manufacturer
Dale Gustavson	Better Buildings	Building Consultant
Kristin Heinemeier	Western HVAC Performance Alliance	Industry Representative
Peter Jacobs	BuildingMetrics	Engineering Consultant
Kurt Kluck	Greenheck	Manufacturer
Robert Long	Rheem	Manufacturer
Richard Lord	Carrier	HVAC Manufacturer
Mark Lowry	Western HVAC Performance Alliance	Industry Representative
Mike Milliken	MicroMetl	Manufacturer
Tony Moffett	Ruskin	Manufacturer
Laura Petrillo-Groh	Air Conditioning, Heating and Refrigeration Institute (AHRI)	Industry Representative
Hung Pham	Emerson	HVAC Manufacturer
John Proctor	Proctor Engineering	Engineering Consultant
Dale Rossi	Field Diagnostics Services, Inc. (FDSI)	Manufacturer
Aniruddh Roy	Air Conditioning, Heating and Refrigeration Institute (AHRI)	Industry Representative
Chuck Sloop	Ezenics	Manufacturer
Wade Smith	Air Movement and Control Association (AMCA)	Industry Representative
John Stoops	DNVGL	Engineering Consultant
Bob Sundberg	Western HVAC Performance Alliance (WHPA)	Industry Representative
Adrienne Thomle	Honeywell International	Manufacturer
Matthew Tyler	PECI	Statewide CASE Team
Bart Weiland	Weiland Consulting	EE Program consultant
David Yuill	Purdue University	Researcher

5. ANALYSIS AND RESULTS

The development of each proposed measure is briefly discussed below. As mentioned earlier, because the measures are clarifications and modifications, energy, demand, cost, and environmental impacts analyses were not completed.

5.1 Measure Development

Since October 2013, several iterations of measure proposals have been developed. Summaries of these measure descriptions can be found in the CASE Work Plan body and appendices. The development of the measures ultimately proposed by the Statewide CASE Team are summarized below.

5.1.1 Section 120.2(f) - Clarify that outdoor air supply dampers shall only open during pre-occupancy or occupied periods, or when economizing conditions are favorable

The Statewide CASE Team briefly discussed this issue with one concerned stakeholder who suggested that under the 2013 Standards, outdoor air dampers can be tied to fan operation at all times. If the outdoor dampers are tied to fan operation, then when the building is unoccupied and the thermostats are in setback mode and the air handling unit turns on to ensure that the indoor temperatures meet the setbacks, the outdoor air dampers may be opening and unnecessarily ventilating the building and consuming energy to condition the ventilation air.

The Statewide CASE Team revised language to clarify the intent of the code – that outdoor air dampers remain closed when the building does not require ventilation. Ventilation is only required during occupied periods, pre-occupancy purging, or when economizing conditions are favorable.

5.1.2 Section 120.2(i) - Clarify that economizer controls can be either stand-alone or integrated with the system controller

When the Statewide CASE Team introduced this measure to the WHPA FDD Committee, members indicated that manufacturers can have both stand-alone and integrated controllers. The type of controller would not affect its ability to meet Title 24 requirements. This clarification was straightforward and proposed to be added to the description of the economizer FDD in Section 120.2(i).

5.1.3 Section 120.2(i)3, NA7.5.11.1, and 7.5.11.2 - Delete refrigerant pressure sensor requirements

This measure was proposed because refrigerant pressure sensors are unrelated to economizer FDD. WHPA FDD committee members agreed with its removal, though it is unclear why the language was added with the 2013 Title 24. This measure proposes to delete 120.2(i)3.

5.1.4 Sections 120.2(i)5D and 120.2(i)6 - Clarify economizer FDD heating requirements

One stakeholder reported to the CEC concerns that air conditioning units that do not contain heating capabilities still must meet economizer FDD requirements that the controller indicate that heating is enabled, and that the heating mode can be independently verified. The Statewide CASE Team clarified section of language by adding the language 'if applicable' to the appropriate sections.

5.1.5 Section 120.2(i)7 - Clarify how faults are reported

By clarifying how faults are reported, this measure attempts to increase the chances of faults being serviced. During WHPA FDD Committee meetings, committee member comments indicated that property management would not want occupants to know the type of fault occurring or to be concerned about the fault annunciation. Committee members also said that the existing language may encourage all zone thermostats to simultaneously indicate a fault with one unit, which may again attract unnecessary concern. Discussions with the WHPA pointed out several issues that could be remediated by proposed language:

- "Energy Management Control Systems" (EMCS) were added as an option, as EMCSs are typically associated with larger and more complex buildings and thus likely to be monitored more frequently by facility personnel.
- Faults may still be reported on zone thermostats, but can also be reported via other devices such as indicator lights. Language is proposed to ensure that the faults reported be visible, and that they only need to be annunciated in one location per HVAC unit.
- In conditions where building occupants, rather than facility personnel, will be the first to be alerted of faults on zone thermostats, language was proposed to ensure they have the appropriate information for how to contact appropriate building personnel or an HVAC technician.
- Because of the variety of commercial building types possible, language is proposed to require faults to be reported in common spaces accessible by property management, as opposed to private offices.
- Off-site communication to technicians directly from the economizer FDD system would relieve occupants or building personnel from the duty of having to call technicians themselves. This could particularly be an issue if the HVAC system has recurring faults, and occupants or building personnel start to ignore them. However, this approach needs to consider how to address situations such as when the building owner changes technician services, or the technicians change their contact information.

During the stakeholder meeting, some manufacturers expressed concern that the 2016 language would alter the device descriptions enough to exclude systems developed specifically to meet the 2013 Title 24. The Statewide CASE Team modified the proposed language to use similar language as the 2013 code, and verified with manufacturers to ensure their FDD systems would still be applicable.

5.1.6 Section 140.4(e)1A and NA7.5.4.1 - Modify language to specify economizer and return air damper open and closed positions, rather than percent of design airflow

Existing code language required that economizers be designed to meet 100% of the design airflow requirement. Based on correspondence with researchers currently conducting tests on air-cooled unitary direct expansion systems, airflow through fully open economizers is generally well below 100%, due to a multitude of reasons.[10] Airflow is very difficult to measure in the field, and the current acceptance testing procedures only require damper modulation and position to be verified. The proposed language follows the language in the acceptance testing procedures, and references only damper position as opposed to airflow.

The Air Movement and Control Association (AMCA) indicated in several emails that although the 2013 language allows insufficiently sized economizer dampers to be installed, the proposed revisions would exacerbate the problem by removing the 100% design airflow requirement. AMCA recommended that the following language be added to the end of the Statewide CASE Team's proposed language in Section 140.4(e)1A:

> "<u>If the airflow pressure loss through the economizer outside air intake is greater than that of the return air system at the design airflow rate, then the capacity of the fan shall be adjusted to deliver design airflow rates when outside air dampers are 100% open and return dampers are 100% closed.</u>"

The Statewide CASE Team ultimately maintained the proposed language shown in Section 6.1 Standards until the method described in the AMCA recommendation can be validated for effectiveness through further research. In order to ensure proper economizer sizing, the Statewide CASE Team proposed additional language that specifies that the economizer must be specified by the air handler unit or damper manufacturer for the equipment on which it is installed. The Team will continue working with CEC staff to determine clarify the intent without adding overly restrictive language.

5.1.7 Section 140.4(e)4C and NA7.5.4.1- Modify language to require damper leakage testing be certified to the CEC

Some damper manufacturers were concerned that damper leakage testing requirements done in-house by manufacturers could lead to improper testing procedures and/or documentation of test results. The Statewide CASE Team initially considered requiring certification under AMCA Publication 511, but the Team determined that such a requirement could potentially insert proprietary AMCA services into Title 24.[11] Subsequently, a requirement for independent testing by third party labs accredited by A2LA or ICC-ES to be in compliance with ISO 17025

[10] Correspondence with John Stoops, April 23, 2014.

[11] AMCA Publication 511 requires test results from an AMCA accredited lab.

was added to the language, allowing labs such as those by UL and Intertek to also be used.[12] However, after further research the Statewide CASE Team determined that manufacturers would still incur costs to have their dampers tested by a third party, and instead required that manufacturers certify their damper leakage performance compliance to the CEC under a penalty of perjury.

The Statewide CASE Team suggests that damper manufacturers certify damper leakage performance to the CEC using a declaration similar to that required for economizer FDD manufacturers under the 2013 Standards.[13] This CASE Report is proposing that this document be added to the Joint Appendices under Section JA6.3.4 specifically for Economizer FDD, as shown in Section 6.2.1 JOINT APPENDICES. (Note, this does not include a requirement to submit testing results or other evidence for damper leakage, but simply the declaration form requiring manufacturer signature).The CEC may instead wish to locate the form in a section not specific to Economizer FDD, if several other products are referencing the declaration.

The Statewide CASE Team agreed with the AMCA recommendation that language be added that clarifies that dampers already certified by a third party to be in accordance with AMCA Standard 500, such as AMCA Publication 511, satisfy the certification requirement. In addition, AMCA stated that there is no longer an AMCA Standard 500, but rather two standards: 500-D for dampers, and 500-L for louvers. AMCA suggested changing the language to require compliance with AMCA Standard 500-D, to indicate that the standard is for dampers (as opposed to louvers, which have fixed blades).

Refer to Section 2.4, for further details on damper leakage code language development.

5.1.8 Section 140.4(e)4B - Clarify damper reliability requirements

A damper manufacturer suggested the minor modification to Section 140.4(e)4B that changes the word “after” to “for.” The stakeholder asserted that the intention of the language was to ensure that the economizer could effectively operate against air and pressure for the entirety of 60,000 cycles, while the current wording allows for the economizer to run without the burden of air and pressure for the 60,000 cycles, then be tested for one cycle under air and pressure to meet the requirement.

While this measure was proposed after the majority of meetings with the WHPA, there were no disputes during the stakeholder meeting.

[12] ISO 17025 is the International Organization for Standardization general requirements for the competence of testing and calibration laboratories.

[13] Economizer FDD Declaration available at the CEC website: http://www.energy.ca.gov/title24/equipment_cert/fdd/

5.1.9 JA6.3 and Integrate the Economizer Testing Guidance and FDD System Declaration documents

The WHPA finished developing the Economizer Testing Guidance Document in late 2013, to facilitate the manufacturer applications to the CEC for economizer FDD systems.[14] The document suggests the following evidence be provided:

- Photo of sensors and mounting instructions
- Sensor specifications
- Laboratory test results
- Photocopy of instructions manual
- Photograph of fault management application or zone thermostat
- Fault test specifications and procedures

A Declaration developed by the CEC accompanies this Guidance Document, and requires that a representative of the manufacturer "execute a declaration under penalty of perjury attesting that all information provided is true, complete, accurate, and in compliance with the applicable provisions of Part 6." Manufacturers that complete this declaration and submit it to the CEC are certifying that their FDD system is compliant. These systems are then listed by the CEC.

During the stakeholder webinar, some manufacturers expressed concern that they would be penalized if the economizer FDD is not properly installed in the field. However, the process listed above implies that manufacturers apply once to prove that installers have the ability to install a properly working device, not that manufacturers are held liable if they are installed properly.

The Statewide CASE Team modified the language in the original Guidance Document from suggestions to requirements, and proposes inserting it along with the Declaration in Joint Appendix 6.3.

5.2 Develop the scope of work for projected 2019 Title 24 modifications

Several measures initially considered for the 2016 Title 24, were not able to be achieved due to limited time, data, and resources. In order to make significant improvements for the 2019 Title 24, a scope of work will need to be developed that may include some of the following measures that could not be pursued during the 2016 code cycle.

- Coordinate with findings from the Commercial Rooftop Unit Working Group (RTUG) to develop a more comprehensive economizer control retrofit protocol.[15] Current Title 24

[14] Currently available at: http://www.energy.ca.gov/title24/equipment_cert/fdd/FDD_Certification_Guidance.pdf

[15] More information on the Commercial Rooftop Unit Work Group available at: http://rtf.nwcouncil.org/subcommittees/rtug/

language generally requires that additions and alterations of space-conditioning systems meet the economizer requirements for new construction systems, but findings from the RTUG efforts may improve or add to the existing language.

- ASHRAE Standard Project Committee 207, launched in 2012, is responsible for developing a method to define an FDD tool's function and a method of laboratory test for the performance of FDD tools on commercial air-cooled packaged equipment. They have a goal to provide a public review draft of their findings by January 2015. Coordinating with ASHRAE SPC 207 may have significant implications for expanding the role of FDD in commercial applications.[16]
- The impact of the economizer FDD measures added with the 2013 Title 24 Standards needs to be researched to further improve the code. During the stakeholder meeting, two stakeholders described how economizer FDD accuracy is highly dependent on the cause of the problem. The variety of problems that economizer FDD can detect (see Appendix B: Economizer FDD Logic) leads to uncertainty regarding the accuracy of these systems. Field studies ascertaining the performance of economizer FDD are crucial to further improving economizer FDD, and expanding the scope of nonresidential FDD.
- The impact of economizer damper performance measures added with the 2013 Title 24 language needs to be researched in order to further improve code. Research of buildings and systems meeting the 2013 Standards is needed to estimate compliance rates and energy savings associated with economizer performance such as damper leakage and sizing. The Statewide CASE Team initially proposed reducing the leakage of economizer dampers to 4 cfm/sf at 250 Pascals, but ultimately dropped the proposal due to the need for more complete cost-effectiveness analysis. The majority of damper manufacturers with nationwide markets stated that their dampers meet the 4 cfm/sf requirement to adhere to ASHRAE 90.1-2013 requirements. Nonetheless, a TDV-based cost-effectiveness analysis is needed to justify the change. The Statewide CASE Team will consider conducting the research and analysis for the 2019 Title 24 update cycle using the results of field and lab findings on compliance rates and potential energy savings.
- Section 120.2(i) requires economizer FDD only for air-cooled unitary direct expansion systems. Expanding this requirement to include air-cooled and water-cooled built-up systems would likely lead to energy savings. Outreach to stakeholders indicated this change would have minor implications for manufacturers.[17,18] A possible revision to Section 120.2(i) would change 'air-cooled unitary direct expansion units' to 'fan systems.' A complement to this requirement may be located in Section 120.2(j), which is a set of requirements proposed for 2016 Title 24 for systems with Direct Digital Controls

[16] More information on ASHRAE SPC 207 available at: http://spc207.ashraepcs.org/
[17] DeAngelis, Daryl (Belimo). 2014. Personal communication. June 25.
[18] Lord, Richard (Carrier). 2014. Personal communication. June 29.

(DDC) proposed by the DDC CASE report. A possible addition to section 120.2(j) could be to require that DDCs detect and report faults when air side economizers are required.

- Acceptance tests for outdoor ventilation systems (in section NA7.5.1) currently do not contain steps for testing to ensure outdoor air dampers only open when the building is occupied, or the unit is completing a pre-occupancy purge or economizing during a setback condition. In other words, testing steps may be added to test that the outdoor air damper remains closed when the building is unoccupied and the air handling unit fan turns on to have indoor temperatures meet setback conditions.

6. PROPOSED LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2013 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

6.1 Standards

At the time of writing this report, the 2013 Title 24 Section 120.2(i) language includes the following definition: "Air-cooled unitary direct expansion units include packaged, split systems, heat pumps, and variable refrigerant flow (VRF), where the VRF capacity is defined by that of the condensing unit." CEC staff and stakeholders are working to move the definition of air-cooled unitary direct expansion units to another section of the Standards before the 2013 Standards implementation date of July 1, 2014. The language has thus been stricken through to show the 2016 language based on the likely 2013 language.

120.2 - REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS

(f) **Dampers for Air Supply and Exhaust Equipment.** Outdoor air supply and exhaust equipment shall be installed with dampers that:

1. Automatically close upon fan shutdown; and,

2. Automatically close during unoccupied periods; and

EXCEPTION 1 to Section 120.2(f)2: During pre-occupancy as per Section 120.1(c)2.

EXCEPTION 2 to Section 120.2(f)2: When enabled by an Occupant Sensor per 120.1(c)5.

EXCEPTION 3 to Section 120.2(f)2: When enabled by an Override signal per 120.2(e)1 and dampers open to provide outdoor air ventilation

3. Remain closed during setback heating and cooling per 120.2(e)2

EXCEPTION 1 to Section 120.2(f)3: When equipped with an economizer per 140.4(e) and the outdoor air conditions are below the high limit shutoff in TABLE 140.4-B.

[…]

(i) **Economizer Fault Detection and Diagnostics (FDD).** All newly installed air-cooled unitary direct-expansion units, equipped with a economizer and with mechanical cooling capacity at AHRI conditions of greater than or equal to 54,000 Btu/hr, shall include a stand-alone or integrated Fault Detection and Diagnostics (FDD) system in accordance with Subsections 120.2(i) through 120.2(i)9. ~~Air-cooled unitary direct expansion units include packaged, split systems, heat pumps, and variable refrigerant flow (VRF), where the VRF capacity is defined by that of the condensing unit.~~

1. The following temperature sensors shall be permanently installed to monitor system operation: outside air, supply air, and when required for differential economizer operation, a return air sensor; and

2. Temperature sensors shall have an accuracy of ±2°F over the range of 40°F to 80°F; and

~~3. Refrigerant pressure sensors, if used, shall have an accuracy of ±3 percent of full scale; and~~

3~~4~~. The controller shall have the capability of displaying the value of each sensor; and

4~~5~~. The controller shall provide system status by indicating the following conditions:

A. Free cooling available;

B. Economizer enabled;

C. Compressor enabled;

D. Heating enabled, if applicable;

E. Mixed air low limit cycle active

5~~6~~. The unit controller shall manually initiate each operating mode so that the operation of compressors, economizers, fans, and heating system, if applicable, can be independently tested and verified; and

~~7. Faults shall be reported to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats; and~~

6. Faults shall be reported in one of the following ways:

A. To an Energy Management Control System, regularly monitored by facility personnel, and with the ability to log faults for later review

B. Annunciated locally on one or more zone thermostats, or on a device within five (5) feet of zone thermostat(s), clearly visible, at eye level, and meeting the following requirements:

i. On the thermostat, device, or an adjacent written sign, display instructions to contact appropriate building personnel or an HVAC technician

ii. In buildings with multiple tenants, the annunciation shall either be within property management offices, or in common space accessible by the property or building manager.

C. To a fault management application which automatically provides notification of the fault to a remote HVAC service provider

7~~8~~. The FDD system shall detect the following faults:

A. Air temperature sensor failure/fault;

B. Not economizing when it should;

C. Economizing when it should not;

D. Damper not modulating

E. Excess outdoor air

8~~9~~. The FDD System shall be certified by the Energy Commission as meeting requirements of Sections 120.2(i)1 through 120.2(i)8 in accordance with Section 100(h) and JA6.3.

[…]

140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

(e) Economizers.

1. Each cooling fan system that has a design total mechanical cooling capacity over 54,000 Btu/hr shall include either:

A. An air economizer specified by the air handler unit or damper manufacturer for the equipment on which it is installed, and capable of modulating outside-air dampers to 100 percent open and return-air dampers to ~~supply~~ 100 percent closed ~~of the design supply air quantity as outside air~~; or

B. A water 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 50°F dry-bulb and 45°F wet-bulb and below.

[…]

4. If an economizer is required by Section 140.4(e)1, and an air economizer is used to meet the requirement, then the air economizer, and all return air dampers on any

individual cooling fan system that has a total mechanical cooling capacity over 54,000 Btu/hr shall have the following features:

A. Warranty. 5-year Manufacturer warranty of economizer assembly.

B. Damper reliability testing. Suppliers of economizers shall certify that the economizer assembly, including but not limited to outdoor air damper, return air damper, drive linkage, and actuator, have been tested and are able to open and close against the rated airflow and pressure of the system for ~~after~~ 60,000 damper opening and closing cycles.

C. Damper leakage. Economizer outside air and return air dampers shall be certified by the manufacturer to have a maximum leakage rate of 10 cfm/sf at ~~1.0 in. w.g.~~ 250 Pascals when tested in accordance with AMCA Standard 500-D. The economizer outside air and return air damper leakage rates shall be certified to the Energy Commission in accordance with Section 100(h). Manufacturer participation in a third party certification program referencing ANSI/AMCA Standard 500-D that is accredited by A2LA, or ICC-ES, or the Federal EPA to be in compliance with ISO 17065 shall satisfy this certification requirement.

6.2 Reference Appendices

Please note that the recommendations for the Joint Appendices include testing results as well as a declaration form requiring manufacturer signature (in section JA 6.3.4). The CEC may instead wish to locate the form in a section not specific to Economizer FDD, if several other products are referencing the declaration (such as economizer manufacturers wishing to certify economizer leakage testing).

6.2.1 JOINT APPENDICES

JA6.3 Economizer Fault Detection and Diagnostics Certification Submittal Requirements

Title 24, Part 6 Section 120.2(i) requires that economizer FDD functions be installed on air-cooled unitary air conditioning systems over 54,000 Btu/hr cooling capacity, with the ability to detect the faults specified in Section 120.2(i). Each air conditioning system manufacturer, controls supplier, or FDD supplier wishing to certify that their FDD analytics conform to the FDD requirements of Title 24, Part 6 may do so in a written declaration. This requires that a letter be sent to the California Energy Commission declaring that the FDD conforms to Title 24, Part 6 Section 120.2(i). The declaration at the end of this section shall be used to submit to the California Energy Commission.

JA6.3.1 Information that shall be included with the Declaration

The air conditioning system manufacturer, controls supplier, or FDD supplier provides evidence as shown below:

a. The following temperature sensors are permanently installed to monitor system operation:
    i. Outside air
    ii. Supply air
    iii. Return air, when required for differential economizer operation.

    Evidence: Photograph or schematic of all required sensors indicating their recommended mounting instructions.

b. Temperature sensors have an accuracy of ±2°F over the range of 40°F to 80°F
Evidence: Photocopy of sensor specification

c. The controller is capable of providing system status by indicating the following:
    i. Free cooling available
    ii. Economizer enabled
    iii. Compressor enabled
    iv. Heating enabled, if applicable
    v. Mixed air low limit cycle active
    vi. The current value of each sensor

    Evidence: Laboratory test: describe how the mode is simulated and the wording used to indicate the status.

d. The unit controller is capable of manually initiating each operating mode so that the operation of compressors, economizers, fans, and heating system, if applicable, can be independently tested and verified.
Evidence: Photocopy of controller manual showing instructions for manually initiating each operating mode.

e. The unit controller is capable of reporting faults one of the following ways:

    A. To an Energy Management Control System regularly monitored by facility personnel

    B. Annunciated locally on one or more zone thermostats, or on a device within five (5) feet of zone thermostat(s), clearly visible, at eye level, and meeting the following requirements:

        i. On the thermostat, device, or an adjacent written sign, display instructions to contact appropriate building personnel or an HVAC technician

        ii. In buildings with multiple tenants, the annunciation shall either be within property management offices, or in common space accessible by the property or building manager.

    C. To a fault management application which automatically provides notification of the fault to a remote HVAC service provider

    Evidence: Supplier’s description of how they comply, and supporting documentation such as a photocopy of controller manual or photograph of fault

management application, zone thermostat, or other device showing indication of a fault.

f. The unit control is capable of detecting the following faults:
   i. Air temperature sensor failure/fault
   ii. Not economizing when it should
   iii. Economizing when it should not
   iv. Damper not modulating
   v. Excess outdoor air

JA6.3.2 Fault Detection Test Specifications

To provide evidence that the required faults are detected by the FDD functionality, the FDD Provider shall perform a No-Fault and Fault test for each of the tests in Table 1. A pre-defined Test Procedure such as the one provided in the example shown in Table 2 could be used to fill out Table 1.

Table 1 – Sample of a completed fault test

	Faults				
Tests	Air temperature sensor failure/fault	Not Economizing when it should	Economizing when it Should not	Damper not modulating	Excess outdoor air
1. Damper is Stuck Open			X	X	X
2. Damper Stuck at Minimum		X		X	
3. Bad or Unplugged Actuator		X	X	X	
4. Sensor Hard Failure	X	X	X		X
5. Actuator Mechanically Disconnected		X	X	X	X

JA6.3.3 Reporting of Test Results

The results of each test shall be provided in a report using a standard test results reporting format that provides the following information for each test:

a. Organization and individual conducting the test
b. Time, Date, and Location of test
c. Make and model of unit/control tested
d. Range of models represented by test
e. Test procedure used, including description of the method for imposing fault with repeatability
f. Test driving Conditions (outdoor air temperature, return air temperature or enthalpy as required by the type of high limit control being used)
g. Results of the test: Which alarms were generated?
h. Provide a bill of materials for the configuration that is being certified.
i. The FDD supplier shall describe any special field or data verifications that are required for the particular FDD analytics (beyond those included in Acceptance Test requirements).
j. Sample of documentation that would accompany each qualifying set of FDD analytics.
k. Name and contact information of company personnel in charge of certification
l. A mapping from the manufacturer's alarm description to what is required by Title 24 similar to Table 1.

Table 2 - Sample Test Procedure

Step	**Description**	**Purpose**
1	Close the economizer damper fresh air blades, then secure the blades in a manner that prevents opening.	Test alarm response when "Damper Stuck at Minimum"
2	Simulate conditions such that the damper actuator attempts to open the fresh air blades. Verify the damper blades remains secured and that the fault(s) specified in Table 1 are detected. Record the annunciated fault(s) and fault text.	
3	Release the blades and allow the economizer damper to modulate open. Verify the annunciated fault(s) have cleared.	
4	Open fully the economizer damper fresh air blades, then secure the blades in a manner that prevents closing.	Test alarm response when "Damper is Stuck Open"
5	Simulate conditions such that the damper actuator attempts to modulate the fresh air blade closed. Verify the damper remains secured and that the fault(s) specified in Table 2 are detected. Record the annunciated fault(s) and fault text.	

6	Release the blades and allow the economizer damper to modulate. Verify the annunciated fault(s) have cleared.	
7	Disconnect 1 sensor and verify the fault(s) specified in Table 1 are detected. Record the annunciated fault(s) and fault text.	Test alarm response when "Sensor Hard Failure"
8	Reconnect the sensor and verify that the annunciated fault(s) have cleared.	
9	Repeat steps 7 – 8 for each available sensor.	
10	Electrically disconnect the damper actuator and verify the fault(s) specified in Table 1 are detected. Record annunciated fault(s) and fault text.	Test alarm response when "Bad or Unplugged Actuator"
11	Reconnect the damper actuator. Verify the fault(s) have cleared and normal economizer operation has resumed.	
12	Mechanically disconnect the damper actuator from the damper blade assembly.	Test alarm response when "Actuator Disconnected"
13	Simulate conditions such that the damper actuator would be moving the damper blades. Verify the fault(s) specified in Table 2 are detected. Record annunciated fault(s) and fault text.	
14	Reconnect the damper actuator to the damper blade assembly. Verify the fault(s) have cleared and normal economizer operation has resumed.	
15	Simulate conditions necessary to generate system status of "Free cooling available". Record text of annunciated status.	Test for System Status Capability
16	Simulate system conditions necessary to generate system status of "Economizer enabled". Record text of annunciated status.	
17	Simulate system conditions necessary to generate system status of "Compressor enabled". Record text of annunciated status.	
18	If equipped with a heating system, simulate system	

	conditions necessary to generate system status of "Heating enabled". Record text of annunciated status.	
19	Simulate system conditions necessary to generate system status of "Mixed air low limit cycle active". Record text of annunciated status.	

JA 6.3.4 Declaration

Consistent with the requirements of Title 24, Part 6 Sections 100.0(h) and 120.2(i), companies wishing to certify to the California Energy Commission shall execute a declaration under penalty of perjury attesting that all information provided is true, complete, accurate, and in compliance with the applicable provisions of Part 6. Companies may fulfill this requirement by providing the information, signing the declaration below and submitting to the California Energy Commission as per instructions in JA6.3.5. Electronic copies of this form can be found at http://www.energy.ca.gov/title24/equipment_cert/fdd/.

Manufacturer, Model Name and Number of all devices being certified

Manufacturer	Model Name	Model Number
_____	_____	_____
_____	_____	_____
_____	_____	_____

When providing the information below, be sure to enter complete mailing addresses, including postal/zip codes.

Certifying Company

Contact Person Name * _____	Phone 1 _____
Certifying Company Name ** _____	Phone 2 _____
Address _____	Fax _____

(Address) _____	E-mail _____
(Address) _____	Company Website (URL) _____

* If the contact person named above is NOT the person whose signature is on the Declaration, then the full contact information for the person whose signature is on the Declaration must also be provided on a separate page.

** If the company named above is: A) a parent entity filing on behalf of a subsidiary entity; B) a subsidiary entity filing on behalf of a parent entity; or C) an affiliate entity filing on behalf of an affiliate entity, the above contact information must be provided for any additional entities on a separate page.

Manufacturer (if different from Certifying Company)

Contact Person Name _____	Phone 1 _____
Manufacturing Company Name _____	Phone 2 _____
Address _____	Fax _____
(Address) _____	E-mail _____
(Address) _____	Company Website (URL) _____

Declaration

I declare under penalty of perjury under the laws of the State of California that:

(1) All the information in this statement is true, complete, accurate, and in compliance with all applicable provisions of Section 120.2(i) of Title 24, Part 6 of the California Code of Regulations.

(2) Each Fault Detection and Diagnostic (FDD) system has been tested in accordance with all applicable requirements of Section 120.2(i)1-120.2(i)7 of Title 24, Part 6 of the California Code of Regulations.

(3) [If the party submitting this statement is a corporation, partnership, or other business entity] I am authorized to make this declaration, and to file this statement, on behalf of the company named below.

Certifying Company Name	Date
Name/Title (please print)	Signature

JA6.3.5 Certification

a. Send declarations and evidence of functionality or test reports to the addresses below. Electronic submittals are preferred.

CertifiedtoCEC@energy.ca.gov

Attn: FDD Certification

Building Standards Development Office

California Energy Commission

1516 Ninth St., MS 37

Sacramento, CA 95814

6.2.2 NONRESIDENTIAL APPENDICES

NA7.5.4 Air Economizer Controls

NA7.5.4.1 Construction Inspection

Prior to Functional Testing, verify and document the following:

(a) Economizer lockout setpoint complies with Table 140.4(e)-C of Section 140.4(e)3.

[…]

(i) Economizer reliability features are present per Standards Section 140.4(e)4.

(j) Economizer inlet damper ~~System~~ is designed to modulate ~~provide~~up to 100 percent open, and return air damper to 100 percent closed, ~~outside air~~ without over-pressurizing the building.

(k) For systems with DDC controls lockout sensor(s) are either factory calibrated or field calibrated.

[…]

(o) Provide an economizer specification sheet proving capability of at least 100,000 actuations.

(p) Provide a product specification sheet proving compliance with AMCA Standard 500-D damper leakage ~~at~~ no greater than 10 cfm/sf at ~~1 in. w.g.~~ 250 Pascals, and certification to the Energy Commission. Manufacturer participation in a third party certification program referencing ANSI/AMCA Standard 500-D that is accredited by A2LA, or ICC-ES, or the Federal EPA to be in compliance with ISO 17065 shall satisfy this certification requirement.

(q) Unit has a direct drive modulating actuator with gear driven interconnections.

[…]

NA7.5.11 Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units

NA7.5.11.1 Construction Inspection

Prior to Functional Testing, verify and document the following:

(a) Verify fault detection and diagnostics (FDD) hardware is installed on HVAC unit.

[…]

(d) Verify the controller has the capability of displaying the value of the following parameters:

1. Air temperatures: outside air, supply air, return air.

~~2. Refrigerant pressure and temperature sensors (if present, their output should be made available).~~

[…]

NA7.5.11.2 Functional Testing

For each HVAC unit to be tested, complete the following:

[…]

~~**NA7.5.11.2.4 Functional Testing for Refrigerant Diagnostic Sensors**~~

~~Step 1: During normal cooling operation, record refrigerant temperatures and pressures, and saturated discharge temperature and saturated suction temperature, if displayed by the unit controller.~~

~~Step 2: During same operating conditions as Step 1, install calibrated refrigerant gauge with an accuracy of plus or minus 3% shall be used to determine and record saturated discharge temperature and saturated suction temperatures. If either temperature determined is more than 5 F different than recorded in Step 1, test has failed. Otherwise, test passes.~~

> ~~(a) Refrigeration gauges shall be calibrated according to the manufacturer's calibration procedure to conform to the accuracy requirement specified. All testers performing diagnostic tests shall obtain evidence from the manufacturer that the equipment meets the accuracy specifications. The evidence shall include equipment model, serial number, the name and signature of the person of the test laboratory verifying the accuracy, and the instrument accuracy. All diagnostic testing equipment is subject to re-calibration when the period of the manufacturer's guaranteed accuracy expires.~~

6.3 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

6.4 Compliance Manuals

Chapters 4 and 13 of the Nonresidential Compliance Manual will need to be revised. Specific recommendations have not yet been developed.

For Section 120.2(i)6Bi, the Compliance Manual should clarify that instructions can be an adjacent written sign next to the thermostat/device, and not necessarily an integrated part of the thermostat. This type of display is the responsibility of the HVAC contractor and/or building owner. Furthermore, for Section 120.2(i)6C, the Compliance Manual can clarify that offsite HVAC technicians can be contacted through the method of the building owner or operator's choice: email, text, or automated call.

6.5 Compliance Forms

No new forms will be created.

NRCA-MCH-05-A, Part A, Section 3:

> Economizer reliability features are present per 2013 Building Energy Efficiency Standards Section 140.4(e):
>
> […]

C. Provide a product specification sheet proving economizer damper ~~sections~~s are tested in accordance with AMCA Standard 500-D to have a maximum leakage rate of 10 cfm/sf at 250 Pascals, and certified to the CEC. Manufacturer participation in a third party certification program referencing ANSI/AMCA Standard 500-D that is accredited by A2LA, or ICC-ES, or the Federal EPA to be in compliance with ISO 17065 shall satisfy this certification requirement. ~~certified by AMCA 511 for a maximum damper leakage rate of 10 cfm/sf at 1.0 in. w.g. (Class 1A, 1, and 2 are acceptable)~~

7. REFERENCES AND OTHER RESEARCH

Please refer to Section 4.1 Stakeholder Outreach for a list of experts that were involved in developing the proposed code change. Some personal communications with these experts is listed in the references below. Further research produced from Work Order 32 and the Applied Technology Services at Pacific Gas & Electric Company may be used to update the proposed code change.

7.1 Literature Reviewed and Used

DNV KEMA, WO32 EM&V Team. 2013. "WO32 EM&V Interim Findings Memo for Commercial Quality Maintenance – Volume 1 - Field Observations." HVAC Project Coordination Group.

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PECI and Taylor Engineering. 2011. Code and Standards Enhancement Initiative: Light Commercial Unitary HVAC. California Utilities Statewide Codes and Standards Team.

7.2 Literature Reviewed and Not Directly Used

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7.3 Other References

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Regional Technical Forum. 2013. "Commercial Rooftop Unit Working Group." http://rtf.nwcouncil.org/subcommittees/rtug/.

Roland-Holst, David. “Energy Efficiency, Innovation, and Job Creation in California.” October 2008. http://are.berkeley.edu/~dwrh/CERES_Web/Docs/UCB%20Energy%20Innovation%20and%20Job%20Creation%2010-20-08.pdf, Accessed May 27, 2014.

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APPENDIX A: JOB CREATION BY INDUSTRY

Table 8 shows total job creation by industry that is expected from all investments in California energy efficiency and renewable energy (Source: UC Berkeley 2010, Appendix D). While it is not specific to codes and standards, this data indicates the industries that generally will receive the greatest job growth from energy efficiency.

Table 8: Job Creation by Industry

NAICS	Industry Description	Direct Jobs	
		2015	2020
23822	Plumbing, Heating, and Air-Conditioning Contractors	8,695	13,243
2361	Residential Building Construction	5,072	7,104
2362	Nonresidential Building Construction	5,345	6,922
5611	Office Administrative Services	2,848	4,785
23821	Electrical Contractors	3,375	4,705
551114	Corporate, Subsidiary, and Regional Managing Offices	1,794	3,014
54133	Engineering Services	1,644	2,825
5418	Advertising and Related Services	1,232	2,070
334413	Semiconductor and Related Device Manufacturing	1,598	1,598
541690	Other Scientific and Technical Consulting Services	796	1,382
23831	Drywall and Insulation Contractors	943	1,331
3334	Ventilation, Heating, Air-Conditioning, & Commercial Refrigeration Equip. Manf.	453	792
3351	Electric Lighting Equipment Manufacturing	351	613
926130	Regulation and Administration of Communications, Electric, Gas, Other Utilities	322	319
23816	Roofing Contractors	275	277
54162	Environmental Consulting Services	151	261
484210	Used Household and Office Goods Moving	137	239
23835	Finish Carpentry Contractors	120	120
23829	Other Building Equipment Contractors	119	113
3352	Household Appliance Manufacturing	63	110
other	other	454	547
	Total	**35,788**	**52,369**

APPENDIX B: ECONOMIZER FDD LOGIC

Stakeholders from Honeywell and Rheem, two manufacturers, submitted a table containing the faults currently required to be reported by economizer FDD in Section 120.2(i), and the variety of problems that may lead to these faults. This table exemplifies the challenges with understanding and improving FDD accuracy, and is a helpful resource for economizer FDD field studies.

Table 9: Faults Detected by Economizer FDD and Possible Causes

A. Air temperature sensor failure/fault			
No.	**Description**	**Cause**	**Notes**
1	Disconnected or failed outdoor air enthalpy or dry bulb sensor		An alarm is issued if the outdoor enthalpy sensor is disconnected.
2	Missing or failed mixed Air sensor	For Field Installed economizers, the provided sensor must be connected.	An alarm is issued if the mixed air sensor is not present.
3	Disconnected or failed return air enthalpy sensor	For Rheem, this is always a Field Installed option.	An alarm is issued if the return enthalpy sensor was present and is disconnected.

B. Not economizing when it should			
Definition: Outdoor enthalpy or dry bulb temperature is below setpoint, but economizer is not economizing. Possible Reasons:			
No.	**Description**	**Cause**	**Notes**
1	Indoor fan not running	Thrown belt, failed indoor blower motor.	This would probably be noticed by occupants if space is served by a single unit. In multiple units serving space issue may be masked.
2	Indoor fan not providing proof of operation	Caused by disconnected wire to economizer.	Economizer controller has no indication of fan operation
3	No cooling demand detected	Caused by bypass of economizer input and output to compressor or disconnected wire.	Mandatory checkout of system operation for Y1 and Y2 operation.
4	Stuck damper	Caused by debris in damper blade or lack of lubrication.	An alarm can be detected by the feedback from actuator.
5	Damper actuator not connected to damper blade	Can be caused by loose actuator shaft clamp.	Very unlikely with present actuator square hub.
6	Mixed Air low limit cycle active (freeze protection)	Mixed air sensor is downstream of evaporator coil because of space constraints. When 100% economizer cannot satisfy load, a compressor is engaged. If the resulting mixed air temperature is below the low limit, then the economizer outside air damper will close until the compressor disengages.	An alarm is issued, but the solution may be complex. This typically occurs when the indoor airflow is too low, but it is not uncommon.

7	Improperly located Mixed Air Sensor	For Field Installed economizers, must be properly located. In some applications even for factory installed economizers the sensor must be relocated for proper sensing of mixed air temperature. If the sensor measures too much cold outside air instead of mixed air, the economizer will not open as much as it should.	An alarm is issued if the mixed air sensor is not present, but not if the sensor is improperly located. The sensor is typically a "point" sensor and not an averaging sensor.
8	Poor location of outdoor air sensor	Affected by direct sunlight heating and/or 0% outside air minimum position.	Usually not a problem with designed systems as the sensor location is carefully specified.
Definition: Outdoor enthalpy is above setpoint, but outdoor conditions are favorable compared to return air conditions:			
1	Enthalpy Comparison set point too low for area	Enthalpy Comparison setpoint is set by the installer.	Location and application specific. Comparison setpoint is generally set too low because indoor airflow is too low to provide proper cooling. Regional guidelines and application guidelines would be helpful, but cannot overcome specific application problems. Dual enthalpy sometimes is a better solution.

C. Economizing when it should not - Need Definition			
Definition: Outdoor enthalpy is above setpoint, but economizer is bringing in excess air.			
1	Minimum Position Set too high	Minimum setpoint is set by the installer.	
2	Stuck damper	Caused by debris in damper blade or lack of lubrication.	An alarm can be detected by the feedback from actuator.
3	Damper actuator not connected to damper blade	Can be caused by loose actuator shaft clamp.	Very unlikely with present actuator square hub.
Definition: Outdoor enthalpy is below setpoint, but outdoor conditions are NOT favorable.			
1	Enthalpy Comparison set point too high for area	Enthalpy Comparison setpoint is set by the installer.	Location and application specific. Regional guidelines and application guidelines would be helpful, but cannot overcome specific application problems. Dual enthalpy sometimes is a better solution.

D. Damper Not Modulating			
Definition: Outdoor enthalpy is below setpoint, but Damper is not Modulating			
No.	**Description**	**Cause**	**Notes**
1	Stuck damper	Caused by debris in damper blade or lack of lubrication.	An alarm can be detected by the feedback from actuator.
2	Damper actuator not connected	Can be caused by loose actuator shaft	Very unlikely with present

	to damper blade	clamp.	actuator square hub.
3	Improperly located Mixed Air Sensor	For Field Installed economizers, must be properly located. If the mixed air sensor is located out of the mixed air stream it may not respond to changes in mixed air temperature.	An alarm is issued if the mixed air sensor is not present, but not if the sensor is improperly located. The sensor is typically a "point" sensor and not an averaging sensor.
4	Mixed Air low limit cycle active (freeze protection)	Mixed air sensor is downstream of evaporator coil because of space constraints. When 100% economizer cannot satisfy load, a compressor is engaged. If the resulting mixed air temperature is below the low limit, then the economizer outside air damper will close until the compressor disengages.	An alarm is issued, but the solution may be complex. This typically occurs when the indoor airflow is too low, but it is not uncommon.

E. Excess or inadequate outdoor air			
Definition: Outdoor enthalpy is above setpoint, but economizer brings in excessive outside air or inadequate OA			
No.	**Description**	**Cause**	**Notes**
1	Large Minimum Outdoor Air Position - Occupied Mode	Minimum Position setpoint is set by the installer.	Application Dependent. Air conditioner/heater must be sized for load including outside air requirement. Outside air requirement set by building size, use, and occupancy. If a return air enthalpy sensor and an outdoor air enthalpy sensor are installed, the discharge air can be used to apply the lever rule can determine proportion of outside air to return air. This however would need some confirming information such as indoor airflow.
2	Large Minimum Outdoor Air Position - Unoccupied Mode	Thermostat must provide an occupancy signal to unit. Unit must be designed to accept occupancy signal and connected to economizer to close outside air damper during unoccupied mode.	
3	Static Pressure	High external static in return air duct or balance of pressure in system	
4	Excess or inadequate outdoor air for number of occupants	CO2 changeover setting wrong	
5	Mismatched CO2 sensor to economizer controller	Selectable CO2 output not matching input expected by controller	
6	Excess exhaust air from power exhaust	Power exhaust fan set at wrong speed or oversized	

7	Clogged filters	poor maintenance	Dirty OA filter upsets balance between OA and RA due to additional pressure drop.