



**CALIFORNIA
ENERGY**
CODES & STANDARDS

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2019 Title 24 Codes & Standards Enhancement (CASE) Proposal Fault Detection & Diagnostic (FDD) for Built Up Systems

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Proposed Code Change Overview

- Description of change:
 - Expand current air-side economizer FDD requirements for packaged systems in section 120.2(i) to built-up systems
- Types of building impacted:
 - Nonresidential buildings with built up systems
- Building system impacted:
 - Air handlers > 4.5 tons in size
- Anticipated type of change:
 - Mandatory

Proposed Code Change Overview

- Section 120.2(i) requires
 - Standalone or integrated economizer FDD (permanently installed)
 - No diagnostics
 - Provide status
 - Free cooling available
 - Compressor enabled, etc...
 - Fault reporting to EMCS, a thermostat, or fault management application
 - Fault detection:
 - Air temperature sensor failure/fault
 - Not economizing when it should
 - Economizing when it should not
 - Damper not modulating
 - Excess outdoor air

Proposed Code Change History

- Why are we proposing this measure?
 - Built-up HVAC air-handling units have no FDD requirements
 - Energy savings opportunity - Economizer malfunctions are prevalent
 - Direct Digital Control systems can integrate fault detection relatively easily
 - New DDC module
 - Controls contractor sequence of operations
 - 3rd party FDD vendor

Current Code Requirements

- Existing Title 24 Requirements
 - 2013: Economizer FDD added for packaged units >4.5 tons
 - 2016: Guidance for certifying FDD to the CEC, and more specific fault reporting requirements
- Existing Model Code Requirements
 - ASHRAE Guideline 36: Sequences of operation
 - ASHRAE SPC 207: Developing a lab test method
 - 2015 IECC: Same requirements as 2013 Title 24

Typical Practices

- Contractors and technicians frequently don't repair economizers appropriately
 - Lack of time
 - Lack of training
 - Customers unwilling to pay for appropriate repair
- Packaged units
 - with standalone control have FDD installed and acceptance tested
 - controlled by DDC have economizer control (and FDD) removed and not replaced
- Built up systems typically controlled by DDC, and have some fault detection (not necessarily economizer FDD)

Do you agree with this description?

Market Overview and Analysis

- Current Market
 - FDD market is well established
 - 118 products on the market, 73 certified to CEC
 - A handful of FDD products intended to be integrated with DDC
 - No known utility incentives for installing FDD
- Market impacts if proposal is implemented
 - Expand FDD practices to all large systems controlled by DDC, including packaged
 - DDC manufacturers may need to transfer algorithms to BU control platforms
 - Designers and control contractors will need to update and iterate sequences to achieve alarm “sweet spot”
- Market barriers
 - Uncertainty about effectiveness of existing FDD algorithms
 - Lack of impetus for building occupants, owners and operators to understand and fix economizer faults

Other market information sources we should know about?

Incremental Cost Discussion

- How we collect costs
 - Interviews with manufacturers, designers, contractors, Cx agents, acceptance test technicians, facility managers
 - Cost of the economizer FDD
 - Additional sensors/wiring (none?)
 - Controls sequences (first time cost – replicable and improved over time)
 - Product add-on (more economical with broader FDD objectives)
 - Cost of the acceptance test
 - Performed similarly to packed systems
- Is there an incremental cost if a DDC is already part of the design?
 - Can an effective sequence be effectively replicated across AHUs and platforms?

Are there other cost components to consider?

Methodology for Savings Analysis

- Methodology for energy and demand Impacts
 - CBECC-COM simulations mimicking 2013 CASE effort
 - **Air temperature sensor failure:** Adjust setpoints by +/- 3F
 - **Not economizing when it should:** High limit setpoint to from 75F to 55F
 - **Economizing when it should not:** High limit setpoint to from 75F to 85F(?)
 - **Damper not modulating:** No economizer
 - **Excess outdoor air:** 100% outside air system
 - Prototype Buildings
 - Office >150,000 ft² with VAV
 - Large retail
 - Meet Prescriptive Requirements
 - About 25% of forecasted new construction (including colleges)

Other building types that commonly employ BU systems with rooftop economizers?

Assumptions for Energy Impacts Analysis

- Key assumptions – further research needed
 - Fraction of new construction square footage with built-up air handlers (any suggestions?)
 - Rest would be split systems, radiant, chilled beams, etc.. with DOASs
 - 25% of units would have an economizer fault over 15 years considering:
 - Incidence (2-30%)
 - FDD accuracy (75%)
 - Remediation without FDD (25%)
 - Maintenance costs
- Data sources
 - 2013 CASE report
 - Aircare Plus program
 - Stakeholder feedback

Assumptions for Energy Impacts Analysis

- 2013 Incidence Rates

	Fault incidence over 15 years	Prob. of detecting the fault w/FDD	Prob of detecting the fault w/o FDD	Fault incidence x FDD benefit	Note
Air temperature sensor malfunction	2%	75%	25%	1%	Does not impact comfort conditions
Not economizing when it should	30%	75%	75%	0%	Likely detected through regular service
Economizing when it should not	no data				
Damper not modulating	24%	75%	25%	12%	Does not impact comfort conditions
Excess outdoor air	24%	75%	25%	12%	Does not impact comfort conditions
Total				25%	

Do these seem about right? Do you have any data to support other numbers?

Incremental Cost Savings

- Energy savings lead to cost savings
 - Incremental cost savings are calculated based on TDV cost savings associated with energy savings over the entire period of analysis.
 - Present TDV cost multiplier (\$/TDV kBTU)

Preliminary Cost Effectiveness Estimates

	Benefit (2020\$)	Cost (2020\$)
Total Per Unit Incremental Cost over Period of Analysis		\$500
<ul style="list-style-type: none"> <i>Incremental first cost (sensors, writing sequence)</i> <i>Incremental maintenance cost (replacement equipment, regular maintenance) over period of analysis</i> 		\$600
		(\$100)
Per Unit TDV Cost Savings over Period of Analysis	\$750	
	TOTAL	\$500
	Benefit/Cost Ratio	1.5

Compliance and Enforcement- Market Actors

- Who would be involved in implementing this measure?
 - Manufacturers
 - Mechanical designer
 - HVAC subcontractors / installers
 - Acceptance test technicians
 - Building Owner
 - Building enforcement agency / plan check
 - Energy consultants
- Others?

Compliance and Enforcement - Tasks

Market Actor	Task(s)	Success Criteria
DDC and FDD Manufacturers	<ul style="list-style-type: none"> - Develop control platform and/or logic - Develop FDD algorithms 	
Mechanical Designer	<ul style="list-style-type: none"> - Write specifications, sequences, and compliance forms - Coordinate commissioning 	
HVAC Subcontractors	<ul style="list-style-type: none"> - Select and install economizer and controllers - Write control sequences 	
Acceptance Test Technicians	<ul style="list-style-type: none"> - Verify proper installation and functionality 	
Building Owner / Facility Personnel	<ul style="list-style-type: none"> - Maintain equipment for occupant satisfaction - Lower operational costs 	

What are we not capturing?

Compliance and Enforcement - Resources

Market Actor	Resource(s)
DDC and FDD Manufacturers	
Mechanical Designer	
HVAC Subcontractors	
Acceptance Test Technicians	
Building Owner / Facility Personnel	

What resources or tools are typically used for compliance?

Strawman Code Change Language

- Title 24 Standards

120.2(i): Economizer Fault Detection and Diagnostics (FDD). All newly installed ~~air-cooled packaged direct expansion units with an air handler~~ **air handling units with a** mechanical cooling capacity greater than 54,000 Btu/hr with an installed air economizer shall include a stand alone or integrated Fault Detection and Diagnostics (FDD) system

141.0(b)2: Prescriptive approach. The altered components of the envelope, or space conditioning, lighting, electrical power distribution and water heating systems, and any newly installed equipment serving the alteration, shall meet the applicable requirements of Sections 110.0 through 110.9, Sections 120.0 through 120.6, and Sections 120.9 through 130.5

EXCEPTION to Section 141.0(b)2: The requirements of Section 120.2(i) shall not apply to alterations of space-conditioning systems or components.

Strawman Code Change Language

- Nonresidential Appendix NA7.5.11 – FDD for ~~Packaged DX~~ Air Handling Units
 - Construction inspection
 - Verify installation of FDD hardware and sensors
 - Verify controller system status capabilities
 - Functional testing
 - Verify FDD faults resulting from disconnected sensors and immobilizing outdoor air damper
- Nonresidential Appendix NA7.5.12 – Automatic FDD for Air Handling Units and Zone Terminal Units
 - Functional testing for AHU
 - Verify FDD faults resulting from disconnected sensors and immobilizing outdoor air damper
 - Verify from control system workstation that simultaneous heating and cooling results in a fault

Input needed for Energy Impacts and Cost Effectiveness Analysis

Compliance

- How would an acceptance test for BU economizer FDD differ from packaged systems?
 - Should functional test be removed for BU versus FDD?
- Can BU FDD be certified to the CEC?
 - JA6.3 provides submittal requirements included sensor schematics, laboratory tests, instruction manuals, and more

Input needed for Energy Impacts and Cost Effectiveness Analysis

Market Data

- Is it common for built-up systems to install and implement economizer FDD?
- Are economizers fundamentally controlled the same in packaged FDD and BU FDD?
- Is data available showing
 - FDD savings (packaged or BU)?
 - Fault incidence?
 - Fault remediation rate without FDD or programs?
- Can DDC systems have pre-programmed FDD algorithms?

Costs

- Would initial costs go to \$0 in the long-run?
 - Assuming designers or controls contractors develop and improve language over time

Feedback Request from Stakeholders

- Please let us know if you have data on:
 - Fault incidence or prevalence
 - FDD accuracy
 - Potential energy savings
 - Potential costs
- To respond:
 - Call or email CASE author
 - Email info@title24Stakeholders.com

Thank you.

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