**CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)**

# Residential HVAC Verification and Diagnostics

Measure Number: 2016-RES-HVAC1-F

Residential 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 proposal for Residential HVAC (Heating, Ventilation, and Air Conditioning) Verification and Diagnostics. 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

Residential HVAC Verification and Diagnostics 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 | | Yes | | | Yes |

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

## Measure Description

Section 2 of this report provides detailed information about the code change proposal including: Section 2.2 Summary of Changes to Code Documents (page 5) 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 6)
- Table 4: Appendices Impacted by Proposed Code Change (page 6)

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

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.

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

- **Impact on builders:** No expected impact on builders as the protocols and actions are related entirely to installers and HERS Raters.
- **Impact on building designers:** These particular measures will have no impact on building designers, as the protocols and actions are related entirely to installers and HERS Raters.
- **Impact on occupational safety and health:** The proposed code change is not expected to have an impact on occupational safety and health.
- **Impact on building owners and occupants:** If FIDs are utilized more frequently, occupants will be able to contact technicians at the onset of a fault, improving the life of the equipment and potentially saving significant energy. Building owners will also be notified by the installer of delayed charge verification, reducing the likelihood of surprise or confusion when a HERS Rater returns to verify charge.
- **Impact on equipment retailers (including manufacturers and distributors):** More manufacturers may develop FIDs or convert commercial FDD products to residential applications. Manufacturers currently producing FIDs may see slight increases in sales. However, CIDs have yet to gain market traction since being added as a compliance option in the 2008 Standards, so the expectations for the impact of the FID name change should be contained. Manufacturers of air-conditioning systems will not directly

experience changes in product sales, though their equipment will be installed more carefully and according to their recommended procedures.

- **Impact on energy consultants:** No expected impact on energy consultants.
- **Impact on building inspectors:** There are slight clarifications in protocol for HVAC installers. In cases where an installer charges a unit when outside temperatures are below 55ºF, and the enforcement agency grants an occupancy permit before refrigerant charge has been verified, installers must notify homeowners that their charge verification is not yet complete. Installers will be required to present to the enforcement agency an agreement for delayed charge verification, including signatures from the HERS Rater and building owner. Minor changes to currently existing forms are proposed. 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:** There are no expected impacts on statewide employment from this particular measure, because these measures only slightly modify the components and protocols related to refrigerant charging.
- **Impacts on the creation or elimination of businesses in California:** No appreciable impact to California businesses.
- **Impacts on the potential advantages or disadvantages to California businesses:** No appreciable impact to California businesses.
- **Impacts on the potential increase or decrease of investments in California:** No appreciable impact expected on investments in California.
- **Impacts on incentives for innovations in products, materials or processes:** No appreciable impact expected on incentives for innovative products, materials, or processes.
- **Impacts on the State General Fund, Special Funds and local government:** No appreciable impact expected on State General fund, Special Funds, or local government funds.
- **Cost of enforcement to State Government and local governments:** The proposed measure is not a new requirement, nor does it modify existing requirements. It serves to reduce confusion by field technicians and lead to improved verification processes and equipment performance, but will not affect standard protocol. As such, it is expected to have no appreciable impact on state and local enforcement bodies. If anything, the clarification could help alleviate some burden on enforcement bodies as the measure helps clarify existing code requirements.
- **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):** If FIDs are utilized more frequently, homeowners will be able to contact technicians at the onset of a fault, improving the life of the equipment and potentially saving significant energy.

- **Impact on Renters:** If FIDs are utilized more frequently, renters will be able to contact building owners or technicians at the onset of a fault, improving the life of the equipment and potentially saving significant energy.
- **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

No energy savings are anticipated. The proposed measures are clarifications and minor modifications to code language, therefore the Statewide CASE Team did not 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.

## Cost-effectiveness

No cost effectiveness was conducted. This measure has no additional costs or savings. The proposed measures include clarifications and minor modifications to code language, for which the Statewide CASE Team reached out to stakeholders for feedback on the proposed measures, impacts on market actors, and suggestions for improvement.

## Field Verification and Diagnostic Testing

The proposed measures are primarily dependent on field technicians adding liquid line filter drier verification to their routine installation process. This is anticipated to be a simple adjustment for installers and Raters. Verification of liquid line filter drier orientation has been incorporated into the modified HERS procedures.

The clarification that prioritizes manufacturer specifications is not a new requirement, nor does it modify existing requirements. It serves to reduce confusion by field technicians and lead to improved verification processes and equipment performance, but will not affect standard protocol.

# 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 efficiency design practices and technologies.

The overall goal of this CASE Report is to propose a code change proposal for Residential HVAC Verification and Diagnostics. 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 held 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 calculate energy, demand, and environmental impacts.

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

# 2. MEASURE DESCRIPTION

## 2.1 Measure Overview

### 2.1.1 Context

The Residential HVAC Verification and Diagnostics measure is intended to reduce inefficiencies in residential HVAC (heating, ventilation, and air conditioning) equipment by improving refrigerant charging and verification procedures.

Most residential air conditioners and heat pumps are split systems with an inside coil and an outside compressor bearing unit which are connected with refrigeration tubing. Many systems are installed on-site without production line and manufacturing quality control. Though manufacturer's installation manuals instruct the technician how to safely and correctly assemble and then charge the system, many of the new air conditioners in California fail to achieve their rated efficiency due to improper amounts of refrigerant, improper evacuation, metering device malfunctions, and other problems. The energy impact of this degraded performance over the life of the equipment may be large statewide.

According to a 2012 study, technicians in the field may not understand how to test, diagnose, and repair faults properly.[1] These faults are often related to refrigerant charge. Laboratory work has shown the impact of refrigerant charge levels on energy efficiency can be significant. The proposed measures intend to ameliorate charge-related faults through minor clarifications in language.

***Liquid Line Filter Driers***

Liquid line filter driers are components of air-conditioners and heat pumps that are installed in the refrigerant line in order to remove noncondensables, like moisture and particles, from the refrigerant stream. These noncondensables may appear in the refrigerant line due to improper charging procedures, and results in reduced efficiency and capacity for the air-conditioner.

***Charge Indicator Displays (CIDs) and Fault Indicator Displays (FIDs)***

Section 150.1(c)7A prescriptively requires that builders with projects in Climate Zones 2 and 8 through 15 must complete either refrigerant charge verification or install a charge indicator display (CID) on air-cooled air-conditioning equipment or heat pump systems. CID devices detect when a unit is improperly charged, and notify occupants of the fault.

JA6.1 outlines the instrumentation specifications and the calculations required for a CID. Section JA6.1.1 states that charge indicator display technologies other than what is described in Section JA6.1 are possible "when vapor compression air conditioner and heat pump system

[1] DNV KEMA, WO32 EM&V Interim Findings Memo for Commercial Quality Maintenance – Volume 1 - Field Observations, From WO32 EM&V Team to HVAC Project Coordination Group. August 14, 2013.

refrigerant charge, metering device and airflow operating performance can be reliably determined by methods and instrumentation other than those specifically defined." Such alternative technologies may be allowed for the CID compliance credit if the manufacturer of the product requests approval from the CEC. The Commission may then approve the device, and add the device description to the Appendix.

The Statewide CASE Team developed the term 'fault indicator display,' or FID, to convey a device that must detect a fault occurrence, including but not exclusive to refrigerant charge, metering device, and airflow related faults. The CID requirements in the 2013 Standards can also apply to devices that could be categorized under this broader term.

Both CIDs and FIDs are a subcategory of a more general set of devices known as fault detection and diagnostics devices, or FDDs. The market of FDD devices detect a range of faults in a variety of ways, described more fully in Section 3.2.2 CIDs, FIDs, and FDDs.

### 2.1.2 Measure Description

Modifications and additions are proposed for the 2013 update cycle to improve Title 24 requirements, including the following:

1. Require that a liquid line filter drier be installed and verified on air-cooled air-conditioners and heat pump systems.
2. Rename Charge Indicator Displays (CIDs) to Fault Indicator Displays (FIDs) to reflect that a broader range of devices can be submitted for approval with the CEC.
3. Clarify that manufacturer installation specifications should be used, when available, as the basis for charge verification.
4. Require that installers provide notice to homeowners that their units have not been verified of charge if outside temperatures are below 55ºF and the installer has charged the unit(s) using the weigh-in procedure, but has not used the HERS observation of weigh-in procedure for verification compliance.

The proposed changes will only modify existing code language, and will not modify the scope of the Standards. The only equipment required as a result of the standard are liquid line filter driers, which are regularly shipped and required for installation by manufacturers, and are easy to install. In addition to clarifying 2013 code language, the Statewide CASE 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 Western HVAC Performance Alliance (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, California Public Utilities Commission, and the Western Cooling Efficiency Center (WCEC).

### 2.1.3 Measure History

Residential refrigerant charging procedures and fault detection are all regulated by Title 24 Standards. Prescriptive compliance for refrigerant charging was added in the 2008 Standards, either through HERS charge verification, or through HERS verification of a Charge Indicator Display installation. These requirements are outlined in Section 150.1(c)7Ai in the 2013 Standards.

The 2013 Residential Refrigerant Charge Testing CASE report responded to shortcomings in the 2008 Title 24 Standards by revising the Reference Appendices methods of verifying correct refrigerant charge and air conditioner operation, potentially improving compliance by field technicians. These improvements included:

- Adding a Winter Setup for the Standard Charge Measurement Procedure, which allows charge testing under low outside air temperatures
- Allowing manufacturers to submit and be approved by the CEC for Special Case charge verification protocols
- Modifying criteria for testing with the subcooling method
- Eliminating the temperature split qualification method

For nonresidential buildings, fault detection and diagnostic devices (FDDs) on economizers were included in 2008 Title 24 as a compliance option, and in 2013 Title 24 as a mandatory requirement. At the time of the 2013 HVAC Controls and Economizers CASE study, FDD installation levels were very low. But due to the new mandatory requirement for units with cooling capacities greater than or equal to 54,000 Btu/h and economizers to have economizer FDD, and the constantly increasing number of new commercially available FDD tools, FDD installation levels may increase in both the residential and nonresidential sectors.

### 2.1.4 Existing Standards

Residential outdoor condensing units and refrigerant charging are already regulated by Title 24, and there are no federal preemption concerns.

The results of the American Society for Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) Standard Project Committee (SPC) 207 may have significant implications for expanding the role of Fault Indicator Displays and more generally, fault detection and diagnostic devices.[2] ASHRAE SPC 207P, launched in 2012, is responsible for establishing a laboratory test method to test various fault scenarios. SPC 207P is not attempting to define what functionalities the FDD technologies should have in order to qualify as FDD. The SPC 207P activities are relevant to similar devices for residential applications. The committee has a goal for a public review draft in January of 2015.

[2] More information on ASHRAE SPC 207 available at: http://spc207.ashraepcs.org/

### 2.1.5 Alignment with Zero Net Energy Goals

The Statewide CASE Team and the California Energy Commission 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 residential 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.

### 2.1.6 Relationship to Other Title 24 Measures

The Nonresidential HVAC Economizer Modifications CASE may have slight overlap with these proposed measures. The nonresidential CASE proposes adding economizer FDD application requirements to JA6.3, to serve as a resource for manufacturers developing FDD devices to meet the mandatory economizer FDD requirements in Section 140.4(e) of the Standards.

No other Title 24 code change proposal for the 2016 Standards pose any significant overlap with the measures proposed in this report.

## 2.2 Summary of Changes to Code Documents

The sections below provide a summary of how each Title 24 document 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").

**Table 2: Scope of Code Change Proposal**

| Mandatory | Prescriptive | Performance | Compliance Option | Trade-Off | Modeling Algorithms | Forms |
|---|---|---|---|---|---|---|
| Yes | Yes | No | No | No | No | 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) |
|---|---|---|---|
| 150.0(h)3 | Mandatory Features and Devices – Space Conditioning Equipment | M | E |
| 150.1(c)7A | Prescriptive Standards/Component Package – Space Heating and Space Cooling, Refrigerant Charge | Ps | E |
| 150.2(b)1F | Alterations – Prescriptive Approach, Altered Space-Conditioning System - Mechanical Cooling | Ps | E |

### *Appendices*

The proposed code change will modify the sections of the indicated appendices 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**

| JOINT APPENDICES | | |
|---|---|---|
| **Section Number** | **Section Title** | **Modify Existing (E) New Section (N)** |
| JA6.1 | HVAC System Fault Detection and Diagnostic Technology - Charge Indicator Display (CID) | E |
| **RESIDENTIAL APPENDICES** | | |
| **Section Number** | **Section Title** | **Modify Existing (E) New Section (N)** |
| RA2.4.4 | Residential HERS Verification, Testing, and Documentation Procedures – Summary of Responsibilities: Enforcement Agency | E |
| RA3.2 | Field Verification and Diagnostic Testing of Refrigerant Charge for Air Conditioners and Heat Pumps | E |

### *Simulation Engine Adaptations*

Impacts from specific charge verification protocols, outside of the installation of a CID to attain a compliance credit, are not currently modeled in the simulation engine. Changes to simulation engine algorithms are not anticipated.

### 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 to the scope.

**Changes in Mandatory Requirements**

In Section 150.0(h), the proposed measure requires the use of liquid line driers on air-cooled air conditioners and heat pump systems.

**Changes in Prescriptive Requirements**

In Section 150.1(c), the proposed measure renames charge indicator displays (CIDs) to fault indicator displays (FIDs). In Section 150.2(b), the proposed measure also updates CIDs to FIDs.

### 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**

**JA6.1 – HVAC System Fault Detection and Diagnostic Technology - Charge Indicator Display (CID):** The proposed measure revises the name of the CID section to FID to reflect that a broader range of devices can be submitted for approval with the CEC.

**RESIDENTIAL APPENDICES**

**RA2.4.4 – Enforcement Agency:** When air conditioning systems are charged in outside air temperatures below 55°F, but are not verified for charge compliance, the proposed measure requires that installers notify homeowners that their units have not completed charge verification.

**RA3.2 – Field Verification and Diagnostic Testing of Refrigerant Charge for Air Conditioners and Heat Pumps – Standard Charge Verification Procedure:** The proposed measure reinforces that manufacturer installation specifications should be used, when available, as the basis for charge verification prior to the generic superheat Table RA3.2-2. Also, liquid line filter drier verification requirements are added to the HERS verification procedures.

### 2.2.4 Residential Alternative Calculation Method (ACM) Reference Manual Change Summary

The proposed code change will require that ACM Reference Manuals change the name of Charge Indicator Display to Fault Indicator Display. No algorithm changes will be necessary.

### 2.2.5 Compliance Forms Change Summary

The proposed code change will modify the following compliance forms listed below. Compliance forms will be changed to reflect HERS verification of liquid line filter driers, the name change from CID to FID. Compliance forms that will be revised accordingly include:

- **CF2R-MCH-25a-H** – Refrigerant Charge Verification – Superheat Method (Standard Charge Procedure)
- **CF2R-MCH-25b-H** – Refrigerant Charge Verification – Subcooling Method (Standard Charge Procedure)
- **CF2R-MCH-25c-H** – Refrigerant Charge Verification – Weigh-in Procedure
- **CF2R-MCH-25e-H** – Refrigerant Charge Verification – Charge Indicator Display (CID)
- **CF2R-MCH-25f-H** – Refrigerant Charge Verification – Winter Setup for Standard Charge Verification
- **CF3R-MCH-25a-H** – Refrigerant Charge Verification – Superheat Method (Standard Charge Procedure)
- **CF3R-MCH-25b-H** – Refrigerant Charge Verification – Subcooling Method (Standard Charge Procedure)
- **CF3R-MCH-25c-H** – Refrigerant Charge Verification – Weigh-in Procedure
- **CF3R-MCH-25e-H** – Refrigerant Charge Verification – Charge Indicator Display (CID)
- **CF3R-MCH-25f-H** – Refrigerant Charge Verification – Winter Setup for Standard Charge Verification

In the CF2R-MCH-25c form only, a requirement will need to be added that installers notify homeowners that refrigerant charge has not yet been verified, if installers charge units when outside temperatures are below 55ºF and do not use the Section RA3.2.3.2 HERS Rater Observation of Weigh-In Charging Procedure. Also in CF2R-MCH-25c, the installer would also be required to present to the local building enforcement signatures of agreement for the delayed charge verification from the HERS Rater and homeowner or building owner.

### 2.2.6 Simulation Engine Adaptations

The proposed measures are in-field protocol improvements, which cannot be modeled with simulation engines. The addition of liquid line drier equipment will likely reduce energy penalties when noncondensables faults occur in air conditioning units. But since energy impacts of air conditioner faults are not modeled in the Residential ACM, and the variation in energy savings depend on the fault present, changes to modeling algorithms will not be necessary.

### 2.2.7 Other Areas Affected

The proposed code change will modify the following additional areas: no other areas affected.

## 2.3 Code Implementation

### 2.3.1 Verifying Code Compliance

The proposed measures will primarily impact HERS Raters (in addition to installers). Liquid line filter driers will be added to the HERS charge verification procedures, which are a quick and simple check.

As described in Section 3.2.3 Refrigerant Charge Verification, the Residential Appendices already prioritize manufacturer specifications in the charge verification procedures. Neither HERS Raters nor HERS Providers will be required to check whether installers have notified homeowners that their unit has not yet been charged.

There will be no additional compliance forms as a result of this measure, rather only modifications to existing forms.

### 2.3.2 Code Implementation

The proposed measures will not significantly impact the ability of builders and installers to comply, as the measures are clarifications of 2013 Title 24 requirements and do not add significant expense, and the building industry is accustomed to complying with Title 24. The proposed measures do not change the status quo of the 2013 Title 24 Standards, and will not alter the design of HVAC systems nor the timing of compliance verification.

HVAC Installers will need to ensure that liquid line filter driers are installed, which is common practice, but occasionally overlooked. Liquid line filter driers pre-installed by manufacturers are sometimes installed within condensing units, making it difficult for technicians to access. However, manufacturers have begun changing this practice and installing liquid line filter driers outside of condensers, so that they can be easily serviced by technicians, and consequently, more easily verified for installation by HERS Raters.

HVAC installers will need to notify homeowners that their charge verification process is not yet complete, but the notification method is left up to the installers' discretion. An example notice will be provided in the Residential Compliance Manual.

### 2.3.3 Field Verification and Diagnostic Testing

The proposed measures are primarily dependent on field technicians adding liquid line filter drier verification to their routine installation process. This is anticipated to be a simple adjustment for installers and Raters. The quality of installation is important to the effectiveness of the liquid line filter drier, as some liquid line filter driers can be installed without regard to the direction of refrigerant flow. Heat pumps, for example, allow refrigerant flow in both directions. However, in other air conditioners where refrigerant flow only occurs in one direction, the orientation of the liquid line filter drier will matter. Verification of liquid line filter drier orientation has been incorporated into the modified HERS procedures.

The clarification that prioritizes manufacturer specifications is not a new requirement, nor does it modify existing requirements. It serves to reduce confusion by field technicians and lead to

improved verification processes and equipment performance, but will not affect standard protocol.

## 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 key members of the WHPA Fault Detection and Diagnostics (FDD) 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.

- **Liquid line filter drier:** The development of the code language further developed through the aid of several HERS Raters. The Statewide CASE Team incorporated their suggestions on specific language into the proposal.
- **Rename CIDs to FIDs:** This measure originally had the scope of rewording the instrumentation specifications and the calculations language in Section JA6.1 to allow more types of fault indicator displays to comply. After discussions with several fault detection and diagnostic device manufacturers, the Statewide CASE Team determined that the current device description in JA6.1 was far too specific to allow a broad range of devices to comply. Stripping back instrumentation and calculation methods would be necessary to broaden the types of devices that would be compliant.

  Rather than stripping back the specifications, and possibly needing to add them back in future code cycles, the Statewide CASE Team opted to encourage and emphasize the CEC device approval process[3] by changing the names of devices from CIDs to FIDs.

# 3. MARKET ANALYSIS

The Statewide CASE Team performed a market analysis with the goals 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 held in May 2014.

[3] Section JA6.1.1 states that charge indicator display technologies other than what is described in Section JA6.1 are possible, and that such alternative technologies may be allowed for CID compliance credit if the manufacturer of the product requests approval from the CEC. The Commission may then approve the device, and add the device to the Appendix.

## 3.1 Market Structure

The market impacted by this proposal is primarily composed of FDD manufacturers (including FID manufacturers), builders, installers, HERS Providers, HERS Raters, and enforcement agencies. The Statewide CASE Team has been working with the Western HVAC Performance Alliance (WHPA) to ensure that the perspectives of manufacturers and technicians are understood. Stakeholders engaged during WHPA meetings and/or the stakeholder meeting included members of:

- **HVAC Manufacturers:** Trane, Lennox, Daikin McQuay, Emerson, Rheem, Carrier
- **FDD Manufacturers:** Field Diagnostics, EcoFactor, Honeywell, Johnson Controls
- **HERS Raters:** BG Rater Services, E3 Norcal, George Nesbitt
- **HERS Providers:** CalCERTS, CHEERS
- **Research Organizations, Consultants, and Industry Representatives:** Air Conditioning Heating and Refrigeration Institute (AHRI), WHPA, Purdue University, Proctor Engineering, 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

### 3.2.1 Liquid Line Filter Driers

Liquid line filter driers are common, inexpensive, easily installed, and usually shipped by original equipment manufacturers (OEMs) along with their cooling systems, but are occasionally not installed on site. Manufacturers typically require the installation of these components for optimal performance, when they do not install them themselves. Liquid line filter driers remove particulates and moisture from the refrigerant line, and one stakeholder suggested that lab testing shows that liquid line filter driers remove sequestered moisture from the refrigerant R-410A lubrication system, which is hydrophilic.[4]

### 3.2.2 CIDs, FIDs, and FDDs

Both CIDs and FIDs can be categorized as subsets of fault detection and diagnostic (FDD) devices. FDD devices, described further below, detect when a fault occurs in an air-conditioning unit, diagnose the cause of the fault, and typically notify an occupant or technician. Since CIDs have not yet become prevalent in the market, this proposal encourages a more expansive range of tools that can comply with the prescriptive requirement.

Charge indicator displays operate similarly to general FDD devices. JA6.1 requires that CIDs, at a minimum, detect when an air-conditioning unit has a fault related to charge, metering

[4] Discussion with Robert Mowris. July 29, 2014.

device, or airflow, and that the CID notify the occupant. CIDs are not yet prevalent in the HVAC market, though a compliance credit has been offered for their implementation since the 2008 Title 24 Standards. At this time, Fault Indicator Displays are not a distinct product subset, just as charge indicator displays were not at the time of the 2008 Standards updates. Nonetheless, the name suggests the functionality of FIDs – they detect when an air-conditioning unit has a fault (even beyond those required in JA6.1), and notify the occupant.

Changing the name from a CID to an FID will not alter the scope of JA6.1, but will serve as a signal to the market that other types of faults are encouraged to be detected and reflect the variety of capabilities that are being developed in FDD systems.

The PIER Rooftop Unit Fault Detection and Diagnostics report, prepared by New Buildings Institute (NBI) for the CEC and published in March 2013, provides a summary of FDD tools available at the time, as shown in Figure 1 below (PIER 2013). There have been updates to several of these products since the publication of this report. The information provided here illustrates that there are a variety of commercially available FDD tools.

The majority of the systems in Figure 1 are for nonresidential applications, although residential FDD systems are becoming more prevalent, by manufacturers such as Emerson and EcoFactor. Furthermore, various stakeholders have indicated the HERS charge verification is more affordable than purchasing an FDD system, and is thus a more likely option to builders and installers, though recent research has shown that charge verification isn't always completed appropriately.[5]

[5] DNV KEMA, WO32 EM&V Interim Findings Memo for Commercial Quality Maintenance – Volume 1 - Field Observations, From WO32 EM&V Team to HVAC Project Coordination Group. August 14, 2013.

| O | Basic FDD |
|---|---|
| X | Extended FDD |

| | FDSI Insight V.1 Production | Sensus MI | ClimaCheck | SMDS | NILM | Low Cost NILM | Sentinel/Insight Beta Testing | Virtjoule | Low Cost SMDS |
|---|---|---|---|---|---|---|---|---|---|
| Low Airflow | O | O | O | | O | O | O | O | |
| Low/High Charge | | O | O | | O | O | O | O | |
| Sensor Malfunction | O | X | O | O | | | O | X | |
| Economizer not Functioning | O | X | X | O | | | O | O | |
| Compressor Short Cycling | O | X | O | | O | O | O | O | O |
| Excessive Operating Hours | O | X | O | | | | O | O | O |
| Performance Degradation | | O | O | O | O | O | O | O | O |
| Insufficient Capacity | O | X | O | | | | O | X | O |
| Incorrect Control Sequence | O | X | O | | O | O | O | O | |
| Lack of Ventilation | O | X | | O | | | O | X | |
| Unnecessary Outdoor Air | O | X | X | O | | | O | X | |
| Control Problems | O | X | O | O | | | O | O | |
| Failed Compressor | O | O | O | O | O | O | O | O | |
| Stuck Damper | O | O | O | O | | | O | X | |
| Slipping Belt | O | O | O | | O | | O | O | |
| Leaking Valves | | | O | | O | | O | X | |
| Unit Not Operational | O | X | | O | O | O | O | O | O |

**Figure 1: Overview of FDD tools. (PIER 2013)**

There is no mistaking that the primary driver for manufacturers to develop residential FDD systems is a profitable nationwide market, and that simply changing the name in JA6 will not spur new product development. However, as new residential FDD products develop, and if manufacturers can apply their commercial FDD products to the residential market with moderate adjustments, more manufacturers may pursue submitting their devices for CEC approval.

### 3.2.3 Refrigerant Charge Verification

***Installer Notification to Homeowners***

Installers using the standard charge verification procedure may have the HERS Rater independently verify charge using a group sampling procedure. Installers employing the weigh-in charging method must have HERS Raters observe the weigh-in method for charge verification, and 100% of the units must be tested (e.g., no group sampling).

Section RA2.4.4 describes how the enforcement agency can grant approval of dwelling units if an installer uses the weigh-in charge method without yet having a HERS Rater verify the charge. This can only happen when the unit is charged with the weigh-in procedure when

outside temperatures are below 55ºF, if allowed by manufacturer instructions, and requires that the installer submit to the enforcement agency a signed declaration agreeing to return to correct refrigerant charge if a HERS Rater determines that correction is necessary. (This assumes that the HERS Rater verifies the system when outside temperatures are above 55ºF). Under this process, the HERS Rater may use the standard charge verification procedure outlined in Section RA3.2.2, but cannot use group sampling procedures according to RA2.4.4.

There is currently no requirement for installers to ensure that homeowners are made aware that their unit has not been verified for correct charge. Homeowners may call technicians if trying to operate a unit that is malfunctioning due to improper charge, or be surprised or unwilling to comply when a HERS Rater or installer returns to their dwelling to verify charge.

***Manufacturer's Instructions***

The Residential Appendices of the 2013 Standards generally defer charge verification to the manufacturer's specifications:

- Table RA3.2-1 – Refrigerant Charge Verification Protocols and Compliance Criteria, states that for variable metering devices the subcooling is within a tolerance of the manufacturer-specified target, and that the superheat must meet the manufacturer's specifications for both installer and HERS Rater testing.
- Section RA3.2.2 states that "The standard charge verification procedure […] does not relieve the installing contractor from any obligation to conform to the manufacturers' specifications for installation, refrigerant charge, or system operation."
- In Section RA3.2.2.6.1, item (b), which outlines fixed metering device calculations, the target superheat must be determined using the generic Table RA3.2-2 in the Appendices or the manufacturer's superheat chart.
- In Section RA3.2.3 Weigh-in Charging procedures state that HVAC installers shall use the weigh-in charging procedure in accordance with the space conditioning system manufacturer's specifications.

These instructions confirm that manufacturer's specifications should be prioritized when verifying charge.

## 3.3 Useful Life, Persistence, and Maintenance

The proposed measures are not necessarily expected to improve the life of the systems. The installation of liquid line filter driers or FIDs on air-conditioning units may help maintain efficient equipment operation and reduce cycling, but the Statewide CASE Team is unaware of studies that document how much improvement they may yield over a lifetime of operation. Nonetheless, the modifications proposed should not significantly alter field practices, but rather reinforce what is already common practice or required by the Standards.

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 reduced energy expenditures as noted below in Section 3.5, which would likely increase demand for construction.

This particular code change proposal will have little impact on builders, as the protocols and actions are related mostly to installer and HERS Rater procedures.

Installers may need to prepare simple notices similar to the example proposed to be included in the 2016 Residential Compliance Manual for distribution to homeowners. We do not anticipate that this will require a significant amount of resources or effort on the part of the installer.

### 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. These particular measures will have no impact on building designers, as the protocols and actions are related entirely to installers and HERS Raters.

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.

### 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 of occupants or those involved with the construction, commissioning, and ongoing maintenance of the building.

### 3.4.4 Impact on Building Owners and Occupants

If FIDs are utilized more frequently, occupants will be able to contact technicians at the onset of a fault, improving the life of the equipment and potentially saving significant energy. Building owners will also be notified by the installer of delayed charge verification, reducing the likelihood of surprise or confusion when a HERS Rater returns to verify charge.

### 3.4.5 Impact on Retailers (including manufacturers and distributors)

More manufacturers may develop FIDs or convert commercial FDD products to residential applications. Manufacturers currently producing FIDs may see slight increases in sales. However, CIDs have yet to gain market traction since being added as a compliance option in the 2008 Standards, so the expectations for the impact of the FID name change should be contained. Manufacturers of air-conditioning systems will not directly experience changes in product sales, though their equipment will be installed more carefully and according to their recommended procedures.

### 3.4.6 Impact on Energy Consultants

There is no expected impact on energy consultants.

### 3.4.7 Impact on Building Inspectors

There are slight clarifications in protocol for HERS Raters. In cases where an installer charges a unit when outside temperatures are below 55ºF, and the enforcement agency grants an occupancy permit before refrigerant charge has been verified, installers will need to notify homeowners that their charge verification is not yet complete. Installers will also be required to present to the enforcement agency an agreement for delayed charge verification, including signatures from the HERS Rater and building owner.

### 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, because these measures only slightly modify the components and protocols related to refrigerant charging.

## 3.5 Economic Impacts

The proposed Title 24 code changes 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.[6]

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 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)7, 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).

These particular proposed measures are minor modifications that not expected to have any impact on California's economy:

- Any increase in the installation of FIDs would be a result of complex market dynamics, and not necessarily attributable to this measure.
- Liquid line filter driers are already predominantly installed. This measure underscores the importance of installing them and requires their verification by a HERS Rater, but this is a minor addition to 20 minute or longer procedure.
- Clarifications that prioritize manufacturers' specifications only reinforce the 2013 Standard intent.

### 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).

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[6] 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.

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

These particular proposed changes are not expected to affect jobs in California, because the minor changes are not expected to result in energy impacts.

### 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 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).[8] 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 the

[8] 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.

Appendix A: Job Creation by Industry of this CASE Report.

**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 |
| 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 |

These particular proposed changes are not expected to affect businesses in California, because the minor changes are not expected to result in energy impacts.

### 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.

These particular proposed changes are not expected to affect businesses in California, because the minor changes are not expected to result in energy impacts.

### 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).

These particular proposed changes are not expected to affect businesses in California, because the minor changes are not expected to result in energy impacts.

### 3.5.5 Incentives for Innovation in Products, Materials, or Processes

As discussed in Section 3.2.2, there may be an incentive for FDD manufacturers to innovate and develop an FID product specific to the California market. However, when CIDs were introduced in the 2008 Standards, they were not shown to have this affect. Furthermore, increases in sales of FIDs cannot be attributable solely to the Standards, but are dependent on complex market dynamics.

### 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.

**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 Standards are expected to increase economic growth and income with positive impacts on local revenue.

This standard 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

We expect that the proposed code changes for the 2016 Title 24 code change cycle would reduce energy costs and could put potential first-time homeowners in a better position to afford mortgage payments. On the other hand, homeowners may experience higher first costs to the extent that builders pass the increased costs of Title 24 compliance through to home buyers. Some financial institutions have progressive policies that recognize that home buyers can better afford energy efficient homes (even with a higher first cost) due to lower energy costs.[9]

Renters will typically benefit from lower energy bills if they pay energy bills directly. These savings should more than offset any capital costs passed-through from landlords. Renters who do not pay directly for energy costs may see more of less of the net savings based on how much landlords pass the energy cost savings on to renters.

On average, low-income families spend less on energy than higher income families, however lower income families spend a much larger portion of their incomes on energy (Roland-Holst 2008). Thus it seems reasonable that low-income families would disproportionately benefit from Title 24 standards that reduce residential energy costs.

[9] For example, see US EPA's Energy Star website for examples: http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.showStateResults&s_code=CA.

# 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 |
| 4/28/14 | FDD Committee | Nonresidential and residential proposed measures |
| 5/12/14 | FDD Committee | Residential proposed measures |
| 5/14/14 | Statewide CASE Team and Kristin Heinemeier, John Proctor | Residential proposed measures |

| Date | Meeting | Description |
|---|---|---|
| 6/9/14 | FDD Committee | Status update of residential and nonresidential measures |

The stakeholder meeting for the Residential HVAC Verification and Diagnostics measure was held via webinar on May 21st, 2014. The Statewide CASE Team also presented this measure at the CEC Staff Workshop on July 21st, 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 |
|---|---|---|
| Mark Cherniack | Western HVAC Performance Alliance | Efficiency Advocate |
| Abram Conant | Proctor Engineering | Engineering Consultant |
| Jon Douglas | Lennox International | HVAC Manufacturer |
| Shane Easter | EcoFactor | Manufacturer |
| Tom Garcia | California Building Officials | Industry Representative |
| Bruce Goetz | BG Rater Services | HERS Rater |
| Dale Gustavson | Better Buildings | Building Consultant |
| Kristin Heinemeier | Western HVAC Performance Alliance | Industry Representative |
| Scott Hublou | EcoFactor | Manufacturer |
| Paul Layton | Emerson | Manufacturer |
| Richard Lord | Carrier | HVAC Manufacturer |
| Mark Lowry | Western HVAC Performance Alliance | Industry Representative |
| George Nesbitt | Consultant | HERS Rater |
| Vance Payne | National Institute of Standards and Technology | Researcher |
| 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 |
| Bob Sundberg | Western HVAC Performance Alliance (WHPA) | Industry Representative |
| Adrienne Thomle | Honeywell International | Manufacturer |
| Bart Weiland | Weiland Consulting | EE Program consultant |
| Thomas Young | Consultant | HERS Rater |
| 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 Appendix B: Original Residential FDD Measure Description. The development of the measures ultimately proposed by the Statewide CASE Team are summarized below. All of the measures were initially proposed by Marshall Hunt of Pacific Gas and Electric.

### 5.1.1 Liquid Line Filter Driers

Generally, all stakeholders contacted were supportive of this measure and considered it easy to comply. The Statewide CASE Team reached out to HERS Raters with suggestions of simple verification procedures for verification. One HERS Rater provided feedback, and minor adjustments were made accordingly.

During one of the stakeholder workshops, one stakeholder suggested adding clarification for whom the manufacturer is in situations where a third-party indoor coil is used. After the workshop, the CASE Team reached out to several stakeholders, and all agreed that the manufacturer of the outdoor unit specifies the installation of the liquid line filter drier. Also during a workshop, another stakeholder suggested making the liquid line filter drier proposal in the mandatory section, rather than prescriptive section. The CASE Team determined that the mandatory section of the Standards, under requirements for outdoor condensing units, was a more suitable location for the liquid line filter drier requirement because filter driers are specific to outdoor condensing units, rather than charge verification. These modifications were made to the proposed language, and liquid line filter drier installation verification was maintained in the refrigerant charge verification procedures in the Residential Appendix.

### 5.1.2 CIDs to FIDs

In December of 2013, the WHPA FDD committee members drafted an unofficial recommendation for the 2016 Title 24 that performance degradation devices be prescriptive for both residential and nonresidential units. This suggestion was made based on the number of FDD devices available (predominantly in the commercial market), the variety of faults could be captured when measuring performance degradation, and the variety of methods that could detect degraded performance. However, in the context of the limited scope and abridged schedule for this measure, the necessary analysis associated with the WHPA's proposed change was ultimately determined to be too large. Instead, minor changes to the Charge Indicator Display specifications in JA6 were pursued to attempt to encourage more fault

detection devices in the residential market, though the Statewide CASE Team recommends revisiting this proposal ahead of the 2019 code, as described in Section 5.2.

Section JA6.1.1 states that CID technologies other than what is described in Section JA6.1 are possible, and that such alternative technologies may be allowed for CID compliance credit if the manufacturer of the product requests approval from the CEC. The Commission may then approve the device, and add the device to the Appendix. The Statewide CASE Team offered the simple solution of changing the name from a CID to an FID, as discussed in Section 3.2.2 CIDs, FIDs, and FDDs. For further information, please see Section 2.4 Issues Addressed During CASE Development Process.

In the long term, the results of ASHRAE Standard Project Committee 207 will significantly inform the development of all FDD device testing and functionality, including FIDs. In the 2019 code cycle, JA6 may be able to award compliance credits to devices adhering to the requirements developed in this committee.

### 5.1.3 Use of Manufacturers' Specifications

The generic superheat tables RA3.2-2 Target Superheat were originally developed several years ago because manufacturer instructions may not have been available, particularly in retrofit situations. The tables remain in case manufacturer instructions cannot be found, but typical practice is for installers to leave the instructions at the unit, and instructions are more frequently being made available online.

The 2013 Standards include language referring to the manufacturer instructions, and code change proposals to clarify and strengthen the use of manufacturer instructions in the 2016 Title 24 were generally unopposed.

### 5.1.4 Installers Notifying Homeowners That Charge Verification is Not Complete

The Statewide CASE Team discussed the potential impact of this measure with building officials, and no significant impacts were anticipated. One stakeholder, a CALBO member, suggested that an agreement between installers, HERS Raters, and building owners be included in the proposed changes to the compliance form, to indicate to the local building department that all parties were aware of the delayed charge verification. The Statewide CASE Team proposed adding this section to an existing compliance form accordingly.

Neither the proposal nor the original section of code allow for 'conditional approvals' of dwelling units.

## 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 insufficient data and resources. In order to make significant improvements for the 2019 Title 24, a scope of work will be developed that may include some of the following measures that could not be pursued during the 2016 code cycle.

- As mentioned several times in this report, coordinating with ASHRAE Standard Project Committee 207 may have significant implications for expanding the role of FDD in residential applications. Pursuing the WHPA's (unofficial) proposal that performance degradation devices be prescriptive for both residential and nonresidential units, described in Section 5.1.2 CIDs to FIDs, may benefit significantly from developments in ASHRAE SPC 207. Furthermore, several nationwide manufacturers that have thousands of residential FID systems in operation have indicated to the Statewide CASE Team that they are willing to share field data available for research efforts to further the inclusion of FID systems in the Standards.[10]
- The Statewide CASE Team generally believes there is uncertainty when an enforcement agencies approve occupancy when installers delay the charge verification procedures. For example, RA2.4.4 requires that the weigh-in procedure be used if installers would like to delay charge verification, but some manufacturers require alternate procedures instead of the weigh-in process when temperatures are below 55ºF (such as charging based on the change in factory lineset length). Furthermore, HERS Raters who find that charge correction is needed may be faced with the dilemma of pursuing unresponsive installers and builders, versus receiving their payment for their services. Solutions to these issues must be explored leading up to the 2019 code cycle. In discussions with the CEC, some of the code language proposed for the compliance manual and compliance form in this CASE Report may be implemented as an addendum for the 2013 code cycle. Asking installers to indicate on compliance forms whether they notified homeowners of a delayed charge verification will effectively add data to the HERS registry on the frequency of this practice. This may lead to a better understanding of the potential scope of incorrectly charged units.
- Reducing the mandatory W/CFM and increasing the mandatory CFM/ton requirements were briefly explored during this code cycle, but the Statewide CASE Team determined that significant research and cost effectiveness analysis is necessary to develop a code change proposal. The Department of Energy (DOE) recently passed fan efficacy legislation taking effect in 2019 that set W/CFM maximums for furnace fans, depending on fan size. The DOE efficacy requirements are often stricter than the 0.58 W/CFM that Title 24 requires for ducted space conditioning systems.[11] Developing a scope of work for attaining appropriate field and lab data to support these code changes will be very important for the 2019 code cycle.
- One stakeholder suggested that the superheat tolerances in the variable metering device charge verification protocols (Table 3.2-1) are too wide (they are currently 3ºF ≤ Superheat ≤ 26ºF for HERS Raters). The stakeholder suggested further research for the potential impact of reducing this tolerance.

[10]Pham, Hung (Emerson) and Hublou, Scott (EcoFactor). 2014. Personal communication. June 10.
[11] Hunt, Marshall (PG&E). 2014. Personal communication. July 8.

- A stakeholder suggested to improve test procedures to allow only outdoor/environmental test conditions when testing refrigerant pipe temperature sensors, as opposed to also allowing the pipe sensor to be in a test enclosure. In the field, the on-pipe temperature sensor is adjacent to the outdoor condensing unit and is exposed to airflow, which can affect sensor readings, but current testing procedures allow the pipe sensor to be in still air. This update was proposed for 2013, but dropped because it was pursued late in the code adoption process and became difficult to attain enough stakeholder support in time.
- Noncondensables are a fault describing air, water, or another contaminant being mixed into the refrigeration charge. Several studies show that this fault causes an increase in power consumption of between 8% and 22%.[12] To completely remediate noncondensables, proper vacuuming procedures may be necessary to include in the building standards. (Liquid line filter driers proposed in this CASE report are able to capture the water and particles in the refrigerant stream, but not the air). Noncondensables are both a residential and nonresidential issue. A field study that investigates the prevalence of residential noncondensables could inform future standard updates, or initiate commercial field studies on the same fault.

# 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

**150.0 - MANDATORY FEATURES AND DEVICES**

(h) **Space-Conditioning Equipment** […]

3. Outdoor Condensing Units

A. **Clearances.** Installed air conditioner and heat pump outdoor condensing units shall have a clearance of at least five (5) feet (1.5 meters) from the outlet of any dryer vent.

B. **Liquid Line Filter Drier**. Installed air conditioner and heat pump systems shall be equipped with liquid line filter driers if required per manufacturer's instructions.

[…]

[12] Mowris R, E. Jones, and R. Eshom. 2012. "Laboratory Measurements of HVAC Installation and Maintenance Faults." ASHRAE Transactions.

## 150.1 - PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR NEWLY CONSTRUCTED RESIDENTIAL BUILDINGS

(c) **Prescriptive Standards/Component Package** […]

7. Space Heating and Space Cooling […]

A. Refrigerant Charge. When refrigerant charge verification or ~~charge~~ fault indicator display is shown as required by TABLE 150.1-A,

i. air-cooled air conditioners and air-source heat pumps (including but not limited to ducted split systems, ducted packaged systems, and mini-split systems) shall comply with the following requirements if the procedures are applicable to the system:

a. Have measurement access holes (MAH) […]; or,

b. Be equipped with a ~~charge~~ fault indicator display (~~C~~FID) device that provides a clearly visible indication to the occupant when the air conditioner fails to meet the required system operating parameters specified in the applicable section of Reference Joint Appendix JA6 for the installed ~~C~~FID technology. The ~~C~~FID indication shall be constantly visible and within one foot of the air conditioner's thermostat. ~~C~~FID installations shall be confirmed by field verification and diagnostic testing utilizing the procedures specified in Reference Residential Appendix RA3.4.2.

*CONTINUED: TABLE 150.1-A COMPONENT PACKAGE-A Standard Building Design*

| | | | Climate Zone | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| HVAC SYSTEM | Space Heating[5] | Electric-Resistance Allowed | No | No | No | No | No | No | No | No | No |
| | | If gas, AFUE | MIN | MIN | MIN | MIN | MIN | MIN | MIN | MIN | MIN |
| | | If Heat Pump, HSPF[6] | MIN | MIN | MIN | MIN | MIN | MIN | MIN | MIN | MIN |
| | Space cooling | SEER | MIN | MIN | MIN | MIN | MIN | MIN | MIN | MIN | MIN |
| | | Refrigerant Charge Verification or ~~Charge~~ Fault Indicator Display | NR | REQ | NR | NR | NR | NR | NR | REQ | REQ |
| | | Whole House Fan[7] | NR | NR | NR | NR | NR | NR | NR | REQ | REQ |
| | [illegible] | | | | | | | | | | |

## 150.2 – ENERGY EFFICIENCY STANDARDS FOR ADDITIONS AND ALTERATIONS

(b) **Alterations** […]

1. Prescriptive approach. […]

F. Altered Space-Conditioning System - Mechanical Cooling: […]

Additionally, these systems shall comply with the following requirements as applicable:

i. In Climate Zones 2, 8, 9, 10, 11, 12, 13, 14, and 15, air-cooled air conditioners and air-source heat pumps (including but not limited to ducted split systems, ducted package systems, and minisplit systems) shall have proper refrigerant charge field verified in accordance with all applicable procedures specified in Reference Residential Appendix Section RA3.2.2, or Reference Residential Appendix RA1 if the procedures in Section RA3.2.2, or RA1 are applicable to the system, or be equipped with a ~~C~~FID that meets the requirements in Section 150.1(c)7Aib if the ~~C~~FID is applicable to the system.

a. Systems that do not comply with the minimum 300 cfm per ton airflow requirement as specified in Reference Residential Appendix Section RA3.2.2.7.2 shall comply with the procedures in Section RA3.2.2.7.3;

[…]

# 6.2 Reference Appendices

## 6.2.1 Joint Appendices

**JA6.1 – HVAC System Fault Detection and Diagnostic Technology – ~~*Charge*~~ *Fault Indicator Display (~~C~~FID)***

JA6.1.1 Purpose and Scope

[…]

~~Charge~~Fault indicator display technologies other than what is described in Section JA6.1 are possible, and when vapor compression air conditioner and heat pump system refrigerant charge, metering device and airflow operating performance can be reliably determined by methods and instrumentation other than those specifically defined in section JA6.1 such alternative ~~charge~~ fault indicator display technologies may be allowed for ~~Charge~~ Fault Indicator Display compliance credit if the manufacturer of the product requests approval from the Energy Commission. The Commission may grant such approval after reviewing submittals from the applicant.

## 6.2.2 Residential Appendices

***RA2.4 – Residential HERS Verification, Testing, and Documentation Procedures – Summary of Responsibilities***

**RA2.4.4 Enforcement Agency**

[…]

If necessary to avoid delay of approval of dwelling units completed when outside temperatures are below 55°F, the enforcement agency may approve compliance with the refrigerant charge verification requirements when installers have used the Weigh-in Charging Method described in Reference Residential Appendix RA3, Section RA3.2.3.1 and have not used the Section RA3.2.3.2 option for HERS verification compliance. This approval will be on the condition that installers submit to the enforcement agency a registered Certificate of Installation that includes a signed declaration indicating agreement to return to correct refrigerant charge if a HERS Rater determines at a later time when the outside temperature is 55°F or above, that correction is necessary. Installers must also notify homeowners that their systems have not been verified of charge. The HERS Provider shall track these projects to ensure a HERS Rater conducts the required refrigerant charge verification for all such systems. When the outdoor temperature is 55°F or above, the HERS Rater shall use the RA3.2.2 standard charge verification procedure, or a procedure approved by the HVAC system manufacturer and Energy Commission for the refrigerant charge verification. The HERS Rater shall report the diagnostic results on the applicable Certificate of Verification, and shall register the certificate with the HERS Provider. When refrigerant charge verification testing performed by the HERS Rater indicates adjustment to the charge is required, the HERS Provider shall notify the installer, and the builder or building owner that corrective action is required. The HERS Provider may also notify the enforcement agency that corrective action is required. All air-cooled air conditioners and air-source heat pumps that utilize the Weigh-In Method shall be verified by a HERS Rater using one of the applicable refrigerant charge verification procedures. Compliance with HERS verification requirements cannot utilize group sampling procedures when the installer utilized the Weigh-In Method.

***RA3.2 Field Verification and Diagnostic Testing of Refrigerant Charge for Air Conditioners and Heat Pumps***

**RA3.2.1 Purpose and Scope**

(a) The procedures in Appendix RA3.2 are for use for residential air-cooled air conditioners and air-source heat pumps to verify the systems have the required refrigerant charge.

[…]

(d) Failure to follow the manufacturer's installation and charging instructions may result in significant refrigeration system faults that may invalidate refrigerant charge and metering device verification results. The installer shall certify that he/she has conformed to the manufacturer's instructions and specifications for charging the system prior to proceeding with the verification procedures in this appendix. In the case where the manufacturer has certified to the Energy Commission a "Special Case Refrigerant Charge Verification Protocol" meeting the requirements of RA1.1.1, HERS Rater refrigerant charge verification procedures shall adhere to approved special case protocol.

*RA3.2.1.1 Scope of the Standard Charge Verification Procedure*

(a) The procedures in Section RA3.2.2 are applicable to ducted split system air-cooled air conditioners and ducted split system air-source heat pumps, and may be applicable to packaged air-cooled air conditioners and packaged air-source heat pumps.

[…]

(f) The applicable procedures in Section RA3.2.2 shall always be used by the HERS Rater for verification of the system's refrigerant charge when HERS verification is required for compliance unless ~~an applicable alternate procedure~~ a Special Case Protocol is available in Reference Residential Appendix RA1, or the Standards specify the Section RA3.2.3.2 procedure (observation of weigh-in) as mandatory for compliance, or as an available option for compliance and the HVAC installer elects to use the RA3.2.3.2 procedure for HERS verification.

[…]

*RA3.2.1.2 Scope of the Weigh-In Charging Procedure*

(a) The procedures in Section RA3.2.3 are applicable to air-cooled air conditioners or air-source heat pumps.

[…]

(e) The procedures in Section RA3.2.3.1 may be used by the HVAC installer as an alternative to the Standard Charge Verification Procedure in RA3.2.2~~, or as an alternative to any applicable Special Case Refrigerant Charge Verification Protocol in Reference Residential Appendix RA1~~.

[…]

**RA3.2.2 Standard Charge Verification Procedure**

[…]

*RA3.2.2.5 Liquid Line Filter Drier Installation*

Liquid line filter driers shall be installed if required per outdoor condensing unit manufacturer's instructions, and installed with the proper orientation with respect to refrigerant flow, if applicable.

[…]

**RA3.2.3 Weigh-in Charging Procedure**

[…]

*RA3.2.3.1 HVAC Installer – Weigh-in Charging Procedure*

[…]

RA3.2.3.1.5 Liquid Line Filter Drier Installation

Liquid line filter driers shall be installed if required per outdoor condensing unit manufacturer's instructions, and installed with the proper orientation with respect to refrigerant flow, if applicable.

[…]

*RA3.2.3.2 HERS Rater – Observation of Weigh-in Charging Procedure*

When the Standards indicate this procedure is required, or is an option for compliance, the HERS Rater shall coordinate with the HVAC Installer to observe the weigh-in charging procedure.

HERS Rater shall observe and confirm:

(a) The system is evacuated to 500 microns or less and, when isolated, rises no more than 300 microns over five minutes.

(b) The lineset correction is calculated based on the length and diameter of the lineset, including the liquid line filter drier if required per outdoor condensing unit manufacturer instructions.

(c) The indoor coil correction to refrigerant weight is used if it is supplied by the manufacturer.

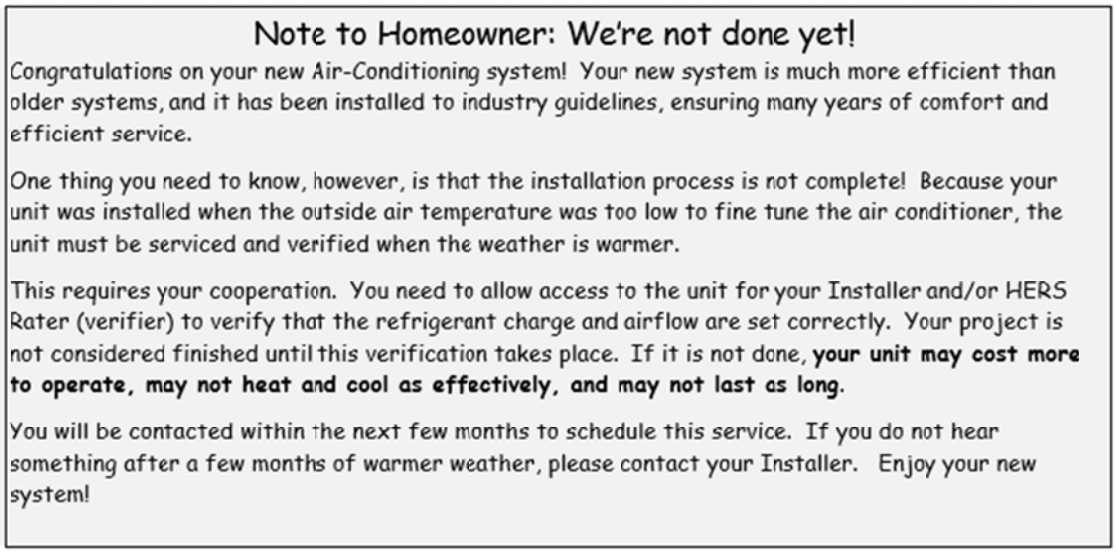
(d) The installer adds or removes the amount of charge calculated for the lineset correction or installs the total charge based on lineset, indoor coil, and standard label charge.

## 6.3 ACM Reference Manual

The proposed code change will require that ACM Reference Manuals change the name of Charge Indicator Display to Fault Indicator Display. No algorithm changes will be necessary.

## 6.4 Compliance Manuals

Chapter 4 Building HVAC Requirements and Chapter 9 Additions, Alterations and Repairs of the Residential Compliance Manual will need to be slightly revised. Chapter 4 will provide the following example of an adequate notice that installer should provide to homeowners when dwellings have been approved for occupancy without refrigerant charge verification.



Note to Homeowner: We're not done yet!

Congratulations on your new Air-Conditioning system! Your new system is much more efficient than older systems, and it has been installed to industry guidelines, ensuring many years of comfort and efficient service.

One thing you need to know, however, is that the installation process is not complete! Because your unit was installed when the outside air temperature was too low to fine tune the air conditioner, the unit must be serviced and verified when the weather is warmer.

This requires your cooperation. You need to allow access to the unit for your Installer and/or HERS Rater (verifier) to verify that the refrigerant charge and airflow are set correctly. Your project is not considered finished until this verification takes place. If it is not done, **your unit may cost more to operate, may not heat and cool as effectively, and may not last as long.**

You will be contacted within the next few months to schedule this service. If you do not hear something after a few months of warmer weather, please contact your Installer. Enjoy your new system!

**Figure 2: Example of notification to homeowners**

## 6.5 Compliance Forms

No new compliance forms will need to be created. Instructions on the following forms will need to be revised to include liquid line filter drier verification instructions.

- **CF2R-MCH-25a-H** – Refrigerant Charge Verification – Superheat Method (Standard Charge Procedure)
- **CF2R-MCH-25b-H** – Refrigerant Charge Verification – Subcooling Method (Standard Charge Procedure)
- **CF2R-MCH-25c-H** – Refrigerant Charge Verification – Weigh-in Procedure
- **CF2R-MCH-25e-H** – Refrigerant Charge Verification – ~~Charge~~Fault Indicator Display (~~C~~FID)
- **CF2R-MCH-25f-H** – Refrigerant Charge Verification – Winter Setup for Standard Charge Verification
- **CF3R-MCH-25a-H** – Refrigerant Charge Verification – Superheat Method (Standard Charge Procedure)
- **CF3R-MCH-25b-H** – Refrigerant Charge Verification – Subcooling Method (Standard Charge Procedure)
- **CF3R-MCH-25c-H** – Refrigerant Charge Verification – Weigh-in Procedure
- **CF3R-MCH-25e-H** – Refrigerant Charge Verification – ~~Charge~~Fault Indicator Display (~~C~~FID)

- **CF3R-MCH-25f-H** – Refrigerant Charge Verification – Winter Setup for Standard Charge Verification

Furthermore, any compliance forms that reference charge indicator displays will need to be revised to instead reference fault indicator displays.

In the CF2R-MCH-25c form only, a requirement will need to be added that installers notify homeowners that refrigerant charge has not yet been verified, if installers charge units when outside temperatures are below 55ºF and do not use the Section RA3.2.3.2 HERS Rater Observation of Weigh-In Charging Procedure. The Statewide CASE Team suggests adding this to the "Section F. Weigh in Charge Procedure – Additional Requirements", as a third requirement (shown in Figure 3).

| **F. WEIGH IN CHARGE PROCEDURE – ADDITIONAL REQUIREMENTS** | |
|---|---|
| 01 | All brazing of refrigerant lines done with dry nitrogen in lines and evaporator coil |
| 02 | Prior to introducing refrigerant, system is evacuated to 500 microns or less and, when isolated, has risen no more than 300 microns after 5 minutes. |
| 03 | If HERS Rater charge verification is being delayed until after dwelling is occupied, notice is provided to homeowners that charge has not yet been verified. |
| **The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.** | |

**Figure 3: Proposed language for CF2R-MCH-25c**

Also in CF2R-MCH-25c, the installer would also be required to present to the local building enforcement signatures of agreement for the delayed charge verification from the HERS Rater and homeowner or building owner, as shown in Figure 4.

<<If F03 = "Homeowner has been notified of delayed charge verification", then display this section>>

**I. DELAYED CHARGE VERIFICATION – ADDITIONAL REQUIREMENTS**

The following agreement form shall be completed:

Homeowner/builder: _____
Project Address: _____
Permit Number: _____

**Agreement**

The permit can be finalled by the local building department, because the undersigned all agree that:

- The HERS Rater will return to test the refrigerant charge and airflow at a later time when the outside temperature is above 55°F,
- The Installer will return if the HERS Rater determines that correction is necessary, and, at the Installer's expense, will correct refrigerant charge and airflow, and
- The Homeowner will provide access to the home for the HERS Rater and/or Installer at a mutually

convenient time.

**Payment for Service**

□ The fee for this service has already been paid to the HERS Rater.

□ Upon receipt of service, the fee for this service, in the amount of _____, shall be paid to the HERS Rater by the: □ Homeowner/Builder □ Installer

| | | |
|---|---|---|
| HERS Rater Name: | Signature: | Date: |
| Installer Name: | Signature: | Date: |
| Homeowner/Builder Name: | Signature: | Date: |

**Figure 4: Delayed charge verification agreement between installer, HERS Rater, and homeowner/builder.**

# 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 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.

DNV KEMA, WO32 EM&V Team. 2013. "WO32 EM&V Interim Findings Memo for Commercial Quality Maintenance – Volume 2 – Laboratory Tests." HVAC Project Coordination Group.

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

[PIER] New Buildings Institute. 2013. "Rooftop Units Fault Detection and Diagnostics: Part of the Evidence-based Design and Operations PIER Program." Prepared for the California Energy Commission Energy Research and Development Division (contract number 500-08-049). The CEC is in the process of reviewing this Final Report.

## 7.2 Literature Reviewed and Not Directly Used

Bonneville Power Administration. 2014. "National Energy Efficiency Technology Roadmap Portfolio."

Mowris, R., Eshome, R., & Jones, E. 2013. "Lessons Learned from Field Observations of Commercial Sector HVAC Technician Behavior and Laboratory Testing." 2013 International Energy Program Evaluation Conference, Chicago.

## 7.3 Other References

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American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. (ASHRAE). 2013. "ASHRAE Standard Project Committee 207 (SPC 207), Laboratory Method of Test of Fault Detection and Diagnostics Applied Commercial Air-Cooled Packaged Systems." http://spc207.ashraepcs.org.

American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. (ASHRAE). 2013. "Standard 90.1-2013: Energy Standard for Buildings Except Low-Rise Residential Buildings." ASHRAE.

[CARB] California Air Resources Board. 2008. "Climate Change Scoping Plan Appendices, Volume I." December 2008. http://www.arb.ca.gov/cc/scopingplan/document/appendices_volume1.pdf. Accessed May 27, 2014.

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Garcia, Tom (CALBO). 2014. Personal communication. July 10.

Goetz, Bruce (BG Rater Services). 2014. Personal communication. June 19.

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Proctor, John (Proctor Engineer). 2014. Personal communication. April 20.

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.

[UC Berkeley] University of California Berkeley Donald Vial Center on Employment in the Green Economy. “California Workforce Education and Training Needs Assessment for Energy Efficiency, Distributed Generation, and Demand Response”. 2011. http://www.irle.berkeley.edu/vial/publications/WET_Part1.pdf, Accessed May 27, 2014.

# 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 2010b, 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 programs.

**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: ORIGINAL RESIDENTIAL FDD MEASURE DESCRIPTION

The Statewide CASE Team spoke with the WHPA, Marshall Hunt, and John Proctor to identify potential measures for the 2016 Title 24 CASE proposal. The Statewide CASE Team also attended the Expert Meeting for HVAC Fault Detection, Diagnosis, and Repair/Replacement, hosted at the Western Cooling Efficiency Center on September 10, 2013.

***Original Residential FDD Measure, as of December 2013***

This measure description was developed primarily through interviews with John Proctor, Marshall Hunt, and the WHPA.

1. *Expand the Residential performance credit beyond charge indicator displays (CIDs) to allow third-party FDD tools that can specifically detect performance degradation. Similar to CID operation, the on-board FDD device would detect performance degradation and provide a maintenance alert, but capture the effects of a wider range of faults, or the combination of several minor faults.*
2. *Improve the accuracy of testing procedures with industry input, including the wintertime charging procedures, weigh-in method, and the lack of uniform instrumentation.*
    a. *HERS verification of refrigerant charge improves the Proposed Design model efficiency. However, because of the intrusive procedure and opportunities for error, charge verification often results in incorrect charge, especially by technicians who are not specialized in servicing cooling systems, like HERS verifiers. Revising charge verification procedures to include low cost, non-invasive methods that are also insensitive to other system faults could reduce errors when verifying charge. One method that may work well is the virtual refrigerant charge (VRC) sensor, developed by scientists at Purdue University, which can either be permanently installed to monitor system charge, or used as a standalone tool by technicians.*
    b. *Review procedures with manufacturer input to more precisely adhere to manufacturer procedures, improve test accuracy, and reduce false alarms during HERS Rater testing. One example of the latter may be done by widening the testing temperature tolerances provided by manufacturers for subcooling and superheat.*
3. *Identify paths to minimize the uncertainty of energy losses due to faults:*
    a. *For several faults, inexpensive methods can be incorporated into air-conditioning equipment that would reduce fault occurrence. Minimizing fault occurrence using existing methods, such as sight glasses, TXVs, and/or liquid line driers, could be a*

*relatively inexpensive path. This method would be preferable if, for a certain fault, field studies are deemed too difficult to conduct and would likely lead to inconclusive results on prevalence or potential energy savings.*

b. *For faults where mandating fault prevention equipment would be too costly and/or to determine uncertain energy savings, field studies may yield data that would inform if the measure is prevalent and thus cost-effective. For example, a field study investigating the prevalence of non-condensables in AC units to lay the foundation for more significant changes for the 2019 standards update. Non-condensables are a fault describing air, water, or another contaminant being mixed into the refrigeration charge. Several studies by Robert Mowris show that this fault causes an increase in power consumption of between 8% and 22%.[13] To completely remediate non-condensables, proper vacuuming procedures and/or liquid line driers may be necessary to include in the building energy efficiency standards*

4. *Increase the minimum of 350 cfm/ton of airflow and reduce the maximum of 0.58 W/cfm for ducted systems, informed by the U.S. Department of Energy furnace fan test standards.*

The measure description above omit a couple of details contained in earlier versions. These detailed suggestions, listed below, were excluded to keep the measure description fairly general:

- Requiring the use of a micron gauge during refrigerant evacuation
  - Note that John Proctor and Marshall Hunt believed that this would be difficult to enforce
- Improve test procedures to allow only outdoor/environmental test conditions when testing refrigerant pipe temperature sensors, as opposed to also allowing the pipe sensor to be in a test enclosure. In the field, the on pipe temperature sensor is adjacent to the outdoor unit and is exposed to airflow, which can affect sensor readings, but current testing procedures allow the pipe sensor to be in still air. This update was proposed for 2013, but dropped because it was pursued late in the code adoption process and became difficult to obtain sufficient stakeholder support in time.

[13] Mowris R, E. Jones, and R. Eshom. 2012. "Laboratory Measurements of HVAC Installation and Maintenance Faults." ASHRAE Transactions.