

Energy Efficiency Program Evaluation
Report - 2014 Program Year
Prepared for
Redding Electric Utility



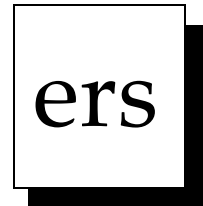
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Executive Summary

This report documents the evaluation activities undertaken by ERS for Redding Electric Utility (REU). The evaluation focuses on the energy savings impacts of the REU HVAC program for the 2013–14 fiscal year. The primary objective of the evaluation was to provide independent verification of REU’s HVAC program energy savings. The secondary objective was to provide recommendations for the program’s improvement based on the findings of this report.

The evaluation effort consisted of five primary activities: conducting research, developing evaluation plans, recruiting customers for site inspections, collecting data, and estimating energy savings. ERS combined the research and data collection results to analyze and develop energy savings estimates using standard engineering principles and evaluation methodologies. For residential HVAC measures, ERS used the Energy+Environmental Economics (E3) reporting tool and California Municipal Utilities Association Technical Reference Manual (CMUA TRM), the same source used by REU for reporting the savings. Table 1-1 provides the HVAC unit energy savings and peak demand reduction results.

Table 1-1. HVAC Program Savings – High Efficiency Units

Description	Quantity	Energy Savings (kWh)	Peak Demand Reduction (kW)
HVAC program	329 HVAC units	83,338	31.5

Based on our observations and analysis, ERS offers the following recommendations for REU’s consideration:

- ❑ For commercial HVAC units, REU should require that the applicant indicate the building or space end-use type to help identify the appropriate measure for the E3 reporting tool.
- ❑ REU should require that applicants provide the age and operating condition of their existing HVAC equipment so that early retirement savings can be reported in the E3 reporting tool.
- ❑ REU should require that commercial HVAC and heat pump units meet the applicable Consortium for Energy Efficiency (CEE) recommended efficiency ratings, which are the same as those used in the E3 reporting tool/(CMUA TRM).
- ❑ REU should modify the program-tracking database and rebate-application forms to capture more details about the equipment type, including options to identify the unit as a ductless mini-split unit and record the heating seasonal performance factor (HSPF) for the

heat pump units. CEE has minimum efficiency recommendations for the heat pump seasonal energy efficiency ratio (SEER) and HSPF.

- ❑ For HVAC system incentives, REU should determine whether the property is owner-occupied, a rental, or being purchased for resale.
- ❑ For rebate applications where the owner does not reside at the home, REU should require a post-installation inspection with pictures of the installed units and their nameplates. This will help with the potential access problems that occur when a home is sold or a tenant resides in the home, and it provides an inexpensive way to verify that the proper equipment is installed and operational.
- ❑ REU should consider offering rebates for HVAC units with evaporative-cooled condensers.

Introduction

This report documents the evaluation activities undertaken by ERS for REU. The evaluation focuses on the energy savings impacts of specific programs and projects completed during the 2013–14 fiscal year.

2.1 Focus of Evaluation

The evaluation focuses on the energy savings impacts of the HVAC program. For 2013–14, the HVAC program provided rebates for the installation of high efficiency air conditioning units for residential and commercial customers. In addition, rebates were provided for HVAC duct repair and whole-house fans.

2.2 Evaluation Objectives

The primary objective of the evaluation was to provide independent verification of REU's HVAC program energy savings. The secondary objective was to provide recommendations for the program's improvement based on the findings of this report. The initial HVAC program savings estimates indicate that more than 99% of the reported savings are associated with the installation of high efficiency air conditioning units. The evaluation focuses on verifying the savings of these units.

2.3 Overview of Evaluation Activities

The evaluation comprised the following five primary activities:

1. **Conducting research** – ERS conducted limited research and reviewed of the following:
 - a. Similar evaluation efforts
 - b. REU program process and procedures
 - c. Publicly owned utility (POU) compliance reporting requirements and methodologies
 - d. Savings estimate sources for high efficiency HVAC units
 - e. Savings estimate sources for HVAC tune-up, duct repair, and evaporative coolers
2. **Developing evaluation plan** – ERS developed a measurement and verification (M&V) plan that included site inspections and rebate application reviews to verify savings.
3. **Recruiting customers** – ERS assisted REU with the development of recruitment letters to send to the homes selected for site visits. ERS then recruited customers via telephone calls.

4. **Collecting data** – ERS obtained rebate documentation and a spreadsheet database for the program and visited selected sites to obtain information about the installation and operation of the HVAC units.
5. **Estimating energy savings** – ERS combined the research and data collection results to analyze and develop the energy savings estimates per the methodologies described in Section 3 of this report.

2.4 Report Structure

The remainder of this report consists of three segments:

1. Section 3 describes the evaluation methodologies employed for data collection, sampling, and estimating energy savings. It also provides recommendations for reporting the program's impact in terms of net-to-gross energy savings.
2. Section 4 provides the results of the HVAC program evaluation and includes key findings and recommendations for future program implementation.
3. Section 5 provides a brief discussion on the other HVAC measures included in the HVAC program.

Methodology

This section describes the M&V approach and methodologies used by ERS for sampling, data collection, and savings verification. It also provides our recommendations for reporting the program influence in terms of net-to-gross (NTG) energy savings.

3.1 Measurement and Verification Approach

The overall evaluation approach involves installation verification, documentation review, and estimation of program energy savings using the best available information.

3.2 Data Collection

ERS reviewed the REU program spreadsheet database and rebate application documentation and visited selected customer sites to collect operational (in-service, out of service, and noticeable deficiencies) and equipment (unit make, model, type, and size) information.

3.3 Verified Energy Savings

ERS used the best-available and updated information for calculating verified savings. For residential HVAC measures, ERS used the E3 reporting tool and CMUA TRM, the same source used by REU for reporting the savings. Because the savings estimates are from the same source, the only variation between the reported and verified savings would be due to the site verification. For verified savings, the HVAC units that were found to be not operating or not installed would be reported as zero savings; if units were found to be of a different size or efficiency than expected, the verified savings would be based on the unit observed on-site. However, as discussed in Section 4, all of the inspected units were found to be installed and operational, and all of the units verified were found to be the same size and type as reported.

3.4 Sampling

Using simple random sampling, twenty HVAC projects were initially selected for site evaluations to achieve a relative precision of 20% at the 90% confidence level (precision of 90/20), which is consistent with the recommendations found in the California Public Utilities Commission (CPUC) evaluation protocols¹ for the verification level of rigor. Although a sample size of sixteen sites would have met the precision requirements, ERS choose twenty to ensure that the precision requirements were met.

¹ 2006 California Energy Efficiency Evaluation Protocols, California Public Utilities Commission

The initial sampling size was twenty sites with twenty back-up sites; a total of fifteen were successfully contacted. Of those, twelve were owner-occupied and two were rental properties. One home had been sold soon after the unit was installed and we were unable to inspect it. Three of the sites had two applications, and one site had received an incentive for one unit but installed two qualifying units. Multiple attempts were made to contact the remaining sites but they were unsuccessful either because of a phone number change or non-returned voice messages.

In total, ERS verified the installation of twenty-four HVAC units by reviewing each rebate application and its supporting documentation. In addition, ERS inspected seventeen HVAC units on-site to verify their installation and operation.

3.5 Program Impact

It is important to understand and properly reflect on the impact of utility energy efficiency programs. The net impact of the program is used to demonstrate that the program is cost-effective and a wise use of ratepayer funds.

One measure of program impact is net energy savings, which is the difference between the total energy savings and the savings expected to occur in the absence of the program. To determine the net energy savings, an NTG factor is used to adjust the gross energy savings for free ridership and spillover. Free ridership describes program participants who would have implemented energy efficiency in the absence of the program, and spillover describes the program's ability to indirectly influence customer or market behavior, leading to increased energy efficiency.

Net energy savings are difficult to assess, and the results of efforts to quantify them at the measure or program level have a high degree of uncertainty. Given this uncertainty and the relatively high cost to conduct primary research, most, if not all, of the small- to medium-sized utilities choose to use stipulated NTG factors for reporting program net savings.

The POU regulatory compliance reporting tool (E3) includes stipulated NTG factors from large investor-owned utilities' (IOUs') programs. Although the scale and program delivery methods for these larger programs can greatly differ from POU programs, their NTG factors are the best available resource. For the HVAC program, the NTG factor from the E3 reporting tool is 80% for residential HVAC units and 85% for nonresidential HVAC units.

4.1 Program Summary

REU offers incentives to residents and commercial customers that purchase new HVAC units that exceed the defined minimum EER and SEER ratings. These incentives are available for retrofit and new construction projects. REU paid a total of \$179,119 in rebates for the installation of 329 high efficiency HVAC units during the 2013–14 fiscal year. REU maintains a spreadsheet-based database for the program that includes the following:

- Customer contact information
- Site address
- Make and model of unit
- Unit capacity
- Unit efficiency (EER, SEER)
- Unit type (package, split system, heat pump)
- Unit condition
- Building type (residential or commercial)
- Rebate amount

The program database also includes savings estimates for each HVAC unit. However, it does not appear as though these values are used in reporting the program savings. Consistent with the methodology used by all California POU's, REU utilizes the E3 reporting tool to report the results of its programs. HVAC unit savings values in the E3 reporting tool come from the CMUA TRM. REU also maintains hard copies of each completed rebate program application. Each application package comprises the original application, installation invoice, and duct leakage test results.

4.2 Verification of Installed HVAC Units

ERS verified twenty-four randomly-selected HVAC units. For each, the rebate application and supporting documentation was reviewed, and it was confirmed that the program database records were accurate. The documentation was found to be complete and included all of the necessary information required by the program rules. Seventeen of the twenty-four units were also verified by site inspection during the week of April 20, 2015. For each site, ERS inspected the unit and obtained the make and model numbers from the unit nameplate (pictures were

taken of each nameplate). In addition, ERS confirmed that the units were installed and connected electrically and mechanically. Disconnect switches were confirmed to be in the on position. All seventeen units were found to be operating and matched the database records for unit size, type, and efficiency rating.

4.3 Energy Savings

The energy savings for each rebate application was estimated and summed to determine the total program savings attributable to the installation of new HVAC units. The complete analysis is provided in a separate Excel spreadsheet (Analysis_2015-6-3.xlsx) as Appendix B. The verified annual savings is 83,338 kWh with a peak demand reduction of 31.5 kW.

The verified savings were estimated using modified savings values from the E3 reporting tool. The most applicable E3 tool's measure was identified for each unit. When the installed unit's efficiency did not match the E3 tool's measure efficiency, the unit savings values were proportionally adjusted based on the actual efficiency improvement compared to the efficiency improvement assumed for the E3 tool's measure. For commercial HVAC units where the building type was not known, ERS used the generic building type (commercial) available in the E3 reporting tool. When the building type was known, the applicable E3 tool's measure for that building type was selected.

A large number of installed residential units were packaged HVAC units. The E3 reporting tool does not include savings estimates specific to this type of unit. However, the savings are similar to the split-system units in the tool; therefore, ERS used split-system measure values to estimate the savings for residential package units. REU paid a large number of rebates for residential package units (199 out of 329). It is possible that these units have additional savings associated with the use of high efficiency supply fans and motors, but without additional information, the potential savings could not be reasonably estimated.

The verified energy savings are based on "natural replacement," which is defined in the CMUA TRM as the installation of a new HVAC unit to replace a preexisting unit that has either stopped working or is past its effective useful life (EUL), which is 15 years for most units. The E3 reporting tool allows for the reporting of savings when the preexisting unit is still working and has not yet reached the end of its EUL. This scenario, known as "early retirement," has a much higher first-year energy savings. Since first-year savings are used for reported savings, it is beneficial to report the savings for HVAC replacements as early retirement, when applicable. Without capturing the age of the replaced HVAC unit in the rebate application documentation, the default (natural replacement) savings values are used.

4.4 Key Findings

The following list shows the evaluation effort findings that ERS believes are important to REU:

- ❑ One-hundred-and-ninety-nine residential package HVAC units were installed, which represents more than 60% of the total units installed. This is a large percentage and is much greater than expected.

- ❑ Twenty-nine percent of the units verified (seven units) were heat pumps. This suggests that a significant number of heat pumps are used in REU's service territory.
- ❑ The majority of rebates (309 out of 329) went to residential customers.
- ❑ ERS found one customer (Site ID 52) that installed two new HVAC units but only applied for one HVAC unit rebate.
- ❑ Two of the verified units were found to be ductless mini-split heat pump units.
- ❑ Two verified sites were for applications from owners who did not live at the home where the units were installed. In one case, the owner had already sold the home. The previous owner was not aware of the new owners' contact information, which led to recruiting problems when ERS sought permission to access the site.
- ❑ Energy savings for future program years will see a reduction in residential HVAC savings (approximately 7%) because of the new federal requirements that took effect on January 1, 2015. In the E3 reporting tool, a separate measure is available for units installed after this date.
- ❑ Our analysis suggests that units classified as early retirement would provide about four times greater savings than those classified as natural replacement. This suggests it would be advantageous to report early retirement savings, where applicable.
- ❑ Using the E3 reporting tool, the total measures savings are cost-effective per the Total Resource Cost test (3.1) and Program Administrator Cost test (1.3 – not including overhead costs). However, the levelized costs are relatively high at \$0.21 per kWh.

4.5 Recommendations

For future program years, ERS offers the following recommendations:

- ❑ For commercial HVAC units, REU should require that the applicant indicate the building or space end-use type to help identify the appropriate measure for the E3 reporting tool.
- ❑ REU should require that applicants provide the age and operating condition of their existing HVAC equipment to enable the use of the early retirement reported savings in E3.
- ❑ REU should require that commercial HVAC and heat pump units meet the applicable CEE recommended efficiency ratings, which are the same as those used in the E3 reporting tool/CMUA TRM.
- ❑ REU should modify the program-tracking database and rebate-application forms to capture more details about the equipment type, including an option to identify the unit as a ductless mini-split unit and record the HSPF for the heat pump units. CEE has minimum efficiency recommendations for both heat pump SEER and HSPF.
- ❑ For HVAC system incentives, REU should determine whether the property is owner-occupied, a rental, or being purchased for resale.

- ❑ For rebate applications where the owner does not reside at the home, REU should require a post-installation inspection with pictures of the installed units and their nameplates. This will help with the potential access problems that occur when a home may have been sold or a tenant resides in the home, and it provides an inexpensive way to verify that the proper equipment is installed and operational.
- ❑ REU should consider offering rebates for HVAC units with evaporative-cooled condensers.

Additional HVAC Program Measures

In addition to high efficiency HVAC units, REU offers rebates for other HVAC measures, including the following:

- ❑ Duct repair and replacement
- ❑ HVAC tune-up/service
- ❑ Whole-house fans and evaporative coolers

The CMUA TRM and E3 reporting tool have savings estimates for whole-house fans and duct-leakage reductions. HVAC tune-ups are not included, but the IOUs have savings estimates for many a number of the individual measures that make up an HVAC tune-up. If requested, ERS can provide copies of the HVAC tune-up work papers for REU to use in reporting program savings. Savings estimates are not available for the installation of evaporative coolers, but they are for air conditioning units with evaporative-cooled condensers. REU may wish to consider offering rebates for these units.

Regarding duct repair and replacement, program claimed savings are only applicable in limited retrofit scenarios. If certain components of an HVAC system are replaced, the code requires that the system's ducts be repaired to minimize air leakage. The circumstances under which the code applies are complicated, but there is online information available to help interpret the code requirements. Appendix A features a sheet from the Title 24 Energy Code assistance website (www.energycodeace.com) designed to help identify when code requirements for low-leakage ducts applies. ERS recommends that, where applicable, the energy savings for these measures be included in REU's program reported savings.

Appendix A



ACE Residential HVAC Code Triggers



TRIGGERS for 2013 Title 24, Part 6 Residential HVAC Alterations

sponsored by the Statewide Codes and Standards Program under the auspices of the CPUC



20131007

Split Systems & Packaged Systems	Mandatory Measures					Prescriptive Requirements	
	Setback Thermostat	Cooling Load Calcs	Heating Load Calcs	HERS: Duct Seal and Test	HERS: Cooling Coil Airflow and Fan Watt Draw	Duct Insulation	HERS: Refrigerant Charge
Change this (and nothing else)	§110.2(c) §150.2(b)F	§150.0(h), §150.2(b)1C	§150.0(h), §150.2(b)1C	§150.0 (m)1-3 & 11 §150.2(b)1C,D, & E	§150.0(m)12, 13 & 15 §150.2 (b)1C, D	§150.1(c)9 §150.2(b)1D	§150.1(f)7 A §150.2(b)1 F
Whole split or packaged system (no ducts added or replaced)	YES	no	no ^A	YES^B	no	no	YES^{C, D}
Evaporator coil (cooling coil), condenser coil , or outdoor condensing unit	YES	no	no ^A	YES^B	no	no	YES^{C, D}
Furnace (air handler)	YES	no	no ^A	YES^B	no	no	YES^{C, D}
Compressor, refrigerant metering device	YES	no	no ^A	no	no	no	YES^{C, D}
Some ducts	no	maybe ^E	maybe ^{A, E}	YES^B	no	YES^F	no
"All new" ducts^G	no	maybe ^E	maybe ^{A, E}	YES^H	YES^I	YES^F	no
Whole split or packaged system and all new ducts	YES	YES^E	YES^{A, E}	YES^H	YES^I	YES^F	YES^{C, D}

NOTE:

- Replacing the blower wheel fan is considered a repair and does NOT trigger the Standards.
- All new HVAC equipment must meet minimum federal efficiency requirements
- Cooling line insulation is triggered if the line set (cooling system, suction line) is replaced or repaired. Line sets ≤1.5" in diameter must have 0.5" thick insulation.

^A Heating equipment must meet CBC minimum capacity requirements.

^B Duct systems must be sealed and verified if >40 feet of ducts in unconditioned space. Duct system leakage must be ≤15% in total, or ≤10% to the outside. Or, if unable to meet the sealing requirements, all accessible leaks must be sealed and verified by a HERS rater.

^C HERS verification of refrigerant charge is required in **climate zones 2 and 8–15 only** when a refrigerant containing component of an air conditioner or heat pump is replaced or installed in an existing building.

^D Although there are no commercially available HVAC systems with approved Charge Indicator Display (CID) devices at the time of publication (October 2013), the Standards do allow use of a CEC-approved CID should such equipment become available during the 2013 code cycle.

^E Cooling and heating load calculations are required when ducts are added to **serve new conditioned space**, such as an addition.

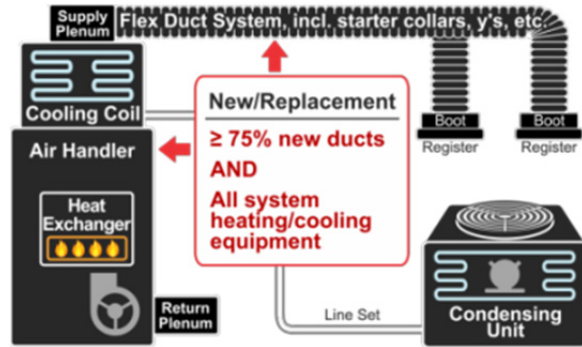
^F Mandatory duct insulation requirements (R-6) apply to all new or replacement ducts (not existing or unaltered ducts). When replacing >40 feet of ducts in unconditioned space: CZ 1-10 and 12-13: R-6; CZ 11 and 14-16: R-8. HERS verification is required for insulated ducts in conditioned space.

^G The system is considered to have "all new" ducts when 75% or more of the ducts are new material and up to 25% reused parts from the existing duct system ((e.g., registers, grilles, boots, air handler, coil, plenums, duct material) if the reused parts are accessible and can be sealed to prevent leakage.

^H In all climate zones, when new duct systems are installed in unconditioned space, leakage must be ≤6% of the air handler airflow.

^I When new duct systems are installed, cooling coil airflow must be >350 CFM per ton, and fan watt draw must be ≤0.58W/CFM. Alternatively, the system can meet the requirements in Table 150.0-C or Table 150.0-D (Return Duct Sizing and Filter Sizing).

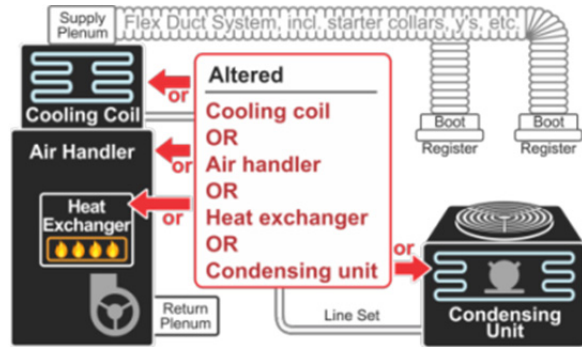
2013 Entirely New or Complete Replacement Space-Conditioning System §150.2(b)1C



A space-conditioning system is considered entirely new or a complete replacement when all of the following are installed or replaced:

- All the system heating/cooling equipment
- $\geq 75\%$ new duct material^G

2013 Altered Space-Conditioning System §150.2(b)1E, F

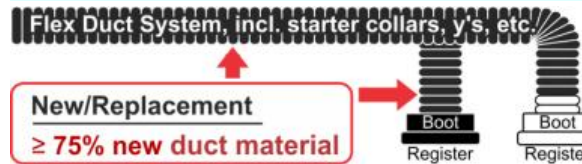


A space-conditioning system is considered altered when it is not a new or replacement system and any of the following components is installed or replaced:

- Evaporator coil (cooling coil)
- Compressor
- Condenser coil
- Air handler
- Outdoor condensing unit
- Refrigerant metering device

Replacing other components is considered a repair — not an alteration. For example, replacing the blower wheel fan, but not the heat exchanger or air handler in the furnace, is a repair.

2013 Altered or Replaced Duct Systems (Duct Sealing) §150.2(b)1D



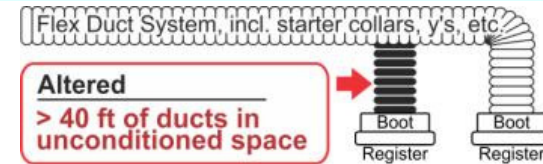
Entirely New or Complete Replacement Ducts

Entirely new or complete replacement duct systems are those that contain at least 75% new duct material. Existing duct system components (up to 25%) may be reused if they are accessible and can be sealed.^G

The Duct Sealing and Testing HERS measure must demonstrate a leakage rate less than or equal to 6% of the system air handler airflow.

In addition, verification of Cooling Coil Airflow and Fan Watt Draw (HERS measure) is required. The system must have airflow >350 CFM per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy ≤ 0.58 W/CFM.

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Alteration or Extension of Existing Ducts

In all climate zones when more than 40 feet of new or replacement system ducts are installed as an extension of an existing duct system, Duct Sealing and Testing (HERS measure) is required, and the measured leakage shall be equal to or less than 15%.

(There are alternatives to meeting the maximum 15% leakage. Consult your Building Department or §150.2(b)1Diib in the Standards.)

Required Documentation

For All HVAC Alterations

All HVAC alterations require:

- **Permit** — for all HVAC changeouts
- **CF1R: Certificate of Compliance: Alteration to an HVAC System** (CF1R-ALT-02*-E, or CF1R-ALT-03-E or CF1R-ALT-04-E) Submitted to the building department by the contractor or the home owner
- **CF2R-MCH-01-H: Certificate of Installation for Space Conditioning Systems, Ducts and Fans** Completed and signed by the installing contractor and made available for final inspection by building department

For HERS Measures

Projects with HERS measures require:

- **Registration of the CF1R, via HERS Provider**
 - **CF2R-MCH...H: Certificates of Installation for mechanical system with HERS measures** Completed and signed by the installing contractor; must be submitted to a HERS Provider Registry after the contractor has signed it, and made available for inspection by the building department
 - **CF3R-MCH...H: Certificates of Field Verification for mechanical system with HERS measures** Completed and registered by a HERS Rater for each CF2R-H; the HERS Rater or contractor ensures the relevant CF3Rs are available for final inspection by the building department.
 - **HERS: Duct Leakage Diagnostic Test**
 - CF2R-MCH-20*-H and CF3R-MCH-20*-H
 - **HERS: Fan Efficacy (Fan Watt Draw)**
 - CF2R-MCH-22-H and CF3R-MCH-22-H
 - **HERS: Space Conditioning System Airflow Rate**
 - CF2R-MCH-23*-H and CF3R-MCH-23*-H
 - **HERS: Refrigerant Charge Verification**
 - CF2R-MCH-25*-H and CF3R-MCH-25*-H
 - or
 - CF2R-MCH-25f-E (for packaged systems with refrigerant charge certified by manufacturer)
- * Correct version (e.g., "a" or "b" or "c") varies depending upon the project scope and approach used to demonstrate compliance

For Projects with New or Replacement Duct Systems using Duct and Filter Sizing

Projects that use Duct and Filter Sizing instead of the Cooling Coil Airflow and Fan Watt Draw HERS Measure require:

- **CF2R-MCH-28-H and CF3R-MCH-28-H**