

Residential Quality Installation (RQI) & WO32 HVAC Impact Evaluation



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Presentation Overview

Objective:

- DEER - Overview
- DEER – Prototype Characteristics
- DEER – Calibration
- RQI Workpaper Overview
- RQI Workpaper Measures
- WO32 (RQI) Overview
- RQI Calculation Parameters WP/WO32
- Performance Parameters for Evaluation
- **ResQI - Program Perspective by Scott Higa/SCE**

DEER - Overview

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- Energy/Demand savings estimates for “typical” energy efficient technologies and measures
- Savings ~ DEER Prototypes (e.g., SFM)
- Building characteristics
 - Building type
 - Vintage
 - CZ,
 - HVAC configuration/type
- Building Weights – Relative floor space of each building type within each IOU service territory per Bldg. Type, Vintage, and CZ

DEER – Prototype Characteristics

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| | Nonresidential Variability | | | Residential Variability | | |
|--|----------------------------|--------------|---------|-------------------------|--------------|---------|
| | Building Type | Climate Zone | Vintage | Building Type | Climate Zone | Vintage |
| General Building Characteristics | | | | | | |
| Floor Area | X | | | X | X | X |
| Number of stories | X | | | X | X | X |
| Footprint shape | X | | | X | | |
| Building Usage and Operation | | | | | | |
| Overall operating hours (open/closed) | X | | | X | | |
| Area and distribution of building activity/use types | X | | | X | | |
| Architectural Design and Performance | | | | | | |
| Glazing area | X | | | X | X | X |
| Glazing orientation | X | | | X | | |
| Glazing performance | X | X | X | | | |
| Wall/Roof/Floor construction types | X | | | X | | X |
| Wall/Roof/Floor construction performance | X | X | X | X | X | X |
| HVAC Design and Performance | | | | | | |
| Predominant HVAC system types and configuration | X | | X | X | | |
| HVAC design and operating parameters | X | X | X | X | X | X |
| HVAC equipment efficiency levels | X | | X | X | | X |
| Internal Gains Characteristics | | | | | | |
| End-use usage profiles | X | | | X | | |
| End-use intensity levels | X | | X | X | | X |
| | | | | | | |

DEER – Calibration

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- Calibration
 - Nonresidential building weights - CEUS
 - Residential building weights - RASS

RQI Workpaper Overview

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- Quality Installation (QI) of standard (SEER 14) and higher efficiency split and packaged HVAC units
- Properly sized unit, properly matched components, refrigerant charge, airflow, and sealed ducts
- Measure Objective:
 - Improve Quality Installation (QI) of mechanical (HVAC) systems in Residential applications
 - Improve HVAC system performance with QI
 - Improve HVAC system performance with efficiency upgrade
 - Savings ~ performance approach [QI + Efficiency (SEER) Upgrade]

RQI Workpaper Measures

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| QI Measure | DEER Applicability | Description |
|-------------------------------|--------------------|--|
| HVAC system sizing | N/A | ACCA Manual J ACCA Manual S |
| Air leakage reduction | DEER | Air leakage reduction of nominal system airflow |
| Reduced static pressure | N/A | kW/cfm ~ f(fan power, system airflow, and temp. gain) |
| Efficiency (SEER) Upgrade | N/A | Title-24 Baseline (SEER 14) |
| Refrigerant Charge Adjustment | DEER | N/A, assumed to be adequate between base case and measure case |

WO32 (RQI) Overview

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- Goals
 - HVAC impact evaluation of statewide programs
 - Field assessments focused on residential systems
- Field measurements
 - HVAC system sizing
 - Airflow
 - Duct leakage
- Energy/Demand savings
 - Field measurements
 - DEER Prototype eQuest/DOE2.2
- Participants – SCE (100%)
- Non-participants - PG&E, SCE (36%), and SDG&E

WO32 (RQI) Key Findings

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- On average installations exceeded T-24
- Utilities to review program opportunities to exceed T-24
- Support evaluation “to-code” pilots
- WP does not fully capture improved fan efficiencies
- WP does address ACCA Manual S to system sizing
- Realization rates:
 - ❑ 35% for energy (kWh) savings
 - ❑ 38% for demand (kW) savings
 - ❑ “Exceeding code will improve realization rates, but it is unknown if cost effective savings exist”
 - ❑ Driven by “system sizing” and “duct leakage”

Calculation Parameters WP/WO32

Flow Performance (kW/cfm)

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| WP (Basecase) | WP (Measure) | WO32 (Non-Part.) | WO32 (Part.) |
|---------------------------|---------------------------|---------------------------|---------------------------|
| 0.000510 kW/cfm | 0.000383 kW/cfm | 0.000569 kW/cfm | 0.000486 kW/cfm |

- When possible WO32 measured fan power in cooling and either heating or fan-only modes.
- “More important than airflow is the difference in the total fan power between participants and non-participants.”
- Sample input parameter from SFM DEER prototype in eQuest

Fan Power Parameters for single-duct systems

| | Design kW/cfm | Delta T °F | Static in WG | Tot Eff Frac | Mech Eff Frac | Fan EIR = f(PLR) |
|---------|---------------------------------------|-----------------------------------|----------------------|----------------------------------|----------------------------------|--|
| Supply: | <input type="text" value="0.000365"/> | <input type="text" value="1.15"/> | <input type="text"/> | <input type="text" value="n/a"/> | <input type="text" value="n/a"/> | <input type="text" value="Residential Fix Vol-Fan EIR"/> |

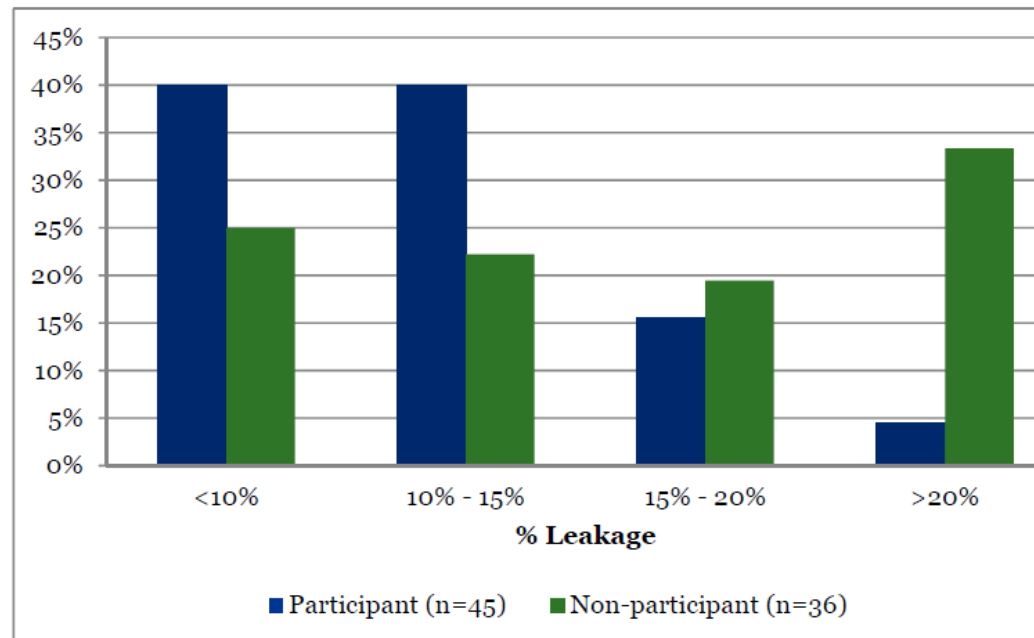
Calculation Parameters WP/WO32

Duct Leakage (%)

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| WP (Basecase) | WP (Measure) | WO32 (Non-Part.) | WO32 (Part.) |
|---------------|--------------|------------------|--------------|
| 24% (DEER) | 12% (DEER) | 16.6% | 11.5% |

- ~ 40% of participant <15%
- All part. systems required duct testing and sealing
- T-24 required duct leakage < 15% if a major component of the HVAC system is replaced or installed.
- T-24 required duct leakage <= 6% on new or significantly renovated air distribution ducts.



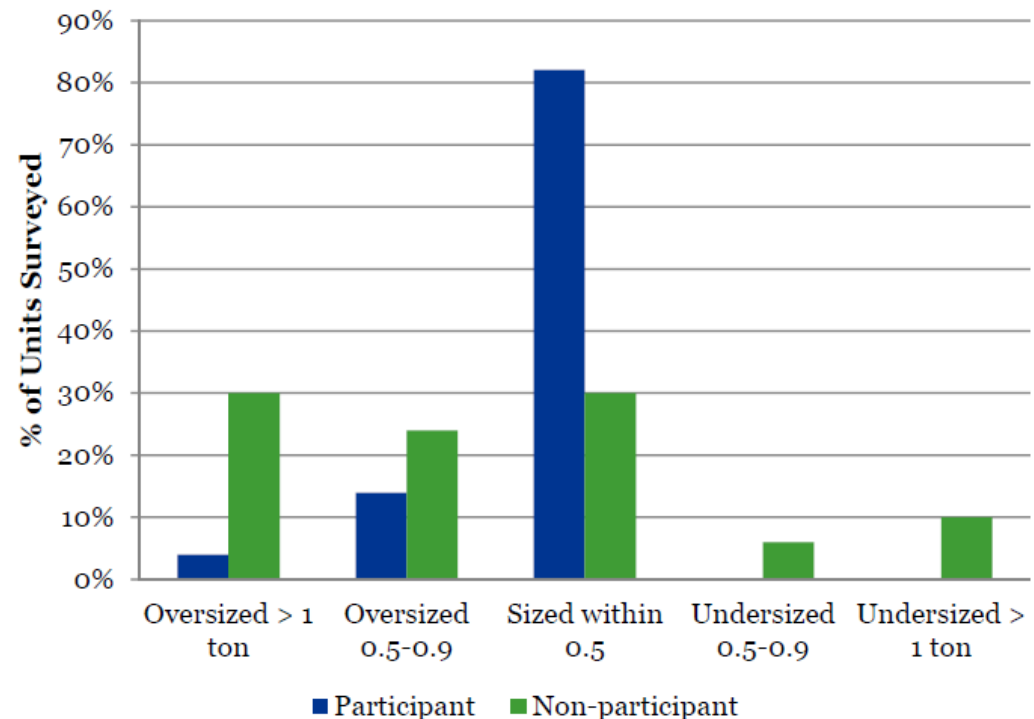
Calculation Parameters WP/WO32

System Sizing (%)

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| WP (Basecase) | WP (Measure) | WO32 (Non-Part.) | WO32 (Part.) |
|---------------|--------------|------------------|--------------|
| 20% | 0% | 13% | 10% |

- The RQI requires Manual J/S for equipment sizing
- Primary analysis in WO32 compared calculated size (Manual J) to the installed tonnage to determine over or under-sizing
- Data collected onsite informed the development of Manual J-based system-sizing model for all Part. and Non-Part.



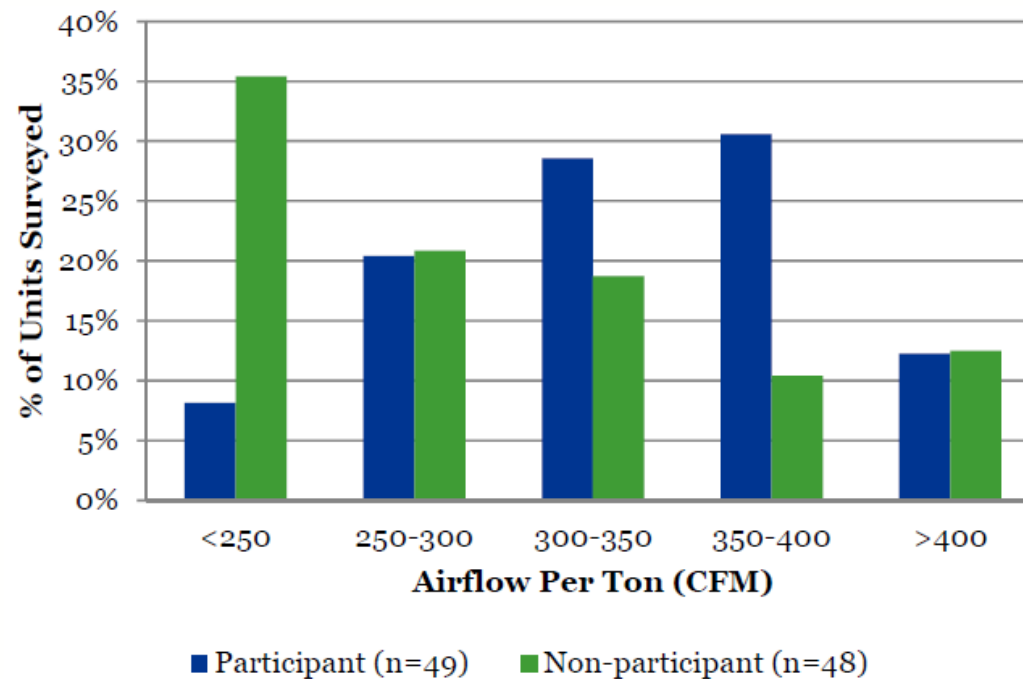
Calculation Parameters WP/WO32

Airflow Capacity (cfm/ton)

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| WP (Basecase) | WP (Measure) | WO32 (Non-Part.) | WO32 (Part.) |
|------------------|-----------------|---------------------|-----------------|
| 350 cfm/ton | 400 cfm/ton | 300 cfm/ton | 338 cfm/ton |

- WO32 used nominal cooling tons established by AHRI ratings
- “Most values within the 300–350 cfm/ton range for T-24 compliance”
- ~ 35% non-part systems < 250 cfm/ton
- RCA Implications?



Calculation Parameters WP/WO32 System Efficiency (SEER)

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WP (Basecase)

WP (Measure)

Title-24 (SEER 14*)

Above Code (> SEER 14*)

- Efficiency Upgrade:
“Code Case” vs.
“Measure Case”
- Sub-systems: “Customer
Average (CAv) vs.
“Measure Case”

| DEER2015 Residential split-system AC and HP Technologies | | | | | | | |
|--|-----------------|-------------|------------|------------|------|------------------|-------------|
| Size Range | Efficiency Tier | System Type | Rated SEER | Rated HSPF | EER | Supply Fan W/CFM | Fan Control |
| < 45 kBTU/hr | Code | Split AC | 14 | | 12.2 | 0.29 | one speed |
| | 1 | Split AC | 15 | | 12.8 | 0.25 | one speed |
| | 2 | Split AC | 16 | | 11.8 | 0.27 | two speed |
| | 3 | Split AC | 17 | | 12.5 | 0.27 | two speed |
| | 4 | Split AC | 18 | | 13.3 | 0.27 | two speed |
| | 5 | Split AC | 19 | | 14.0 | 0.23 | two speed |
| | 6 | Split AC | 20 | | 14.8 | 0.23 | two speed |
| | 7 | Split AC | 21 | | 15.5 | 0.23 | two speed |
| 45 - 65 kBTU/hr | Code | Split AC | 14 | | 11.7 | 0.29 | one speed |
| | 1 | Split AC | 15 | | 12.8 | 0.25 | one speed |
| | 2 | Split AC | 16 | | 11.8 | 0.27 | two speed |
| | 3 | Split AC | 17 | | 12.5 | 0.27 | two speed |
| | 4 | Split AC | 18 | | 13.3 | 0.27 | two speed |
| | 5 | Split AC | 19 | | 14.0 | 0.23 | two speed |
| | 6 | Split AC | 20 | | 14.8 | 0.23 | two speed |
| | 7 | Split AC | 21 | | 15.5 | 0.23 | two speed |
| <65 kBTU/hr | Code | Split HP | 14 | 8.2 | 11.9 | 0.29 | one speed |
| | 1 | Split HP | 15 | 8.7 | 12.8 | 0.25 | one speed |
| | 2 | Split HP | 16 | 9.0 | 12.5 | 0.27 | two speed |
| | 3 | Split HP | 17 | 9.4 | 13.3 | 0.27 | two speed |
| | 4 | Split HP | 18 | 9.7 | 14.0 | 0.27 | two speed |

Performance Parameters for TF Subcommittee Evaluation

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| ID | Evaluated Parameter | General Parameters | Unit | Keyword | Supporting/Informing Documentation |
|----|---|---|--------------------------------------|--|---|
| 1 | Flow Performance | Design full-load power of the supply fan per unit of supply airflow - Fan power; System airflow | kW/CFM | SUPPLY-KW/FLOW | WO32 + NIST 1848 + Manual D + ASHRAE + DEER + T24 |
| 2 | Flow capacity | System airflow; system delivery capacity; system (ARI) rated capacity | CFM/Ton | - | WO32 + NIST 1848 + DEER + T24 |
| 3 | Duct Leakage | Duct leakage - fraction of the supply air that is lost from the ductwork, thereby reducing the design supply air at the zones | Leakage (%) | DUCT-AIR-LOSS | WO32 + NIST 1848 + DEER + T24 |
| 4 | Equipment Sizing | HVAC equipment capacity | Manual J Manual S | COOLING-CAPACITY COOL-SH-CAP | WO32 + NIST 1848 + ACCA Manual J/ACCA Manual S + ASHRAE 90.1 + eQuest + T24 |
| 5 | HVAC System basecase HVAC Sub-systems basecase | SEER; duct leakage; duct insulation; flow performance; etc. | - | - | WO32 + NIST 1848 + Title-24 + DEER |
| 6 | Delivery Mechanism | ROB | - | - | Program Requirements |
| 7 | System Efficiency | System Efficiency (SEER) | EIR (at ARI rated conditions) | COOLING-EIR | Title-24 / DEER |
| 8 | Refrigerant Charge Adjustment (RCA) | - | - | - | WO32 + DEER |

References:

1. NIST Technical Note 1848 - Sensitivity Analysis of Installation Faults on Heat Pump Performance - Piotr A. Domanski
2. HVAC Impact Evaluation FINAL Report WO32 HVAC – Volume 1: Report - CPUC, ED - Prepared by DNV GL
3. ACCA - Residential Load Calculation (Manual J)
4. ACCA - Residential Equipment Selection (Manual S)
5. ANSI/ASHRAE/IES Standard 90.1-2013 - Energy Standard for Buildings Except Low-Rise Residential Buildings
6. 2013 RESIDENTIAL COMPLIANCE MANUAL FOR THE 2013 BUILDING ENERGY EFFICIENCY STANDARDS, Title 24, Part 6

Q&A

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Thanks!

Current SCE Res QI Program Offering

- Energy Star Quality Installation Model
 - ANSI/ACCA 5 QI: HVAC Quality Installation Specification
 - ANSI/ACCA 9 HVAC Quality Installation Verification Protocols
- 2015 Incentive Qualifications
 - Above Code 15 SEER or greater
 - DX Air source A/C and heat pumps (split and packaged)

Mission:

Address program and marketplace implementation and success barriers: significantly underfunded and unreliable long term funding for IOU RQI programs; improve the approach and basis for IOU claimed energy savings; develop an agreed upon, measurable approach for system performance evaluation for marketplace baseline systems, replaced systems and newly installed systems. Gain more accurate quantification and measurement for RQI program actual delivered savings.

Program Team's Expected Outcome from the Cal TF Process



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- **Review RQI work paper assumptions**
- **Establish protocols for utilizing best available information and data to inform work paper development**
- **Establish energy and demand savings estimates representative of RQI program participants**