

# Residential Quality Installation (RQI) & WO32 HVAC Impact Evaluation



**ANDRES FERGADIOTTI, P.E., LEED AP**  
**SCE/DSM ENGINEERING**  
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# Presentation Overview

- RQI Measure Objective
- RQI Measure Overview
- Performance Parameters Informing the Energy Model
- WO32 (RQI) Overview
- WO32 (RQI) Key Findings
- Description of Performance Parameters (WP/WO32/SubcTF)
- References

# RQI Measure Objective

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- Improve Quality Installation (QI) of mechanical (HVAC) systems in Residential applications
- Improve HVAC system performance with QI
- Improve HVAC system performance with efficiency upgrade

# RQI Measure Overview

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## Base Case Description

- Standard (SEER 14, 80% AFUE) split and packaged HVAC unit (Replace-on-Burnout)
- Oversized HVAC unit
- Low airflow
- Leaky ducts

## Measure Description

- Quality Installation (QI) of Standard (SEER 14, 80% AFUE) and higher efficiency split and packaged HVAC units
- Properly sized HVAC unit
- Optimized airflow
- Sealed ducts

## Calculation Method

Performance (single point value) approach using DEER (DOE2.2) prototype

# Performance Parameters Informing the Energy Model

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QI Measure	Keyword	Description
HVAC equipment sizing	COOLING-CAPACITY; COOL-SH-CAP	ACCA Manual J (cooling load) ACCA Manual S (equipment sizing)
Air duct leakage	DUCT-AIR-LOSS	Air leakage reduction of total system airflow
Airflow Performance	SUPPLY-KW/FLOW	kW/cfm ~ f(fan power, system airflow, and temp. gain)
Airflow Capacity	SUPPLY FLOW	cfm/ton - stablished using nominal cooling tons per AHRI ratings and measured system airflow
Equipment Efficiency (SEER)	COOLING-EIR	2013 Title-24 Baseline (SEER 14)

# 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 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”

# Performance Parameters Informing the Energy Model

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## Description on Parameters informing the energy model

- Assumptions used current version of WP
- **WO32 Evaluations findings/recommendations**
- **Current Subcommittee Recommendations**



# Airflow Performance (kW/cfm)

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WP (Base)	WP (Measure)	WO32 (NPart)	WO32 (Part)	SubcTF (Base)	SubcTF (Measure)
0.510 W/cfm	0.383 W/cfm	0.569 W/cfm	0.486 W/cfm	0.580 W/cfm (T24)	0.369 W/cfm

## Base Case

- T24 - Central forced air systems to produced W/cfm  $\leq 0.580$
- Consistent with WO32 (Non-Participant)
- Consistent with WP

## Measure Case

- 2014-2015 program data - 2,400 jobs throughout SCE's territories
- Consistent with AHRI 210/240 - 0.365 W/cfm
  - Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment

# General Notes

## Airflow Performance (kW/cfm)



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### Program Data

- There are 3 methods allowed in the program for measuring air flow including (1) Flow hood at the return; (2) rotating vane 4" anemometer measured at the return; and (3) Flow plates measured at the furnace entrance or the return.
- Estimated system airflow performance (kW/cfm) assume a PF of 0.78.
- Most new HVAC systems include ECM motors

# Air Duct Leakage (%)

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WP (Base)	WP (Measure)	WO32 (NPart)	WO32 (Part)	SubcTF (Base)	SubcTF (Measure)
<b>24%</b> (DEER)	<b>12%</b> (DEER)	<b>16.6%</b>	<b>11.5%</b>	<b>29.7%</b> (Non-T24)	<b>10.5%</b>

## Base Case

- Program data and T24 leakage requirement per permitted jobs
  - T24 = 15%
  - Program Leakage = 38.7%
  - T24 Permitting Rate = 38.0%
    - ★ PGE – “HVAC Permitting: A Study to Inform IOU HVAC Programs, by DNV-GL”

**% Leakage = (Perm. at T24\_Leak) + (Non-Perm. at Program\_Leak) = 29.7%**

## Measure Case

- Program data = 10.5%
- Consistent with WO32 (Participants)

# General Notes

## Duct Leakage (%)



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### A. Permitting Rates

- Permitting rates based on PGE's study - **HVAC Permitting: A Study to Inform IOU HVAC Programs**, by DNV-GL dated 10/10/2014.
- "Testimony to the Little Hoover Commission March 27, 2014", referenced in WO32 HVAC evaluation, that suggests lower permitting - 10%.
- WHPA – "Over 95% of jobs are non-permitted, because the current process has no perceived benefit for consumers"

### B. Duct Leakage

Measured using the "Minneapolis duct blaster" at 25 Pa.

### C. Energy Modeling Methods

eQuest/DOE2.2 methods for modeling airflow (including duct leakage) may not be adequate – "Weighting Factor". Validation of tool is recommended.

# General Notes

## Duct Leakage (%) (Cont.)



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### **DUCT-AIR-LOSS**

Fraction of the supply air that is lost from the ductwork, thereby reducing the design supply air at the zones.

### **DUCT-AIR-LOSS-OA**

Specifies the fraction of the supply duct air loss that is made up by outside air.

# Equipment Sizing (%)

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WP (Base)	WP (Measure)	WO32 (NPart)	WO32 (Part)	SubcTF (Base)	SubcTF (Measure)
20%	0%	13%	10%	13.9%	0%

## Base Case

- Program (pilot) data – total of 32 projects
- Equipment sizing based on Manual J and Manual S
- Manual S accounts for 115% of total cooling load per Manual J
- Manual S – equipment sizing meets latent and sensible loads at design conditions used in Manual J
- WO32 included Manual J, but excluded Manual S
- WO32 compares Manual J to installed capacity

## Measure Case

- Equipment sizing follows Manual J and Manual S requirements
- T24 – ACCA Manual J (only); ACCA Manual S (Not required)

# General Notes

## System Sizing (%)



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- Manual S engineering is used to determine the operating capacity and Sensible Heat Ratio (SHR) of an installed system at local conditions
- The Manual S capacities were modeled using custom software (by Roltay) to approximate the Original Equipment Manufacturers (OEM) data.
- Software created by Roltay Inc. is similar in computation function as the DOE/ORNL Heat Pump Design Model.
- The QI program requires the use of both ACCA Manual J [\*] for calculating cooling loads and ACCA Manual S [\*\*] for estimating equipment sizing based on sensible and latent loads.

# Airflow Capacity (cfm/ton)

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WP (Base)	WP (Measure)	WO32 (NPart)	WO32 (Part)	SubcTF (Base)	SubcTF (Measure)
350 cfm/ton	400 cfm/ton	<b>300</b> cfm/ton	<b>338</b> cfm/ton	<b>300</b> cfm/ton	<b>350</b> cfm/ton

## Base Case

- WO32
- Consistent with Proctor study

Existing - Cochella Valley, CA – 310 cfm/ton (Proctor et al. 1995)

## Measure Case

- Parameter falls between Proctor study on California replacement – 388 cfm/ton (Proctor and Downey 1998) and WO32 – 338 cfm/ton
- **T24 – 300 cfm/ton** - Altered systems
- **(N/A) T24 – 350 cfm/ton** - Entirely New or Complete Replacement systems



# General Notes

## Airflow Capacity (cfm/ton)

- Nominal cooling tons established by AHRI ratings for each unit.
- Airflow generally measured at the return-air vent
- There are 3 methods allowed in the program for measuring air flow including the following:
  - (1) Flow hood at the return;
  - (2) rotating vane 4" anemometer measured at the return; and
  - (3) Flow plates measured at the furnace entrance or the return.
- T24

*Altered HVAC systems must meet the minimum 300 cfm/ton airflow rate compliance criterion; example include but not limited to replacing the outdoor condensing unit, replacing the furnace or air handler, and entire replacement of the duct system.*

*Entirely New or Complete Replacement Space Conditioning Systems, as specified in §150.2(b)1C, must meet the minimum 350 cfm/ton airflow rate compliance criterion or the duct design alternative specified in 150.0(m)13.*

# References

ID	Evaluated Parameter	General Parameters	Supporting Documentation
1	<b>Flow Performance (kW/cfm)</b>	Design full-load power of the supply fan per unit of supply airflow - Fan power; System airflow	Program Data; [5]
2	<b>Flow capacity (cfm/ton)</b>	System airflow; system delivery capacity; system (ARI) rated capacity	[1] [5]
3	<b>Duct Leakage</b>	Duct leakage - fraction of the supply air that is lost from the ductwork, thereby reducing the design supply air at the zones	Program Data; [4]; and [5]
4	<b>Equipment Sizing</b>	HVAC equipment capacity	Program Data per [2] and [3]
7	<b>System Efficiency</b>	System Efficiency (SEER)	[5]

- [1] HVAC Impact Evaluation FINAL Report WO32 HVAC – Volume 1: Report - CPUC, ED - by DNV GL
- [2] ACCA - Residential Load Calculation (Manual J)
- [3] ACCA - Residential Equipment Selection (Manual S)
- [4] PGE – “HVAC Permitting: A Study to Inform IOU HVAC Programs, by DNV-GL”
- [5] 2013 RESIDENTIAL COMPLIANCE MANUAL FOR THE 2013 BUILDING ENERGY EFFICIENCY STANDARDS, Title 24

# Q&A

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# Thanks!