Residential Quality Installation (RQI) & WO32 HVAC Impact Evaluation

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“PART 2”

Presentation Overview

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- RQI Measure Overview
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  - Equipment Sizing (%) – Pending approval
  - Airflow capacity (cfm/ton) – Pending approval
- References
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RQI 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

RQI Measure Overview

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

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

- **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

- 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

Description on Parameters informing the energy model

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

Airflow Performance (W/cfm)

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	0.57 W/cfm (WO32)	0.37 W/cfm

Base Case

- CPUC HVAC Impact Evaluation - WO32 (Non-Participant)
- Consistent with "Proctor and Downey 1998," California replacement – 0.57 W/cfm
- Consistent with T24 – 0.58 W/cfm

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)

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

T24 – Building HVAC Requirements (Section 4-23)

- *Air Handler Watt Draw and System Airflow – "It is mandatory that central forced air systems produce fan watt draws less than or equal to 0.58 watts/CFM and flow at least 350 CFM per nominal cooling ton."*

Air Duct Leakage (%)

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

Base Case

- Program data + T24 leakage requirement per permitted jobs
  - T24 Leakage Requirement = 15%
  - RQI 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 (%)

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.
- **Development of an ASHRAE 152-2004 Duct Model for the SFM Residential House** – this paper presents the results of the development of the duct model based on ASHRAE 152 using DOE2.1e

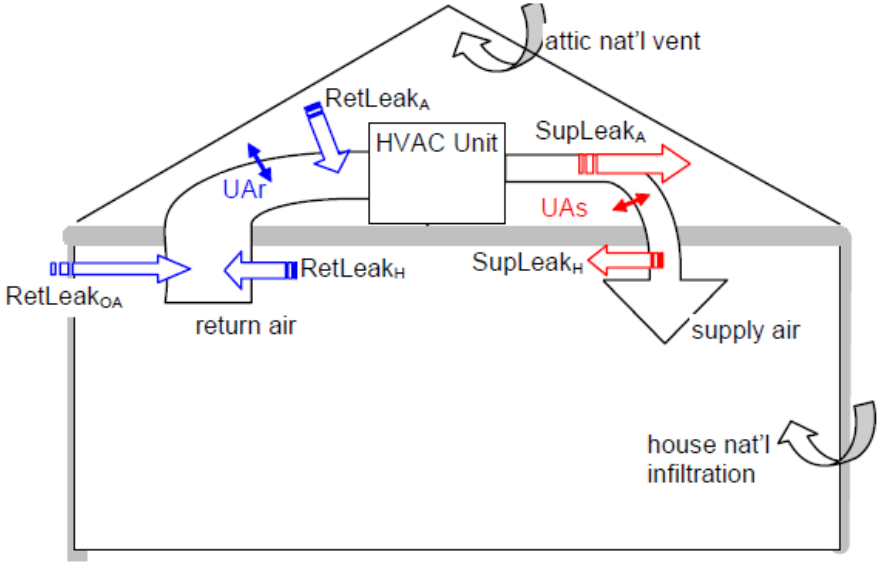
General Notes
Duct Leakage (%) (Cont.)

DUCT-AIR-LOSS

- Fraction of the supply air that is lost from the ductwork, thereby reducing the design supply air at the zones.
- Air lost from the ductwork will change the temperature of the zone specified by DUCT-ZONE, which must be a plenum or unconditioned space.

General Modeling Assumptions (SFM Single Story)

- Total L ~ 50% SA_L + 50% RA_L
- 75% SA_L to unconditioned attic
- 25% SA_L to conditioned space
- RA ~ 80%_SA
- Total RA ~ 80%_SA + 20%_OSA



Duct loss and gain components in DOE2.2

Source: DEER2005UpdateFinalReport_Itron

Equipment Sizing (%)

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

Base Case

- Program Pilot – 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 (Non-Participants)

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 (%)

- 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)

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

Base Case

- WO32
- Consistent with Proctor study
  - Existing - Cochella Valley, CA – 310 cfm/ton (Proctor et al. 1995)

Measure Case

- Midpoint between WO32 and Proctor
- Supported by proctor study on California replacement ~ 388 cfm/ton
  - Source: Hidden Power Drains: Residential Heating and Cooling Fan Power Demand - Proctor and Parker

T24 Requirements

- 300 cfm/ton - Altered systems
- (N/A) 350 cfm/ton - Entirely New or Complete Replacement systems

Airflow Capacity (cfm/ton)

Measure Case – based on best available data

Source: Hidden Power Drains: Residential Heating and Cooling Fan Power Demand - Proctor and Parker

	No. of Samples	Average capacity (tons)	System air flow (cfm)	cfm/ton
Las Vegas new, blasnik	40	3.4	1,150	338
Phoenix new, blasnik	28	3.6	1,220	339
Las Vegas new, proctor	37	3.5	1,320	377
California replacement, Proctor and Downey	**5**	**3.4**	**1,320**	**388**
New Jersey, new townhouses, proctor	15	2.7	1,050	389

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	**Flow Performance (kW/cfm)**	Design full-load power of the supply fan per unit of supply airflow - Fan power; System airflow	Program Data; [5]
2	**Flow capacity (cfm/ton)**	System airflow; system delivery capacity; system (ARI) rated capacity	[1] [5]
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	Program Data; [4]; and [5]
4	**Equipment Sizing**	HVAC equipment capacity	Program Data per [2] and [3]
7	**System Efficiency**	System Efficiency (SEER)	[5]

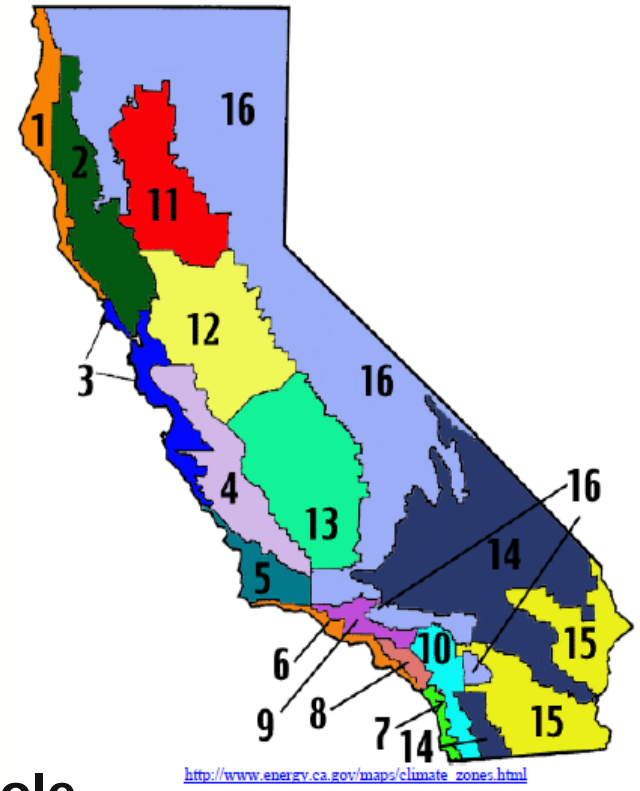
[1] HVAC Impact Evaluation FINAL Report WO32 HVAC – Volume 1: Report - CPUC, ED - by DNV GL
[2] ACCA - Residential Load Calculation (Manual J)
[3] ACCA - Residential Equipment Selection (Manual S)
[4] PGE – “HVAC Permitting: A Study to Inform IOU HVAC Programs, by DNV-GL”
[5] 2013 RESIDENTIAL COMPLIANCE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

Weather Data Simplification

EUCA Climate Zones

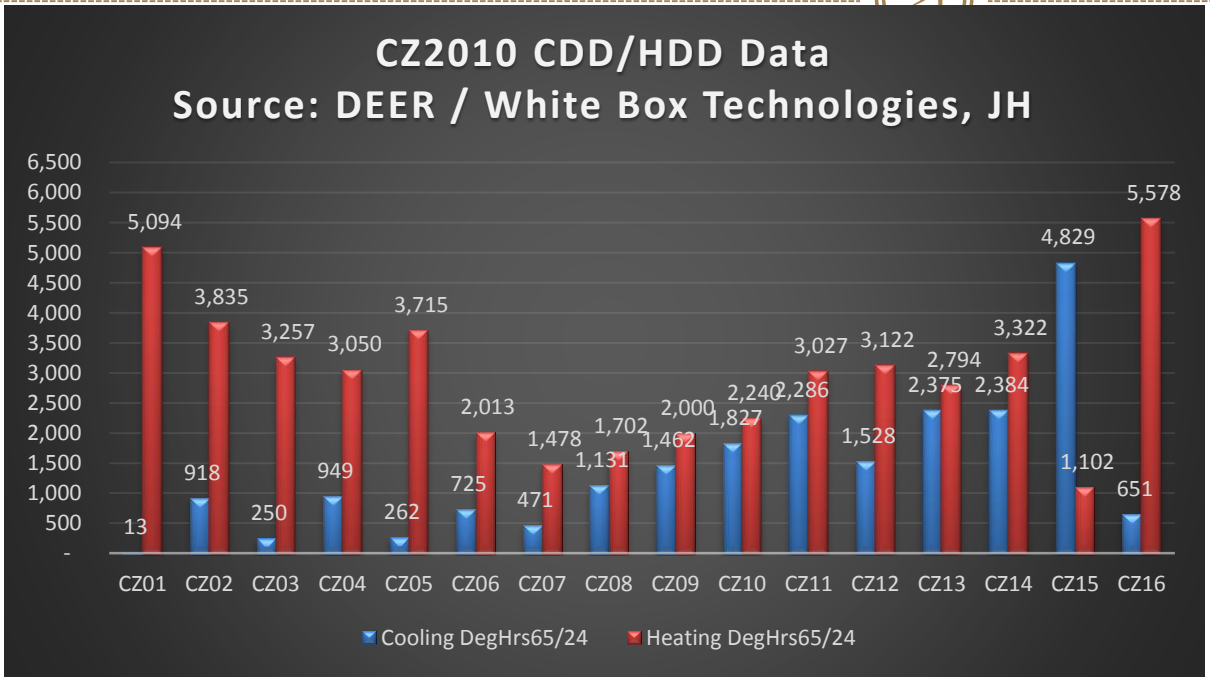
Table 2 Climate Regions

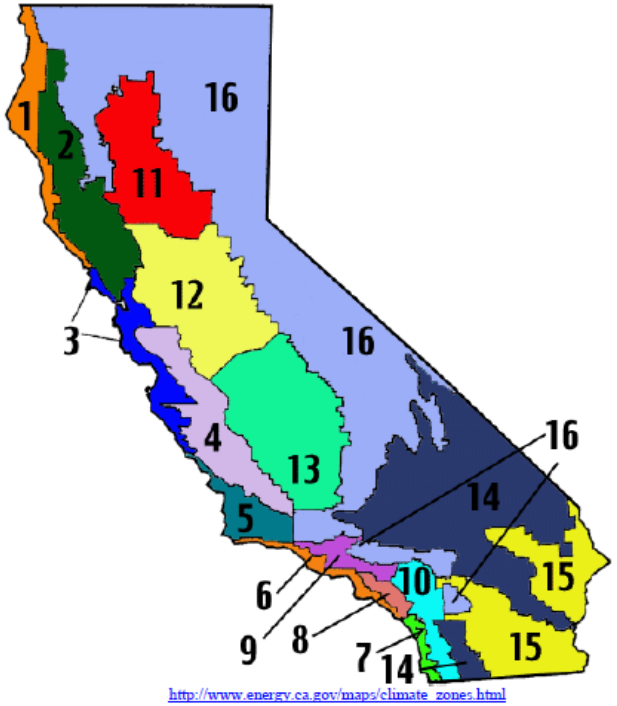
Climate Region	DEER Climate Zones	Primary DEER Climate Zone
North Coast (NC)	1,3,5	3
Coast Ranges (CR)	2,4	4
Central Valley & Sierra (CVS)	12,16	12
Central Valley & Desert (CVD)	11,13,14,15	13
South Coast (SC)	6,7,8	7
Inland Southwest (IS)	9,10	9



SCE13MI005.2
Energy Upgrade California – Prescriptive Whole Home Upgrade

Weather Data Simplification



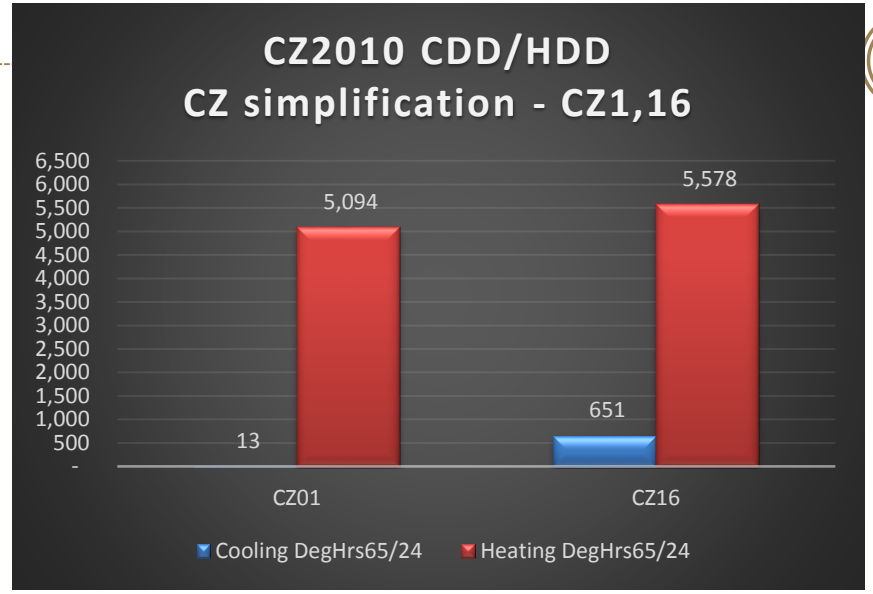


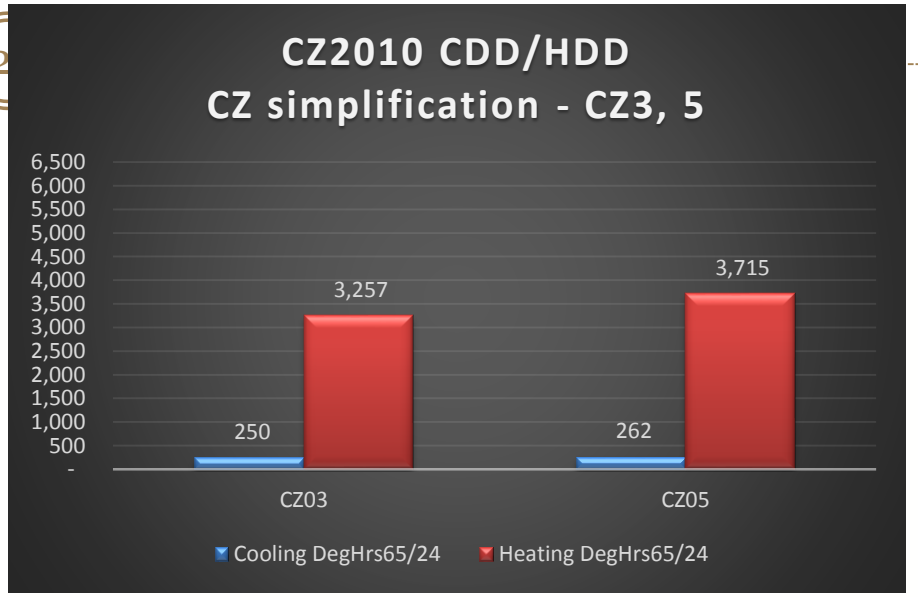
http://www.energy.ca.gov/maps/climate_zones.html

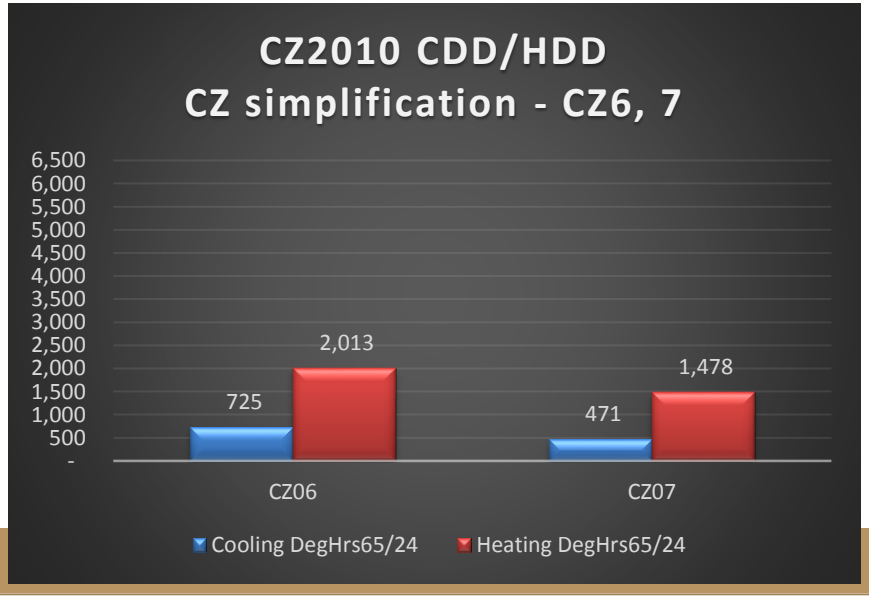
General Assumptions

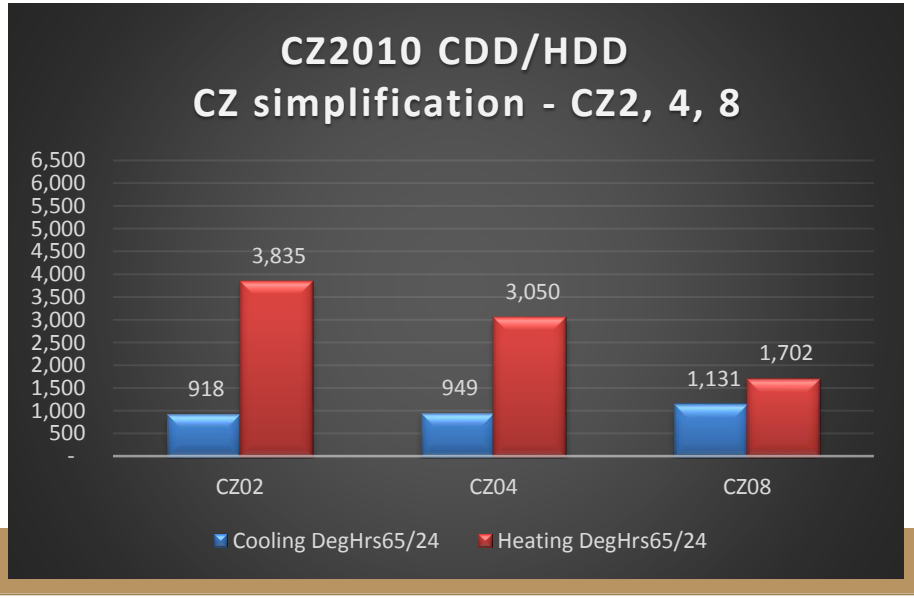
- CZ2010 – Weather set adopted by the CEC for the 2013 T-24
- CZ2010 – Last 12 years / 88 weather sites
- CDD/HDD – Summation of degrees (or hours) of the average temperature per day below/above reference temperature – e.g., 65 deg. F.

Weather Data Simplification









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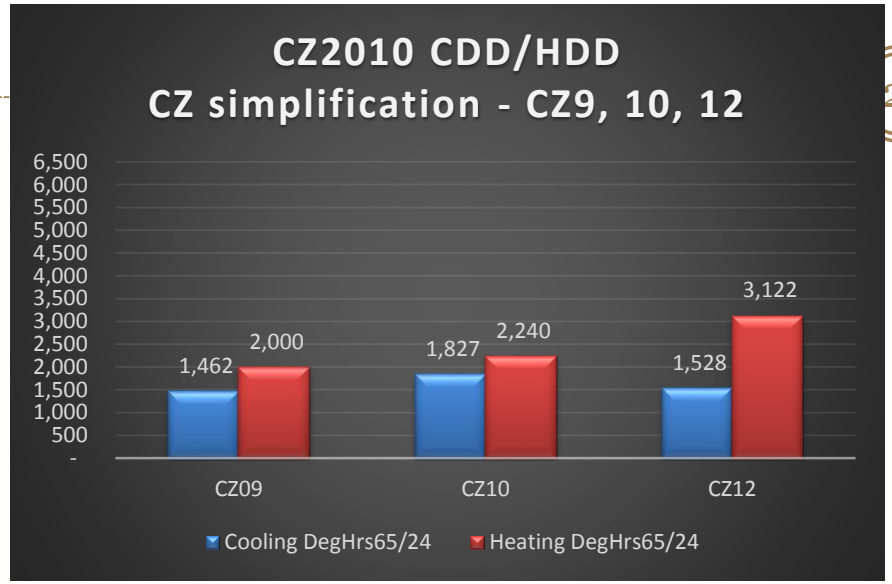

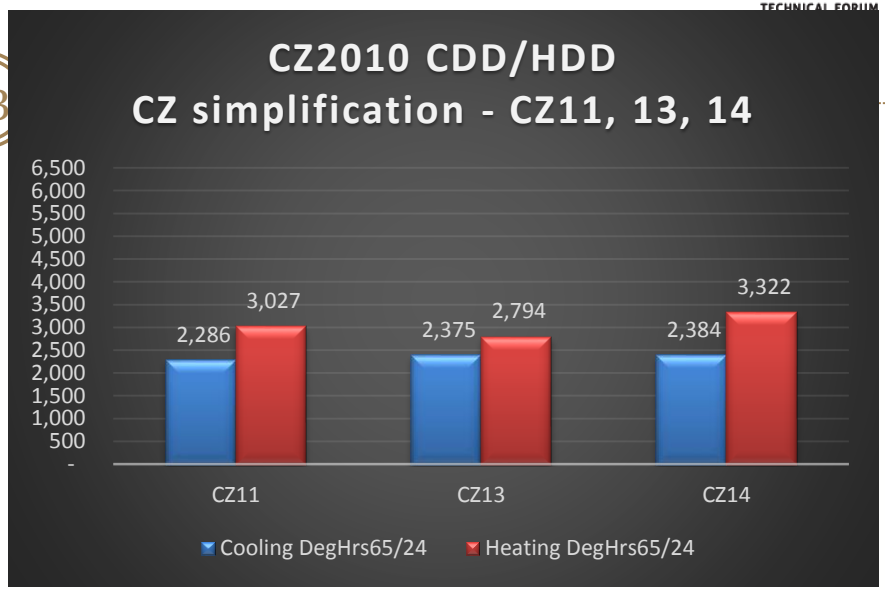

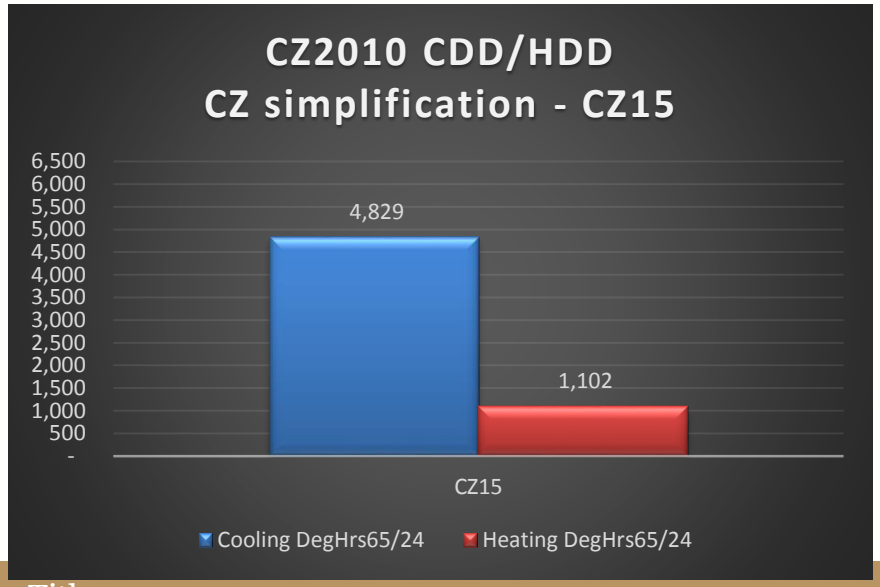

CZ	Average CDD	Average HDD	Representative CZ
3, 5,	256	3,486	5
6, 7	598	1,746	6
2, 4, 8	999	2,862	8
1, 16	332	5,336	16
11, 13, 14	2,348	3,048	13
9, 10, 12	1,606	2,454	10
15	4,829	1,102	15

Q&A

Thanks!

Airflow Capacity (cfm/ton)

Measure Case – based on best available data (continuation)

Source: Central Air Conditioning in Wisconsin – ECW Report No. 241-1

FIGURE 33, AS-FOUND AIRFLOW
(2005 STAC AND 2007 FOCUS SITES).