Subcommittee Tracking Sheet: Residential HVAC Quality Installation Data Sources

Meeting #4: May 28th, 2015

I. Agenda Items for Discussion/Materials

a) Duct leakage: group to make final recommendations
   i. Consideration of NW findings (report not currently available)
   ii. Source for % of permitted vs unpermitted projects for baseline assumptions

b) Identify potential data sources for additional workpaper performance parameter and discuss the merits and limitations of each source; make final recommendation on best data source for workpaper.

ID	Impact	Evaluated Parameter	General Parameters	Keyword	Current WP Source	Other Sources to Consider
1	High Impact	**Flow Performance** **kW/CFM**	Design full-load power of the supply fan per unit of supply airflow - Fan power; System airflow	SUPPLY-KW/FLOW	DEER [1] [2] KW/cfm - Design full load power of the supply fan per unit of supply air flow rate. Note that in the DEER SFM prototype this parameter is defaulted to 0.000365 kW/cfm Proctor study [3]	WO32 [11] Evaluation when possible measured fan power in cooling and either heating or fan-only modes. This difference may be partially due to the fact that QI participants also installed high efficiency units with more efficient fans. This aspect, however, was not studied as the focus was on the QI aspects not the unit efficiency and fan motor efficiency. Additional information on static pressure, fan settings, and design airflow were not part of the analysis, but collected and documented in WO32 - Appendix C.
2	High Impact	**Airflow capacity** **CFM/Ton**	System airflow; system delivery capacity; system (ARI) rated	-	Proctor study [3] Referenced study suggests that design flow capacity (cfm) in Measure Case may be lower than	WO32 [11] Evaluation used nominal cooling tons established by AHRI ratings for each unit. The collected data showed that the averages were closer to 300

			capacity		the “standard” 400 cfm/ton (e.g., in the order of 340 cfm/ton in new California homes) assumed in the analysis of the measure.	cfm/ton for non-participants and 338 cfm/ton for participants. These values are within the 300–350 cfm/ton range for Title 24 compliance. The 10% difference between participant and non-participant airflow was similar to workpaper assumptions. Mowris et al, Lab Measurements of HVAC Install & Maintenance [9] NIST Sensitivity Analysis [10]
3	High Impact	**Duct Leakage** **Leakage (%)**	Duct leakage - fraction of the supply air that is lost from the ductwork, thereby reducing the design supply air at the zones	DUCT-AIR-LOSS	DEER [1] [2] Duct Leakage (Duct Air Loss Ratio) Fraction of the supply air that is lost from the ductwork, thereby reducing the design supply air at the zones. DEER 2005 Report [4] Baseline: 24% Leakage Measure: 12% Leakage Supply air leakage estimated as follow: (% leakage/2) x 0.75 - single-story house (% leakage/2) x 0.67 - two-story house	WO32 [11] According to evaluation, almost half of the participant tested systems had leakage meeting program requirements of 15% or less. Note that 2008 Title 24 required duct leakage less than 15% (of nominal system airflow) if a major component of the HVAC system (air handler, outdoor condensing unit, cooling or heating coil, or furnace heat exchanger) is replaced or installed. The evaluation also measured the leakage outside the conditioned space (LTO) relative to nominal unit airflow. Per evaluation, duct leakage to outside for recent residential installations are 7.42% and 10.73% for participants and non-participants respectively. Note that total duct leakage is the sum of leakage into conditioned spaces and leakage to outside of conditioned spaces. Mowris et al, Lab Measurements of HVAC Install & Maintenance [9] NIST Sensitivity Analysis [10]
4	High Impact	**Equipment Sizing** **Manual J**	HVAC equipment capacity	COOLING-CAPACITY COOL-SH-CAP	Energy Center of Wisconsin [5]	WO32 [11] Data collected onsite informed the development of an ACCA Manual J-based system-sizing model for all participants and non-participants. The primary analysis compared the calculated size to the

		Manual S				installed tonnage to determine the amount of over or under-sizing The QI programs require the use of both Manual J [*] and Manual S [**] for equipment sizing. The evaluation used program approved Manual J software in the analysis. Impact evaluation finding suggests oversized and undersized units in both the participant and nonparticipant samples. Both groups tended to have oversized units with a small difference in mean sizing ratio, but non-participants had a wide distribution with more cases of significant oversizing. Further, evaluation suggests that approximately 82% of evaluated participant systems were sized within 0.5-ton of design cooling capacity. [*]*ACCA Manual J is a standard for producing air conditioning and heating load calculations for single family homes, small multi-unit residential structures, condominiums, town houses, and manufactured homes.* [**]*ACCA Manual S provides sizing requirements for cooling and heating equipment, allowing the selection of equipment based on sensible and latent loads and ensuring the selected equipment will be properly matched to the local climate.* Mowris et al, Energy Savings from Properly Sized AC [8]
5		**HVAC System basecase HVAC Sub-systems basecase**	SEER; duct leakage; duct insulation; flow performance; etc.	-	DEER [1] [2]	WO32 [11]
6		**Delivery Mechanism**	ROB	-	Program Requirements	
7	Medium Impact	**System Efficiency**	System Efficiency (SEER)	COOLING-EIR	Since the delivery mechanism on measure is Replace on Burnout (ROB), equipment efficiency (including base case efficiency)	

		EIR (at ARI rated conditions)			compares between the Code Case (e.g., SEER 14) and Measure Case **Updated Residential HVAC Measures** - SEER ratings and tiers on equipment efficiency in 2015 version of the workpaper, including both Air Conditioners and Heat Pumps, will be consistent with that documented in 2015 DEER updates, which includes additional tier levels and size ranges as required by the code update.	
8		**Refrigerant Charge Adjustment (RCA)**	-	-	DEER [1] [2]	WO32 [11]

[1] CPUC's MASControl software application created to generate DEER prototypical buildings (including latest building vintages (e.g., 2013) with current code updates) and to overview pre-developed DEER measures. The software application allows the use of existing prototypes to addressed non-DEER measures – www.deeresources.com.

[2] DEER SFM prototype with 1975 building vintage and California climate zone 6 (e.g., CZ06).

[3] Hidden Power Drains: Residential Heating and Cooling Fan Power Demand - John Proctor, Proctor Engineering Group, Ltd., Danny Parker, Florida Solar Energy Center. http://aceee.org/files/proceedings/2000/data/papers/SS00_Panel1_Paper19.pdf

[4] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. http://deeresources.com/files/deer2005/downloads/DEER2005UpdateFinalReport_ItronVersion.pdf

[5] Energy Center of Wisconsin | ECW Report Number 241-1 | Central Air Conditioning in Wisconsin | A compilation of recent field research. http://ecw.org/sites/default/files/241-1_0.pdf

[6] ASHRAE Handbook – Fundamentals | Energy Estimating and Modeling Methods.

[7] Homes by Building, Vintage, and Utility Climate Zone, Source: RASS, KEMA Estimates 2002-2007

[8] Peak Demand and Energy Savings from Properly Sized and Matched Air Conditioners, Robert Mowris and Ean Jones, Verified, Inc. http://aceee.org/files/proceedings/2008/data/papers/1_692.pdf

[9] Laboratory Measurements and Diagnostics of Residential HVAC Installation and Maintenance Faults, Robert Mowris, Ean Jones, and Robert Eshom, Robert Mowris & Associates, Inc. http://aceee.org/files/proceedings/2014/data/papers/1-195.pdf

[10] NIST Technical Note 1848 - Sensitivity Analysis of Installation Faults on Heat Pump Performance, Piotr A. Domanski, Hugh I. Henderson http://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1848.pdf

Other sources to consider

[11] HVAC Impact Evaluation FINAL Report WO32 HVAC – Volume 1: Report - CPUC, ED - Prepared by DNV GL
http://www.energydataweb.com/cpuc/search.aspx?did=1225
[12] ACCA - Residential Load Calculation (Manual J)
[13] ACCA - Residential Equipment Selection (Manual S)
[14] ANSI/ASHRAE/IES Standard 90.1-2013 - Energy Standard for Buildings Except Low-Rise Residential Buildings
[15] 2013 RESIDENTIAL COMPLIANCE MANUAL FOR THE 2013 BUILDING ENERGY EFFICIENCY STANDARDS, Title 24, Part
http://www.energy.ca.gov/title24/2013standards/residential_manual.html%5d

II. Meeting Attendees

Jenny Roecks, Cal TF staff
Annette Beitel, Cal TF staff

Tom Eckhart, TF Member
Christopher Rogers, TF Member
Steven Long, TF Member
Andres Fergadiotti, SCE
Scott Higa, SCE
Chris Ganimian, Energy Analysis Technologies
Buck Taylor, Roltay Energy Services Inc.
Chris Li, PG&E
Justin Kjeldsen, PG&E
Josephine Unverferth, SDG&E
Ed Reynoso, SDG&E
Chan Paek, SCG
Eli Caudill, Conservation Services Group
Mark Modera, UC Davis

III. Key Issues Discussed

- Tom Eckhart concern re: viability of California duct leakage measures – Cadmus did an evaluation of PG&E and SCE measures
- Deliverable: Duct Leakage
    - Other data limitations: program data from southern CA region, may not be representative of Northern CA, measurement quality
    - Further expectations: explore PG&E program data on leakage, evaluate EUCA data as well

ACT: Andres to investigate EUCA data

- Assumption about split between indoor and outdoor duct leakage – follow up on what DEER assumes, where it comes from.

ACT: Andres to follow up on DERE assumptions for indoor/outdoor leakage

- DuctBlaster may not measure duct leakage correctly – look into ASHRAE standard 152
- Mark Modera has additional data on duct leakage from homes, but would require additional analysis