Subcommittee Tracking Sheet: Residential HVAC Quality Installation Data Sources

Meeting #2: May 12th, 2015

I. Agenda Items for Discussion/Materials

a) Identify potential data sources for each 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 capacity	-	Proctor study [3] Referenced study suggests that design flow capacity (cfm) in Measure Case may be lower than the “standard” 400 cfm/ton (e.g., in the order of 340 cfm/ton in new	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 cfm/ton for non-participants and 338 cfm/ton for participants. These values are within the 300–350

					California homes) assumed in the analysis of the measure.	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 Manual S**	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 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** **EIR (at ARI rated conditions)**	System Efficiency (SEER)	COOLING-EIR	Since the delivery mechanism on measure is Replace on Burnout (ROB), equipment efficiency (including base case efficiency) 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

Srinivas Katipamula – TF Member
David Pruitt – TF Member
Steven Long – TF Member
Christopher Rogers – TF Member
Tom Eckhart – TF Member

Andres Fergadiotti, SCE
Scott Higa, SCE
John Neal, Association for Energy Affordability
Chris Ganimian, Energy Analysis Technologies
Buck Taylor, Roltay Inc. Energy Services
Justin Kjeldsen, PG&E
Jesse Martinez, SCG
Raad Bashar, SCG
Joseph Pan, SCG
JoJo Unverferth, SDG&E
Eli Caudill, Conservation Services Group

III. Key Issues Discussed

- Seeking recommendations on whether better data is available to inform workpaper performance parameters than what is currently used in the Res QI workpaper.
- **Duct Leakage**
    - 2014-2015 RQI program data indicates average existing duct leakage of 38.73% (based on 1024 jobs) and average post duct leakage of 10.51% (based on 2406 jobs).
        - All southern CA housing stock (30's vintage up to present vintage)
    - Base case leakage assumption:
        - Existing duct leakage represents systems that had not been touched
        - Workpaper base-case meant to represent counter-factual, or what leakage would result after the customer replaces system outside of utility RQI program
        - If non-participant system would have been T24 compliant (permitted) when modifying system without the RQI program, then 15% base case makes sense. However, the vast majority of new residential HVAC projects are unpermitted and may not be code compliant, warranting a lower base case leakage assumption in workpaper.

    - Recommendation for base case to use a weighted average of % leakage between typical number of permitted and unpermitted residential projects
        - Source for weighting / % of permits?
- Andres recommends a base case leakage rate of 15% consistent with T24 leakage requirements, since the Res QI program is ROB and equipment replacement triggers T24
- Tom Eckhart: the NW has found no correlation between energy savings and reduced leakage in ducts. The savings opportunity for reducing duct leakage in CA should be evaluated. Have there been any CA impact studies that demonstrate the energy savings potential?
    - Through impact evaluation, Bonneville Power Administration could find no statistical difference in savings between those with leakage reductions and those without.
    - Many measure in DEER that haven't been challenged or looked at.
- Group response:
    - No, there haven't been any programs where that single measure has been implemented to single that measure out.
    - Concerns about duct location. Having ducts in a hot attic makes a huge different in the temperature deltas versus in crawl spaces, garages, and conditioned spaces.
    - Majority of duct systems in hot attics, leakage is on the return side, so under hottest conditions, drawing a lot of very hot air.
    - Until a definitive study is done in S.CA, should proceed with current measure.
    - Climate and practices in CA could be substantially different than in NW

- SCE Res QI program is focused on single family homes with flex ducts only
- PG&E average initial duct leakage was 22% based on 2010 duct test and seal program data

ACT: Tom Eckhart to provide NW impact evaluation on duct leakage reduction for group consideration.

- Recommendation: Baseline could be a weighted combination between leakage associated with unpermitted projects (existing leakage conditions) and leakage associated with permitted projects (T24 maximum allowable leakage)
- Possible sources for study
    - WHPA doesn't have information that would likely work

- WO32: footnote 42, page 68, references Little Hoover Commission testimony regarding rates of pulling permits.

ACT: Group to review Little Hoover study and NW information. Tentative recommendation in meantime is to use a weighted average for baseline, and use program data for measure case.

- **Equipment sizing**

  - Upstream program data (PG&E, SCE) with engineered sizes based on Manual J and Manual S provided; average engineered size was compared to DEER cooling capacity for single family building prototype to estimate system oversizing.
    - Approach does not account for fact that units do not operate at design conditions due to duct location in hot attic and higher return temperatures
    - Approach is comparing program engineered units to DEER prototype (modeled) sizes, not actual unit size versus design size for given location.
    - Because upstream units were sized according to Manual J and Manual S, cannot realistically downsize
    - Only data available to program team at moment
  - Do not want contractors to use nominal sizing
  - Pushing the SEER and EER envelop may lead to lower realized efficiency in the field
  - Better program design is needed to ensure systems are properly engineered and equipment is appropriately sized.
    - Contractors replace like for like.
    - Need incentive for right-sized equipment. Need to identify activities to achieve efficiency for proper sizing.
    - Consider incentivizing contractors to do better engineering
  - Res QI program only applies to homes that have gone through retrofit and have oversized equipment
    - Requires use of Manual J and Manual S; manual S allows for some oversizing
    - All program participants must be within Manual S sizing guidelines, but equipment availability from manufacturer creates issues.
  - Residential upstream data is “best available information;” could be used in conjunction with Energy Center of Wisconsin data from the workpaper
  - Discussion of Wisconsin data:
    - Wisconsin study assumes 20% oversizing

    - Not a huge demand for AC in Wisconsin, so the contractor mindset is different than CA.
    - Could use the CA data and put in a footnote describing the market and the need to use engineered capacities and not nominal values.
    - Wisconsin data is consistent with the CA data so there is no compelling reason not to average
    - Program data is only for participants
    - Only linkage between Wisconsin and program data is the contractor engineering process.
- The model doesn't work for this type of equipment. Studies need to do a better job of correlating monitored equipment with engineered data.
- Given that Manual S allows for up to 15% oversizing, suggestion to subtract out 7.5% (half) to account for projects slightly under that number for conservative buffer.
- There may be a random effect on savings in switch from R22 to R10A.

Recommendation: Combine Wisconsin and program data, reduce by 7.5%. Include notes that this is not the best approach, but okay in short term. Need better data moving forward.

IV. Action Items

1. ACT: Tom Eckhart to provide NW impact evaluation on duct leakage reduction for group consideration.
2. ACT: Group to review Little Hoover study and NW information. Tentative recommendation in meantime is to use a weighted average for baseline, and use program data for measure case.