Comment Received From: NegaWatt Consulting on behalf of SoCalGas
Submitted On: 4/22/2016
Docket Number: 16-BSTD-03

SoCalGas Reponse to 2016 Residential ACM Reference Manual and Software

Additional submitted attachment is included below.

Updates to 2016 Residential Alternative Calculation Manual Reference Manual and Software

Comments Regarding CEC Docket #16-BSTD-03

April 22, 2016

Prepared for:

SOUTHERN CALIFORNIA
GAS COMPANY

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1 Background

The Energy Commission adopted the 2016 Building Energy Efficiency Standards (Standards), California Code of Regulations, Title 24, Part 6; developed the Residential ACM Reference Manual; and developed compliance software to support the Standards on November 12, 2015. On March 29, 2016, California Energy Commission staff conducted a workshop to present updates and solicit public comment on draft guidance documents and implementation tools to Standards[1]. The document under development is the Residential Alternative Calculation Method (ACM) Reference Manual, and the tool is the public domain compliance software, CBECC-Res, used under the performance approach in the Standards. During this workshop, staff presented information regarding various topics, including revised water heating calculations, as follows:

- Updated hot water draw schedules
- Improved simulation of heat pump water heater efficiency

2 Summary of IOU Support of Staff Proposal

The CA IOUs are broadly supportive of CEC staff's proposal and we commend CEC staff for their thoughtful and thorough proposal. However, we recommend the following questions, comments and specific recommendations to improve the staff proposal be addressed prior to the adoption of the new software and draw schedule.

3 Impact of Staff Proposal to Energy Budget of Water Heaters

The annual energy budget for heat pump water heaters (HPWH) changed dramatically from version 1.0 to version 2.0 of CBECC-Res 2016 as can be seen in Figure 2 for the 2,100 square foot model home and Figure 2 for the 2,700 square foot home (albeit both with HPWH instead of instantaneous gas) for all climate zones. The average reduction is 26% for the smaller home and 25% for the larger home. In the version 2.0 model, chosen "Heater Type" is "Heat Pump 2016", "HPWH Type" is "Rheem HB 50", and "Location" is "Garage". The AHRI Directory lists this model with an Energy Factor of 2.45 and storage volume of 50 gallons. Those values were used in the v1.0 software to match. We recognize that the v1 HPWH model is a legacy model developed in 1990 when the HPWH and modeling technology was less mature. Regardless, the magnitude of the change is significant and unexpected at first sight, since a spikier draw schedule ought to result in more resistance heating for the load to be met. We recognize that there are plausible explanations for the drop. However, it remains important that stakeholders clearly understand the basis for the change and that its validity is confirmed.

Similar calculations were performed for the completely standard models of instantaneous gas water heaters and for small gas storage water heaters, but only for the 2,100 square foot home for brevity's sake. The percent reduction in energy budget for those from version 1.0 to 2.0 was much smaller at 4 to 5%.

[1] http://www.energy.ca.gov/title24/2016standards/postadoption/documents/#16-BSTD-03

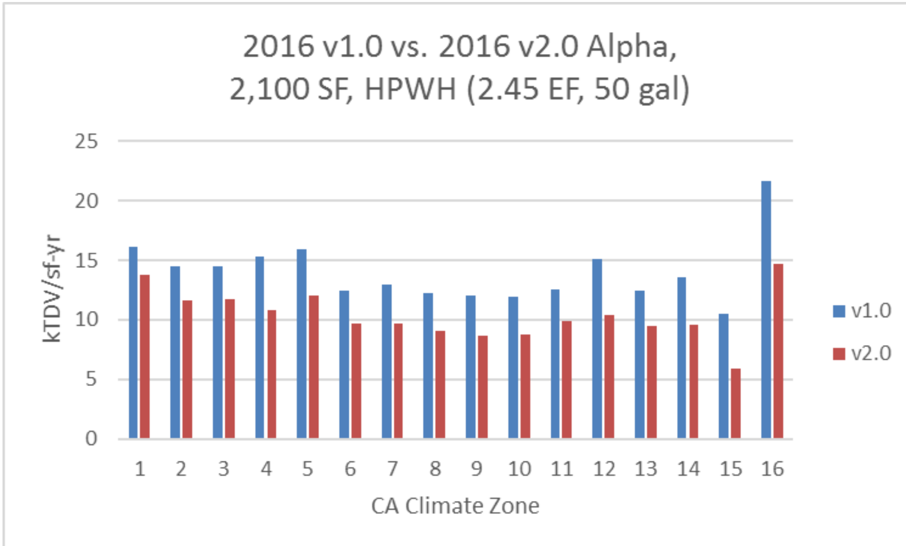

Figure 1: Comparison of HPWH TDV Energy Budget for CBECC-Res 2016 v1.0 and v2.0, 2,100sqft standard home

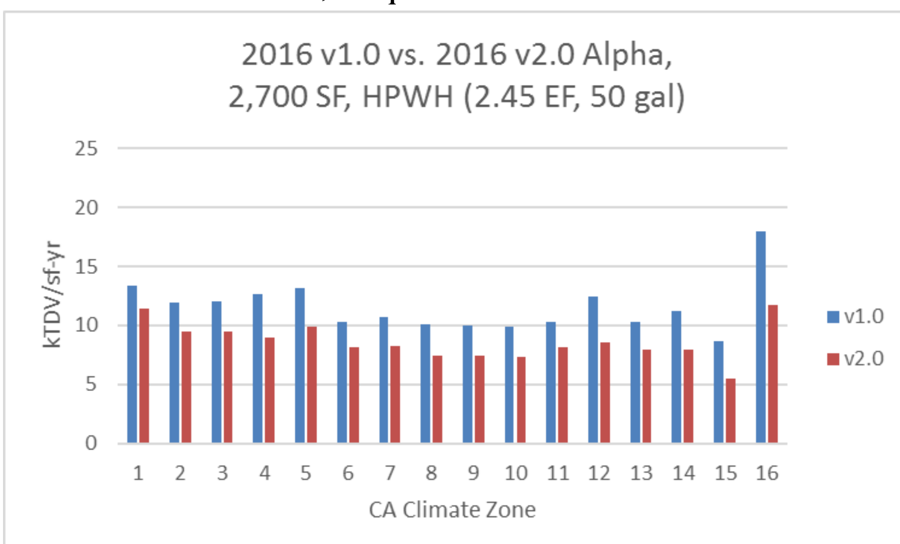

Figure 2: Comparison of HPWH TDV Energy Budget for CBECC-Res 2016 v1.0 and v2.0, 2,700sqft standard home

4 Comments and Recommendation on hot water draw schedules

4.1 Lack of justification for slide deck statements

While the presentation touched on numerous analysis steps, sufficient justification was not always provided and the final draw schedule was not sufficiently described. For instance, Slide 10 refers to non-California research but doesn't provide a citation. For a second example, Slide 18 describes correcting for year 2017 but doesn't detail modeling error or sources for the choices made.

Regarding the final draw schedule, some details are missing. Weekend and holiday draw schedules are not shown. For weekday schedules, no plots are provided which would allow for direct comparison to the existing draw schedule on Slide 7 or to the plots in Slides 6 and 9. We understand that the newer draw schedule is more sophisticated but comparison is still warranted for validation. For Slide 7, at minimum a comparison with a "typical" subset of the new draw schedule should be provided, if a fully weighted averaging calculation cannot be completed with reasonable effort. As a "typical" subset one might select the 2,100sf model home with 3 bedrooms.

Slides 32-37 appear to indicate the exact 30 weekday draws that are used in various combinations depending on number of bedrooms in a given model and the occupant data on Slide 13. However, the resulting annual draw schedules are not shown anywhere. Furthermore, there is no proof that the random placement of these 30 days of draw patterns according to Slide 13 percentages represent a realistic annual draw pattern for a given home and accurately calculate annual energy usage. One possible improvement would be to consecutively place draws by number of occupants instead of randomly placing them throughout.

4.2 Other Questions, Comments and Recommendations

Slide 10 states, "Load by end use allows precise credit for end use efficiency measures". So, each unique annual draw schedule should be provided, *and* disaggregated into end uses, and then provided with the Residential ACM Manual so they may be used to help calculate the savings of energy conservation measures that target a particular hot water end use such as showering.

What is the plan for diversity in draw profiles for multi-family central water heating? This should be integrated now to accommodate future implementation of drain water heat recovery and potentially a central heat pump water heater model. Diversity is essential in correctly modeling these impacts for multi-family applications.

Our understanding is that the characterization of discrete hot water draw events will likely result in shower draws being apportioned uniformly to each bathroom with a shower, since little field data exists to show how showers are actually used. This impacts the calculated benefit of drain water heater recovery devices (soon to be proposed for inclusion). In most applications, these devices will likely not be connected to all showers in a single family home. We strongly suggest that a more reasonable approach be used for assigning showers. For example, for the first assumed occupant 100% of showers are in the master bath. For the 2nd occupant, 85% of showers are in the master bath, with the remaining equally distributed to other showers (note- the 85% is used as an example in this case). And so on, for additional occupants. Demographic data could inform this, but the model needs to capture the reality of the occupancy (a two-person household is most likely a couple that would predominantly use the master bath) rather than uniformly assign shower usage among the various bathrooms.

How was the Aquacraft water use data corrected for climate region? Hot water usage (in terms of gallons/day) will vary with climate. In cold climates (e.g. CZ16) one would expect higher per capita gal/day consumption than in Palm Springs. The current cold water inlet temperature seasonal variability assumed in the ACM does not capture the true variability that has been shown to exist in a handful of detailed California temperature monitoring studies. We would be interested in seeing monthly hot water recovery load output from the CBECC model to see how the seasonal variability compares to California data from prior field studies.

5 Comments and Recommendation on simulation of heat pump water heater efficiency

5.1 Lack of justification for slide deck statements, software features and underlying simulation model (HPWHsim)

Sufficient justification is lacking for multiple steps in the analysis and neither the docketed presentation nor the software documentation describes the new HPWH simulation model in sufficient depth to allow for an independent verification and validation. The presentation heavily relies on NEEA/Ecotope work without providing unambiguous citations. It was learned during the development of these comments that the underlying modeling tool is called HPWHsim; that project and its documentation are in progress. An early draft guide to HPWHsim is available on GitHub[2]. One background study was apparently cited[3] (NEEA/Ecotope study) and Ecotope has done numerous prior HPWH studies. Our comments below are based primarily on the presentation, and both the study and draft guide.

The draft guide does not provide validation or sources for many of the stated facts (and we appreciate that the document development is in progress). It states the following, that we fully agree with, and that stresses the need for proper model validation:

"As a general comment, the operation of heat pump water heaters, and especially those with resistance elements, is highly complex, interdependent, and non-linear. Subtle changes in seemingly benign inputs like inlet water temperature or ambient air temperature can lead to different heat sources firing at different times, which, especially in the case of resistance elements, can cause dramatically reduce efficiency. For a HPWH trigger happy with its resistance element, the difference between a daily energy factor of 3 and 1.5 could be a mere gallon during the morning shower."

The proposed solution of "simulate draw patterns with as much randomness as possible [...]" needs to be fully justified with background research and source citations.

The HPWHsim guide's authors themselves agree that more work is necessary to establish the model's accuracy under warmer ambient conditions, as they occur in many California CZ. We understand that Ecotope is planning to perform COP lab experiments at 95F ambient for one new HPWH model as part of a project funded by PG&E. We strongly recommend this as well as California field tests if possible. All future work should be reviewed by the statewide IOU team prior to the adoption of the new HPWH model, as even small updates can have a significant effect.

Slide 39 refers to resistance heater control, but even with the flow chart of operation shown in the software guide, the exact criteria of when resistance heating is used remain unclear. Slide 46, based on data from 2012, is given as proof that the model accurately predicts resistance heating mode. We understand that past Ecotope studies indicate that resistance heating enabling/disabling was modeled after studying manufacturer specifications, performing lab tests to verify those sequences, and comparing to field test data when possible.

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[2] https://goo.gl/E4hLMV

[3] http://neea.org/docs/default-source/reports/heat-pump-water-heater-saving-validation-study.pdf?sfvrsn=8

At this time, only few HPWH models were tested and are available for selection in CBECC-Res, and all of them are compliant with "NC Spec"[4], which favors Northern Climates. One heater model with a CO2 refrigeration cycle has been included but is documented as being inadequate for warmer climates. The available product set is too restrictive and needs to be expanded to cover the California marketplace. Like-product substitutions by the software users are not a viable alternative due to the many non-trivial heater design aspects that would need to be considered for a valid substitution. As is, software updates are needed to add support for new heater models.

It may behoove the California energy community to adopt a HPWH certification program loosely analogous to "NC Spec", where all equipment would have to be DOE Standards compliant, and in addition would have to meet certain California-only criteria, such as implement a resistance heating strategy that is well known and optimized for our warmer climates. In turn, California would be assured of deploying only the most adequate equipment for our climates, and HPWHsim could easily implement a precise model of the control strategy. Also, the software would not need to be updated each time a new HPWH model is released[5].

Slide 38 indicates that interactions with building heating and cooling are addressed in the model, and Slide 47 states that the new model favors hot climates. These goals and findings are reasonable but the magnitude of the impact on HVAC energy use and the modeling assumptions are unclear, and the related research again appears to have been done only for Northwestern climates.

The HPWHsim guide further states that the model used for Sanden CO2 HPWH is inaccurate at warmer temperatures and should not be used; this and similar equipment can therefore not be modeled in California, which again makes the software incomplete at this time.

5.2 Other Questions, Comments and Recommendations

Electric storage and HPWHs are both more prone to running out of hot water than gas water heaters due to their lower Btu input rating. The effect is small and may well be worth ignoring, but it is worth noting that if not included, the current model projections would be slightly optimistic in this regard.

Will the CBECC output allow for disaggregation of the HPWH energy use into compressor energy use, resistance heat energy use, and standby energy use?

When HPWHs draw energy from a confined space such as a garage, the ambient temperature change rate will depend on the moisture content of the air. Average COP and in turn total energy to meet a certain load would therefore vary with relative humidity (RH) under these circumstances. This effect should be studied and included in the model if found to be significant.

Slide 38 states that HPWHs are valuable for ZNE. However, instantaneous gas water heaters (IWH) in the base case 2,100sf and 2,700sf model buildings still have a lower annual TDV than HPWHs, even by the calculations of the new model and using the new draw schedule (i.e. 2016 v2.0). Figure 3 below illustrates this fact for climate zone 7 by example; other climate zones have comparable results and have only been omitted for brevity.

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[4] http://neea.org/northernclimatespec

[5] For lack of time we have not researched to what extent the DOE Standard considers the resistance heating control strategy; rather, we modeled this idea after NC Spec which gives credit for a well-designed control sequence.

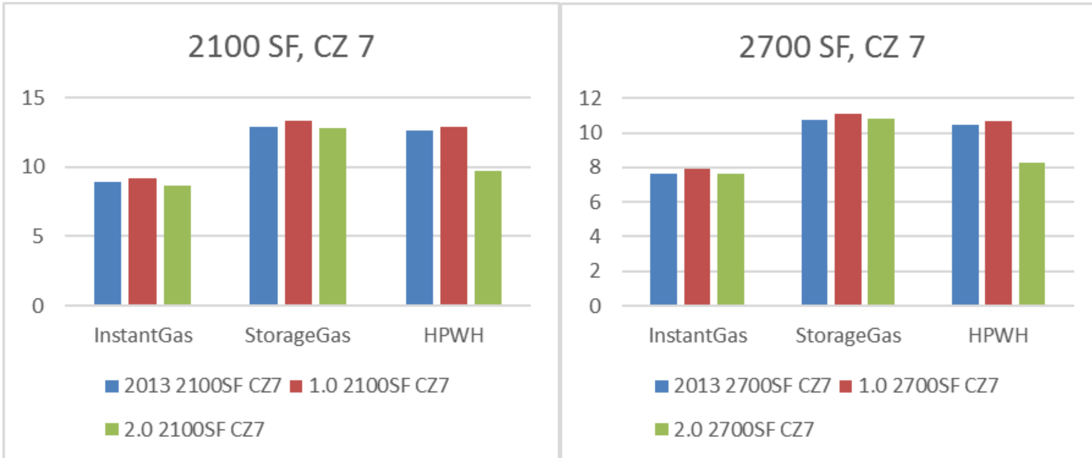

Figure 3: Water heater energy use comparison of different software versions for Climate Zone 7 (San Diego coastal) in kTDV/sqft-yr, for standard homes[6].

[6] Both 2016 "InstantGas" calculations are for the unmodified example model building files that come with each respective software version. The IWHs have 0.82 EF, 125,000 Btu/hr input (120,000 for 2,700sf), and 70% recovery efficiency. The 2013 "InstantGas" calculation matches those conditions. The "StorageGas" calculations mimic the gas storage water heater than was standard in 2013: 0.60 EF, 50 gallons, 40,000 Btu/hr input, and 78% recovery efficiency. All "HPWH" models are based on one of the models in the v2.0 software that is also listed in the AHRI directory: Rheem HB 50 which has 2.45 COP and 50 gallons. It is located in the garage in v2.0. Please note that not all HPWH models could be tested in the interest of time. Also note that all calculations have "Standard" dwelling unit distributions.