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2019 Alliance Cost Effectiveness Model Review for Heat Pump Water Heaters

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To: Amy Webb, Northwest Energy Efficiency Alliance

From: Adria Banks, Ecotope and Ben Larson, Larson Energy Research

RE: Heat Pump Water Heater ACE Model Review

Ecotope has been contracted by the Northwest Energy Efficiency Alliance (NEEA) to review the current Heat Pump Water Heater (HPWH) Alliance Cost Effectiveness (ACE) Model. Specific review questions were as follows:

Task 1: The model savings rate has been updated to reflect Residential Building Stock Assessment (RBSA) 2017 data. Are there errors in the model related to the RBSA II inputs?

Additional topics: Specifically, review processes were to focus on the methods proposed to categorize the provided RBSA II data into aggregate groupings to approximate Regional Technical Forum (RTF) measure categories. These values will then be used to update RBSA I weights currently used to generate regionalized savings forecasts. Questions to address for the grouping methodology were:

- Is it fair/reasonable to include all unconditioned spaces as "basement"?
- For heating types, does it make sense to categorize all non-electric types as gas?

This memorandum is organized according to these topics.

Task 1: Update savings rate weighting based on RBSA II data.

NEEA Planning Analysts provided data extracts from the RBSA II single-family dataset related to water heating type and install location, and space heating fuel by equipment[1]. Source data had been aggregated by the analysis team, and review of the methodology was requested.

To prepare for review of this topic, the ACE Model Review team accessed the 2016-2017 RBSA Supporting Documentation and RBSA II Single Family Homes Report. Of particular interest to users of RBSA II data, are the RBSA II Alternate Weighting Technical Memo[2] and RBSA II

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[1] 2019 ACE Model Review Qs – DHP&HPWH workbook. Provided to Ecotope 9 January 2020.

[2] Bonneville Power Administration Market Research Team. Memo to NEEA & the RBSA II Sampling Working Group. 8 March 2019 https://neea.org/img/documents/RBSA-II-Alternate-Weighting-Technical-Memo.pdf Accessed 2020-01-15.

Update Memo[3] released in March and April 2019, respectively. Among other topics, these memoranda outline an unintentional selection bias in the RBSA II study, an approach to recalculating sample weights, and the release of an alternative weighting scheme. The new "alternate" weights are recommended for use in analyses as they improve population representation, particularly at more granular (sub-regional) levels. NEEA database experts confirmed that the "alternate" RBSA II weights had been applied to the provided data extracts.

Installation Location by Water Heater Type and Heating Zone

NEEA Planning Analysts provided RBSA II locations of water heater system installs by water heater type and heating zone for single-family homes. Source data summaries included the following water heater types:

List 1

1. Electric Heat Pump (Packaged)
2. Non-hpwh DWH
3. Electric Resistance
4. Fossil Fuel Condensing
5. Indirect Water Heater
6. Unknown Type

and the following installation locations:

List 2

1. Attic
2. Basement
3. Crawlspace
4. Exterior
5. Garage
6. Main House
7. Other
8. Unknown

The provided information included an approach to aggregate the install location data for total electric water heaters to align with RTF savings categories including "Main House", "Garage", and "Basement" install locations. To consolidate install locations, all locations (other than "Main House" and "Garage") were summed into the "Basement Category".

[3] NEEA Market Intelligence Team. Memo to RBSA Users. 4 April 2019. https://neea.org/img/documents/RBSA-II-Update-Memo.pdf. Accessed 2020-01-20.

To best align with RTF measures, the ACE Model Review Team suggests first restricting the installation location aggregation to only the electric resistance water heater portion of the RBSA II data extract – water heater type three in List 1. Second, specific to the topic of combining all non-Main House and non-Garage locations into the Basement category, the ACE Model Review team has the following suggestions. Implementing the suggestions will more closely align with the categories intended in the RTF workbook.[4]

1. Attic and exterior locations will more closely approximate garage conditions. Basements typically experience significant thermal buffering (even when unconditioned) and can be expected to have less extreme seasonal fluctuations than above ground unconditioned areas. Aggregating "Attic" and "Exterior" into the "Garage" category, rather than the "Basement" category is recommended. The re-calculated electric water heater installation locations do not currently show any attic or exterior installations, so the sum of garage installations remains unchanged.
2. Crawlspace areas also experience some temperature moderation due to their proximity to heated space and ground contact. It would be appropriate to lump these with "Basement" installations as the ambient air conditions experienced by a HPWH would be similar in those installation locations (assuming an unconditioned basement).
3. The "Basement" identifier in the RTF measure is intended to capture unheated conditions. If RBSA II data includes details about the conditioning of these spaces, heated basements would be more appropriately assigned to a "Main House/Interior" category. We recommend that NEEA ensure that the "Basement" category in the RBSA II data extract only includes unheated basement spaces. In fact, a specific suggestion is to examine the data for any sort of basement conditioning. If the conditioning is clear, place that site in the "Main House/Interior" category. If there is any ambiguity about the basement being heated, treat it as a "Basement" for purposes of aligning with unheated basements in the RTF measure identifier.
4. The additional install locations that require aggregation into one of the RTF installation locations are "Other" and "Unknown". "Other" suggests that the installation location could be categorized and was not one of the known specific locations in List 2. If additional information about these records is available through the database, it may be possible to parse them into one of the three RTF categories. However, review of the RBSA II data collection form, shows that "Other" was a data selection choice, suggesting additional information may not be available.[5] In which case, for the purposes of categorizing the installation to appropriately calculate HPWH savings estimates, these installation locations may essentially be treated as "Unknown". Unless more detailed information is available, the ACE Model Review team would recommend aggregating the "Other" and "Unknown" categories and assuming an equal distribution across the

[4] Per ACE Model Review team member, Ben Larson, who worked to create the initial measure identifiers for RTF use.

[5] Further, given the complete list of location choices in the survey form, it's unclear what the "other" locations might be.

remaining categories (i.e., renormalizing), rather than attributing them solely to the "Basement" category and shifting the proportions.

Heating System Fuel

Regional space heating fuel distributions for existing homes in combination with the water heater location information (described above) are used to align with RTF savings rates in order to weight savings forecasts for the HPWH ACE Model. Similar to the installation locations of water heaters, RBSA II information on heating fuel and equipment was collected on a more granular level (including electric, gas, other, unknown, and wood fuels along with associated equipment types) than what is used in RTF measure categories of electric resistance, heat pump HSPF 8.5, and gas. NEEA provided a possible approach to align RBSA II heating fuels/systems with RTF measure categories.

Electric heating types were parsed by heating equipment to isolate heat pumps from electric resistance, all remaining heating fuels (Other, Unknown, and Wood) were attributed to the gas category. The ACE Model Review team supports NEEA's current approach. The "Other" heating fuel categories likely contain oil and propane. These, in addition to "Wood", are all non-utility / non-electric fuels and assigning these to a non-electric fuel type should allow a reasonable, best guess, at electric savings. The "Unknown" category could be distributed over the summary categories (as was suggested in the "installation aggregation" methods); however, in the current RBSA II data, those categories represent < 1% and will likely have an undetectable impact.

In reviewing the proposed aggregation method, the ACE Model Review team's assumption was that NEEA's program is targeting only homes with electric resistance water heating. The sum of total homes in the provided data extract suggested that homes with other water heating types were included. The ACE Model Review team supports the current aggregation method, with the suggestion that the RBSA II heating types extract be restricted to homes with electric resistance water heat.

Comparisons to RBSA I

NEEA's request was specific to the aggregation methodology to ensure alignment with RTF HPWH measures. However, in comparing the aggregated distributions for both electric resistance water heater install locations, and space heat fuel, the ACE Model Review team noted some differences between the RBSA II values intended to replace RBSA I HPWH ACE Model inputs. Changes in the summaries reviewed in this task are expected to be small because existing homes are a much larger fraction of the building stock than single-family homes constructed since the original RBSA in 2011. As a result, changes in recent construction practices (as captured in RBSA II) are not expected to substantially shift the regional distributions (of water heater install locations, for example).

The ACE Model Review team compared the aggregated water heater installation distributions (following the recommendations in this memo) and noted several areas where the changes from

the RBSA I aggregation were greater than ± 5 percentage points. For example, RBSA I heating zone three, interior installations were 27%, but increased to 38% in the same heating zone in the RBSA II "Main House" category. The biggest decrease was 14 percentage points from 69% of electric resistance water heaters installed in heating zone three unheated basements in RBSA I to 55% in RBSA II basements. As discussed in the "Installation Location" section of this memo, the RTF "Basement" measure identifier is intended to capture unheated basements. The current RBSA II data extract's "Basement" category doesn't provide transparency as to whether those areas are heated or not. Shifts between interior and basement installation locations could be related to the RBSA II data query. The ACE Model Review team suggests that install location definitions (as extracted from the database) are reviewed.

Conclusion

The ACE Model Review team studied NEEA's suggested methods to aggregate RBSA II data so that new regionalized savings weights can be used to generate savings forecasts in the HPWH ACE Model. NEEA staff confirmed that RBSA II extracts were prepared with newly developed alternate weights. Corrections and refinements to proposed aggregation methods are outlined so that RBSA II data summaries align with RTF HPWH measures. These suggestions include:

- adjusted aggregation methods for water heater installation location,
- review of installation location information as extracted from the RBSA II dataset (particularly basements),
- and restricting the heating type summary to homes with electric resistance water heating.

It is anticipated that comparison between RBSA I aggregated values and refreshed RBSA II extracts/aggregations will show increased agreement.