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Cost Benefit Model Analysis for Heat Pump Water Heaters

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Executive Summary

The Northwest Energy Efficiency Alliance (NEEA) contracted with Larson Energy Research (LER) to review the Heat Pump Water Heater (HPWH) Benefit/Cost Model Analysis (B/CM). The work consisted of three topic areas, addressed in subsequent sections, including:

- Reviewing extrapolation methodologies for estimating annual heat pump water heater sales in Idaho, Montana, Oregon, and Washington.
- Independently assessing NEEA estimates of heat pump water heater market share in new construction.
- Reviewing a new branch (revision) being developed for the Benefit/Cost Model, one that removes measures for tiers 1 and 2 HPWHs from future forecasts. This review included both an assessment of the new savings calculation method as well as a comparison of the outputs of the new and old branch models.

LER's review of the B/CM produces the following recommendations.

Recommendation 1: Consider an alternative method for extrapolating HPWH sales in the four states. This method would require fewer assumptions. (See section 1.1.)

Recommendation 2: LER recommends updates to several input assumptions for estimating the number of HPWHs installed in new construction single-family homes in the four-states, including:

- Increase the percentage of Oregon homes assumed to have electric water heating from 30% to 37%.
- Increase the share of Washington homes built to WSEC 2018 assumed to have electric water heating from 37% to 86%.
- Increase the share of Washington homes with electric water heating assumed to have HPWHs from 93% to 94%.
- Consider an alternative method for estimating the number of Idaho and Montana code homes with HPWHs.

Recommendation 3: LER recommends that NEEA adopt the new branch (revision) of the model that removes measures for tier 1 and 2 HPWHs. (See section 1.3.)

1. Assessment

1.1. Extrapolation Methodologies for HPWH Sales

LER reviewed NEEA's method to estimate HPWH sales in Idaho, Montana, Oregon, and Washington. NEEA has been unable to access sales data from all HPWH manufacturers since 2019, making it challenging to estimate sales. However, NEEA estimates that the data it currently receives captures between 75% and 85% of heat pump water heater shipments to the region. NEEA asked LER to review these key assumptions for validity and to make recommendations that improve the efficacy of the modeling approach.

NEEA's model for HPWH sales assumes three manufacturers and two major retail stores. To avoid disclosing specific manufacturer company names, we refer to them as Manufacturer X and Y throughout. In approaching the review, LER needed to determine how many units Manufacturer X sold in 2022?"

NEEA's method for estimating Manufacturer X's retail sales in Idaho and Montana is highly dependent on the number of a given retailers' stores in any given year. The implication is that the number of a retailers' locations is related to demand for a HPWH manufacturer's products. While retailers consider demand for all of their products in a given market, it is far from the only factor, and it is highly unlikely that HPWH demand is considered at all in store siting. Further, the per-store Manufacturer X-to-Manufacturer Y sales ratio used in the ID/MT estimate (5.7) is very different from the Manufacturer X-to-Manufacturer Y sales ratio seen in the estimates for OR (3.3).

Consequently, LER offers an alternative method, requiring fewer assumptions for estimating sales:

1. Make two estimates of Manufacturer X's wholesale sales:

    a. The first estimate is based on the historical relationship between sales reported by wholesale plumbing distributors and those reported by Manufacturer X: That Manufacturer X's report is the accurate value, and exceeds distributor reports by 10.5% (based on 2018 and 2019 data).

    b. The second estimate is based on the historical relationship between distributor-reported and manufacturer-reported wholesale market share, again assuming that the manufacturer data was the more reliable: Using historical data, determine Manufacturer X's share of the wholesale market as reported by Manufacturer X and as reported by distributors. Apply that ratio to present distributor-reported units sold to estimate a wholesale value for Manufacturer X.

2. Average the two wholesale sales estimates.

3. Assume Manufacturer X's sales through retail equal approximately 20%. (This is based on historical records and can be adjusted based on new market intelligence over time.)

4. Calculate a total sales figure for Manufacturer X by adjusting the wholesale estimate, derived in step 2, by the estimated retail share of 20%.

1.2. Share of New Construction with HPWH

LER reviewed NEEA's method to estimate the share of new-construction single-family homes with HPWHs. As part of that review, LER researched sources of data that could improve estimates.

For Oregon and Washington, LER finds the current formulas used to be sound, but recommends changing three input values to those formulas based on new sources of information.

For Idaho and Montana, LER outlines an alternative estimation method that could improve estimates for that market.

1.2.1. Size of New Construction Market

The current model uses values from the NEEA Residential New Construction model, which tracks both historical and forecasted counts of new single-family homes built by state. LER does not recommend changing the source for these values. The Northwest Heat Pump Water Heater Market Progress Report #6 (MPER6) uses a state-level Building Permits Survey to determine the number of new homes (NMR Group, Inc. 2022). LER expects that these sources have similar data.

1.2.2. Share of Market that is Code Homes

The current model uses values derived from the benefit-cost model that NEEA developed for the New Homes program to determine what share of new homes are "code homes" (homes built to code-minimum requirements). LER is not aware of any better data sources and has no recommended changes.

1.2.3. Share of Code Homes with Electric Water Heating

The current model assumes 30% of Oregon code homes and 37% of Washington code homes have electric water heating.

LER recommends increasing the assumed percentage for Oregon from 30% to 37%. The current 30% value is attributed to the Oregon Residential Specialty Code: Energy Efficiency Analysis (Ecotope, Inc. 2020). That estimate was performed with little primary source data available for the value. MPER6 uses a value of 37% for the entire four-state region (p47). MPER6 is based on more recent data.

LER recommends increasing the assumed percentage for Washington from 37% to 86% for homes built to WSEC 2018. The 37% value is attributed to the 2019-2020 Washington Residential New Construction Code Study (CLEAResult. 2020). That study was undertaken to evaluate the effect of WSEC *2015* on the single-family new-construction market. The Washington Residential Post-Code Market Research Report collected data on the impact of

WSEC *2018* (TRC Engineers. 2022). It concluded that there has been a significant shift in fuel choices for new homes. Based on 178 permits reviewed, 83-87% of homes had electric water heating (p11). (The four-point spread comes from permits that did not specify water heating fuel. Applying the 83:13 ratio, from the permits with the information to those without, yields the 86% value LER recommends.) Based on LER's interpretation of the changes between the 2015 and 2018 WSEC, it is reasonable that the fraction of homes built with electric water heating has increased substantially.

1.2.4. HPWH Share of Electric Water Heaters

The current model assumes of 47% of electric water heaters in Oregon and 93% of electric water heaters in Washington are HPWH.

LER has no recommended changes to the value for Oregon.

LER recommends increasing the assumed percentage for Washington to 94%. The Washington Residential Post-Code Market Research Report found that 81% of all new homes claimed code credit for installing a HPWH. Assuming 86% of homes have electric water heating, then approximately 94% of electric water heating homes claim code credit for installing a HPWH.

1.2.5. Above-Code Homes

The current model uses values from another internal NEEA market tracking tool, the "AXIS" database, to determine the number of HPWH installed in above-code homes. LER does not recommend any changes.

LER does note a discrepancy that becomes apparent when comparing the estimates related to code homes with the number of above-code homes taken from AXIS. Estimating the share of new homes that are code homes implies a share that are above-code. Using 2020 as an example, the modeled results for the New Homes program estimates shares of 94% and 91% code homes in Oregon and Washington, respectively, implying that 6% and 9%, respectively, are above-code. If the 30% and 37% electric water heating ratios are then applied, it follows that Oregon and Washington have a total of 935 above-code homes with electric water heating. For the same year, AXIS reports 1,298 above-code homes with HPWHs.

LER does not recommend any changes to the model to force agreement between these two estimation methods. There are insufficient data to inform such a change. LER mentions this discrepancy primarily as evidence that the estimated number of code-homes with HPWHs are low. Increasing the electric share of water heating fuels and HPWH share of electric water heating, as recommended above, would bring the results of the two methods closer together.

1.2.6. Idaho and Montana Code Homes

The current model estimates that zero HPWHs are installed in new-construction single-family code homes in Idaho and Montana. At present, this does not affect the final outputs of the B/CM as neither ID nor MT codes have stipulations for HPWHs, and the model considers all new-construction HPWH installations through its treatment of above-code homes.

Further, the data needed to make an estimate for code-home installations in the same way as is done in Oregon and Washington are not available. If, in the future, an estimate for ID/MT code-home HPWH installations is needed, LER recommends a new method:

The estimation method used for OR/WA can be thought of as a demand-side approach. (Houses need water heaters. What kind do they get?) This is the best approach for OR/WA, but infeasible for ID/MT given the available data. A supply-side approach is also possible. (Water heaters get installed when they're sold – Where do they go?) This approach would require two new values:

1. **Number of HPWH sold in ID/MT.** This can be estimated from data already collected from manufacturers, retailers, and distributors. A margin of error would be introduced when allocating market share between the states, but a useable estimate should still be possible.

2. **Share of HPWHs that are installed in new construction.** LER is unaware of any reliable source for this number and would therefore rely on general consensus in the industry that HPWHs are currently more readily installed in new-construction single-family homes. MPER6 estimated that share at 65% for 2020 (p48). LER suggests 50% as a reasonable and conservative estimate.

This method is likely less accurate than the one used for OR/WA, but LER believes it will be more accurate than the current assumption of zero. Idaho and Montana make up less than 10% of four-state HPWH market, so no method used to estimate new-construction HPWH market share will significantly alter the regional analysis.

1.3. New Branch of Model

LER reviewed a new branch being developed for the B/CM model, one that removes measures for tier 1 and tier 2 HPWHs from future forecasts. This review included both an assessment of the new savings calculation method as well as a comparison of the outputs of the new and old models. LER finds that the change is appropriate.

1.3.1. New Savings Calculation Method

Both the old and new branches use the same calculation method to produce cumulative net average megawatt (aMW) savings:

1. **Savings Rates**. Appropriate Savings Rates, in annual kilowatt hours (kWh), are referenced/calculated for every year and for each of four product groups and each of five tiers. For the replacement of existing water heaters, the full Savings Rate from *Tech Inputs* is used. For new water heaters, that rate is adjusted by the appropriate factor from *Tech Inputs*.

2. **Apply Savings Rates to Units**. Savings Rates are applied to cumulative net units of HPWHs, as found in *Units*. A value is calculated every year for the number of units of each of four product groups, each of five tiers, and each of four attributes. At the same time, annual kWh are converted to aMW.

3. **Sum aMW by Attribute**. For every year and each attribute, the aMW savings of all product groups and tiers are summed.

Because the new branch uses a different organization of data, LER carefully reviewed the formulas that carry out this procedure. LER found no errors. The review assumes that the source data used in the process described above is accurate. Those sources include:

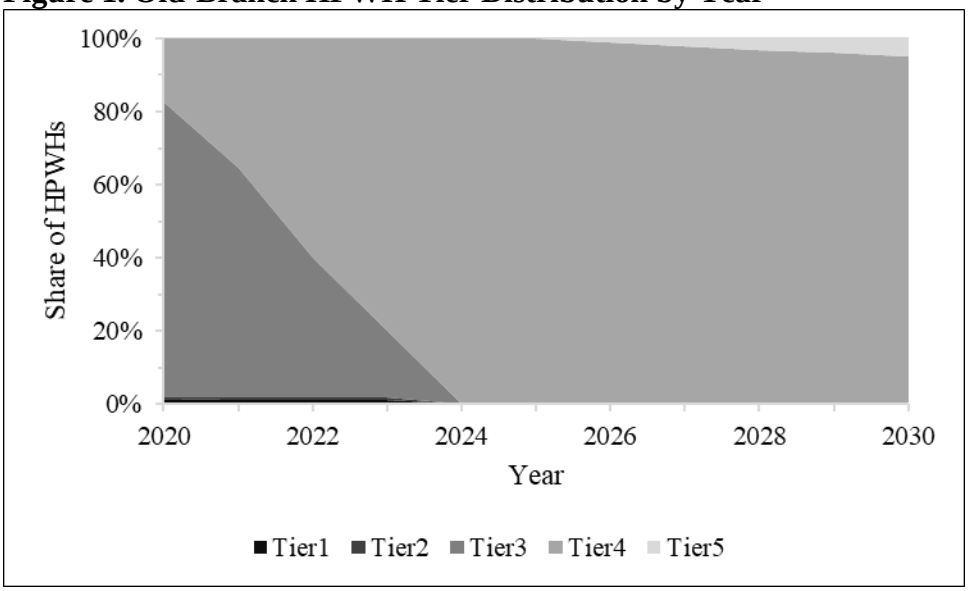
- Savings rates for each HPWH tier (*Tech Inputs* worksheet, cells L8:L13; and their precedents)
- Savings factors of new water heater installations to existing water heater replacement (*Tech Inputs* worksheet, cells L510:M531; and their precedents)
- Cumulative net units of each product group, performance tier, and attribute (as listed in the *Units* worksheet, cells M21:HU49; and their precedents)

One larger scale change LER observed was the elimination of the C4, C5, and C6 labels from the old model (*Units* sheet and others) to new model. These labels appear to delineate according to years 2012-2014, 2015-2019, and 2020+ respectively. The reorganization in the new branch model eliminates the need for the labels and speaks to the value of creating the new branch model: it simplifies the approach in places and improves overall spreadsheet usability.

1.3.2. Output Comparison

One of the most significant changes in the new model is that tiers 1, 2, and 3 are all treated with the savings rates of tier 3. This change represents an acknowledgement that tier 1 and 2 products make up an insignificant share of the market and are only expected to diminish. The old model estimates their share at less than 2%.

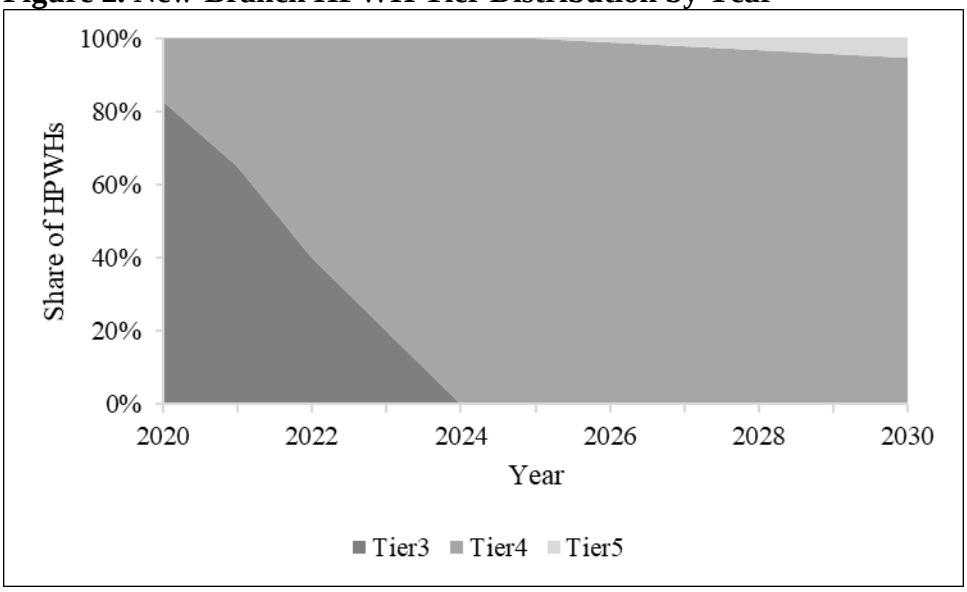
Figure 1. Old-Branch HPWH Tier Distribution by Year



Notes: Data extracted from B/CM before new branch developed. Note the

minimal share of tier 1 and tier 2 HPWHs and their predicted disappearance from market in 2024.

Figure 2. New-Branch HPWH Tier Distribution by Year



Notes: Data extracted from B/CM after new branch, which removes categories for tier 1 and tier 2 HPWHs, applied. Compare to Figure 1 to see the effect of this change on counts of HPWHs by tier.

All other things being equal, this would cause only a miniscule increase in estimated savings. Not only are the unit counts for tier 1 and 2 low, their savings rates are still 67% and 86% of tier 3, respectively. Because the savings rate factors applied to HPWHs installed in new-construction houses are lower than those applied to HPWHs installed in existing houses, the effect of treating tier 1 and tier 2 HPWHs as tier 3 HPWHs is further muted.

LER supports the adoption of the new branch on the basis that it simplifies the B/CM without reducing the quality of the outputs. Any effect that tier 1 and 2 units would have is miniscule.

Anecdotally, LER also notes that there are HPWH models that meet the most important efficiency and performance values required for tier 4 but are qualified as tier 2 because they lack certain other features. While these models likely also make up an inconsequential share of the market, their existence further supports the model change.

2. Synopsis of Recommendations

LER's review of the B/CM produces the following recommendations.

2.1. Extrapolation Methodologies for HPWH Sales

Consider an alternative method, requiring fewer assumptions, for estimating sales. (See section 1.1.)

2.2. Share of New Construction with HPWH

Increase the percentage of Oregon homes assumed to have electric water heating from 30% to 37%. (See subsection 1.2.3.)

Increase the share of Washington homes built to WSEC 2018 assumed to have electric water heating from 37% to 86%. (See subsection 1.2.3.)

Increase the share of Washington homes with electric water heating assumed to have HPWHs from 93% to 94%. (See subsection 1.2.4.)

Consider an alternative method for estimating the number of Idaho and Montana code homes with HPWHs. (See subsection 1.2.6.)

2.3. New Branch of Model

Adopt the new branch. (See section 1.3.)

3. References

CLEAResult. 2020. *2019-2020 Washington Residential New Construction Code Study*. Portland, OR: Northwest Energy Efficiency Alliance. Retrieved from https://neea.org/resources/2019-2020-washington-residential-new-construction-code-study

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