OPC's Comments to EAG Work Group in response to
GTI Energy's *EHP vs GHP Methodology for Washington Gas Maryland Gas Heat Pump Pilot* of December 21, 2023
Prepared by Synapse Energy Economics, Inc. on behalf of OPC
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On December 21, 2023, GTI Energy prepared a memo titled "EHP vs GHP Methodology for Washington Gas Maryland Gas Heat Pump Pilot" ("GTI's December memo") on behalf of Washington Gas Light Company (WGL). GTI's December memo describes GTI's proposed methodology to conduct a comparative analysis of a gas heat pump (GHP) and an electric heat pump (EHP) with regard to WGL's Gas Heat Pump (GHP) Pilot program, in response to Maryland Public Service Commission (PSC) Order No. 90663. In particular, this PSC order requires the following under Section 12:

> *b. GHPs may not be included in WGL's programming until the Pilot Program is finalized and has been subject to the EmPOWER evaluation, measurement, and verification ("EM&V") process;*
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> *c. The analysis performed on the Pilot Program shall:*
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> *i. Utilize Maryland-specific assumptions;*
>
> *ii. Be over the lifespan of the asset;*
>
> *iii. Include a comparative analysis between GHPs and EHPs; and*
>
> *iv. Assume changing emissions from the electric grid over time and assess both current Maryland state policy and zero emissions grid by 2045 for electric emissions, providing both marginal and average emissions results.*
>
> *d. All assumptions used in the analysis of the Pilot Program shall be vetted by the EmPOWER EM&V Work Group.* [1]

The Maryland Office of People's Counsel requested that Synapse review GTI's December memo. As noted below, as well as during the February 21, 2024 EAG Work Group meeting, GTI's proposed method lacks key costs and benefits to comprehensively

[1] Maryland PSC. Order on Semi-Annual EMPOWER Reports. Case No. 9468. June 9, 2023. Available at: https://www.psc.state.md.us/wp-content/uploads/Order-No.-90663-2022-Q3Q4-Semi-Annual-Report.pdf.

evaluate and compare the cost-effectiveness of GHPs and EHPs. The proposed method does not assess the equipment and labor costs of a GHP and an EHP. It also excludes space cooling from its analysis, although this is an essential component of an EHP. Exclusion of cooling would result in an underestimation of the overall cost of a GHP option when compared to an EHP option. Finally, GTI's proposed method underestimates the performance of EHPs. Below are Synapse's findings and recommendations based on our review of GTI's December memo.

GTI should include equipment and labor costs in its analysis and use the Maryland Jurisdiction Specific Test (MJST) to fully assess the cost-effectiveness of GHP and EHP and determine the viability of GHP technology.

The proposed analytical framework focuses on operation costs and excludes equipment and installation labor costs. This would not provide the full picture of the cost-effectiveness of a GHP for EmPOWER Maryland programs. The Commission's Order No. 90663 requires that the GHP Pilot program is subject to the EmPOWER EM&V process. This is a critical requirement for the results of the GHP Pilot program to be useful because WGL's ultimate objective is to incorporate GHP in EmPOWER Maryland's program portfolio. This means that the evaluation of the performance of GHP needs to be more comprehensive than what GTI proposed. More specifically, WGL and GTI must use the Maryland Jurisdiction Specific Test (MJST) – the primary cost-effectiveness test used for the EmPOWER Maryland programs – to evaluate the cost-effectiveness of GHPs and EHPs. This means that GTI needs to incorporate in its analysis all the benefits that are necessary to perform the MJST, including avoided GHG emissions and avoided methane leaks.[2] WGL and GTI also need to incorporate all the measure costs in this evaluation, including the total equipment and labor costs in addition to operating costs.

To properly and fairly assess the cost-effectiveness of a GHP and an EHP, WGL needs to include the cost of cooling for all the scenarios that include gas heating, including GHP

EHPs provide space cooling, in addition to space and water heating. Thus, in order to properly and fairly assess all costs and benefits of a GHP and an EHP, WGL needs to expand the scope of the analysis to ensure that all options provide the same energy services. It can do this by including the total measure cost (both equipment and

[2] National Energy Screening Project. 2022. *National Standard Practice Manual – Case Study: Maryland*. Available at: https://www.nationalenergyscreeningproject.org/wp-content/uploads/2022/06/Maryland-NSPM-Case-Study-2022-06-28.pdf.

installation labor costs) and operating cost of cooling (e.g., central air-conditioner) for the scenarios that include a GHP and other gas heating systems in this analysis. This logic is similar to GTI's proposed approach to add electric water heaters to the EHP Scenarios 2 and 3: GHP Combi systems provide water heating, so the EHP scenarios should also include water heating. EHPs provide cooling so the GHP Combi scenario must also provide cooling.

GTI Energy's analysis should rely on as much real-world performance data as possible for EHPs. The proposed performance ratings for EHPs are likely to be overly conservative for Maryland's climate.

GTI's December memo proposed to use data for the performance of energy systems based on real-world performance in Maryland as follows:

> "For the EHP performance, GTI Energy will incorporate any EmPOWER provided performance data into these energy models, enabling a comparison based on real-world performance in Maryland across the equipment types. Per footnote 30 listed in Order, "There have been multiple EHPs installed in the State of Maryland through the EmPOWER program. WGL shall coordinate with the other EmPOWER utilities to gather the data necessary to perform the comparative analysis." Alternatively, the hourly performance data for EHPs in BEOpt or EnergyPlus or peer-reviewed publications will be used for comparison." (page 8)

We support the use of real-world performance data, as noted above. This includes the use of Maryland specific weather data that is important to develop and model space heating performance data relevant for Maryland. We also support the use of hourly performance data based on in-field evaluation studies of EHPs. It is not clear to us whether the hourly performance data for EHPs in BEOpt or EnergyPlus are based on real-world performance data.

While GTI's December memo indicates the use of real-world performance data for EHPs, the memo also provides energy efficiency ratings to be used in GTI Energy's evaluation in Table 2 of the memo, all of which are not based on real-world performance data. For heat pumps for space heating, GTI's December memo indicates an efficiency of 7.5 HSPF2 (Heating Seasonal Performance Factor 2) for a regular EHP and 8.1 HSPF2 for a cold climate EHP.[3] The efficiency rating for a cold climate EHP is based on the minimum

[3] HSPF stands for Heating Seasonal Performance Factor and indicates the energy efficiency of a space heating system. HSPF specifically represents the ratio of heating energy output (in Btus) to energy input

rating for a cold climate EHP developed by the Consortium of Energy Efficiency (CEE). These values are not based on real-world performance of cold climate EHPs. Instead of these proposed ratings, we recommend that WGL and GTI use data based on in-field evaluation of EHPs available in the market today. We believe that such data would show higher heating and cooling performance.

The Brattle Group recently completed its statewide electrification study for Maryland ("the Brattle Electrification Study") on behalf of the Commission, for which Brattle received significant input from the Electrification Study Workgroup (ESWG) over the course of a year.[4] This study used detailed heat pump performance curves (as shown in Figure 1) based on real-world performance data to estimate the performance of EHPs. More specifically, the study used these performance curves to model coefficient of performance (COP) values as a function of hourly temperature in Maryland and estimated energy consumption from EHPs.[5] The study developed these curves primarily based on a meta-analysis of several in-field performance evaluation studies of heat pumps, which reflect the actual performance of approximately 550 heat pumps (with 2,760 measurements).[6]

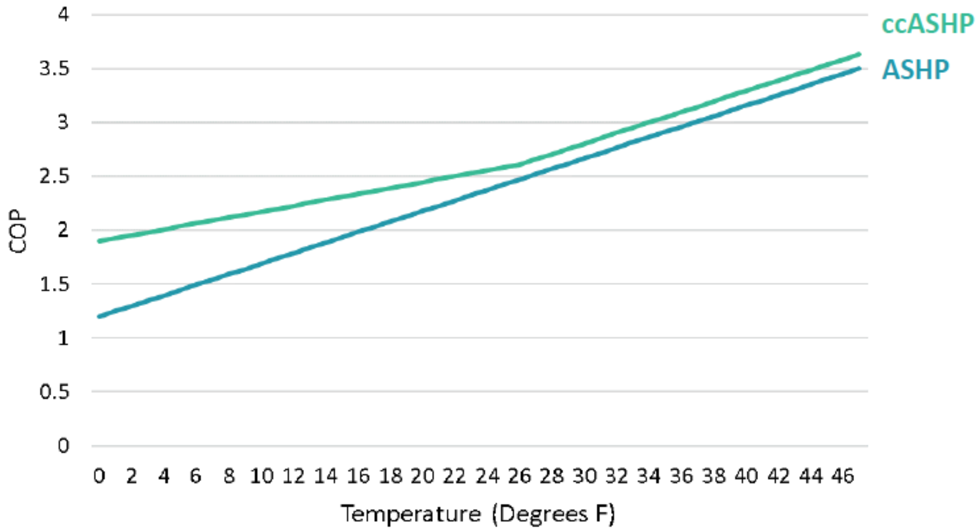
(in watt hours). HSPF2 is the second generation of the heating system efficiency factor that the U.S. Department of Energy (DOE) recently adopted to improve the accuracy of the performance metric.

[4] The Brattle Group. 2023. An Assessment of Electrification Impacts on the Maryland Electric Grid. Prepared for the Maryland Public Service Commission. Available at: https://www.psc.state.md.us/wp-content/uploads/Corrected-MDPSC-Electrification-Study-Report-2.pdf.

[5] COP is a unitless metric often used to indicate the energy efficiency of heat pump technologies. It represents a ratio of energy output to energy input (in the same units, such as Btus).

[6] Gibb, et. al. 2023. "Coming in from the Cold: Heat Pump Efficiency at Low Temperatures." *Joule*. Volume 7, Issue 9. Available at: https://www.cell.com/joule/abstract/S2542-4351(23)00351-3.

Figure 1. Brattle Study heat pump space heating COP curves



Source: The Brattle Group. 2023. Technical Appendix. Slide 61. Notes: ccASHP stands for cold climate air-source heat pump and ASHP stands for air-source heat pump.

We estimated average COP values using Brattle's COP curves for Maryland to assess the reasonableness of GTI's proposed heating efficiency ratings for EHPs. More specifically, we applied the COP curves to hourly weather data (the typical meteorological year 3 data or TMY3 data) specific to Montgomery County, Maryland to estimate COP values.[7] The resulting average COP values are 3.3 for a cold climate EHP and 3.1 for a regular EHP. These values can be translated into 11.2 HSPF2 and 10.7 HSPF2, respectively, if we convert these values based on a pure physical unit conversion.[8] These values are approximately 40 percent greater than the HSPF2 ratings GTI Energy proposed.

We recommend that GTI use Brattle Electrification Study's COP performance curves and Maryland-specific hourly temperature data to estimate the performance of EHPs because (a) these performance curves reflect real-world performance of numerous heat pumps and because (b) they were already vetted and approved by the ESWG for the Brattle Electrification Study. Further, we recommend that GTI collect additional data from the other EmPOWER utilities as directed by the Commission in Order No. 90663. Such local

[7] TMY3 data for Montogmery County (file name: G2400310_TMY3.csv) is available at: https://data.openei.org/s3_viewer?bucket=oedi-data-lake&prefix=nrel-pds-building-stock%2Fend-use-load-profiles-for-us-building-stock%2F2022%2Fresstock_tmy3_release_1%2Fweather%2Fstate%3DMD%2F.

[8] HSPF2 represents the ratio of heating output (in Btus) to its consumed electricity (in Watt-hours).

data would help improve the COP performance curves employed in the Brattle Electrification Study or verify the reasonableness of the COP performance curves.

GTI Energy's analysis should rely on as much real-world performance data as possible for an electric heat pump water heater (HPWH). GTI Energy's proposed performance rating for HPWH is overly conservative and does not reflect the performance of available Energy Star HPWHs.

GTI Energy proposed 2.2 UEF (Uniform Energy Factor) for an electric HPWH, based on the minimum UEF value for 120-volt HPWH models (instead of widely installed 240-volt HPWH models) for Energy Star labeling.[9] There are three main issues with this proposed value.

First, the proposed value does not reflect the real-world performance of HPWHs. We recommend that GTI seek to obtain data based on in-field evaluation studies of HPWHs.

Second, the proposed value also does not reflect the performance of available Energy Star HPWHs in the market. It is not possible to buy a HPWH with the low performance that GTI Energy proposes to assume. U.S. EPA currently list 42 products in the category of 120-volt HPWH. UEF values range from 2.8 to 3.5 with an average of 3.1 (See Figure 2 below).[10] This average UEF value for a 120-volt HPWH is approximately 41 percent more efficient than the proposed UEF value by GTI Energy.

Third, 120-volt HPWH units recently have become available in the market and the number of available models is only about one-fifth of the number of standard 240-volt HPWH models available. Thus, it may make sense to develop and use a UEF value based on 240-volt models or an average of the two types of technologies. There are currently 215 Energy Star HPWH models that use 240 volts. The UEF values for 240-volt HPWH models are considerably higher than the values for 120-volt models and range from 3.3 to approximately 4.1, with an average UEF of 3.7 (Figure 3 below).

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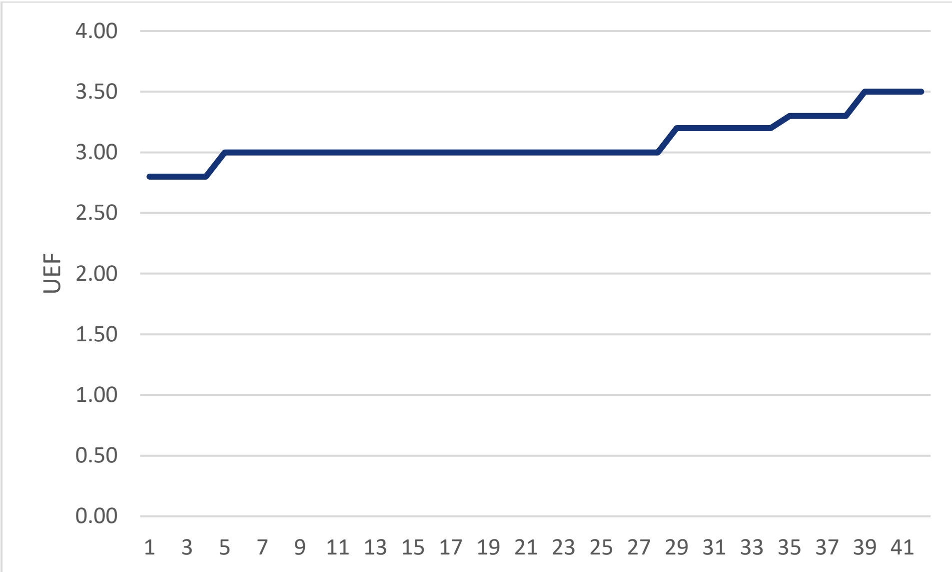
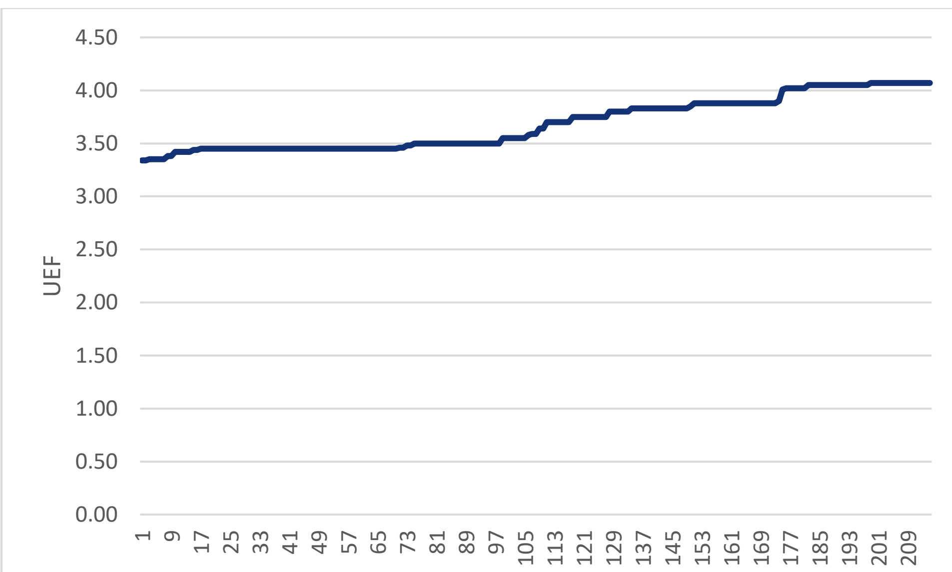
[9] A Uniform Energy Factor (UEF) is the U.S. DOE's industry standard for measuring energy efficiency of a water heater. A UEF represents a ratio of energy output to energy input, measured under certain test conditions defined by U.S. DOE.
[10] The data for Energy Star HPWH models are available at: https://www.energystar.gov/productfinder/product/certified-water-heaters/results.

Figure 2. UEF ratings for 120-volt Energy Star HPWHs



Source: U.S. EPA Energy Star Certified Water Heaters. Available at: https://www.energystar.gov/productfinder/product/certified-water-heaters/results.

Figure 3. UEF ratings for 240-volt Energy Star HPWHs



Source: U.S. EPA Energy Star Certified Water Heaters. Available at: https://www.energystar.gov/productfinder/product/certified-water-heaters/results.

Lastly, it is important to note that the Brattle Electrification Study assumes a COP of 3.3 for 2022 (which is equivalent to a UEF of 3.3) and a COP of 3.79 for 2031.[11] If GTI Energy cannot find any real-world performance data for HPWH, we recommend a UEF of 3.3 to be consistent with the Brattle study's assumption.

The proposed efficiency rating for GHPs contradicts GTI's stated intent to use actual metered data from GHP pilot sites

GTI's December memo states that "[m]etered data from the residential GHP field pilot sites will be used to calibrate and validate the energy models."[12] However, the memo also provides a COP of 1.4 for a GHP Combi system in Table 2. This stated value is misleading because GTI's stated plan is to use the value based on the metered data from the GHP pilot sites. We recommend that GTI Energy remove the value of 1.4 from the table or provide a clear explanation about how this value is used in its analysis.

GTI's December memo does not provide sufficient information about the proposed formulas for calculating gas furnace efficiency

GTI's December memo provides the following two formulas that account for the effect of part load conditions and estimate the total efficiency of baseline and high-efficiency gas furnaces.[13]

- Efficiency_gas (baseline) = Efficiency_(steady state)*(0.8 + 0.2*PLR)
- Efficiency_gas (high efficiency) = Efficiency_(steady state)*(0.9 + 0.1*PLR)

The memo does not provide adequate explanation about these formulas. For example, it does not explain what "Efficiency_(steady state)" means, what values should be used for "Efficiency_(steady state)", or how GTI is planning to obtain the data necessary to estimate PLR (part-load ratio). Further, the memo does not explain the data sources for these formulas and how valid these formulas are.

[11] The Brattle Group. 2023. Technical Appendix. Slide 60.
[12] GTI's December memo. Page 7.
[13] GTI's December memo. Pages 8 and 9.