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October 29, 2021

Attn: Ms. Melissa Weitz
U.S. Environmental Protection Agency
Climate Change Division
Office of Air and Radiation
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Re: AGA Comments on EPA Memoranda: (1) Proposing to Add Post Meter Emissions Estimates; and (2) Proposing to Change the Assessment of Natural Gas STAR and Methane Challenge Reductions in the 2022 Inventory of U.S. Greenhouse Gas (GHG) Emissions and Sinks (1990-2020)

Dear Ms. Weitz:

The American Gas Association (AGA) appreciates the opportunity to comment on the U.S. Environmental Protection Agency's (EPA) two technical memoranda (1) proposing to add post meter methane emissions estimates and (2) proposing to change the assessment of methane emission reductions achieved under EPA's Natural Gas STAR and Methane Challenge programs in the 2022 Inventory of U.S. GHG Emissions and Sinks (1990-2020) (2022 GHGI). The two memoranda were posted at the end of September 2021 on EPA's GHGI stakeholder process website.[1] We appreciate your decision to allow us additional time until Oct. 29, 2021 to submit our comments.

The American Gas Association, founded in 1918, represents more than 200 local energy companies that deliver clean natural gas throughout the United States. There are more than 76 million residential, commercial, and industrial natural gas customers in the U.S., of which 95 percent — more than 72 million customers — receive their gas from AGA members. Today, natural gas meets more than thirty percent of the United States' energy needs.

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[1] https://www.epa.gov/ghgemissions/stakeholder-webinar-sept-2021-natural-gas-petroleum-systems-ghg-inventory.

The GHGI directly affects AGA and its members because it provides the best available estimate of national average GHG emissions from our members' operations – including natural gas local distribution, transmission, and storage. As demonstrated by previous Inventories, the methane intensity of delivered natural gas in the U.S. already falls well below even the most stringent thresholds for immediate climate benefits achieved through coal to natural gas switching.[2]

AGA Supports Gas STAR & Methane Challenge Adjustments: EPA's Memorandum on Natural Gas STAR and Methane Challenge examines how EPA plans to reflect methane reductions achieved under those voluntary programs in the 2022 GHGI. AGA does not object to your plans for reflecting methane reductions from Natural Gas STAR and Methane Challenge in the GHGI.

AGA Recommends Postponing EPA's Addition of Estimated Post-Meter Emissions Until Further Data and Analysis Can Be Developed and Applied: EPA's September 2021 Memorandum on GHGI "Updates Under Consideration for Post-Meter Emissions" (Post-Meter Memo) explains that EPA is proposing to add estimates of post-meter residential, commercial, and industrial customer methane emissions as well as certain natural gas vehicle emissions in response to a recommendation in the 2019 Refinement to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories for natural gas systems (IPCC 2019). AGA recommends postponing the addition of post-meter emissions to the 2022 GHGI. The available studies reveal a fat tail distribution suggesting a small number of sources contribute a disproportionate amount of total emissions. However, the studies do not have a sufficiently large or representative data sample to provide reliable national emissions estimates. We believe that at such time that more reliable data is available, post-meter emissions – if able to be sufficiently determined and appropriately quantified -- should be grouped in a separate segment for "other" emissions sources. It would not be appropriate to include them in the distribution segment because natural gas distribution ends at the customer meter. In addition, not all industrial and commercial customers are served by distribution lines.

AGA also recommends using PHMSA's public data for midstream activity rather than a proprietary data base: There are significant problems with EPA's proposal to use a proprietary data (from Enverus) instead of PHMSA public date for midstream activity factors, including for counts of compressor stations and for miles of interstate and gas utility-operated intrastate transmission pipeline miles and numbers of compressor stations. Because it is a private, proprietary data base, there is a lack of transparency regarding how the activity counts were derived.

In our detailed comments, we will focus on EPA's proposal for residential post-meter emissions.

[2] See AGA's Analysis of EPA's 2021 GHGI at https://www.aga.org/research/reports/epa-updates-to-inventory-ghg/.

I. Data Gaps, Small Sample Size, Orders of Magnitude Differences and Uncertainties Should Preclude Adding Residential Post-Meter Emissions Estimates to the GHGI Pending Further Research

The Post-Meter Memo based its proposed emissions estimate for residential post-meter emissions on the 2.54 kg per natural gas house emission factor developed by the California Air Resources Board (CARB) based on a 2018 study of 75 homes in California (Fischer et al.).[3] EPA is proposing not to use the IPCC's emission factor as it is based on European appliances and homes rather than U.S. homes and gas appliances. AGA agrees with that decision. However, we question the use of a study of only a limited number of California homes to represent the experience of homes across the country in vastly different climates and with presumably different building Code requirements. Other studies EPA considered provide widely varying estimates and only serve to illuminate the range of data gaps and uncertainties.

Based on the analysis below of the four residential papers EPA considered, AGA urges EPA to postpone adding an estimate of residential post-meter emissions to the GHGI until data gaps and uncertainties we outline below can be more reliably addressed.

1. **There are no standard test methods or standard practices** for measuring and determining the flow rate or volume of methane emissions from end-use natural gas appliances. Differences in the types of measurement equipment used, performance-related attributes of the equipment, and standardization of the measurement protocols themselves should be addressed first before utilizing any individual study on these types of methane emissions. The standards development for testing protocols would be time-intensive work but essential to establish the credibility for estimating post-meter methane emissions.

2. **The use of a limited set of studies conducted on a small sample of homes is unlikely to be representative of a national U.S. estimate**.

3. **There are considerable data gaps, large uncertainties, and orders of magnitude difference among the available studies** EPA reviewed for these methane emissions estimates.

4. **There were no repeated tests to determine the reproducibility of the methods referenced or to determine whether emissions vary with time or environmental conditions.**

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[3] See Post-Meter Memo page 10, section 6 "Preliminary National Emissions Estimates" and page 2 citing Marc L. Fischer et al, An estimate of natural gas methane emission from California homes, ES&T, 52, 10205-10213.

5. **The blower door method used to produce EPA's proposed emission factor may in fact have caused additional emissions – and an overstated emission factor -- by blowing out pilot lights.**

II. Analysis of Residential Studies EPA Considered Demonstrates the Need for Further Research with More Robust, Representative

1. Analysis of Fischer Study of California-Only Homes, Using a Blower

The Fischer et al. paper describes measured methane emission rates for whole-houses in California (with no gas appliances in operation) along with a subset of specific gas appliance methane emission rates. The study included measurements for 75 houses in California using a novel way to measure whole-house emissions using a blower door to draw air through the house along with a sensitive Los Gatos methane analyzer to measure methane concentrations indoors and outdoors and a sophisticated statistical treatment of the results to extrapolate the data to all of California. Controlled methane releases in each house were used to verify the method. The overall accuracy of the whole house measurements was not stated. However, there were no repeated tests on the same house at different times to determine the reproducibility of the method or to see if emissions vary with time or environmental conditions. The tests were conducted on a variety of house types and ages and appear to be reasonably representative of California housing stocks, but not housing in other parts of the country. No tests were conducted on apartments, although the extrapolation assumed that the single-family house results were also representative of multi-family structures. This assumption should be addressed in future studies. There was also no mention of houses with attached garages, although it can be assumed that many or most of the houses had attached garages. In some houses, it is possible that the gas furnace and water heater are located in an attached garage, but it isn't clear how the blower door tests were applied for these cases or whether this raises issues with how well the method works for houses with attached garages. Finally, all of the houses were sampled in California, so there are uncertainties about how California houses compare to houses in other parts of the US, where building codes and practices might be quite different.

The test results showed a fat-tail distribution of measured emission rates with only a small number of high emission rate points. There appeared to be six points with whole house emissions greater than 15 scfm. The range of emissions was from near zero to a maximum rate near 35 scfm. This maximum rate is approximately 0.024 g/min.

Another important aspect of the results was that only a very small number of leaks were identified in only a few houses. Since appliances were not running during the whole house tests, this suggests that either pilot lights were the major source or that undetected leaks were a significant factor. Since natural gas is odorized in city distribution systems, it seems likely that homeowners would detect any significant pipe leaks and have those fixed immediately. In terms of the overall whole house emissions, pilot lights were estimated to account for only 25% of the total. However, the study made no attempt to reconcile the fact that very few leaks were detected, but leaks must account for 75% of whole house emissions. This is a significant weakness and efforts are needed to account for all sources in whole house emission measurements. There may also be issues associated with the effects of the negative pressure imposed by the blower door on pilot light or leak emissions. In other words, the blower used in the study may have blown the pilot out and caused the emissions.

The paper describes a sophisticated statistical treatment where a gamma function was fit to the data to account for the skewed distribution of measured rates and a Monte Carlo re-sampling method was used to estimate 5% and 95% confidence limits and “central” (mean?) values. As shown in Figure S5, for the whole house fit of the gamma function to the data, it appears that the higher emission rates lie above the best-fit line such that there might be a point where one gamma distribution fits the lower rates and a second-best fit with a great slope fits the higher rates. This seems to suggest that the higher emission rates were over-estimated using the gamma function to represent the leak rate distribution. Further work is needed to reduce the uncertainty in the higher end of the leak rate distribution. More measurements from more houses in areas across the U.S. would be required.

The Fischer et al. paper also describes results for single appliance emission rate measurements. These were derived from measuring the CH4 to CO2 ratio (with background levels subtracted) and by tracking natural gas consumption during each appliance test. The accuracy in this method was estimated to be ±11%, as noted in the Supplemental Information (SI). This is a reasonable approach and appears to be relatively accurate. A large number of water tank heaters (62) and stovetops (54) were measured, but only a few (2 to 6) of other appliances (dryer, furnace, tankless water heaters) were measured. Since there are about four natural gas appliances per house, more measurements of these other appliances are needed for a complete picture of appliance emissions. The measurements were focused on steady-state operations and, except for three tankless water heaters, the transient emissions from start-up and stop were not captured.

Overall, this research provides a valuable database of whole house and appliance methane emission rates. However, future work should address sampling across the U.S., and an effort to better represent the high end of the emission rate distribution is needed. For whole-house emissions, future work should also attempt to identify all sources in the house and reconcile the bottom-up contribution of leaks and pilot lights versus top-down whole-house emissions. More appliance measurements are needed beyond the stovetop and water tank heaters tested in this study.

2. Analysis of Merrin and Francisco 2019 Study in Boston and Indianapolis[4]

The Merrin and Francisco paper[5] reports measurements of methane emission time series and totals for a variety of natural gas appliances. Approximately 100 different appliances were measured in homes in Boston, Indianapolis, and nearby locations. The results were used first to characterize the ignition, steady-state, and extinguishment phases of appliance operations. Then the data were extrapolated to estimate US total methane emissions by appliance type.

The primary value of this work is the characterization of appliance operation emission patterns (Figure 4) which shows spikes in emission during ignition and extinguishment and relatively constant emissions during steady-state operations. The authors provide box plots of the distribution of emission rates by appliance at steady-state (Figure 5) and also for the spike events (Figure 6). The box plots extend over an order of magnitude in most cases. These results are useful for understanding how emissions are similar or different for different types of appliances. Stove burners and tankless water heaters had the highest steady-state emissions per mass of natural gas consumed, while furnaces, boilers and water tank heaters were an order of magnitude less. However, when extrapolated nationwide, furnaces accounted for 39% of total appliance annual emissions and ovens contributed 17%. Other appliances were in the range 8% to 14% of the total U.S. estimate.

These measurements were collected by measuring exhaust gas methane concentrations with a Picarro analyzer, calculating the total exhaust gas flow rate based on combustion stoichiometry and measured CO2 exhaust gas concentrations, and estimating natural gas consumption rates based on appliance energy ratings.

There are serious issues with each of these steps. First, there were gaps in peak concentration measurements when the levels exceeded the instrument range. These were addressed by linear extrapolation from the within-range concentrations. This applied to some of the spike events for some appliances. Second, it isn't clear how accurate the exhaust gas flow rates were since they were not directly measured, and there was no attempt made to confirm the calculations with any specific measurement tests. Third, the natural gas consumption was estimated from the appliance rating, and no attempt was made to use the house gas meter to measure the gas consumption while the appliance was operated (as Fischer et al did in the whole house and appliance study). The authors noted that because of these uncertainties, the results were at best an order of magnitude estimate of emission rates for individual appliances. It should be noted that the steady-state results were 15 times (water heaters) and 3 times (stove top) smaller than the corresponding appliance measurements from Fischer et al. This may give some indication of the level of error in the results. Given this large degree of

[4] **Merrin and Francisco, 2019. Unburned methane emissions from residential natural gas appliances, *ES&T, 53*, 5473-5482**

uncertainty, the extrapolated U.S. totals can only be considered as very preliminary estimates.

The distribution of measured emissions exhibited a skewed, fat-tail distribution for all appliances, and the authors assumed a log-normal distribution to estimate confidence limits. There were factors of two to three in the estimated confidence limits about the mean.[6]

Overall, this work is valuable for the characterization of appliance emission patterns and for comparing these patterns among different appliances. Because of the methods, confidence in the quantitative emission totals is low. These are difficult and time-consuming measurements to make, but more work is needed to reduce the measurement uncertainties and improve confidence in the extrapolated results.

3. Analysis of Lebel et al., 2020 Study of Natural Gas Water Heaters[7]

This paper describes a relatively comprehensive assessment of methane emissions from storage hot water heaters and tankless hot water heaters. This includes documentation of the emission data base as well extrapolation of these results to the US housing stock. Emission measurements, including spikes due to on/off events and steady state conditions, are reported for 35 California homes and water tank usage data are reported for 46 homes. The usage data were used as part of the extrapolation process for total US emissions.

The measurement approach and efforts to provide quality assurance of the methods were quite good. A custom-built high flow sampling system was used to capture all of the appliance exhaust. The total air flow rate was directly measured, and the dilution associated with the high flow reduced the exhaust concentrations of CH4 and CO2 to ranges suitable for measurement with a Picarro gas analyzer. Tests of the system with controlled CH4 releases showed a small bias of ~10% which was used to correct the measured emission rates. Although not stated, it appears the accuracy in the emission rate measurements were of order ±20%. Natural gas consumption was estimated from the CO2 levels in the exhaust flow and validated with readings from the residential gas meter. Overall, the approach used here and the associated quality assurance tests appear to provide emission data with a relatively high degree of accuracy compared to the methods used by Merrin and Francisco (2019) as noted above. The authors provide a quantitative comparison between the two studies in Table S7. However, the results do not exhibit a consistent positive or negative bias between the two studies for the different operation phases. This probably reflects differences in methods as well as differences in the population of hot water heaters sampled.

[6] The authors provided graphs of the distribution in the Supplemental Information.

[7] **Lebel et al., 2020. Quantifying methane emissions from natural gas water heaters, *ES&T, 54*, 5737-5745.**

Emissions were measured for steady state off, the on pulse, steady state on, and the off pulse periods (see Figure 1). It should be noted that there were emissions due to pilot light incomplete combustion in the steady state off condition. In fact, for storage hot water heaters, the steady state off condition represented 96% of the total emissions. For each operation phase, there was a skewed distribution of emission rates as shown in Figures 2 and 4. During the off phase, storage tank heaters had much higher emissions than tankless heaters due to the pilot light, but for the pulse on/off and steady on phases, the tankless heaters had much higher emissions. On a per heater basis for the combined phases, the tankless heaters had emissions twice as high as the storage tank heaters. The emissions data were bootstrapped to provide estimates of the mean and confidence levels. When these individual emission rates were combined with usage data for both types of water heaters, the tankless heaters emitted at 0.93% of NG consumed while storage heaters emitted at 0.39% of NG consumed. However, because the tankless heaters are relatively new, these represent only 2% of all US heaters.

Overall, this study provides a good initial database for emissions from both storage and tankless water heaters as well as new data on the duty cycles of hot water usage in a number of homes. However, additional measurements in other locations are needed to address any regional differences and to improve estimates of the fat-tail portion of the emission rate distribution. There is also a need to obtain additional usage data for other locations to improve the activity factors used in a US inventory.

4. Analysis of Saint-Vincent and Pekney, 2020 Literature Review[8]

This is primarily a broad review paper of methane emissions from previous studies of natural gas sectors, with an emphasis on the distribution system (Section 3) and post-meter emissions (Section 4). *There are no new emissions data provided in this paper*.

It may be noted that considering only combustion efficiency of residential furnaces in the range of 50% (older units) to 95% (new units) along with the number of natural gas furnaces in the US yields methane emissions that are an extremely small percentage (<0.0005%) of the US annual methane budget.

The most useful portion of this paper is summarized in Table 5 where the authors compare annual budgets of residential CH4 emissions using the results from Fischer et al. (2019) and Merrin and Francisco (2020). For major appliances, the total CH4 annual rate is 30 Gg/yr from Merrin and Francisco, including all phases of operation of appliances, and 45 Gg/yr from Fischer et al. for only steady state appliance emissions. In comparison, Lebel et al. (2020) estimated 82 Gg/yr for only hot water heaters and, based on Fischer et al., the estimate for whole-house plus appliance emissions is 165

[8] **Saint-Vincent and Pekney, 2020. Beyond the meter: Unaccounted sources of methane emissions in the natural gas distribution sector, *ES&T, 54,* 39-49.**

Gg/yr. These comparisons, while rough and somewhat indirect, provide some measure of the uncertainties that exist for residential post-meter emissions.

It is clear that much more work is needed to improve methodologies, to acquire better activity data, to investigate similarities and differences on a regional basis and to account with better accuracy the fat-tail distributions of emissions that are typical of all of these sources.

Summary

Three of the above papers provide direct measurements of residential post-meter methane emissions that account for indoor pipeline leaks, steady pilot light emissions, and emissions from appliances for on/off and steady state conditions. Even so, the data bases have total sample numbers on the order of 50 to 100 for any specific type of source which is a very small portion of total US house or appliance counts.

Given the considerable data gaps and uncertainties remaining and the orders of magnitude difference among the available studies, AGA urges EPA to postpone adding an estimate of residential post meter emissions to the GHGI until further research can produce a more reliable national estimate.

III. Conclusion

AGA urges EPA to postpone adding an estimate of residential post-meter emissions to the GHGI until these data gaps and uncertainties can be more reliably addressed.

1. There are no standard test methods or standard practices for measuring and determining the flow rate or volume of methane emissions from end-use natural gas appliances. Differences in the types of measurement equipment used, performance-related attributes of the equipment, and standardization of the measurement protocols themselves should be addressed first before utilizing any individual study on these types of methane emissions. The standards development for testing protocols would be time-intensive work but essential to establish the credibility for estimating post-meter methane emissions.

2. The use of a limited set of studies conducted on a small sample of homes is unlikely to be representative of a national U.S. estimate. It is especially inappropriate to rely on a small sample size in a data set known to have a fat tail distribution.

3. There are considerable data gaps, large uncertainties, and orders of magnitude difference among the available studies EPA reviewed for these methane emissions estimates.

4. There were no repeated tests to determine the reproducibility of the methods referenced or to determine whether emissions vary with time or environmental conditions.

5. Moreover, the blower door method used in the Fischer et al study to produce the emission factor EPA proposes to use may in fact have *caused* additional emissions – and an overstated emission factor -- by blowing out pilot lights.

It is essential that a reliable foundation for estimating national emissions from residential natural gas end-use equipment and piping be established to ensure the credibility of EPA's reported methane emissions from these sources.   The studies identified by EPA have illuminated an important issue that requires significantly more time and attention. A foundation to build upon starts with the development of standard test methods or standard practices for methane measurement and determining the reproducibility of reported methane emissions from natural gas end-use equipment through studies with larger, more representative samples using those standard methods.

AGA appreciates the opportunity to comment. If you have any questions, please do not hesitate to contact me or Tim Parr, AGA Deputy General Counsel, at tparr@aga.org.

Respectfully Submitted,

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