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Featured Research Review:

Lebel, E., Michanowicz, D., Bilsback, K., et al. (2022). Indoor air quality impacts of hazardous air pollutants in unburned methane gas leaked from stoves not in use

December 19, 2022

Terms to know:

Hazardous air pollutants – chemicals, also known as air toxics, that are known or suspected to cause cancer and other serious non-cancer health effects (e.g., benzene, toluene, ethylbenzene, and xylene or BTEX).

Non-methane volatile organic compounds (NMVOCs) – organic chemical compounds that exclude methane and that under normal conditions can vaporize and then enter the air.

Trace gas analyses – tests that accurately measure even small amounts of specific gases from air samples.

EPA Method TO-15 – the procedure used to analyze air samples collected through canister sampling, where TO stands for "toxic organics." It measures up to 97 volatile organic compounds (VOCs) of the total 189 hazardous air pollutants listed in the Clean Air Act. It is used for testing grab samples of ambient air.

Parts per million by volume (ppmv) – a unit of measurement for gases.

In 2021, almost one third of the total United States energy consumption came from processed methane gas, 15% of which was consumed by an estimated 74.6 million residential households. Unprocessed methane gas is known to naturally contain non-methane volatile organic compounds (NMVOCs), many of which are dangerous to human health and have been identified as hazardous air pollutants or HAPs, under the U.S. Clean Air Act.

While the federal government does regulate NMVOCs in methane gas transmitted through pipelines, there are currently no restrictions on HAPs in pipeline gas. In fact, there are only a few studies and limited publicly available information describing the chemical make-up of gas at the transmission and storage stages of the process.

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Even less is known about the types or amounts of HAPs in processed methane gas when it reaches households or "end users." In California, 88% of all households (11.5 million in total) used gas as an energy source in 2020. Of these, about 70% cooked with a gas-powered stove or oven. That accounts for the highest percentage of gas stove users in the country and further highlights the need to understand the impact of leaked in-home gas on household air quality.

A recent study done in California, "Composition, Emissions, and Air Quality Impacts of Hazardous Air Pollutants in Unburned Natural Gas from Residential Stoves" (Lebel, E. D., Michanowicz, D. R., & Bilsback, K. R. et al., 2020), attempted to better understand the impact of in-home leakage of unburned methane gas on indoor air quality and its potential health implications. To accomplish this, researchers performed trace gas analyses on 185 unburned samples collected from 159 gas stoves in homes throughout California. Samples were then analyzed for NMVOCs using U.S. Environmental Protection Agency Method TO-15. Complex statistical analyses were then applied to estimate regional and statewide emissions and to model indoor air quality.

Analyses in the study detected several hazardous air pollutants in varying amounts known to be associated with adverse health impacts.

- Of the 76 known NMVOCs, 21 were detected.
    - Of these 21, 12 were identified as HAPs and known to cause negative acute and chronic health effects.
    - Notably, benzene was found in 99% of samples, with average amounts ranging from 0.7−12 ppmv. While average regional benzene, toluene, ethylbenzene, and total xylenes (BTEX) amounts in homes ranged slightly higher, from 1.6−25 ppmv.
- The study also reported that gas leakage from stoves and ovens while not in use can result in indoor benzene concentrations that can exceed the California Office of Environmental Health Hazard Assessment 8-h Reference Exposure Level of 0.94 ppbv (a level comparable to environmental tobacco smoke).
- Additionally, researchers estimated that statewide benzene emissions of about 4,200 kg per year (equal to the annual benzene emissions from nearly 60,000 light-duty gasoline vehicles) are currently not included in any statewide inventories.

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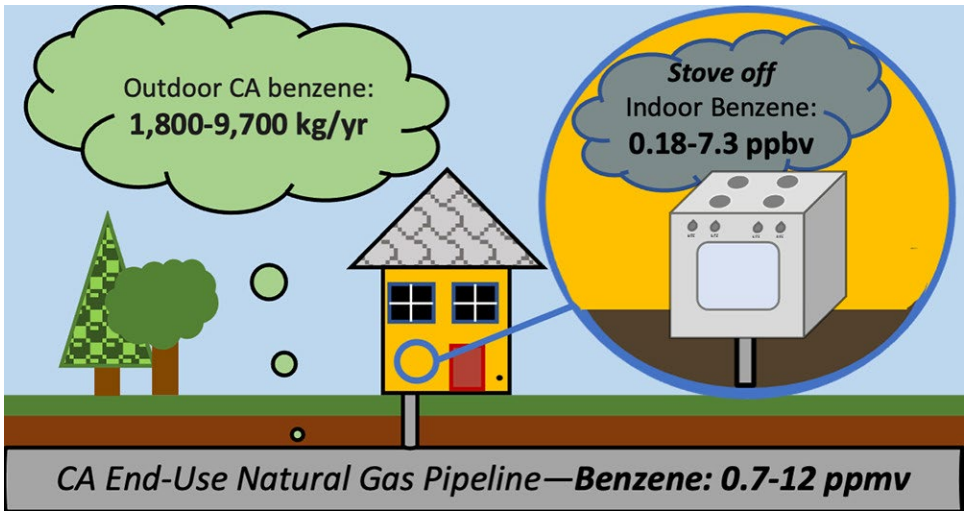

Image courtesy of the study authors, 2020.

The authors of this study concluded that the need to further explore and better understand the potential health risks associated with leaked in-home methane gas is key to informing more health-protective policies.

To learn more about this study, explore these links:

- Lebel, E. D., Michanowicz, D. R., Bilsback, K. R., Hill, L. A. L., Goldman, J. S. W., Domen, J. K., Jaeger, J. M., Ruiz, A., & Shonkoff, S. B. C. (2022). Composition, Emissions, and Air Quality Impacts of Hazardous Air Pollutants in Unburned Natural Gas from Residential Stoves in California. *Environmental Science &Amp; Technology*, *56*(22), 15828–15838. https://doi.org/10.1021/acs.est.2c02581
- *Consumption & Efficiency - U.S. Energy Information Administration (EIA)*. (n.d.). https://www.eia.gov/consumption/residential/+data/2020/
- Marrero, J. E., Townsend-Small, A., Lyon, D. R., Tsai, T. R., Meinardi, S., & Blake, D. R. (2016). Estimating Emissions of Toxic Hydrocarbons from Natural Gas Production Sites in the Barnett Shale Region of Northern Texas. *Environmental Science &Amp; Technology*, *50*(19), 10756–10764. https://doi.org/10.1021/acs.est.6b02827
- Faramawy, S., Zaki, T., & Sakr, A. E. (2016). Natural gas origin, composition, and processing: A review. *Journal of Natural Gas Science and Engineering*, *34*, 34–54. https://doi.org/10.1016/j.jngse.2016.06.030
- Nordgaard, C. L., Jaeger, J. M., Goldman, J. S. W., Shonkoff, S. B. C., & Michanowicz, D. R. (2022). Hazardous air pollutants in transmission pipeline natural gas: an analytic assessment. *Environmental Research Letters*, *17*(10), 104032. https://doi.org/10.1088/1748-9326/ac9295
- Michanowicz, D. R., Dayalu, A., Nordgaard, C. L., Buonocore, J. J., Fairchild, M. W., Ackley, R., Schiff, J. E., Liu, A., Phillips, N. G., Schulman, A., Magavi, Z., & Spengler, J. D. (2022). Home is Where the Pipeline Ends: Characterization of Volatile Organic Compounds Present in Natural Gas at the Point of the Residential End User. *Environmental Science &Amp; Technology*, *56*(14), 10258–10268. https://doi.org/10.1021/acs.est.1c08298

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