# Gas appliances, GHG emissions, and indoor air pollution

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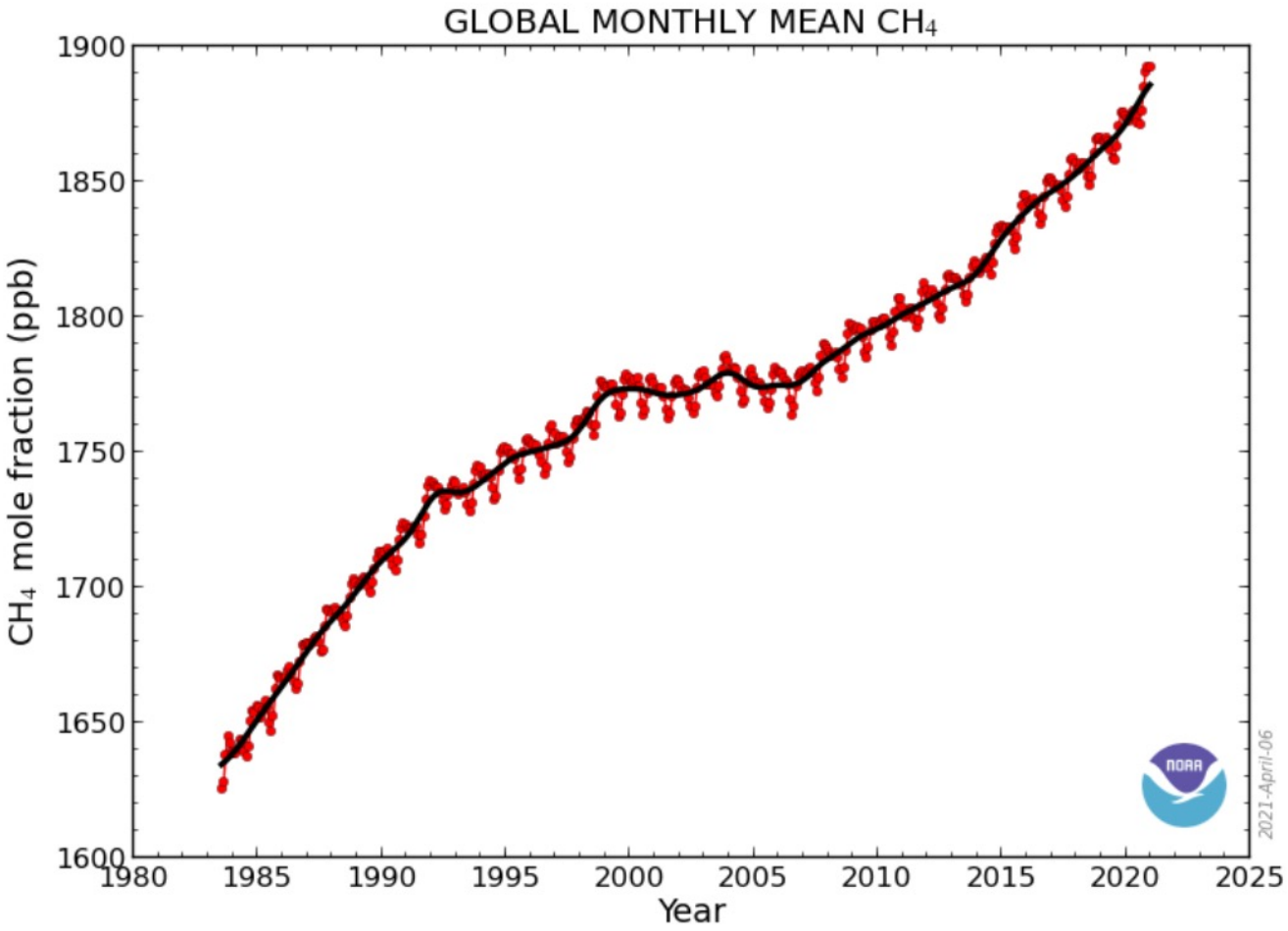
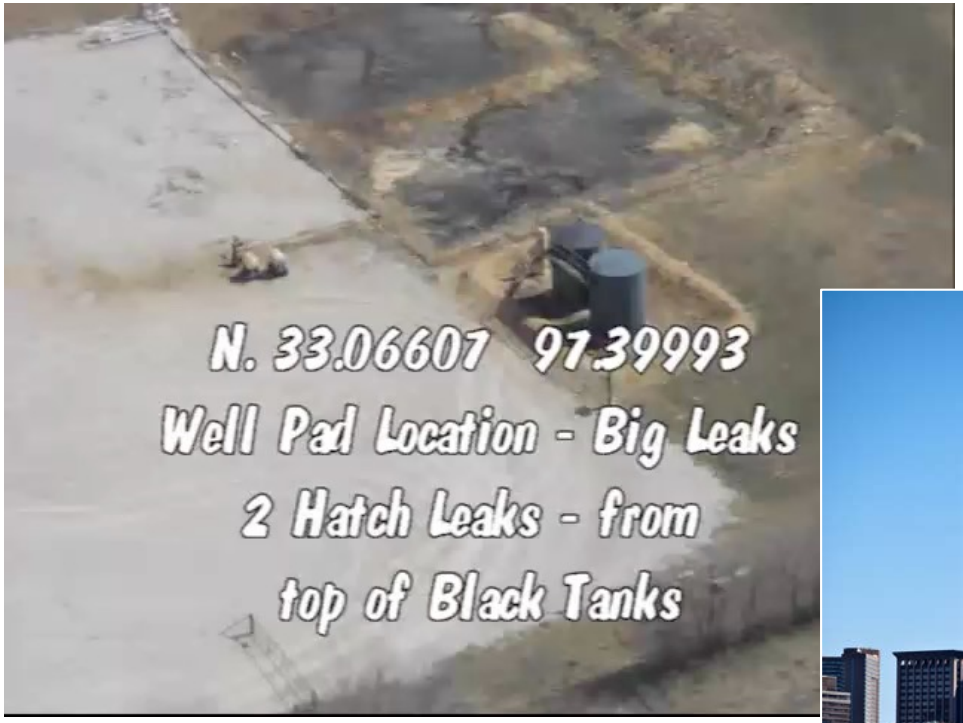
Methane is rising relatively faster than carbon dioxide. The rise in 2020 was 15.7 ppb, the biggest jump in 40 years. For 2021, the increase was a record 17 ppb.




*Ed Dlugokencky, NOAA/GML (www.esrl.noaa.gov/gmd/ccgg/trends_ch4/)*

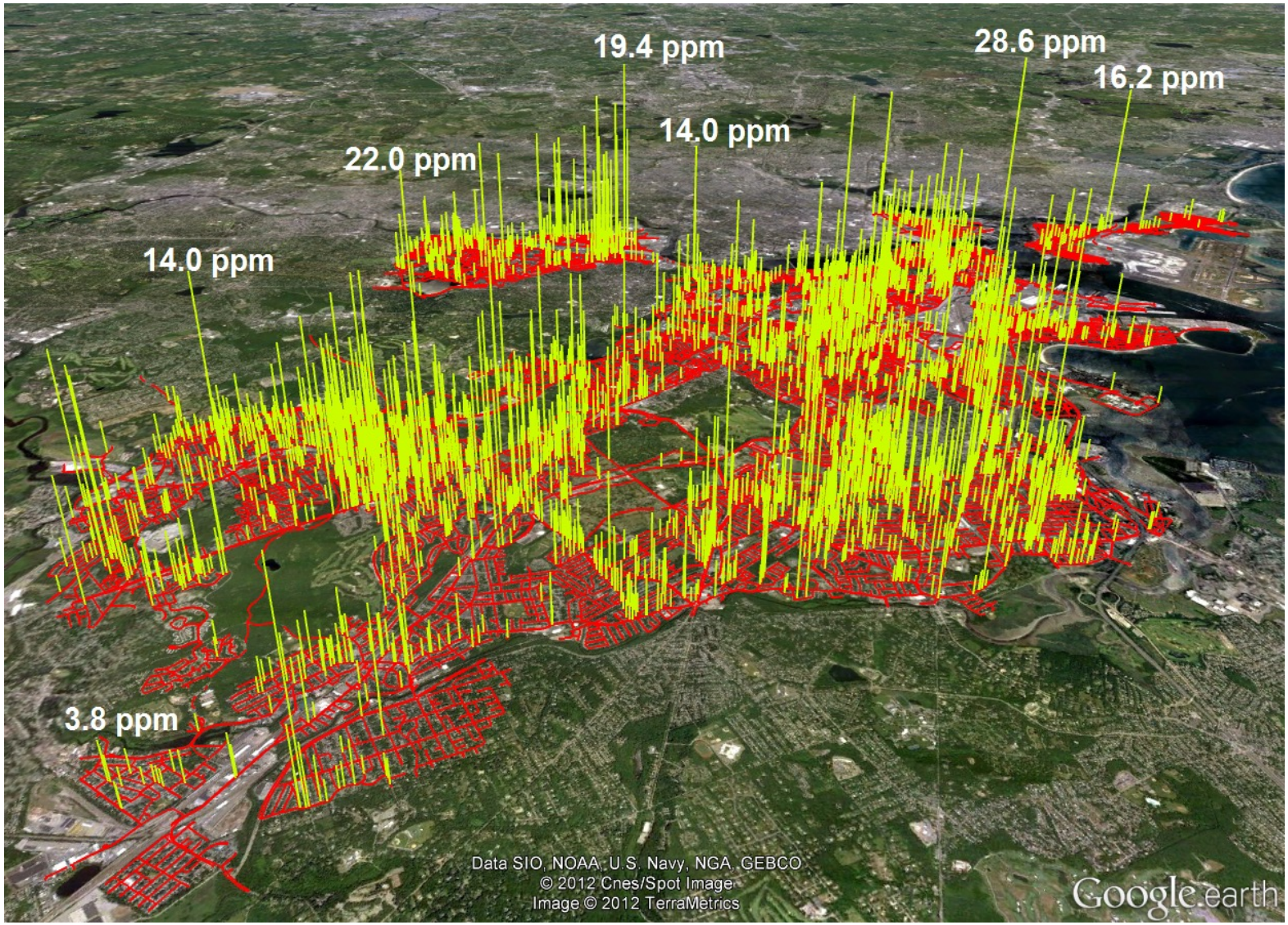
https://www.copernicus.eu/en/news/news/observer-copernicus-climate-and-atmosphere-services-provide-2021-climate-insights-global

# We work to reduce methane leakage




# ”Restaurant Inspections” of oil and gas facilities

We produced the first public maps of natural gas leaks in cities:
Boston overall (~3,400 leaks; 800 road miles; Phillips et al. 2014)




Red = roads driven; Yellow = leaks
Phillips et al. 2013 Env Pollution

#1 predictor – miles cast iron pipes

# Some Quick Responses

Boston Mayor Tom Menino
"Mayor Menino has written a strongly worded letter to the state Department of Public Utilities urging its chairwoman to step up scrutiny of utilities following a story in today's Globe about more than 3,300 natural gas leaks from the vast pipeline system under Boston."

Congressman Ed Markey, MA 7th District
"This study shows that we need a plan to ensure leaks from aging natural gas pipelines in Boston and other cities and communities are repaired, so that we can conserve this important natural resource, protect the consumers from paying for gas that they don't even use, and prevent emissions of greenhouse gases into the environment," Markey wrote to PHMSA

July, 2014: MA passes pipeline safety bill, including accelerated natural gas pipeline replacements and faster cost recovery for companies. Same outcome in Washington, D.C. ("Project Pipes"), after we mapped 6,000 leaks.

# Quantifying Methane Emissions from Natural Gas Water Heaters

Eric D. Lebel*, Harmony S. Lu, Simone A. Speizer, Colin J. Finnegan, and Robert B. Jackson

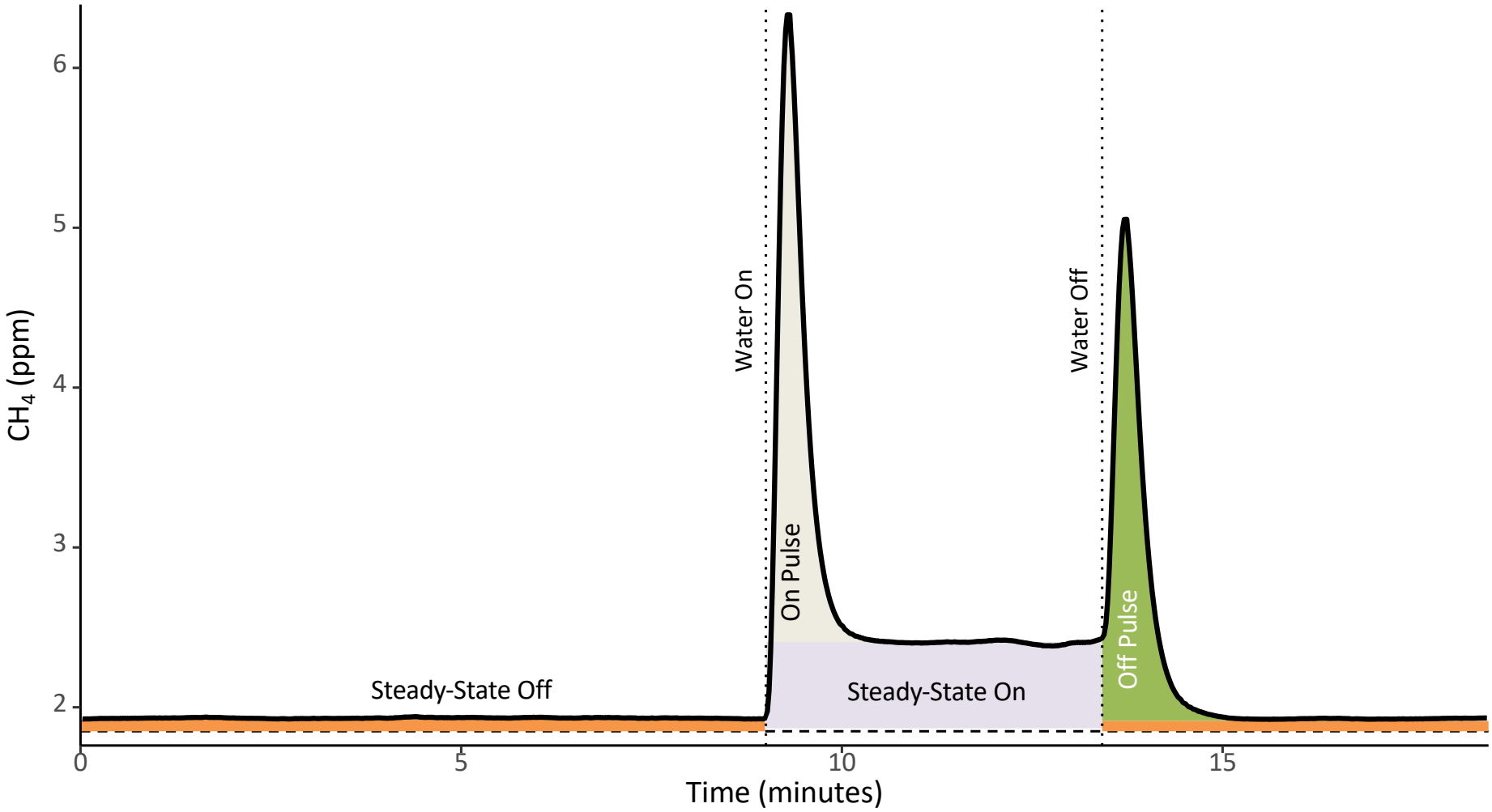

Storage Water Heater

On-demand (or “tankless”) Water Heaters

https://pubs.acs.org/doi/10.1021/acs.est.9b07189

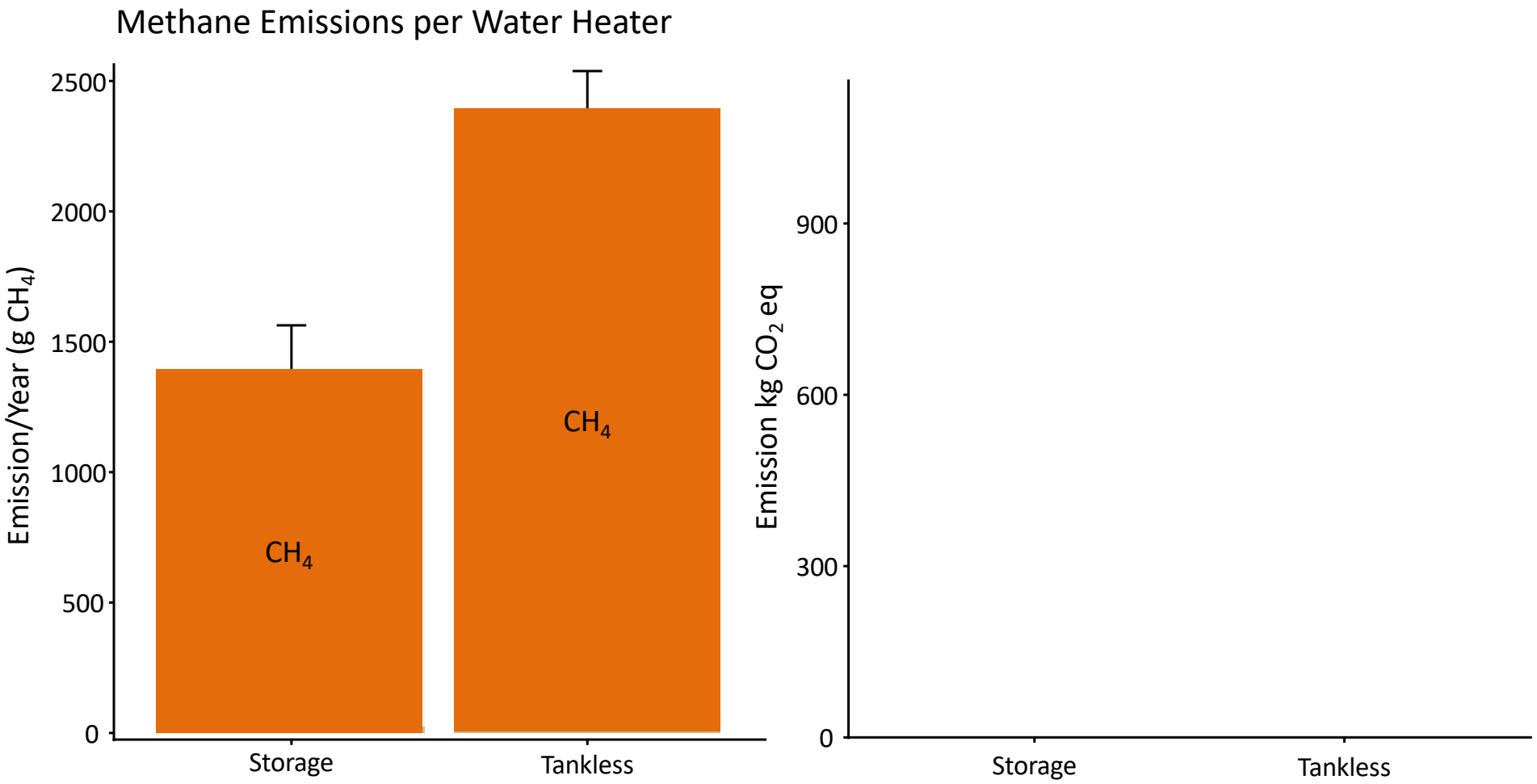

Emissions of **methane** and **carbon dioxide** measured on a Picarro Cavity Ring Down Spectrometer

# Typical methane plot during water heater testing



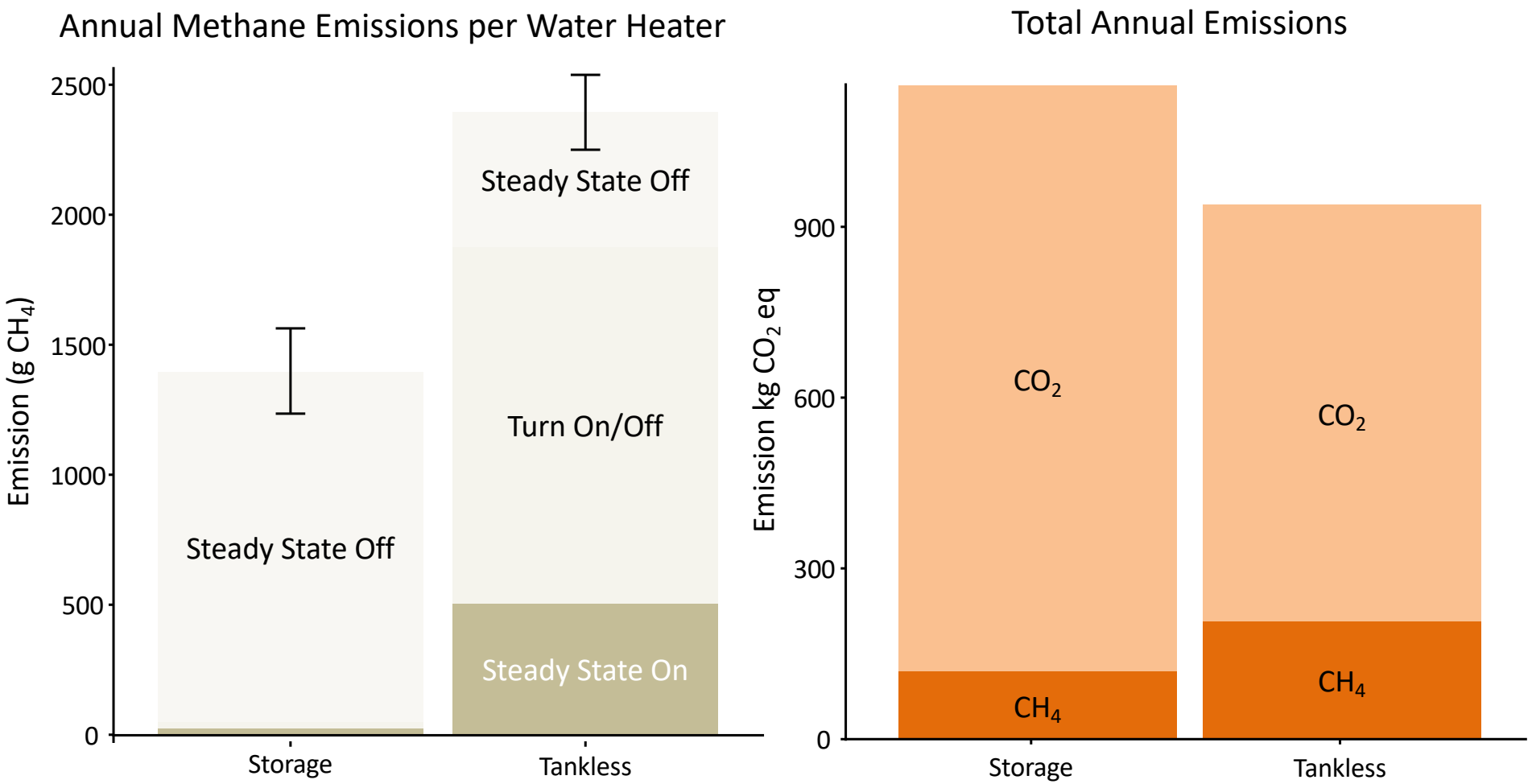

Lebel et al. Quantifying Methane Emissions from Natural Gas Water Heaters, *Environmental Science and Technology.* 2020.

Tankless water heaters emit more methane overall than storage water heaters, primarily driven through on/off pulses, while storage water heaters emit their methane through steady-state off




Lebel et al. Quantifying Methane Emissions from Natural Gas Water Heaters, *Environmental Science and Technology.* 2020.

Hoewver, the additional methane emitted by tankless water heaters does not offset the greater carbon emissions from storage water heaters.




Lebel et al. Quantifying Methane Emissions from Natural Gas Water Heaters, *Environmental Science and Technology.* 2020.

Our new work measures stove emissions. More than three quarters of methane emissions occur while stoves are off.

# Methane and $NO_x$ Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes

Eric D. Lebel*, Colin J. Finnegan, Zutao Ouyang, and Robert B. Jackson

https://pubs.acs.org/doi/10.1021/acs.est.1c04707

## *Did I Turn Off the Stove? Yes, but Maybe Not the Gas*

New research finds that gas stoves emit methane, a potent greenhouse gas, even when turned off and adds to the debate over electrifying homes.

The New York Times

Give this article 354

## Gas stoves in kitchens pose a risk to public health and the planet, research finds

Stanford University study comes as cities across the country seek to ban natural gas in new buildings, prompting industry pushback

By Maxine Joselow

January 27, 2022 at 3:00 a.m. EST

The Washington Post

Listen to article 5 min

Flames burn blue on a natural gas-powered kitchen stove on Nov. 3. (Sean Gallup/Getty Images)

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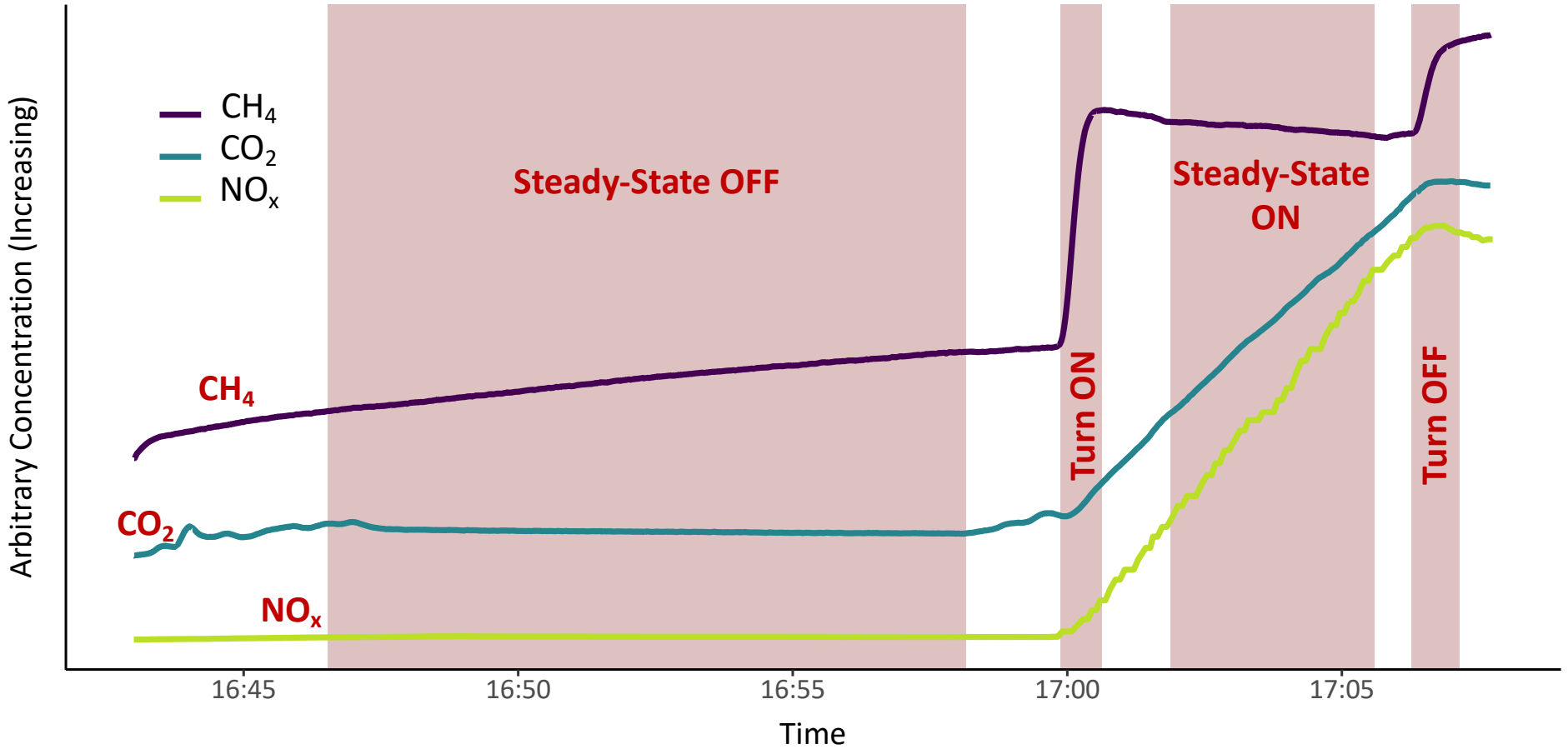
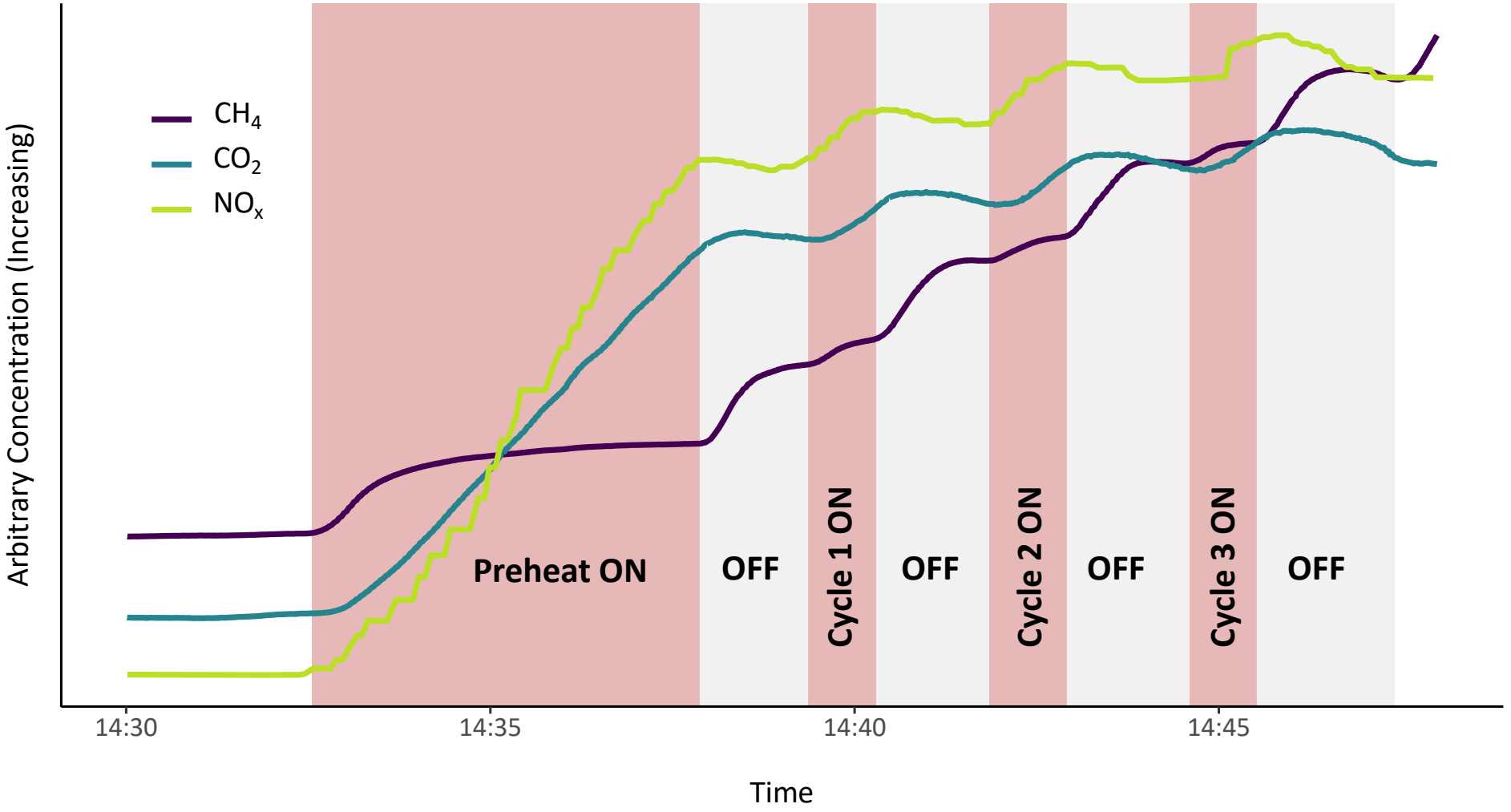
# Example concentration profile of **COOKTOP** emissions



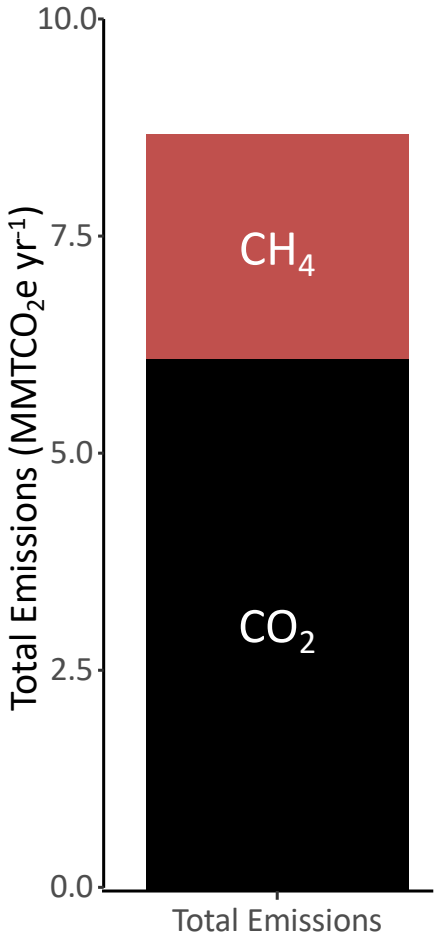

Lebel et al. Methane and $NO_x$ Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes, *Environmental Science and Technology.* 2022.

# Example concentration profile of **OVEN** emissions




Lebel et al. Methane and $NO_x$ Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes, *Environmental Science and Technology.* 2022.

Methane emissions from stoves increase their climate impact by ~40% (and the red bar below includes only the methane leaked indoors, not leaked from wells to home).

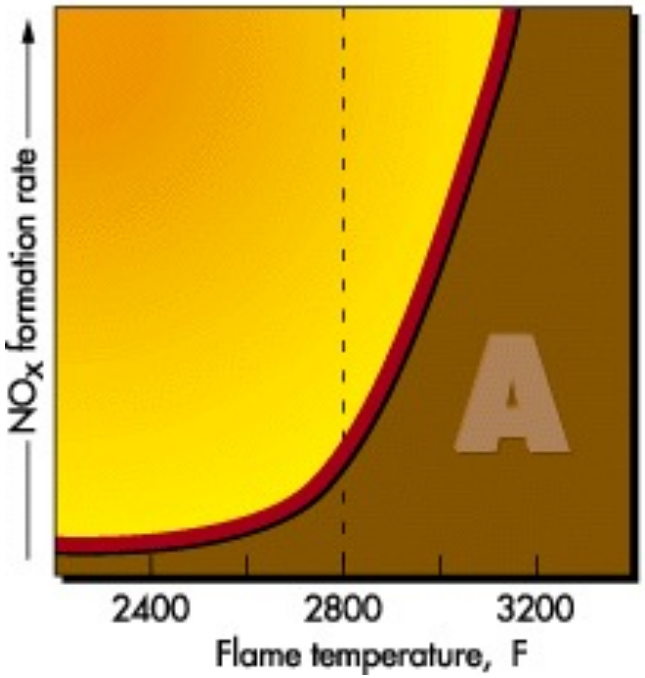



Total $CH_4$ emissions: 2.4 $MMTCO_2e\ yr^{-1}$

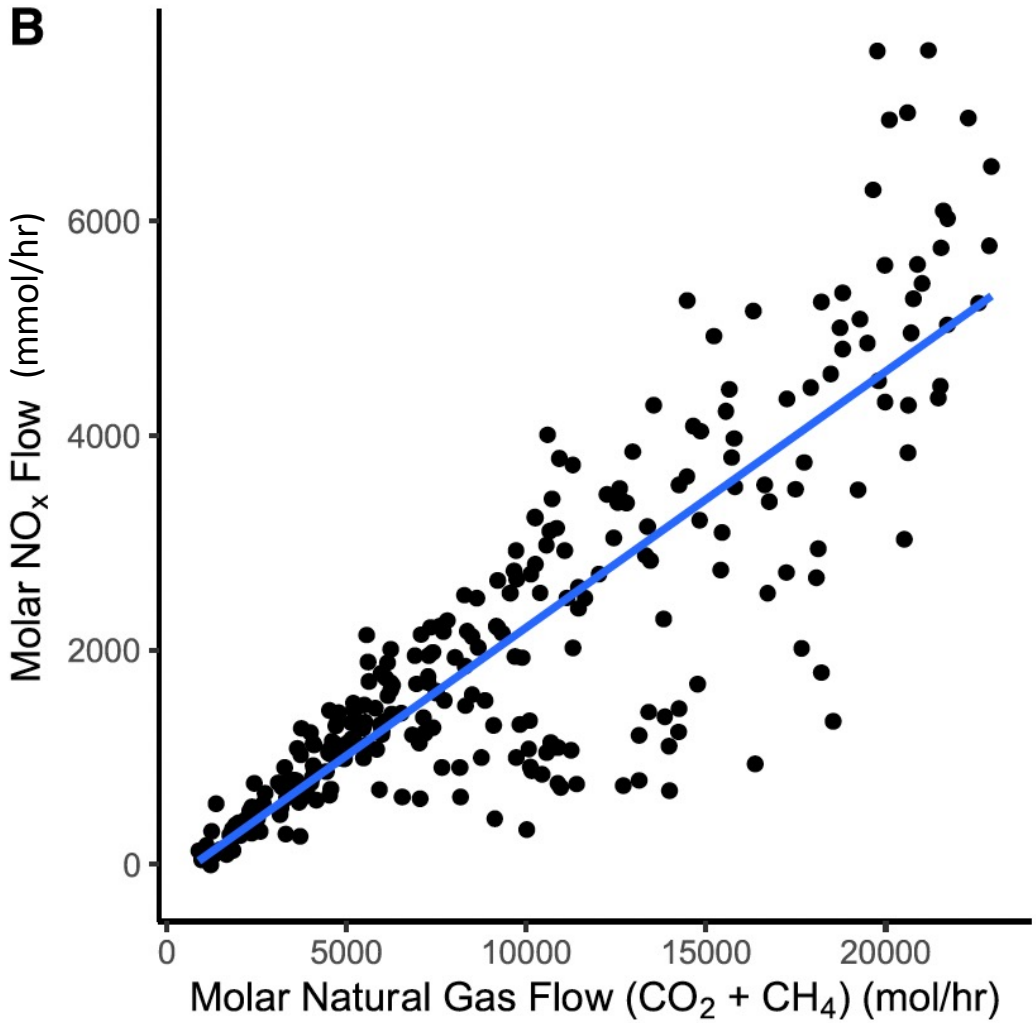
Total $CO_2$ emissions: 6.2 $MMTCO_2\ yr^{-1}$

Lebel et al. Methane and $NO_x$ Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes, *Environmental Science and Technology.* 2022.

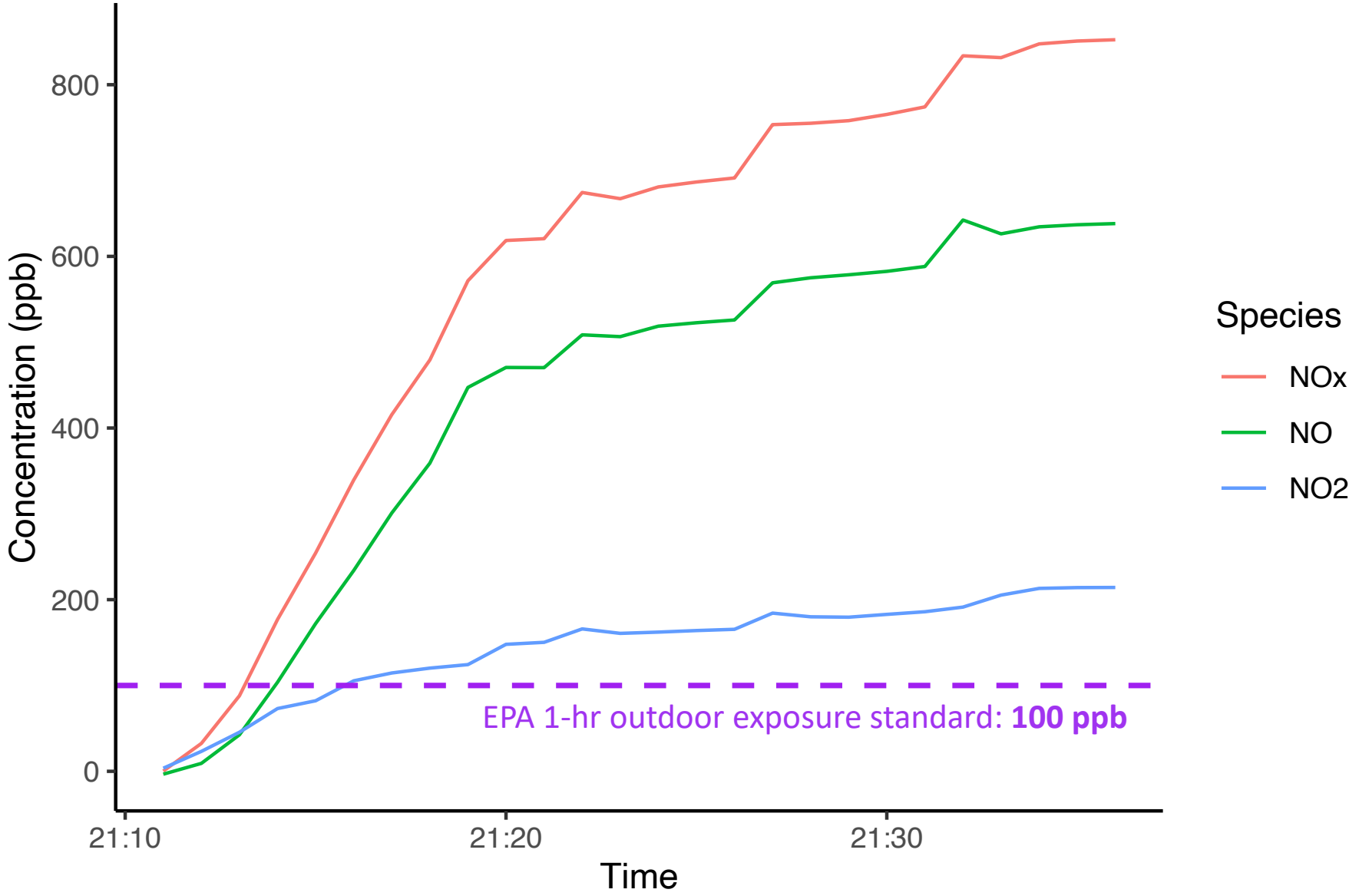
$NO_2$, a respiratory health pollutant, is formed from the oxidation of nitrogen in combustion flames at high temperatures with excess oxygen




$NO_x$ and $NO_2$ emissions are directly related to natural gas burned



# $NO_2$ concentrations in an unenclosed kitchen/living room exceeded 100 ppb within minutes just by running the oven




Lebel et al. Methane and $NO_x$ Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes, *Environmental Science and Technology.* 2022.

- Next Steps:

1) GHG emissions estimates for all appliances in homes and buildings.

2) Measurements in lower-income residences, including last week in Bakersfield (smaller kitchens, poorer ventilation perhaps).

3) Measurements of additional indoor pollutants (CO, formaldehyde, VOCs).

4) Measurements in commercial kitchens with multiple stoves.

5) Having EPA include post-meter methane emissions fully in their emission inventories.

6) Working with the Med School on health consequences and electrification interventions.

7) Measurements of electric stoves and cooking to compare with gas.

8) More houses (and funding, of course).

Addressing criticisms of our paper (Washington Times, "Gas Stoves and Mythical Health Risks"; https://www.washingtontimes.com/news/2022/feb/16/gas-stoves-and-mythical-health-risks/):

"For example, what is being cooked is often the predominant source of emissions, rather than how you cook it… Since a major source of emissions in your kitchen is the food you cook, replacing your gas stove with electric will do very little to address indoor air quality or health."
Not so. The most comprehensive direct comparison is this one:

Fortmann et al. 2001 "Indoor Air Quality: Residential Cooking Exposures"; for the CA ARB;
Table 3.24 Average $NO_2$ concentrations (ppb) measured at four locations during the cooking period.
https://ww2.arb.ca.gov/sites/default/files/classic/research/apr/past/97-330a.pdf

| | Gas | Electric | Gas-Electric |
|---|---|---|---|
| Oven clean | 402 | 35 | 377 |
| Stovetop stir fry | 40 | 15 | 25 |
| Bacon | 53, 13 | 26, 24 | 27, 11 |
| Tortillas | 31 | 35 | 4 |
| French Fries | 70 | 34 | 36 |
| Broil fish | 94, 115 | 25, 27 | 69, 88 |
| Bake lasagna | 91 | 28 | 63 |

The list above shows each gas-to-electric comparison for every meal in the paper. In almost every case, the difference between gas and electric is bigger than the total emission from electric (note: 100 ppb is the EPA 1-hr outdoor exposure standard).

Addressing criticisms of our paper (Washington Times, “Gas Stoves and Mythical Health Risks”; https://www.washingtontimes.com/news/2022/feb/16/gas-stoves-and-mythical-health-risks/):

“The body of research on this issue points less to the costly and drastic measure of replacing all of your gas appliances and more to ensuring proper ventilation in your kitchen. That’s true whether you use a gas cooktop or an electric one.”

Ventilation is indeed critical for health-related exposures. However, surveys show people turn on their ventilation hoods only about one-third of the time. Thus, hood off is people’s “normal” usage. I expect people in lower-income neighborhoods face the greatest risk, because their kitchens are typically smaller and their ventilation hoods may not function as well.

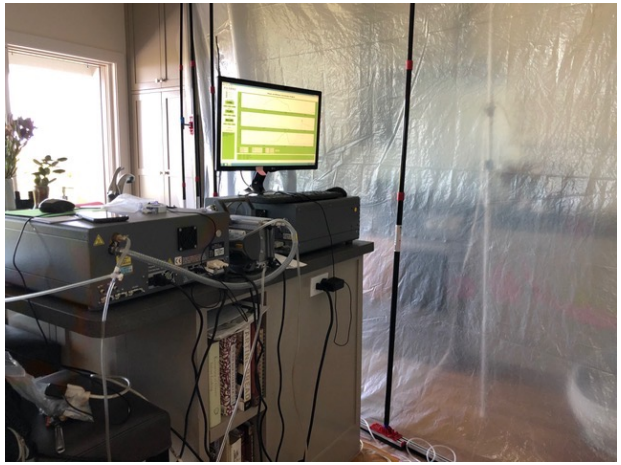
From our paper (Lebel et al. 2022): “Among all gas appliances, the stove is unique in that the byproducts of combustion are emitted directly into home air with no requirement for venting the exhaust outdoors. In fact, some kitchens have “ductless” hoods that recirculate fumes through activated charcoal filters, which are generally less effective at cleaning the air. Vented hoods have a range of effectiveness and function best when overhanging the stove. Because exhaust hoods are separate from the stove and must be operated manually, vented hoods in practice are used only 25−40% of the time.”

Zhao, H, WR Chan, WW Delp, H Tang, IS Walker, BC Singer 2020 Factors impacting range hood use in California houses and low-income apartments. Int. J. Environ. Res. Public Health 17:8870.

Sun L, LA Wallace 2021 Residential cooking and use of kitchen ventilation: the impact on exposure. J. Air Waste Manage. Assoc. 71, 830−843.

Addressing criticisms of our paper (Washington Times, “Gas Stoves and Mythical Health Risks”; https://www.washingtontimes.com/news/2022/feb/16/gas-stoves-and-mythical-health-risks/):

“It’s also useful to note how the measurements were taken. The researchers sealed their test kitchens in plastic tarps to concentrate the emissions so they would be easier to measure. While this is a novel and interesting method, the study results are useless for evaluating health-based exposures because no kitchen is set up like that. In other words, they weren’t simulating a real-life cooking experience.”



The goal of our study was to measure emission factors: the amount of methane, NOx, and other gases emitted per unit time and gas burned. With emission factors in hand, health professionals can model exposures in kitchens of different sizes, ventilation rates, and burner and oven scenarios (e.g., multi-burner use, which we did not study).

However, we did measure high levels of NO2 and NOx in kitchens without plastic (see Slide 18 above), and have seen this many times in homes since our study came out.

globalcarbonproject.org
jacksonlab.stanford.edu

Thank you for your attention.
Comments or questions?