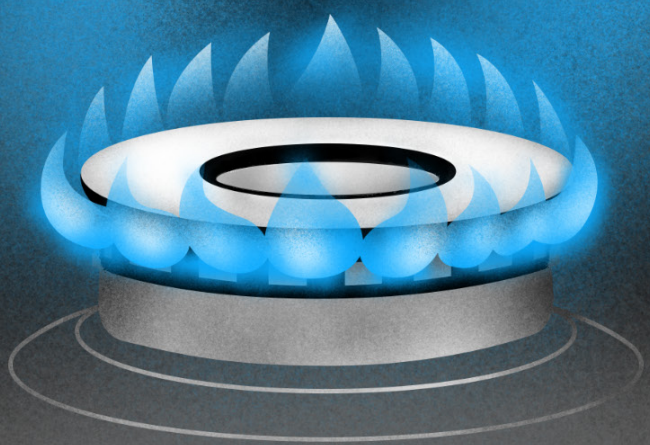
UNSEEN EMISSIONS:

Health Risks Cut by Shifting from Gas to Electric Cooking in Real Homes



GREENPEACE

Report by Greenpeace Research Laboratories, Greenpeace CEE Croatia and Greenpeace Hungary

Executive Summary - November 2025

Key findings

- Cooking emits hazardous air pollutants into our homes, some of these pollutants come from using fossil gas.

- Nitrogen Dioxide and benzene levels were lower in all homes after they switched from gas to electric cooking, some of this change was due to outdoor pollution and some due to indoor pollution.

- The World Health Organisation guideline for daily nitrogen dioxide is 25 µg/m^3:
  - ▷ When the homes used gas to cook, our 2-week measurement was over this health guideline in 3 homes.
  - ▷ When the homes used electricity to cook, our 2-week measurement did not exceed this health guideline in any home.

- There is no safe level for benzene in the air, we detected benzene in all of the homes when they used gas to cook, but we could not detect any benzene in 3 of the homes when they used electricity.

- We modelled how much pollution was coming from inside the homes, rather than outside.
  - ▷ Our model estimate for indoor nitrogen dioxide was lower in all homes after they switched from gas to electric cooking. The average across all homes dropped by 90%.
  - ▷ Our model estimate for indoor benzene was lower in 9 out of 12 homes after they switched from gas to electric cooking. In the other three homes we did not find a drop in benzene levels. This could be due to other sources of benzene.

- Changing from gas to electric powered cooking can reduce concentrations of some harmful air pollutants.

Introduction

The air we breathe inside our homes is increasingly recognised as important for our health. This is because in Europe, on average, adults spend as much as 90% of their time breathing air indoors[1]. **Cooking can be an important cause of indoor air pollution.**

A common fuel for cooking is fossil gas, sometimes known as natural gas. Fossil gas is mainly made of methane, a powerful climate pollutant. It also contains other chemicals including non-methane volatile organic compounds (VOCs).

Some VOCs, like benzene, are hazardous to health. Benzene is classed as a known carcinogen by the International Agency for Research on Cancer. Cooking using gas emits NO_2 directly into the home of the user[2–5], and can raise VOC concentrations to levels relevant for health[6]. NO_2 can worsen respiratory problems, trigger asthma attacks, and reduce lung function, especially in children and people with pre-existing conditions[7].

To examine how gas stoves contribute to indoor air pollution, Greenpeace conducted a field study in 12 homes - 9 in Croatia and 3 in Hungary - to see whether switching from gas to electric cooking improves indoor air quality.

Methods

To test if switching from gas to electric cooking has a measurable impact, it is necessary to control for other factors which affect indoor air quality. To do this, the study measured air quality in the same homes, with the same occupants before and after they switched from gas to electric cooking. This experiment design has previously been used to investigate NO_2 concentrations but, to our knowledge this work is the first of its kind to also assess changes in indoor VOC concentrations as well.

Measurements of NO_2 and VOC concentrations were made in the kitchens of study participants over two 2-week periods. During the first period, Phase 1, the participants cooked using gas. Each household then independently replaced their gas cooker with an electric appliance. During the second period, Phase 2, the households used electricity to cook. In both phases measurements outdoors were also made to account for the influence of air pollution entering the homes from outside.

The sampling for NO_2 used Palmes diffusion tubes, provided and analysed by Gradko International Limited. For VOCs the samples were collected using thermal desorption tubes and analysed by thermal desorption-gas chromatography-mass spectrometry at the Greenpeace Research Laboratories. Each measurement was made in triplicate.

Results

Average indoor concentrations of NO_2, benzene and xylene reduced between Phase 1 and Phase 2. They remained similar for toluene and ethylbenzene. Outdoor concentrations of all species decreased at all households between Phase 1 and Phase 2. Of the 12 households completing the

study, absolute indoor reductions were larger than outdoor reductions in eight households for NO_2, nine for benzene, eight for toluene, eight for ethylbenzene, seven for m/p-xylene and nine for o-xylene *(Figure 1 and 2)*.

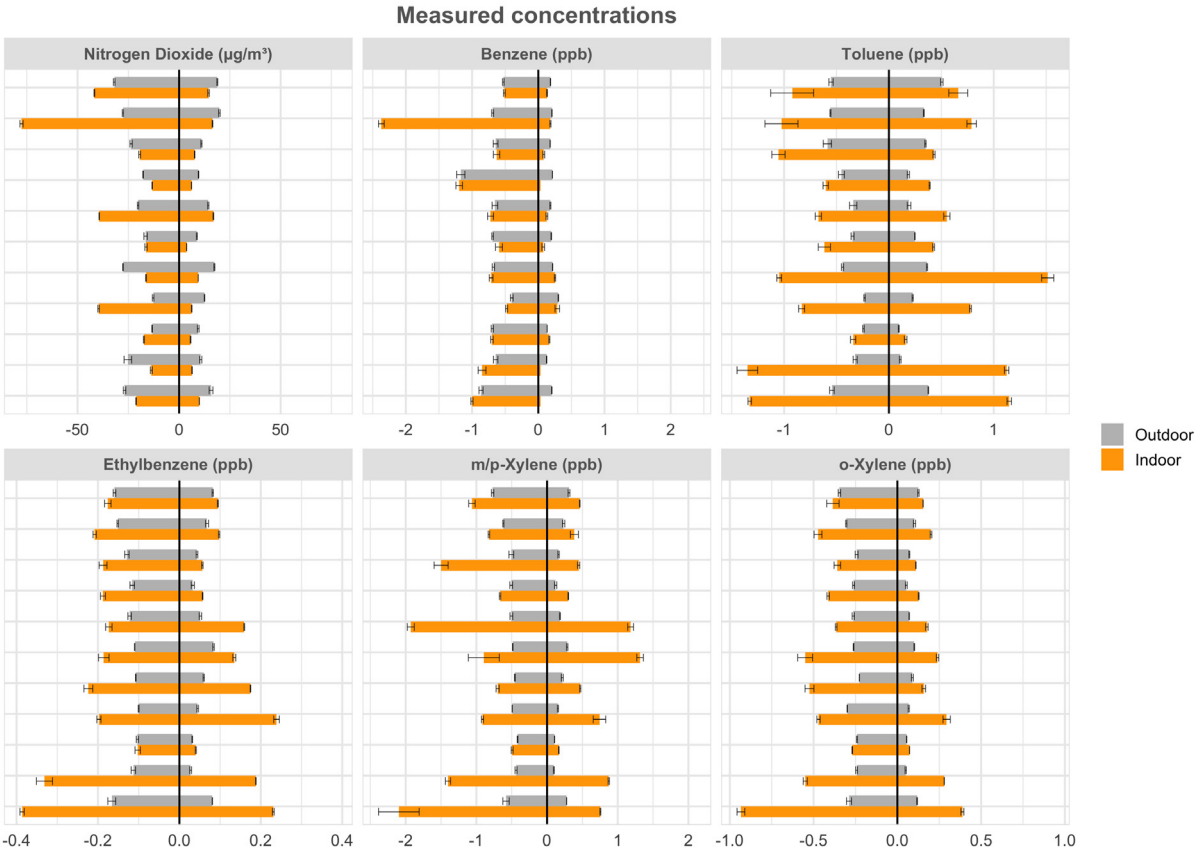


Figure 1. Measured Phase 1 (left) and Phase 2 (right) concentrations of NO_2 (µg/m³), benzene, toluene, ethylbenzene, m/p-xylene and o-xylene (ppb) for indoor and outdoor samples.

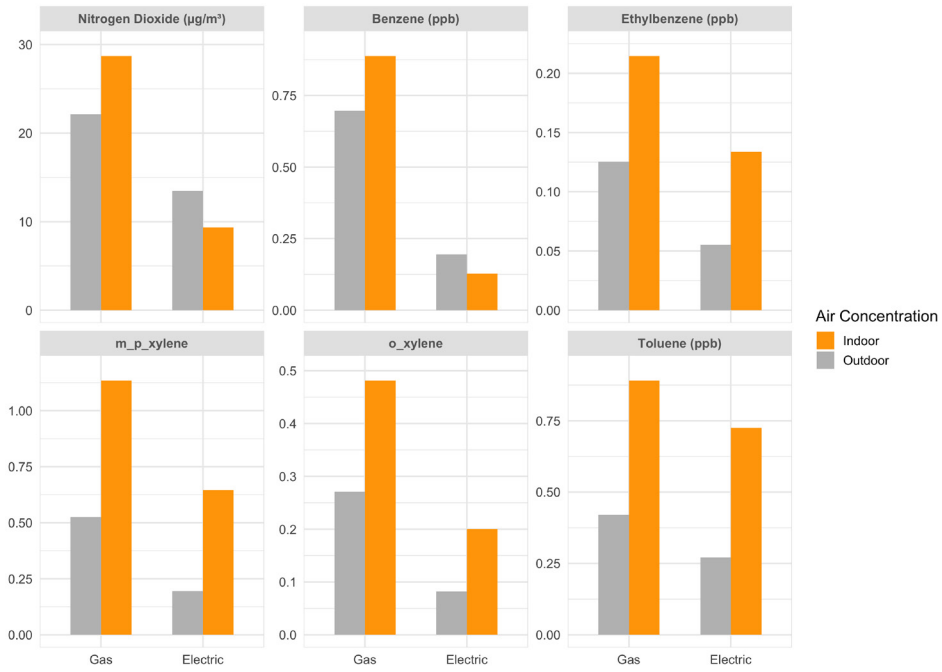


Figure 2. Average of measured Phase 1 (gas) and Phase 2 (electric) concentrations of NO_2 (µg/m³), benzene, toluene, ethylbenzene, m/p-xylene and o-xylene (ppb) for indoor and outdoor samples.

Greater indoor than outdoor reductions in NO_2 and benzene concentrations across the majority of households between Phase 1 and Phase 2 strongly suggests that removal of the gas cooking stove contributed to improved indoor air quality.

In some cases the change in outdoor pollution between Phase 1 and Phase 2 was bigger than the change in indoor pollution. Outdoor changes may have affected indoor concentrations. To account for this, a simple modelling approach was used to estimate how ventilation changes and outdoor air pollution changes between Phase 1 and 2 affected the indoor air. The model estimated what proportion of the pollution measured indoors could have come from indoor sources if conditions had been the same in Phase 1 and 2. We call this estimate 'indoor-modelled' pollution. Estimates of this value are an educated guess, not an accurate measurement. **Model based estimates of the indoor-modelled NO_2 and benzene support the conclusion that removal of the gas cooking stove reduced concentrations of these pollutants** *(Figure 3 and 4)*.

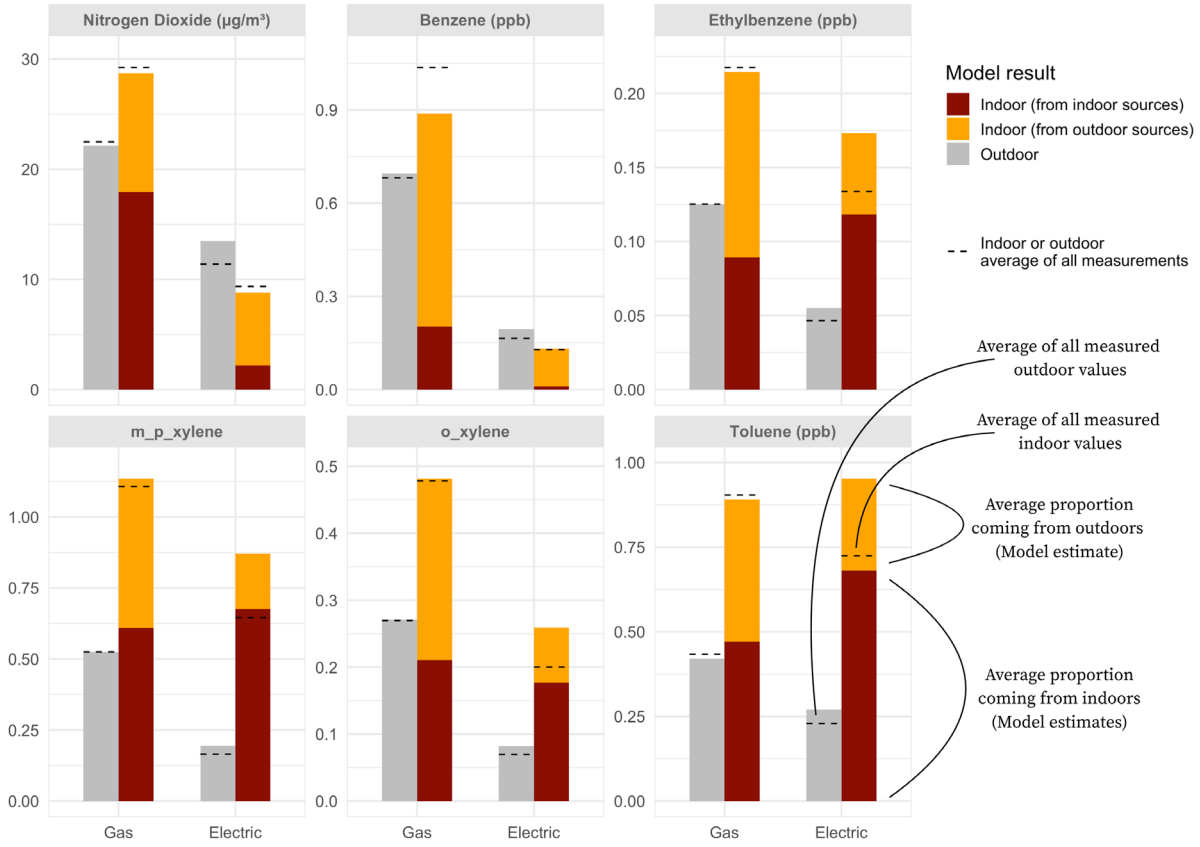


Figure 3. Average proportions of modelled outdoor and indoor concentrations of NO_2 (µg/m³), benzene, toluene, ethylbenzene, m/p-xylene and o-xylene (ppb) for Phase 1 (Gas) and Phase 2 (Electric) across all households. Dashed lines show average measured concentrations. The average of modelled outdoor and indoor-modelled values does not always sum to the average of the measured values.

A Wilcoxon statistical test supported the finding that NO_2 and benzene concentrations were reduced by the switch from gas to electric cooking, however it found no clear evidence of this effect for the other VOCs. **The average reduction for NO_2 and benzene were approximately 90% and 100% respectively.**

Actions to reduce public health risks could include the provision of financial support to replace gas cooking equipment with electric alternatives, prohibiting the installation of gas stoves in new residential buildings, and indoor air quality regulations for NO_2 and health relevant VOCs. Priorities for financial support should be given to homes where vulnerable groups - including children or those with existing health conditions - are present, to poorly ventilated or over-crowded homes and homes on low incomes.

Full details of this research can be found in:

[‘Unseen Emissions: Health Risks Cut by Shifting from Gas to Electric Cooking in Real Homes - Report by Greenpeace Research Laboratories, Greenpeace CEE Croatia and Greenpeace Hungary’]

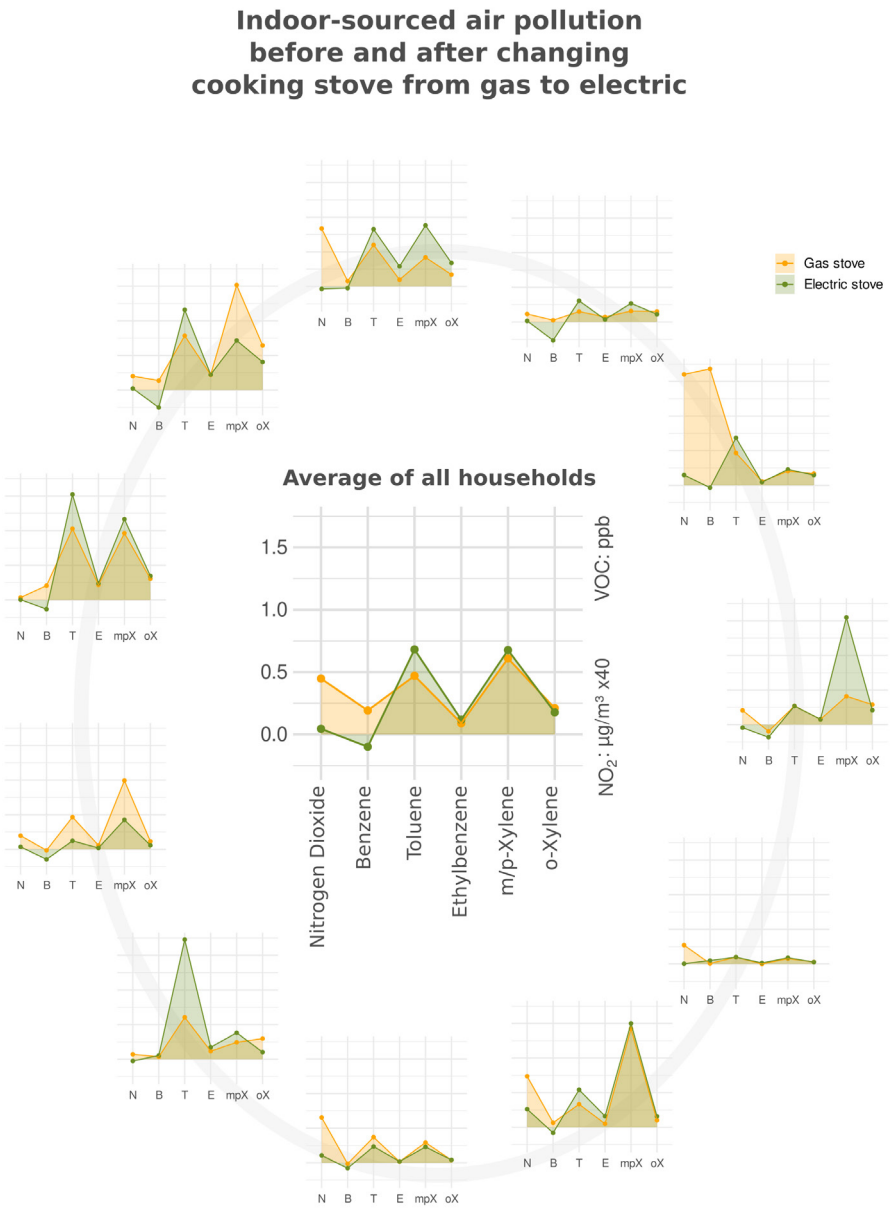


Figure 4. Model estimated concentrations of indoor-modelled NO_2 (µg/m³), benzene, toluene, ethyl-benzene, m/p-xylene and o-xylene (ppb) for Phase 1 (Gas stove) and Phase 2 (Electric stove).

References

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