Efficient Appliances for People & the Planet

Clearing the Air: Gas Cooking and Pollution in European Homes

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Executive Summary

Cooking with gas emits harmful pollutants into homes, but policymakers in the European Union and United Kingdom have done little to address this serious public health issue. A large-scale study spanning seven European countries shows that homes with gas cooking appliances frequently experience levels of indoor air pollution that exceed legal limits for outdoor air pollution, pointing to the urgent need for government intervention.

Across Europe, households using gas hobs and ovens have been found to breathe in twice as much indoor air pollution as those with electric appliances. In-home air quality monitoring performed in more than 250 homes across seven countries — the Netherlands, Italy, Spain, France, Slovakia, Romania, and the United Kingdom (UK) — provides insight into the prevalence and severity of this problem. The results point to the critical need for governments, appliance manufacturers, and other stakeholders to take immediate action to protect public health by cutting emissions generated from cooking equipment.

KEY FINDINGS

Gas-cooking households experience concerning levels of nitrogen dioxide (NO_2), an air pollutant linked to severe respiratory issues. Across all countries monitored in the study, data showed that cooking with gas led to significant levels of the pollutant throughout the home.

Electric-cooking households did not experience NO_2 pollution from their cooking equipment. In homes with electric-cooking appliances, average indoor NO_2 levels were lower than outdoor levels.

Cooking with gas frequently leads to levels of indoor air pollution that would be illegal outdoors. In the European Union (EU) and UK, standards for air pollution apply only to outdoor air. However, this study found that homes with gas cooking appliances experience levels of indoor air pollution that regularly exceed limits for outdoor environments.

Gas-cooking households regularly exceed benchmarks established by World Health Organization (WHO) air quality guidelines designed to protect public health. Pollution above these recommended levels is proven to contribute to significant adverse health impacts. Cooking with gas can therefore put residents at greater risk of respiratory diseases like asthma, particularly for people who are more vulnerable, such as children or those with existing health conditions.

Elevated levels of harmful fine particulate matter ($PM_{2.5}$) found in kitchens stem from cooking practices and outdoor pollution, not the appliance type. Levels of $PM_{2.5}$, which can affect the lungs and the bloodstream, routinely exceeded WHO guidelines in both gas- and electric-cooking households.

The presence of cooker hoods in the home had little impact on indoor air quality. Households with cooker hoods (both recirculating and vented to the exterior) saw no substantial reduction in cooking-related indoor air pollution. This shows that relying on individuals to ventilate their homes is not enough to mitigate the health risks from gas hobs and ovens.

Major findings were consistent across the seven nations studied.

RECOMMENDATIONS

To protect public health, policymakers across the EU and UK should take immediate action to reduce indoor air pollution related to gas cooking. Accelerating the transition to electric cooking is the most effective solution, but raising awareness about the need for adequate ventilation is also vital.

Appliance manufacturers, building professionals, healthcare providers, researchers, individuals, and others also have important roles to play.

Governments should cut NO_2 emissions from gas cooking appliances by strengthening appliance standards. They should apply a combination of informative product labels, incentives, subsidies, and regulations to increase the penetration of induction hobs, the cleanest and most efficient hob technology. They should also require that cooker hoods capture pollutants effectively.

Industry should champion the transition to electric cooking appliances, committing to stop making, selling, and installing polluting gas hobs and ovens. Manufacturers and retailers should use a new energy label to ensure their customers know whether hobs and ovens are polluting or not, and to enable consumers to compare the performance of different technology types. Manufacturers should also develop user-friendly cooker hoods that adequately capture pollutants.

Civil society and healthcare should raise awareness of the health risks of gas cooking appliances through further research, education, and advocacy.

Individuals should limit exposure to gas cooking appliances by using small electric appliances or upgrading to cleaner electric hobs and ovens wherever possible. They should also ventilate their kitchens when cooking, ideally with cooker hoods vented to the outdoors.

1. Introduction

Every day, home cooks across Europe prepare meals using their gas appliances, having been led[1] to believe that gas hobs are the quickest and most optimal way to cook, producing the best flavours.[2] But unbeknownst to them, these appliances release harmful but invisible pollutants into the air. Often, it is only once food starts to burn that people switch on the cooker hood,[3] although the pollution they should be concerned about hits the room the moment the hob is turned on.[4]

A substantial body of research[5] has shown that gas hobs and ovens release pollutants such as NO_2, carbon monoxide (CO), and benzene[6,7] into homes, increasing inhabitants' risk of serious health issues such as respiratory disease (e.g., asthma), dementia, and cancer. Despite this, little has been done to address indoor air pollution from gas hobs and ovens in the EU or UK. Air pollution limits in both the EU[8] and the UK[9] apply only to outdoor air, while existing regulations that could limit air pollution directly from the source (e.g., the Gas Appliances Regulation[10i] and the Ecodesign[11] and Energy Labelling[12] appliance efficiency policies[ii]) fail to do so.

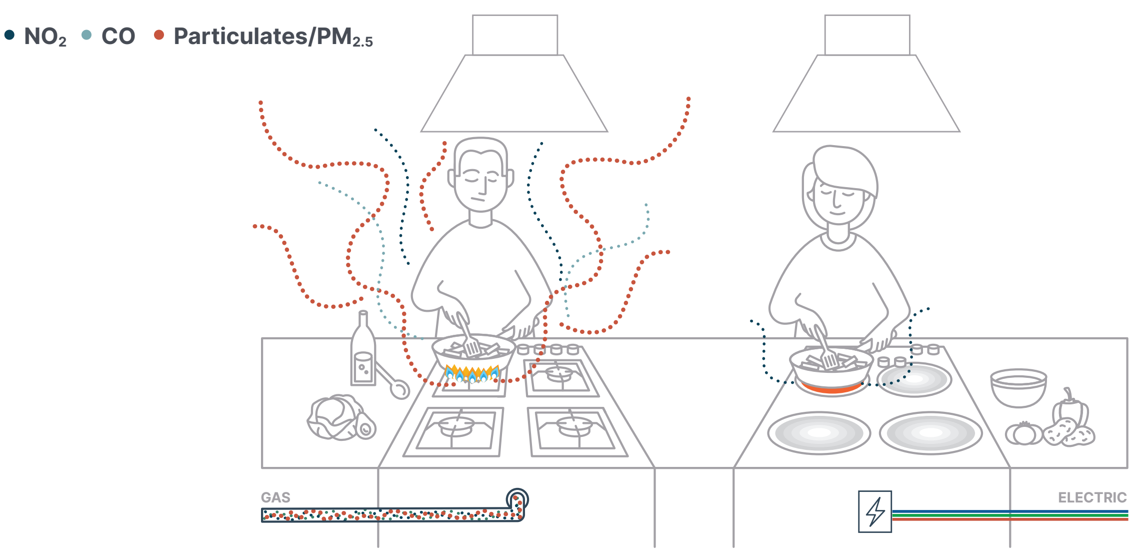
To determine whether indoor air pollution from Europe's gas hobs and ovens is severe enough to warrant government intervention, CLASP partnered with the Netherlands Organisation for Applied Scientific Research (TNO) and Opinium Research, a marketing research and polling firm based in the UK, in late 2022. The resulting pan-European in-home study is the first large-scale investigation into indoor air pollution from gas and electric hobs, recording minute-by-minute data to determine how household pollutant levels compare to official outdoor air quality limits and WHO air quality guidelines.

The results were clear: ***Gas cooking appliances emit health-damaging pollutants into homes across Europe at levels that exceed well-established benchmarks set by WHO guidelines,[13] as well as EU[14] and UK[15] mandatory limits for outdoor air pollution.*** While pollution levels from this source vary by country, the overall picture is consistent.

In particular, the study confirmed NO_2 as a pollutant of concern in European households that cook with gas. Generated through the interaction of the gas flame and naturally occurring nitrogen in the air[16], NO_2 is recognised by the WHO as a health-damaging air pollutant linked to severe respiratory issues.[17] The organisation estimates that children in homes with gas cooking appliances have a 20% increased risk of lower-respiratory illness.[18]

The research also found that harmful $PM_{2.5}$ is produced in many kitchens throughout the continent. However, $PM_{2.5}$ was measured in both gas- and electric-cooking kitchens, as it is produced mainly through the cooking of food rather than the burning of fossil gas. The study showed $PM_{2.5}$ levels increasing or decreasing based on the duration and type of cooking (e.g., when food is burned).

FIGURE 1. GAS COOKING APPLIANCES DIRECTLY EMIT HARMFUL POLLUTANTS, WHEREAS $PM_{2.5}$ IS EMITTED BY THE PROCESS OF COOKING FOOD[19]



[i] The Gas Appliances Regulation, Regulation (EU) 2016/426, sets out essential requirements that must be met before appliances burning gaseous fuels can be placed on the EU or UK market.

[ii] Ecodesign sets common EU-wide minimum standards to eliminate the least-performing products from the market. The energy labels provide a clear, simple indication of energy efficiency and other key features at the point of purchase.

The research, which took place in 2023, involved:

- **Recruiting demographically diverse households** from across the EU and UK to participate in the field study. To prevent any change in typical cooking behaviours (e.g., opening windows or turning on cooker hoods) during the study, the research team did not inform participating households about its focus on the links between gas cooking and harmful indoor air pollution.

- **Monitoring cooking and ventilation practices and resulting indoor air quality** in over 250 homes across seven European countries: the Netherlands, Italy, Spain, France, Slovakia, Romania, and the UK. Participating households were tasked with setting up indoor air quality monitoring equipment and logging their daily cooking activities and behaviours over a period of two weeks. The equipment monitored NO_2, CO, and $PM_{2.5}$ concentration levels, as well as hob and gas oven temperatures indicating cooking activity. The in-home monitoring kicked off in January 2023 and ended in May.

- **Analysing the in-home monitoring data** to determine:

    - The pollutant concentration levels emitted by gas cooking appliances and how this compares to electric appliance with no open flame;
    - Whether European households exceed WHO and EU, or UK, concentration limits of air pollutants, and how this differs between households using gas and electric appliances; and
    - How ventilation, specifically cooker hoods, impacts pollutant concentration levels.

The study focused primarily on households that cook with gas appliances, which are established sources of indoor air pollution, seeking to understand the severity of pollution levels in the kitchen and the rest of the home. Electric-cooking households were included as a baseline, to assess the effect of other indoor pollution sources and the infiltration of polluted outdoor air, as prior research has confirmed that electric hobs and ovens do not emit air pollution into the kitchen.

This report presents the study and its findings, illuminating the extent of indoor air pollution caused by gas cooking in our homes, and discusses the urgent need for awareness, action, and change.

> In addition to releasing harmful pollutants into homes, gas cooking appliances use, and leak, methane[20] — a potent greenhouse gas. These appliances are a significant contributor to climate change, which poses serious challenges for public health in Europe and around the world. According to the WHO, climate change “threatens the essential ingredients of good health — clean air, safe drinking water, nutritious food supply, and safe shelter — and has the potential to undermine decades of progress in global health.”
>
> Source: WHO on Climate Change

2. Field Study Approach

CLASP collaborated with TNO and indoor air quality and health experts[iii] to craft a field study methodology for measuring the severity of indoor air pollution caused by gas cooking appliances in Europe.

Researchers conducted in-home measurements in **the Netherlands, Italy, Spain, France, Slovakia, Romania, and the UK.** These countries have among the highest share of gas-cooking households in the region[21] and face the greatest public health risk from this source (as indicated by current national levels of paediatric asthma associated with cooking on gas).[22]

FIGURE 2. CRITERIA FOR HOUSEHOLD MONITORING SELECTION: THE NUMBER OF GAS-COOKING HOMES[i] AND NUMBER OF PAEDIATRIC ASTHMA CASES LINKED TO GAS COOKING, BASED ON PRIOR RESEARCH BY CLASP AND TNO[i]

2.1. HOUSEHOLD SAMPLE SIZES AND MONITORING TIMELINES

In collaboration with experts, CLASP decided on a sample size of around 280 households, with 40 in each target country. To collect sufficient data to assess the impact of gas cooking appliances on indoor air quality, the team determined that around 80% of the selected households should cook with gas. Since electric equipment is not a source of indoor air pollution,[23] the researchers decided that the remaining households should use electric cooking appliances, providing a baseline for comparison.

Household monitoring took place over a **five-month** period between January and May 2023. The research team selected this timeframe because households are more likely to keep windows closed during cooler months, minimising the infiltration of outdoor air pollution (from sources such as petrol and diesel cars) that could impact indoor air quality measurements. Each monitoring phase took place over the course of two weeks, with measurements conducted in no more than two countries at a time. The research laboratory had three weeks between testing rounds to transport equipment to and from households, download data, and recalibrate testing equipment.

iii CLASP engaged a peer-review panel of experts to contribute to the research design. The proposed methodology was discussed at the 17th International Conference of the International Society of Indoor Air Quality & Climate, held in Finland in June 2022.

TABLE 1. TIMELINE, LOCATIONS, AND NUMBER OF EQUIPMENT BOXES SENT OUT FOR EACH FIELD-TESTING ROUND

ROUND	1	2	3	4
Drop-off	27 January 2023	3 March 2023	7 April 2023	12 May 2023
Pick up	13 February 2023	17 March 2023	21 April 2023	26 May 2023
Set #1 Country Number of households	Netherlands* 40	Italy 40	France 40	UK 40
Set #2 Country Number of households	-	Spain 35	Slovakia 41	Romania 40

** Testing was conducted in only one country during the first round, enabling researchers to address issues and build on lessons learned for subsequent rounds*

2.2. RECRUITING HOUSEHOLDS FOR INDOOR AIR QUALITY MONITORING

The project team selected households based on criteria designed to ensure that data gathered reflected the demographics, cooking conditions, and housing types in each country. Other factors impacting indoor air quality, such as ventilation, were also considered. Priority criteria included:

- All households should be non-smoking and not have or use a wood-burning stove (to avoid indoor pollution contamination).
- Participants should cook in their kitchens at least three to four times a week (to provide sufficient data).
- Households should not be located near a busy road or industrial zone (to avoid outdoor pollution contamination).

The recruitment sample frame is set out in Table 2.

TABLE 2. HOUSEHOLD RECRUITMENT SAMPLE FRAME

MARKET	PER COUNTRY
Total # of households	40
# with a gas hob (and oven, where possible)	32
# with electric hobs and ovens	8
# with a vent hood	Min 15
# without a vent hood	Min 15
# in social or affordable housing	Min 15
# in rented housing	Min 10
# with children under 16	Min 10
Household income levels	Wide mix

Opinium Research collaborated with local partners to coordinate household recruitment and provide ongoing support to households throughout the monitoring period. To minimise the risk of dropouts, households were offered a financial incentive to participate. However, some dropouts did occur. (In some cases, this was due to sickness or personal conflicts; in a few others, households did not correctly install the equipment, did not install it at all, or decided they no longer wanted to participate once they had set up the equipment.) Any data from dropout households were omitted from the study.

Prospective households completed an online recruitment screener[24] to confirm eligibility and address General Data Protection Regulation (GDPR) requirements. Once selected for the study, households completed a detailed “Welcome Activity” questionnaire[25] gathering information about their home, kitchen, and cooking habits (e.g., kitchen size, cooking equipment, and ventilation habits, as well as home age and airtightness). This information was occasionally confirmed through photographs.[iv] **To prevent households from changing cooking behaviours during the study, thereby impacting results, they were not provided with specific details about the research objectives.**

TABLE 3. SELF-REPORTED PARTICIPATING HOUSEHOLD CHARACTERISTICS

	NETHERLANDS (N=37)	ITALY (N=36)	SPAIN (N=34)	FRANCE (N=35)	SLOVAKIA (N=36)	UK (N=35)	ROMANIA (N=34)
Homeowner characteristics							
Average age (year)	47.1	41.1	47.3	43.3	39.2	42.7	42.5
Living alone (%)	21.6	13.9	26.5	17.1	13.9	2.9	17.6
Living with partner (%)	24.3	33.3	23.5	20.0	33.3	57.1	35.3
Children over 16 (%)	8.1	8.3	8.8	20.0	11.1	-	-
Children under 16 (%)	45.9	44.4	41.2	42.9	41.7	40.0	50.0
Housing characteristics							
Detached house (%)	8.1	22.2	5.9	51.4	27.8	22.9	38.2
Terraced house (%)	64.9	13.9	-	8.6	5.6	34.4	-
Apartment/flat (%)	27	63.9	94.1	40.0	66.7	42.9	61.8
Kitchen characteristics							
Open kitchen (%)	75.7	55.6	20.6	37.1	38.9	20.0	5.9
Kitchen volume (m^3)	57	59	38	64	51	40	35
Gas hob (%)	78.4	86.1	44.1	68.6	83.3	80.0	85.3
Gas oven (%)	0	5.6	0	5.7	25.0	60.0	55.9
Electric hob and oven (%)	21.6	13.9	55.9	31.4	16.7	20.0	14.7
Using an extraction hood (%)	43.2	97.2	85.3	60.0	52.8	57.1	58.8
Recirculation hood (%)	14.3	48.6	3.4	38.1	26.3	22.2	5.0
Extraction hood to outside (%)	85.7	51.4	96.6	61.9	73.7	77.8	95.0
Extraction fan to outside (%)	-	-	2.9	-	-	5.7	-
Housing status							
Own house (%)	24.3	91.7	76.5	48.6	58.3	28.6	76.5
Social housing (%)	40.5	-	2.9	22.9	13.9	51.4	-
Rented from private landlord (%)	35.1	8.3	20.6	28.6	27.8	20.0	23.5

[iv] This data will be collated and made publicly available in 2024.

2.3. INDOOR AIR QUALITY MONITORING

Building on research conducted by TNO and published by CLASP and the European Public Health Alliance in 2022,[26] the study monitored several pollutants of concern that have been linked to gas cooking — specifically NO_2, CO, and $PM_{2.5}$. Although burning gas is also known to emit ultrafine particles ($PM_{0.1}$),[27] there are no EU, UK, or WHO levels against which to compare pollution concentrations, and the process required to test for this pollutant is more extensive than was possible in the scope of this project.

The equipment chosen for this study, outlined in Table 4,[28] was intentionally compact and easy for households to install and use. The research team gave participants detailed written[29] and video[30] instructions on how to correctly set up the equipment and pack it up at the end of the monitoring period. National helpdesks were set up and trained to answer questions, while participants were asked to share photos of their equipment setup. During the monitoring period, households completed a "daily diary" to document the food they cooked and any ventilation used.[31] This information was used to better understand measurement data.

Once the field measurements were completed in each country, equipment was sent back to TNO. Researchers calibrated the monitoring equipment to detect any changes in measurement sensitivity or accuracy, then conducted a thorough analysis of all the measurement data and prepared findings.[32]

TABLE 4. POLLUTANTS MEASURED, REASON FOR MEASURING, AND MONITORING METHODOLOGY

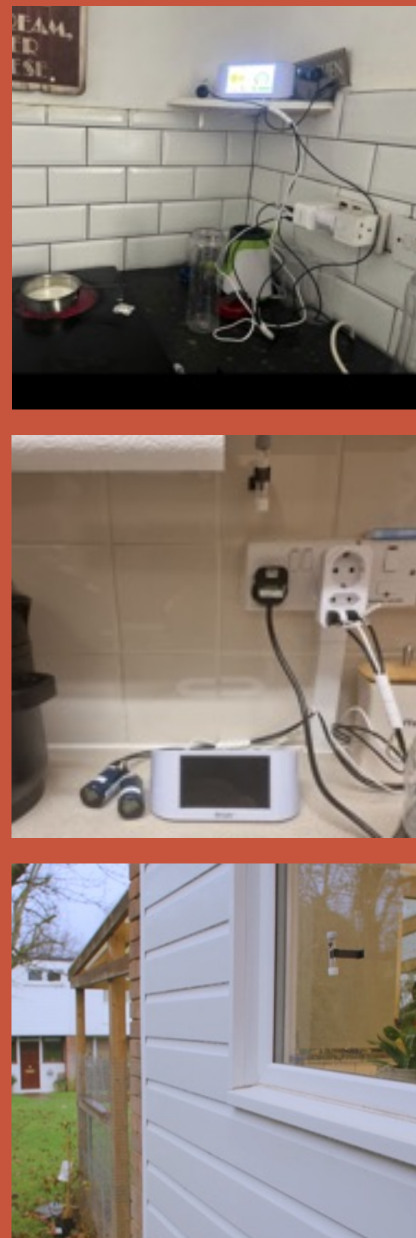
POLLUTANT	HEALTH CONCERN	HOW IT WAS MONITORED	
Nitrogen Dioxide (NO_2)	NO_2 causes a range of harmful effects on the lungs, including increased inflammation of the airways; coughing and wheezing; reduced lung function; and increased asthma attacks, especially in children.	Actively monitored in the kitchen with one-minute continuous measurements using the ENVEA Cairsens® NO_2 Micro-sensor to determine whether pollutant concentrations breached hourly and daily WHO guidelines and/or EU/UK standards. Passively[v] monitored in kitchen, living room, bedroom, and outdoors using Gradko NO_2 Diffusion Tubes. Indoor measurements were taken to determine if and how gas cooking pollution spreads throughout the home. A tube was placed on a wall outside the home to monitor ambient (i.e., outdoor) pollution and its impacts on indoor air quality.	 
Carbon Monoxide (CO)	At low levels, CO can cause headaches, nausea, dizziness, and confusion. Long-term exposure may cause permanent mental or physical problems and can increase chances of dementia and potentially Parkinsonism. At high levels, CO poisoning can be fatal.	Actively monitored in the kitchen with one-minute continuous measurements using the ENVEA Cairsens® CO | Micro-sensor to determine whether pollutant concentrations breached hourly and daily WHO guidelines and/or EU/UK standards.	
Particulate Matter ($PM_{2.5}$)	$PM_{2.5}$ can penetrate deep into the lungs and the bloodstream, causing decreased lung function and heart attacks. Short-term rises in particle pollution can increase mortality in infants and lead to cardiovascular disease and asthma attacks in all age groups.	Real-time monitoring in the kitchen with the Air Quality Sensor — AirVisual Pro. $PM_{2.5}$ measured, as well as CO_2 and temperature.	

[v] Gathering longer-term information to determine indicative average rates of pollutant concentrations.

FIGURE 3. USE OF IBUTTONS ON THE HOB AND OVEN

A stove-usage monitoring sensor, the iButton DS1922-L, was used to detect hob and gas oven use. The iButton tracks time and temperature to identify when the household is cooking. Two sensors were placed on the gas or electric hob. One sensor was placed on the gas oven.

FIGURE 4. TYPICAL PLACEMENTS OF NO_2 AND CO SENSORS, THE $PM_{2.5}$/CO_2 SENSOR, AND PASSIVE NO_2 SENSORS



The passive NO_2 sensors were stuck to the wall in the kitchen (see top of the top picture) and in rooms around the house, as well as on a wall or surface outdoors, ideally outside the kitchen and away from any ventilation exhaust, as shown in the bottom picture. The other sensors were placed in the kitchen between 1 and 3 metres from the cooking area (but not above or below it), away from an open window or door.

3. Field Study Results

3.1. LEVELS OF NO_2 IN GAS- AND ELECTRIC-COOKING HOUSEHOLDS

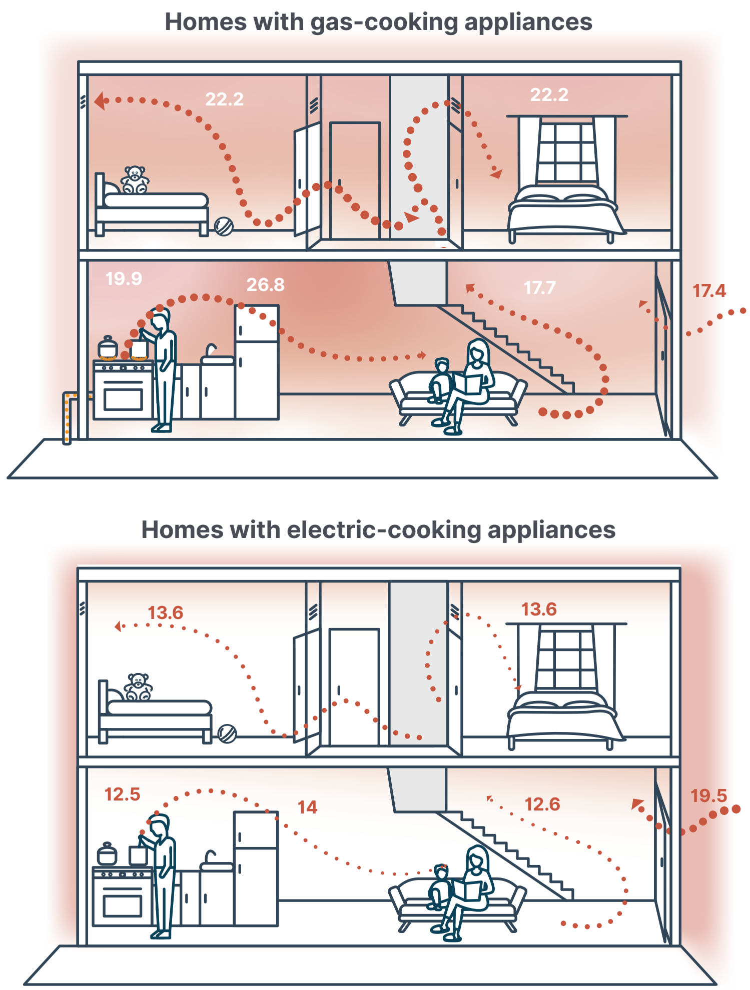
Air quality measurement data collected over the course of two weeks in each country revealed that **gas-cooking homes were exposed to around twice the level of NO_2 as those cooking with electric appliances.**[33] From the kitchen to the bedroom, NO_2 concentrations were consistently higher in homes equipped with gas cooking appliances.

> **Homes with gas hobs have much higher concentrations of NO_2 than those with electric hobs.**

Reviewing all country data together, Figure 5 shows how average NO_2 levels differed in each room and outdoors in electric- and gas-cooking households. In households using electric hobs and ovens, average NO_2 concentrations were lower indoors, reaching a maximum rate of 14 μg/m³ in the kitchen. Outdoor NO_2 concentration levels were often higher, likely due to the combustion of fuels to power cars or industrial facilities,[34] with results showing an average concentration of 19.5 μg/m³.

The opposite was found in gas-cooking homes, with average levels in the kitchen of around 26.8 μg/m³, compared to lower outdoor pollution concentrations of around 17.4 μg/m³.[35] In some households, indoor levels exceeded the upper measurement limits of the sensor, peaking at around 478 μg/m³.

FIGURE 5. COMPARISON OF AVERAGE NO_2 CONCENTRATIONS IN GAS- AND ELECTRIC-COOKING HOMES IN ALL FIELD STUDY COUNTRIES



● **Average NO_2 concentrations by μg/m³ in European homes and surrounding outdoor air**

Homes with electric-cooking appliances experienced significantly lower levels of indoor air pollution throughout the home, compared to gas-cooking homes.

These findings are even clearer when broken down by country. Figure 6 shows the average NO_2 concentration levels per country, as measured by the passive sensors in the kitchen, living room, bedroom, and outdoors. In all countries, electric-cooking homes had cleaner air indoors, with the highest NO_2 concentrations being identified outdoors. In gas-cooking homes, however, NO_2 levels were on average higher in the kitchen than outdoors.

The results indicate that electric-cooking households with higher levels of indoor air pollution likely suffer from outdoor contamination as opposed to cooking appliance-related pollution. For example, in Romania, the electric-cooking households were located in highly polluted areas; as a result, indoor NO_2 concentration levels were higher than in other countries.[36]

> **Pollution from gas cooking appliances regularly exceeded NO_2 levels found outside the home, regardless of outdoor pollution levels.**

FIGURE 6. AVERAGE NO_2 CONCENTRATIONS PER COUNTRY AND PER COOKING METHOD IN DIFFERENT ROOMS

3.2. FACTORS CONTRIBUTING TO HIGHER INDOOR AIR POLLUTION IN GAS-COOKING HOMES

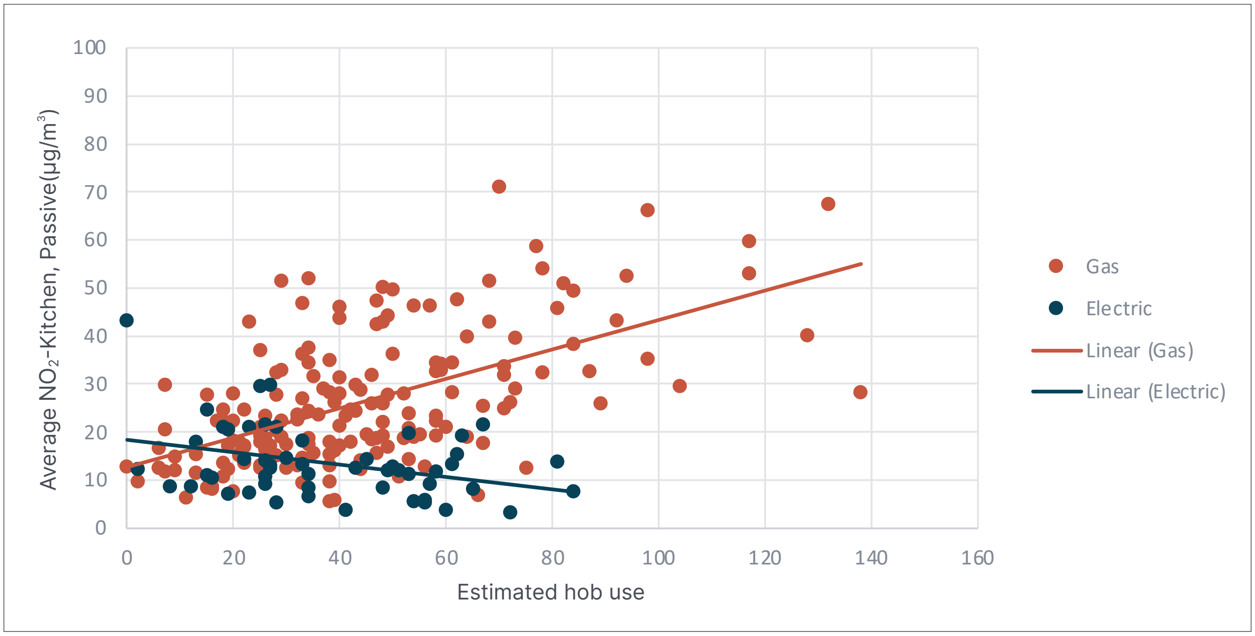
The study identified several factors that contributed to higher indoor air pollution levels in gas-cooking homes. These factors had no impact on pollution levels in electric-cooking homes.

Cooking Duration

When gas-cooking households spent a longer time cooking, indoor NO_2 concentrations continued to increase while the hob or oven was running. This did not occur in households cooking with electric hobs and ovens.

> **Cooking for longer with gas equates to increased NO_2. The same is not true for electric cooking.**

FIGURE 7. INDOOR-ATTRIBUTED NO_2 CONCENTRATIONS IN THE KITCHEN FOR GAS- AND ELECTRIC-COOKING HOMES, BASED ON AVERAGE COOKING TIMES



Homes with electric cooking appliances can maintain the same levels of NO_2 regardless of cooking duration, whereas homes with gas cooking appliances tend to have a much broader spread, with patterns showing a correlation between increase in cooking time and higher NO_2 pollution.

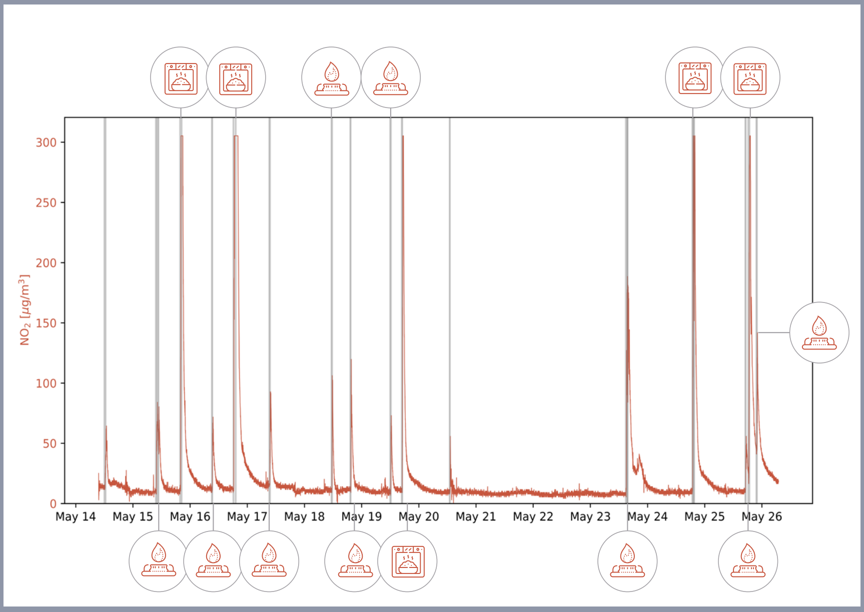
Impact of Ovens on Indoor Air Quality: A UK Case Study

Gas oven sales have been decreasing across Europe in favour of more efficient and user-friendly electric ovens. During household recruitment for this study, more gas ovens were found in the UK than in other countries. On average, these households experienced slightly higher NO_2 concentrations in the kitchen. One UK kitchen included in the study provides a helpful example of how gas ovens can negatively impact indoor air quality.

This household lived in a rented terrace house with a $32m^3$ kitchen and no range hood. It used a gas cooker with a gas hob on top and a gas grill and oven underneath. During the field study, members of the household kept a log of what they cooked and how, and these patterns were confirmed by the iButton temperature sensors. Figure 8 shows the measurements taken by the active NO_2 microsensor (red lines) and the iButton readings (grey lines). The gas oven was used an average of 32 minutes per day, compared to an average of 40 minutes for the gas hob.

As shown in Figure 8, whenever the gas oven was used, the active NO_2 microsensors registered very high peaks, often above the maximum range of the sensor, surpassing the WHO and EU/UK limit values. The passive NO_2 sensors recorded significantly higher levels of pollutants in comparison (46.1 $\mu g/m^3$ with the passive sensors and 22.1 $\mu g/m^3$ with the active sensors), indicating that the actual concentration exceeded the WHO and EU/UK limit values by an even greater amount.

FIGURE 8. AIR QUALITY TRENDS WHEN COOKING ON GAS HOBS AND GAS OVENS IN THE UK



In the graph to the left, the grey lines indicate when food was cooked, based on iButton measurements. The red lines show NO_2 levels, based on the active sensor measurements. The research team was able to determine whether the oven or hob was used by checking time-stamped photos provided by the household in its daily diary. Whenever the gas oven was used, the NO_2 levels peaked, often above the maximum range of the sensor, exceeding WHO and EU/UK limit values.

3.3. POLLUTION LEVELS COMPARED TO INTERNATIONAL AND EUROPEAN STANDARDS

To assess the severity of indoor air pollution from gas and electric cooking in European households, TNO compared the in-home monitoring results with the pollutant limit values mandated by the 2010 European Ambient Air Quality Directive[37] and UK Air Quality Standards Regulations[38] for outdoor pollution, as well as the recommended levels relevant to both outdoors and indoors in the 2021 WHO air quality guidelines.[39] The data gathered from the kitchen sensors were used to compare against the WHO guidelines and EU/UK limit values, as they contained readings from both the active and passive sensors. Readings from sensors in the rest of the house could not be meaningfully compared to international or European standards, as only passive sensor data was collected.

International and European Limit Values for Different Pollutants

The WHO's guidelines set out recommended pollutant levels that countries can apply in their local regulations to protect public health. Reflecting the most up-to-date scientific evidence, they define levels of pollution above which are proven to contribute to significant adverse health impacts.[40]

Tables 5, 6, and 7 show recommended levels for NO_2, CO, and $PM_{2.5}$, respectively.

TABLE 5. EU/UK LIMIT VALUES AND WHO GUIDELINES FOR NO_2 (1 µg/m³ = 0.523 PPB)

LEVELS	INDOOR/ OUTDOOR	YEARLY [µg/m³]	24 HOUR [µg/m³]	1 HOUR [µg/m³]
EU and UK NO_2 limit values	Outdoor	40	-	200*
WHO guidelines	Both	10	25	200

* Not to be exceeded more than 18 times during a calendar year

TABLE 6. EU/UK LIMIT VALUES AND WHO GUIDELINES FOR CO (1 µg/m³ = 0.858 PPM)

LEVELS	INDOOR/ OUTDOOR	24 HOUR [µg/m³]	8 HOUR [µg/m³]	1 HOUR [µg/m³]	15 MINUTES [µg/m³]
EU and UK CO limit values	Outdoor	-	10	-	-
WHO guidelines	Both	4	10	35	100

TABLE 7. EU/UK LIMIT VALUES AND WHO GUIDELINES FOR $PM_{2.5}$

LEVELS	INDOOR/ OUTDOOR	YEARLY [µg/m³]	24 HOUR [µg/m³]
EU and UK $PM_{2.5}$ limit values	Outdoor	25	-
WHO guidelines	Both	5	15

In 2021, the WHO revised the 2005 guidelines, lowering the yearly NO_2 concentration level from 40 µg/m³ to 10 µg/m³.[41] While the 2005 target of 40 µg/m³ is considered achievable in many parts of the world, it is still associated with significant adverse respiratory effects such as asthma and increased respiratory infections, especially in vulnerable populations like children and the elderly.[42]

Despite this change at the international level, the mandatory NO_2 concentration limits set out in the 2010 EU and UK air quality standards remain at 40 µg/m³.[43] There are positive signs that the limits will be amended to reflect the WHO guidelines, as the European Parliament agreed in September 2023 to improve air quality and strengthen air quality limits, to achieve a clean and healthy environment for Europeans.[44]

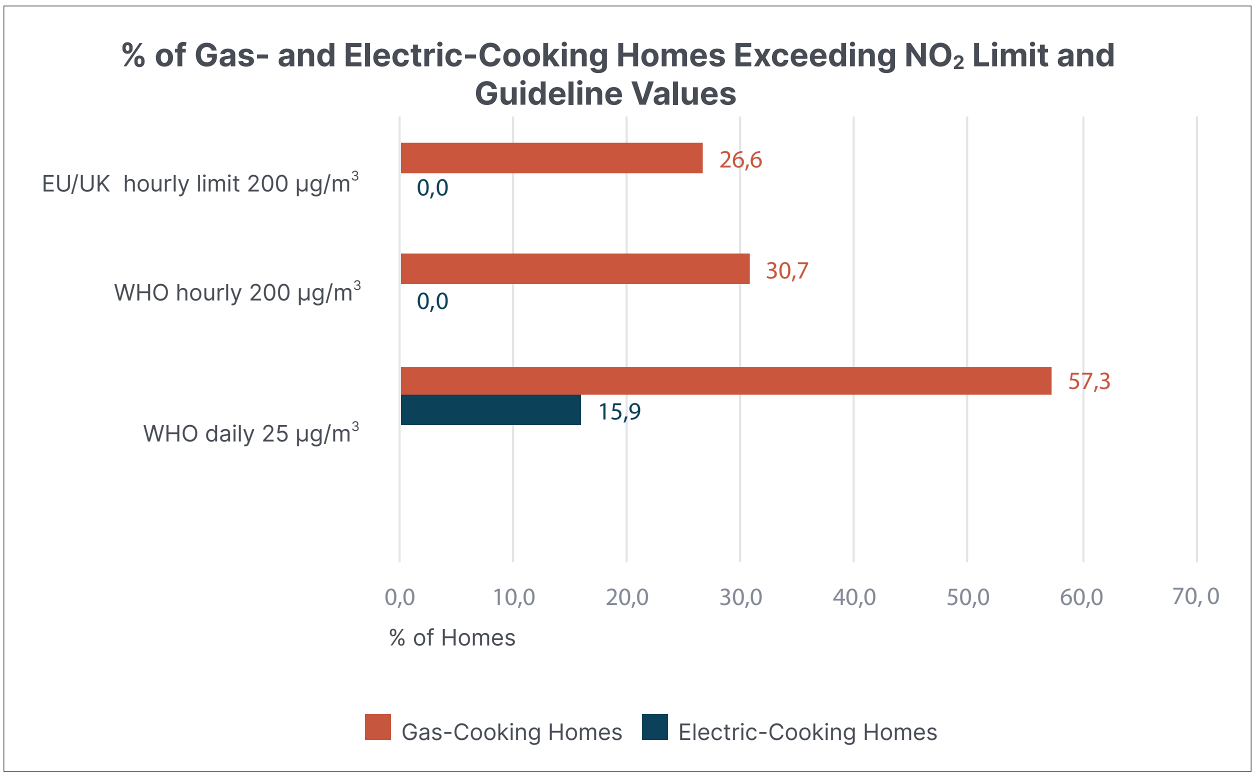
NO_2 Exceedances in Gas- and Electric-Cooking Households

Minute-by-minute data for NO_2 concentrations were collected from monitored households and the results were used to assess whether homes with gas and electric cooking appliances experienced levels of NO_2 pollution exceeding limits put forward by the WHO as well as the EU and UK governments. Exceedances against yearly values were not assessed since monitoring took place over 13 days in each country and cannot be representative of the full year, as cooking and ventilation practices are likely to change in different seasons.

> **Gas-cooking households regularly exceeded the WHO guidelines and the EU and UK air quality standards for NO_2.**

Figure 10 shows that, on average, gas-cooking households exceeded both the hourly[vi] and daily limit values, compared to a significantly smaller proportion of homes with electric cooking appliances. As explained above, the electric exceedances are likely due to outdoor NO_2 pollution entering homes when windows are opened.

FIGURE 9. AVERAGE EXCEEDANCE OF WHO AND EU/UK NO_2 LIMIT VALUES IN GAS- AND ELECTRIC-COOKING HOMES



vi The WHO and EU/UK hourly limit values were defined as follows: The EU/UK hourly limits were based on the average concentrations by hour (e.g., between 9:00 and 10:00), whereas the WHO hourly limits were based on when peak pollution levels were identified. For example, if cooking results in peak concentrations between 9:15 and 10:15, this time interval was used to calculate the hourly average. Since the WHO limits for NO_2 exposure are lower, the number of hours exceeding the WHO hourly guidelines will always be equal to or higher than the EU/UK hourly limit values.

This finding is also shown in Table 8, which shows exceedance levels by country.

TABLE 8. EXCEEDANCES OF NO_2 LIMITS AND GUIDELINE VALUES IN MONITORED KITCHENS IN ALL COUNTRIES

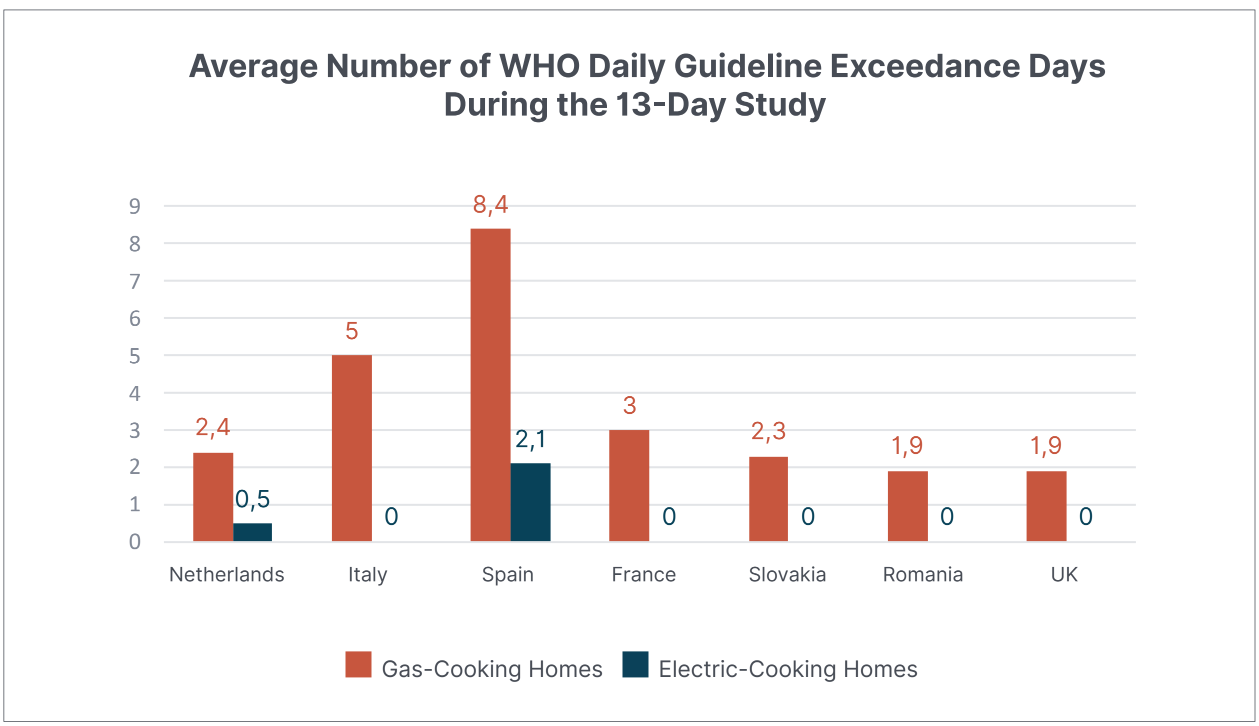
NO_2 LIMIT/ GUIDELINE VALUE	% OF HOUSEHOLDS ABOVE LIMIT VALUE													
COUNTRY	Netherlands		Italy		Spain		France		Slovakia		UK		Romania	
ELECTRIC VS GAS	El	Gas	El	Gas	El	Gas	El	Gas	El	Gas	El	Gas	El	Gas
EU HOURLY 200 µg/m³	0	27*	0	24*	0	69*	0	29*	0	15*	0	25	0	19*
WHO DAILY 25 µg/m³	17	54	0	72	50	85	0	53	0	44	0	55	0	52
WHO HOURLY 200 µg/m³	0	31	0	28	0	77	0	29	0	22	0	25	0	24

* Extrapolation of 13 days of measurement data to yearly exceedance

Study data showed that:

- In all seven countries, **the majority of gas-cooking households exceeded the WHO daily guideline limits for NO_2.** On average, households in Spain exceeded these limits 8 out of the 13 measurement days, while Italian households exceeded them 5 out of 13 days. In the Netherlands and Spain, several electric-cooking households also exceeded these limits. Because outdoor NO_2 measurements were higher than indoor NO_2 levels in these electric-cooking households, the research team concluded that the indoor pollution measurements may have been influenced by the infiltration of outdoor air pollution into the buildings.[vii]

FIGURE 10. AVERAGE NUMBER OF EXCEEDANCE DAYS OF THE WHO DAILY GUIDELINE VALUE DURING THE 13-DAY MEASUREMENT PERIOD



vii As per the WHO 2021 air quality guidelines, indoor air pollution is generated not only from indoor sources but also from outdoor air pollutants that are brought indoors by means of ventilation and penetration through the building envelope. In indoor environments without indoor sources of air pollution, pollutants from outdoors are the main cause of air pollution.

- The mandatory EU and UK ambient NO_2 hourly limits were exceeded by 15% to 69% of gas-cooking households, depending on the country [viii] This means that **indoor NO_2 pollution levels linked to gas cooking appliances frequently violate regulated outdoor air pollution limits** — however, no one is monitoring levels indoors, nor have indoor air pollution limits been established. **Electric-cooking households did not exceed the outdoor limits.**

- **The NO_2 limits set out in the WHO hourly guidelines were exceeded by 22% to 77% of all participating gas-cooking households. Electric-cooking households did not exceed these limits.**

Based on these findings, residents of gas-cooking homes regularly experience short-term exposure to higher NO_2 concentrations exceeding an hourly concentration of 200 µg/m³. These are not one-off situations, given the high number of days households were found to exceed the WHO daily guidelines. **As a result, people who cook with gas appliances, particularly those who are more vulnerable or who have pre-existing conditions, may be at a higher risk of immediate health issues, such as aggravated asthma symptoms and other respiratory illnesses.**

> Short-term exposure to higher concentrations of NO_2, particularly those exceeding an hourly concentration of 200 µg/m³, can cause immediate health problems, aggravating or leading to respiratory symptoms such as coughing, wheezing, and difficulty breathing, resulting in increased hospital visits.[45]

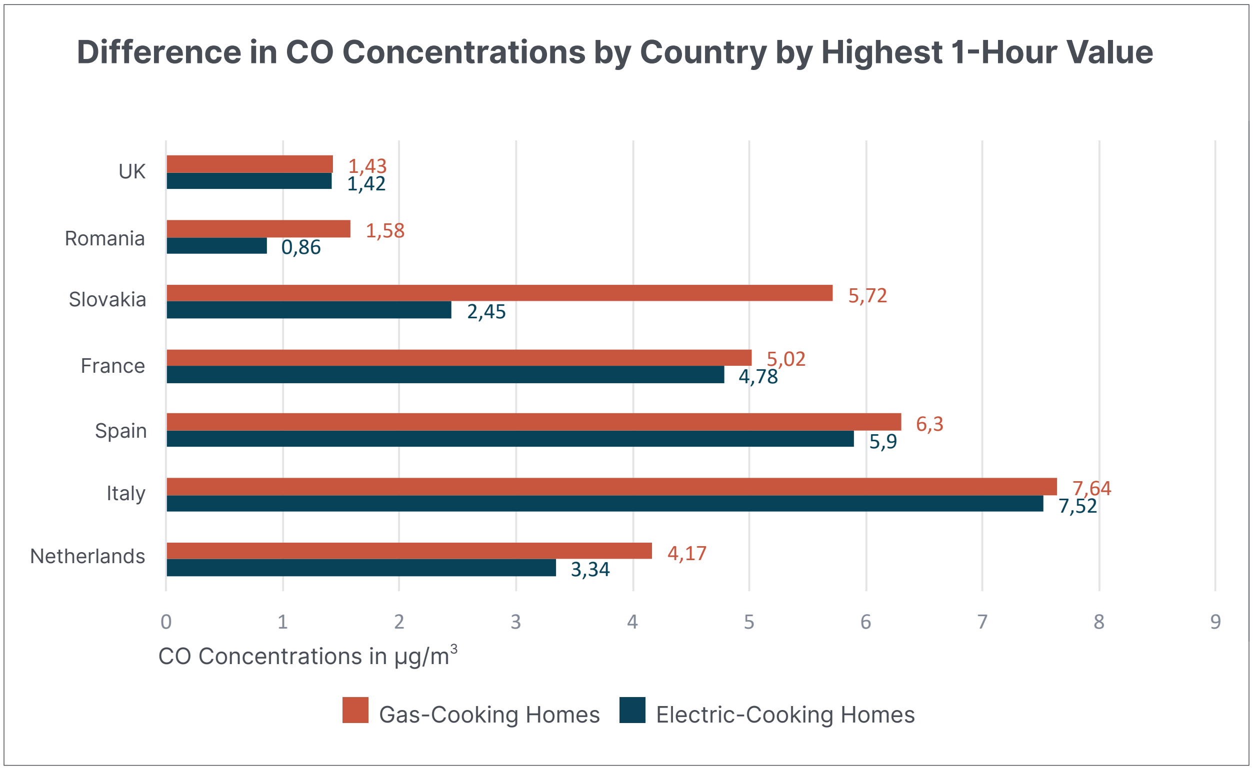
viii Based on the number of hours that gas-cooking households exceeded the EU and UK hourly NO_2 limits over the course of the monitoring period, it can be assumed that these households will exceed the 18 hours per year set out in the air quality directives and standards.

Challenges Monitoring Carbon Monoxide

The in-home monitoring revealed a small but significant difference in CO levels amongst gas- and electric-cooking households. Gas-cooking households tended to experience higher levels of CO. However, the differences were not significant in all countries. **A total of four gas-cooking households across all countries may have exceeded the daily CO limits put forward in the WHO guidelines. Electric-cooking households did not exceed these limits.**

Results were, however, impacted by a sensitivity in the CO sensor used to monitor the pollutant.[46] Upon examination of the final results, the CO sensor was found to be reactive to ethanol and other volatile organic compounds. Household CO data may therefore have been contaminated by alcohol or cleaning agents present in the kitchens.[47] Additional research into actual CO concentration levels from cooking is needed to determine whether this pollutant is a concern in European kitchens.

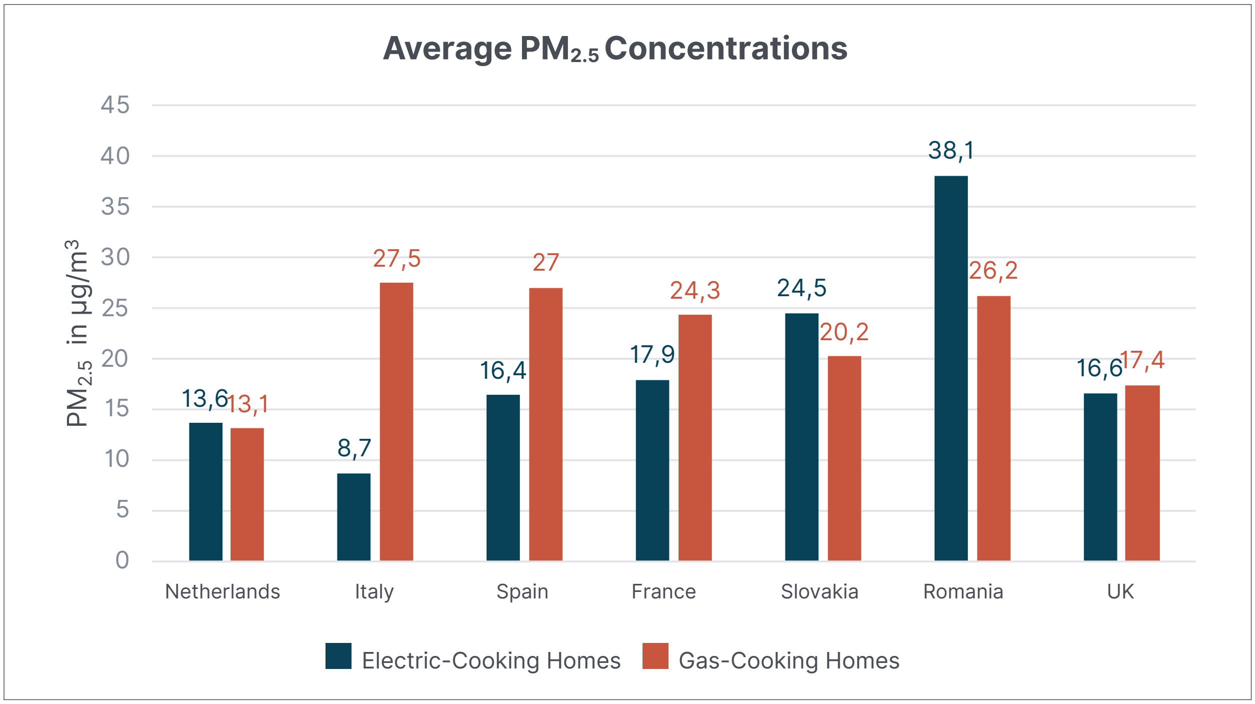
FIGURE 11. HIGHEST HOURLY CO CONCENTRATIONS FOUND IN THE KITCHEN, PER COUNTRY AND PER COOKING METHOD



$PM_{2.5}$ Caused by Cooking Activity Rather Than Cooking Appliance

Both gas- and electric-cooking households experienced comparably high levels of $PM_{2.5}$, the vast majority of which exceeded the WHO daily guidelines of 15 µg/m^3. As no $PM_{2.5}$ sensors were placed outdoors, it was not possible to determine whether indoor concentrations were impacted by ambient air pollution. Based on findings from other studies and the ambient NO_2 pollution levels identified for some households, it is possible that indoor $PM_{2.5}$ levels were impacted by high outdoor concentrations.

FIGURE 12. AVERAGE $PM_{2.5}$ CONCENTRATIONS IN THE KITCHEN, PER COUNTRY AND PER COOKING TECHNOLOGY



Indoor $PM_{2.5}$ is generated by the evaporation of oil and ingredients in a pan, and the amount emitted depends on the cooking method and temperature, the oil used, and the fat content of the food.[49,50] Throughout the study, participants were asked to record information about and photos of the food they cooked and the ventilation they used. In homes presenting higher $PM_{2.5}$ levels, participants shared photos or explanations demonstrating that food was burned or that excess smoke was generated by the cooking process (Figure 13). These findings highlight the importance of using cooker hoods with high pollutant-capture efficiency that move air from the kitchen to the outdoors.

FIGURE 13. DOCUMENTATION OF COOKING STYLES IMPACTING $PM_{2.5}$ LEVELS

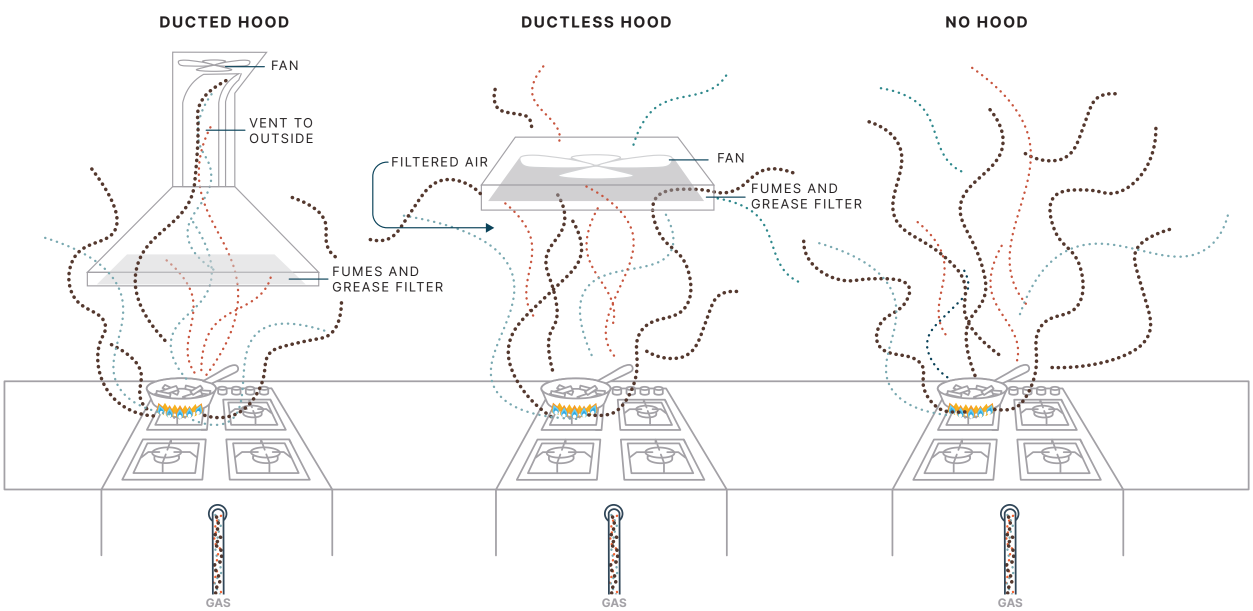
Photos taken by participating households in France showing slightly burnt food that resulted in higher $PM_{2.5}$ levels.

$PM_{2.5}$ concentrations are emitted by the act of cooking food rather than by the cooking appliance itself.

3.4. IMPACT OF DOMESTIC VENTILATION ON INDOOR AIR QUALITY

The study set out to determine the potential impact of ventilation on indoor air quality. Prior research indicates that adequate ventilation can be effective in reducing air pollution in the kitchen.[51,52] During the household recruitment process, potential participants provided information on the ventilation in their homes. The research team asked specifically whether they have whole-home ventilation, cooker hoods ducted to the outside, no ventilation, or recirculating hoods that filter the cooking air and recirculate it back into the kitchen. The majority of households (104) reported using externally ducted cooker hoods, while 68 reported not using or having any type of cooker hood. Thirty households reported having a recirculation hood. The project team provided guidance to the participants explaining different ventilation types and requested photos of their equipment, but no home visits were conducted to confirm the accuracy of the information submitted.

FIGURE 14. OVERVIEW OF VENTILATION TYPES RECORDED IN THE STUDY



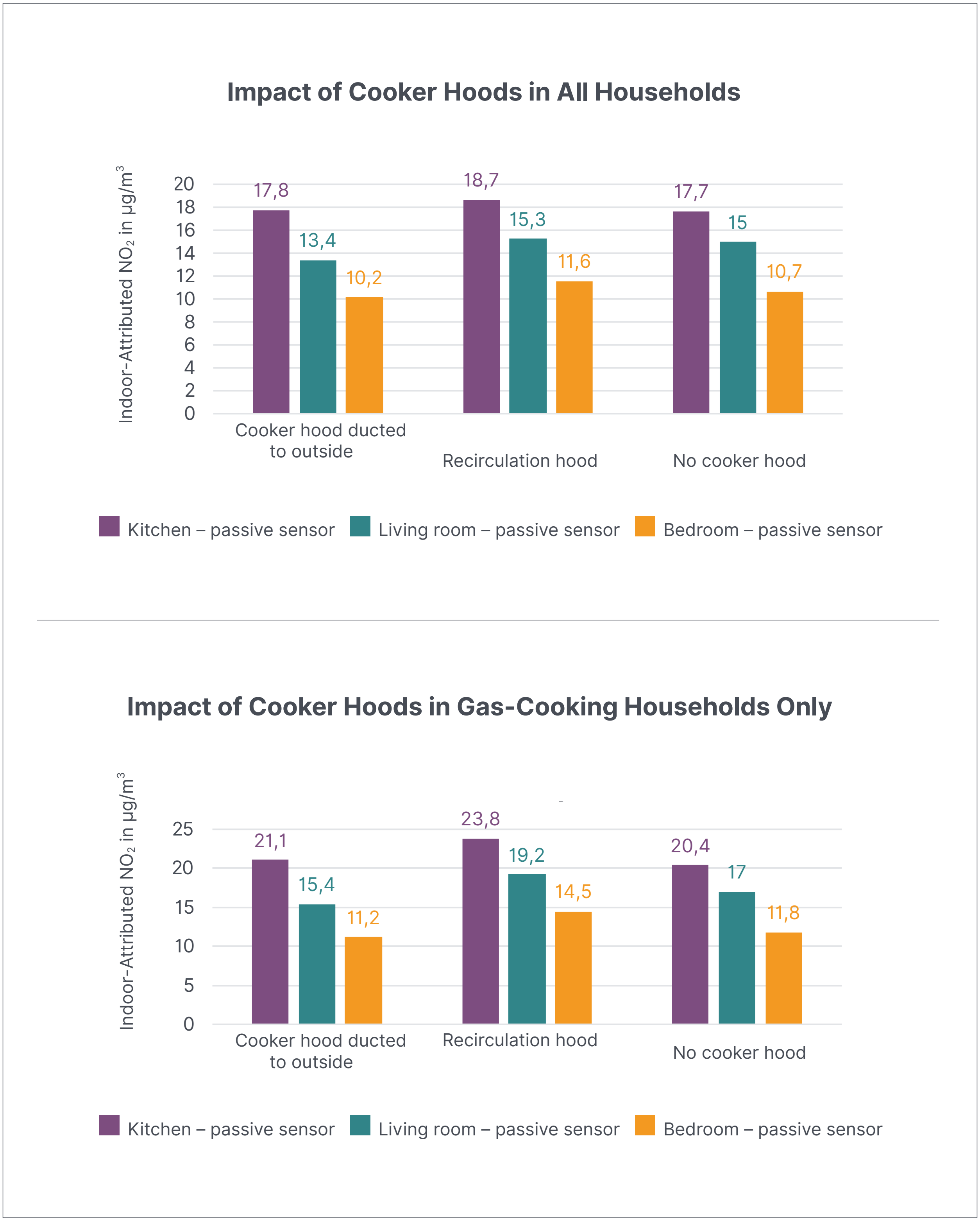
● NO_2 ● CO ● Particulates/$PM_{2.5}$

The results were surprising. On average, **households who reported having externally ducted or recirculating cooker hoods did not experience significantly lower NO_2 or $PM_{2.5}$ levels than those who reported having no ventilation.[53]**

As shown in Figure 15, ducted cooker hoods were slightly more effective at reducing NO_2 indoor pollution levels than recirculating hoods. **Recirculating hoods were the least effective at reducing indoor NO_2 levels.** However, pollution concentrations for all ventilation conditions were higher in gas-cooking households.

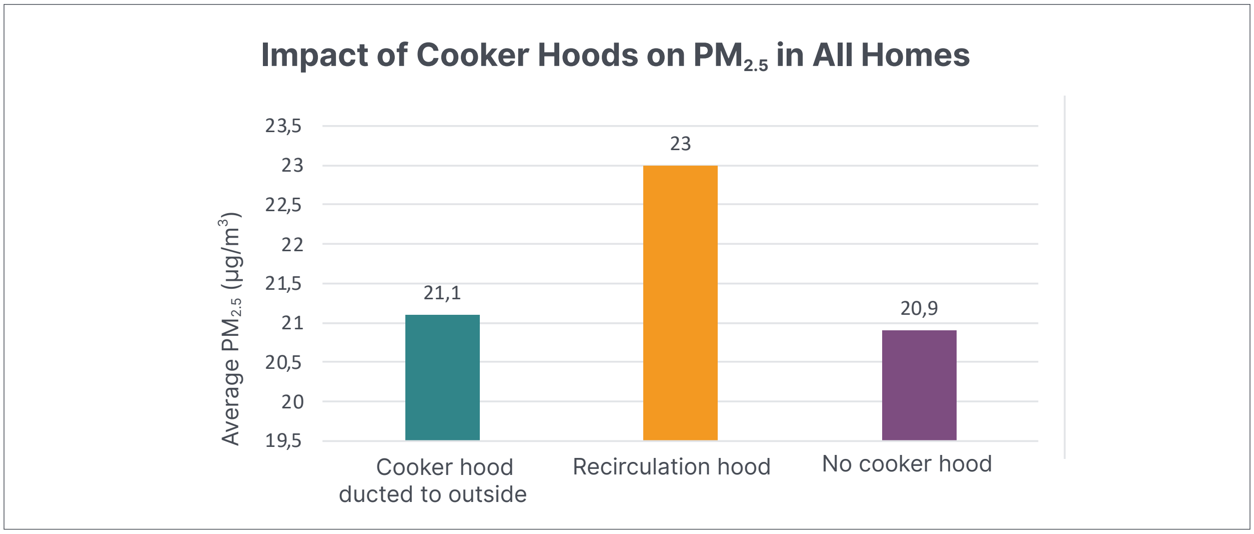
The presence of cooker hoods had little impact on indoor air pollution.

FIGURE 15. COMPARISON OF AVERAGE INDOOR-ATTRIBUTED NO_2 CONCENTRATION THROUGHOUT THE HOME, BY COOKER HOOD TYPE, FOR ALL HOMES AND GAS-COOKING HOMES



The same trend was observed for $PM_{2.5}$ concentration levels in the kitchen, as shown in Figure 16.

FIGURE 16. AVERAGE $PM_{2.5}$ CONCENTRATION IN KITCHEN FOR ALL HOMES COOKING ON GAS AND ON ELECTRIC HOBS



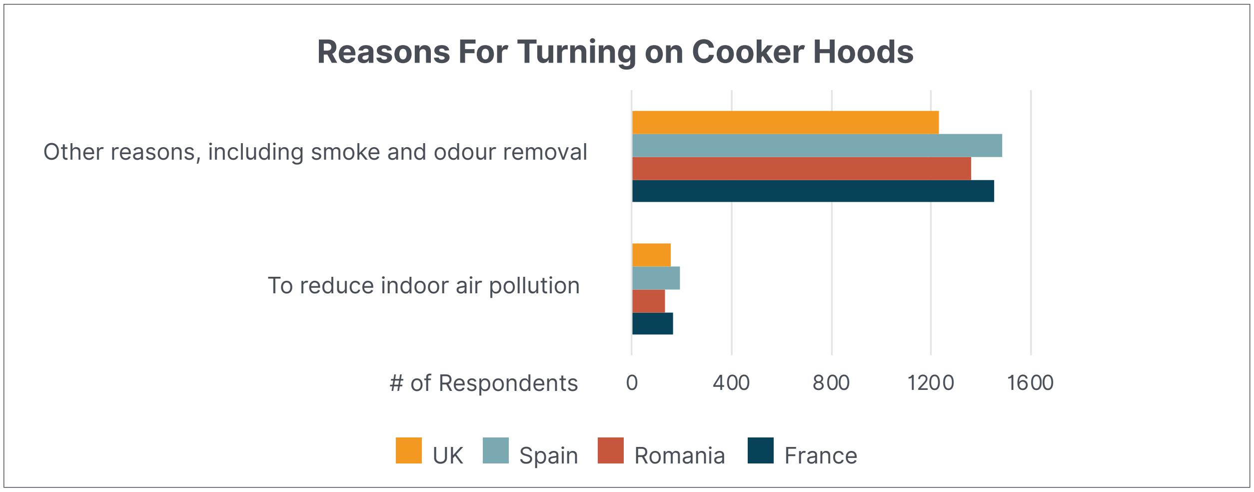
These findings suggest that recirculation hoods, which are often found in apartments, are the least-effective ventilation mechanism. The efficiency of the recirculation hood and filter decrease incredibly quickly over time.[54] Because this technology is focused primarily on removing odours from the cooking process (as opposed to pollutants) through the activated carbon filter, users may use the hood less, turn it off to reduce noise levels, and/or keep windows closed once odours are removed — behaviours that result in higher NO_2.[55]

Before the in-home monitoring period, households shared whether they have and use a cooker hood. Participants may have changed usage patterns compared to what they initially reported, which may explain why there were no significant differences from the impact of the cooker hood used. (Researchers had no insight into the efficiency of cooker hoods used or at what power level they were running during the survey.)

Ensuring households have access to and use adequate ventilation is critical to mitigating indoor NO_2 and $PM_{2.5}$ pollution.

ix For guidance on how to mitigate NO_2 emissions from gas cooking and $PM_{2.5}$ from all cooking, see CLASP's "How to Improve Air Quality in Your Home When You Have a Gas Hob or Oven" resource, available at https://www.clasp.ngo/cook-cleaner-europe.

FIGURE 17. REASONS FOR USING VENTILATION IN THE KITCHEN: RESULTS FROM A 2023 CLASP CONSUMER SURVEY CONDUCTED IN THE UK, SPAIN, ROMANIA, AND FRANCE



Existing research confirms that even when available, cooker hoods are not always used [56] or even functional, and that many ventilation strategies are inadequate.[57] In early 2023, CLASP conducted a survey in the UK, Spain, Romania, and France, revealing that people ventilate primarily to eliminate cooking odours and reduce steam, with only 20% ventilating to reduce indoor air pollution.[58] This implies that cooker hoods are mostly turned on when triggered by smoke or fumes, rather than run from the start of cooking till around ten minutes after finishing using the hob, as per best practice recommendations.[ix,59]

Ventilation, specifically cooker hoods, can be an effective mechanism to mitigate NO_2 pollution from gas cooking appliances, as well as $PM_{2.5}$ levels from cooking food — with the caveat that there are no "safe" pollution levels. Manufacturers must design cooker hoods that effectively capture pollutants whilst not creating noise levels that will deter use, while households must switch them on and use them properly throughout and after the cooking process.

Tips for adequate ventilation in the kitchen when cooking

1. Whenever possible, use a cooker hood, turn it on as soon as the hob is switched on, and keep it running for ten minutes after turning the hob off.

2. Follow the manufacturer's guidance on replacing/cleaning the grease filters in the cooker hood.

3. If the fan in the cooker hood is not working, fix or replace it as soon as possible.

4. If replacing or installing a new cooker hood, ensure it is vented to the outside. Research the pollutant capture efficiency and airflow rate of the product to ensure it has sufficient ability to remove air pollution.

5. If a cooker hood is not an option, open windows during and after cooking to enable NO_2 pollution from the gas hob and $PM_{2.5}$ from cooking to leave the room as quickly as possible.

4. Country-Level Findings

65.4% OF HOUSEHOLDS COOK ON GAS
72,961 CHILDREN WITH CURRENT ASTHMA LINKED TO GAS COOKING
*CLASP and European Public Health Alliance (EHPA), 2023

4.1. THE NETHERLANDS

Overview of Country Findings[x]

Field study data was successfully collected from a total of 37 Dutch households:

- 29 with gas hobs and electric ovens. No houses with gas ovens.
- 8 with electric hobs and ovens.

Indoor air quality was significantly worse in households that cooked with gas:

- NO_2 levels were much higher in gas-cooking households' kitchens and living rooms. More than half of the Dutch gas-cooking households exceeded WHO daily guideline values compared to one electric-cooking household. Only gas-cooking households exceeded the WHO hourly guidelines and EU hourly limits.
- There was no significant difference in CO levels between gas- and electric-cooking households.
- There was no significant difference in $PM_{2.5}$ concentrations between gas- and electric-cooking households. Both gas- and electric-cooking households exceeded WHO daily guideline values for $PM_{2.5}$.

NO_2 Pollution Concentrations

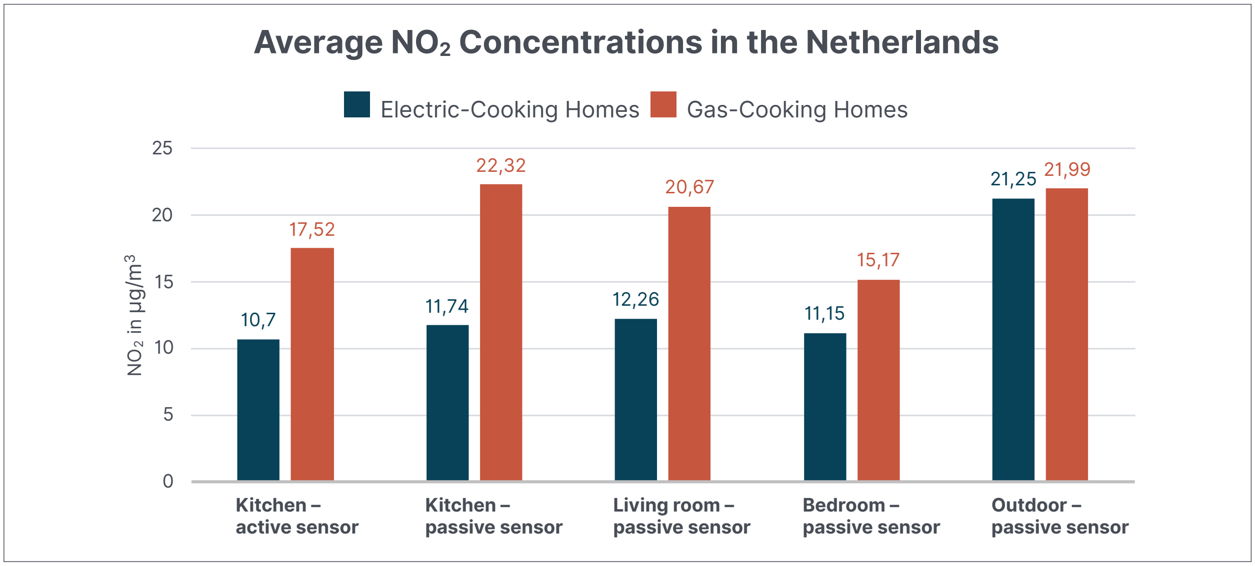
NO_2 levels were significantly higher in the majority of gas-cooking households. One electric-cooking household experienced higher NO_2 levels, which was likely caused by high outdoor NO_2 levels.

Exceedances of WHO and EU Pollutant Limits

Only gas-cooking households exceeded the WHO hourly guideline NO_2 limits as well as the EU's hourly NO_2 limits. One electric-cooking household exceeded the WHO daily guideline NO_2 limits, which, as explained above, is likely due to other influencing factors.

No significant CO or $PM_{2.5}$ pollutant level differences were identified between gas- and electric-cooking households. Most homes exceeded the WHO daily guideline values for $PM_{2.5}$ due to outdoor infiltration of $PM_{2.5}$, the type of food cooked, and the cooking method used, as well as a lack of adequate ventilation to capture pollutants.

FIGURE 18. AVERAGE NO_2 CONCENTRATIONS IN THE NETHERLANDS IN THE KITCHEN, LIVING ROOM, BEDROOM, AND OUTDOORS FOR HOMES WITH ELECTRIC COMPARED TO GAS COOKING



x For full details, see the TNO 2023 Report: Health Effects in Europe from Cooking on Gas — Phase II Field Study

FIGURE 19. MAP OF GAS- AND ELECTRIC-COOKING DUTCH HOUSEHOLDS SHOWING NO_2 LEVELS

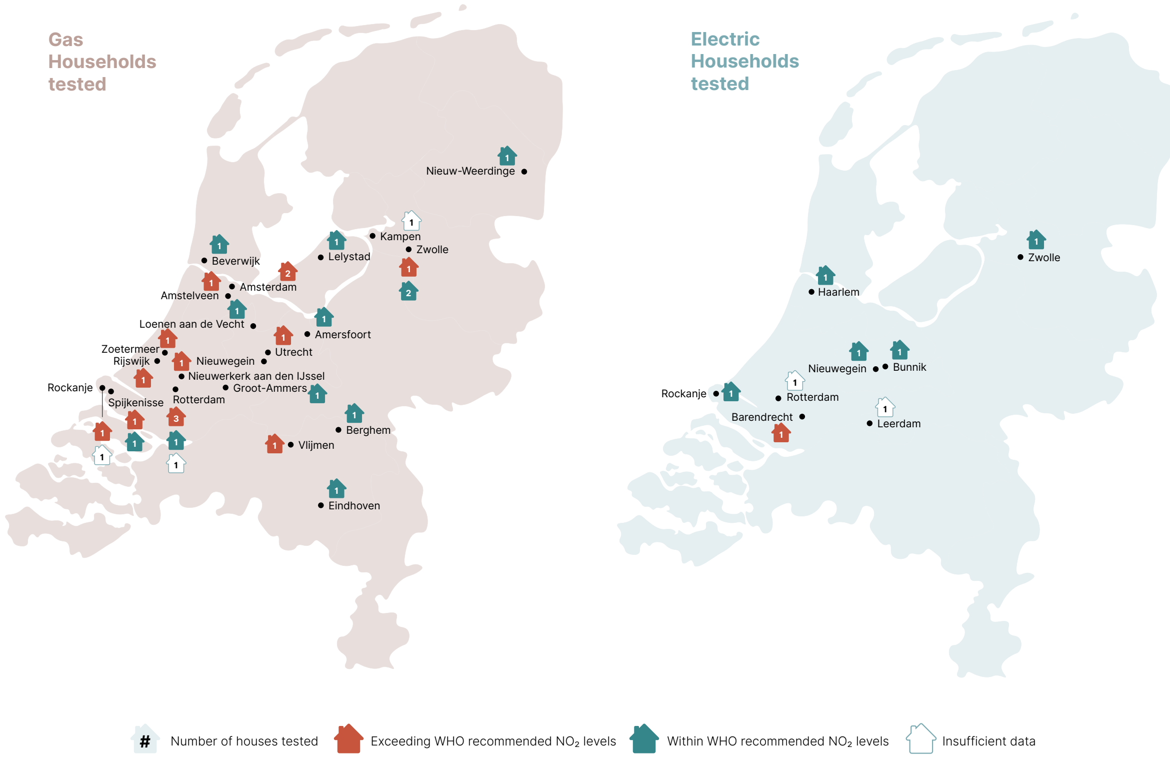
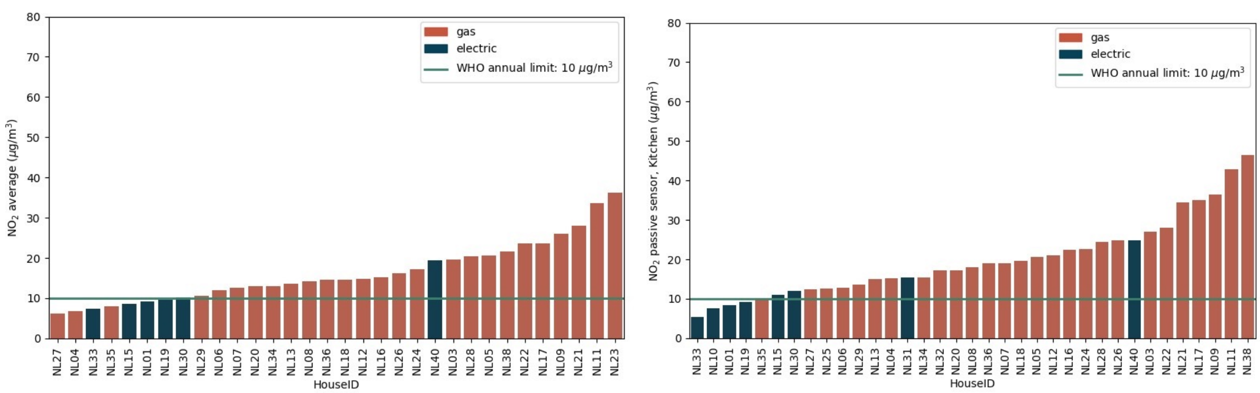


TABLE 10. NO_2 LIMIT EXCEEDANCES FROM GAS- AND ELECTRIC-COOKING HOUSEHOLDS IN THE NETHERLANDS

NO_2 STANDARDS	EXCEEDANCES FOR GAS-COOKING HOMES	EXCEEDANCES FOR ELECTRIC-COOKING HOMES
WHO daily guidelines	54%	17%
WHO hourly guidelines	31%	0%
EU hourly limits	27%*	0%

*Extrapolation of 13 days of measurement data to yearly exceedance

FIGURE 20. AVERAGE NO_2 CONCENTRATIONS IN THE KITCHEN PER DUTCH HOME, BASED ON ACTIVE SENSORS (ON LEFT) AND PASSIVE SENSORS (ON RIGHT), WITH THE WHO ANNUAL LIMIT VALUE OF 10 µg/m³ AS A REFERENCE[60]



4.2. ITALY

68.7% OF HOUSEHOLDS COOK ON GAS
234,605 CHILDREN WITH CURRENT ASTHMA LINKED TO GAS COOKING

*CLASP and EPHA, 2023

Overview of Country Findings[xi]

Field study data was successfully collected from a total of 36 Italian households:

- 31 with gas hobs and electric ovens; one home with a gas oven.
- 5 with electric hobs and ovens.

Indoor air quality was significantly worse in households that cooked with gas than in households with only electric cooking appliances:

- NO_2 levels were much higher in gas-cooking households' kitchens and living rooms. Over 70% of Italian gas-cooking households exceeded WHO daily guideline values, with only gas-cooking households exceeding WHO hourly guidelines and EU hourly limits. No electric-cooking households exceeded WHO or EU limits.
- CO levels in gas-cooking households were significantly higher than in electric-cooking households. However, the electric-cooking sample of homes was too small to discern a trend.
- Households cooking with gas experienced higher levels of $PM_{2.5}$ compared to electric-cooking households, likely due to longer cooking periods. However, both gas- and electric cooking households exceeded WHO daily guideline values for $PM_{2.5}$.

NO_2 Pollution Concentrations

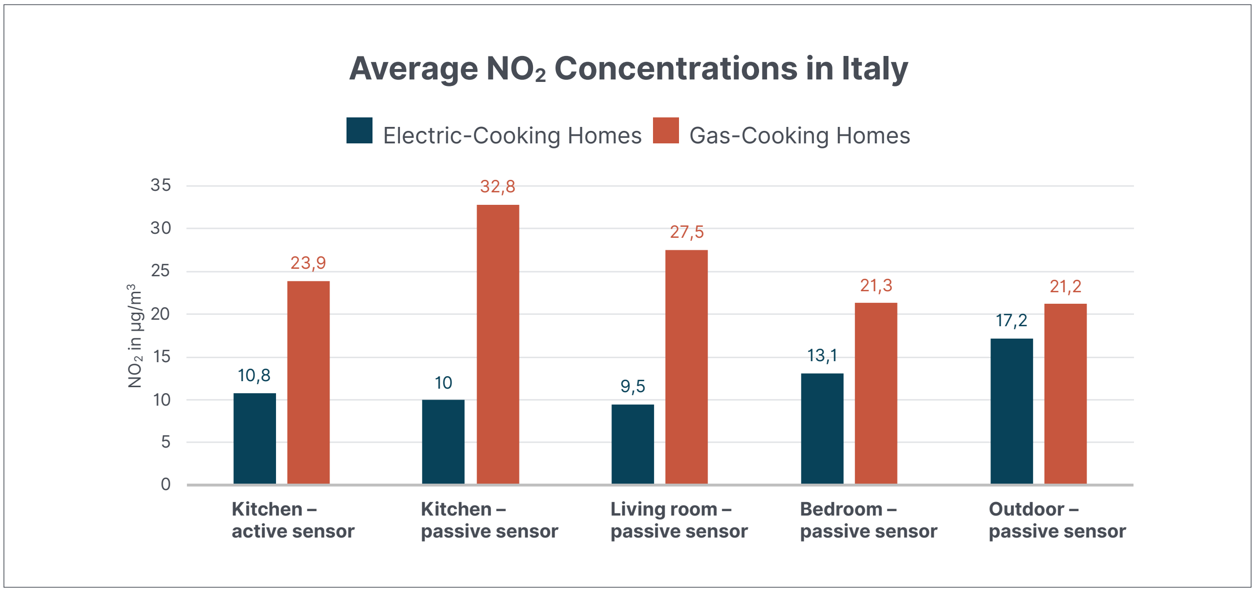
NO_2 levels were significantly higher in the majority of gas-cooking households, with indoor pollution levels higher than those monitored outdoors.

Exceedances of WHO and EU Pollutant Limits

Only gas-cooking households exceeded the WHO hourly guideline NO_2 limits as well as the EU's hourly NO_2 limits.

Although CO levels were higher in gas-cooking households, no exceedances were identified. $PM_{2.5}$ pollutant levels were generally higher in households cooking with gas, likely due to longer cooking periods. However, both gas- and electric-cooking households exceeded WHO daily guideline values due to the infiltration of outdoor $PM_{2.5}$, the type of food cooked, and the cooking method used, as well as to a lack of adequate ventilation.

FIGURE 21. AVERAGE NO_2 CONCENTRATIONS IN ITALY IN THE KITCHEN, LIVING ROOM, BEDROOM, AND OUTDOORS FOR HOMES WITH ELECTRIC COMPARED TO GAS COOKING



xi For full details, see the TNO 2023 Report: Health Effects in Europe from Cooking on Gas — Phase II Field Study

FIGURE 22. MAP OF GAS- AND ELECTRIC-COOKING ITALIAN HOUSEHOLDS, BASED ON SEVERITY OF NO_2 LEVELS

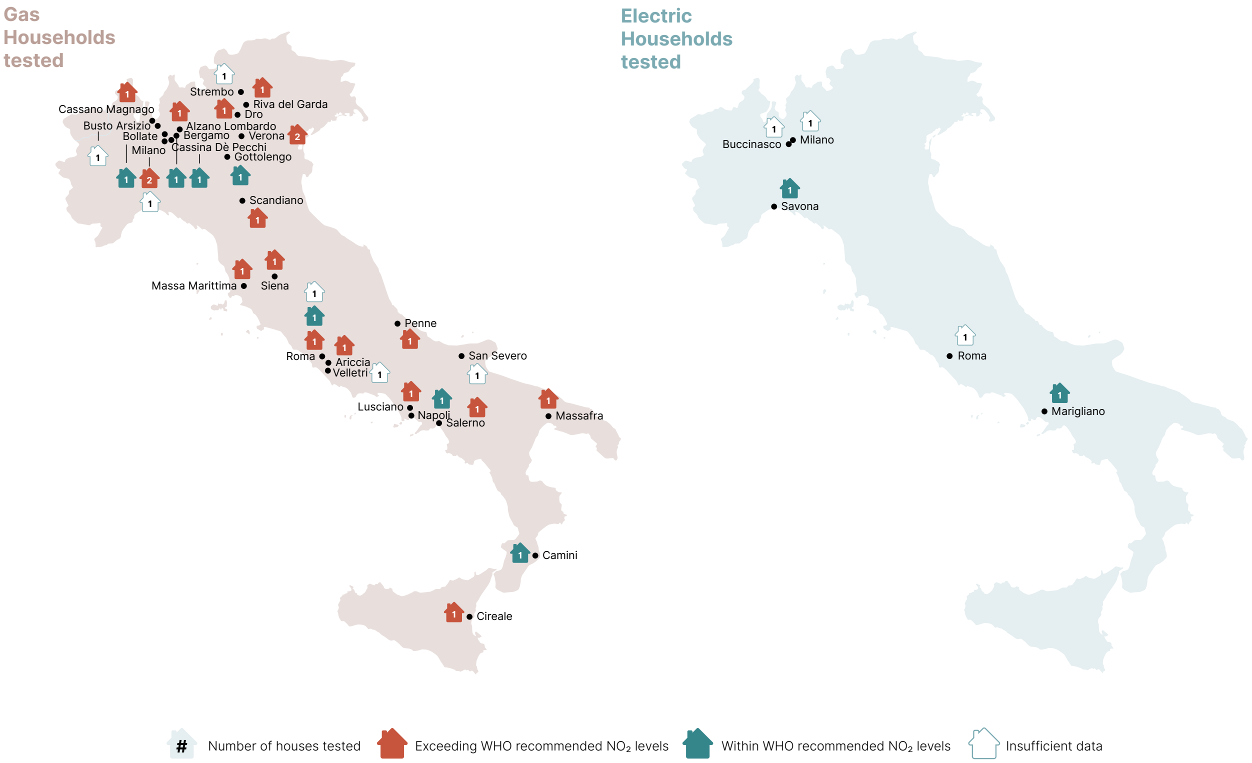
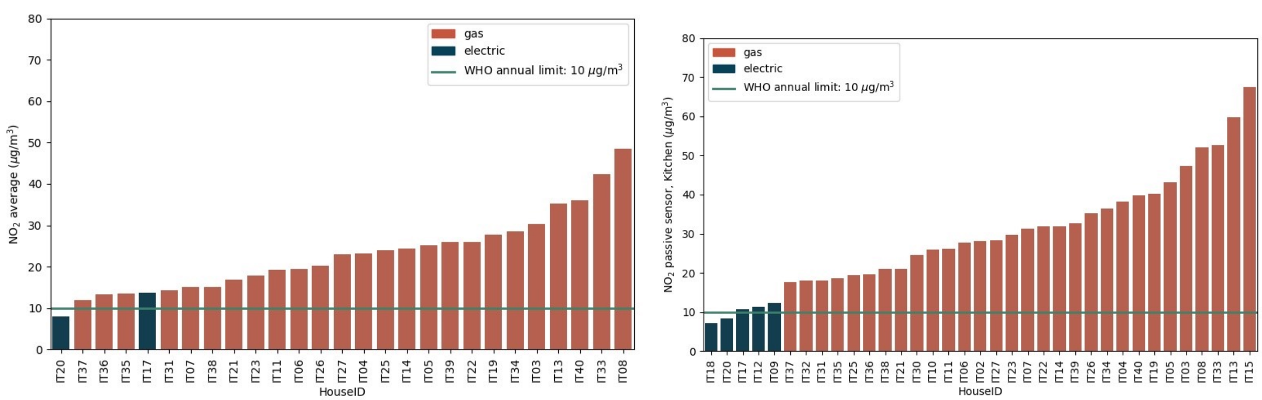


TABLE 11. NO_2 LIMIT EXCEEDANCES FROM GAS- AND ELECTRIC-COOKING HOUSEHOLDS IN ITALY

NO_2 STANDARDS	EXCEEDANCES FOR GAS-COOKING HOMES	EXCEEDANCES FOR ELECTRIC-COOKING HOMES
WHO daily guidelines	72%	0%
WHO hourly guidelines	28%	0%
EU hourly limits	24%*	0%

*Extrapolation of 13 days of measurement data to yearly exceedance

FIGURE 23. AVERAGE NO_2 CONCENTRATIONS IN THE KITCHEN PER ITALIAN HOME, BASED ON ACTIVE SENSORS (ON LEFT) AND PASSIVE SENSORS (ON RIGHT), WITH THE WHO ANNUAL LIMIT VALUE OF 10 µG/M³ AS A REFERENCE[61]



4.3. SPAIN

Overview of Country Findings[xii]

Field study data was successfully collected from a total of 34 Spanish households:

- 15 with gas hobs and electric ovens. No houses with gas ovens. The recruitment team encountered logistical challenges in identifying sufficient households that met the study criteria.
- 19 with electric hobs and ovens, the largest national sample of electric-cooking households captured in the study.

Indoor air quality was significantly worse in households that cooked with gas than in those with only electric cooking appliances:

- NO_2 levels were significantly higher in gas-cooking households' kitchens and living rooms. Eighty-five percent of Spanish gas-cooking households exceeded WHO daily guideline values compared to fifty percent of electric-cooking households, for which the data shows high levels of outdoor NO_2. Seventy-seven percent of gas-cooking households exceeded the WHO hourly guidelines and sixty-nine percent exceeded the EU hourly limits. No electric-cooking households exceeded them.
- There was no significant difference in CO levels between gas- and electric-cooking households.
- There was no significant difference in $PM_{2.5}$ concentrations between gas- and electric-cooking households. Both gas- and electric-cooking households exceeded WHO daily guideline values for $PM_{2.5}$.

NO_2 Pollution Concentrations

NO_2 levels were significantly higher in the majority of gas-cooking households. A number of electric-cooking households experienced higher-than-average levels of NO_2. High outdoor levels of NO_2 were witnessed amongst the electric-cooking households, as shown in Table 13, which could have contaminated the kitchen NO_2 measurements. In comparison, gas-cooking households experienced higher levels of NO_2 pollution indoors.

Exceedances of WHO and EU NO_2 Limits

Only gas-cooking households exceeded the WHO hourly guideline NO_2 limits, as well as the EU's hourly NO_2 limits. A total of 50% of electric-cooking households exceeded the WHO daily guideline NO_2 limits, which may be due to higher NO_2 pollution levels entering the kitchen from outdoors, as explained above.

No significant CO or $PM_{2.5}$ pollutant level differences were identified between gas- and electric-cooking households. Both gas- and electric-cooking households exceeded WHO daily guideline values due to infiltration of outdoor $PM_{2.5}$, the type of food cooked, and the cooking method used, as well as a lack of adequate ventilation.

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xii For full details, see the TNO 2023 Report: Health Effects in Europe from Cooking on Gas — Phase II Field Study

FIGURE 24. AVERAGE NO_2 CONCENTRATIONS IN SPAIN IN THE KITCHEN, LIVING ROOM, BEDROOM, AND OUTDOORS FOR HOMES WITH ELECTRIC COMPARED TO GAS COOKING

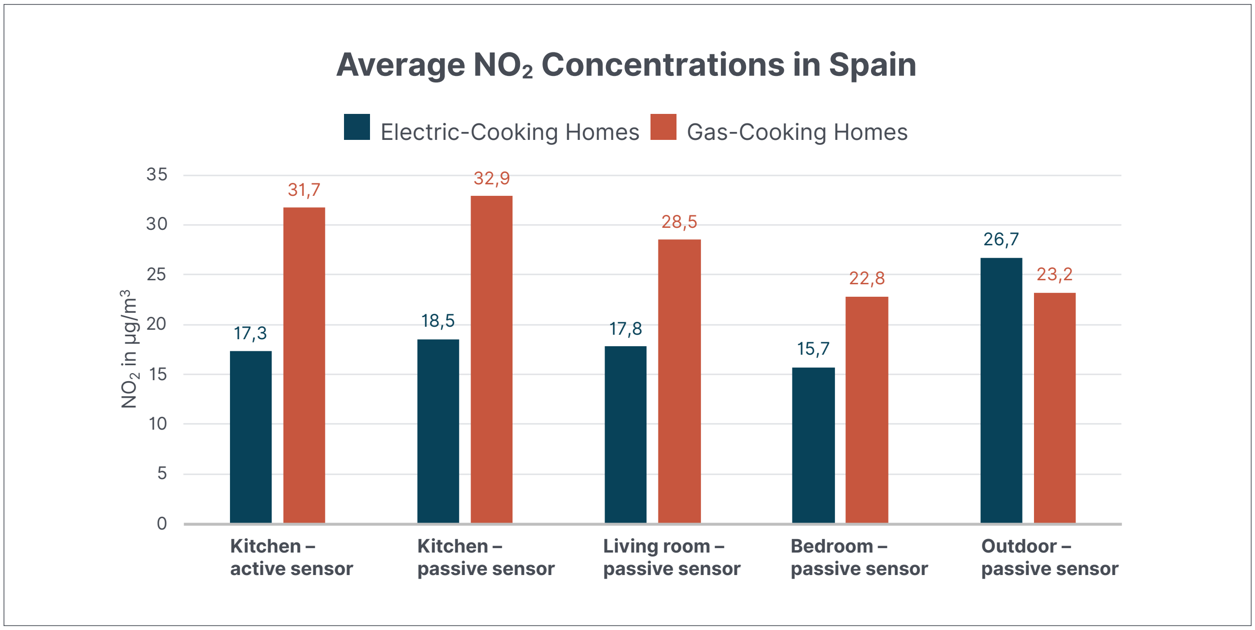


FIGURE 25. MAP OF GAS- AND ELECTRIC-COOKING SPANISH HOUSEHOLDS, BASED ON NO_2 LEVELS

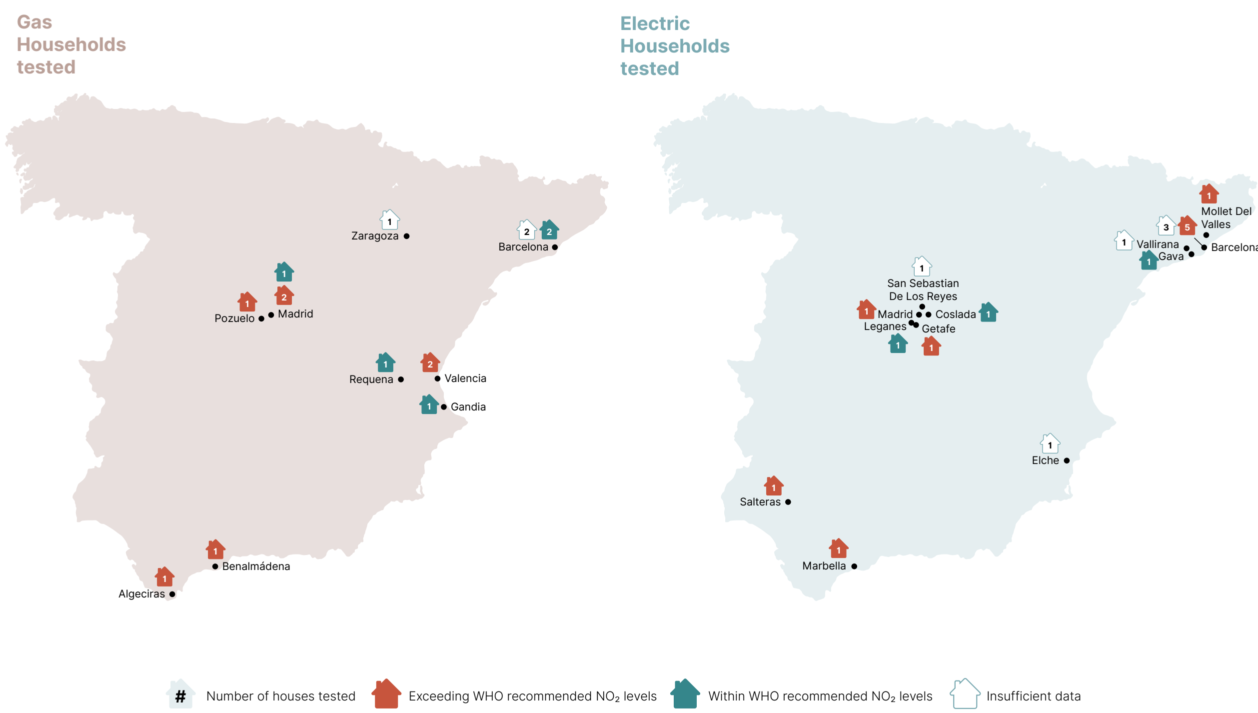
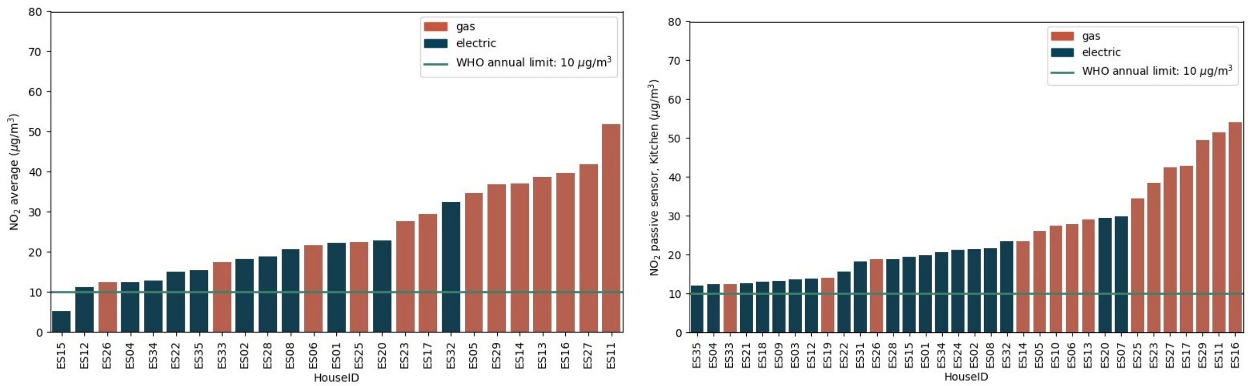


TABLE 12. NO_2 LIMIT EXCEEDANCES FROM GAS AND ELECTRIC COOKING HOUSEHOLDS IN SPAIN

NO_2 STANDARDS	EXCEEDANCES FOR GAS-COOKING HOUSEHOLDS	EXCEEDANCES FOR ELECTRIC-COOKING HOUSEHOLDS
WHO daily guidelines	85%	50%
WHO hourly guidelines	77%	0%
EU hourly limits	69%*	0%

*Extrapolation of 13 days of measurement data to yearly exceedance

FIGURE 26. AVERAGE NO_2 CONCENTRATIONS IN THE KITCHEN PER SPANISH HOME, BASED ON ACTIVE SENSORS (ON LEFT) AND PASSIVE SENSORS (ON RIGHT), WITH THE WHO ANNUAL LIMIT VALUE OF 10 µG/M^3 AS A REFERENCE[62]



4.4. FRANCE

Overview of Country Findings[xiii]

Field study data was successfully collected from a total of 35 French households:

- 24 with gas hobs and mostly electric ovens. Two homes with gas ovens.
- 11 with electric hobs and ovens.

Indoor air quality was significantly worse in households that cooked with gas than in those with all electric cooking appliances:

- NO_2 levels were significantly higher in gas-cooking households' kitchens and living rooms. More than half of the French gas-cooking households exceeded WHO daily guideline values, while 29% exceeded both the WHO hourly guidelines and the EU hourly limits. Electric-cooking households did not exceed WHO or EU limits.
- There was no significant difference in CO levels between gas- and electric-cooking households.
- There was no significant difference in $PM_{2.5}$ concentrations between gas- and electric-cooking households. Both exceeded WHO daily guideline values for $PM_{2.5}$.

NO_2 Pollution Concentrations

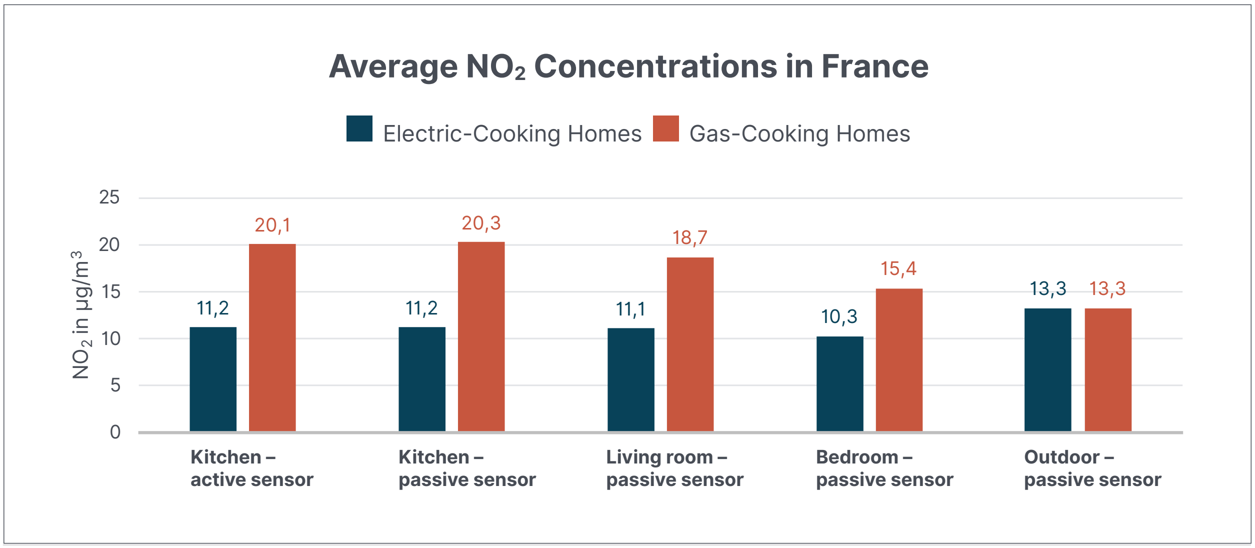
NO_2 levels were significantly higher in gas-cooking households. NO_2 levels were significantly higher indoors than outdoors in gas-cooking homes.

Exceedances of WHO and EU NO_2 Limits

Only gas-cooking households exceeded the WHO daily and hourly guideline NO_2 limits as well as the EU's hourly NO_2 limits. No electric-cooking households exceeded these limits.

No significant CO or $PM_{2.5}$ pollutant level differences were identified between gas- and electric-cooking households. Both gas- and electric-cooking households exceeded WHO daily guideline values due to outdoor infiltration of $PM_{2.5}$, the type of food cooked, and the cooking method used, as well as a lack of adequate ventilation to capture pollutants.

FIGURE 27. AVERAGE NO_2 CONCENTRATIONS IN FRANCE IN THE KITCHEN, LIVING ROOM, BEDROOM, AND OUTDOORS FOR HOMES WITH ELECTRIC COMPARED TO GAS COOKING



xiii For full details, see the TNO 2023 Report: Health Effects in Europe from Cooking on Gas — Phase II Field Study

FIGURE 28 . MAP OF GAS- AND ELECTRIC-COOKING FRENCH HOUSEHOLDS, BASED ON SEVERITY OF NO_2 LEVELS

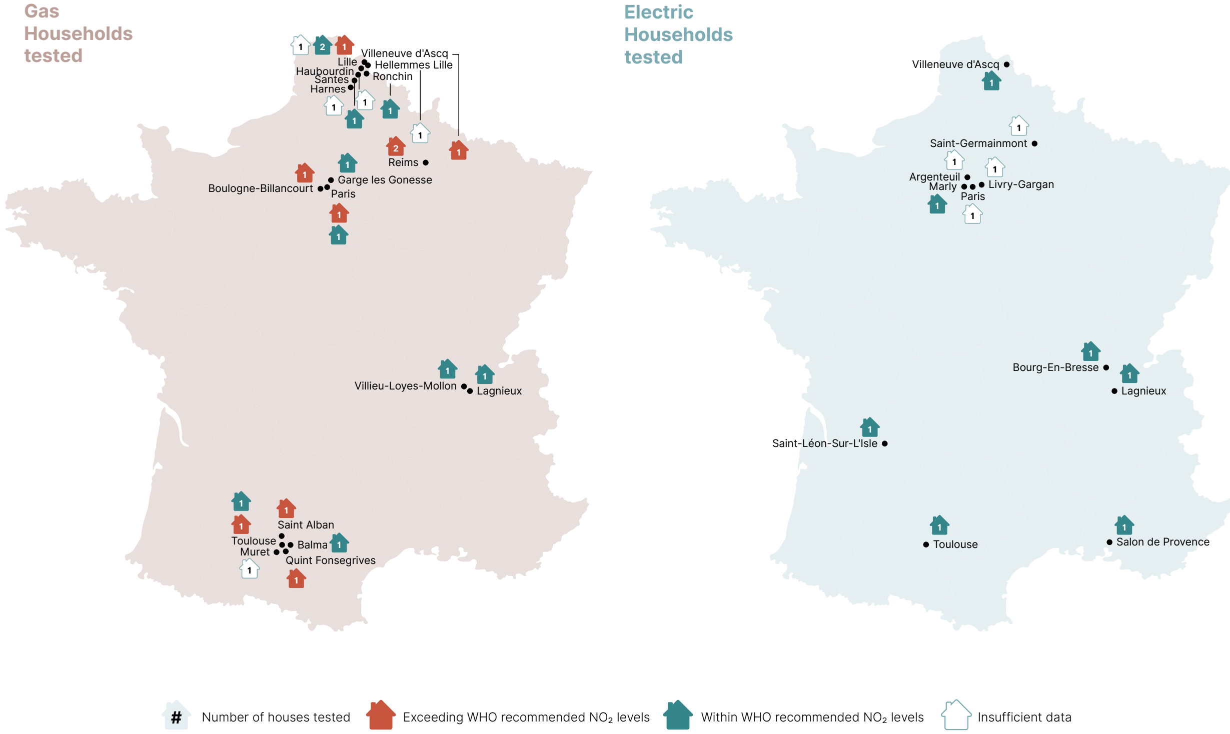
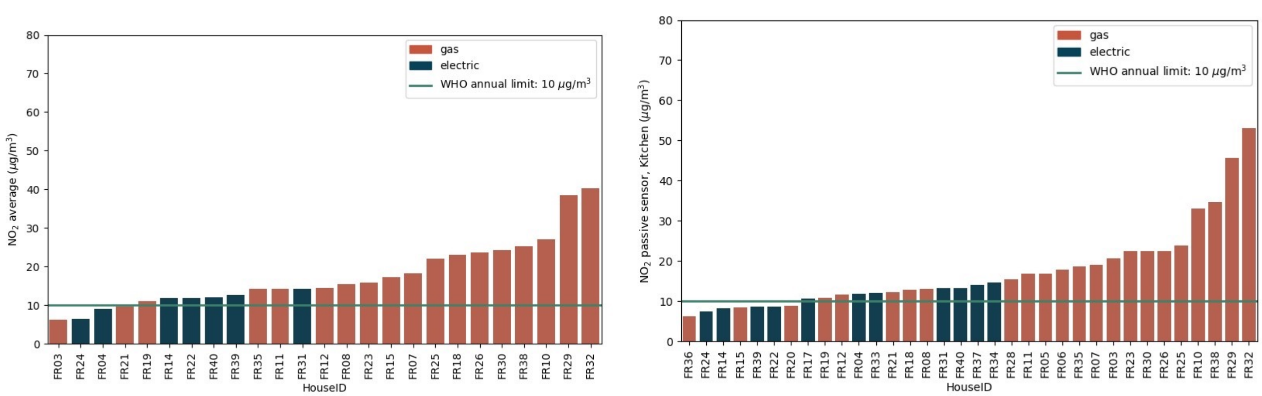


TABLE 13. NO_2 LIMIT EXCEEDANCES FROM GAS- AND ELECTRIC-COOKING HOMES IN FRANCE

NO_2 STANDARDS	EXCEEDANCES FOR GAS-COOKING HOUSEHOLDS	EXCEEDANCES FOR ELECTRIC-COOKING HOUSEHOLDS
WHO daily guidelines	53%	0%
WHO hourly guidelines	29%	0%
EU hourly limits	29%*	0%

*Extrapolation of 13 days of measurement data to yearly exceedance

FIGURE 29. AVERAGE NO_2 CONCENTRATIONS IN THE KITCHEN PER FRENCH HOME, BASED ON ACTIVE SENSORS (ON LEFT) AND PASSIVE SENSORS (ON RIGHT), WITH THE WHO ANNUAL LIMIT VALUE OF 10 µG/M^3 AS A REFERENCE[63]



4.5. SLOVAKIA

68.5% OF HOUSEHOLDS COOK ON GAS

DATA NOT AVAILABLE FOR NUMBER OF CHILDREN WITH CURRENT ASTHMA LINKED TO GAS COOKING

***CLASP and EPHA, 2023**

Overview of Country Findings[xiv]

Field study data was successfully collected from a total of 36 Slovakian households:

- 30 with gas hobs and electric ovens. No homes with gas ovens.
- 6 with electric hobs and ovens.

Indoor air quality was significantly worse in households that cooked with gas than in those with all electric cooking appliances:

- NO_2 levels were much higher in gas-cooking households' kitchens and living rooms. Forty-four percent of gas-cooking households exceeded the WHO daily guideline values, twenty-two percent exceeded the WHO hourly guidelines, and fifteen percent exceeded the EU hourly limits. Electric-cooking households did not exceed WHO or EU limits.
- CO levels in gas-cooking households were significantly higher than in electric-cooking households. No households exceeded WHO or EU limits.
- There was no significant difference in $PM_{2.5}$ concentrations between gas- and electric-cooking households. Both household types exceeded WHO daily guideline values for $PM_{2.5}$.

NO_2 Pollution Concentrations

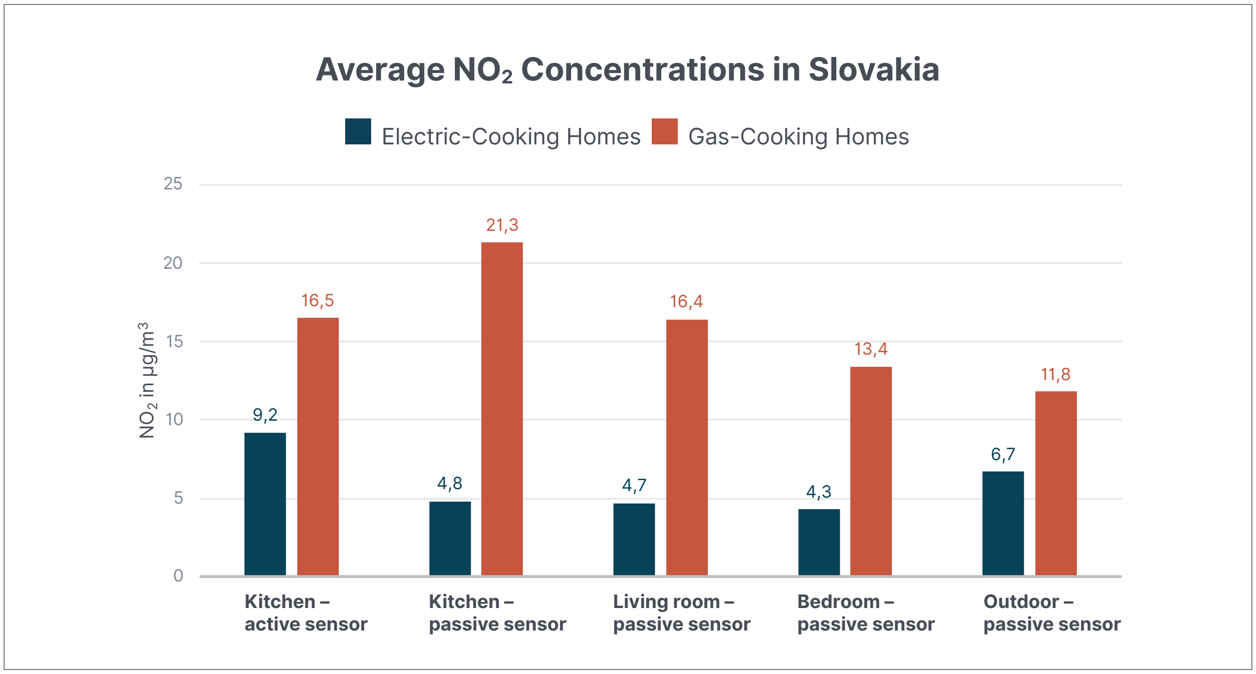
NO_2 levels were significantly higher in the majority of gas-cooking households. Kitchen NO_2 levels were higher indoors compared to outdoors in both electric- and gas-cooking homes.

Exceedances of WHO and EU Pollutant Limits

Only gas-cooking households exceeded the WHO hourly guideline for NO_2 limits, as well as the EU's hourly NO_2 limits.

Although CO levels were higher in gas-cooking households, no exceedances were identified. No significant $PM_{2.5}$ pollutant level differences were identified between gas- and electric-cooking households. Both gas- and electric-cooking households exceeded WHO daily guideline values, due to outdoor infiltration of $PM_{2.5}$, the type of food cooked, and the cooking method used, as well as a lack of adequate ventilation to capture pollutants.

FIGURE 30. AVERAGE NO_2 CONCENTRATIONS IN SLOVAKIA IN THE KITCHEN, LIVING ROOM, BEDROOM, AND OUTDOORS FOR HOMES WITH ELECTRIC COMPARED TO GAS COOKING



xiv For full details, see the TNO 2023 Report: Health Effects in Europe from Cooking on Gas — Phase II Field Study

FIGURE 31. MAP OF GAS- AND ELECTRIC-COOKING SLOVAKIAN HOUSEHOLDS, BASED ON SEVERITY OF NO_2 LEVELS

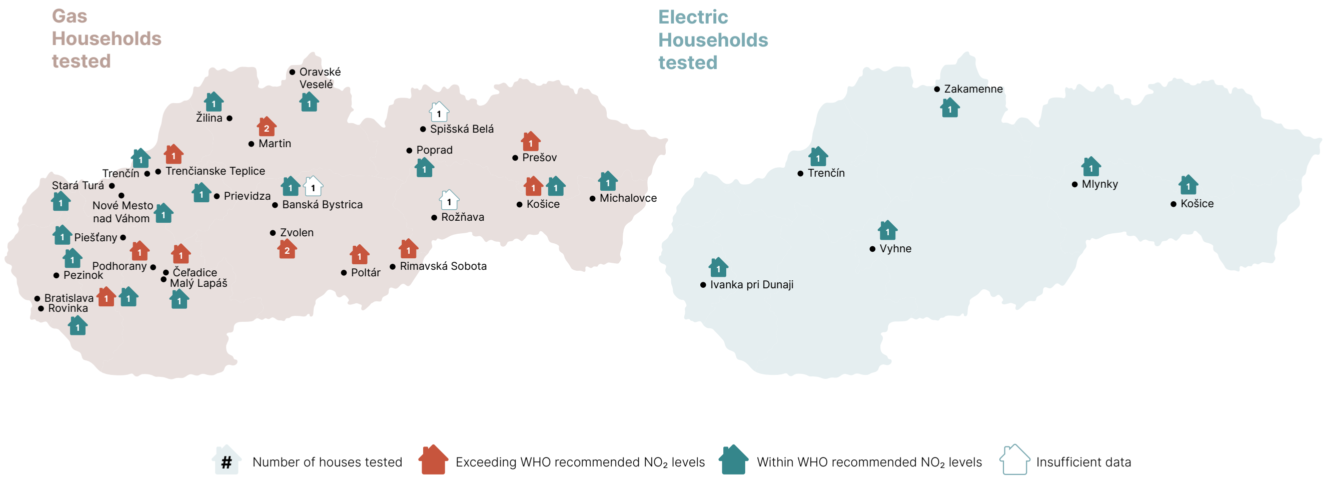
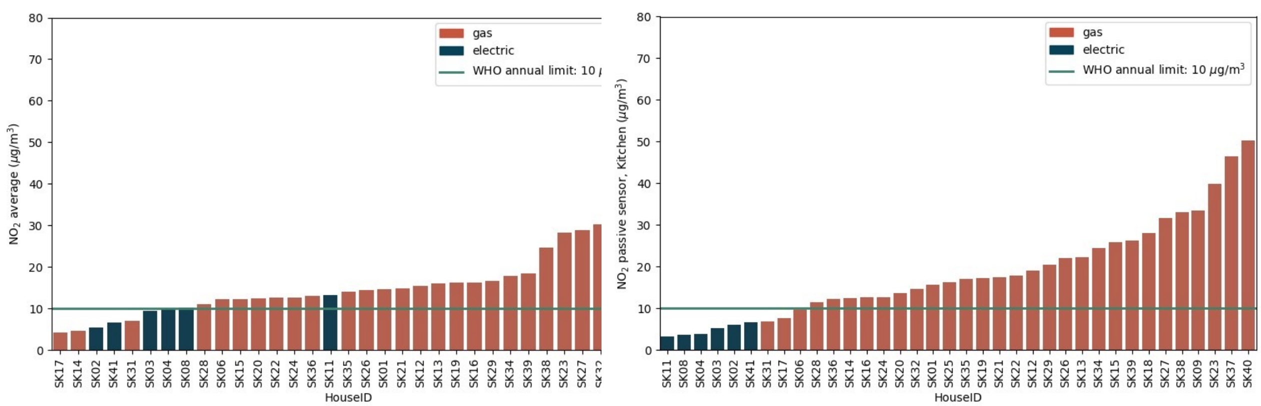


TABLE 14. NO_2 LIMIT EXCEEDANCES FROM GAS- AND ELECTRIC-COOKING HOUSEHOLDS IN SLOVAKIA, BASED ON ACTIVE SENSOR RESULTS

NO_2 STANDARDS	EXCEEDANCES FOR GAS-COOKING HOUSEHOLDS	EXCEEDANCES FOR ELECTRIC-COOKING HOUSEHOLDS
WHO daily guidelines	44%	0%
WHO hourly guidelines	22%	0%
EU hourly limits	15%*	0%

*Extrapolation of 13 days of measurement data to yearly exceedance

FIGURE 32. AVERAGE NO_2 CONCENTRATIONS IN THE KITCHEN PER SLOVAKIAN HOME, BASED ON ACTIVE SENSORS (ON LEFT) AND PASSIVE SENSORS (ON RIGHT), WITH THE WHO ANNUAL LIMIT VALUE OF 10 µG/M³ AS A REFERENCE[64]



64.9%	OF HOUSEHOLDS COOK ON GAS
55,744	CHILDREN WITH CURRENT ASTHMA LINKED TO GAS COOKING

*CLASP and EPHA, 2023

4.6. ROMANIA

Overview of Country Findings[xv]

Field study data was successfully collected from a total of 34 Romanian households:

- 29 with gas hobs, of which 19 homes have gas ovens.
- 5 with electric hobs and ovens. Outdoor NO_2 concentrations for these households were very high during the monitoring period, which is believed to have affected the indoor pollution levels.

Indoor air quality was significantly worse in households that cooked with gas than in those with all electric cooking appliances:

- After correction for outdoor pollution concentrations, NO_2 levels were significantly higher in gas-cooking households' kitchens and living rooms. Over half the gas-cooking households exceeded WHO daily guideline values, with 24% exceeding the WHO hourly guidelines and 19% exceeding EU hourly limits. No electric-cooking households exceeded WHO or EU limits.
- CO levels in gas-cooking households were significantly higher than in electric-cooking households. However, no households exceeded limit levels.
- There was no significant difference in $PM_{2.5}$ concentrations between gas- and electric-cooking households. Both household types exceeded WHO daily guideline values for $PM_{2.5}$.

NO_2 Pollution Concentrations

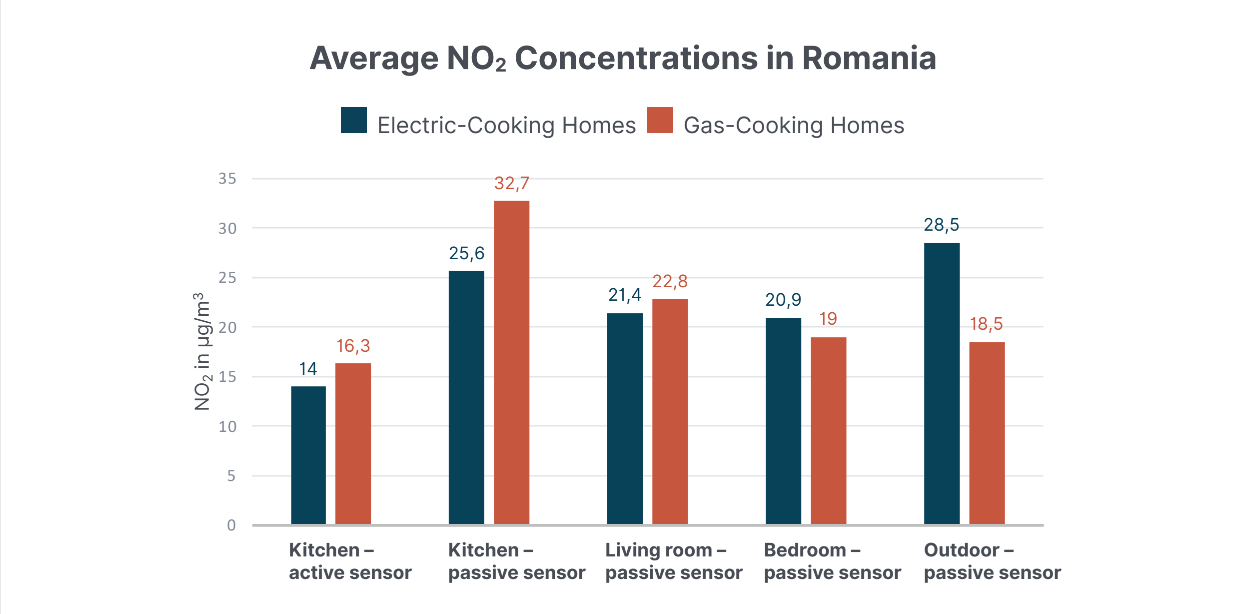
After correction for outdoor pollution concentrations, NO_2 levels were significantly higher in the majority of gas-cooking households. High outdoor pollution levels are assumed to have impacted the indoor pollution levels in those households cooking with electric appliances.

Exceedances of WHO and EU Pollutant Limits

Only gas-cooking households exceeded the WHO daily and hourly guideline NO_2 limits as well as the EU's hourly NO_2 limits.

Although CO levels were higher in gas-cooking households, no exceedances were identified. No significant $PM_{2.5}$ pollutant level differences were identified between gas- and electric-cooking households. Both household types exceeded WHO daily guideline values due to outdoor infiltration of $PM_{2.5}$, the type of food cooked, and the cooking method used, as well as a lack of adequate ventilation to capture pollutants.

FIGURE 33. AVERAGE NO_2 CONCENTRATIONS IN ROMANIA IN THE KITCHEN, LIVING ROOM, BEDROOM, AND OUTDOORS FOR HOMES WITH ELECTRIC COMPARED TO GAS COOKING



xv For full details, see the TNO 2023 Report: Health Effects in Europe from Cooking on Gas — Phase II Field Study

FIGURE 34. AVERAGE CORRECTED NO_2 CONCENTRATIONS, TAKING INTO ACCOUNT HIGHER LEVELS OF OUTDOOR AIR POLLUTION

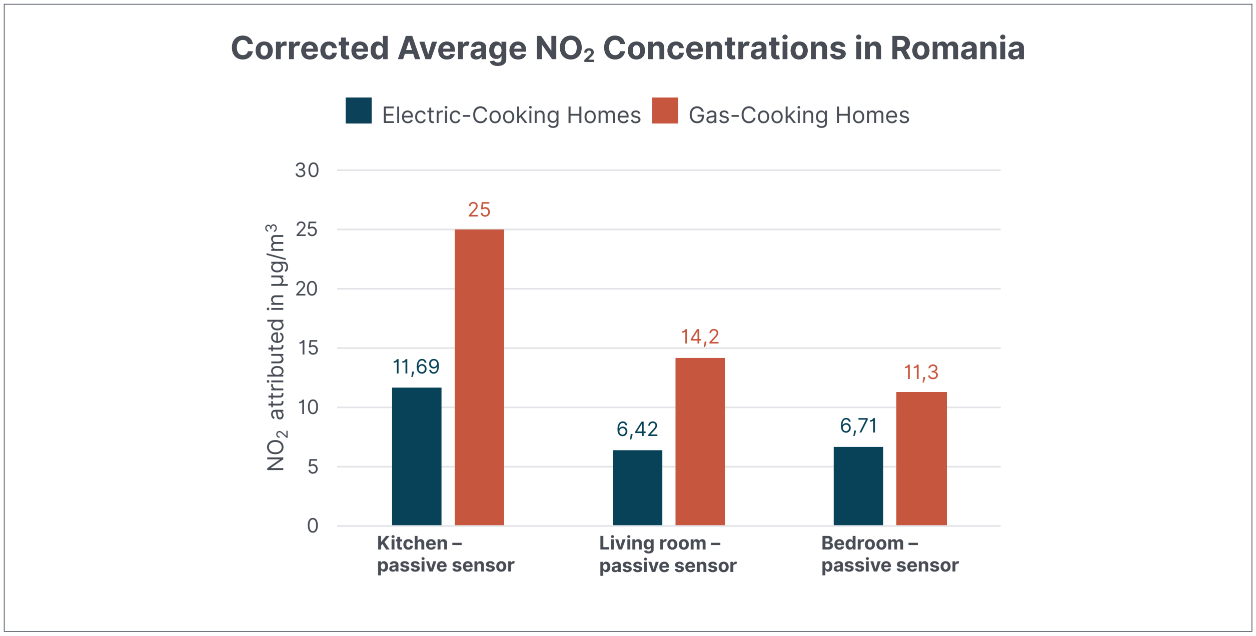


FIGURE 35. MAP OF GAS- AND ELECTRIC-COOKING ROMANIAN HOUSEHOLDS, BASED ON SEVERITY OF NO_2 LEVELS

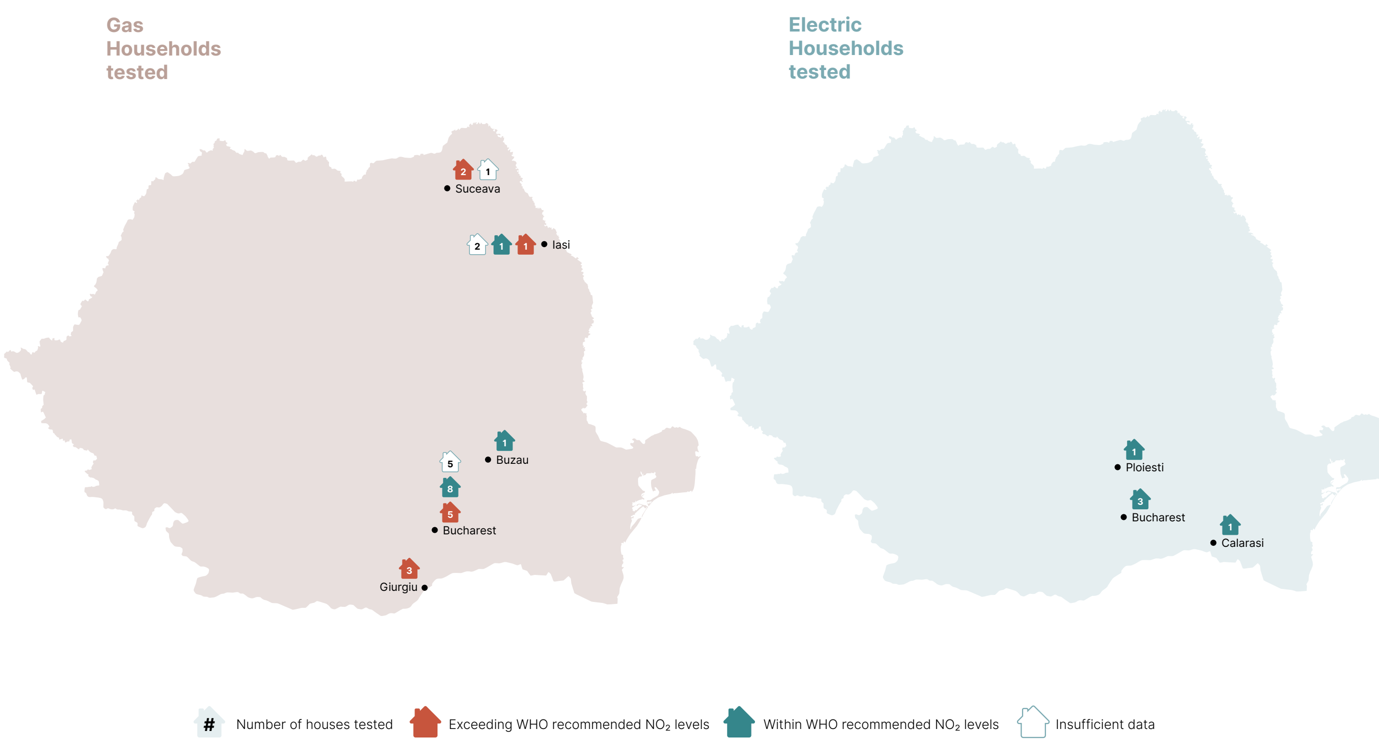
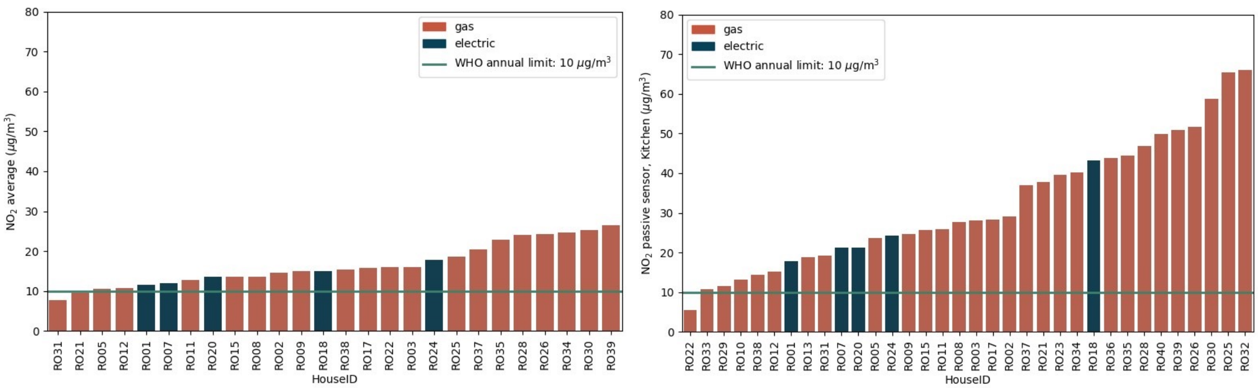


TABLE 15. NO_2 LIMIT EXCEEDANCES FROM GAS- AND ELECTRIC-COOKING HOMES IN ROMANIA

NO_2 STANDARDS	EXCEEDANCES FOR GAS-COOKING HOUSEHOLDS	EXCEEDANCES FOR ELECTRIC-COOKING HOUSEHOLDS
WHO daily guidelines	52%	0%
WHO hourly guidelines	24%	0%
EU hourly limits	19%*	0%

*Extrapolation of 13 days of measurement data to yearly exceedance

FIGURE 36. AVERAGE NO_2 CONCENTRATIONS IN THE KITCHEN PER ROMANIAN HOUSEHOLD, BASED ON ACTIVE SENSORS (ON LEFT) AND PASSIVE SENSORS (ON RIGHT), WITH THE WHO ANNUAL LIMIT VALUE OF 10 µG/M^3 AS A REFERENCE[65]



4.7. UNITED KINGDOM

53.9% OF HOUSEHOLDS COOK ON GAS
557,326 CHILDREN WITH CURRENT ASTHMA LINKED TO GAS COOKING
*CLASP and EPHA, 2023

Overview of Country Findings[xvi]

Field study data was successfully collected from a total of 35 British households:

- 28 with gas hobs. 21 of these households with gas ovens.
- 7 with electric hobs and ovens.

Indoor air quality was significantly worse in households that cooked with gas than in those with all electric cooking appliances:

- NO_2 levels were much higher in gas-cooking households' kitchens and living rooms. Over half the gas-cooking households exceeded WHO daily guideline values, with 25% of gas-cooking households exceeding both the WHO hourly guidelines and the UK/EU hourly limits. No electric-cooking households exceeded WHO or UK/EU limits.
- There was no significant difference in CO levels between gas- and electric-cooking households.
- There was no significant difference in $PM_{2.5}$ concentrations between gas- and electric-cooking households. Both gas- and electric-cooking households exceeded WHO daily guideline values for $PM_{2.5}$.

NO_2 Pollution Concentrations

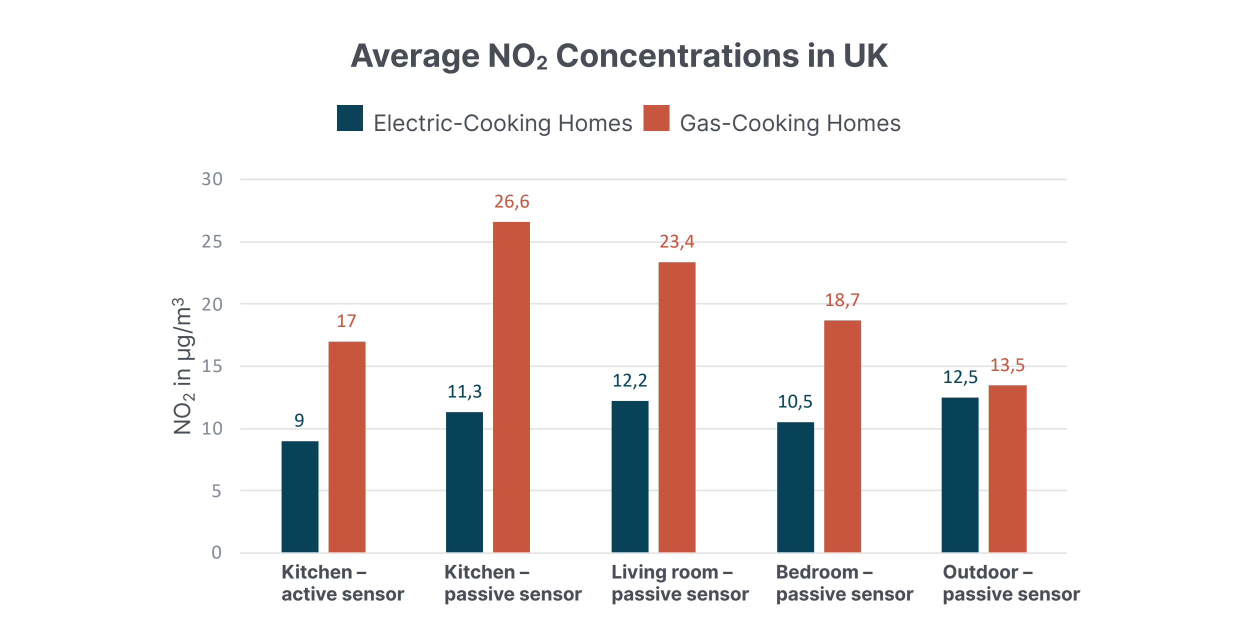
NO_2 levels were significantly higher in the majority of gas-cooking households. NO_2 levels were significantly higher indoors compared to outdoors in gas-cooking homes.

Exceedances of WHO and EU Pollutant Limits

Only gas-cooking households exceeded the WHO hourly guideline NO_2 limits as well as the UK/EU's hourly NO_2 limits.

No significant CO or $PM_{2.5}$ pollutant level differences were identified between gas- and electric-cooking households. Both gas- and electric-cooking households exceeded WHO daily guideline values due to outdoor infiltration of $PM_{2.5}$, the type of food cooked, and the cooking method used, as well as a lack of adequate ventilation to capture pollutants.

FIGURE 37. AVERAGE NO_2 CONCENTRATIONS IN THE KITCHEN, LIVING ROOM, BEDROOM, AND OUTDOORS FOR UK HOMES WITH ELECTRIC COMPARED TO GAS COOKING



xvi For full details, see the TNO 2023 Report: Health Effects in Europe from Cooking on Gas — Phase II Field Study

FIGURE 38. MAP OF GAS- AND ELECTRIC-COOKING UK HOUSEHOLDS, BASED ON SEVERITY OF NO_2 LEVELS

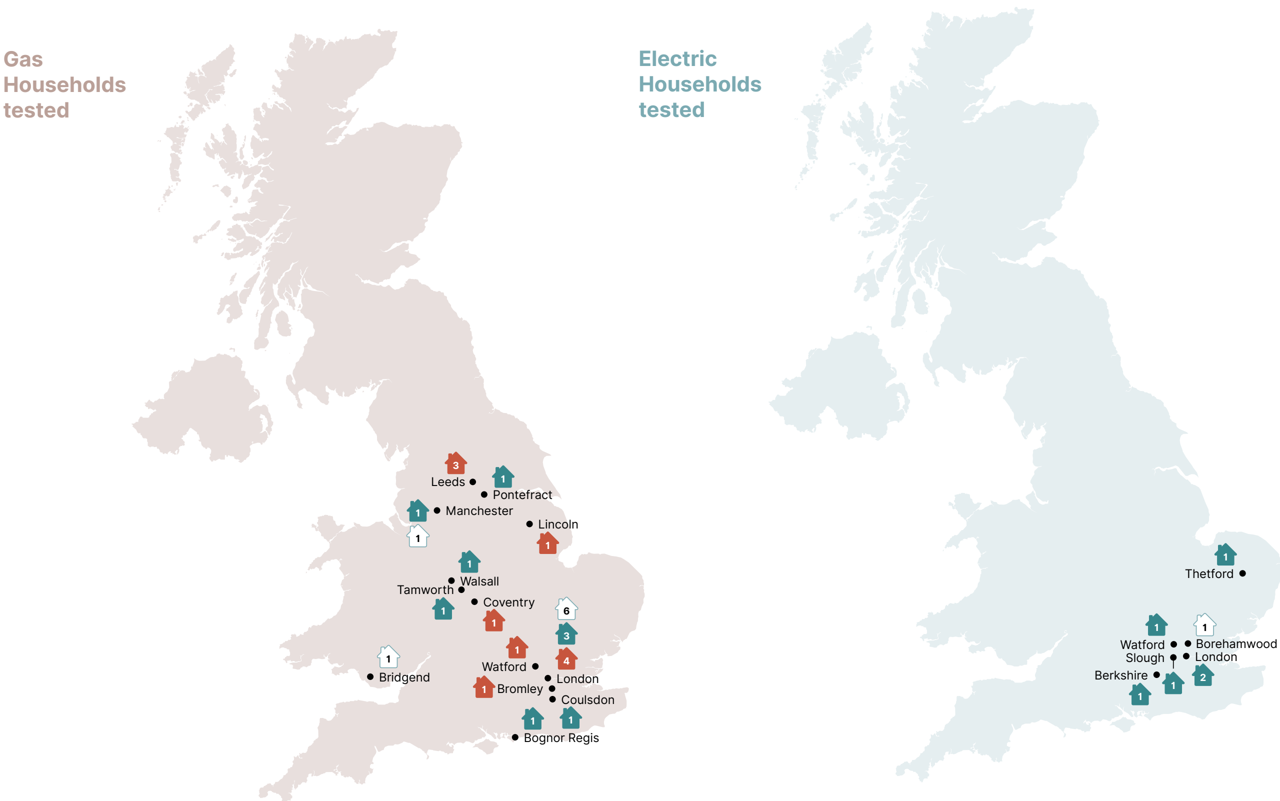
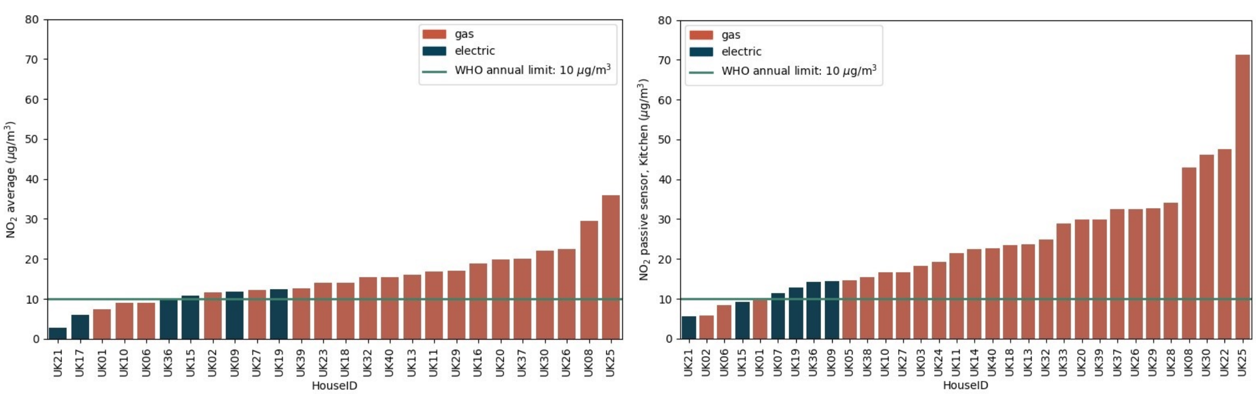


TABLE 16. NO_2 LIMIT EXCEEDANCES FROM GAS- AND ELECTRIC-COOKING HOUSEHOLDS IN THE UNITED KINGDOM

NO_2 STANDARDS	EXCEEDANCES FOR GAS-COOKING HOMES	EXCEEDANCES FOR ELECTRIC-COOKING HOMES
WHO daily guidelines	55%	0%
WHO hourly guidelines	25%	0%
UK hourly limits	25%*	0%

*Extrapolation of 13 days of measurement data to yearly exceedance

FIGURE 39. AVERAGE NO_2 CONCENTRATIONS IN THE KITCHEN PER UK HOUSEHOLD, BASED ON ACTIVE SENSORS (ON LEFT) AND PASSIVE SENSORS (ON RIGHT), WITH THE WHO ANNUAL LIMIT VALUE OF 10 µG/M^3 AS A REFERENCE[66]



5. Key Takeaways

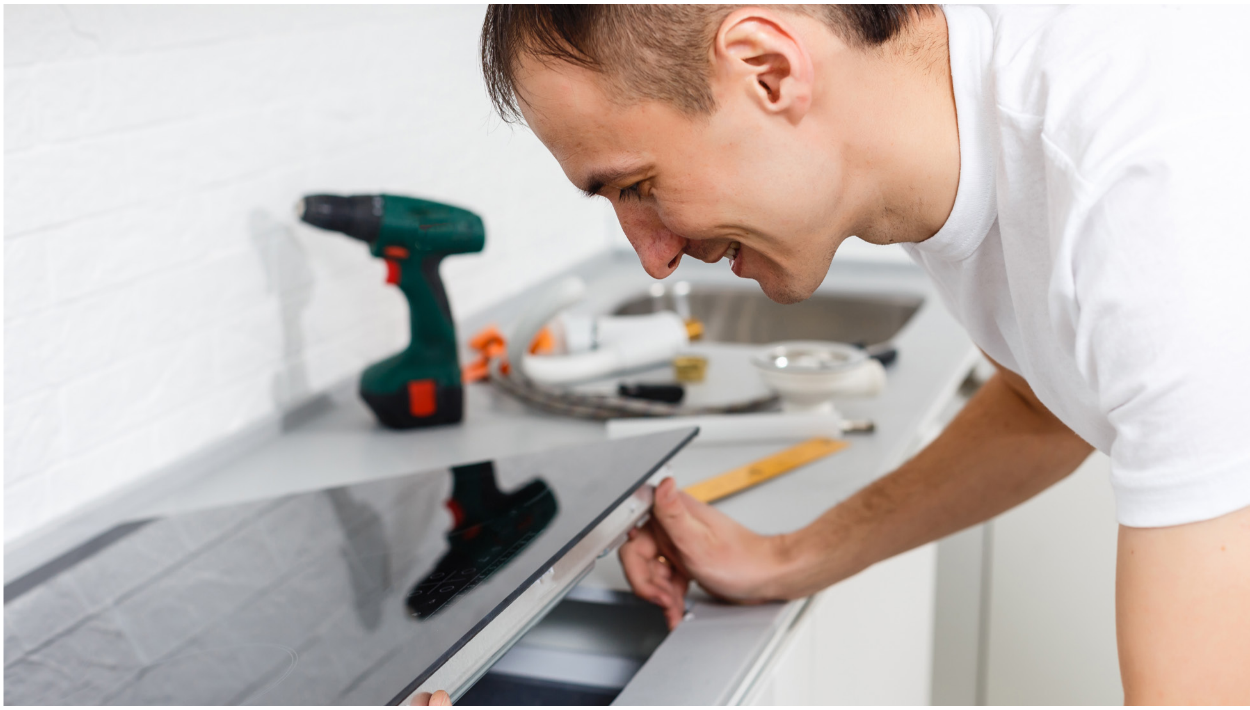
- **Gas cooking is a significant source of indoor air pollution in Europe.** The measurement results from this study demonstrate just how severe the levels of NO_2 can be. Homes with gas hobs experienced much higher concentrations of NO_2 than those with electric hobs, even when outdoor pollution concentrations were higher.

- **The health risks of cooking with gas raise concerns about equity.** The study found that cooking with gas for longer periods, especially using gas ovens, which are typically found in lower-income housing or on the second-hand market, equated to higher levels of NO_2.

- **Gas-cooking households regularly exceeded the WHO guidelines and the EU/UK air quality standards for NO_2.** By comparison, only a minority of electric-cooking households exceeded the WHO daily guideline limits in two countries where levels of outdoor air pollution were so high that it likely infiltrated the kitchen. People who cook with gas appliances are, therefore, at higher risk of developing asthma and other respiratory diseases. For children, even small increases in short-term exposure can increase the risk of asthma attacks.[67] Unfortunately, most people are unaware of the health risks associated with gas cooking due to the invisible nature of the pollution. However, a consumer survey conducted by CLASP revealed that the majority of respondents (58% to 74%) would consider getting rid of their gas cooking appliances if they knew there was an associated health risk.[68] **More communication is therefore needed to raise awareness of the potential health harms of cooking with gas.**

- Government intervention is currently mostly focused on outdoor air pollution. According to the European Environmental Agency, preliminary data collected by outdoor pollution monitoring stations in 2022 show that the EU and UK hourly NO_2 limit values of 200 $\mu g/m^3$ were not exceeded for more than 18 hours, which is the legal annual limit for ambient air pollution.[69] By comparison, in all seven countries monitored in this study, several gas-cooking households exceeded these hourly limits to such a degree that it is highly likely they would exceed the allowable 18 hours a year. This indicates that **indoor air pollution is a serious health hazard that requires similar attention to ambient air quality.**

- However, **there is currently no legally binding standard that can be used to address the health hazards of gas cooking in the EU or the UK.** The WHO guidelines are non-binding, while the EU and UK air quality limit values are intended for outdoors only.



Defining "Appropriate" NO_2 Pollution Limits

Without adequate, binding European regulation, it is not possible to determine whether indoor air pollution levels are "harmful" or "unacceptable."

The European Ambient Air Quality Directives[70] and UK Air Quality Standards Regulations 2010[71] set maximum outdoor pollution concentration limits for NO_2 and other pollutants, but these are not applicable to indoor settings. The World Health Organisation 2021 Air Quality Guidelines,[72] which apply to both indoor and outdoor air pollution, reflect the latest scientific evidence but offer non-binding pollution limits.

When considering pollution levels that are allowed directly from the source, the Gas Appliances Regulation,[73,74] which applies in both the EU and UK, specifies that gas-fuelled appliances "shall be so designed and constructed that, when normally used, the combustion process is stable and combustion products do not contain unacceptable concentrations of substances harmful to health."

However, there is no definition of "unacceptable concentrations." Clearly defined and mandatory limits must be set to manage indoor air quality. Ideally, product-specific regulations such as the Gas Appliances Regulation or the Ecodesign and Energy Labelling policies will set limits or, at a minimum, require information to be shared with prospective buyers about pollutants emitted directly by the appliance.

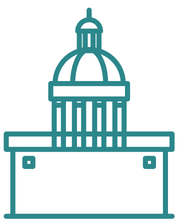
- **$PM_{2.5}$ concentrations were exceptionally high in nearly all households in all countries but are due to the act of cooking food, rather than the cooking appliance itself.** Concentrations may also be higher due to outdoor $PM_{2.5}$ levels infiltrating indoors. Both electric- and gas-cooking homes exceeded the WHO guidelines for $PM_{2.5}$, which highlights a serious concern around the effectiveness of ventilation, particularly for cooker hoods. This pollutant is recognised as a serious health hazard, yet we breathe in harmful levels of $PM_{2.5}$ while we cook.

- **Cooker hoods were found to be ineffective at reducing pollution concentrations compared to not using a cooker hood at all**. Externally ducted cooker hoods are expected to help mitigate levels of air pollution from cooking, but the study results showed little impact from this ventilation technology. Recirculation hoods were confirmed as having the least effect on indoor air pollution. In the case of externally ducted cooker hoods, it is possible that households reported having the wrong hood type, did not use it while cooking, had not cleaned or changed the filter, or used it at insufficient power levels for effective operation. The pollutant-capture efficiency of the cooker hoods may also be low. Because of the uncertainty around these variables, relying on ventilation alone is an unreliable solution to eliminating the health harms of gas cooking. Research shows that serious behaviour changes are needed to make sure cooker hoods are used correctly (when used at all).[75,76] The technology itself also needs improvement to ensure that hoods run continuously while food is cooking, extract sufficient pollutants from indoor air, and operate quietly.[77] **Ecodesign requirements and Energy Labelling for cooker hoods can help achieve these changes by requiring better pollutant-capture efficiency, as well as by communicating the impact on indoor air pollution on the Energy Label.**

- **Additional research is surfacing that will help facilitate the transition to electric cooking.** CLASP and other organisations have been publishing studies and analyses that put forward the case for greater investment in and use of electric cooking technologies. To learn more about the case for transitioning to electric cooking, visit www.clasp.ngo/cook-cleaner-europe.

6. Recommendations and Conclusion

Based on the findings of this study, work is needed to reduce high levels of indoor air pollution examined in gas-cooking kitchens, which will help alleviate adverse health impacts. Awareness-raising is key to ensuring households have adequate ventilation installed in their homes and that they use it regularly and correctly. However, transitioning to cleaner electric cooking appliances is the most impactful, and likely quickest, solution to eliminating a significant source of indoor air pollution.



Government — Facilitate the transition to cleaner electric cooking

- **Reduce air pollution caused by gas cooking appliances:** Set Ecodesign standards to limit the air pollution emitted by gas cooking appliances. Require pollutant-capture efficiency and automated ventilation in Ecodesign requirements for cooker hoods. Define appropriate limits for NO_2 levels and other pollutants in the Gas Appliances Regulation. Establish indoor NO_2 air quality requirements that reflect health-based exposure levels.

- **Communicate the health risks of gas cooking:** Include air pollution risks on a new comparative Energy Label for hobs. Highlight pollutant-capture efficiency on the Energy Label for cooker hoods. Support campaigns on mitigating indoor air pollution.

- **Accelerate the transition to cleaner electric cooking:** Require induction (the most efficient hob type) and other electric technologies to be installed in new construction and social housing. Subsidise the purchase and installation of new induction hobs. Act on commitments to reduce electricity tariffs, making renewable energy more affordable than gas. Launch retrofit schemes, primarily focused on social and low-income housing. Couple incentives for the purchase and installation of induction stoves with incentives for solar photovoltaic (PV) systems.

Industry — Remove health risks from gas cooking appliances and champion the transition to electric cooking

- **Invest in cleaner, healthier, and more sustainable technologies:** Retailers and manufacturers should follow the example of industry leaders such as IKEA Netherlands[78] by committing to no longer make or sell gas hobs and ovens. Construction companies should commit to only installing induction cooking technologies. Manufacturers should invest in developing efficient and effective automated cooker hoods with strong pollutant-capture efficiency.

- **Establish trade-in schemes to replace less efficient and polluting gas hobs with cleaner and more efficient induction hobs:** Retailers can launch incentives to encourage the take up of cleaner induction cooking, motivating individuals to replace their gas cooking appliances.

- **Communicate risks of gas cooking technology:** Manufacturers should test for and report on pollutants emitted by gas appliances on a new Energy Label. They should also offer mitigation strategies to limit exposure to those pollutants and advise customers on the health and environmental benefits of electric cooking, as well as promote the technology over gas equipment.

Civil Society, Healthcare (Including Doctors and Paediatricians, and Academia) — Raise awareness and engage all stakeholders in the transition to cleaner and healthier cooking

- **Increase and improve indoor air quality research:** Continue running field studies and health-focused research projects. Collect more insights on CO in the home, as well as health risks and associated costs due to indoor air pollution.

- **Help educate stakeholders and run awareness campaigns:** Develop educational materials and conduct awareness-raising on health impacts associated with gas cooking and mechanisms to cook cleaner. Advise patients on the risks of indoor air quality and sources of indoor air pollution. Support policies calling for cleaner cooking.

Individuals and Households — Limit exposure to indoor air pollution from cooking and support the transition to electric cooking

- **Minimise exposure to gas cooking emissions:** Minimise gas cooking by using plug-in appliances such as electric kettles, fryers, and plug-in induction hobs. Ask retailers questions about gas-hob pollution and cooker-hood pollutant-capture efficiency.

- **Improve ventilation if gas cooking is the only option:** Use cooker hoods while cooking and for at least ten minutes after. Clean filters regularly to ensure the exhaust capacity is not blocked by grease and grime. Use back burners that are closest to the cooker hood. If possible, vent cooker hoods outdoors so fumes are directed out of the kitchen. If there is no cooker hood that vents outdoors, open windows during and shortly after cooking.

- **Replace gas cooking equipment:** Replace gas cooking technologies with cleaner, energy-efficient electric alternatives whenever possible. Support politicians and manufacturers who are leading on cooking electrification.

- **Educate yourself on electrification options and identify incentives to support the cost-effective electrification of your household:** for example, coupling the installation of induction stoves with solar PV panels and heat pumps.

- **If you are a parent, call for lessons on indoor air quality in schools** and work with your family to make an electrification plan for your household.

CONCLUSION

The field study results confirm that gas cooking is hazardous to our health, with NO_2 pollution levels regularly exceeding standards advised by the WHO as well as mandatory pollution limits for outdoor air. Gas cooking appliances increase pollution in our homes to levels that can trigger and exacerbate asthma attacks and other respiratory conditions, particularly for children. This invisible health risk has been swept under the rug, while gas hobs have long been promoted as clean, efficient, and culinarily superior.

Ventilation is often pushed as the answer to any concerns over gas cooking appliances. However, it is clear from this study that ventilation alone will not suffice to cut down on NO_2 and $PM_{2.5}$, amongst other pollutants. Improvements to ventilation efficiency, as well as individual behaviour changes to use ventilation properly, are needed to help mitigate the polluting emissions from gas cooking.

A quicker and more effective solution, coupled with ventilation improvements, is to eliminate pollution directly from the source. Governments have a responsibility to protect public health. They must take action to accelerate and facilitate a transition to cleaner and healthier electric cooking. Industry can reap the benefits of this transition by investing in new and innovative technologies, building up new skills, and helping bring down the price of induction cooking so that this clean, efficient, high-quality technology is available to all.

Making the switch from gas to electric cooking will improve indoor air quality, protecting the health of millions of people across Europe.

ABOUT CLASP

Efficient Appliances for People & the Planet

CLASP focuses on appliance & equipment energy performance and quality, to mitigate and adapt to climate change and expand access to clean energy. CLASP has worked in more than 100 countries since its inception in 1999. CLASP is headquartered in Washington, DC, with teams in Europe, Kenya, India, China, and Indonesia. CLASP is committed to a culture of diversity, transparency, collaboration, and impactful work. To know more about us, please visit our website.

CLASP programmes are designed to maximise impacts by targeting high emitters, raising the bar through ground-breaking policies, and advancing technologies to meet sustainable development aspirations around the world.

https://www.clasp.ngo/

ENDNOTES

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