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The Public Health and Environmental Impacts of Cooking with Gas

Cooking with gas produces indoor air pollution which negatively impacts our health and environment. UK policy measures and interventions are required to protect public health and to achieve national net-zero and energy security targets.

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Executive Summary

While gas hobs and ovens release pollutants that are harmful to human health and the environment, electric cooking appliances offer a cleaner, healthier, and environmentally-friendly alternative. This report synthesises old and new research on the health risks of cooking with gas, quantifies the societal cost, and provides actionable solutions to mitigate and remove indoor air pollution from gas cooking, with recommendations to help the UK transition to cleaner, electric alternatives.

Cooking with gas releases hazardous air pollutants into our homes. Over 36 million people in the UK cook with gas appliances. They may be exposed to levels of indoor air pollution that would violate UK outdoor air pollution regulations. When in use, gas hobs and ovens emit carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen dioxide (NO_2) which can linger indoors after use. Research indicates an association between NO_2 exposure and the development of asthma in children. Gas cooking appliances also leak unburned methane, a potent greenhouse gas.

Indoor air pollution from gas cooking harms children and adults. The Government recognises air pollution as the biggest environmental health risk in the UK. There is growing evidence linking combustion-related air pollution with adverse health effects on brain development in young children. For adults, pollutants from gas cooking can lead to negative impacts on the brain, respiratory, and nervous systems.

Gas is not 'natural' or 'clean.' The gas industry has invested heavily in marketing to position gas as a safe and preferred cooking option. In part because of these efforts, people are generally unaware of the health and environmental risks posed by gas cooking, despite these risks being well documented through decades of research.

Cooking with gas is costly. Many people believe cooking with gas is a cheaper option, however, our research shows the opposite is true when all associated costs are considered. Indoor air pollution from gas cooking is estimated to cost the UK around **£1.4 billion** annually in healthcare costs, lost earnings and productivity, and disability adjusted life years (DALY). Clean electric hobs and ovens are already available at similar or lower cost. Government incentives designed to promote electric hobs would yield 6 to 18 times return on investment when considering healthcare costs.

Ventilation helps, but is not enough. Cooker hoods aren't always turned on during cooker use, can be energy-intensive and noisy to run, and must be properly maintained and externally vented to effectively reduce combustion pollution. Recirculating cooker hoods – common in apartments – are aimed at odour removal and hardly remove any NO_2, a primary combustion pollutant of concern.

Gas cooking undermines UK targets to become a climate-neutral economy by 2050. As a fossil fuel, burning gas when cooking emits both CO_2 and unburned methane, two potent greenhouse gases. And even when switched off, gas cooking appliances have been found to leak significant amounts of methane – further contributing to the climate impact of these appliances.

Building efficiency upgrades must include electric cookers. In lockstep with the UK's efforts to insulate and improve the efficiency of homes and buildings, cooking should be upgraded from gas to electric in order to improve indoor air quality. Without changing the cooking fuel, indoor air pollution from gas cooking could get worse in sealed buildings with less fresh air infiltration from outside.

Hydrogen is not a viable cooking fuel. Testing performed for this study found that mixing hydrogen with gas can increase levels of air pollutants harmful to human health. Mixing hydrogen with methane changes the chemistry of the fuel, which can affect burner performance and decrease efficiency. Gas cookers would likely need to be adapted or entirely replaced to function properly with hydrogen fuel.

The UK Government has set ambitious decarbonisation and air quality goals, but is failing to act. Despite the health risks of gas cooking and the UK Government's decarbonisation goals, UK policy does not currently support the transition to electric cooking. Boilers in the UK have NO_2 emission limits, and incentives are available to upgrade to more efficient and climate-friendly heat pumps. No such policies exist for cooking appliances, even though there is a clear need to mitigate the health and environmental risks of cooking with gas.

Recommendations

- **UK Government** should adopt laws protecting consumers by setting limits on pollution emissions from gas cooking appliances and ensuring hobs and ovens are efficient. The Government should provide a new Energy Label to enable people to directly compare the efficiency and emissions of gas and electric cooking appliances. The Government should also accelerate the transition to cleaner electric cooking, by coupling incentives for heating and home upgrades with incentives for electric hobs and ovens. All homes, but especially new builds, should be efficient, healthy, and powered by electricity.
- **Civil Society and Academia** should conduct more research on the impacts of cooking fuels, increase public awareness about the link between gas cooking and health, and call for policy interventions from the Government.
- **Industry** should invest in cleaner, healthier and sustainable technologies, focusing on bringing down the costs of and promoting induction cooking.
- **Health Professionals** should work through the National Health Service, Public Health England and other health organisations to increase public awareness about the link between gas cooking and health, and support appropriate actions to mitigate harm.
- **Individuals** should protect their health by making the switch from gas to electric cooking when and where possible, including using small plug-in appliances if they cannot upgrade to electric hobs and ovens. People must ensure they properly ventilate their kitchens when cooking, preferably with a functioning range hood that is vented to the outside, by mechanical ventilation, or by opening windows while cooking. Households should also install a low-concentration carbon monoxide detector in the kitchen and get an annual gas safety check on gas hobs and ovens. For more information on actions individuals can take, see page 32.

1 Introduction

Across the United Kingdom (UK), tens of millions of people sit down to dinner cooked with gas, unaware of the invisible air pollution coming from their gas appliances. Decades of research have established a correlation between emissions from these appliances and detrimental impacts on health, including asthma and wheezing – particularly for children. The UK Government has an opportunity and responsibility to protect public health and the environment by facilitating and accelerating the transition to clean, electric cooking.

Air pollution has been recognised by the Government as the biggest environmental health risk in the UK,[1] while the World Health Organisation included it on the list of ten major threats to global health.[2] Exposure to high levels of air pollution is known to cause strokes, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma.[3] The economic and welfare burden of air pollution is significant, including lower life expectancies, illnesses, greater healthcare expenditure, and lower productivity. Emerging evidence shows that even low levels of air pollution are associated with negative health outcomes, including mortality.[4] While the health risks of air pollution have been widely explored and publicised, the relationship between cooking on gas and indoor air quality are yet to receive the same level of public awareness.

FIGURE 1: SHARE OF HOUSEHOLDS IN EUROPEAN COUNTRIES COOKING ON GAS IN %[5]

CLASP partnered with the Netherlands Organisation for Applied Scientific Research (TNO) to conduct research on the health and environmental impacts of cooking with gas, including ovens, hobs, and cookers –collectively referred to as "gas cookers" or "gas cooking appliances" throughout this report. We found that over 50% of households in the UK cook on gas (Figure 1), releasing toxic pollutants - including nitrogen dioxide (NO_2), carbon monoxide (CO) and other emissions - into these homes. **Gas cookers may be exposing an estimated 36 million people in the UK to levels of indoor air pollution that regularly violate the UK's Air Quality Standards Regulations 2010[6] and WHO Air Quality Guidelines 2021.**[7] The proportion of UK households cooking on gas is higher than the EU (around 30%).[8]

The UK Government is currently conducting a review of the Ecodesign[9] and Energy Labelling[10] requirements for domestic cooking appliances,[i] presenting a key opportunity to address health and environmental impacts caused by gas cookers. A similar review is ongoing in the European Union. For this reason, CLASP, the European Public Health Alliance (EPHA) and TNO conducted a study to understand the health, environmental, and economic impacts of cooking with gas compared to electric cooking, and to identify both practical and policy solutions to remove the risk. Our research included:

- A review of existing literature on pollutants and health impacts from gas cooking;
- Laboratory testing on both gas and electric hobs, to quantify the differences in pollutant emissions, and how they change as hydrogen is blended into the fuel mix;
- An indoor air quality simulation of gas and electric cooking to determine if and how often the UK's Air Quality Standards Regulation, the EU's Ambient Air Quality Directive and WHO's Air Quality Guidelines are exceeded;
- A review of the testing standards associated with gas and electric cooking to determine gaps and opportunities in cooking appliance testing requirements, and to ensure people can make easy efficiency and emissions performance comparisons;
- A market assessment and cost of cooking analysis and a new assessment of the economic impacts of gas cooking associated to health issues; and
- A review of policies and efforts around the UK and EU to determine what is being done to address the health, environmental, and economic impacts of gas cooking.

The relevant UK findings from the above research tasks are summarised in this report. **The analysis determined that there is a significant but solvable public health and environmental problem created by the emissions from cooking with gas, and that the UK Government has a policy opportunity to prioritise and protect public health and environmental objectives.**

i. The Ecodesign Directive and Energy Labelling Framework Regulation are European legislation intended to improve the energy and environmental performance of residential, commercial, and industrial products, such as kitchen appliances, lighting, and motors.

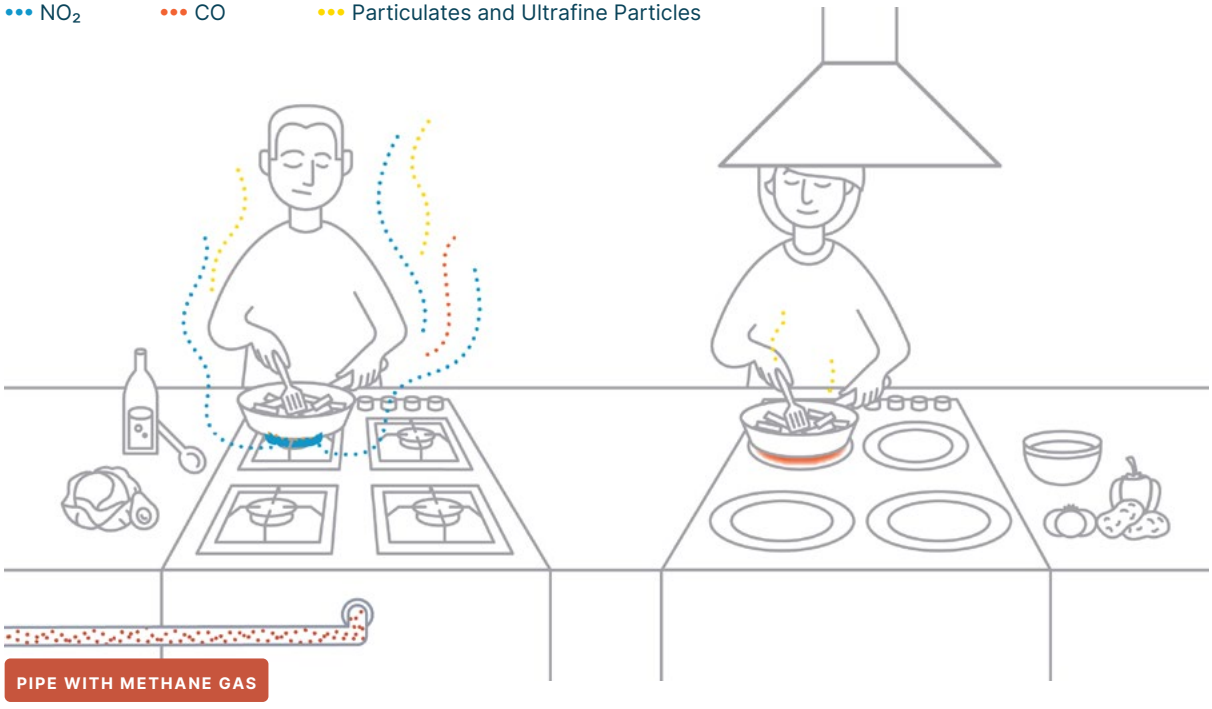
2 Cooking with Gas Releases Hazardous Air Pollutants into Our Homes

Gas cooking appliances may be exposing millions in the UK to levels of indoor air pollution that violate outdoor air pollution regulations. Sources of outdoor air pollution — such as transport vehicles and industrial factories — are easily identifiable, present in societal discourse about climate and health. Knowledge on the impacts of indoor pollution exposures are critically important as well, with people spending approximatively 90% of their time indoors.[11] Gas cookers and heating are a main source of indoor air pollution for houses that utilise these gas powered technologies,[12] risking detrimental health impacts to those exposed. Indeed, World Health Organisation (WHO) Europe recognises gas appliances as one of the major factors in people's overall exposure to nitrogen dioxide (NO_2).[13]

NO_2 is one of the major health-damaging air pollutants,[14] resulting from the interaction of the gas flame and naturally occurring nitrogen in the air.[15] The European Environment Agency estimates that 94% of the European urban population is exposed to ambient NO_2 concentrations above the WHO's 2021 Air Quality Guidelines.[16]

There is a documented association between levels of exposure to NO_2 — a primary pollutant from gas cooking — and asthma in children.

FIGURE 2: SWITCHING TO ELECTRIC COOKING RIDS HOMES OF UNHEALTHY LEVELS OF INDOOR AIR POLLUTION CREATED FROM BURNING A FOSSIL FUEL IN THE KITCHEN.



Indoor air pollution levels should be lower than outdoors because of the NO_2 deposition rate and blocking of NO_2 ingress by the building envelope.[17] However, indoor levels may in fact exceed outdoor levels,[18] when a major source of NO_2 emissions — like a gas hob — is used.

In households that use gas cookers and have ineffective ventilation, indoor air pollution levels can be so high as to exceed the outdoor standards set by the UK's Air Quality Standards Regulations as well as the 2021 WHO Air Quality Guidelines.[19] The WHO's Guidelines are established by an international group of independent health experts and serve as a global guideline for public health based on the best scientific evidence. The guidelines apply to both indoor and outdoor environments. Although the WHO Guidelines are not legally binding, they do inform legislation such as the UK Air Quality Standards Regulations.[i]

The key pollutants generated by gas cooking appliances are outlined and explained in the table below.

TABLE 1: POLLUTANTS FROM COOKING WITH GAS

POLLUTANT	HEALTH RISKS & CLIMATE IMPACTS
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.[20]
Carbon monoxide (CO)	CO is an odourless, colourless, dangerous air pollutant. Breathing low levels of CO can cause headache, nausea, dizziness and confusion. At high levels, CO poisoning can cause nausea, anxiety or depression, vomiting, unconsciousness, and death.[21] Long-term exposure to low levels of CO may cause permanent mental or physical problems, and can increase chances of dementia, and possibly, Parkinsonism.[22]
Nitrogen monoxide (NO)	NO is a primary gas associated with combustion and is a precursor to NO_2. NO is not considered harmful at the concentrations generated when cooking on gas, so there are no limit values formulated for the general public. However, ozone can easily convert NO to NO_2, so NO might be of importance where ozone generating equipment is present, such as plasma or ionizing air filters in range hoods.[23]
Methane (CH_4)	CH_4 in low concentrations is not harmful to human health, but it is a potent greenhouse gas. In the US, the national emissions of CH_4 from gas appliances were calculated to have a climate impact comparable to the annual CO_2 emissions of 500,000 cars.[24] CH_4 contributes to the formation of ground-level ozone, which is associated with premature mortality.[25]
Ultra-Fine Particles (UFP)	Ultra-fine particles are particulates with a diameter less than or equal to 100 nanometres (or 0.1 micrometres). UFPs are so small that they enter the body through the respiratory system and move to all organs. Compared to $PM_{2.5}$, they cause increased pulmonary inflammation and remain in the lungs for longer.[26]
Particulate Matter ($PM_{2.5}$)	$PM_{2.5}$ is the mass fraction of particles with a diameter up to 2.5 micrometres. They are still small enough to penetrate deep into the lungs, and the smaller particles may enter the bloodstream. Particle pollution has harmful effects on health, ranging from decreased lung function to heart attacks. Short-term increases in particle pollution can increase mortality in infants, cardiovascular disease, COPD and asthma attacks, and hospital admissions.[27]

i. The 2010 UK Air Quality Standards Regulations are based on and the same as the EU Ambient Air Quality Directives.

Over 36 million people living in the UK (53.9% of the population) are regularly exposed to indoor air pollution caused by cooking on gas. As part of our study, TNO ran various computer simulations to assess how emissions from cooking changed in different scenarios, considering kitchens typical of the UK and Southern, Eastern and Western Europe.[28]

The simulation study revealed that across the four typical European households, cooking on gas resulted in levels of indoor air pollution that exceeded the WHO daily NO_2 guideline value of 25 µg/m³ in nearly all scenarios. The current UK and EU outdoor hourly limit value of 200 µg/m³ NO_2 was also exceeded indoors multiple times each week. The only exception was for a large kitchen with mechanical ventilation[ii] or when using a range hood that vents to the outside.

The UK kitchen was modelled in a city setting, with high ambient NO_2 concentrations (50 µg/m³) due to traffic and other pollutant sources. The UK kitchen was assumed to be closed and relatively small (a volume of 30 cubic metres), with relatively low levels of ventilation and air infiltration.

The typical kitchen simulations were based on average cooking frequency and duration, paired with building and ventilation conditions, with and without use of cooker hoods venting to the outside. Table 2 presents the simulated indoor air pollution (NO_2) levels for kitchens using gas cookers typically found in the UK, as well as rural areas of Southern and Eastern Europe and an urban area in Western Europe. These simulation findings are in line with previous research[29] — for example a different modelling study that found homes using gas cooking appliances daily regularly experienced average NO_2 exposures of over 280 µg/m³ for at least one hour every day.

The kitchens are projected to experience air pollution levels that would exceed the World Health Organisation's 2021 Air Quality Guidelines and the UK's Air Quality Standards Regulations 2010 — multiple times per week, every week. For example, in the UK kitchen model, the Air Quality Standards Regulations hourly limit of 200 µg/m³ will be exceeded fifteen times per week. The last column on the right shows that when the household converts to electric cooking, it dramatically reduces indoor air pollution in the home – with NO_2 concentrations dropping to levels that do not exceed pollution limits (except in the UK and urban Western Europe, due to the modelling assumption of high levels of outdoor air pollution in urban areas).

In 2023, CLASP is gathering real time data on air quality in over 250 kitchens across Europe, including 40 households in the UK, to confirm these modelled results. Data are expected to be published in late 2023.

Homes can achieve the largest reduction in indoor concentrations of NO_2 by transitioning from gas cooking to electric. Switching to electric cooking eliminates the pollution produced by burning gas – including NO2, CO and the ultrafine particles produced from burning gas. In addition, methane leaks from the appliance, both when on and off, would be eliminated.[iii]

Depending on where the gas was extracted from the ground, there can also be concentrations of other hazardous substances such as benzene, a carcinogenic chemical that can lead to serious blood defects including cancer. A recent study of Californian homes found that benzene concentrations from gas cooking appliances may result in hazardous indoor levels of benzene under certain conditions.[30] In Europe, a 2013 study[31] found benzene in methane gas in levels equal to and higher than those documented in California, raising the concern that this carcinogenic molecule may also be present at dangerous levels in kitchens across Europe.[iv]

Kitchens in the UK that still burn wood or other solid fuels can experience even higher levels of indoor air pollution, including when emissions to the outside come back into the home due to air infiltration.

ii. Mechanical ventilation is a ventilation system with an active fan that is running continuously, removing air from the kitchen, toilet and bathroom and exhausting that air outside. These systems are not very common in the UK, and are different from a cooker exhaust hood which is located directly above the cooktop and may exhaust to the inside or outside, but they ensure that there are regular air changes in the kitchen and thus reduce the level of indoor air pollution.

iii. See Chapter 7

iv. Although tests were not conducted on UK gas, the 2013 study states the following about North Sea gas fields: "However, in some gas fields such as those situated in source rocks beneath the Netherlands and the North Sea, outside the Groningen field, the predominant conditions and materials leading to the formation of natural gas led to a higher proportion of benzene relatively to other C6+ hydrocarbons than in other gas fields."

TABLE 2: INDOOR AIR QUALITY SIMULATION STUDY — THREE SCENARIOS FOR TYPICAL KITCHENS IN EUROPE

NO_2 CONCENTRATION LIMIT VALUES	YES/NO	REFERENCE (TODAY)	IMPROVED AIR TIGHTNESS	WITH USE OF COOKER HOOD	ELECTRIC COOKING
Scenario: UK, Urban Household – closed kitchen					
Exceeds WHO annual limit of 10 µg/m³	Yes/No	Yes	Yes	Yes	Yes***
Exceeds WHO daily limit of 25 µg/m³	Yes/No	Yes (7)*	Yes (7)*	Yes (7)*	No
Exceeds EU annual limit of 40 µg/m³	Yes/No	Yes	Yes	No	No
Exceeds EU hourly limit of 200 µg/m³	Yes/No	Yes (15)**	Yes (16)***	No	No
Scenario: Southern Europe, Rural Household – closed kitchen					
Exceeds WHO annual limit of 10 µg/m³	Yes/No	Yes	Yes	Yes	No
Exceeds WHO daily limit of 25 µg/m³	Yes/No	Yes (5)*	Yes (5)*	No	No
Exceeds EU annual limit of 40 µg/m³	Yes/No	No	No	No	No
Exceeds EU hourly limit of 200 µg/m³	Yes/No	Yes (5)**	Yes (5)**	No	No
Scenario: Eastern Europe, Rural Household – open kitchen					
Exceeds WHO annual limit of 10 µg/m³	Yes/No	Yes	Yes	Yes	No
Exceeds WHO daily limit of 25 µg/m³	Yes/No	Yes (2)*	Yes (2)*	No	No
Exceeds EU annual limit of 40 µg/m³	Yes/No	No	No	No	No
Exceeds EU hourly limit of 200 µg/m³	Yes/No	Yes (7)**	Yes (9)**	No	No
Scenario: Western Europe, Urban Household – open kitchen					
Exceeds WHO annual limit of 10 µg/m³	Yes/No	Yes	Yes	Yes	Yes***
Exceeds WHO daily limit of 25 µg/m³	Yes/No	Yes (5)*	Yes (5)*	No	No
Exceeds EU annual limit of 40 µg/m³	Yes/No	No	No	No	No
Exceeds EU hourly limit of 200 µg/m³	Yes/No	No	No	No	No

** Number of days exceeding 25 µg/m³ in a week*
*** Number of hours exceeding 200 µg/m³ in a week*
**** Household exceeds limit value due to outdoor air pollution infiltration*

Our modelling found that the 2021 WHO Air Quality Guidelines are regularly exceeded indoors when cooking with gas.

3 Indoor Air Pollution from Gas Cooking Harms People

Gas cooking is linked to asthma in children and worse symptoms in asthmatic adults, alongside small decrements in pulmonary function that can result in other serious health impacts. In 2010, when revising their Indoor Air Quality Guidelines, the WHO reviewed evidence of NO_2 exposure indoors and concluded: "*The main health outcomes of interest are respiratory symptoms, bronchoconstriction, increased bronchial reactivity, air way inflammation and decrease in immune defence leading to increased susceptibility to respiratory infection.*" **The WHO also found that children in homes with gas cooking appliances have a 20% increased risk of lower respiratory illness.**[32] Subsequent research ties domestic gas combustion with the development of attention deficit hyperactivity disorder (ADHD)[33, 34] in young children.

A global meta-analysis of 41 indoor air pollution studies and asthma rates in children found that children living in a home with gas cooking have a 42% increased risk of having experienced asthma symptoms in the last 12 months (current asthma), a 24% increased risk of ever being diagnosed with asthma by a doctor (lifetime asthma), and a 32% increased risk of having current and lifetime asthma.[35] No significant variations were found across the different regions where studies were conducted (Europe, North America, Asia-Pacific), suggesting that differences in the built environment, including building codes, do not play a major role.

For children already suffering from asthma symptoms, increases in indoor NO_2 exposure have been associated with increases in the number of days with limited speech, cough, and nocturnal symptoms.[36] Research conducted in the UK indicates that exposure to NO_2 increases the risk of aggravated asthma following respiratory infections, even at relatively low levels of exposure.[37, 38] Children suffering from asthma also have higher levels of school absence, which may be associated with worse educational outcomes, including leaving school earlier and achieving lower examination grades.[39] Meanwhile, short-term exposure to NO_2 levels over 150 $\mu g/m^3$ can lead to negative outcomes for all children, such as significant increases in sore throats, colds and absences from school.[40] If childhood asthma persists into adulthood, it is likely to cause more severe symptoms than adult-onset asthma.[41]

As shown in Table 3, **it is estimated that over 500,000 children in the UK have experienced current asthma symptoms in the last 12 months associated with gas cookers.**[42] This compares to over 700,000 children in the EU.[43] Research in the United States[44] and Australia[45] reveals similar findings to the EU. The high percentage of UK households cooking with gas, the high number of children in the UK, and a higher percentage of UK children with self-reported current asthma symptoms account for the UK's comparatively high number of children impacted in the last 12 months with current asthma symptoms linked to gas cooking. Upgrading those gas cookers across the country to electric would eliminate that source of indoor air pollution and alleviate that health burden on those children.

Research indicates that over 500,000 children in the UK have experienced current asthma symptoms in the last 12 months that can be linked to gas cooking.

TABLE 3: ESTIMATED NUMBER OF CHILDREN WITH CURRENT ASTHMA (HAVING ASTHMA SYMPTOMS OCCURRING WITHIN THE LAST 12 MONTHS) LINKED TO COOKING WITH GAS, BASED ON 2003 ASTHMA PREVALENCE DATA[i]

COUNTRY/ REGION	HOUSEHOLDS COOKING ON GAS	# OF CHILDREN	% CHILDREN WITH CURRENT ASTHMA SYMPTOMS IN LAST 12 MONTHS	POPULATION ATTRIBUTABLE FRACTION	#CHILDREN WITH CURRENT ASTHMA LINKED TO GAS COOKING
UK	**53.9%**	**12,028,800**	**25.1%**	**18.5%**	**557,326**
EU27 Total:	32.6%	67,678,078		12.0%	771,464
Italy	68.7%	9,190,198	11.4%	22.4%	234,605
France	31.7%	9,921,574	12.6%	11.7%	146,885
Spain	33.5%	7,106,726	13.9%	12.3%	121,845
Netherlands	65.4%	2,604,501	13.0%	21.5%	72,961
Romania	64.9%	2,924,129	8.9%	21.4%	55,744
Poland	43.7%	5,752,685	6.1%	15.5%	54,419
Hungary	60.4%	1,468,373	7.8%	20.2%	23,176
Belgium	26.7%	1,761,623	8.5%	10.1%	15,098
Ireland	21.1%	750,543	21.5%	8.1%	13,136
Germany	2.9%	12,735,159	8.0%	1.2%	12,260
Other EU-27	0.0-68.5%	13,462,567	2.5-14.7%	0.2-22.3%	21,336

Sources: Eurostat 2020 and 2022; European Respiratory Society, 2003; TNO 2022.

CALCULATING THE IMPACT OF GAS COOKING ON CHILDREN WITH THE POPULATION ATTRIBUTABLE FRACTION

The Population Attributable Fraction (PAF) is a scientifically accepted methodology for determining the theoretical proportion of a health burden that could be avoided if the risk factor causing the burden were to be removed.[46] The PAF is calculated using the following equation[47]:

$$PAF = \frac{p \times (RR - 1)}{p \times (RR - 1) + 1}$$

where p is the percentage of households cooking on gas and RR is the relative risk (or odds ratio) of asthma for children exposed to gas cooking. The percentage of UK households cooking on gas is 53.9%.[48] The increased odds of current asthma (odds ratio) in children exposed to gas cooking is estimated at 1.42, based on existing research.[49] Plugging these two values into the PAF equation above, the PAF of current asthma associated to gas cooking in the UK is calculated as 0.185, or 18.5%. This means that, in theory, 18.5% of children who experienced current asthma symptoms in the last 12 months could be avoided if the risk factor of cooking on gas is removed.

Estimating the number of children that could be affected by gas cooking in their homes involves multiplying the number of children in the UK, the percentage of children with asthma, and the PAF of children with current asthma symptoms linked to gas cooking.

- Number of children in the UK: 12,028,800
- Percentage of UK children with current asthma symptoms in the last 12 months: 25.1%
- PAF of UK children with current asthma symptoms linked to gas cooking: 18.5%

12,028,800 x 25.1% x 18.5% ***= 557,326 children with current paediatric asthma symptoms associated with gas cooking appliances.***

i. According to research from the Global Burden of Disease, asthma rates in the UK have only slightly decreased between 2003 and 2019.

According to the UK Government, the annual mortality of air pollution in the UK is roughly between 29,000 and 43,000 deaths every year.[50] Researchers look to gas cookers as one of several instigators of the public health risks posed by indoor air pollution. The effects of cooking with gas also have an impact on quality of life and Disability Adjusted Life Years (DALYs). DALYs measure the burden from mortality, specifically years lost because of premature death due to disease; and morbidity, the number of years lived in poor health. One DALY represents the loss of the equivalent of one year of full health. Based on 2019 health data,[51] the number of DALYs lost due to asthma in the UK was 275,000, compared to 1 million in the EU. Of these, the TNO study determined that in the UK, 32,000 DALYs are lost due to asthma linked to cooking on gas.

In the UK, 32,000 DALYs are lost due to asthma linked to cooking on gas.

There is growing evidence linking combustion related air pollution with adverse effects on brain development in young children.[52] A 2009 Spanish study[53] found linkages between the presence of gas cooking appliances and the concentration NO_2 during the first three months of life and the neuropsychological development by four years old. Early life exposure to household gas appliances was associated with decreased general cognitive functioning and with a higher risk of developing ADHD.[54] A recent Chinese study[55] suggests that cooking during pregnancy is associated with an increased risk of hyperactive behaviours in children at around three years old. These risks were higher when mothers cooked frequently, when the household used gas or solid fuels for cooking, or when the kitchen was poorly ventilated.[56]

Cooking on gas adds to the health burden of air pollution, with NO_2, PM, and CO impacting virtually the entire human body (Figure 4). Electric cooking does not involve combustion of a fossil fuel; therefore, it does not release any harmful combustion pollutants in the home, making it the cleanest cooking option.

More research is needed to expand understanding of the various health impacts of gas cooking and associated NO_2 emissions on human health. In July 2021, UK Research and Innovation provided millions in funding for three new research projects to explore the link between indoor air quality and child asthma; air quality in urban homes; and the impact of common pollutants on neurological disease and cognitive function - each of these will review the air pollutants and health impacts from cooking.[57]

However, the findings are clear — cooking on gas adds to the health burden of indoor air pollution, with NO_2, PM, and CO impacting virtually the entire human body (Figure 3). Electric cookers do not involve combustion of a fossil fuel; therefore, the appliance itself does not release any harmful combustion pollutants in the home, making it the cleanest cooking option. Smoke generated from cooking food can still produce PM, so ventilating the kitchen is still necessary regardless of which appliance is used.

LOW-INCOME HOUSEHOLDS FACE DISPROPORTIONATE RISK FROM POOR INDOOR AIR QUALITY

In the UK, low-income households are at increased risk of negative health outcomes due to gas cooking. A 2021 London-focused study[58] found that low-income households have higher rates of respiratory and cardiovascular diseases compared to higher-income households. These health challenges are exacerbated by higher levels of indoor air pollution, as a result of factors including cooking behaviours, housing size and ventilation, and local outdoor air pollution. In smaller homes and kitchens, pollution from gas cooking can reach higher concentrations faster. Lower-income households also spent more time cooking in the kitchen, which can lead to higher concentrations of indoor air pollution. The study also noted that lower income households may not be able to maintain or repair ventilation systems due to high costs, or because they rely on landlords to make repairs.

FIGURE 3: HEALTH IMPACTS OF POLLUTANT EXPOSURE

CHILDREN

NERVOUS SYSTEM

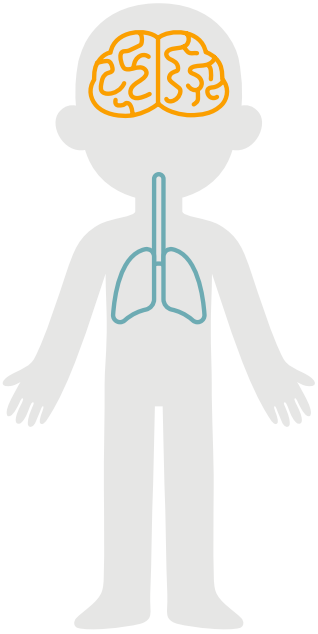
IQ, learning deficits, psychiatric problems in the transition to adulthood (CO, PM, NO_2)

RESPIRATORY SYSTEM

Irritated airways and aggravated respiratory symptoms, such as wheeze, cough, chest tightness, difficulty breathing (PM, NO_2)

Asthma, reduced lung function and increased susceptibility to lung infections (NO_2)

Changed lung function



ADULTS

NERVOUS SYSTEM

Impacts on the central nervous system (CO, PM)

RESPIRATORY SYSTEM

Pulmonary function/breathing problems (PM, NO_2)

Irritation of the eyes, nose and throat

Irritation, inflammation and infections

Asthma and reduced lung function (NO_2)

Chronic obstructive pulmonary disease (PM)

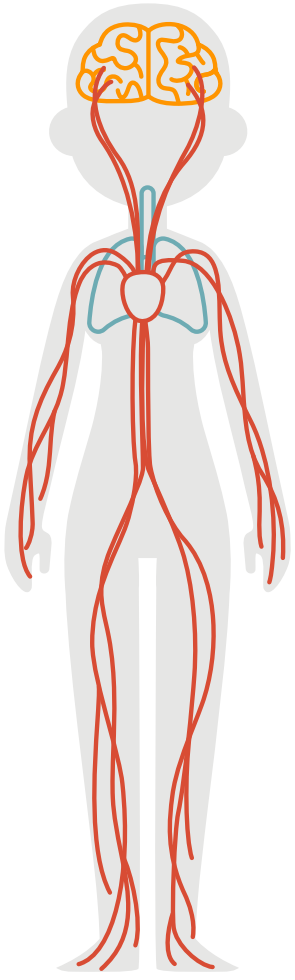
Cancer (PM)

CIRCULATORY SYSTEM

Cardiovascular diseases (PM, NO_2)

Impacts on liver, spleen and blood (NO_2)

Blood pressure (NO_2)



4 Cooking with Gas is Costly

Cooking with gas, though often promoted as inexpensive, actually costs society and individuals a lot. In 2019, the International Respiratory Coalition estimated the UK's annual societal cost of asthma to be €14 billion.[59] This amount includes increased health costs, lost earnings and productivity, and DALYs.[60] By multiplying that total cost by 11.5% as the population attributable fraction (PAF) of only the paediatric asthma diagnosed by a doctor linked to gas cooking appliances, CLASP estimates the societal cost of gas-cooking indoor air pollution at least at £1.4 billion annually.[61] In the EU, those same costs are estimated at €3.5 billion annually.

Asthma related to gas cooking costs UK society at least £1.4 billion annually.

In the United States, children living in homes with gas cookers and higher concentrations of NO_2 reported increased use of asthma rescue medication in the evenings and nights following their exposure in the kitchen.[62] Changing a gas cooking appliance to an electric one reduced US asthma patients' need for medication, which resulted in annual savings of £154 (US $180) per patient.[63] Given the rising costs and resource constraints within the UK National Health Service, and the impacts of the cost of living crisis for individuals purchasing asthma inhalers,[64] there is an immediate opportunity to reduce costs from the health impacts of gas cooking.

A study by the European Public Health Alliance (EPHA) and CE Delft found that the total health-related costs of outdoor air pollution due to heating and cooking activities by households in the EU27+UK amounted to over £25 billion (0.2% of total GDP) in 2018.[65] Across the EU, this translates into a cost of £115 per year for an average household. **In the UK specifically, these costs amounted to over £2.2 billion in 2018, which translates into a cost of £77 per year for an average household.**[66] A vast majority of those costs were related to the direct emissions from households using fossil fuels and biomass for heating and cooking. A small fraction of the costs was associated with indirect emissions caused by electricity and heat production, from households that used electricity or district heating for heating and cooking.

On the other hand, there are readily available clean alternatives to gas cookers. Households and the UK Government can invest in electric cooking technologies to remove the burden of societal health costs resulting from gas cooking.

Studies[67, 68] show that electric cookers can be purchased at similar or lower costs to gas cooking appliances, depending on technology and their functionalities - an average of £190 for a 4-hob gas cooker, compared to £128 for a comparable electric hotplate cooker, £250 for infrared and £440 for induction. Although induction technology currently comes with more expensive upfront costs, infrared hobs are close in price to gas options. Electric hotplates are the cheapest cooking hob option of any technology in the UK market.

CLASP conducted a survey of 2,000 UK adults in October 2022 to assess awareness of the health risks of gas cooking, and attitudes towards the switch to electric. When asked about barriers to switching to electric, 22% of respondents cited the upfront cost of purchasing a new electric cooker. However, when asked about motivations to switch to electric cooking, about **a third of gas cooking appliance users (32%) reported that they would be motivated to switch if there was a financial incentive.**

Incentives for electric cooking would yield massive returns for Government. CLASP modelled various scenarios to compare the total cost of ownership for gas and different electric cooking technologies, considering the energy prices and trends before the war in Ukraine.

Cooking with electricity can be cost-effective.

Looking at the average costs of the different hobs over their whole lifetime, CLASP explored the possibility of a Government-led incentive programme to accelerate the uptake of more efficient electric options. The cost to Government for such incentives would be outweighed by the larger societal benefit, in terms of healthcare costs. For example, we found that:

- The total cost of ownership costs for electric hotplates and infrared hobs would be about £180 and £30 (respectively) cheaper than for gas, while the total cost of ownership for induction would remain higher than gas, by about £150. These numbers were calculated based on the 2021 average prices for gas and electricity and the energy prices increases observed after the energy price cap rise of October 2021.
- The average societal cost of health bills attributable to gas cooking was estimated to be about £1750 per household over the operating life of the appliance.[i]
- Government incentives, providing households with grants of £100 for infrared and of £300 for induction hobs would compensate for the differences in purchase prices between those electric options and a gas hob, also making the potential cost of disconnecting an existing gas hob more acceptable. Such incentives, compared to the societal cost associated with gas cooking, would have returns of investments of almost 18 to 1 for infrared hobs and 6 to 1 for induction.

Recent analysis in the UK has shown that in the short term, using small electric cooking appliances is an even lower cost solution – including air fryers, microwave ovens and slow cookers.[69] In addition to being less expensive to operate, these electric appliances do not emit any of the pollutants produced by burning gas when in use.

i. This number is based on the £1.4 billion estimated national annual cost attributed to gas cooking. Dividing that number by the estimated 15 million households that cook on gas in the UK, cooking on gas costs each household roughly £91.22 annually. Considering that those costs are distributed across the lifetime of the appliance, CLASP applied a formula to include maintenance and repair costs, a discount rate of 4% and escalation rate of 6%. The resulting number is £1750, cumulative actualised cost over the lifetime of 15 years.

5 Ventilation is Not Enough

Ventilation, when used properly, can help mitigate pollution released while cooking on gas. When correctly installed, maintained, and operated, externally vented, or ducted, cooker hoods located directly over or behind the hob can reduce NO_2 and other pollutant levels, resulting in better respiratory health.[70] An American study[71] of houses with gas cookers found that the prevalence of asthma, wheeze, and bronchitis was lower for children where ducted ventilation was used, compared to those houses where it was not. The study also found that some households used their cookers to help heat their homes without using any ventilation, which could increase the odds for asthma by 59%.

Using gas cookers to help heat homes without any ventilation could increase odds of asthma by 59%

Households should use cooker hoods to remove as many pollutants as possible from cooking foods, irrespective of whether they are cooked on gas or electric hobs. Cooking on any appliance can generate certain pollutants such as particulate matter ($PM_{2.5}$) and volatile organic compounds.[72] Effective kitchen ventilation should therefore be available in all homes and operated as a precaution during and after cooking.[73]

80% of homes in the UK have inadequate ventilation.

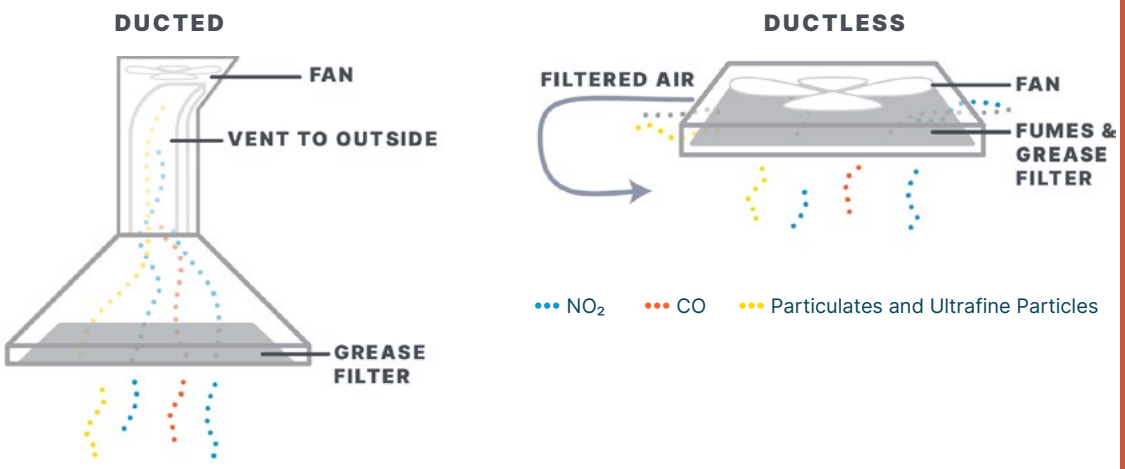
Cooker hoods can be more effective, particularly in reducing $PM_{2.5}$ concentrations, if used during and for a period of time after cooking. Using ventilation for ten minutes after cooking lowered $PM_{2.5}$ concentrations by an average of 58% in one study, conducted in a full-scale test house.[74] However, these indoor air quality and health benefits come at the expense of higher energy consumption, as the fan must run for longer.[75]

However, existing ventilation strategies are largely inadequate to address the pollutants created from gas hobs or ovens and they can be inconvenient for users, according to research. Many kitchens across the UK include a cooker hood — however, not all ventilation technologies are equally effective, nor do people use them every time when they cook.

HOW DOES COOKING VENTILATION WORK?

The cooker hood uses a mechanical fan and grease filter to collect steam, smoke, and fumes, and extract airborne particles generated while cooking. Cooker hoods can be externally vented, or ducted, where pipes carry airborne particles from the kitchen to the outdoors.[76] They can also be ductless, often referred to as recirculating hoods, where air is pushed through filters which are supposed to clean the fumes and remove grease and odours before venting them back into the room.[77]

FIGURE 4: DUCTED AND DUCTLESS (RECIRCLATION) RANGE HOODS



The filters in recirculation range hoods — common in apartments — are not appropriate for capturing NO_2 and ultrafine particles.

Existing domestic kitchen ventilation strategies and airflow rates are inadequate in over 80% of UK houses when the cooker hood is used only while cooking, research shows.[78] Cooker hoods are more effective when using the back burner than they are for the front burner,[79] but households do not necessarily always use the back burners. Additionally, studies show that cooker hoods are not always turned on while cooking. In Germany, for example, cooker hoods were turned on only during 29% of cooking times.[80]

Many households do not have cooker hoods ducted to the outside, but instead have ductless hoods that simply recirculate the air in the kitchen.[81] Recirculation hoods are especially popular in apartment buildings. However, the efficacy of the hood and filter quickly decrease over time. A study by TNO found that recirculation hoods with a new activated carbon filter can reduce NO_2 peak concentration by 67%, but efficiency of the hood with the filter rapidly decreases in the first month out of the box to a 19% efficiency in as little as 19 days. Even with a new filter, the hourly average NO_2 concentration remained above the WHO's 1-hour Air Quality Guideline.[82]

Optimised absorption filters could help reduce the NO_2 emissions, but they would also need to capture ultra-fine particles to better protect household health. To do so, the filter would introduce a pressure drop, a higher noise level, and would need to be replaced more regularly. The combined maintenance and noise burden makes this a less attractive option. Plasma filters producers claim that their products do not require as regular replacement, but they generate ozone which can react with NO realised during cooking to generate NO_2, hence doubling the NO_2 concentration due to gas cooking.[83]

From an energy efficiency perspective, increasingly powerful ventilation systems cannot be the solution, as the replacement air needs to be heated, which consumes more energy.

Current Ecodesign Regulations address performance requirements for cooker hoods — specifically for input power, pressure, flow, grease absorption capacity, odour extraction, and effectiveness of the hood light. The regulation should consider the long-term filtration efficacy and performance with regard to all pollutants, as the standard today does not consider the capture efficiency of pollutants and other contaminants that are generated by cooking.

Although efficient and effective cooker hoods can reduce the hazardous air pollution caused by gas cooking, the responsibility falls to individuals to ensure they are ventilating in the right way and cleaning their filters regularly. Rather, onus should be on the Government, manufacturers, and home builders to remove a key source of pollution from kitchens. Phasing out gas cooking appliances is the sustainable, robust solution to mitigate the challenge of indoor air pollution and protect the health of people across the UK.

TIPS FOR ADEQUATE VENTILATION IN THE KITCHEN WHEN COOKING

1. Preferably use a cooker hood, turn it on as soon as the gas burners are switched on and keep it running for 10 minutes afterwards to try and remove any lingering pollution.
2. Follow manufacturers guidance replacing / cleaning the grease filters in the cooker hood to ensure it is as effective as it can be.
3. If the fan in the cooker hood isn't working or stops working, get it fixed or replaced as soon as possible.
4. If replacing or installing a new cooker hood, ensure it is vented to the outside, so it takes pollution from the gas stove and blows it outside. Research the capacity and air flow-rate of the product, to ensure it has a sufficient air flow rate to remove the air pollution from cooking on gas.
5. If a cooker hood is not an option, open windows during and after cooking to enable pollution from the gas stove to leave the living space as quickly as possible.

6 Gas Cooking Undermines UK Efficiency & Electrification Agendas

The transition to energy-efficient buildings provides an opportunity to rethink our relationship with indoor spaces, and focus on creating a healthy, pollution-free environment. With the rising cost of living, driven in part by steep energy prices, good building insulation and reliably sealing up draughts and air leaks is economically beneficial for households and businesses. Outdoor air ventilation is one of the primary mechanisms to remove indoor air pollution from gas cooking. While less air entering the home will save on winter heating bills, it will also result in increased gas cooking air pollutant concentrations and extend the household's exposure to these pollutants — undermining efforts to achieve more sustainable and safe living and working spaces.[84] Any efforts to improve housing insulation should therefore be coupled with a shift to electric cooking.

Home and appliance efficiency regulations can lead to higher indoor air pollution when not paired with strict pollution limits. While gas cooking appliances have become generally safer and more efficient due to regulations,[85] pollution emissions have increased. Ecodesign and Energy Labelling Regulations[86] have required gas cookers to become more efficient — meaning gas burners must be hotter. A hotter flame produces more NO_2.[i, 87] Building efficiency and insulation has also improved in recent years, with Government incentivising efficiency upgrades and reducing draughts (natural ventilation), trapping gas cooker air pollutants indoors. Higher NO_2 produced on "efficient" gas hobs and better insulated homes with less ventilation results in higher levels of gas cooker air pollution trapped indoors.

Pollutant concentrations from indoor sources — like gas cookers and heating — dangerously increase in more airtight buildings, especially if the kitchen does not have an effective ventilation system.

Although energy efficient homes can trap polluted air inside the building, they can also serve to keep polluted air out. TNO corroborated this finding through the computer simulation model and further showed that changing the cooking fuel from gas to electric at the time of a building upgrade will, in all scenarios and situations, improve the indoor air quality by eliminating the pollution from gas cooking in the living space.

CASE STUDY: ECO Scheme to Improve Energy Efficiency of Homes Should Be Coupled with Subsidies to Switch to Electric Cooking

In November 2022, the UK Government launched the £1 billion Energy Company Obligation (ECO)+ scheme to make homes more energy efficient and reduce household energy bills.[88] Working through large energy suppliers, the ECO+ scheme will provide grants to incentivise people to insulate their homes. The scheme will include those on the lowest incomes, as well as those living in the least energy efficient homes in lower council tax bands. It will begin in Summer 2023 and run for three years. This initiative builds on the existing ECO scheme launched in 2013 that has helped 2.4 million people to improve the energy efficiency of their homes.

Today, 46% of British homes have an Energy Performance Certificate (EPC) of C or above, which has increased from 13% in 2010, before the ECO scheme was first launched. The UK's Clean Growth Strategy sets a target to get all homes to an EPC of C or above by 2035, and by 2030 for rented homes.

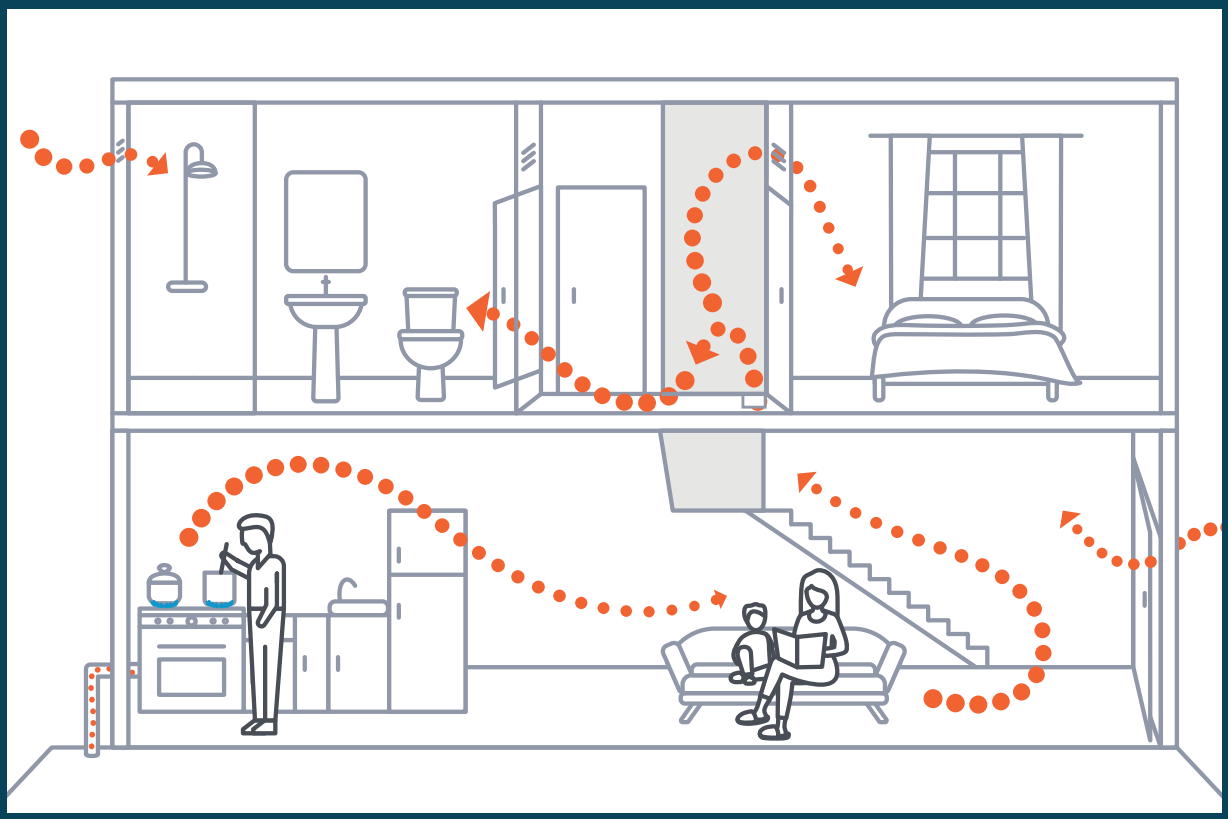
National insulation schemes are critical to improve home efficiency across the UK. However, if no complementary investment is made towards transitioning to electric cooking in those homes, indoor air quality can worsen with greater health impacts.

i. Comparing results for gas hobs from 1992–2007 (Based on Singer 2009 data, outlined in TNO Health report, p. 20) with results from emission measurements on current 2022 gas hobs (TNO Report - Effect of hydrogen gas mixes on gas hob emissions, page 10 - 11). The 2022 NO_2 emissions are higher, although there are differences in the test methods.

Increasing Air Tightness and the Impact on Indoor Air Quality

To better understand how gas cookers affect indoor air pollution, TNO conducted a computer simulation study to examine NO_2 exposures.[89] The simulation looked at typical households and conditions representative of different regions in Europe: Southern, Eastern and Western EU countries and the UK. The modelling considered four simulation scenarios: the first was the impact of improved building performance on air quality as air tightness improved and the external air infiltration rate reduced. **The simulation found that insulating dwellings can degrade or improve indoor air quality depending on the level of NO_2 concentration in the outdoor environment.**

For Eastern Europe and UK, the model predicted an increase in the number of hours the NO_2 concentration were above 200 µg/m³. For Southern Europe, Eastern Europe and the UK the weekly averaged concentration increased by 25%, 3% and 10%, respectively. In contrast, Western Europe saw a predicted decrease of 4%; the decreasing trend is due to the lower infiltration and therefore less NO_2 from ambient air entering the house. This reduces the background concentration. These findings are aligned with the results of an Irish indoor air quality study of 15 households that measured the indoor air quality before and after a retrofit. After the air leakage was reduced, there was a non-significant decrease of the NO_2 concentration from 6.8 to 6.0 µg/m³; at the same time, there was a significant increase of CO_2 and $PM_{2.5}$. Another study that modelled the performance of houses in Boston predicted a 15% increase in NO_2 concentration due to weatherisation of these homes.



In all scenarios, switching from gas to electric during a building upgrade will improve the indoor air quality of a household.

7 Gas Cooking Undermines UK Climate Goals

Gas cooking hinders UK targets to become a climate-neutral economy by 2050. In October 2021, the UK published a policy paper titled "Net Zero Strategy: Build Back Greener" which sets out policies and proposals for decarbonising all sectors of the UK economy to meet a net zero target by 2050.[90] However, as a fossil fuel, cooking gas emits environmental pollutants like methane, benzene, and CO_2. Cooking accounts for roughly 2% of total UK carbon emissions.[91] Allowing new installations of gas cookers undermines UK climate goals by keeping fossil fuel in use, instead of transitioning to cleaner electrical cooking.

Even when switched off, gas hobs leak methane — a potent greenhouse gas. Methane is the main component of fossil gas used for cooking. When leaked, methane can warm the Earth more than 80 times as much as the same amount of CO_2 over a 20-year period. Methane also contributes to ground-level ozone pollution, which can cause breathing problems and other health issues.[92] A US study estimated that gas cookers emit between 0.8 - 1.3% of the natural gas they consume as unburned methane. During the course of a typical year, three-quarters of these emissions occur when the devices are shut off, which could suggest leaky fittings and connections with gas service lines. US gas cookers were estimated to emit 2.4 million tonnes of methane a year, equivalent to the annual greenhouse gas emissions of 500,000 cars.[93]

TNO tested six different gas built-in and standalone hobs and found that European appliances react similarly to American appliances in terms of methane leakage, averaging 56 mg/hour methane leakage compared to the US 57.9 mg/hour findings.[94] Most users are unaware that their gas hob is likely to leak gas even when it is switched off. Leaking likely occurs because the valves that control the gas flow to the hobs do not create a perfect seal.

According to the WHO and the Intergovernmental Panel on Climate Change (IPCC), climate change is the greatest threat to public health. The IPCC concludes that to avert catastrophic health impacts and prevent millions of climate change-related deaths, the world must limit temperature rise to 1.5°C.[95] Every tenth of a degree of warming past 1.5°C will take a serious toll on people's lives and health. This is why the WHO, health organisations, and health professionals have called for a Fossil Fuel Non-Proliferation Treaty[96] to protect lives of current and future generations. Phasing out gas cookers will advance the UK's climate agenda, reducing considerable amounts of methane and CO_2 emissions.[97]

A US study estimated that gas cookers emit between 0.8–1.3% of the gas they consume as unburned methane. TNO found that European hobs have similar rates of methane leakage.

8 Marketing Matters — Gas is Not 'Natural' or 'Clean'

Decades of marketing have oriented public opinion to view gas as a safe, clean, and "natural" product. The IPCC names the fossil fuel industry's advertising and public relations efforts[98] in favour of gas as a key obstacle to ending the climate emergency. These well-funded endeavours directly undermine work to reduce indoor air pollution and efforts to educate the public on the health risks of gas cookers.

IPCC scientists argue that advertising and media strategies employed by the fossil fuel industry have become central obstacles to climate action by sowing doubt in the minds of the public and policymakers. According to Clean Creatives,[99] the fossil fuel industry's public relation campaigns are creating legal and reputational risks for advertising agencies. Over 1800 cases[100] are pending worldwide related to the fossil fuel industry, many of them focused on misleading advertising. Both Shell and BP have been rebuked by regulators in the EU and UK,[101] respectively, demanding that they end campaigns misleading the public. Fossil fuel advertisements have now been banned in France,[102] and bans are being considered elsewhere.[103]

The Advertising Standards Agency (ASA), the UK's advertising watchdog, launched a series of investigations into gas companies for falsely advertising gas as environmentally friendly, and exaggerating efforts on renewable energy projects.[104] In 2020, ASA opened an investigation into claims made by Shell that customers at its petrol stations can "drive carbon neutral." Critics of the scheme said that it gave the false impression that carbon credits take meaningful action to slow global warming, despite the scientifically demonstrated need to rapidly scale back the use of fossil fuels.[105] In 2019, a complaint lodged by ClientEarth to the UK national point of the OECD's guidelines, argued that two of BP's global campaigns were misleading the public about the scale of BP's clean energy focus. The adverts in the 'Keep Advancing' and 'Possibilities Everywhere' campaigns focus on BP's low carbon energy products but in reality, BP are spending just £4 in every £100 on clean energy investments. The rest is spent on their traditional oil and gas business.[106] The gas industry has invested heavily in positioning gas cooking as a safe, superior alternative to electric. For example, in the United States there are documented instances[107] of PR agencies organising community support for gas cookers to thwart initiatives restricting the use of fossil fuels in new buildings. In Spain, the gas industry is running "A gas sabe mejor" campaign - which translates to "With gas tastes better."[108] Outside of proper advertisements, media sources like newspapers and television programming depict positive representations of gas cooking appliances across the culinary realm. Popular cooking shows like BBC's Saturday Kitchen often showcase demonstrations on gas hobs.

Because of successful and well-funded marketing efforts, people are widely unaware of the immediate health and environmental risks posed by their gas cookers.

However, many popular shows in the UK are transitioning to electric or induction hobs. Representation on shows like Masterchef and the Great British Bake Off[109] echo sentiments shared across the culinary community[110] that electric cooking improves working conditions in commercial kitchens without lowering the quality of meals produced.[111] The use of induction and electric hobs in TV highlights the product as a desirable and functional appliance, while also improving safety and air quality in the studio.

Hydrogen: the gas industry's new 'clean' and 'green' fuel?

Following the marketing and advertising strategies employed by the fossil fuel industry to position fossil gas as 'clean' and 'safe,' gas companies are shifting focus to fund considerable lobbying efforts in favour of using hydrogen in homes, paving the way to continue residential fossil gas use and rework local infrastructure to enable this fuel to be safely piped in households. The "Hello Hydrogen"[112] campaign aims to encourage the Government to "commit to a hydrogen future." The campaign is funded by gas network operators, including Cadent and Northern Gas Networks; the boiler manufacturers Baxi and Vaillant; the supplier British Gas; and Ryze Hydrogen. The health impacts and safety of hydrogen for cooking remains understudied, while electric cooking appliances are already widely available across the UK.

Global Efforts to Scale Electric Cooking

In 2022, the Global Cooksafe Coalition launched to promote universal access to safe and sustainable cooking by 2030 in new kitchens and 2040 in existing kitchens. GCC's work accelerates fossil-fuel-free cooking with electric appliances powered by renewable energy. GCC brings together founding health and environmental organisations, as well as corporate partners and celebrity chefs who are raising awareness about the opportunity to switch to induction cooking and create a cleaner and healthier working environment in their restaurants.

Empowered with the evidence on the health and environmental impacts of gas cooking, as well as widespread cost and energy-effective and high-quality electric alternatives, people no longer need to tolerate polluting and dangerous gas cookers in their homes.

WHAT DOES THE BRITISH PUBLIC THINK ABOUT GAS COOKING?

While gas cookers can be a large source of toxic pollutants indoors, the British public is widely unaware of these risks and remain attached to their gas appliances. Further, there are widespread misconceptions about the quality and performance of electric cooking options. In a survey of 2,000 UK respondents exploring participants' cooking practices, preferences and willingness to deviate from legacy cooking methods, CLASP found:

- **Consumers would switch to electric cooking if better aware of health risks from gas** — 61% of respondents said they would consider getting rid of a gas cooker if there was a negative health implication for those in the household.
- **Consumers cite cost as a barrier to transition to electric cooking, but gas appliance users say an incentive would motivate them to switch.** 22% of respondents cited 'high purchase cost' as a reason not to switch to electric. However, a third (32%) of gas cooking users said that a financial incentive would motivate them to switch.
- **Consumers are unaware of health risks associated with gas cooking** — only 41% of respondents identified a link between gas appliance use and health issues.
- **People have misconceptions about the functionality of induction cooking** — 22% of respondents denoted they would consider buying an electric hob if were easier to control the appliance's heat levels, and 20% would switch if the hob was quicker to heat up.
- **People prefer to cook with familiar appliances** — 50% of respondents reported cooking with a gas hob in their home and the majority (47%) said they like to cook with the fuel they are used to. Notably, 62% of gas users over the age of 65 saying they preferred gas because they are used to it.

Gas hob users reported they were willing to consider swapping their appliance for an electric alternative if made aware of the health implications yet are hesitant to switch based on misconceptions about the performance of electric hobs. These findings highlight a clear information gap that could be filled by further public awareness raising efforts.[113]

9 Mixing Hydrogen with Gas is Not a Viable Solution

Despite investments and political interest in hydrogen, it is not a viable solution to mix with or replace gas as a home cooking fuel. The UK Government is investing millions in hydrogen solutions to strengthen the country's energy security and to meet its 2050 net-zero climate targets.[114] In April 2022, the Government committed £366 million to invest in hydrogen, including the production of hydrogen as a clean, low-cost energy technology within a broader support package to power British homes and businesses.[115] While the focus is primarily on the potential for the industrial sector, the Government, gas and appliance industries are also looking to hydrogen as an alternative solution to replace gas for residential heating and cooking. They have gone so far as to develop prototype hydrogen-ready cooking appliances[116] and trial the roll-out of hydrogen in British homes.[117]

The potential health impacts of cooking with hydrogen and hydrogen-gas mixes need further analysis. In-depth testing is needed to understand how burning hydrogen impacts indoor air pollution and health. CLASP conducted an exploratory study to understand emissions from gas-hydrogen mixes. We found that blending hydrogen with gas can increase indoor air pollution and that gas appliances are poorly adapted to hydrogen mixing. Moreover, the particulate matter median size appears to decrease when hydrogen is added, which is a concerning trend because smaller particles can penetrate deeper into the body — meaning they are even more harmful to human health. Mixing hydrogen and gas is not a viable or reliable solution for reducing the threat of indoor air pollution associated with gas cooking.

UNDERSTANDING HEALTH IMPACTS FROM BLENDING HYDROGEN WITH GAS FOR COOKING

In 2022, CLASP and TNO Laboratories conducted an exploratory study[118] to understand how blending hydrogen with methane gas impacts indoor air pollution and, ultimately, human health. We tested six different gas hobs while burning different concentrations of hydrogen blended with methane gas, from 0 to 40% in 10% increments. Emissions produced by two electric hobs, one induction, and one ceramic were also measured for comparison. The key findings from the study showed:

1. **Mixing hydrogen can increase levels of pollutants that are harmful to human health.** Our testing found that on some models, NO_2 levels increased with hydrogen mix and on others it decreased. On average there was a 6.5% increase in NO_2. We found that carbon monoxide levels increased on all models with increasing hydrogen, by almost a factor 9 for one model at 40% hydrogen.
2. **Electric cooking options eliminate all the pollutants of concern that are emitted by a gas hob.** When limited to boiling a pot of water, electric hobs did not emit any of these pollutants: UFP, NO_2, CO, CO_2, CH_4. Electric cooking was confirmed to be the safer, cleaner cooking option in domestic settings.

Gas cooking appliances would likely need to be adapted or entirely replaced to accommodate hydrogen fuel.

One of the supposed benefits of adding hydrogen to the cooking gas mix is that it supports the UK's climate goals. However, in its UK Hydrogen Strategy, the Government recognises that most hydrogen produced and used in the UK and globally is high carbon, coming from fossil fuels with no carbon capture; and that only a small fraction can be called low carbon.[119] The European Commission has found that blending hydrogen with methane gas "diminishes gas quality, can increase overall system costs and the costs of heating for the residential sector, and it is in most applications a less efficient alternative to direct electrification".[120] The American Medical Association has also recognised the health, safety, and climate risks of current methods of producing fossil-fuel derived hydrogen and the dangers of adding hydrogen to 'natural' gas.[i, 121]

Piping hydrogen into homes and businesses would require significant time and investment. The existing gas network would require substantial infrastructure changes, with upgrades and testing to support the transition from methane gas to hydrogen.[122] The heat content per unit volume of hydrogen is lower than gas; households would need 3.3 times the volume of hydrogen in order to obtain the same heat output.[123] This represents a highly inefficient and costly option for the Government and households.

Bringing hydrogen into homes poses a threat of leakage and combustion. Hydrogen molecules are significantly smaller and are therefore more prone to leak in old gas networks and domestic gas pipelines.[124] Because hydrogen has a lower ignition concentration, a higher flame speed, greater flammability range, and will burn at a higher temperature than methane gas, it presents significant engineering challenges that would affect the burners in different gas cooking appliances.[125] The UK Government has found that hydrogen boilers could cause four times as many house explosions as gas.[126]

To ensure households can cook safely with hydrogen, Governments and industry would need to invest heavily in modifying and transitioning existing appliances in peoples' homes.[127,128,129] The Government aims to phase out gas heating by 2035 at the latest,[130] however allowing hydrogen-ready boilers, or cooking appliances, is ultimately a way to keep households connected to the gas-grid for longer.[131] The investment in hydrogen for residential use could instead be funnelled towards electric heating and cooking solutions, which are accessible, ultimately more affordable, and safer for people and the planet.

i. The American Medical Association House of Delegates (A-22) Report of Reference Committee D, which states "Resolution 438: RESOLVED, That our American Medical Association recognize the health, safety, and climate risks of current methods of producing fossil fuel-derived hydrogen and the dangers of adding hydrogen to natural gas."

10 UK Policies Can Support Transition to Electric Cooking

There are currently no UK policies in place to mitigate the health and environmental risks of gas cooking. The Government has indicated strong signals to move away from gas appliances by 2035,[132] supporting decarbonisation and energy security goals — but so far, no concrete action has been taken to support the transition to clean cooking.

No UK policies or regulations directly target indoor air quality.

A growing body of evidence demonstrates that indoor air pollution is a health hazard to people across the UK. The UK Government has an existing air quality legislative framework focused on outdoor air quality, setting binding limits for outdoor air pollution concentrations, namely the **Air Quality Standards Regulations 2010**.[133] Not only are these regulations outdated and not in line with the 2021 WHO Guidelines, they are also inappropriate to monitor and enforce indoor air pollution levels. There are no other policies directly focused on improving indoor air quality, but it has been recognised as an area requiring further attention.[134]

In 2022, a group of indoor air quality experts,[i] funded by the Department for Environment, Food and Rural Affairs, assessed this issue in depth. They recognised that indoor air quality and household energy efficiency must be considered together, and that decarbonising homes can remove substantial NO_2 and $PM_{2.5}$, with significant improvements to indoor air quality.[135]

UK decarbonisation strategies place little focus on gas cookers.

The Government's **Net-Zero Strategy,**[136] **Heating and Buildings Strategy**,[137] and **Powering Up Britain policy papers**[138] outline the need to decarbonise residential buildings across the UK with a commitment to phase out gas heating over a lengthy timeline, by 2035. In these documents, the Government committed to change the current energy pricing system to reduce the overreliance on gas and push down electricity prices. Incentives and subsidies are listed as favourable solutions to encourage the switch from gas to electric technologies. These strategies recognise cooking appliances can run on fossil fuels, however, most policy solutions are focused on heating alone. **Heating and cooking appliances are inextricably linked when it comes to residential decarbonisation.** If gas and hydrogen-ready cooking appliances remain in the home, not only will air quality continue to deteriorate, households will remain connected to the gas-grid with lasting consequences.

The **Energy-related Products Framework**[139] and the **Ecodesign**[140] and **Energy Labelling**[141] policies are called out as the mechanisms to switch to greener cooking technologies, opening the door to phasing out the sale of new gas cooking appliances.

Ecodesign is the quickest opportunity to mitigate the health impacts of gas cooking, improving indoor air quality by eliminating harmful pollutants at the source.

Rather than rely on people to mitigate the emissions in their kitchen, the responsibility should be placed on Government and those manufacturing and selling the polluting products.[142] Environmental and health-harming indoor air pollutants must be addressed at the source,[143, 144] from the gas cooking appliances themselves. In the 2022 Annual Report on air pollution, the UK's Chief Medical Officer states the importance of regulation to address

i. The Department of Environment, Food and Rural Affairs (Defra) Air Quality Expert Group

pollution from appliances used indoors.[145] The Ecodesign and Energy Labelling Regulations are the mechanism to do so — these policies require manufacturers to design their products to minimum energy efficiency and performance standards, and to label their products accordingly.

Gas cooking appliances cannot reach electric efficiency levels.

The **Energy Related Products Policy Framework** suggests that gas-fuelled cookers can be phased out, specifically, by introducing stricter efficiency requirements for hobs and ovens to reduce fuel consumption and cooking times.[146] Indeed, research indicates that gas hobs are significantly less efficient than electric alternatives, requiring longer to heat up pots and pans with more heat loss.[147] Although these appliances perform the same functions and are used in the same way, buyers have no way of realistically comparing their efficiency or emissions.

Gas and electric cooking appliances are tested to different standards and there is no common A-G Energy Label for ovens, and no label at all for hobs. The Energy-related Products Policy Framework neglects the need for a comparable energy label, and omits reference to setting NO_2 or other pollutant limits, as has been done in similar regulations for space heating which also emit harmful pollutants.[ii] Without comparative energy labels, people are unable to make informed purchasing decisions that are best for their finances, the climate, and their family's health. At a minimum, people deserve information on whether or not the products they purchase emit harmful pollutants.

Government should subsidise the transition to electric cooking, providing access to cleaner and healthier alternatives to all.

Decarbonisation of the built environment is a priority for the UK Government, and household support schemes have been set up in the last few years to accelerate the move away from fossil fuels. However, these initatives have focused primarily on improving energy efficiency of the home through better insulation or by moving to low-carbon heating technologies. Gas cooking will keep households connected to the grid, even if they have converted to heat pump technologies. Any Government incentive or subsidy scheme should provide holistic support, including incentives to switch from gas to electric hobs and ovens. Further, CLASP's research has found that **32% of gas appliance users in the UK would be motivated to switch to electric with a financial incentive.** Priority should be given to low-income or council housing, to ensure an equitable transition for all.

This forward-thinking policy approach would lead to a greater uptake of low-carbon alternatives,[148] supporting progress towards the net-zero goal. **A national transition to cleaner, electric cooking offers the UK Government the opportunity to reduce dependency on Russian gas while simultaneously improving economic and public health.**

ii. Including for local space heaters (Commission Regulation (EU) 2015/1188 and Commission Regulation (EU) 2015/1185), space and water heaters (Commission Regulation (EU) No 813/2013 and Commission Regulation (EU) No 814/2013), solid fuel boilers (Commission Regulation (EU) 2015/1189), and air heating and cooling products (Regulation (EU) 2016/2281).

The Boiler Upgrade Scheme: Residential Gas Heating and Cooking Should Phase Out Simultaneously

The domestic sector is responsible for 60% of total energy consumption in the UK — primarily from heating and cooking.[149] The UK Government set a target to install 600,000 electric boilers per year by 2028, in a move to end the UK's reliance on fossil fuels and help fight climate change. The £450m Boiler Upgrade Scheme is a UK Government initiative to encourage more people in England and Wales to install low carbon heating systems, such as heat pumps and biomass boilers. Households are incentivised to make the switch to environmentally friendly alternatives compared to their legacy systems. From 2022 to 2025, eligible households can apply through their installer to receive financial support to cover costs of purchase and installation:

£5,000 for air source heat pumps

£6,000 for ground source heat pumps

£5,000 for biomass boilers in rural locations, for properties not connected to the gas grid and with an emissions certificate to demonstrate polluting emissions are kept to a minimum.

Notably, a third of UK adults (33%) say they would be more likely to get an electric heat pump.[150] **While increasing accessibility of heat pumps will support large-scale household electrification efforts, phasing out gas cookers must be included in electrification plans.** Gas cooking keeps homes connected to the gas supply, and therefore keeps the option to connect other gas-powered appliances like heating systems available. To equitably transition UK homes to electricity-powered appliances, gas cooking and heating must be phased out simultaneously.

11 Recommendations

UK Government

- **Phase out harmful gas cooking:** Phase out the sale of new gas cookers as soon as possible, supported by health and environmental considerations. Through the ongoing revision of the Ecodesign regulations for domestic cooking appliances, the Government can achieve a phase out setting stringent energy efficiency and emission requirements for new gas cookers.
- **Provide information on harmful gas cooking emissions to consumers, ideally on a comparative Energy Label:** While gas cookers remain on the market, ensure they are tested in the same way reflecting real-world usage, and adopt a common Energy Label so people can compare products as they shop. If the pollutants cannot be removed from the source, information on emissions should be provided at point of sale on the Energy Label.
- **Include pollutant capture efficiency in the Ecodesign requirements for cooker hoods:** This will ensure cooker hoods better remove pollutants from the kitchen, when used appropriately.
- **Install electric ovens and hobs in new construction:** Require electric heating and cooking to be installed in new buildings as soon as possible, in support of the UK's net-zero targets.
- **Accelerate the transition to cleaner electric cooking:** Establish trade-in schemes and retrofit programmes, providing incentives to upgrade from residential gas to efficient electric cooking technologies. Funding for low-income households and council housing should be the priority. Incentives for cooking appliances should be prioritised alongside space heating upgrade schemes. Subsidies to improve insulation in British homes should be coupled with support to switch to electric cooking, to ensure indoor air quality is not degraded with greater home efficiency. Extend the subsidised transition to electric cooking to workplaces, particularly in hospitality settings.
- **Act on existing commitments to reduce electricity tariffs:** Take action and implement reductions to electricity tariffs, cutting electricity bills to encourage take up of electric appliances, and reforming electricity market pricing.
- **Electrify, electrify, electrify!** Invest in electrification infrastructure to ensure households can drastically minimise indoor air pollution by leapfrogging from solid fuels to electric cooking. Build infrastructure upgrades and investments into national and local plans to allow for electrification of energy grids and favour the transition to healthier cooking.
- **Improve indoor air quality around the UK:** Establish indoor air quality standards for NO_2 that reflect health-based exposure limits

Industry

- **Invest in cleaner, healthier and sustainable technologies:** Commit to phasing out production and sale of harmful gas cookers, and focus on bringing down the costs of induction appliances.
- **Promote electric cooking technology:** Advise customers on the health and environmental benefits of electric cooking and promote the technology over gas equipment.

Civil Society and Academia

- **Increase and improve indoor air quality research:** Continue field studies and health-focused research projects that focus on gathering data and quantifying the impact of gas cooking appliances on indoor air quality, including the health burden on UK society.
- **Run public health awareness campaigns:** Work with local government to develop appropriate education and awareness-raising efforts on the health impacts associated with gas cooking. Awareness raising activities should be customised to local needs and habits.
- **Support people- and planet-conscious regulations:** Stand behind the phase-out of gas cookers by supporting strict emission limits in the Ecodesign Regulations. Call for a common Energy Label and test method for electric and gas cookers that addresses pollutants so people can make informed purchasing decisions.

Healthcare Organisations and Professionals

- **Advocate for greater investment in indoor air pollution awareness and mitigation:** The WHO recognised[151] over two decades ago "the right to healthy indoor air," yet indoor air quality has not been adequately high on the political agenda.
- **Communicate gas cooking health risks:** Communicate about the health impact of gas cooking, particularly for children, to raise awareness. The American Medical Association has recently taken an important step in this direction, adopting a resolution to inform physicians, health care providers, and the public that cooking with gas increases household air pollution and the risk of childhood asthma.[152]
- **Conduct additional health research:** Continue research on the health risks from poor indoor air quality and pollution levels due to gas cooking.

Individuals and Households

- **Replace the gas cooker:** Replace gas cooking technologies with energy-efficient electric alternatives, whenever possible.
- **Minimise exposure to gas cooking emissions:** Minimise gas cooking use by using plug-in appliances, such as electric kettles, fryers, or induction hobs.
- **Improve ventilation if gas cooking is the only option:** Use cooker hoods while cooking and for at least 10 minutes after. Clean grease filters regularly to ensure the exhaust capacity is not blocked by grease and grime. Use back burners that are closest to the cooker hood. Ideally, cooker hoods should vent outdoors so fumes are directed out of the kitchen. Open windows if outdoor air pollution is low, or you live in a low-traffic area.
- **Install and maintain carbon monoxide detectors:** Install detectors in kitchens and near bedrooms. Use devices that detect low levels. Get a Gas Safety inspection conducted annually. If carbon monoxide is detected, open all windows and doors, turn off your gas cooking appliances and leave the house. If you suspect you have carbon monoxide poisoning, see a health professional to take a blood or breath test. Call for a gas safety inspection, by a Gas Safety-registered engineer.

How to Improve Air Quality in Your Home When You Have a Gas Hob or Oven

1. VENTILATE YOUR KITCHEN WHEN COOKING

- If you have a cooker hood, turn it on as soon as you start the gas burners and keep it running for 10 minutes afterwards to try and remove any lingering pollution.
- Follow manufacturers guidance replacing and cleaning the grease filters in your cooker hood to ensure it is as effective as it can be.
- If the fan in your cooker hood isn't working or stops working, get it fixed or replaced as soon as possible.
- If replacing or installing a new cooker hood, ensure it is vented to the outside, so it takes pollution from the gas cooker and blows it outside. Research the capacity and air flow-rate of the product, to ensure it has a sufficient air flow rate to remove the air pollution from cooking on gas.

If a cooker hood is not an option, open your windows during and after cooking to enable pollution from the gas cooker to leave your living space as quickly as possible.

Different types of ventilation systems

- ***Externally vented range hood:*** *an effective form of local ventilation usually situated directly over the cooking hob that, depending on its efficiency, removes some or nearly all of the pollution from the gas burners and blows it outside.*
- ***Mechanical ventilation:*** *a method to continuously remove air pollution from not only your kitchen, but your whole home. This whole-house system is typically found in newer well-insulated homes with intake vents in multiple rooms.*
- ***Recirculating range hood:*** *the least effective form of ventilation which is designed to remove odours with a carbon filter and recirculate the air back into your kitchen. These hoods only remove some of the gas-combustion pollution for a few weeks, and then simply recirculate it around the room.*

2. USE ELECTRIC APPLIANCES WHERE POSSIBLE

- Boil water in your kettle before pouring it into a pot on your gas hob and try to use small plug-in electric appliances (e.g., toasters, slow cookers, air fryers, microwaves) — this does not result in gas-combustion pollution, is also more efficient, and can save money on your energy bills.
- Buy a plug-in induction or other electric cooktop to use instead of your gas hob.
- Buy only electric cooking equipment, including an electric hob — ideally induction — and electric oven.

3. WHEN USING YOUR GAS HOB OR OVEN, TRY TO REDUCE POLLUTION EMISSIONS

- Cook on the back burners to improve the effectiveness of your cooker hood.
- Use a pot that is larger than the burner, to keep the flames under the pot.
- Do not use your hob or oven for space heating, drying hair or clothes, or any other purpose than cooking. Any time the gas flame is on, the appliance is releasing pollution into your home that is harmful to your health.
- Install and maintain low-concentration carbon monoxide detectors. Use devices that meet safety standards and sound alarms at low CO levels. They should be installed in the kitchen, near the boiler (if you have a gas boiler) and near the bedrooms in your home.
- Make sure your gas appliances are checked annually by a registered Gas-Safety engineer.

12 Conclusion

Gas cooking is hazardous to our health and costly to society. Policy interventions to prevent hazardous air pollution from gas cookers are needed to protect human health and the environment. The UK Government should phase out gas cookers through its Ecodesign Regulations, removing this source of indoor air pollution from our homes. Electric cooking does not involve combustion of a fossil fuel in your kitchen; therefore, it does not release any harmful combustion related pollutants in the home. Though electric cooking solutions are a clean and accessible cooking alternative, the transition isn't happening fast enough. The UK Government should incentivise electric cooking appliances, to accessible the clean cooking transition reap the significant societal benefits. Costly investments in hydrogen, or relying on ventilation and individual behaviour to mitigate the risks of gas cooking, are not the answer. Making the switch from gas to electric cooking will improve indoor air quality, thereby protecting the health of millions of families across the UK.

Further Reading

This report is underpinned by several separate analyses, conducted by CLASP and our partners. If you are interested in diving deeper, please find those reports here on our website.

Organisational Information

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 programs are designed to maximize impacts by targeting high emitters, raising the bar through groundbreaking policies, and advancing technologies to meet sustainable development aspirations around the world.

https://www.clasp.ngo/

ABOUT EPHA

EPHA is a change agent, Europe's leading NGO alliance advocating for better health. A member-led organisation made up of public health NGOs, patient groups, health professionals and disease groups, we work to improve health and strengthen the voice of public health in Europe. Our actions and campaigns reflect our values: equity, solidarity, sustainability, universality, diversity and good governance. Since formal establishment in spring 1993, EPHA has built a solid network of 80 members dedicated to provide better health for all. Our mission is to bring together the public health community to provide thought leadership and facilitate change; to build public health capacity to deliver equitable solutions to European public health challenges, to improve health and reduce health inequalities. Our vision is of a Europe with universal good health and well-being, where all have access to a sustainable and high-quality health system: A Europe whose policies and practices contribute to health, both within and beyond its borders.

https://epha.org/

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