



Exposing the Hidden Health Impacts of Cooking with Gas

Cooking with gas produces indoor air pollution which negatively impacts our health. European policy measures and interventions are required to protect public health.

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Executive Summary

Findings

All gas cooking appliances release pollutants that are harmful to human health and the environment. With new research, this report synthesises the health risks of cooking with gas, quantifies the societal cost, and gives actionable solutions to phase out gas cooking appliances across the EU-27, in favour of electric alternatives. The findings are summarised here:

Cooking with gas releases hazardous air pollutants into our homes.

- Cooking on gas appliances may be exposing over 100 million people in Europe to levels of indoor air pollution that would violate EU outdoor air pollution regulations. Gas cooking appliances emit NO₂. There is documented association between NO₂ exposure and the development of asthma in children. Gas cooking also emits carbon monoxide, carbon dioxide, and unburned methane, which can languish indoors after appliance use.

Indoor air pollution from gas cooking harms people.

- The European Environment Agency recognises air pollution as the biggest environmental health risk in Europe. Over 700,000 children in the EU have suffered asthma symptoms in the last year due to cooking on gas. 12% of current paediatric asthma cases could be avoided if gas cookers were removed from EU homes. There is growing evidence linking combustion-related air pollution with adverse 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 positioning cooking with gas as a safe and preferred option. In part because of these efforts, people are widely unaware of the health and environmental risks posed by gas cooking, which are well documented through decades of research.

Cooking with gas is costly.

- Indoor air pollution from gas cooking is estimated to cost the EU **€3.5 billion** annually in healthcare costs, lost earnings

and productivity, and disability adjusted life years (DALY). Cleaner electric alternatives are already available at similar or lower cost. Government incentives for electric technologies would yield five to 16 times return on investment in terms of healthcare costs.

Ventilation is not enough.

- Range hoods aren't always turned on and may not be completely effective when used. Recirculation hoods — common in apartments — are aimed at odour removal and hardly remove NO₂, a primary pollutant of concern. Overall, vents are often ineffective, insufficient or underused.

Gas cooking undermines EU targets to become a climate-neutral economy by 2050.

- As a fossil fuel, cooking gas emits environmental pollutants like methane, benzene, and CO₂. Even when switched off, gas cooking appliances leak methane — a potent greenhouse gas.

Gas cooking undermines the EU's electrification and efficiency agendas.

- There are significant EU-wide efforts to increase efficiency of homes and buildings. Unfortunately, the more energy-efficient and well insulated a building, the worse the indoor air pollution from gas cooking if ventilation is inadequate. Energy efficiency and electrification efforts should go hand-in-hand, not undermine each other. Switching from gas to electric cooking during a building upgrade will improve the indoor air quality of a household.

Clean hydrogen is not a viable cooking fuel.

- Piping hydrogen into homes would require significant time and investment. Mixing hydrogen with methane changes the chemistry of the fuel, which can affect burner performance and decrease efficiency. Gas cookers would also likely need to be adapted or entirely replaced to function properly with hydrogen fuel. Testing performed for this study found that mixing hydrogen with gas can increase levels of pollutants that are harmful to human health.

Recommendations

EU policy does not protect people from the dangers of gas cooking. Despite the evidence, and unlike for cigarettes and cars, there are no warning labels for gas cooking appliances explaining their risks or pollutant emissions. There are no EU-wide or Member State policies in place that sufficiently mitigate the health and environmental risks of gas cooking. This report recommends that groups implement the following actions to change this:

- **The EU Commission** should adopt laws protecting households from harm, specifically by setting pollutant limits in the upcoming review of Ecodesign requirements on Domestic Cooking Appliances. The Commission should also communicate to the public about gas cooking hazards through the Energy Label and other means.
- **Member State and local governments** should vote in favour of people- and planet-conscious regulations, including incentivising efforts to accelerate the transition to electric cooking and full home electrification.
- **Health professionals** should increase public awareness about the link between gas cooking and health, and support actions to mitigate harm.
- **Individuals** should protect their health by making the switch from gas to electric cooking alternatives, such as induction hobs and plug-in appliances, whenever possible. People can also commit to proper ventilation and install a low-level carbon monoxide detector.



1 Introduction

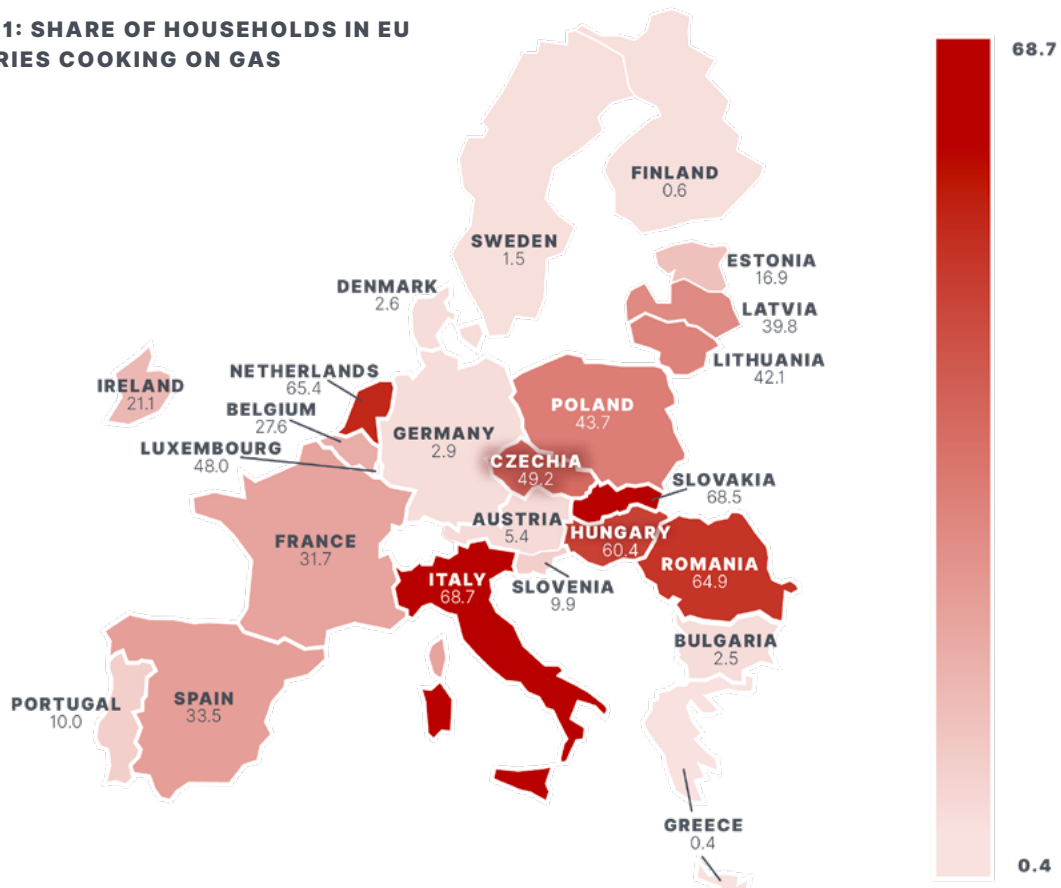
Across the European Union (EU), millions of people sit down to dinner cooked with gas, unaware of the invisible air pollution coming from their appliances. Decades of research have established a correlation between emissions from these appliances and detrimental impacts on health, including asthma and wheezing — particularly for children. The EU has an opportunity and responsibility to protect public health and phase out gas cooking appliances, facilitating the transition to clean, electric cooking.

Air pollution has been recognised by the European Environment Agency as the biggest environmental health risk in Europe,¹ while the World Health Organisation included it on the list of ten major threats to global health.² Exposure to high levels of 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 is significant, as a result of lower life expectancies, illnesses, greater healthcare

spending, and lower productivity. Emerging evidence shows that even low levels of 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.

In 2022, 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 – in this report, collectively referred to as gas “cookers” or “cooking appliances.” We found that throughout the EU, more than 30% of households cook on gas (Figure 1), releasing toxic pollutants — including nitrogen dioxide (NO₂), carbon monoxide (CO) and other emissions — into homes. Gas cookers may be exposing an estimated 144 million people in the EU to levels of indoor air pollution that regularly violate the EU's Ambient Air Quality Directives⁵ and WHO Air Quality Guidelines.⁶

FIGURE 1: SHARE OF HOUSEHOLDS IN EU COUNTRIES COOKING ON GAS



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 EU's Ambient Air Quality Directive and WHO indoor and outdoor Air Quality Guidelines are exceeded;
- A review of the technical standards associated with gas and electric cooking to determine gaps and opportunities to include air quality in cooking appliance testing requirements, and to ensure people can make easy 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 EU to determine what is being done to address the health, environmental, and economic impacts of gas cooking.

The evidence from the above studies is summarised in the rest of this report and can be referenced here. The analysis determined that there is a significant but solvable public health problem created by the emissions from cooking with gas.

The impact of gas cooking on the burden of childhood asthma to be comparable to that of second-hand smoke, research has found.⁷ However, unlike cigarettes⁸ or cars⁹, which carry a health warning to inform people of the risks and pollution levels, there isn't a label on these appliances to warn buyers of the potential health impacts or polluting emissions from burning gas indoors. Despite the documented health risks, the proponents of gas have cultivated positive language and messaging around the fuel, including use of the adjective 'natural' to obscure the risks. This misnomer leads people to believe that gas is clean, good for the environment, and safe for household use. Even though the EU's single market is slowly transitioning away from gas towards electric cooking – including hot plates, infrared heat, and induction – the market for gas cookers remains strong,¹⁰ and the impact on public health persists.

The European Commission is currently conducting a review of the Ecodesign and Energy Labelling requirements for domestic cooking appliances,ⁱ which presents an opportunity to consider and address health and environmental impacts caused by gas cookers. For this reason, CLASP and our partners 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 that can remove the risk.

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

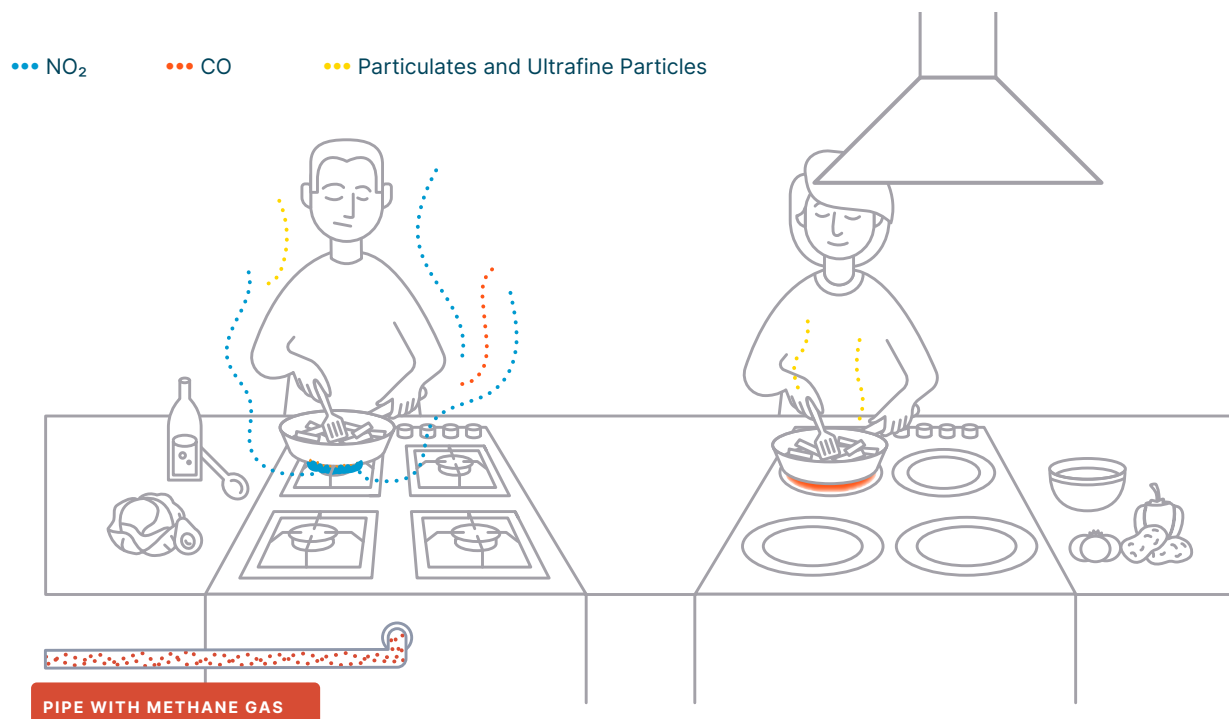
Gas cooking appliances may be exposing millions in the European Union to levels of indoor air pollution that violate outdoor air pollution regulations. There are well-known sources of air pollution outdoors — such as transport vehicles and industrial factories — but indoor exposures are critically important as well, with Europeans spending approximately 90% of their time indoors.¹¹ For households that use them, gas cookers are one of the main sources of indoor air pollution, leading to detrimental health impacts. Indeed, World Health Organisation (WHO) Europe recognises

gas appliances as one of the major factors in people's overall exposure to nitrogen dioxide.¹²

Nitrogen dioxide (NO₂) is one of the major health-damaging air pollutants¹³ and is produced by the gas flame.¹⁴ The European Environment Agency estimates that 94% of the European urban population is exposed to ambient NO₂ concentrations above the WHO's 2021 Air Quality Guidelines, with 4% exposed to concentrations above the EU outdoor standards in the Ambient Air Quality Directive from 2008.¹⁵

There is a documented association between levels of exposure to NO₂ — 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.



Our modelling found that WHO air quality guidelines are regularly exceeded indoors when cooking meals with gas appliances.

Indoor air pollution levels should be lower than outdoor ones due to factors such as removal of NO₂ by the building envelope. However, indoor levels may in fact exceed outdoor levels,¹⁶ when an indoor NO₂ source — like a gas hob — is present.

In households that use gas cookers and have ineffective ventilation, indoor air pollution levels can be so high they exceed the outdoor standards set by the EU's Ambient

Air Quality Directives as well as the WHO Air Quality Guidelines.¹⁷ The WHO's Guidelines are established by an international group of independent health experts. They serve as a global guideline for public health based on the best scientific evidence and apply to both indoor and outdoor environments. While these are not legally binding, they inform legislation such as the EU Ambient Air Quality Directives, which are less strict than the WHO Guidelines.

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. ¹⁸
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. ¹⁹ Long-term exposure to low levels of CO may cause permanent mental or physical problems, and can increase chances of dementia, and possibly, Parkinsonism. ²⁰
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. ²¹
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. ²² CH ₄ contributes to the formation of ground-level ozone, which is associated with premature mortality. ²³
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 lungs and move to all organs. Compared to PM _{2.5} , they cause increased pulmonary inflammation and remain in the lungs for longer. ²⁴
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. ²⁵

144 million people living in the EU (35% 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.²⁶

The simulation study revealed that a typical household in Europe cooking on gas regularly exceeded the WHO daily NO₂ guideline value of 25 µg/m³ in nearly all gas cooking scenarios. The current EU outdoor hourly limit value of 200 µg/m³ NO₂ was also exceeded indoors multiple times each week. The only exception was for a large kitchen with mechanical ventilation or when using a range hood that vents to the outside. The simulation study found that gas cooking households located in urban areas with higher outdoor concentrations of NO₂ due to traffic and other pollutant sources may be exposed to indoor pollution levels that exceed even the existing and soon to be revised EU annual limit value of 40 µg/m³ in ambient air. This limit is set to protect our health.

These findings are in line with previous research. One modelling study²⁷ found homes using gas stoves regularly experienced average NO₂ exposures of over 280 µg/m³ for at least one hour every day.

The typical kitchen simulations were based on average cooking frequency and duration, paired with building and ventilation conditions, with and without use of range hoods venting to the outside. Table 2 presents the simulated indoor air pollution (nitrogen dioxide, NO₂) levels for gas cooking kitchens typically found in rural areas of Southern and Eastern Europe and an urban area in Western Europe.

The kitchens are projected to experience air pollution levels that would exceed the World Health Organisation's 2021 Air Quality Guidelines and the EU's Ambient Air Quality Directive — multiple times per week, every week. For example, in the kitchen modelled in rural Southern Europe, the EU hourly limit of 200 µg/m³ will be exceeded five times per week. The last column on the right reveals that when the family converts to electric cooking, they dramatically reduce indoor air pollution in the home — with NO₂ concentrations dropping such that the pollution limits are no longer exceeded (except in urban Western Europe, due to the outdoor air infiltration).

Starting in early 2023, CLASP will gather real time data on air quality in 280 kitchens across Europe to confirm these modelled results.



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

NO ₂ CONCENTRATION LIMIT VALUES	UNITS	REFERENCE (TODAY)	IMPROVED AIR TIGHTNESS	WITH USE OF COOKER HOOD	ELECTRIC COOKING
Scenario: Southern Europe, Rural Household					
Exceeds WHO annual limit of 10 µg/m ³	Yes/No	Yes	Yes	Yes	No
Exceeds WHO daily limit of 25 µg/m ³	Yes/No	Yes (5)*	Yes (5)*	No	No
Exceeds EU annual limit of 40 µg/m ³	Yes/No	No		No	No
Exceeds EU hourly limit of 200 µg/m ³	Yes/No	Yes (5)**	Yes (5)**	No	No
Scenario: Eastern Europe, Rural Household					
Exceeds WHO annual limit of 10 µg/m ³	Yes/No	Yes	Yes	Yes	No
Exceeds WHO daily limit of 25 µg/m ³	Yes/No	Yes (2)*	Yes (2)*	No	No
Exceeds EU annual limit of 40 µg/m ³	Yes/No	No	No	No	No
Exceeds EU hourly limit of 200 µg/m ³	Yes/No	Yes (7)**	Yes (9)**	No	No
Scenario: Western Europe, Urban Household					
Exceeds WHO annual limit of 10 µg/m ³	Yes/No	Yes	Yes	Yes	Yes***
Exceeds WHO daily limit of 25 µg/m ³	Yes/No	Yes (5)*	Yes (5)*	No	No
Exceeds EU annual limit of 40 µg/m ³	Yes/No	No	No	No	No
Exceeds EU hourly limit of 200 µg/m ³	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

Homes can achieve the largest reduction in indoor concentrations of NO₂ by transitioning from gas cooking to electric. Switching to electric cooking eliminates gas flame-created nitrogen dioxide, carbon monoxide and ultrafine particle emissions. In addition, methane leaks and unburned methane released by the gas cooker would be eliminated. This finding is a key consideration for EU policymakers, as they have an opportunity to transition new domestic cooking appliance installations away from this indoor air health hazard through the Ecodesign Directive.

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 blood cancer. A recent study of Californian homes found that benzene concentrations from gas cooking appliances

resulted in hazardous indoor levels of benzene under certain conditions.²⁸ In Europe, a 2013 study²⁹ found benzene 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.

Kitchens in the EU 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. Often, these households are encouraged to switch to gas, citing it as a clean fuel alternative.³⁰ Instead, these households have the opportunity to “leapfrog” from solid-fuel cooking directly to clean electric cooking, skipping over polluting gas cookers that harm public health.

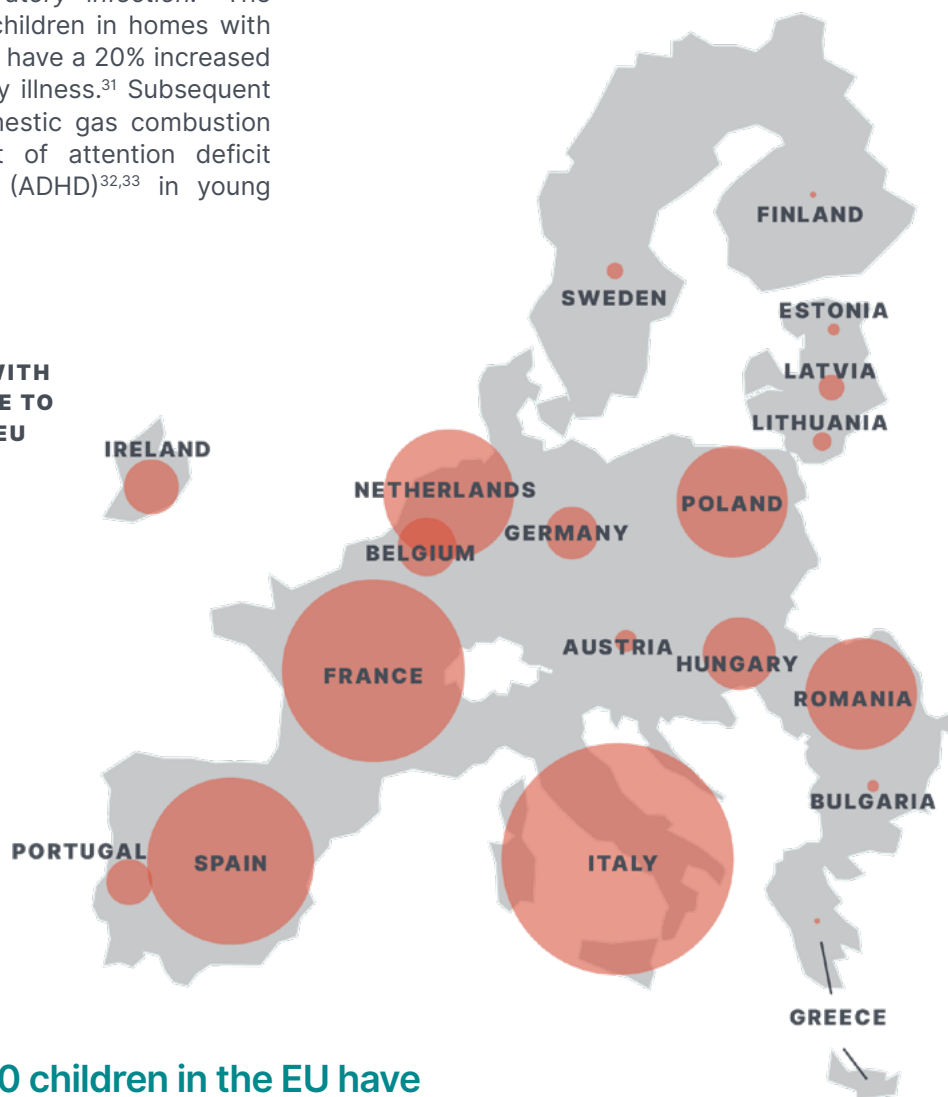
3 Indoor Air Pollution from Gas Cooking Harms People

Gas cooking contributes 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 NO₂ 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.³¹ Subsequent research also ties domestic gas combustion with the development of attention deficit hyperactivity disorder (ADHD)^{32,33} 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.³⁴

FIGURE 3: CHILDREN WITH CURRENT ASTHMA DUE TO GAS COOKING IN THE EU

Red circles are proportionally representative of the number of children



Over 700,000 children in the EU have asthma symptoms linked to gas cooking.

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 NO₂ exposure have been associated with increases in the number of days with limited speech, cough,

and nocturnal symptoms.³⁵ 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.³⁶ Meanwhile, short-term exposure to NO₂ levels over 150 µg/m³ can lead to negative outcomes for all children, such as significant increases in sore throats, colds and absences from school.³⁷

TABLE 3: ESTIMATED NUMBER OF CHILDREN WITH CURRENT ASTHMAⁱ DUE TO COOKING WITH GAS, BASED ON 2003 ASTHMA PREVALENCE DATA³⁸

	HOUSEHOLDS COOKING ON GAS	# OF CHILDREN	% CHILDREN WITH ASTHMA IN 2003	PAF	#CHILDREN WITH CURRENT ASTHMA DUE TO GAS COOKING
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
Portugal	10.0%	1,549,900	14.7%	4.0%	9,183
Latvia	39.8%	286,702	7.2%	14.3%	2,956
Croatia	22.8%	624,001	5.2%	8.7%	2,836
Austria	5.4%	1,368,972	7.0%	2.2%	2,125
Lithuania	42.1%	413,788	2.5%	15.0%	1,554
Sweden	1.5%	1,535,088	12.0%	0.6%	1,153
Estonia	16.9%	201,633	4.8%	6.6%	641
Bulgaria	2.5%	1,056,164	5.5%	1.0%	604
Finland	0.6%	842,189	7.7%	0.3%	163
Greece	0.4%	1,584,304	4.5%	0.2%	120
Slovakia	68.5%	829,866		22.3%	—
Luxembourg	48.0%	95,149		16.8%	—
Czechia	49.2%	1,627,765		17.1%	—
Slovenia	9.9%	315,999		4.0%	—
Denmark	2.6%	880,415		1.1%	—
Cyprus	—	183,519		—	—
Malta	—	67,115	14.1%	—	—
EU27	32.6%	67,678,078		12.0%	771,464

i. Having asthma symptoms occurring within the last 12 months

Based on our research, 12% of the current paediatric asthma cases in the EU (as shown in Table 3, over 700,000 children) could be avoided if gas cookers were removed overnight.³⁹ CLASP used the population attributable fraction to estimate how many children in the EU currently have asthma due to cooking on gas.ⁱⁱ If childhood asthma persists into adulthood, it is likely to cause more severe symptoms than adult-onset asthma.⁴⁰

The European Environment Agency estimates that 40,400 premature deaths⁴¹ are linked to exposure to ambient NO₂. 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. Based on 2019 health data⁴², the number of DALYs lost due to asthma in the EU was estimated at 1 million. Of these, our study determined that 73,000 DALYs were caused by cooking on gas, based on the population attributed fraction of 7.3% of childhood asthma.

There is growing evidence linking combustion related air pollution with adverse effects on brain development in young children⁴³. A 2009 Spanish study⁴⁴ found linkages between the presence of gas cooking appliances and the concentration NO₂ during the first three months of life and the neuropsychological development by 4 years old. Early life exposure to household gas appliances was associated negatively with general cognitive functioning and with a higher risk of developing ADHD. A recent Chinese study⁴⁵ suggests that cooking during pregnancy is associated with an increased risk of hyperactive behaviours in children at around 3 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.⁴⁶

Cooking on gas adds to the health burden of air pollution, with NO₂, 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.

FIGURE 4: HEALTH IMPACTS OF POLLUTANT EXPOSURE

CHILDREN

NERVOUS SYSTEM

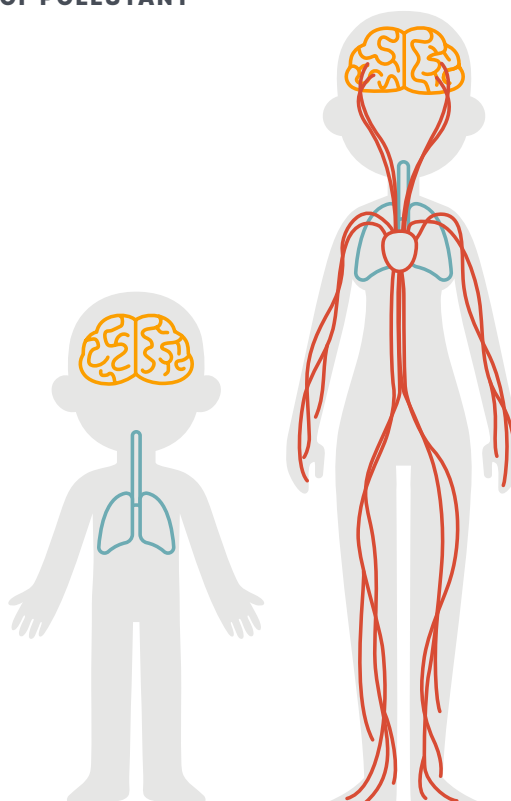
IQ, learning deficits, psychiatric problems in the transition to adulthood (CO₂, PM, NO₂)

RESPIRATORY SYSTEM

Irritated airways and aggravated respiratory symptoms, such as wheeze, cough, chest tightness, difficulty breathing (PM, NO₂)

Asthma, reduced lung function and increased susceptibility to lung infections (NO₂)

Changed lung function



ADULTS

NERVOUS SYSTEM

Impacts on the central nervous system (CO₂, PM)

RESPIRATORY SYSTEM

Pulmonary function/breathing problems (O₃, PM, NO₂, BaP)

Irritation of the eyes, nose and throat

Irritation, inflammation and infections

Asthma and reduced lung function (NO₂)

Chronic obstructive pulmonary disease (PM)

Cancer (PM)

CIRCULATORY SYSTEM

Cardiovascular diseases (PM, NO₂)

Impacts on liver, spleen and blood (NO₂)

Blood pressure (NO₂)

ii. The population attributable fraction (PAF) is an epidemiologic measure widely used to assess the public health impact of exposures in populations. PAF is defined as the fraction of all cases of a particular disease or other adverse condition in a population that is attributable to a specific exposure (9 BMJ 2018;360:k757).

4 Cooking with Gas is Costly

Cooking with gas, though often perceived as inexpensive, costs society and individuals quite a lot. In 2019, the International Respiratory Coalition estimated the EU's annual societal cost of asthma to be €48 billion. This amount includes increased health costs, lost earnings and productivity, and DALYs.⁴⁷ Multiplying that total cost by 7.3% as the population attributable fraction (PAF) of just paediatric asthma due to gas cooking appliances, we estimate the societal cost of gas-cooking indoor air pollution at least at €3.5 billion annually.⁴⁸

In the United States, children living in homes with gas cookers and higher concentrations of NO₂ reported increased use of asthma rescue medication in the evenings and nights following their exposure in the kitchen.⁴⁹ Changing a gas cooking appliance to an electric one reduced US asthma patients' need for medication, which resulted in annual savings of €175 (\$180 USD) per patient.⁵⁰

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 €29 billion (0.2% of total GDP) in 2018.⁵¹ This translates into a cost of €130/year for an average European household. 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.

Asthma related to gas cooking costs the EU society at least €3.5 billion annually.

Cooking with electricity can be cost-effective.

On the other hand, there is a readily available clean technology that households and EU governments can invest in to remove the burden of these societal health costs.

Studies^{52,53} show that electric cookers can be purchased at similar or lower costs to gas cooking appliances, depending on technology and their functionalities. Although induction technology currently comes with more expensive upfront costs, infrared hobs are comparable in price to gas options. Electric hotplates are the cheapest hob solution on the market.

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 price trends of the last five years. We found the costs between gas and electric hotplates comparable.

Looking at the other clean electric cooking options, namely infrared hobs and induction hobs, CLASP explored the possibility of a government incentive programme to accelerate the uptake of these technologies. The cost to government for such incentives would be far outweighed by the larger societal benefit, in terms of healthcare costs. For example, we found that:

- A €75 incentive per purchase to make the total cost of ownership of infrared hobs comparable to gas hobs would yield a sixteen-to-one return on investment.
- A €250 incentive per purchase to make the total cost of ownership of induction hobs comparable to gas hobs would yield a five-to-one return on investment.

5 Ventilation is Not Enough

Existing ventilation strategies are largely inadequate, raise energy bills, and are often inconvenient for users, according to research. When used, range hoods can reduce the hazardous air pollution caused by gas cooking, but the only sustainable and robust solution is to remove the source of pollution from your kitchen. Many kitchens across the EU include a range hood — however, not all ventilation technologies are equally effective, nor do people use them every time when they cook. When used correctly, range hoods ducted to the outside can reduce concentrations of harmful pollutants.

When correctly installed, maintained, and operated, ducted range hoods located directly over or behind the hob can reduce NO_2 and other pollutant levels, with better respiratory health results.⁵⁴ An American study⁵⁵ 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%.

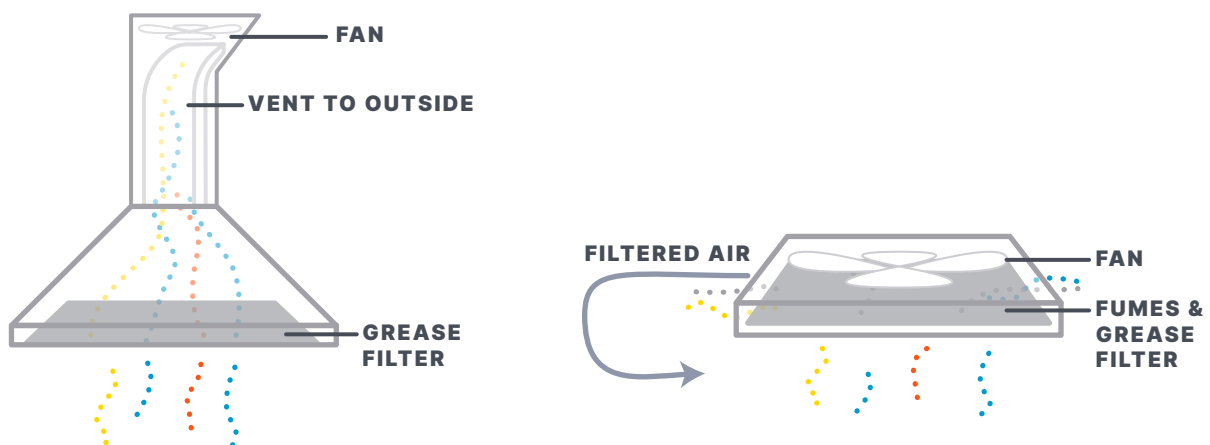
Range hoods can be more effective, particularly in reducing $\text{PM}_{2.5}$ concentrations, if used during and for a period of time after cooking. Using ventilation for ten minutes after cooking lowered $\text{PM}_{2.5}$ concentrations by an average of 58% in one study, conducted in a full-scale test house.⁵⁶ However, these indoor air quality and health benefits come at the expense of higher energy consumption, as the fan must run for longer.⁵⁷

Range hoods are not always turned on while cooking — in Germany, they were only used 29% of the time.

HOW DOES COOKING VENTILATION WORK?

The range hood uses a mechanical fan and grease filter to collect steam, smoke and fumes and extract airborne particles generated while cooking. Range hoods can be ducted, where pipes carry airborne particles from the kitchen to outdoors.⁵⁸ They can also be ductless, 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.⁵⁹

FIGURE 5: DUCTED AND DUCTLESS (RECIRCULATION) RANGE HOODS



The filters in recirculation range hoods — common in apartments — are not appropriate for capturing NO₂ and ultrafine particles.

Existing domestic kitchen ventilation strategies and airflow rates are inadequate in over 80% of houses when the range hood is used only while cooking, research shows.⁶⁰ Range hoods are more effective when using the back burner than they are for the front burner,⁶¹ but households do not necessarily always use the back burners. Additionally, studies show that range hoods are not always turned on while cooking. In Germany, for example, range hoods were turned on during 29% of cooking times,⁶² while a study in the UK found that 27% of the women cooking on gas reported that they had an extractor fan, and of those, 40% were recirculating in the kitchen.⁶³ In the UK, no protective effect was observed for women who reported they used the range hood most of the time, compared with women who had no range hood or who used it infrequently.

Many households do not have range hoods ducted to the outside, but instead have ductless hoods that simply recirculate the air in the kitchen.⁶⁴ 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 NO₂ 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 NO₂ concentration remained above the WHO indoor air 1-hour Air Quality Guideline.⁶⁵

Optimised absorption filters could help reduce the NO₂ 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 NO₂, hence doubling the NO₂ concentration due to gas cooking.⁶⁶

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

Cooking on any appliance can generate certain pollutants such as particulate matter (PM_{2.5}) and volatile organic compounds.⁶⁷ Effective kitchen ventilation should therefore be available in all homes and operated as a precaution during and after cooking.⁶⁸

Cooking on any appliance can generate certain pollutants such as particulate matter (PM_{2.5}) and volatile organic compounds. Effective kitchen ventilation should therefore be available in all homes and operated as a precaution during and after cooking.

Current European Ecodesign Regulations address performance requirements for range 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. However, a move to phase out gas cooking appliances would help to mitigate this challenge of indoor air pollution and protect the health of people across the EU.

HOW TO PROPERLY EMPLOY VENTILATION IN A KITCHEN WITH A GAS COOKER:

- 1 Purchase ventilation equipment that has sufficient capacity and air flow rate (i.e., suction) for your gas cooker;
- 2 Ensure the installation of the range hood is ducted to exhaust to the outside (i.e., do not install the hood in a recirculation mode);
- 3 Operate the range hood on the appropriate setting during and ideally 10 minutes after cooking, regardless of the season; and
- 4 Clean the grease filters frequently and ensure fan and other components remain clean and operable.

6 Gas Cooking Undermines EU 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, there is no question that insulating homes and sealing up draughts and air leaks is economically beneficial. However, insulating households and buildings that rely on gas for cooking can increase levels of indoor air pollution, undermining efforts to achieve more sustainable and safe living and working spaces.

Pollutant concentrations from indoor sources — like gas cookers — dangerously increase in more airtight buildings, especially if the kitchen does not have an effective ventilation system. As the housing stock is made more energy-efficient, less air from outdoors infiltrates the home. 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.

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.

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 gas supply, and therefore keeps the option to connect other gas-powered appliances like heating systems available. To equitably transition European homes to electricity-powered appliances, gas cooking and heating must be phased out simultaneously.

CASE STUDY: RESIDENTIAL GAS HEATING AND COOKING SHOULD PHASE OUT SIMULTANEOUSLY

EU electrification efforts require phasing out gas in homes. Residential heating and cooking activities are major sources of greenhouse gas and air pollutant emissions, accounting for 84% of total household energy consumption.⁶⁹ In the review of Energy Performance of Buildings Directive (EPBD), the Commission is proposing to ban the use of fossil fuels including gas in new buildings. To effectively address high energy prices and reduce dependence on Russian fuel, the EU Commission launched RePowerEU,⁷⁰ a plan that includes doubling the installation of heat pumps in the coming 5 years. In addition, the Commission stated its intent to phase out the sale of stand-alone gas boilers before the end of this decade (via Ecodesign — see EU Save Energy Plan).

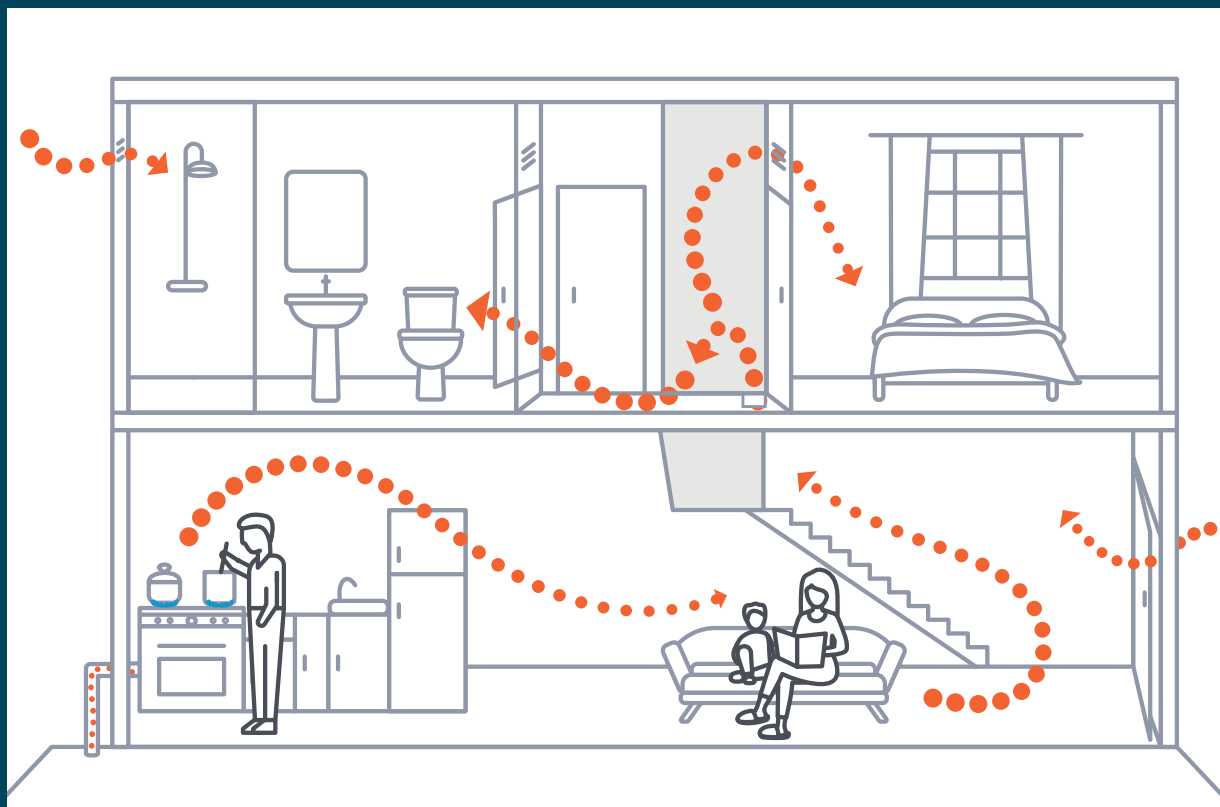
In all scenarios, switching from gas to electric during a building upgrade will improve the indoor air quality of a household.

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.⁷¹ The simulation looked at four 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 air tightening 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 $200 \mu\text{g}/\text{m}^3$. 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 $6.0 \mu\text{g}/\text{m}^3$; at the same time, there was a significant increase of CO_2 and $\text{PM}_{2.5}$. Another study that modelled the performance of houses in Boston predicted a 15% increase in NO_2 concentration due to weatherisation of these homes.



7 Gas Cooking Undermines EU Climate Goals

Gas cooking is antagonistic of EU targets to become an economy with net-zero greenhouse gas emissions by 2050. The EU aims to be climate-neutral by 2050 — this objective is at the heart of the European Green Deal⁷² and in line with the EU's commitment to global climate action under the Paris Agreement.⁷³ As a fossil fuel, gas emits pollutants that cause harmful negative environmental impacts — like methane, benzene, CO₂ and other harmful pollutants.

Even when switched off, gas hobs leak methane — a potent greenhouse gas. Methane is the main component of fossil gas used for cooking, when burned or released it can warm the Earth more than 80 times as much as the same amount of carbon dioxide over a 20-year period. Methane also contributes to ground-level ozone pollution, which can cause breathing problems and other health issues.⁷⁴ A US study estimated that gas cookers emit between 0.8–1.3 percent 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.⁷⁵ The EU is working on a methane strategy, recognising that reduced emissions could play a “very significant role” in enabling it to increase its climate ambitions for 2030.

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 56mg/hour methane leakage compared to the US 57.9 mg/hour findings.⁷⁶

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.⁷⁷ 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 Treaty⁷⁸ to protect lives of current and future generations. Phasing out gas cookers will further the European Union's climate agenda, reducing considerable amounts of methane and CO₂ emissions.⁷⁹

A US study estimated that gas cookers emit between 0.8–1.3 percent 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 efforts⁸⁰ in favour of gas as a key obstacle to ending the climate emergency. These well-funded endeavours directly undermine efforts to reduce indoor air pollution and efforts to educate the public on the health risks of gas cookers.

The 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. Campaigns led by Gas Distributors for Sustainability (G4DS)⁸¹ and Natural Allies⁸² spend millions of euros a year to position gas as a clean energy solution. G4DS for example, is a coalition of five gas companies: Italgas (Italy), GrDF (France), Distrigaz Sud Retele (Romania), Galp Gás Distribuição natural (Portugal) and Gas natural (Spain) to “promote gas as an alternative, clean energy source to the current ones and as a solution, already available and ready, to lead the world towards a more sustainable energy future.” Other campaigns like Rural Futures, led by Liquid Gas Europe, push rhetoric against electrification and stipulate that “Liquid gases represent a healthier, sustainable, and cost-effective solution, especially in homes currently using coal or biomass.”⁸³

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 instances⁸⁴ 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.”⁸⁵

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



According to Clean Creatives,⁸⁶ the fossil fuel industry's public relation campaigns are creating legal and reputational risks for advertising agencies. Over 1800 cases⁸⁷ 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 Netherlands⁸⁸ and UK,⁸⁹ respectively, demanding that they end campaigns misleading the public. Fossil fuel advertisements have now been banned in France,⁹⁰ and bans are being considered elsewhere.⁹¹

Outside of proper advertisements in media sources like newspapers and television programming, positive gas cooking appliance depictions are featured across the culinary realm. Popular cooking shows like the *Top Chef* enterprise often showcase demonstrations on gas hobs.

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.

In 2022, the Global Cooksafe Coalition (GCC) 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.



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 in home cooking. The European Commission is investing billions⁹² in hydrogen solutions to meet its 2050 net-zero climate targets.⁹³ While the focus is on the potential for the industrial sector, the gas and appliance industries are also looking to hydrogen as an alternative solution to replace gas for residential heating and cooking.^{94,95}

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 and are thus more harmful to human health. Mixing hydrogen and gas does not decrease levels of pollutants that are harmful to health, and therefore does not solve the indoor air pollution problem associated with gas cooking.

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

UNDERSTANDING HEALTH IMPACTS FROM BLENDING HYDROGEN WITH GAS FOR COOKING

In 2022, CLASP and TNO Laboratories conducted an exploratory study⁹⁶ 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, nitrogen dioxide (NO₂) levels increased with hydrogen mix and on others it decreased. On average there was a 6.5% increase in NO₂. 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 were confirmed to 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 the pollutants outlined above (UFP, NO₂, CO, CO₂, CH₄). Electric cooking was confirmed to be the safe, clean cooking option in domestic settings.

This is in line with the European Commission's findings 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"**.⁹⁷ 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,98}

Additionally, 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.⁹⁹ 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.¹⁰⁰

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.¹⁰¹ 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.¹⁰² The UK government has found that hydrogen boilers could cause four times as many house explosions as gas.

The UK government found that hydrogen boilers could cause 4x as many house explosions as gas.

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.^{103,104,105} This investment could instead be funnelled towards electric cooking solutions, which are accessible, more affordable, and safer for people and the planet.



i. Per 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 EU and Member State Policies Fail to Protect People

There are currently no EU-wide policies in place to mitigate the health and environmental risks of gas cooking. A growing body of evidence demonstrates that indoor air pollution is a health hazard to people across the EU. While the European Commission has a series of policies to tackle air pollution, significant gaps on indoor air quality remain. Ecodesign is well positioned to cover this gap.

BUILDING POLICY

The **Energy Performance of Buildings Directive**,¹⁰⁶ which is currently under revision,¹⁰⁷ will include indoor air quality

COOKING TO BE PHASED OUT IN NEW BUILDINGS

The existing Energy Performance of Buildings Directive requires that general indoor requirements are respected to avoid negative outcomes, such as inadequate ventilation. The proposed revisions to the Directive include ambitious requirements for “new buildings that, where technically feasible, 100% of on-site energy consumption is covered by renewable energy as of 2030, with an earlier adoption as of 2027 for public buildings.”¹⁰⁸ In theory, gas cookers could not be fitted in new builds under the proposed Directive, unless significant advances are made on infrastructure for clean hydrogen. The proposed legislation also suggests that all Member States must address areas beyond energy performance, including “healthy indoor climate conditions”. However, there is a major policy gap because gas cooking appliances can still be installed in existing or old buildings.

requirements in new builds. However, these plans do not address the situation in older buildings, nor regulate pollutant emissions from cooking or the use of range hoods.

HEALTH & AIR QUALITY POLICY

European policies centre health as a priority. There are a number of EU policy and legislative frameworks that call for health to be considered in decision-making, but they do not yet address gas cooking in a meaningful way. For example:

- The **Treaty on the Functioning of the European Union (TFEU)** Article 191(1) states that EU environmental policy must “protect human health” in addition to improving the quality of the environment.¹⁰⁹
- The **European Ambient Air Quality Directives (AAQD)** state that measures should be taken to reduce emissions at the source.¹¹⁰ They are under revision and are expected to bring EU limit values for NO₂ and other pollutants closer to the latest (2021) WHO Air Quality Guidelines. The new proposal states that legislation setting emission standards for key sources of air pollution is one of the three pillars of the clean air policy framework. They both reference the Ecodesign Directive (2009/125/EC) as a relevant legislative instrument for meeting Directive objectives.¹¹¹
- The European Parliament published a **Resolution on the Implementation of the Directives** in 2021, recognising that existing legislation does not go far enough to tackle indoor emissions. The Resolution requests the European Commission explore possible legislative remedies for all relevant sources of indoor air pollution.¹¹²

- **The Zero Pollution Action Plan to 2050**, a 2021 communication by the European Commission,¹¹³ is intended to improve air quality, with a goal of reducing the number of premature deaths caused by air pollution by 55%. It uses the Precautionary Principleⁱ as its foundation, including protecting human health and eliminating risks at the source.
- The **Gas Appliances Regulation (GAR)** fails to identify pollutants of concern or establish limit values. The GAR¹¹⁴ states that gas appliances shall be designed so that appliance combustion emissions do not contain unacceptable concentrations of substances harmful to health.¹¹⁵ It does not, however, define those combustion substances or the 'unacceptable concentrations' thereof. The GAR states that other pieces of EU legislation, including Ecodesign Directive, take precedence if they cover aspects addressed in the GAR.¹¹⁶

ECODESIGN DIRECTIVE

The Ecodesign Directive is well-positioned to limit harmful pollutants from gas cooking.

The Directive requires “emissions to air” be taken into consideration when developing regulations.ⁱⁱ “Emissions to air” include greenhouse gases, acidifying agents, fine particulate matter, and suspended particulate matter. Despite these requirements, these aspects have not yet been considered by the Commission^{117,118} for domestic ovens, hobs, and range hoods.

The Ecodesign Directive has established limits on air pollutant emissions, specifically NO₂, for other appliances and equipment that involve fuel combustion. All space heating products include NO₂ limits in their design standards.ⁱⁱⁱ

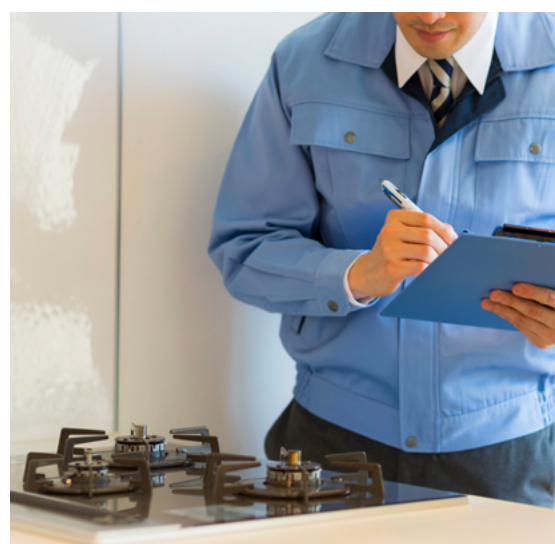
The European Commission is currently revising regulations for domestic cooking appliances. The review study for these regulations, prepared by the Joint Research Centre (JRC),¹¹⁹ provides an in-depth assessment of the oven, hob and range hood market and policies. However, the review

study does not consider polluting or harmful emissions, as required and/or recommended by the policies mentioned above.

ENERGY LABELS & COMPARATIVE TEST METHODS

Currently, the methods by which gas and electric cooking appliances are tested are different, even though they perform the same function. These separate standards mean the products can't be fairly compared or featured on one common energy label. The JRC review study recommends separate performance requirements and Energy Labels for gas and electric ovens, in line with the current Ecodesign domestic cooking appliance regulations. It also recommends separate performance requirements for gas and electric hobs, and no Energy Labels for these product types.

Adopting a transitional test method that sets out a common test method for both gas and electric cookers would allow the Commission to develop an energy label with an A to G performance scale. The label could also convey information on the emissions of hazardous indoor air pollutants such as NO₂ and CO. Without comparative energy labels for gas and electric cooking appliances, people are unable to make informed purchasing decisions that are best for their finances, the climate, and their family's health.



i. The [precautionary principle](#) is detailed in [Article 191 of the Treaty on the Functioning of the European Union](#). It aims at ensuring a higher level of environmental protection through preventative decision-taking in the case of risk. However, in practice, the scope of this principle is far wider and also covers consumer policy, [European Union \(EU\) legislation concerning food](#) and human, animal and plant health.

ii. Annex 1, Method for setting generic Ecodesign requirements; Part 1, Ecodesign parameters for products; Paragraph 1.3(k)

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

MEMBER STATE & LOCAL EFFORTS TO SUPPORT CLEAN COOKING

Member States can do even more to protect public health. Indoor air quality is becoming increasingly important at the national level, and additional efforts are needed to transition from gas to alternative, cleaner technologies. Member States can conduct research, develop policies and guidelines, and implement awareness raising campaigns.

Governments should remove subsidies for fossil fuel-based appliances and incentivise electrification instead. Across the EU, decarbonisation of the built environment is a priority. These efforts include incentives for

building renovation policies and installation or replacement of low-carbon appliances. Many countries still offer incentives for fossil fuel-powered appliances, which undermines the push for cleaner, healthier technologies. Incentive programmes for electric cooking, as well as heat pump technologies, can accelerate decarbonisation.

City governments are pivotal in achieving the transition to healthier cooking and decarbonisation. European cities may be best positioned to build awareness of the health risks of gas cooking and support those households least able to make the transition to cleaner cooking and heating.

CASE STUDY: EQUITY AND CULTURAL CONCERNS VS. INDOOR AIR QUALITY – THE LITHUANIAN LPG REPLACEMENT PROGRAMME¹²⁰

The Lithuanian Ministry of Energy launched a program in 2019 to phase out the use of LPG tanks used for cooking due to safety concerns. On average, 4–5 accidents occur annually due to gas tank explosion. From late 2022, LPG tanks will be banned from apartment buildings with 3 or more stories. The programme targeted 1600 apartment buildings (about 42,000 apartments). The alternative solutions to LPG include: 1) switching to electric cookers or 2) switching to gas cookers connected to central gas supply.

Infrastructure improvements are generally required whether to upgrade the power supply capacity in apartments or to connect to the central gas supply. To cushion the costs, the Government offers up to €726 subsidy per household for purchasing a cooker and upgrading power source/installing gas supply. In 2020–2021 the programme cost the Government €14.5 million; €9.5 million funding was allocated for 2022.



11 Recommendations



European Commission

- **Phase out harmful gas cooking:** Taking into account the health and environmental impacts, the EU Commission should phase out the sale of new gas cookers by setting NO₂ emission limits as early as possible through the ongoing revision of the Ecodesign regulations for domestic cooking appliances.
- **Provide information on harmful gas cooking emissions to consumers, ideally on a comparative Energy Label:** The European Commission should also adopt a common transitional test method for gas and electric cookers, and establish a common Energy Label, so people can compare products. 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 range hoods Ecodesign requirements:** This will ensure range hoods better remove pollutants from the kitchen, when used appropriately.
- **Fund the transition to cleaner electric cooking:** The European Commission should provide funding to Member States and organisations to support the transition to cleaner electric cooking technologies, with low-income households and public housing as a first priority.



Member States and Local Government

- **Vote in favour of people- and planet-conscious regulations in the EU:** Support the phaseout of gas cookers through strict emission limits in Ecodesign Regulations. Support a common Energy Label and test method for electric and gas cookers that addresses pollutants so people can make informed purchasing decisions.
 - **Ban gas cooking appliances in new construction:** Roll out national electrification plans that require electric heating and cooking to be installed in new buildings as soon as possible. This should occur in conjunction with the Energy Performance of Buildings Directive, in support of the EU's net-zero targets.
 - **Accelerate the transition to electric technologies:** Establish trade-in programmes and retrofit schemes to upgrade from gas to electric cooking. Provide industry or consumer incentives to make induction cooking more accessible.
- Eliminate existing subsidies and incentives for fossil fuel-based appliances, which hinder a transition to newer, renewable and efficient technologies. Prioritise retrofits for low-income households and public housing.
- **Run public health awareness campaigns:** Work with local partners to develop nationally 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.
 - **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.



Individuals and Households

- **Replace the gas cooker:** Replace gas 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 range hoods while cooking and for at least 10 minutes after. Clean grease filters regularly to ensure that exhaust capacity is not reduced by grease and grime. Use back burners that are closest to the range hood. Ideally, range hoods should vent outdoors so fumes are directed out of the kitchen. Open windows if there is no ventilation system.
- **Install and maintain carbon monoxide detectors:** Install detectors in kitchens and near bedrooms. Use devices that detect low levels.



Healthcare Organisations and Professionals

- **Advocate for greater investment in indoor air pollution awareness and mitigation:** The WHO recognised¹²¹ 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 informing physicians, health care providers, and the public that cooking with gas increases household air pollution and the risk of childhood asthma.¹²²
- **Conduct additional health research:** Continue research on the health risks from poor indoor air quality and pollution levels due to gas cooking.



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 European Commission should phase out gas cookers through the Ecodesign Directive, removing air pollution directly from the source. Electric cooking does not involve combustion of a fossil fuel; therefore, it does not release any harmful combustion pollutants in the home. Though electric cooking solutions are a clean and viable alternative, the transition isn't happening quickly enough. National governments should incentivise electric alternatives, which will accelerate the transition to clean cooking and offer 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 help ensure our kitchens don't make us sick.

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 providing 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/>



Endnotes

- 1 European Environment Agency, Air pollution is the biggest environmental health risk in Europe, accessed 8 December 2022, <https://www.eea.europa.eu/themes/air/air-pollution-is-the-single>
- 2 WHO, Ten threats to global health in 2019, accessed 8 December 2022, <https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019>
- 3 WHO, From smog hanging over cities to smoke inside the home, air pollution poses a major threat to health and climate across the globe, accessed 8 December 2022, <https://www.who.int/teams/environment-climate-change-and-health/air-quality-and-health/health-impacts>
- 4 Health Effects Institute, 2021, Statement, Synopsis of Research Report 208: "Effects of Low-Level Air Pollution: A Study in Europe (ELAPSE)", accessed 8 December 2022, https://www.healtheffects.org/system/files/brunekreef-rr-208-statement_0_0.pdf
- 5 Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008L0050>
- 6 World Health Organisation (WHO), WHO global air quality guidelines: particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide, 2021, <https://www.who.int/publications/i/item/9789240034228>
- 7 Climate Council, 2021, Invisible Danger: Gas, Asthma and Our Children, accessed 8 December 2022, <https://www.climatecouncil.org.au/resources/invisible-danger-gas-asthma-children/>
- 8 European Commission, Health warnings – the EU Tobacco Products Directive (2014/40/EU), accessed 8 December 2022, https://health.ec.europa.eu/tobacco/product-regulation/health-warnings_en
- 9 European Commission, Climate Action, Car Labelling, accessed 8 December 2022, https://climate.ec.europa.eu/eu-action/transport-emissions/road-transport-reducing-co2-emissions-vehicles/car-labelling_en
- 10 J Rodríguez Quintero, R., Bernad Beltran, D., Ranea Palma, A., Donatello, S., Villanueva Krzyzaniak, A., Paraskevas, D., Boyano Larriba, A. and Stamminger, R., Preparatory study of Ecodesign and Energy Labelling measures for domestic cooking appliances, EUR 31250 EN, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/730095 (online), JRC130716, page 99, <https://publications.jrc.ec.europa.eu/repository/handle/JRC130716>
- 11 WHO Regional Office for Europe, 2013, Combined or multiple exposure to health stressors in indoor build environments. An evidence-based review prepared for the WHO training workshop "Multiple environmental exposures and risks", 16-18 October 2013, Bonn, Germany. https://www.euro.who.int/_data/assets/pdf_file/0020/248600/Combined-or-multiple-exposure-to-health-stressors-in-indoor-built-environments.pdf
- 12 WHO Regional Office for Europe, 2013, Review of Evidence on health aspects of air pollution - REVIHAAP" - First Results, https://www.euro.who.int/_data/assets/pdf_file/0020/182432/e96762-final.pdf
- 13 WHO, 2021, WHO global air quality guidelines: particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Page xiv, <https://www.who.int/publications/i/item/9789240034228>
- 14 United States Environmental Protection Agency, Basic Information about NO₂, accessed on 8 December 2022, <https://www.epa.gov/no2-pollution/basic-information-about-no2>
- 15 European Environment Agency, 2021, Europe's air quality status 2021- update, accessed 8 December 2022, <https://www.eea.europa.eu/publications/air-quality-in-europe-2021/air-quality-status-briefing-2021>
- 16 WHO Regional Office for Europe, 2010, WHO Guidelines for Indoor Air Quality – Selected Pollutants, Page 204, https://www.euro.who.int/_data/assets/pdf_file/0009/128169/e94535.pdf
- 17 Jacobs, P., and Kornaat, W., 2022, Health effects in EU and UK from cooking on gas, TNO Report R12249
- 18 American Lung Association, Nitrogen Dioxide - What are the health effects?, accessed 8 December 2022, <https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/nitrogen-dioxide>
- 19 American Lung Association, Carbon Monoxide - What are the health effects of Carbon Monoxide?, accessed 8 December 2022, <https://www.lung.org/clean-air/at-home/indoor-air-pollutants/carbon-monoxide>
- 20 8th Carbon Monoxide Round Table, held 6 November 2018 in the European Parliament. Hosted by MEP Linda McAvan (S&D, UK) and MEP Marian Harkin (ALDE, Ireland); organised in partnership with the Council of Gas Detection and Environmental Monitoring (CoGDEM).
- 21 Jacobs, P., and Cornelissen, H.J.M., Effect of hydrogen gas mixes on gas hob emissions. TNO (2022) R12248
- 22 Lebel, E.D., Finnegan, C.J., Ouyang, Z., and Jackson, R.B., Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes, Environmental Science & Technology 2022 56 (4), 2529-2539, DOI: 10.1021/acs.est.1c04707, <https://pubs.acs.org/doi/10.1021/acs.est.1c04707>
- 23 Global health benefits of mitigating ozone pollution with methane emission controls; J. Jason West, Arlene M. Fiore, Larry W. Horowitz, and Denise L. Mauzerall, March 6, 2006. PNAS, Environmental Sciences, 103 (11) 3988-3993, <https://doi.org/10.1073/pnas.0600201103>
- 24 Schraufnagel, D.E. The health effects of ultrafine particles. Exp Mol Med 52, 311-317 (2020). <https://doi.org/10.1038/s12276-020-0403-3>
- 25 American Lung Association website, "Particle Pollution. What can particles do to your health? Short-term exposure can be deadly." Link: <https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/particle-pollution>
- 26 Jacobs, P., and Kornaat, W., 2022, Health effects in EU and UK from cooking on gas, TNO Report R12249
- 27 Dimitroulopoulou, C., Ashmore, M.R., Byrne, M.A., and Kinnersley, R.P., 2001, Modelling of indoor exposure to nitrogen dioxide in the UK, Atmospheric Environment, Volume 35, Issue 2, p. 269-279 <https://www.sciencedirect.com/science/article/abs/pii/S13522310000176X>

- 28 Shao, E., New York Times, 2022, Researchers Find Benzene and Other Dangers in Gas Piped to California Homes, accessed 8 December 2022, <https://www.nytimes.com/2022/10/20/climate/gas-stove-benzene-california.html>
- 29 Marcogaz – Technical Association of the European Natural Gas Industry, 2013, Marcogaz answers concerning benzene in natural gas and CAS/EINECS references, https://www.cgoa.cz/informacezahrancici/pdfdoc/marcogazudrzitelnost/2013/UTIL-GQ-13-02_D002_Marcogaz_answers_about_Benzene_in_natural_gas_Final2.pdf
- 30 Nikolov, D., Mayor of Burgas and Trzaskowski, R., Mayor of Warsaw, EURO CITIES, 2022, Mayors to EU: Help us fill our lungs with clean air, accessed 8 December 2022, <https://eurocities.eu/latest/mayors-to-eu-help-us-fill-our-lungs-with-clean-air/>
- 31 WHO Regional Office for Europe, 2010, WHO Guidelines for Indoor Air Quality – Selected Pollutants, Page 204, https://www.euro.who.int/_data/assets/pdf_file/0009/128169/e94535.pdf
- 32 Morales, E. *et al.*, 2009, Association of early-life exposure to household gas appliances and indoor nitrogen dioxide with cognition and attention behavior in preschoolers. *Am. J. Epidemiol.* **169**, 1327–1336, <https://academic.oup.com/aje/article/169/11/1327/159993>
- 33 Fang, X. Y. *et al.*, 2020, Maternal cooking during pregnancy may increase hyperactive behaviors among children aged at around 3 years old. *Indoor Air* **30**, 126–136, <https://pubmed.ncbi.nlm.nih.gov/31797459/>
- 34 Lin, W., Brunekreef, B. & Gehring, U. Meta-analysis of the effects of indoor nitrogen dioxide and gas cooking on asthma and wheeze in children. *Int. J. Epidemiol.* **42**, 1724–1737 (2013).
- 35 Hansel, N.N., Breyse, P.N., McCormack, M.C., Matsui, E.C., Curtin-Brosnan, J., Williams, D.L., Moore, J.L., Cuhnan, J.L., Diette, G.B., 2008, A longitudinal study of indoor nitrogen dioxide levels and respiratory symptoms in inner-city children with asthma. *Environmental Health Perspective*. 2008 Oct;116(10):1428–32. doi: 10.1289/ehp.11349, <https://pubmed.ncbi.nlm.nih.gov/18941590/>
- 36 Fleming, M., Fitton, C.A., Steiner, M.F.C., McLay, J.S., Clark, D., King, A., Mackay, D.F., Pell, J.P., 2018, Educational and health outcomes of children treated for asthma: Scotland-wide record linkage study of 683 716 children. *European Respiratory Journal* 2019 54: 1802309; DOI: 10.1183/13993003.02309-2018 <https://erj.ersjournals.com/content/54/3/1802309>
- 37 Pilotto 1, L.S., Douglas, R.M., Attewell, R.G., Wilson, S.R., 1997, Respiratory effects associated with indoor nitrogen dioxide exposure in children, *International Journal of Epidemiology*, 1997 Aug;26(4):788–96. doi: 10.1093/ije/26.4.788. <https://pubmed.ncbi.nlm.nih.gov/9279611/>
- 38 Sources: Eurostat 2020 and 2022; European Respiratory Society, 2003; TNO 2022.
- 39 P. Jacobs and W. Kornaat, Health effects in EU and UK from cooking on gas, 2022, TNO Report R12249
- 40 Masako To, Ryuta Tsuzuki, Otohiko Katsube, Satoshi Yamawaki, Seiko Soeda, Yuta Kono, Natsue Honda, Ichino Kano, Kosuke Haruki, Yasuo To, 2020, Persistent Asthma from Childhood to Adulthood Presents a Distinct Phenotype of Adult Asthma, *The Journal of Allergy and Clinical Immunology: In Practice*, Volume 8, Issue 6, 2020, Pages 1921–1927.e2, ISSN 2213-2198, <https://www.sciencedirect.com/science/article/pii/S2213219820300507>
- 41 European Environment Agency. Air pollution: how it affects our health. <https://www.eea.europa.eu/themes/air/health-impacts-of-air-pollution#> (2022).
- 42 International Respiratory Coalition. Asthma in numbers. <https://international-respiratory-coalition.org/diseases/asthma/> (2022).
- 43 Payne-Sturges, D. C. *et al.* Healthy air, healthy brains: Advancing air pollution policy to protect children’s health. *Am. J. Public Health* **109**, 550–554 (2019).
- 44 Morales, E. *et al.* Association of early-life exposure to household gas appliances and indoor nitrogen dioxide with cognition and attention behavior in preschoolers. *Am. J. Epidemiol.* **169**, 1327–1336 (2009).
- 45 Fang, X. Y. *et al.* Maternal cooking during pregnancy may increase hyperactive behaviors among children aged at around 3 years old. *Indoor Air* **30**, 126–136 (2020).
- 46 P. Jacobs and W. Kornaat, Health effects in EU and UK from cooking on gas, 2022, TNO Report R12249
- 47 International Respiratory Coalition, Asthma in numbers, accessed 8 December 2022, <https://international-respiratory-coalition.org/diseases/asthma/>
- 48 Jacobs, P. and Kornaat, W., 2022, Health effects in EU and UK from cooking on gas, TNO Report R12249
- 49 Paulin, L. M. *et al.*, 2017, 24-h Nitrogen dioxide concentration is associated with cooking behaviors and an increase in rescue medication use in children with asthma. *Environ. Res.* **159**, 118–123, <https://pubmed.ncbi.nlm.nih.gov/28797886/>
- 50 Ibid.
- 51 CE Delft, 2022, Health-related social costs of air pollution due to residential heating and cooking. In the EU27 and UK, accessed 8 December 2022, <https://cedelft.eu/publications/health-related-social-costs-of-air-pollution-due-to-residential-heating-and-cooking/>
- 52 CLASP, 2023, Exposing the Hidden Health Impacts of Cooking with Gas – Technical and Policy Support Document: Findings from CLASP Research
- 53 J Rodriguez Quintero, R., Bernad Beltran, D., Ranea Palma, A., Donatello, S., Villanueva Krzyzaniak, A., Paraskevas, D., Boyano Larriba, A. and Stamminger, R., Preparatory study of Ecodesign and Energy Labelling measures for domestic cooking appliances, EUR 31250 EN, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/730095 (online), JRC130716., <https://publications.jrc.ec.europa.eu/repository/handle/JRC130716>
- 54 Molly L Kile *et al.*, 2014, A cross-sectional study of the association between ventilation of gas stoves and chronic respiratory illness in US children enrolled in NHANESIII, *Environmental Health* 13:71, 2014, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4175218/>.

- 55 Kile, M. L. *et al.*, 2014, A cross-sectional study of the association between ventilation of gas stoves and chronic respiratory illness in U.S. children enrolled in NHANESIII. *Environ. Heal. A Glob. Access Sci. Source* **13**, Arte Number: 71. ate of Pubaton: 02 Se 2014, <https://pubmed.ncbi.nlm.nih.gov/25182545/>
- 56 Dobbin et al, 2018, The benefit of kitchen exhaust fan use after cooking. An experimental assessment. *Building and Environment*, <https://www.sciencedirect.com/science/article/pii/S0360132318301112>
- 57 J Rodriguez Quintero, R., Bernad Beltran, D., Ranea Palma, A., Donatello, S., Villanueva Krzyzaniak, A., Paraskevas, D., Boyano Larriba, A. and Stamminger, R., Preparatory study of Ecodesign and Energy Labelling measures for domestic cooking appliances, EUR 31250 EN, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/730095 (online), JRC130716., <https://publications.jrc.ec.europa.eu/repository/handle/JRC130716>
- 58 Gannaway, 2015, Ducted vs ductless range hoods. The pros & cons compared. *Compact Appliance*. <https://learn.compactappliance.com/range-hoods-ducted-vs-ductless/>
- 59 Dooley, 2019, How does a range vent hood work? *Hunker*. <https://www.hunker.com/13409670/how-does-a-range-vent-hood-work>
- 60 O'Leary, C., Jones, B., Dimitroulopoulou, S. & Hall, I. P., 2019, Setting the standard: The acceptability of kitchen ventilation for the English housing stock. *Build. Environ.* **166**, 106417, <https://nottingham-repository.worktribe.com/index.php/output/3010772/setting-the-standard-the-acceptability-of-kitchen-ventilation-for-the-english-housing-stock>
- 61 Rim, D., Wallace, L., Nabinger, S. & Persily, A., 2012, Reduction of exposure to ultrafine particles by kitchen exhaust hoods: The effects of exhaust flow rates, particle size, and burner position. *Sci. Total Environ.* **432**, 350–356, <https://pubmed.ncbi.nlm.nih.gov/22750181/>
- 62 Zhao, J., Birmili, W., Hussein, T., Wehner, B. & Wiedensohler, A., 2020, Particle number emission rates of aerosol sources in 40 German households and their contributions to ultrafine and fine particle exposure. *Indoor Air* 818–831 doi:10.1111/ina.12773., <https://pubmed.ncbi.nlm.nih.gov/33247488/>
- 63 Jarvis, D., Chinn, S., Luczynska, C. & Burney, P., 1996, Association of respiratory symptoms and lung function in young adults with use of domestic gas appliances. *Lancet* **347**, 426–431, <https://pubmed.ncbi.nlm.nih.gov/8618483/>
- 64 Zhao, J., Birmili, W., Hussein, T., Wehner, B. & Wiedensohler, 2020, A. Particle number emission rates of aerosol sources in 40 German households and their contributions to ultrafine and fine particle exposure. *Indoor Air* 818–831, doi:10.1111/ina.12773., <https://pubmed.ncbi.nlm.nih.gov/33247488/>
- 65 Jacobs, P. and Kornaat, W., 2022, Health effects in EU and UK from cooking on gas, TNO Report R12249
- 66 Ibid.
- 67 Seals, B. and Krasner, A., 2020, Health Effects from Gas Stove Pollution, Rocky Mountain Institute, Physicians for Social Responsibility, Mothers Out Front, and Sierra Club, <https://rmi.org/insight/gasstoves-pollution-health>
- 68 Singer, B. C., Pass, R. Z., Delp, W. W., Lorenzetti, D. M. & Maddalena, R. L., 2017, Pollutant concentrations and emission rates from natural gas cooking burners without and with range hood exhaust in nine California homes. *Build. Environ.* **122**, 215–229, <https://escholarship.org/uc/item/9bc0w046>
- 69 EuroStat data. <https://ec.europa.eu/eurostat>
- 70 European Commission, 2022, Press Release – REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition, accessed 8 December 2022, https://ec.europa.eu/commission/presscorner/detail/en/ip_22_3131
- 71 Jacobs, P. and Kornaat, W., 2022, Health effects in EU and UK from cooking on gas, TNO Report R12249
- 72 European Commission, A European Green Deal: Striving to be the first climate-neutral continent. Priorities 2019-2024, accessed 8 December 2022, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
- 73 European Commission, Paris Agreement, accessed 8 December 2022, https://climate.ec.europa.eu/eu-action/international-action-climate-change/climate-negotiations/paris-agreement_en
- 74 Zhong R, New York Times, 2022, Did I Turn Off the Stove? Yes, but Maybe Not the Gas, accessed on 8 December 2022, <https://www.nytimes.com/2022/01/27/climate/gas-stoves-methane-emissions.html>
- 75 Lebel E.D., Finnegan C.J., Ouyang Z, J. R. B., 2022, Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes | *Environmental Science & Technology. Environ. Sci. Technol.* 2529–2539, <https://pubs.acs.org/doi/full/10.1021/acs.est.1c04707>
- 76 Jacobs, P., and Cornelissen, H.J.M., 2022, Effect of hydrogen gas mixes on gas hob emissions. TNO R12248
- 77 IPCC, 2018: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, Cambridge University Press, Cambridge, UK and New York, NY, USA, 616 pp., doi:10.1017/9781009157940.
- 78 Health professionals call for Fossil Fuel Non-Proliferation Treaty to protect lives of current and future generations, accessed on 8 December 2022, <https://fossilfueltreaty.org/health-letter>
- 79 WHO Newsroom, 2021, Climate Change and Health, accessed on 8 December 2022, <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>
- 80 Meisel, D., The Drum, 2022, Why the IPCC shone a spotlight on ad agencies still working with fossil fuel clients, accessed on 8 December 2022, <https://www.thedrum.com/opinion/2022/04/07/why-the-ipcc-shone-spotlight-ad-agencies-still-working-with-fossil-fuel-clients>
- 81 Gas Distributors for Sustainability, Who we are, accessed on 8 December 2022, <https://gd4s.eu/about-us/who-we-are>
- 82 Natural Allies for a Clean Energy Future, accessed on 8 December 2022, <https://naturalalliesforcleanenergy.org/>
- 83 Liquid Gas Europe, Rural Futures Ensuring Rural Communities are Part of the Shift to Green Energy, accessed on 8 December 2022, <https://ruralfutures.eu/>

- 84 Leber, R., Mother Jones, 2021, How the Fossil Fuel Industry Convinced Americans to Love Gas Stoves, accessed on 8 December 2022, <https://www.motherjones.com/environment/2021/06/how-the-fossil-fuel-industry-convinced-americans-to-love-gas-stoves/>
- 85 Twitter, Cepsa España, 2022, accessed 8 December 2022, https://twitter.com/hashtag/AGasSabeMejor?src=hashtag_click
- 86 Clean Creatives, The Future of Creativity is Clean, accessed 8 December 2022, <https://cleancreatives.org/>
- 87 Dutta, N., Clean Creatives, 2022, Smoke and Mirrors: The Legal Risks of Fossil Fuel Advertising, accessed 8 December 2022, <https://cleancreatives.org/smoke-and-mirrors>
- 88 Noor, D., Gizmodo, 2021, Netherlands Officials Tell Shell to Stop Its Ads Greenwashing 'Carbon Neutral' Fuel, accessed 8 December 2022, <https://gizmodo.com/netherlands-officials-tell-shell-to-stop-its-ads-greenw-1847613583>
- 89 ClientEarth, BP greenwashing complaint sets precedent for action on misleading ad campaigns, accessed 8 December 2022, <https://www.clientearth.org/latest/latest-updates/news/bp-greenwashing-complaint-sets-precedent-for-action-on-misleading-ad-campaigns/>
- 90 Stewart, R., Adweek, 2022, Why France's Fossil Fuel Ad Ban Matters, accessed 8 December 2022, <https://www.adweek.com/brand-marketing/why-frances-fossil-fuel-ad-ban-matters/>
- 91 Bolger, R., ABC Radio Sydney, 2022, City of Sydney to consider ban on fossil fuel advertising to fight climate change, pollution, accessed 8 December 2022, <https://www.abc.net.au/news/2022-08-20/sydney-council-considers-coal-gas-oil-advertising-ban-motion/101352790>
- 92 Hernandez, A., Politico, 2022, Go big or go green? The EU's massively expanding hydrogen bet, accessed on 8 December 2022, <https://www.politico.eu/article/go-big-or-go-green-the-eus-massively-expanding-hydrogen-bet/>
- 93 European Commission, 2018, Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank: A Clean Planet For All - A European Strategic Long-term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy, COM/2018/773 Final, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0773>
- 94 European Project: Testing Hydrogen admixture for Gas Applications (ThyGA), accessed 8 December 2022, <https://thyga-project.eu/structure-of-the-project/>
- 95 J Rodríguez Quintero, R., Bernad Beltran, D., Ranea Palma, A., Donatello, S., Villanueva Krzyzaniak, A., Paraskevas, D., Boyano Larriba, A. and Stamminger, R., Preparatory study of Ecodesign and Energy Labelling measures for domestic cooking appliances, EUR 31250 EN, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/730095 (online), JRC130716., <https://publications.jrc.ec.europa.eu/repository/handle/JRC130716>
- 96 Jacobs, P., and Cornelissen, H.J.M., 2022, Effect of hydrogen gas mixes on gas hob emissions. TNO R12248
- 97 European Commission, 2022, Commission Staff Working Document Implementing The RePower EU Action Plan: Investment Needs, Hydrogen Accelerator and Achieving the Bio-Methane Targets (COM(2022) 230 final), <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD%3A2022%3A230%3AFIN>
- 98 Bansal, A.K. MD, Chair, American Medical Association House of Delegates (A-22), 2022, Report of Reference Committee D, accessed 8 December 2022, <https://www.ama-assn.org/system/files/a22-refcmt-e-d-report-annotated.pdf>
- 99 Koestner, J., P.E., Power Engineers, 2021, 6 Things to Remember about Hydrogen vs Natural Gas, accessed 8 December 2022, <https://www.powereng.com/library/6-things-to-remember-about-hydrogen-vs-natural-gas>
- 100 Ibid.
- 101 Ibid.
- 102 CLASP, 2023, Exposing the Hidden Health Impacts of Cooking with Gas - Technical and Policy Support Document: Findings from CLASP Research
- 103 UK Department of Business, Energy, and Industrial Strategy funded Hy4Heat project, accessed 8 December 2022, <https://www.hy4heat.info>
- 104 Frazer-Nash Consultancy, 2018, Appraisal of Domestic Hydrogen Appliances, prepared for the Department of Business, Energy & Industrial Strategy, accessed 8 December 2022, <https://www.gov.uk/government/publications/appraisal-of-domestic-hydrogen-appliances>
- 105 Enertek International and HyCookers Consortium, Hydrogen Gas Cookers, accessed 8 December 2022, <https://www.hy4heat.info/s/HyCookers.pdf>
- 106 European Commission, 2018, Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=urisrv:OJ.L_.2018.156.01.0075.01.ENG
- 107 European Commission, 2021, Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast) COM/2021/802 final, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0802&qid=1641802763889>
- 108 Ibid.
- 109 Consolidated Version of the Treaty on the Functioning of the European Union Part Three - Union Policies and Internal Actions Title XX - Environment Article 191 (Ex Article 174 TEC), <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A12016E191>
- 110 Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, OJ L 152, 11.6.2008, p. 1-44, <https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32008L0050>
- 111 European Commission, 2022, Proposal for a Directive of the European Parliament and of the Council on ambient air quality and cleaner air for Europe (recast), COM(2022) 542 final, 2022/0347(COD), <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022PC0542>

- 112 European Parliament, 2021, European Parliament resolution of 25 March 2021 on the implementation of the Ambient Air Quality Directives: Directive 2004/107/EC and Directive 2008/50/EC (2020/2091(INI)), https://www.europarl.europa.eu/doceo/document/TA-9-2021-0107_EN.html
- 113 European Commission, 2021, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil' COM/2021/400 final, <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM%3A2021%3A400%3AFIN>
- 114 Regulation (EU) 2016/426 of the European Parliament and of the Council of 9 March 2016 on appliances burning gaseous fuels and repealing Directive 2009/142/EC <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0426&rid=3>
- 115 Ibid. Annex I, paragraphs 3.4 and 3.4.4
- 116 Ibid. Chapter 1
- 117 Commission Regulation (EU) No 66/2014 of 14 January 2014 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for domestic ovens, hobs and range hoods OJ L 29, 31.1.2014, p. 33–47, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014R0066>
- 118 Commission Delegated Regulation (EU) No 65/2014 of 1 October 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of domestic ovens and range hoods, OJ L 29, 31.1.2014, p. 1–32, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014R0065>
- 119 J Rodríguez Quintero, R., Bernad Beltran, D., Ranea Palma, A., Donatello, S., Villanueva Krzyzaniak, A., Paraskevas, D., Boyano Larriba, A. and Stamminger, R., Preparatory study of Ecodesign and Energy Labelling measures for domestic cooking appliances, EUR 31250 EN, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/730095 (online), JRC130716. <https://publications.jrc.ec.europa.eu/repository/handle/JRC130716>
- 120 CLASP, 2023, Exposing the Hidden Health Impacts of Cooking with Gas - Technical and Policy Support Document: Findings from CLASP Research
- 121 WHO Europe, 2000, The Right to Healthy Indoor Air, Report on a WHO Meeting, Bilthoven, The Netherlands, European Health21 Targets 10 and 13., EUR/00/5020494., https://www.euro.who.int/__data/assets/pdf_file/0019/117316/E69828.pdf
- 122 Bansal, A.K. MD, Chair, American Medical Association House of Delegates (A-22), 2022, Report of Reference Committee D, accessed 8 December 2022, <https://www.ama-assn.org/system/files/a22-refcmt-d-report-annotated.pdf>

