european public health alliance

Towards better indoor air quality in the European residential context

Position Paper

Towards better indoor air quality in the European residential context

Executive summary

The World Health Organization (WHO) recognised "**the right to healthy indoor air**"[1] over two decades ago. Yet little action has been taken at the EU or national level to address this issue, with indoor air quality (IAQ) often being called by scholars a "regulatory no [wo]man's land". **Air pollution** has been recognised as the **largest environmental health risk in Europe**. While a number of European regulations and policies aim to improve outdoor air quality, a cohesive approach to IAQ is yet to emerge.

The sources of indoor pollution are varied and may include cooking and heating appliances and habits, furnishings, coatings or cleaning products. Ventilation, outdoor air pollution, as well as built environment itself also contribute to the final mix of indoor air. While the complexity of the issue should not be underestimated, neither should it be used as an excuse for inaction. Many **studies have found higher pollution concentrations indoors than outdoors**[2] and have established that **poor indoor air quality damages cardiovascular and respiratory health**, including by potentially triggering allergic and irritant reactions, such as asthma.[3] Moreover, there are notable intersections between poor indoor air quality and fuel and energy poverty, which contribute to increasing health inequities.

Against a backdrop of increased societal awareness but political resistance to European action on the matter, **scientists** speaking at the WHO Europe's recent first conference on Indoor Air Quality have **called for a regulatory framework that combines source control, ventilation and concentration limits**. The present paper offers an overview of causes of poor indoor air and environment quality, and explores policy challenges and opportunities in the European context.

1 World Health Organization, 'The Right to Healthy Indoor Air'.
2 Leung, 'Outdoor-Indoor Air Pollution in Urban Environment.
3 World Health Organization, WHO Housing and Health Guidelines, xv.

EPHA recommendations

- **Establish a common European approach to tackling poor IAQ, recognising the major role that it plays in people's health and wellbeing.**
- **Fund research into the indoor air mix in European buildings, with a view towards policy solutions to improve IAQ.**
- **Address IAQ with a multi-pronged policy approach, while taking into account that tackling the source of pollution should always be preferred over mitigation measures.**
- **Consult experts and stakeholders through cross-disciplinary conversations for evidence-based policies that protect the health of all.**
- **Acknowledge and consider the impacts that the built environment has on health, and prioritise interventions that tackle health inequities and lead to the greatest health benefits.**
- **Raise public awareness on the importance of IAQ for health, and provide clear product information to consumers.**
- **Ensure adequate legislative protection for tenants to exercise their right to healthy air and healthy environment.**

Indoor air quality – overview

With **air pollution** being recognised as the **largest environmental health risk in Europe**, a number of European regulations and policies aim to improve outdoor air quality. Despite decades of monitoring and legislative action, and a downward trend in pollution recent decades, the majority of Europeans are still exposed to emissions above the World Health Organization guideline levels and harmful to health.[4] Meanwhile, **little action has been taken to address indoor air quality (IAQ)**, although many **studies have found higher pollution concentrations indoors than outdoors**.[5] Moreover, longer indoor exposure times and **higher intake fractions** – the total mass of inhaled pollutant – mean that even small variations in pollution concentrations may have a significant impact on health. The magnitude of the difference is so significant that researchers refer to the "rule of one thousand" – a gram of pollution indoors results in 1000 time more exposure than a gram outdoors.[6]

While the EU policy framework has been focused on outdoor air pollution only, the **World Health Organization (WHO) recognised "the right to healthy indoor air"** over two decades ago.[7] In a more recent summary of the existing evidence on health impacts from indoor pollution, the WHO states: "[IAQ] is associated with **allergies, a weakened immune system, cancer, and skin, eye, nose and throat irritation**. It can adversely affect the reproductive, nervous and cardiovascular systems".[8] In September 2023, WHO Europe organised its first conference on indoor air quality. Scientists spoke to the need to **control pollution at the source as the most efficient method** to improve indoor air quality, and to the importance of **combining ventilation standards with concentration limits** not only as guidelines, but embedded in the **regulatory framework**.[9]

4 European Environment Agency, 'Europe's Urban Population Remains at Risk Due to Levels of Air Pollution Known to Damage Health'.
5 Leung, 'Outdoor-Indoor Air Pollution in Urban Environment'.
6 Zhang and Smith, 'Indoor Air Pollution'.
7 World Health Organization, 'The Right to Healthy Indoor Air'.
8 World Health Organization, WHO Housing and Health Guidelines, 88.
9 Geneva Health Forum and World Health Organization, 'First WHO Europe Indoor Air Conference 2023'.

Historically, indoor air pollution was considered to originate with the building occupants, and therefore ventilation was thought to be the necessary and sufficient solution. It was only in the last decade of the 20th century that a more complex approach began to develop, acknowledging different factors affecting indoor air quality.[10] We now recognise that numerous elements contribute to the complex air mix inside our buildings and to the indoor environment quality more broadly. These include (1) **indoor emission** sources such as furnishings, coatings, cleaning products, pets, heating and cooking appliances, (2) **the building itself** with its structure, ventilation system, construction materials, insulation, and potential structural problems, such as faulty chimneys and (3) **outdoor air quality**, whose contribution varies depending on pollution levels, air exchange rates, and filtering mechanisms. Other environmental factors such as temperature and humidity influence human health directly and mediate the impact of indoor air quality.

The quality of the built environment plays a central role in influencing the quality of indoor air. More broadly, **housing is a social determinant of health**, meaning lack of housing or poor-quality housing has a negative effect on health and well-being.[11] **Societal inequities** find a very tangible expression in differences in housing quality, which in turn increase **health inequities**. The crucial importance of housing and the built environment as an environmental determinant of health is gaining increasing recognition in the health community, with the WHO pointing to the potential of better housing conditions to "save lives, prevent disease, increase quality of life, reduce poverty, help mitigate climate change and contribute to the achievement of the Sustainable Development Goals (SDGs)".[12] Recent studies make an **economic case for such interventions** too, pointing to the high return on investments from renovation work in energy poor households.[13] On this latter point, it is crucial to point out that vulnerable households may not have the means to make investments in energy renovation. That makes it all the more important to ensure that energy poor people have access to funding or energy efficiency programmes, and that these programmes are efficient, easy to engage with, and cater to the needs of the marginalised populations they serve, which is not always the case with current social protections.[14] For renters, additional safeguards should be put in place to ensure they are protected against renovictions (evictions caused by sudden or disproportionate increases in rent as a result of renovations).

The importance of housing and indoor air quality is underscored by **current societal trends and crises**, as well as the threat and existing impacts of climate change. Firstly, **Europe's ageing population** is of particular note since people over 60 tend to both spend more time at home and have more difficulties regulating their body temperature.[15] Therefore, the extent to which the built environment shields people over 60 from extreme and sudden temperatures variations will represent a significant factor among their health risks. Secondly, **climate change** itself may also prolong the time spent indoors, further increasing the importance of indoor exposures, and disproportionately impacting people who are not able to secure a healthy and safe indoor environment. **Extreme temperatures** are a prime example and have a direct health impact. **Floods** will also have the potential to affect the indoor environment quality, with water infiltration and dampness representing problems that will need to be taken into account in designing and renovating buildings, in addition to regular damp proofing efforts. Climate change has also been linked to **increased indoor fungal spore abundance**[16], which can lead to negative health outcomes, such as asthma exacerbations.[17]

10 Bluyssen, 'Towards an Integrative Approach of Improving Indoor Air Quality'.

11 Rolfe, Steve, et al. Housing as a social determinant of health and wellbeing: Developing an empirically-informed realist theoretical framework. BMC Public Health 20.1 (2020): 1-19.

12 World Health Organization, WHO Housing and Health Guidelines, xv.

13 Lambert, 'How Poor Housing Costs the NHS £1.4bn a Year'.

14 European Anti Poverty Network, 'Energy Poverty in the Context of the Green Transition and the Cost-of-Living Crisis', 6.

15 Kenny et al., 'Heat Stress in Older Individuals and Patients with Common Chronic Diseases'.

16 Leung, 'Outdoor-Indoor Air Pollution in Urban Environment'.

17 Hughes et al., 'Impact of Fungal Spores on Asthma Prevalence and Hospitalization'.

This current paper aims to explore some factors that influence indoor air quality, and the associated health impacts. Elements such as natural and artificial lighting, or proper hygiene facilities and overcrowding, although important elements of a healthy living environment, are outside the scope of this paper. The issues addressed are most typical for home environments, though some may apply to office spaces as well. The particularities of other indoor spaces, such as transportation environments, are not addressed here.

Indoor pollutants

Pollutants found in indoor spaces will include a **mix of substances from indoor and outdoor sources**. Some pollutants, such as ozone, will originate almost exclusively outdoors, others will be specific to the indoor environment. Additionally, the **multitude of possible mixtures of compounds** further complicates the picture; in some cases, individual volatile organic compounds (VOCs)[18], such as formaldehyde, may be below their individual exposure limit, yet in combination lead to adverse health effects such as eye irritation.[19]

In 2010, the **WHO** developed specific **guidelines for pollutants in indoor spaces**.[20] These substances include benzene, formaldehyde, radon, and naphthalene, as well as carbon monoxide (CO) and nitrogen dioxide (NO_2). The guideline levels for these last two pollutants have since been updated; the **WHO Air Quality Guidelines (AQG)** were revised in 2021 and apply to both indoor and outdoor environments. They cover the so-called "traditional pollutants": particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide.[21] The more stringent guidelines – as compared to the 2005 Air Quality Guidelines – following the update, and in particular the four-fold decrease of the guideline limit for NO_2, point to an accumulation of evidence about the negative impacts of these pollutants at lower level than previously thought. Additionally, the AQG alone may not be able to address some of the specific challenges of the indoor environment. They are to be applied to the whole population, but **younger children and people with chronic diseases may spend more time indoors**, therefore increasing their exposure and intake, against a background of existing vulnerability to adverse impacts from what are considered low air pollution concentrations. Moreover, increased exposure to pollution may be

18 VOCs represent a large and diverse group of substances that evaporate easily at room temperature. They are found in many products used to build and maintain our homes, such as paints, cleaners, furniture and construction materials.

19 Bluyssen, 'Towards an Integrative Approach of Improving Indoor Air Quality'.

20 World Health Organization, WHO Guidelines for Indoor Air Quality.

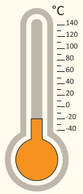
21 World Health Organization, 'WHO Global Air Quality Guidelines'.

Towards better indoor air quality in the European residential context

The WHO recognised "**the right to healthy indoor air**" over two decades ago.

Studies have found that indoor ***air can be more polluted than outdoor air.***

Yet comprehensive and coherent indoor air quality (IAQ) policies are lacking in the EU.



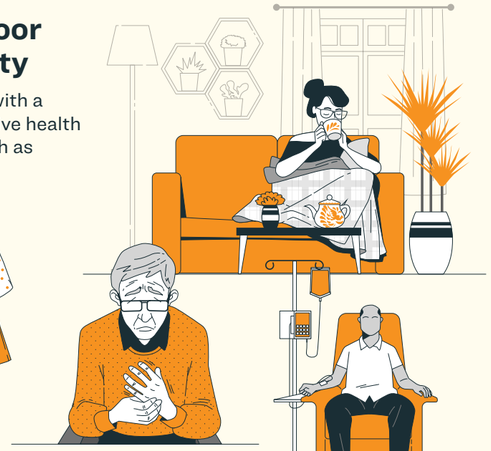
Low air temperatures contribute to a number of negative health outcomes, including increased risk of respiratory conditions such **as asthma, exacerbation of chronic obstructive pulmonary disease (COPD), ischaemic heart disease, stroke and death.**

The **mental health burden** associated with the inability to consistently heat one's home to a healthy temperature is also significant.

Poor Indoor Air Quality

Is associated with a range of negative health outcomes, such as

Allergies

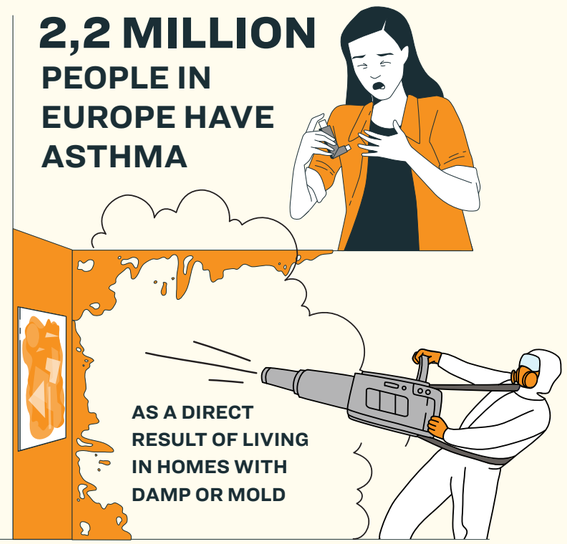


Weakened immune system

Cancer

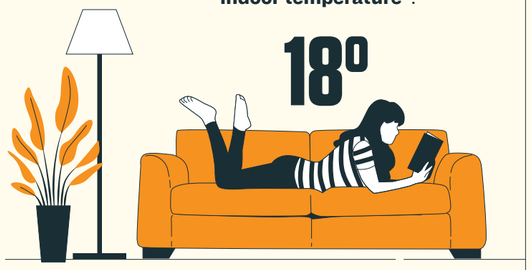
Skin, eye, nose and throat irritation

2,2 MILLION PEOPLE IN EUROPE HAVE ASTHMA



AS A DIRECT RESULT OF LIVING IN HOMES WITH DAMP OR MOLD

The WHO has issued a recommendation for a minimum of 18 degrees as a **"safe and well-balanced indoor temperature"**.

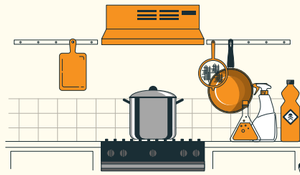


Meanwhile, the number of households that were unable to keep their homes adequately warm increased to

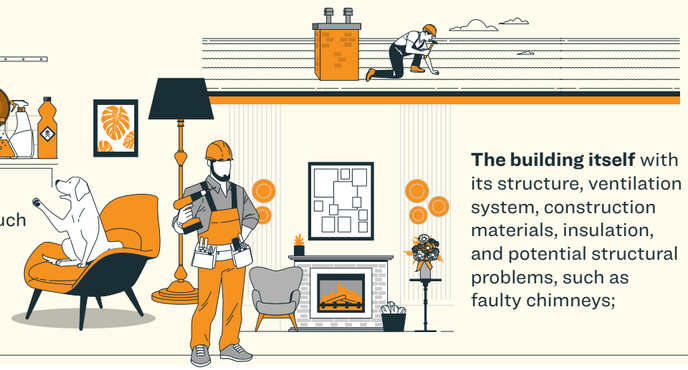
9.3% in 2022

IN THE EU BECAUSE OF RISING ENERGY PRICES

Numerous elements contribute to the complex air mix inside our buildings and to the indoor environment quality more broadly. These include:



Indoor emission sources such as **furnishings, coatings, cleaning products, pets, heating and cooking appliances;**



The building itself with its structure, ventilation system, construction materials, insulation, and potential structural problems, such as faulty chimneys;

Outdoor air quality, whose contribution varies depending on pollution levels, air exchange rates, and filtering mechanisms.

MOST OF THE **BUILDINGS IN EUROPE TODAY ARE NOT ENERGY EFFICIENT**

85-95% OF THESE BUILDINGS WILL STILL BE STANDING IN 2050

THE BIGGEST HEALTH IMPACT WILL BE ACHIEVED BY TARGETING THE EXISTING BUILDING STOCK

epha recommendations

1. Establish a **common European approach to tackling poor IAQ,** recognising the major role that it plays in people's health and wellbeing.
2. **Fund research** into the indoor air mix in European buildings, with a view towards policy solutions to improve IAQ.
3. Address IAQ with a **multi-pronged policy approach**, while taking into account that tackling the source of pollution should always be preferred over mitigation measures.
4. **Consult experts and stakeholders** through **cross-disciplinary conversations** for **evidence-based policies** that protect the health of all.
5. **Raise public awareness on the importance of IAQ** for health, and provide clear product information to consumers.
6. Ensure adequate **legislative protection for tenants** to exercise their right to healthy air and healthy environment.
7. Ensure adequate **legislative protection for tenant**s to exercise their right to healthy air and healthy environment.

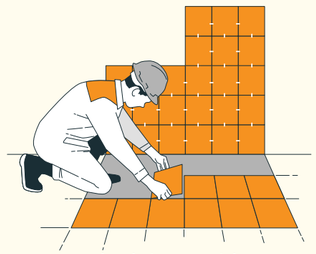
1. World Health Organization, 'The Right to Healthy Indoor Air'.
2. Leung, 'Outdoor-Indoor Air Pollution in Urban Environment'.
3. World Health Organization, WHO Housing and Health Guidelines
4. Urlaub and Grün, 'Mould and Dampness in European Homes and Their Impact on Health'.
5. World Health Organization, 32.
6. World Health Organization, 32.
7. European Commission, 'Energy Poverty in the EU'.
8. European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions on a Renovation Wave for Europe - greening our buildings, creating jobs, improving lives.
9. Braubach, Jacobs, and Ormandy, Environmental Burden of Disease Associated with Inadequate Housing.

Towards better indoor air quality in the European residential context

Formaldehyde

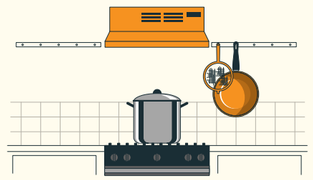
is an important sensory irritant, and almost ubiquitous in indoor environments. Sources include cigarette smoke, insulating materials, certain paints, cleaning agents and disinfectants, and open fireplaces

Cigarette smoke

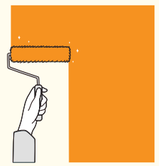


Insulating materials

Cleaning agents and disinfectants



Gas cookers



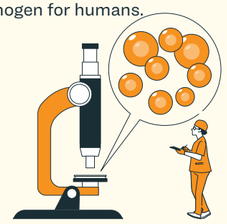
Certain paints

Open fireplaces

The International Agency for Research on Cancer (IARC) classified it as a Group 1 carcinogen for humans.

Skin, eye, nose and throat irritation

Lower airway discomfort



Dysplasia

Carbon monoxide (CO)

Results from the incomplete combustion of carbon-containing fuels – fossil fuels such as coal, oil or gas, and biofuels. Populations that are especially sensitive to chronic health effects from CO exposure include pregnant people, fetuses, children, the elderly, and people living with diseases that restrict oxygen transport between blood and cells, such as anemia.

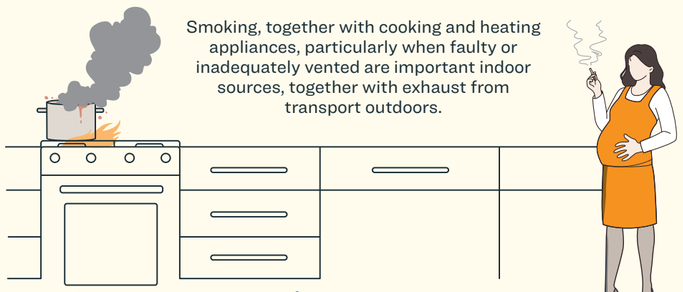
Fetuses

Pregnant people

Children

The elderly

Smoking, together with cooking and heating appliances, particularly when faulty or inadequately vented are important indoor sources, together with exhaust from transport outdoors.



Head Ache

Subtle cardiovascular effects

Unconsciousness and death

Depending on exposure duration and intensity, effects range from headaches and subtle cardiovascular effects to unconsciousness and death. In children, long-lasting effects on cognitive development and behavioural alterations have been observed. People with cardiovascular diseases are the population facing the greatest risk from CO exposure, and may experience earlier onset of myocardial ischemia, increased number and complexity of arrhythmias.

Nitrogen Dioxide (NO_2)

Sources include gas appliances – stoves, ovens, heaters, etc. Health impacts include increases in sore throat, colds and respiratory symptoms; increased rates of absence from school have also been associated with NO2 exposure. People with asthma and with COPD are particularly susceptible to health effects.

Stoves

Heaters

Ovens

Sore throat

People with asthma and with COPD

Cold

Absences from school were noted in children

Benzene

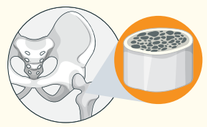
For benzene, indoor sources include cigarette smoke, particle board, various paints and varnishes. The INDEX report estimates that mean indoor concentrations are normally higher than outdoor levels all over Europe. Benzene is recognized as a carcinogen by the IARC;

Particle board

Cigarette smoke

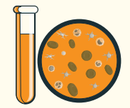
Various paints and varnishes

it is particularly linked to bone marrow damage. Other health impacts associated to various levels of exposure include headaches and weakness, blood cell damage, impairment of the immune function, neurologic and reproductive effects.

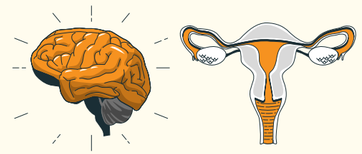


Bone marrow damage

Headaches and weakness



Blood cell damage



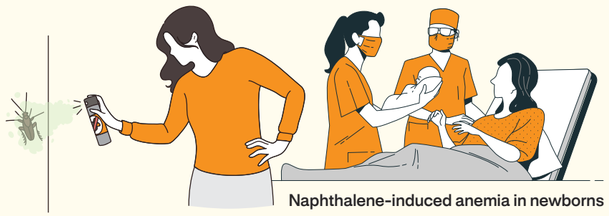
Neurologic and reproductive effects

Impairment of the immune function

Naphthalene

One of the most notable effects is naphthalene-induced anemia in newborns. The INDEX report estimates that Europeans normally experience levels significantly below exposure limits for naphthalene.

Is primarily used indoors as a moth repellent



Naphthalene-induced anemia in newborns

Outdoors, motor vehicle exhaust represents the main source.

associated with longer recovery times from acute respiratory sicknesses (colds and flues) resulting longer away-time from school and work.[22] Indeed, the more research emerges on low air pollution levels, the clearer it becomes that **there is in fact no safe level of air pollution**.[23]

Sources of indoor pollution are numerous and varied; they include environmental tobacco smoke, unvented heating and cooking appliances, cooking, cleaning products, paints, carpets, candles. **Source control is the most effective strategy whenever possible**, and most likely to present a sustainable solution with co-benefits to the environment. For example, gas cookers cause indoor air pollution that is notably linked to asthma in children, a recent study estimating that over 700 000 children in the EU every year would not suffer from asthma symptoms if they were not exposed to gas cooking.[24] While **ventilation** is a mitigation strategy, and should always be employed regardless of the stove type, due to emissions from the cooking process itself, removing the gas stove is the only robust and sustainable option to eliminate the dangers of pollution from this combustion process inside the home. Meanwhile, solid fuel heating is still an important form of heating in Central and Eastern Europe among the poorest households.[25] The use of primary solid biofuels is still present in the Central-Eastern and Southern member states of the EU, and the use of obsolete individual stoves for heating and cooking in unfit housing conditions can lead to fume leaks.[26]

Among the research on substances specific to indoor circumstances, a notable example is the EU-funded Joint Research Centre **INDEX (2005) project**. It identified **5 high priority chemicals**, "with potential of high indoor concentrations, uncontested health impacts, and effective risk management" options. These substances are formaldehyde, nitrogen dioxide, carbon monoxide, benzene and naphthalene.[27]

22 Kyung and Jeong, 'Particulate-Matter Related Respiratory Diseases'.
23 Brunekreef et al., 'Mortality and Morbidity Effects of Long-Term Exposure to Low-Level PM2.5, BC, NO2, and O3'.
24 Jacobs and Kornaat, 'Health Effects in EU and UK from Cooking on Gas'.
25 Eurostat, 'Disaggregated Final Energy Consumption in Households - Quantities'.
26 Feldmar and Bajomi, 'Fuel of the Poor: Household Use of Firewood in Central and Eastern Europe'.
27 Kotzias and et al, 'The INDEX Project - Critical Appraisal of the Setting and Implementation of Indoor Exposure Limits in the EU. Final Report', 14.

INDEX project – summary findings and health effects

Formaldehyde is an important sensory irritant, and almost ubiquitous in indoor environments. Sources include cigarette smoke, insulating materials, certain paints, cleaning agents and disinfectants, gas cookers and open fireplaces. The International Agency for Research on Cancer (IARC) classified formaldehyde as a Group 1 carcinogen for humans in 2004. Mild effects of exposure include eye, nose and throat irritation, lower airway discomfort and dysplasia (abnormal growth or development of cells). The report estimates that almost all Europeans are exposed indoors to concentrations above levels where formaldehyde is considered a chemical of concern.

Carbon monoxide (CO) results from the incomplete combustion of carbon-containing fuels – fossil fuels such as coal, oil or gas, and biofuels. Populations that are especially sensitive to chronic health effects from CO exposure include pregnant people, fetuses, children, the elderly, and people living with diseases that restrict oxygen transport between blood and cells, such as anemia. Smoking, together with cooking and heating appliances, particularly when faulty or inadequately vented, are important indoor sources, together with exhaust from transport outdoors. Depending on exposure duration and intensity, effects range from headaches and subtle cardiovascular effects to unconsciousness and death. In children, long-lasting effects on cognitive development and behavioural alterations have been observed. People with cardiovascular diseases are the population facing the greatest risk from CO exposure, and may experience earlier onset of myocardial ischemia, increased number and complexity of arrhythmias.

The primary indoor sources of **nitrogen dioxide** are gas appliances – stoves, ovens, heaters, etc. Increases in sore throat, colds, respiratory symptoms, absences from school were noted in children. People with asthma and with COPD are also particularly susceptible to health effects.

For **benzene**, indoor sources include cigarette smoke, particle board, various paints and varnishes. The INDEX report estimates that mean indoor concentrations are normally higher than outdoor levels all over Europe. Benzene is recognized as a carcinogen by the IARC; it is particularly linked to bone marrow damage. Other health impacts associated to various levels of exposure include headaches and weakness, blood cell damage, impairment of the immune function, neurologic and reproductive effects.

Finally, **naphthalene** is primarily used indoors as a moth repellent. Outdoors, motor vehicle exhaust represents the main source. One of the most notable effects is naphthalene-induced anemia in newborns. The INDEX report estimates that Europeans normally experience levels significantly below exposure limits for naphthalene.

Microbial pollution and damp

Microbial pollution is an important source of indoor air pollution, and includes pollen and spores of plants from outdoors, as well as bacteria and fungi that grow indoors and thrive when sufficient moisture is available. In addition to leading to the growth of microbes, **dampness** also contributes to the degradation of materials, which in turn also increases indoor pollution.

The individual effects of exposure to specific species of bacteria and fungi are difficult to identify due to the complex exposure to multiple agents simultaneously, sometimes at low, but relevant, concentrations. However, the presence of many such biological agents in an indoor environment has clearly been linked to **increased prevalence of respiratory symptoms, allergies and asthma**, as well as **disturbances of the immunological system**. Mould is a particularly prevalent and harmful form of microbial pollution. Studies suggest a higher risk of certain conditions, such as **hypersensitivity pneumonitis, allergic alveolitis or allergic fungal sinusitis** as a result of exposure to mould and damp.

In Europe, it is estimated that over 80 million people live in a home with dampness, and researchers have determined that the **risk of experiencing asthma increases by 40%** for people who live in a **home with damp or mould**, and that approximately **2.2 million people** across Europe have asthma as a direct result of living in these health-harming conditions.[28] In their Guidelines for indoor air quality: dampness and mould[29], the WHO position is that "there is **no exposure value for mould growth that can be considered safe for health**", and explicitly recommend giving priority to remediating damp and mould issues faced by low-income households. [30]

Air temperature

Together with moisture, temperature has an important effect on the perception of indoor air quality, and **extreme temperatures** have **direct health impacts**. Temperatures also impact indoor air quality indirectly, for example via influencing **ventilation needs and preferences**.

Low air temperatures can lead to **inflammation of the bronchial passages and lungs, vasoconstriction and increased vascular resistance**, contributing to a number of negative health outcomes, including **increased risk of respiratory conditions such as asthma, exacerbation of chronic obstructive pulmonary disease (COPD), ischaemic heart disease, stroke and death.**[31] The **mental health burden** associated with the inability to consistently heat one's home to a healthy temperature is also significant.

28 Urlaub and Grün, 'Mould and Dampness in European Homes and Their Impact on Health'.
29 World Health Organization, WHO Housing and Health Guidelines.
30 World Health Organization, WHO Housing and Health Guidelines, 91.
31 World Health Organization, 32.

The evidence of the harm caused by cold temperatures indoors is so robust that the WHO has issued a recommendation for 18 degrees as a "safe and well-balanced indoor temperature". The report adds a cautionary remark regarding the **potentially different needs of vulnerable groups** such older people, children and people living with chronic diseases, who are more susceptible to cold.[32]

Recent studies conducted in the UK show that **treating conditions linked to cold homes represents one of the top housing-related costs incurred by healthcare systems**, while the investments in warming up vulnerable households result in fourfold returns.[33] Anecdotal evidence of people heating only part of the house, and of using the gas stove in order to do so, is concerning, particularly in light of the potential for carbon monoxide poisoning and explosions.

High temperatures pose health risks as well, which range from **thermal discomfort to cardiovascular, and all-cause, mortality.**[34] **Emergency hospitalisation rates** also increase with high temperatures. Different degrees of vulnerability are a factor to be considered here, with people with schizophrenia having three times higher odds of mortality during heatwaves, due to the effects of antipsychotic medication on thermal regulation.[35] People with cardiovascular, Parkinson's and Alzheimer's diseases, as well as epilepsy and diabetes also experience increased risk.[36]

Building design and ventilation

Architectural and design features such as orientation, construction materials, wall thickness, shading elements, and (natural or mechanical) ventilation can be employed with a view to ensuring a safe indoor environment, including safe temperature control.

32 World Health Organization, 32.
33 Lambert, 'How Poor Housing Costs the NHS £1.4bn a Year'.
34 World Health Organization, WHO Housing and Health Guidelines, 44.
35 Laursen, Nordentoft, and Mortensen, 'Excess Early Mortality in Schizophrenia'.
36 Ormandy D., Ezratty V.: "Health and thermal comfort: From WHO guidance to housing strategies".

Broader **urban planning** elements can help protect against temperature variations as well. For example, blue and green infrastructure (natural and semi-natural land and water areas) can play a role in countering the **heat island effect** encountered in urban environments.

Ventilation and **infiltration** determine the **air exchange rate** (AER) with the outdoors. Infiltration takes place through cracks and leaks in the building envelope. In **new or renovated buildings**, which are more energy efficient and hence more airtight, infiltration rates are lower, leading to an increased **need for purposeful ventilation**, which can be incorporated via mechanical or passive systems. All forms of ventilation are important in order to dilute or remove pollution. Because of this function, ventilation rates are oftentimes used as a proxy for indoor air quality. However, one of the drawbacks of an approach to IAQ that is based solely on ventilation are the complexities of determining ventilation requirements before the pollution levels could be known – i.e. at the design stage, when the number of occupants, their general behaviour and consumer choices such as in terms of appliances, furniture and cleaning products cannot be known in the vast majority of cases. While ventilation remains an important instrument, it is most effective when combined with other pollution reduction strategies.

Mechanical ventilation, particularly when coupled with air filtration and air disinfection, presents renewed interest in the wake of the COVID-19 pandemic and in light of its potential to protect against airborne transmission of diseases.[37] Air filtration has been linked to other health benefits, in particular being considered a feasible means of reducing cardiovascular risk in the elderly.[38] On the other hand, mechanical ventilation contributes to an increase in energy consumption and in carbon emissions, and it can even become a source of pollution itself and lead to health problems if not properly used and carefully maintained. Accumulation of debris, dust and other par-

37 Morawska et al., 'A Paradigm Shift to Combat Indoor Respiratory Infection'.
38 Bräuner et al., 'Indoor Particles Affect Vascular Function in the Aged'.

ticles in ducts and filters, as well as mould and condensation are potential problems that need to be prevented and addressed. Meanwhile, **passive – or natural – ventilation** makes use of pressure differences and natural forces to ensure air exchanges. However, natural ventilation alone may not always be effective or desirable – e.g. in seasons with extreme temperatures or when outdoor pollution levels are high.

Indoor – outdoor air mix

While **indoor and outdoor air** are often treated in **separate research or policy frameworks** in order to address their particular challenges, **the quality of one will influence the other**, as illustrated in the discussion above about ventilation and air exchange rates. The complexity of the indoor – outdoor interplay can further be seen in the context of two domestic appliances: boilers and air conditioning systems.

In Europe, boilers are normally vented to the outside, therefore they are an indoor source of pollution directly affecting outdoor air quality. A study commissioned by EPHA revealed that this outdoor pollution from heating is responsible for 27 billion euros annually in health-related social costs across Europe.[39] However, given indoor-outdoor air exchange rates, in neighbourhoods that rely primarily on polluting fossil fuels or biomass for heating, this increase in local pollution levels will likely affect individual indoor environments as well through AER. Similarly, air conditioning systems can potentially increase the outdoor temperature in their vicinity, as well as noise pollution, therefore affecting the health of others, particularly those who cannot install an AC unit. This in turn increases health inequities even within the local community.

Renovation and insulation

Regulations for new buildings are important to stimulate innovation and drive-up the quality of life but the **biggest health impact** will be achieved by **targeting the existing building stock.**[40] Most of the buildings in Europe today are not energy efficient, and 85-95% of these buildings will still be standing in 2050.[41]

If conceived and funded in an equitable way, renovations represent an **opportunity to improve people's lives in a very concrete way**; better outdoor air quality by phasing out polluting energy sources, lower energy bills as a result of increased efficiency, and increased health and wellbeing, including through more stable and healthier indoor air and temperatures. At the same time, these efforts will contribute to **climate change mitigation**. Reducing greenhouse gas emissions from buildings is essential, as the sector accounted for 35% of energy-related emissions in the EU in 2020.[42] **Insulation** should also play a role in **climate change adaptation**, particularly in the context of extreme weather events. What leads to negative health outcomes are not only extreme temperatures but also **sudden changes in temperature**, therefore the protection and insulation offered by the building envelope as a shelter, providing a barrier to the outdoor environment, is important.

In order to reap the maximum benefits for health and the environment, insulation and renovation interventions thus need to be approached from a sustainability and equality perspective and with a holistic view to the process. For example, while any additional insulation will likely improve energy consumption, insulation materials can affect indoor air quality, and therefore it is important that they do not emit toxic substances.

39 European Public Health Alliance (EPHA), 'Replacing Fossil Fuels and Biomass with Cleaner Alternatives in Residential Heating and Cooking Can Decrease the Social Health Costs'.

40 Braubach, Jacobs, and Ormandy, Environmental Burden of Disease Associated with Inadequate Housing.

41 European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions on a Renovation Wave for Europe–greening our buildings, creating jobs, improving lives.

42 European Environment Agency, 'Greenhouse Gas Emissions from Energy Use in Buildings in Europe'.

As insulation improves, energy efficiency increases and there are fewer uncontrolled airflows. At the same time, this increased airtightness comes with a need to pay more attention to deliberate ventilation. However, the effects of retrofitting on IAQ are not straightforward, with both positive and negative differences in pollutant concentrations having been observed after renovations aimed at energy efficiency improvements.[43] Any potential additional ventilation needs that may come with increased airtightness should also be contrasted with the urgent needs for renovation of at least 13% of European households, who have reported damp or leaks on roofs or walls in the latest European Quality of Life survey.[44]

43 Prasauskas et al., 'Effects of Energy Retrofits on Indoor Air Quality in Three Northern European Countries'.

44 Eurofound, European Quality of Life Survey 2016.

Energy poverty and health inequities

As stated before, indoor air pollution can lead to a wide range of negative health effects. However, it is also important to note that these negative outcomes disproportionately affect certain groups. Many of the factors of the built environment that influence indoor air quality, such as indoor pollutants, damp, mould, air temperature, heating sources, and insulation and ventilation, relate to fuel and energy consumption as well as housing quality and affordability. As such, the concept of **energy poverty (EP)** is crucial in understanding the causes of inequities in energy use and, with that, health inequities.

The European Commission currently defines energy poverty as "a situation in which households are unable to access essential energy services and products." The issue remains highly relevant; the number of households that were unable to keep their homes adequately warm **increased to 9.3%** in 2022 in the EU because of rising energy prices.[45] Consequently, EP is widely considered in the EU's energy policy–more specifically, through the Energy Poverty Advisory Hub, and the requirement for Member States to draft Social Climate Plans to address EP.

To understand the causes of EP and the resulting inequities, the concept of the **energy ladder** is helpful. It implies that, the wealthier a household is, the more likely it is to use more efficient and less polluting fuels. In turn, people from lower socio-economic backgrounds are more likely to use traditional or solid fuels, which are less efficient and more polluting.[46] This disproportionately exposes vulnerable households to health risks. This is because, aside from being more polluting, appliances used for solid fuel may not vent adequately to the outside, further worsening indoor air quality.[47] Addi-

45 European Commission, 'Energy Poverty in the EU'.

46 Culver, 'Energy Poverty: What You Measure Matters'.

47 European Public Health Alliance (EPHA), 'The Impact of Residential Heating and Cooking on Air Quality in Europe: The Health Argument for Clean Heating and Cooking'.

tionally, in the case of biomass, its classification as renewable energy incentivises its continued use. While many environmental organisations call into question the sustainability of biomass for energy production[48], and health experts are categorical on the health harms of air pollution associated with its burning, biomass remains the major contributor to reaching national binding renewable energy targets in many member states.[49] This situation underscores the importance of considering environmental and human health together in all such policies. Housing is a social determinant of health, meaning there is a clear link between lack of housing, or poor quality housing and health. One of the mediators for that link is the ability to keep warm,[50] once again underlining the importance of paying attention to energy poverty, and effective social protections for those experiencing energy poverty. With that in mind, the interaction between energy poverty and health is important to consider as they are in a **bi-causal relationship.** In simpler terms, one of the causes of energy poverty is **healthcare costs** that result from a poor health status, while at the same time energy poverty can **lead to poor health status.**[51] These issues affect certain groups more than others. For example, **people with chronic or severe illnesses** face higher health risks when faced with low temperatures. At the same time, people from a higher socio-economic or educational background are less likely to suffer from energy poverty. [52]

Though a research gap still exists, specific examples of how energy poverty affects health are increasingly being covered. A Wellbased project survey revealed a worrying picture on energy poverty and ill-health; around **65%** of people surveyed felt **anxious or depressed** as a result of energy poverty. Furthermore, **30%** reported being told by a doctor to have **lung disease** (asthma, chronic bronchitis or emphysema), while **29%** reported to have **avoided healthcare because of its cost.**[53] Similarly, research done as part of the EmpowerMed project revealed that **54%** of people affected by energy poverty **report a longstanding illness or health problem,** versus 37% of those not affected by energy poverty.[54]

Energy poverty currently forces an increase in public health budgets to counteract the negative health impacts of energy poverty.[55] At the same time, the energy transition may exacerbate income inequality for low-income households. The reasons for this the high investment costs for higher building standards when someone is a home-owner, with those costs being transferred to tenants when someone rents a home.[56] This means certain groups may increasingly be left behind. Households suffering from energy poverty may be forced to invest their money in feeding the family first. If there is no money left to invest in energy renovation, this significantly slows progress to the improvement of IAQ. This means that rising energy bills may lead to health issues persisting, while the inability to pay those bills may also lead to evictions or homelessness. Additionally, targeted schemes must be adapted to the specific needs and circumstances of the poorest households, who struggle to access mainstream financing streams such as loans or state support due to their vulnerable financial and employment situation.

48 ECOS, 'Out of the Woods'.
49 Euractiv, 'Exposed: How EU Countries Use Firewood to Bloat Their Renewable Energy Stats'.
50 Lima, F., Ferreira, P., & Leal, V. (2022). The Role of Energy Affordability in the Relationship between Poor Housing and Health Status. Sustainability, 14(21), 14435. 14.
51 Polimeni, Simionescu, and Iorgulescu, 'Energy Poverty and Personal Health in the EU'.
52 Thomson, Snell, and Bouzarovski, 'Health, Well-Being and Energy Poverty in Europe'.
53 Wellbased.eu, 'Warnings from WInter 2022-23: Support Measures against Energy Poverty Need to Deliver More Health Benefits'.
54 Pirotte and Žemva, 'EmpowerMed Cross-Pilot Analysis: Exploring the Situations of Households Affected by Energy Poverty'.
55 Polimeni, J. M., Simionescu, M., & Iorgulescu, R. I. (2022). Energy Poverty and Personal Health in the EU.
56 Gore, Stainforth, and Urios, 'Social Justice Priorities in the Fit for 55 Package'.

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The challenges and opportunities of legislating private spaces

Dismissals of attempts to create a regulatory framework for IAQ often cite the challenges of legislating on – and then implementing and monitoring – matters of private property, and the lack of large sets of EU-specific data on pollution and exposure levels. In indoor spaces, individual choices have arguably a higher impact on air quality, given limited dispersion, where even limited emissions can result in high concentrations. Yet **personal choices take place within a choice environment regulated and defined by EU and national legislation and incentives**, which should be health-protective and promoting. In terms of data, **field studies** have become easier and less expensive to conduct, thanks to new and less noisy technology. Smaller sample size and modelling studies can provide guidance in taking the first steps towards legislation. Findings in global literature may not always be applicable to the European context given different cultures, traditions and legislation governing the myriad of products than contribute to IAQ, and the complex interactions between substances; but these findings can inform and shape European thinking, research directions and funding.

Additionally, in the case of **rented properties**, enforcement should be facilitated by the potential for checks and improvements to be mandated at certain key moments (e.g. when a new tenant signs a contract). This would translate into an ability to protect a significant percentage of the population in Europe, often including the most vulnerable. Furthermore, the threat of eviction can deter people from speaking up against poor living conditions, while causing anxiety and making it more difficult for people to embrace the feeling of belonging in a community.[57] Therefore, **mandated minimum indoor environment standards can empower tenants to claim their right to a healthy environment**. Particular attention should be devoted to ensuring that these measures do not however increase the risk of **renovictions** – evictions on the grounds of major renovation works. Similarly, mandated standards may lead to rental properties being taken off the market , while renovations may lead to increases in rent. This should be addressed through targeted policies and dedicated funds so as not to exacerbate the existing financial burden on vulnerable households.

57 Middlemiss et al., 'How Do Interventions for Energy Poverty and Health Work?'.

European and national regulatory environments

The European environment

IAQ has been called a "**regulatory no [wo]man's land**", and this becomes apparent after a first look at the myriad of policies and regulations that impact aspects of indoor air quality, on a background of a **lack of a common EU-wide understanding as to what constitutes "a healthy indoor air quality"**. Some EU initiatives display an awareness of this issue, but fail to directly and comprehensively tackle it.

The environment is a shared competence under the Treaty on the Functioning of the European Union (TFEU), and environmental policy is to contribute to "preserving, protecting and improving the quality of the environment" as well as "protecting human health" (Art 191).[58] While this has been used as the legal basis for the Ambient Air Quality Directive, indoor air quality regulation and policies are currently in the realm of Member States. At a framework level, the 7th **Environmental Action Plan** to 2020 (2013) included in its priorities ensuring that "**indoor air quality has improved**".[59] Regrettably, no mention of indoor air or environment quality is made in the 8th Environmental Action Plan to 2030[60] (2022).

58 European Union, Consolidated version of the Treaty on the Functioning of the European Union.

59 European Parliament, General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'.

60 European Parliament, General Union Environment Action Programme to 2030.

At a political level, the previous **European Parliament** legislature (2014-2019) adopted a **resolution** exposing the "failure to [...] tackle indoor air pollution", hindering the achievement of Priority Objective 3 under the 7th Environmental Action Plan. The European Parliament urged the Commission to define "**harmonised testing standards to measure air pollution in indoor environments**", and to **combat indoor pollution sources.**[61] The current legislature (2019-2024) took another step forward, with its resolution on the implementation of the Ambient Air Quality Directives asking the Commission to "**consider regulating indoor air quality independently or as a part of sustainable buildings legislation**".

Later in 2021, a parliamentary question was raised asking the Commission about the actions it is taking and programmes it is supporting in order to ensure good indoor air quality for European citizens and workers.[62] The answer points to Member States as largely holding responsibility for IAQ, but also to the different pieces of European legislation that impact IAQ, on issues such as chemicals and construction products, to ventilation. The **Commission** also committed to assessing "**policy options to improve indoor air quality"**[63], but any clear outcomes of this assessment are yet to be seen.

One of the most important pieces of European legislation for IAQ is the **Energy Performance of Buildings Directive (EPBD)**, which takes a "whole building" approach. The EPBD published in 2010 already mentioned the need to take into account the "general indoor climate conditions" for minimum energy performance requirements.[64] However, it lacked details or guidelines as to how this should best be achieved. The directive is currently under revision. The draft report by the European Parliament rapporteur proposed the introduction of the concept of "indoor environment quality", which includes IAQ. However, this turned out to be a point of contention, with Member States pushing back against these amendments.[65]

The lack of clarity and explicit definition of "good" or "healthy" indoor air quality can be seen in a number of files, including the **Construction Products Regulation (CPR)**. The article cited below can be found in the Commission proposal for a revision; similar language exists in the current CPR in force as of 2011.

Annex I–PART A–Art. 1.3

> The construction works and any part of them shall be designed, constructed, used, maintained and demolished in such a way that they, throughout their life cycle, do not present acute or chronic threat to the health and safety of workers, occupants or neighbors as a result of any of the following:
>
> (a) the emissions of hazardous substances, volatile organic compounds or hazardous particles into indoor air;
>
> (b) the emission of hazardous radiation into the indoor environment.[66]

The meaningful fulfilment of this requirement would call for an agreed upon level of emissions that are not a threat to health, and for established ways to test, measure and enforce this, at least as guidelines at the national level. Similarly, in the **Renovation Wave**, with "high health and environmental standards" as one of its key principles, the EC identified a number of areas of intervention, including "using renovation as a lever to address energy poverty and access to healthy housing for all households". In the

61 European Parliament, 'Texts Adopted–A Europe That Protects'.

62 Arłukowicz, 'Parliamentary Question | Indoor Air Quality | E-002175/2021 | European Parliament'.

63 Breton, 'Parliamentary Question | Answer for Question E-002175/21 | E-002175/2021(ASW) | European Parliament'.

64 Official Journal of the European Union, 'Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings'.

65 Council of the European Union, Interinstitutional File: 2022/0426(COD). Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast)–Preparation for the trilogue.

66 European Commission, 'Revision of the Construction Products Regulation'.

absence of a common agreement on what constitutes "**healthy housing**", it is difficult to assess whether and which policies and interventions have been successful. Were healthy housing to be defined, it is essential that this definition does not negatively impact the affordability of housing, as this may be counterproductive.

Non-binding international IAQ standards

Standards and guidelines for indoor air and environment quality and ventilation do exist, and their implementation could contribute to improved IAQ. However, their impact has so far been limited due to their **non-binding** nature. Organisations issuing such standards include the International Organization for Standardization, the European Standards Organizations and the American Society of Heating, Refrigerating and Air-Conditioning Engineers.

A critical review of standards from these found ventilation rates and CO2 concentrations to be the factors typically used in standards and guidelines to ensure adequate IAQ. Ventilation rates can be defined using three methods:

- Perceived air quality (limit the odour level in the space perceived by the occupants);
- Limiting the concentration of specific contaminants – usually in line with WHO guideline levels;
- Predefined ventilation flow rates based on occupation or floor area.[67]

The different methods may lead to different requirements, but they can serve as a solid evidence-based starting point for policy-making.

67 Khovalyg et al., 'Critical Review of Standards for Indoor Thermal Environment and Air Quality'.

National legislation

One of the amplest EU-funded projects on the topic of indoor air quality, with findings quoted in subsequent JRC reports, the HEALTHVENT project (2009 – 2013), found that **national legislation across Europe** was **limited** in terms of requirements for: **ventilation** systems and droplets and condensation, **infiltration** of outdoor pollutants and filtering, **maintenance** and **cleaning.**[68] National legislative frameworks are not comprehensive, not aligned with guidelines from bodies such as the European Standards Organizations, nor are they similar or even easily comparable among themselves. Some countries have limits or target values for indoor pollution. These are however often at **levels above the WHO guidelines, cover different substances and recommend different levels across the Member States**. For formaldehyde, one of the more common substances covered, they WHO guideline is 0,1 mg/m^3; meanwhile, national frameworks vary from 0,01 mg/m^3 (Lithuania, Regulation HN 35:2007) to 100 mg/m^3 (Slovenia, ULRS 42/2002).[69] One of the most recent developments in this area is the 2022Belgian law on the improvement of indoor air quality in closed spaces accessible to the public, which covers only CO2 levels.[70] Ventilation rate requirements are provided in different units, which makes direct comparison challenging. The analysis performed under HEALTHVENT shows that these are heterogenous, and inconsistent with European Standards.[71] Finally, **compliance checks** have been found to lack and, when they are being performed, normally happen at the design stage rather than as on-site measurements.[72]

68 Kephalopoulos et al., 'Promoting Healthy and Highly Energy Performing Buildings in the European Union', 54.
69 Kephalopoulos et al., 50.
70 Moniteur Belge, Loi relative à l'amélioration de la qualité de l'air intérieur dans les lieux fermés accessibles au public.
71 Kephalopoulos et al., 'Promoting Healthy and Highly Energy Performing Buildings in the European Union', 39.
72 Buildings Performance Institute Europe (BPIE), 'Indoor Air Quality, Thermal Comfort and Daylight–Executive Briefing'.

Recommendations

Recommendations from the reviewed literature

EU attempts to tackle the IAQ problem have existed for at least two decades, including in the form of recent calls from the European Parliament. But a coherent approach, let alone a legislative or policy framework, is yet to be developed.

One of the more notable attempts, INDEX project proposed a series of recommendations:

- Using building codes and ventilation standards to control indoor air pollution sources and to ensure dilution of chemicals
- Establishing guideline values for key pollutants
- Introducing mandatory maintenance and inspections for sources of pollution such as gas appliances or fireplaces
- Restricting smoking in all indoor spaces, as a common source of many toxic chemicals
- Raising public awareness and providing information to consumers, such as through labels regarding emissions from building products, furnishings and other consumer products
- More broadly, developing an eu-wide strategy for iaq assessment and management.

While the report favoured voluntary measures, the very limited progress in indoor air quality management since its publication almost two decades ago points to the need for mandatory and enforceable policies.

Other regulatory options put forward in the academic literature include:

- Banning the use of certain pollutants or of products whose use results in certain pollutants;
- Regulating maximum allowable emission rates (product-level), maximum allowable concentration levels (space-level), minimum ventilation rates;
- Requirements on products to ensure appropriate functioning[73] – e.G. For the heating, ventilation, and air conditioning (hvac) system.

EPHA recommendations

1. Establish a common European approach to tackling IAQ, recognising the major role that it plays in people's health and wellbeing

Attempts to establish a policy approach to tackling indoor air quality are often met with a resistance that points to the complexity of the matter at hand, in particular the myriad of personal choices that lead to a unique air mix in every household. This complexity should be acknowledged – while making no claims at being comprehensive, the present paper explores some of it – and reflected in the policy approach IAQ. Complexity is in the nature of our modern societies, and commonly makes the subject of legislation. The outdoor air quality is also the result of a combination of factors, including personal choices, societal forces and natural elements. The car that one buys, commuting and mobility patterns, the opening and closing down of fac-

73 Bluyssen, 'Towards an Integrative Approach of Improving Indoor Air Quality'.

tories, wind currents, even choices made in other jurisdictions, all contribute to the outdoor air mix. However, EU legislation establishes that the combined effect of all these activities and choices should not lead to pollution levels that cause excessive harm to human health. The issue of indoor air quality should be approached from a similar perspective.

The WHO Air Quality Guidelines specifically apply to both indoor and outdoor environments. It is therefore established to the highest level of scientific rigour that pollution above these concentrations leads to negative health impacts. European and national policies and legislation should reflect this and protect citizens in view of their human right to clean air, as recognised by the United Nations.[74] Where legislation is not yet possible, guidelines should be set in place as a first immediate step, with incentives for health-protecting practices and monitoring, while studies are funded to better understand all complexities involved. These first steps would signal political will and encourage a societal shift towards integrating IAQ into the design, construction and maintenance of buildings, influencing buying decisions, increasing awareness and shifting the market.

2. Fund research into the indoor air mix in European buildings, with a view towards policy solutions to improve IAQ

To support and inform the emerging IAQ framework, the EU should fund data gathering exercises and subsequent analyses, including in terms of health burden, health costs and potential improvements and savings under different policy and product use scenarios. Several analyses have been run to understand the economic impacts of outdoor air pollution from various sectors[75], and these have helped illustrate the magnitude of the problem from a monetary perspective. The same kinds of research should be undertaken for indoor air quality. Such research should include a focus on the social aspect of IAQ policies to gain an understanding on their social impact, ensuring that IAQ policy does not inadvertently exacerbate (health) inequities.

These research projects should take a comprehensive approach to IAQ, departing from the singular focus on ventilation of many existing studies, and including a wide range of pollutants. When considering indoor air pollution and its impacts, the WHO itself tends to focus on data about polluting fuels, whereby "polluting fuel" is understood to include solid fuels (such as wood, coal, animal dung, charcoal, crop waste) and kerosene. The main pollutant that is normally being considered and monitored, and that these fuels have in common is particulate matter. While solid fuel combustion is a key emission source to be addressed, these are not the only fuels that affect indoor environments and are currently harming the health of Europeans. Enlarging the scope of both pollutants and sources considered will allow for the gathering of better data for a more comprehensive understanding of IAQ.

Steps in this direction are being taken already at the national level, where some guidelines exist in some cases, and with the UK recently recommending that the government evaluate "the costs and benefits of enforceable indoor air quality standards appropriate to broader protection of public health in public places."[76]

3. Address IAQ with a multi-pronged policy approach, while taking into account that tackling the source of pollution should always be preferred over mitigation measures

The EU approach to managing and reducing air pollution, as re-affirmed in the Ambient Air Quality Directive (AAQD), is based on three pillars: the Ambient Air Quality

74 UN News, 'UN General Assembly Declares Access to Clean and Healthy Environment a Universal Human Right'.

75 CE Delft, 'Health Costs of Air Pollution in European Cities and the Linkage with Transport'.

76 Lewis et al., 'Indoor Air Quality'.

Directive itself, which sets pollution limits; regulation for emission sources; and emission reduction obligations.[77] Drawing on this established approach, and taking into account the particularities of indoor pollution, four directions should be considered:

1. IAQ standards and guidelines
2. Emission source regulation
3. Reduction requirements
4. Regulations concerning the built environment as the indoor – outdoor mediator and key factor for iaq through its structural and design properties.

This approach will impact multiple legislative files, including the Energy Performance of Buildings Directive, the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), the Construction Products Regulation (CPR), Eco-design and Energy Labelling for heating and cooking appliances. In true Health in All Policies spirit, health impacts should be taken into account when deciding on sectoral legislation or policies that influence IAQ, and accurate and understandable health-relevant information should be provided to consumers. It is therefore essential that policy coherence and coordination is maintained, and that targeting emission sources remains the priority, as put forward in the EU Zero Pollution Action Plan pyramid on interventions. Whenever possible, eliminating the source of pollution will represent a more robust measure than mitigation strategies. In the implementation of any such legislation and policies, it is important that they do not have a negative social impact. This means that, for example, sufficient funds are ringfenced to prevent the worsening of social inequities, and that these funds are accessible and useful.

4. Consult experts and stakeholders through cross-disciplinary conversations for evidence-based policies that protect the health of all

The approach to addressing the complexity of factors and policies that can affect IAQ should include meaningful dialogue with experts and stakeholders. These kinds of initiatives have existed in the past, with DG SANCO setting up an expert group on IAQ in 2006. A similar approach should inform the steps taken towards a European framework for IAQ. The complexity of the issue should be reflected in the diversity of the group, which could include energy efficiency and building experts, chemists and public health specialists, as well as consumers, patients and representatives of marginalised communities. Understanding air flow dynamics and interactions between different pollutants is as important as understanding consumer behaviours, patient vulnerabilities and the needs of marginalised communities. Furthermore, ensuring dialogue between the different groups will support and enhance policy coherence.

5. Acknowledge and consider the impacts that the built environment has on health, and prioritise interventions that tackle health inequities and lead to the greatest health benefits

Some IAQ considerations are often included or referred to in buildings legislation. However, these rarely accurately reflect the importance or complexity of IAQ. One practical solution that has already been advocated for by civil society is for IAQ requirements to become part of the Energy Performance Certification Process, and for these standards to be reflected in the national renovation strategies.[78] This will firmly embed IAQ into the "building as a whole" approach of the Energy Performance of Buildings Directive.

In relation to housing quality, energy poverty is a crucial consideration in tackling health inequities that result from indoor air pollution. Energy poverty and poor health

77 European Parliament, 'Ambient Air Quality and Cleaner Air for Europe'.

78 Buildings Performance Institute Europe (BPIE), 'Indoor Air Quality, Thermal Comfort and Daylight–Executive Briefing'.

are mutually reinforcing. Therefore, energy interventions should be complemented by health interventions to ensure energy renovations consider long-term health benefits.[79] This is crucial if vulnerable households are to benefit from improved IAQ as part of an improved built environment and an inclusive energy transition.

Seeing how interconnected indoor air quality, energy poverty and energy efficiency are, impact assessments for energy performance and renovations should include health impacts such as healthcare costs, and indirect health costs, such as loss of productivity and wellbeing. EU and national funding should prioritize low-income and vulnerable households in supporting renovations. Adequately designed and sufficient funding should be ringfenced for households living the worst-performing stock and unfit households to carry out energy retrofits in priority. Technical and social accompaniment should be part of renovation programs for the maximum positive impact.

6. Raise public awareness on the importance of IAQ for health, and provide clear product information to consumers

While air pollution is recognised by Europeans as a health threat[80], IAQ and indoor sources are less present in public conversations. There is therefore a need to strengthen science communication and raise public awareness on the health impacts of indoor air quality.

While not sufficient to protect health as a stand-alone policy intervention, labels may support consumers in making more informed decisions. Information in IAQ could be integrated into existing frameworks, such as the Energy Performance Certificate. A separate certificate could be an alternative option, but that would create a more complicated information environment for consumers.

79 Middlemiss, Lucie, et al. How do interventions for energy poverty and health work?. Energy Policy 180 (2023): 113684.

80 European Commission, 'Special Eurobarometer 524–Attitudes of Europeans towards Air Quality'.

For those emissions that result from individual choices and indoor sources that cannot be predicted and controlled at a building-level, the idea of developing "activity-based emission inventories", recently considered by the UK government[81], should be explored in the EU as well.

7. Ensure adequate legislative protection for tenants to exercise their right to healthy air and healthy environment

Renters may face challenges in exercising their right to healthy air and environment, including for fear of eviction. However, rented properties in fact present good potential for implementing IAQ standards, as check and improvements can be mandated at certain key moments (e.g. when a new tenant signs a contract). Particular attention should be devoted to ensuring that these measures do not however lead to an increasing threat of renovictions (evictions on the grounds of major renovation works), to increased rents, or to rental properties being taken off the market. Legislation or IAQ standards should never lead to increasing social inequities, ensuring a healthy environment to all.

81 Lewis et al., 'Indoor Air Quality'.

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By Cristina Pricop, Policy Manager, EPHA.

Contact: About general enquiries, please email epha@epha.org

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The European Public Health Alliance has received funding under an operating grant from the European Union's EU4Health Programme (2021-2027). The content of this document represents the views of the authors only and is their sole responsibility; it cannot be considered to reflect the views of the European Commission and/or the European Health and Digital Executive Agency (HaDEA) or any other body of the European Union. The European Commission and the Agency do not accept any responsibility for use that may be made of the information it contains.

Transparency Register Number: 18941013532-08

Co-funded by the Health Programme of the European Union