UK Health Security Agency

Impact of Climate Change policies on Indoor Air Quality and health

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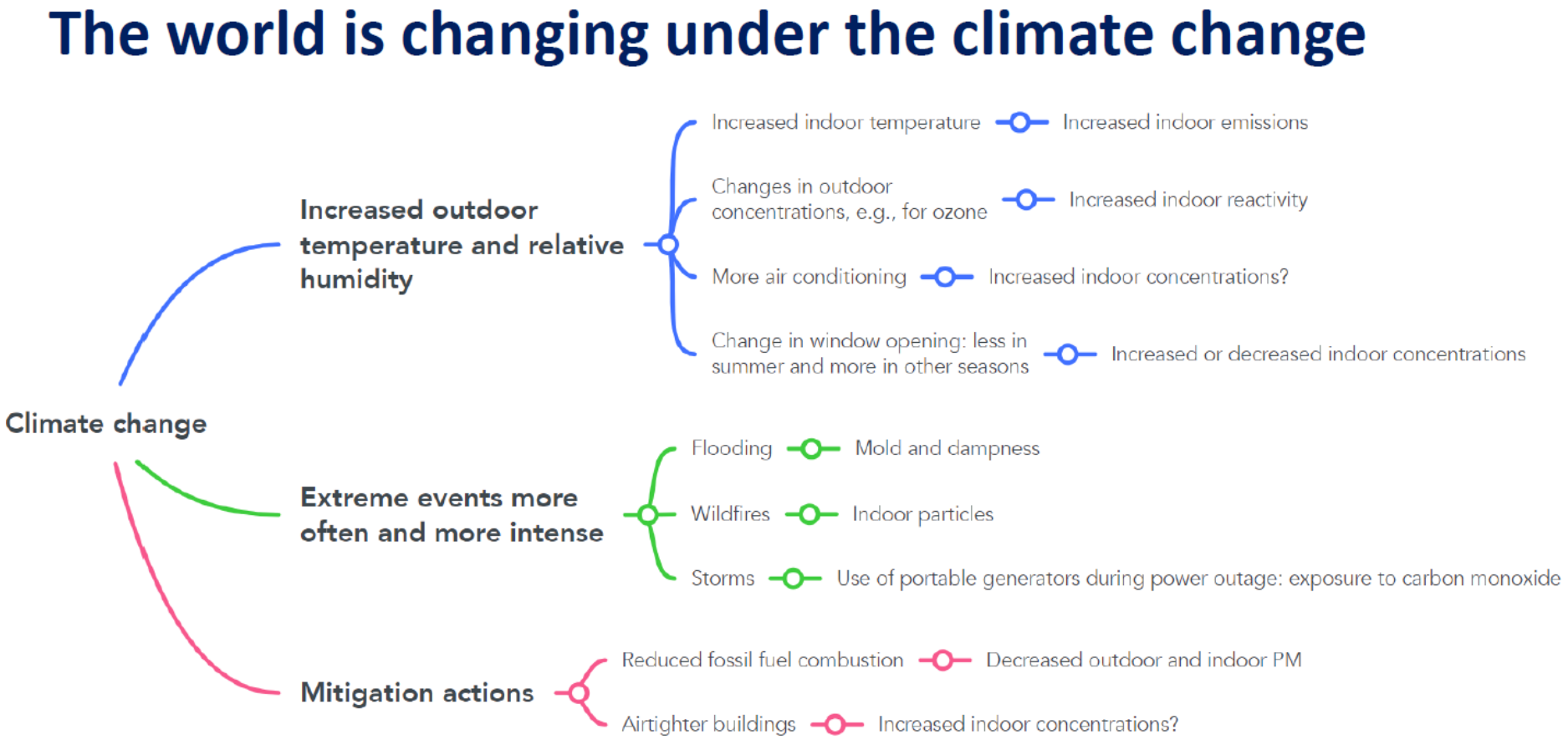
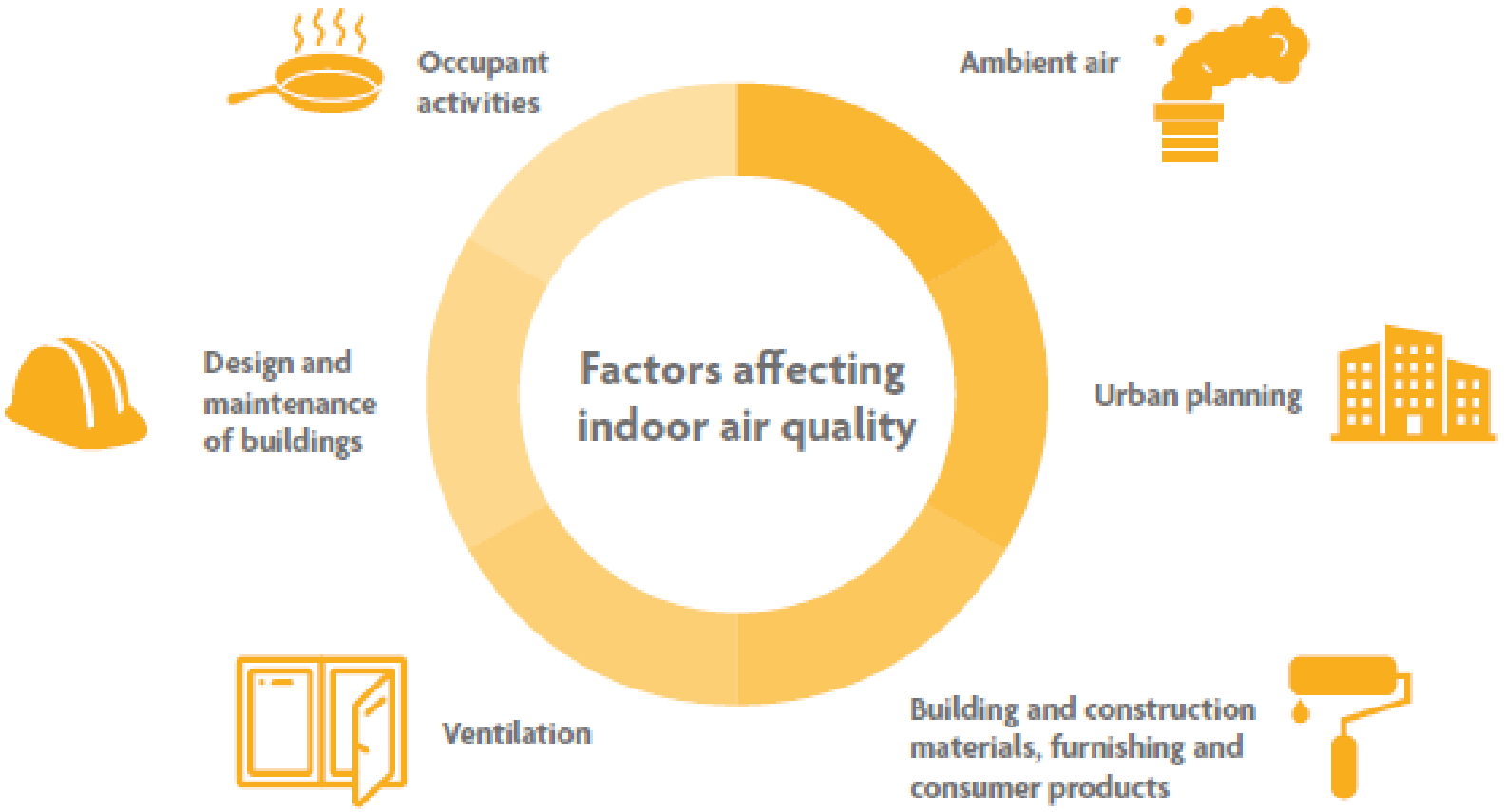
Climate Change Challenge



Kindly provided by Corinne Mandin (IRSN, France)

Why do we care about indoor air?

Factors affecting Indoor Air Quality (IAQ)



▲ Figure 1. Factors affecting indoor air quality.

Dimitroulopoulou, S (2021) Indoor Air Quality and Health. Environmental Scientist, 42-49; https://www.the-ies.org/sites/default/files/journals/improving-indoor-air-quality.pdf

Sources of IA pollutants - homes

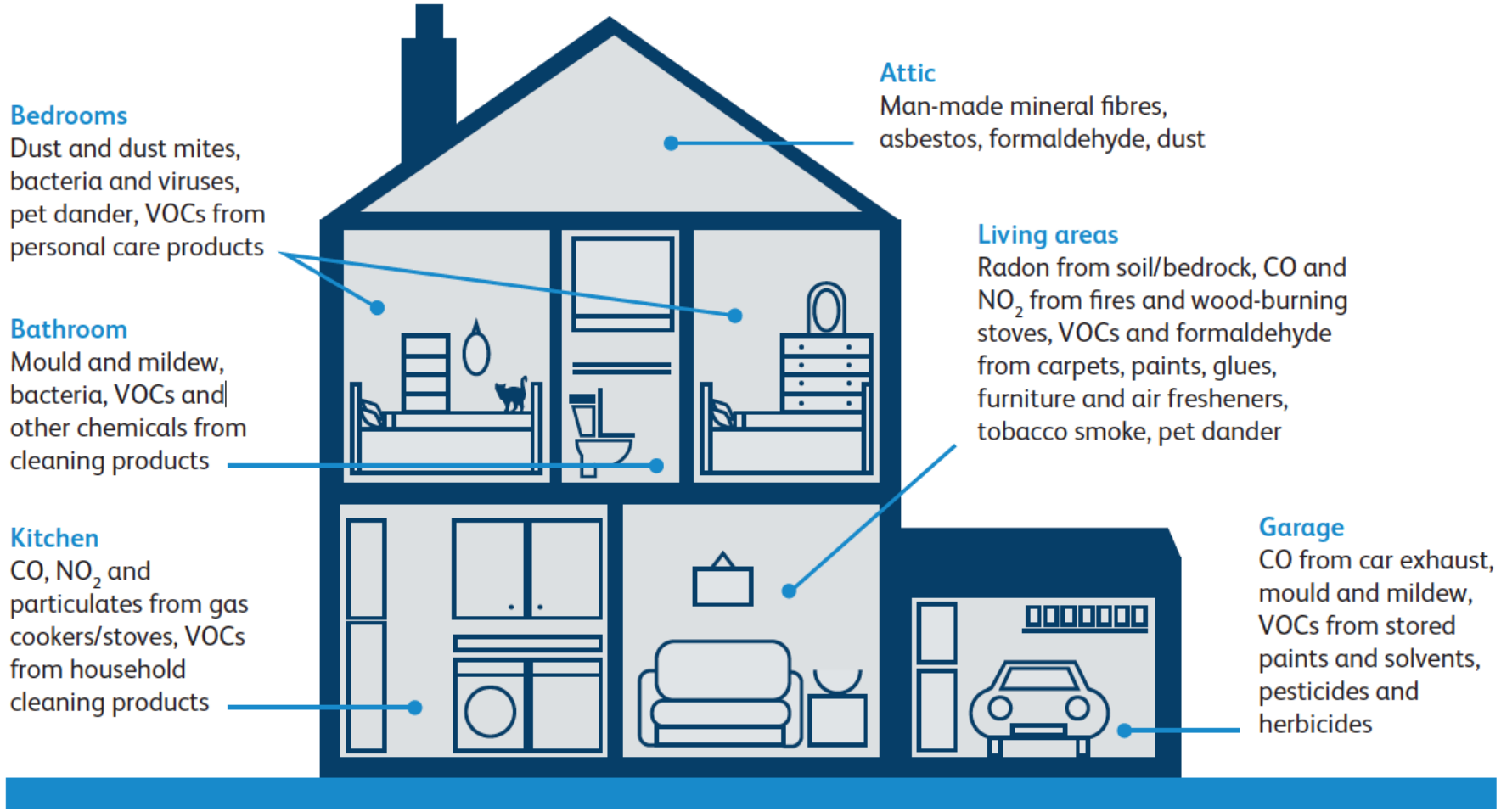


Fig 3. Sources and types of indoor pollution encountered in homes. VOCs = volatile organic compounds. Please note that these lists are not exhaustive and that the actual pollutants present, and their amounts, will vary from household to household.

RCP (2016); RCPCH / RCP (2020)

Health effects

Exposure to indoor air pollutants, chemicals and biological contamination is associated with

- respiratory system
- nervous system
- cardiovascular system
- carcinogenicity
- respiratory irritation

RCPCH (2020) NICE (2020) WHO (2021)

Birth and infancy

- Respiratory problems – wheeze, rhinitis, atopic asthma, respiratory infections
- Low birthweight and pre-term birth

Pre-school

- Respiratory problems – wheeze, allergies, asthma, risk of respiratory diseases and pneumonia
- Eczema and atopic dermatitis
- Greater hyperactivity, impulsivity and inattention

School age

- Respiratory problems – wheeze, rhinitis, asthma, throat irritation, nasal congestion, dry cough
- Eczema, dermatitis, conjunctivitis, skin and eye irritation
- Reduced cognitive performance, difficulty sleeping

RCPCH (2020) https://www.rcpch.ac.uk/sites/default/files/2020-01/the-inside-story-report_january-2020.pdf

The health risks of damp and mould

Images by Freepik

- Damp and mould in the home can produce allergens, irritants, mould spores and other toxins that are harmful to health.
- Damp and mould primarily affect the airways and lungs and can cause serious illness and, in the most severe cases, death.
- Respiratory effects include:
  - general symptoms such as cough, wheeze and shortness of breath
  - increased risk of airway infections, including aspergillosis (an infection of the airways with the fungus Aspergillus)
  - development or worsening of allergic airway diseases e.g. rhinitis, asthma and conditions that involve inflammation of the airways, eg bronchitis, COPD
- Other physical health effects include: irritation of the eyes and skin and other fungal infections, especially in people with weakened immune systems
- Living in a home with damp and mould can also affect tenants' mental health

https://www.gov.uk/government/publications/damp-and-mould-understanding-and-addressing-the-health-risks-for-rented-housing-providers

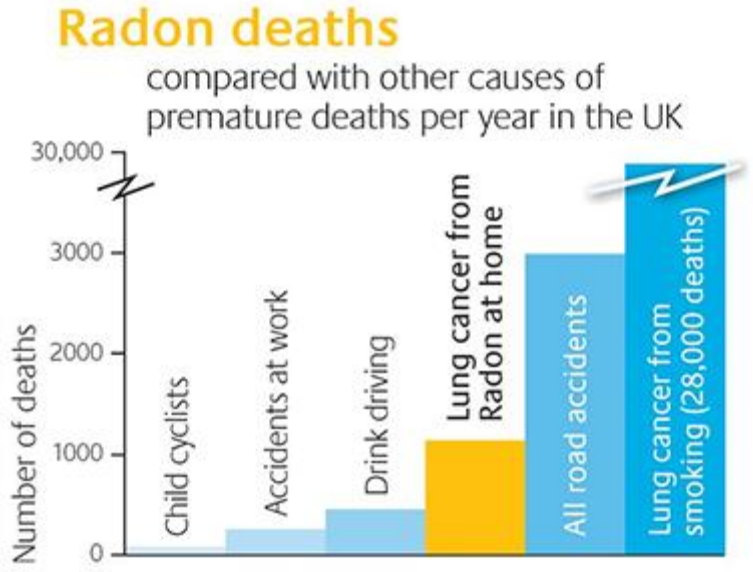
The health risks of radon

The facts

- Radon increases the risk of lung cancer
- The higher the radon, the longer the exposure, the greater the risk
- Radon in the home causes over 1,100 deaths from lung cancer each year in the UK
- The risk from radon is higher if the person is an ex-smoker and significantly greater for current smokers.

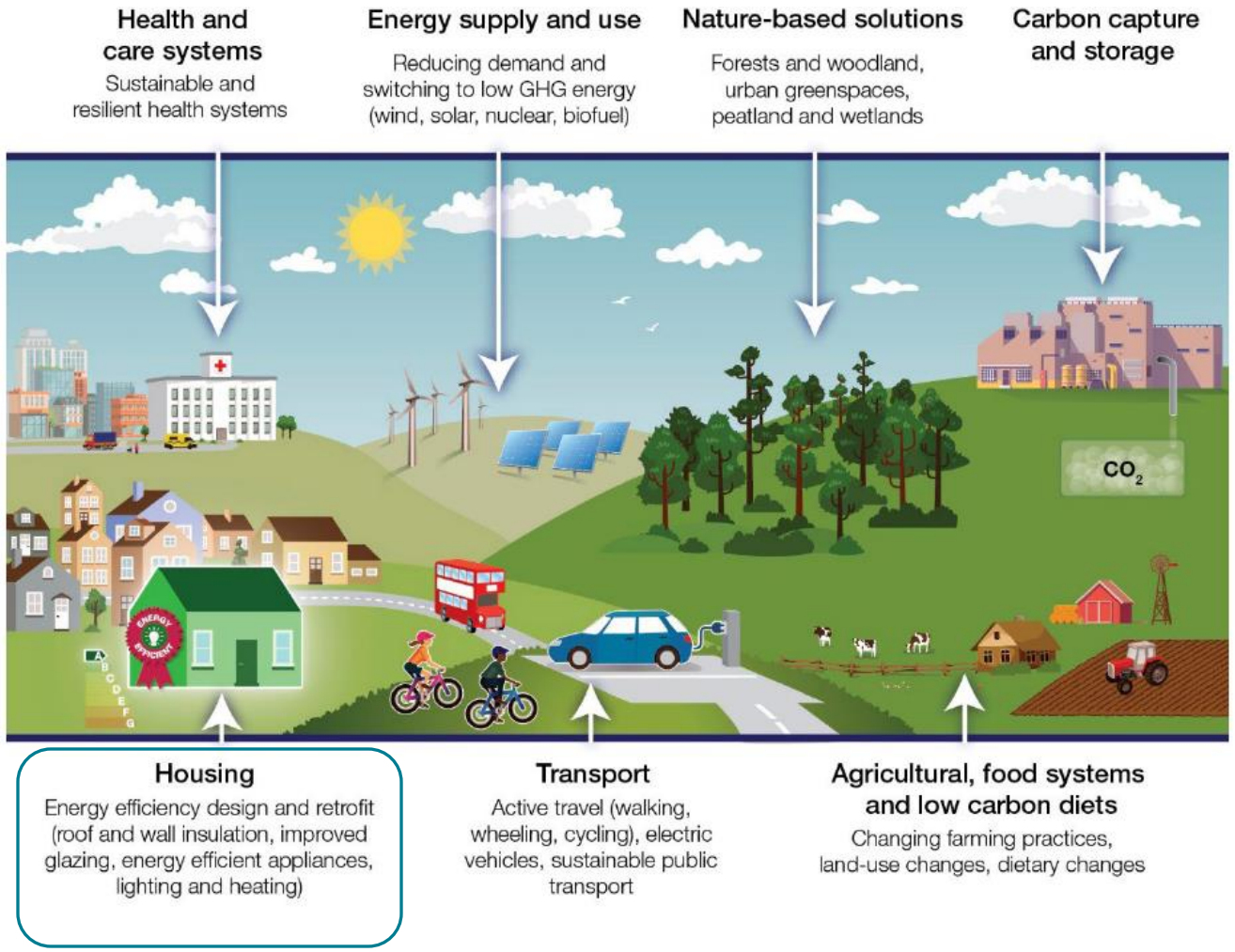
The explanation

Radon produces a radioactive dust in the air we breathe. The dust is trapped in our airways and emits radiation that damages the inside of our lungs. This damage, like the damage caused by smoking, increases our risk of lung cancer.



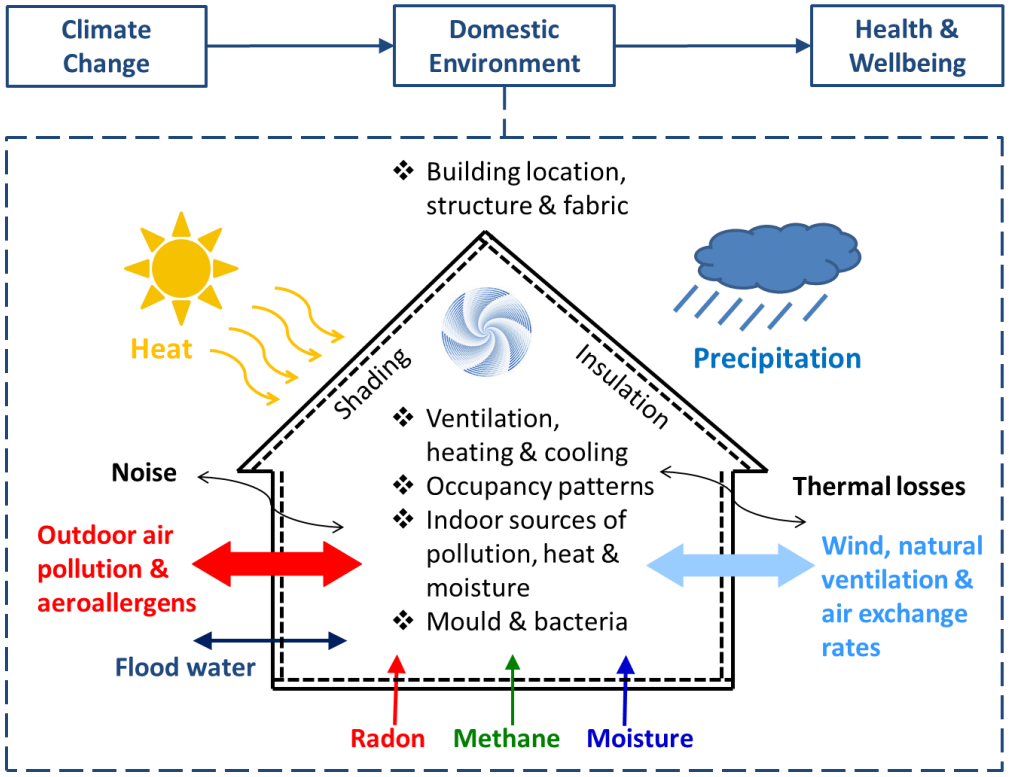
[UKradon - The risks to your health from radon]

Measures to help achieve net zero



[HECC 2023 report chapter 14. Net zero: health impacts of policies to reduce greenhouse gas emissions (publishing.service.gov.uk)]

Net zero policies



Vardoulakis et al., 2015: EnvInternational, 85: 299-313

Challenge:

❑ *Impact of net-zero policies*

- Require significant changes in the performance of both new and retrofitted buildings
- Need to understand how current and emerging building infrastructure design, construction, and materials used may affect IEQ parameters and hence our health and wellbeing.

Net zero policies and IAQ / IEQ / health

Environment International 85 (2015) 299–313

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Review article

Impact of climate change on the domestic indoor environment and associated health risks in the UK

Sotiris Vardoulakis [a,b,c,*], Chrysanthi Dimitroulopoulou [a], John Thornes [a,c], Ka-Man Lai [d], Jonathon Taylor [e], Isabella Myers [f], Clare Heaviside [a,b,c], Anna Mavrogianni [e], Clive Shrubsole [e], Zaid Chalabi [b], Michael Davies [e], Paul Wilkinson [b]

[a] Environmental Change Department, Centre for Radia
[b] Department of Social and Environmental Health Res
[c] Division of Environmental Health and Risk Managem
[d] Department of Biology, Hong Kong Baptist University
[e] UCL Institute for Environmental Design and Engineer
[f] Public Health England Toxicology Unit, Department o

Energy & Buildings 221 (2020) 110102

Contents lists available at ScienceDirect

Energy & Buildings

journal homepage: www.elsevier.com/locate/enbuild

Indoor environmental quality related risk factors with energy-efficient retrofitting of housing: A literature review

Marco Ortiz*, Laure Itard, Philomena M. Bluyssen

Building and Environment 180 (2020) 107067

Contents lists available at ScienceDirect

Building and Environment

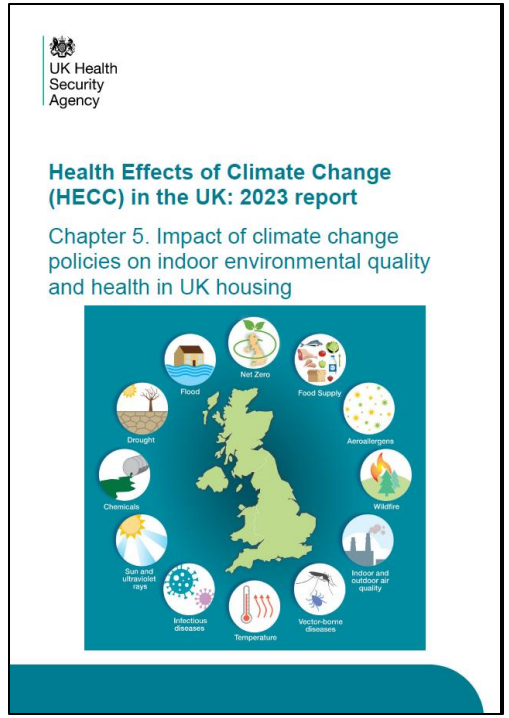
journal homepage: http://www.elsevier.com/locate/buildenv

Association of residential energy efficiency retrofits with indoor environmental quality, comfort, and health: A review of empirical data

William J. Fisk *, Brett C. Singer, Wanyu R. Chan

Indoor Environment Group, 1 Cyclotron Rd. Lawrence Berkeley National Laboratory, Berkeley, CA, USA

HECC report 2023. Chapter 5: Impact of climate change policies on indoor environmental quality and health in UK housing (publishing.service.gov.uk)



"Exploring the Consequences of Climate Change policies for Indoor Air Quality"

Sani Dimitroulopoulou[1], Rohit Chakraborty[1], Mike Davies[2], Tracy Gooding[3], Duncan Grassie[1], Kaja Milczewska[1], Tim Sharpe[4], Marcella Ucci[2]

[1]Air Quality and Public Health, UK Health Security Agency (UKHSA)
[2] UCL Institute for Environmental Design and Engineering, University College London
[3] Radon Group, UKHSA
[4] Department of Architecture, University of Strathclyde

IEQ benefits

IEQ Benefits

- Transition away from reliance on solid fuel heating
- Electrification can remove gas usage (cooking and heating)
- Energy poverty/equity and social challenges

Impact on ventilation

- The provision of adequate ventilation may be disrupted by energy efficiency measures increasing building airtightness:
  - Energy efficient ventilation systems (e.g., MVHR) may not maintain good IAQ, if they are not well specified, designed, installed, commissioned, understood, operated and maintained properly, even in high performance buildings such as Passivhaus

- Ensuring continued operation of ventilation = important as provision
  - Improvements in energy efficiency through airtightness are often ineffective, due to lack of occupants' awareness of how to operate the ventilation systems or due to noise issues

- Dynamic forms of insulation using vapour permeable materials, and additional air vents, trickle vents and encouraging purge ventilation may alleviate some of the problems, caused by failure of MVHR systems

- Use of air conditioning also discourages ventilation (closing windows to keep cool in), but many AC systems only provide cooling and not ventilation
  - air quality benefits by coupling mechanical ventilation systems with AC or air purification systems
  - when air conditioning is used improperly, mould spore formation may occur (de-humidification can be impaired and rendered ineffective)

Impact on indoor air quality - Inorganic, PM, chemicals

- European homes with energy efficient retrofits, **combined with mechanical ventilation**, have:
  - lower indoor concentrations of radon, VOCs (formaldehyde, toluene, butane), CO, CO2, mould, bacteria and dust mites compared to naturally ventilated homes.
  - NO2 and VOCs results other than formaldehyde are mixed, likely due to the presence of both indoor and outdoor sources

- If **whole-house mechanical ventilation is not implemented**, it may lead to:
  - reduced ventilation rates
  - increased levels of benzene, toluene, ethyl benzene, and xylene (BTEX) indoors,

  because of insulation materials (foam sealants and caulks)

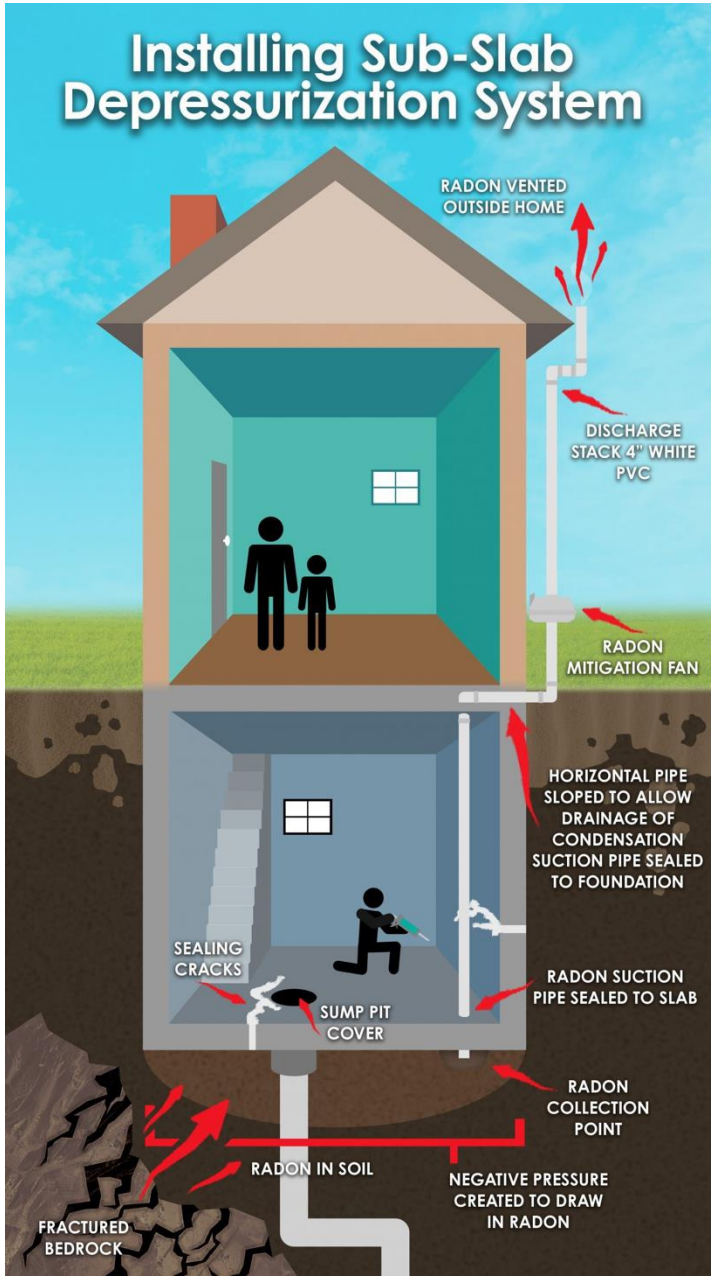
Building Energy Efficiency

- If provision of mechanical ventilation is not possible, addition of passive ventilation systems (e.g. bathroom or kitchen fans, window trickle vents) significantly reduced indoor PM2.5, radon and mould, but slightly increased indoor concentrations of outdoor-generated PM2.5

- Increase in indoor hygrothermal conditions, due to improvements in thermal performance, reduced heating costs and personal preferences, also directly affect the indoor chemistry and off-gassing of pollutants from building materials or furnishings, increasing their concentrations. **The use of low-emission materials is recommended**

Impact on indoor air quality – Radon

- Climate change is not expected to impact the radon being emitted from the ground.
- Making buildings more energy efficient - retrofitting for building weatherization (USA) (loft and wall insulation, double/triple glazing) can increase radon levels by reducing ventilation rates
- The established radon mitigation method of sub-slab depressurisation was effective in energy-efficient houses
- MVHR also reduced the radon levels, although may be unpopular due to noise
- Passive houses in the UK and Ireland, which must demonstrate balanced MVHR within 10% difference in supply and extract, in order to achieve accreditation, showed significantly lower radon levels compared to non-passive houses



Impact on indoor air quality – Biological contamination

- Biological contaminants in indoor environments: bacteria, fungi, viruses, pollen, insects, mites and pet dander.
  - pollen may penetrate from outdoor air,
  - humans can spread biological pathogens (e.g. viruses and bacteria),
  - biological pollutants (HDM) can colonise indoor settings.

- HDMs, moulds or bacteria: flourish in relatively warm and humid environments, although cold conditions also increase the risk of higher relative humidity

- Mechanical ventilation with filtration
  - reduces ingress of outdoor fungi, but
  - does not perform better than natural ventilation at removing fungal particles emitted by indoor mouldy areas

- Mould and damp can occur in
  - old buildings due to poor insulation,
  - energy efficient buildings, due to inadequate ventilation, or design and construction problems leading to thermal bridges.
- 'Green buildings' and properly executed energy retrofits should not increase moisture or bio-contamination

Impact of EE measures on health

- Fabric insulation and new EE heating systems make homes more affordable to heat and have the potential to:
  - reduce the risk of cold-related illnesses and
  - improve both physical (respiratory and asthma) and mental health
- Loft insulation in social housing is positively associated with a significant increase in admission rates for COPD and cardiovascular disease (CVD), but
- Higher levels of boiler and glazing replacement were associated with slightly lower admission rates for COPD and CVD, as a result of increased warmth
- PM emission reduction strategies (building fabric improvements, improved ventilation, fuel switching, and occupant behaviour changes) can have positive impact on health

Conclusions

- There is a growing body of evidence suggesting that both private and public energy efficient buildings have the potential to maintain good IAQ, if implemented with correctly commissioned, installed and maintained ventilation systems.
- Building codes and performance standards should evolve to promote energy efficiency measures that are resilient to future climates, while still protecting IAQ and therefore public health.
- Possible interactions with other aspects of IEQ, such as thermal comfort and noise should also be considered.

Let's work together

to reduce our exposure to indoor air pollution

Thank you!

www.gov.uk/ukhsa

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