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Breathing fresh air into Irelands residential Energy Retrofit programme

2015 - 2026

Dr Marie Coggins



www.pexels.com, Vitaly Gariez, Kaboompics.com, lucie Liz, Mizuno K

University of Galway.ie

Worlds first climate neutral continent by 2050

Decarbonise and reduce GH emissions

EU buildings – 40% of EU energy consumption

Most of housing stock will exist – 2050

EU renovation wave strategy



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Renovate 35 million homes by 2030

European Performance of Buildings Directive (EPBD) EU/2024/1275

2024 EPBD recast, C/2025/6438 Guidance

Indoor environmental quality

‘*the result of an assessment of the conditions inside a building that influence the health and wellbeing of its occupants, based upon parameters such as those relating to the temperature, humidity, ventilation rate and presence of contaminants’ (Article 2(66)*







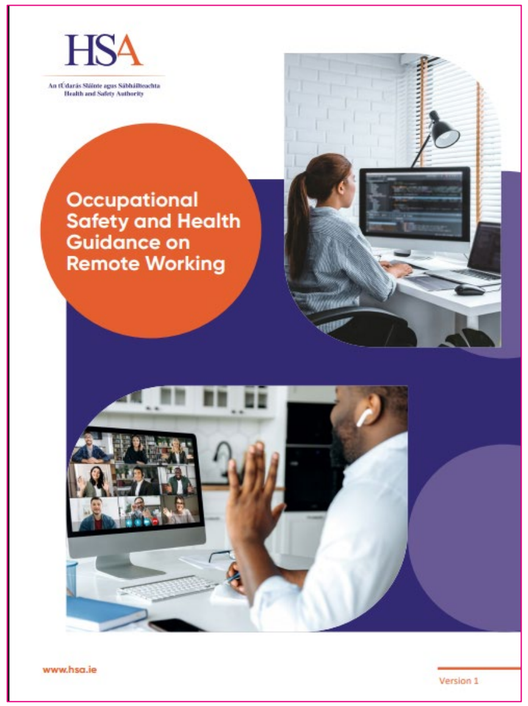
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100% public sector buildings

30% Commercial buildings

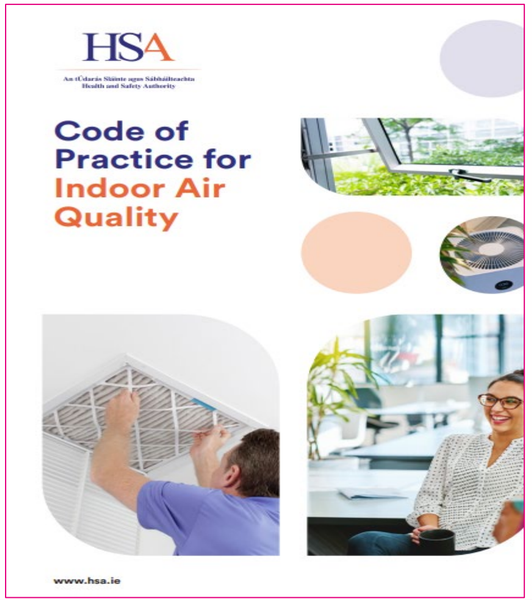
<u>500,000 homes by 2030.</u>

Wall & attic insulation,
Replacing windows & doors,
Air tightness & ventilation
efficient renewable heating system (e.g. heat pump)
Renewable energy technologies (solar PV panels).







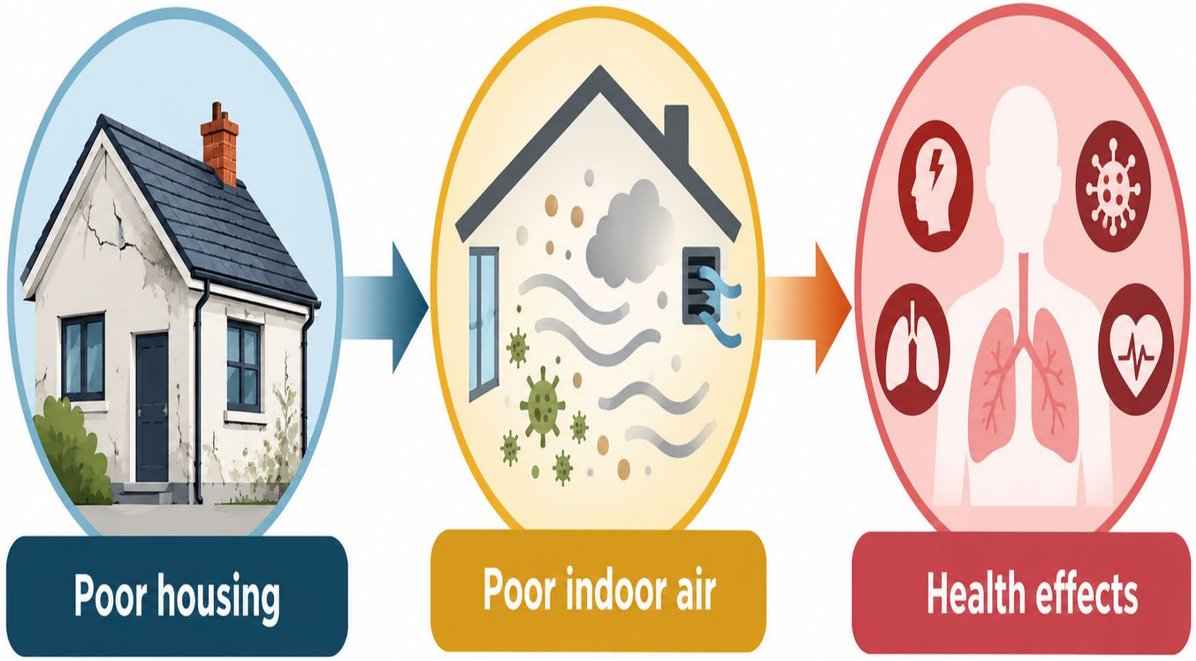








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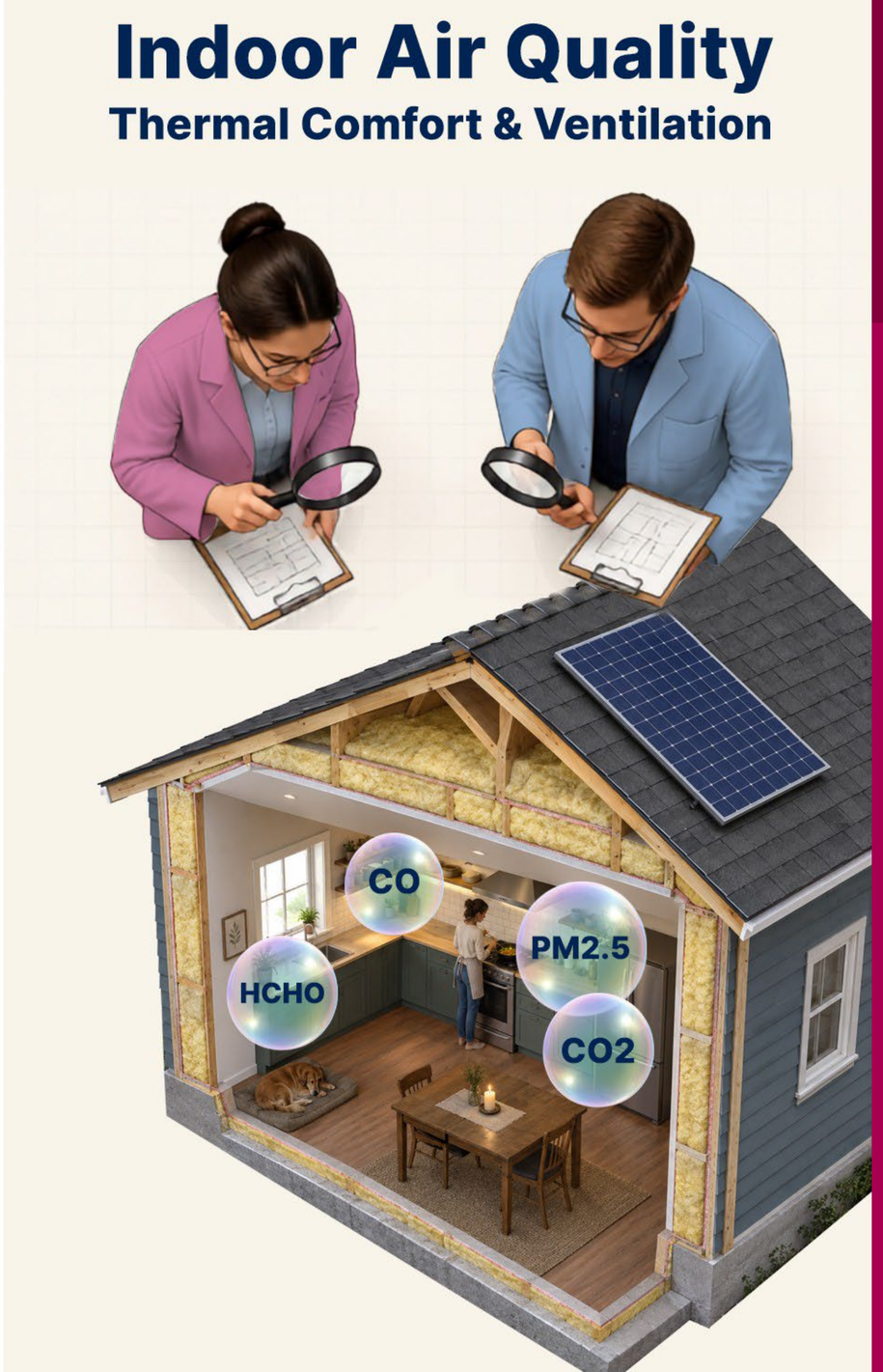


80% of our time indoors

Retrofit – opportunity to improve IEQ

Exposure studies

- *highlight unintended consequences*
- *inform guidance, information general public*
- *Human exposure*



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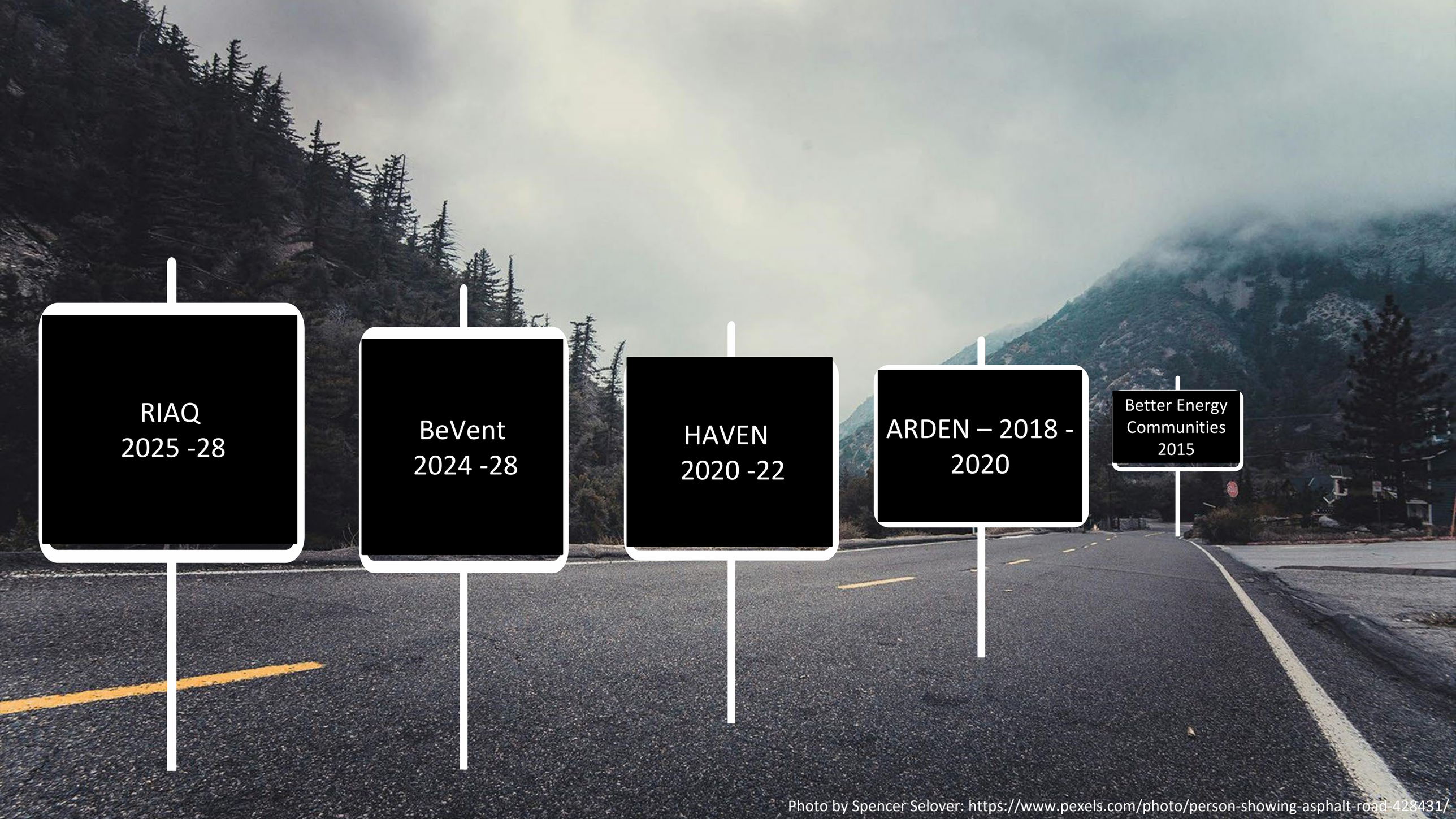
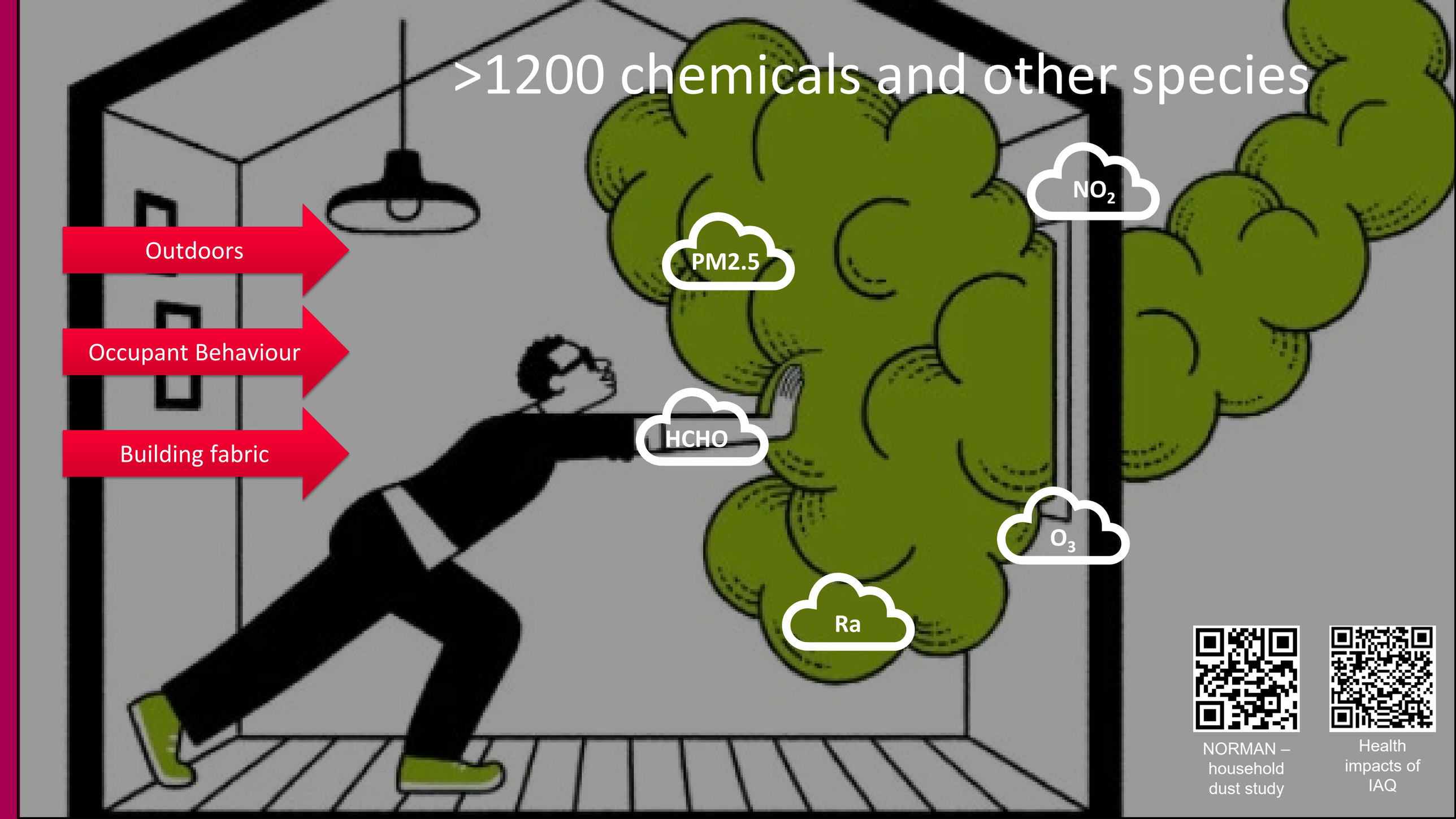


Photo by Spencer Selover: https://www.pexels.com/photo/person-showing-asphalt-road-428431/

>1200 chemicals and other species



NORMAN – household dust study

Health impacts of IAQ

Indoor air quality sampling strategy

Multi-pollutant, dust/microbial and ventilation measurements in homes



Particulate matter ($PM_{2,5}$)
TSI AM520 monitor



CO_2 • CO • TVOCs • Temperature • Relative humidity
GrayWolf / ARANET / AIRTHINGS



EDC collectors
Settled dust and microbial sampling





Formaldehyde
UMEX 500 passive badge



Nitrogen dioxide (NO_2)
Passive diffusion tube



BTEX
Passive TD tubes



Radon
Closed alpha-track detector (Radtrak)





VENTILATION PERFORMANCE • airflow measurements

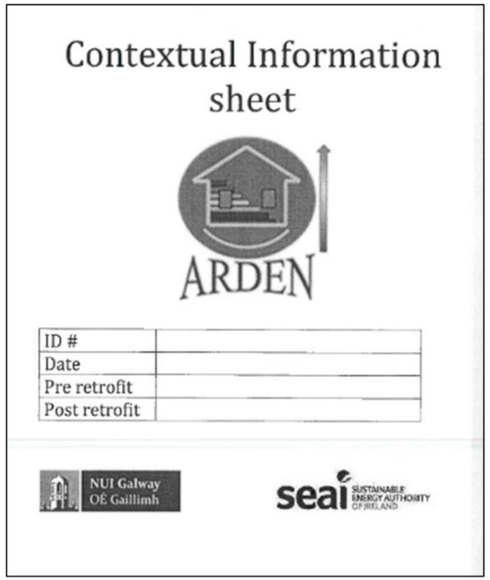
- Trickle vents and extract vents (presence/condition)

AI generated image, Chat gpt

Home visits and activity diaries

1 Researcher's home visit

The researcher visited each home and completed the contextual information form with the homeowner, occupant or tenant.



Contextual Information sheet

ARDEN

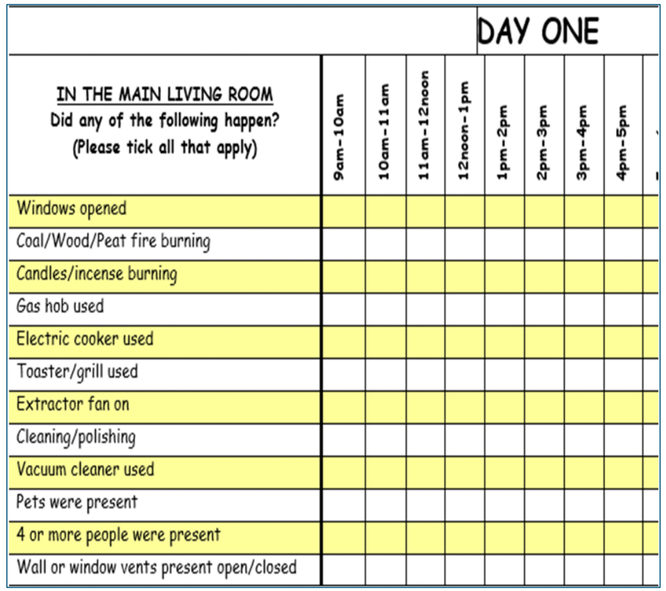
ID #	
Date	
Pre retrofit	
Post retrofit	

NUI Galway OÉ Gaillimh

seai Sustainable Energy Authority of Ireland

2 Diary during IAQ monitoring

During IAQ monitoring, the resident completed an activity diary to record activities that could affect indoor air quality.



	DAY ONE								
IN THE MAIN LIVING ROOM Did any of the following happen? (Please tick all that apply)	9am-10am	10am-11am	11am-12noon	12noon-1pm	1pm-2pm	2pm-3pm	3pm-4pm	4pm-5pm	
Windows opened									
Coal/Wood/Peat fire burning									
Candles/incense burning									
Gas hob used									
Electric cooker used									
Toaster/grill used									
Extractor fan on									
Cleaning/polishing									
Vacuum cleaner used									
Pets were present									
4 or more people were present									
Wall or window vents present open/closed									

These records provided context for interpreting the IAQ measurements.

ARDEN

Indoor **A**ir, Ventilation and comfo**R**t in Irish Domestic dwellings post **DE**ep Energy re**N**ovations – **ARDEN**



26 homes, pre- and post-retrofit

indoor air quality

thermal environment

subjective feedback

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Significant increase in building air tightness (2.4 - 5 $m^3/h.m^2$)

Energy uplift to minimum BER A3

Mechanically ventilated

Significant improvement temperature & occupant comfort



Photo by Lisa Fotios: https://www.pexels.com/photo/close-up-photography-of-person-wearing-pink-house-slippers-1444417/

HAVEN

Health impact and associated benefits of energy renovation to BER B2

14 homes (primarily social) , pre- and post-retrofit indoor air quality thermal environment Health questionnaire (n=56)



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Energy uplift to minimum BER B2

Mostly naturally ventilated

Greater satisfaction with indoor temperature

Significant reductions in sources of thermal discomfort



Photo by Lisa Fotios: https://www.pexels.com/photo/close-up-photography-of-person-wearing-pink-house-slippers-1444417/

Building and Environment 122 (2017) 126–133

Contents lists available at ScienceDirect

Building and Environment

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

A pre and post evaluation of indoor air quality, ventilation, and thermal comfort in retrofitted co-operative social housing

Contents lists available at ScienceDirect

Building and Environment

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

Deep energy renovations' impact on indoor air quality and thermal comfort of residential dwellings in Ireland – ARDEN project

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Building and Environment

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

Indoor air quality, thermal comfort and ventilation in deep energy retrofitted Irish dwellings

Contents lists available at ScienceDirect

Indoor Environments

journal homepage: www.sciencedirect.com/journal/indoor-environments

Energy retrofits: Factors affecting a just transition to better indoor air quality

Contents lists available at ScienceDirect

Building and Environment

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

Energy retrofits – A call for healthier energy practices

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Deep energy renovations in Irish domestic dwellings; unlocking health benefits

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STC 34

Indoor Environmental Quality Guidelines

A global resource for healthier indoor environments

ISIAQ Scientific and Technical Committee 34 has developed a worldwide database of Indoor Environmental Quality guidelines, giving researchers, practitioners and policymakers an easier way to search, compare and explore guidance from around the world.

Explore the IEQ Guidelines Database →

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Summary findings

PM2.5 concentrations increased

Formaldehyde significantly increased post retrofit – on the high end of values reported for European dwellings

No significant increase in concentrations of Benzene, ethyl benzene, xylene

Toluene concentrations decreased

NO_2 higher concentrations in homes with gas cooking





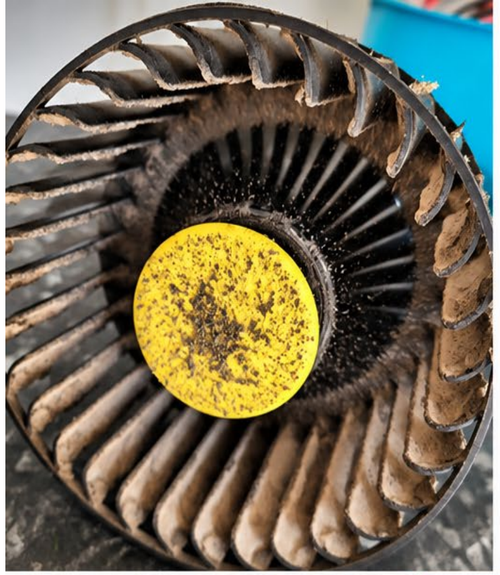


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- *Summary findings*

  Ventilation

  Occupant behaviours
    blocking wall vents
    smoking
    candles/incense
    Wood stoves

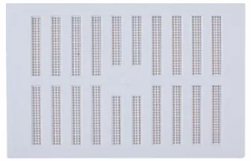







Retrofits, occupant behaviour, CO_2 (ppm)

CO_2

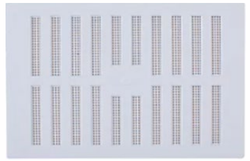
	Pre-retrofit	Post-retrofit	Pre-retrofit	Post-retrofit
	540	802	578	698
	981	1425	748	859

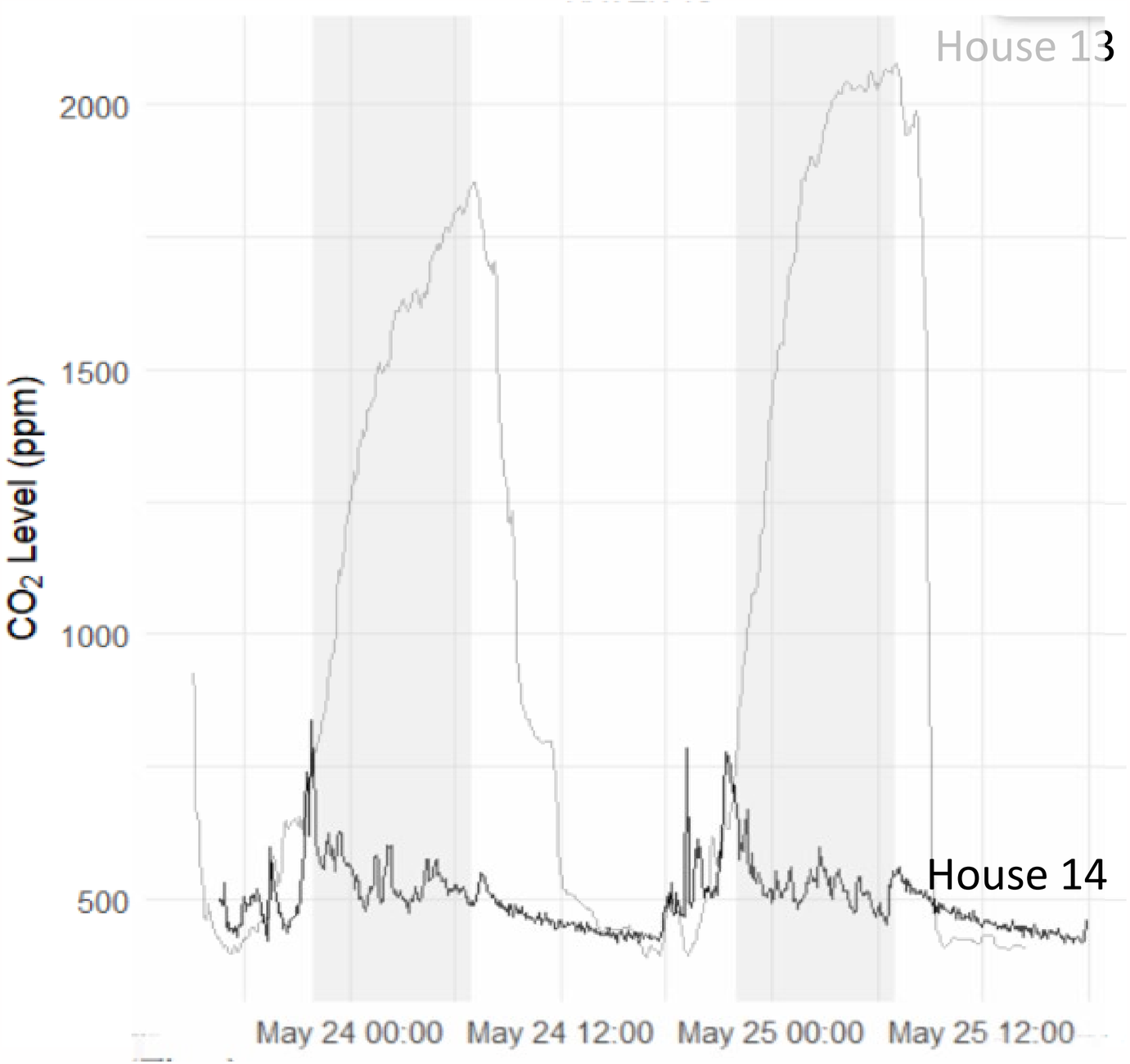
(Median values)

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CO_2 Time Series Profile in Bedroom for Houses 13 and 14







Retrofits, occupant behaviour, $PM_{2.5}$ ($\mu g/m^3$)

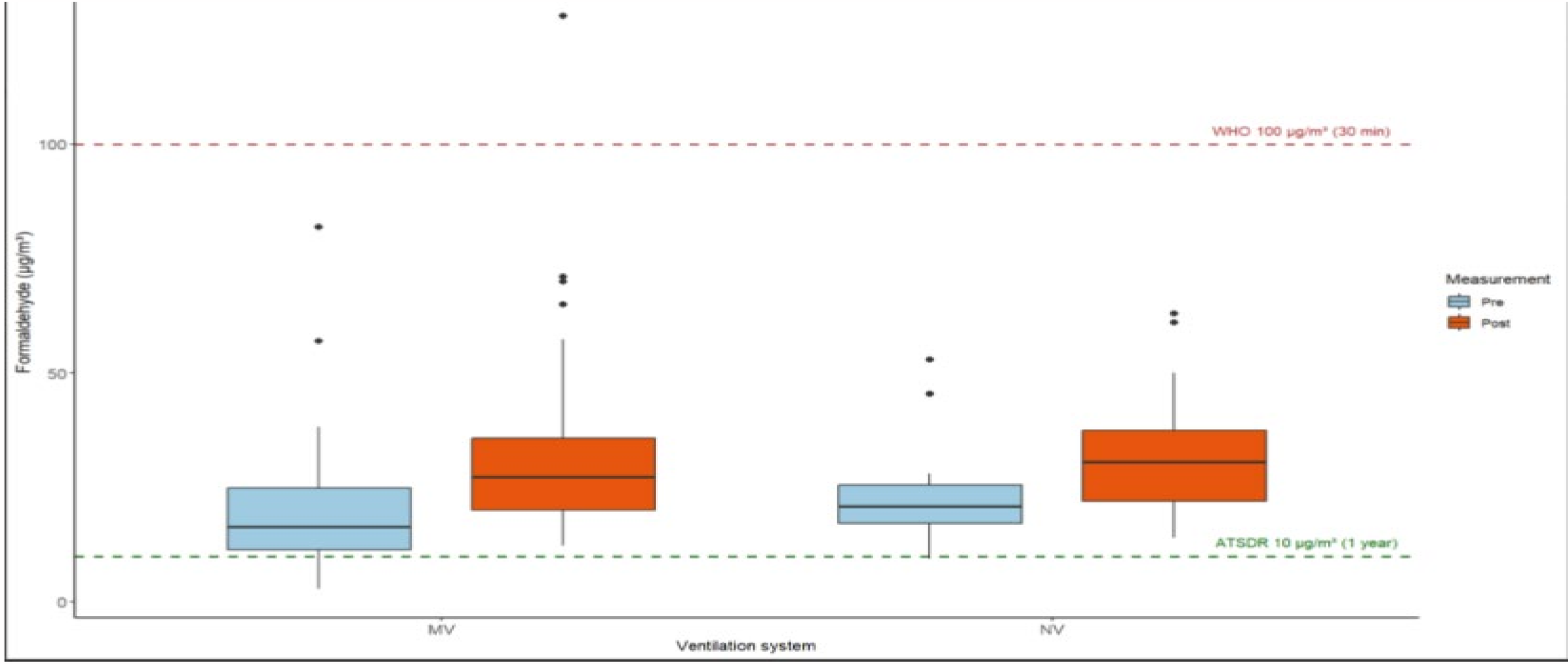


	Pre-retrofit	Post-retrofit	Pre-retrofit	Post-retrofit
Smoking	53	58	75	56
Non-smoking	14	15	13	17

(Median values)

	Annual AQG 2021	24-hour AQG 2021
$PM_{2.5}$ ug/m^3	5	15

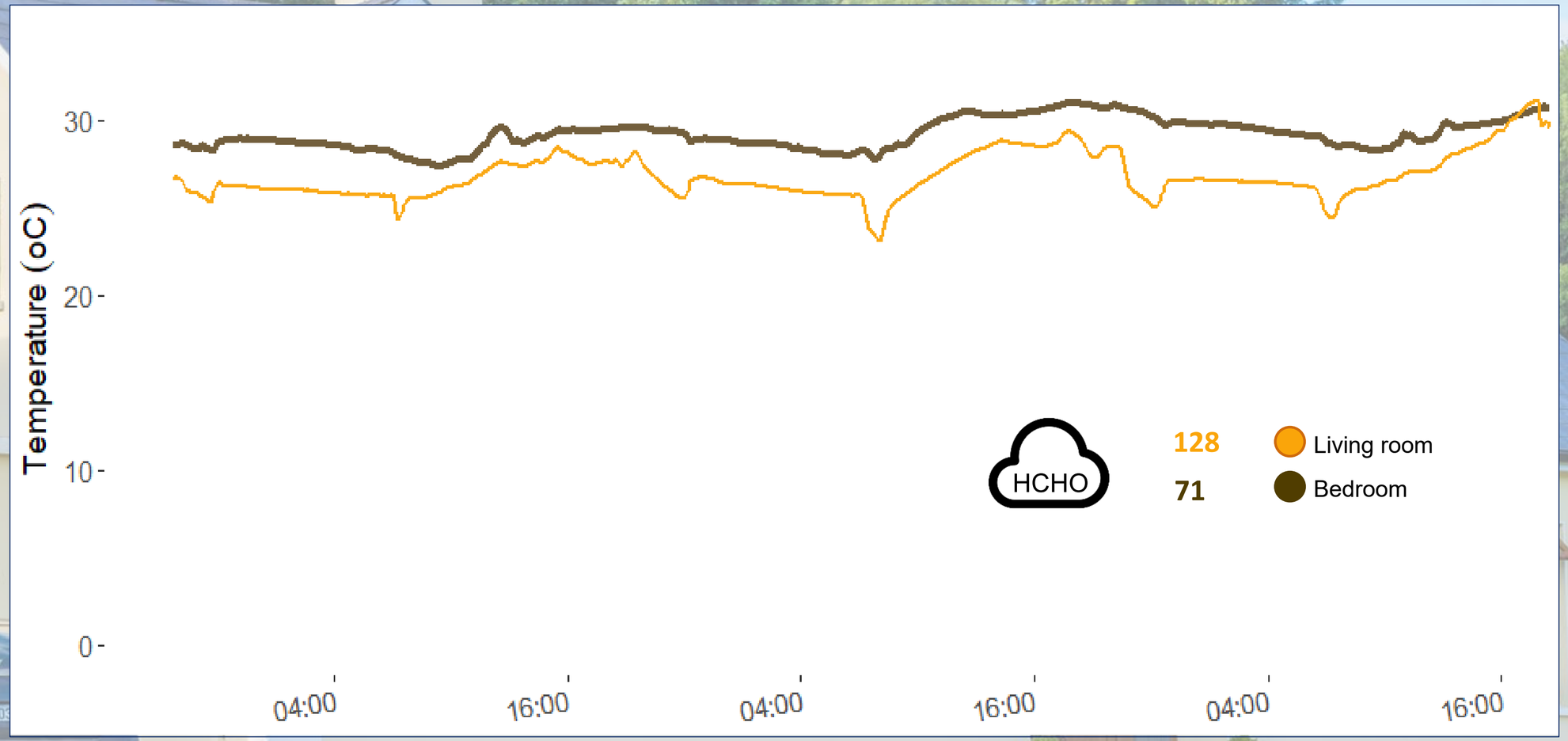
Indoor Formaldehyde concentrations (µg/m³) pre/post (N=54,N=68) residential retrofit –Irish homes



P<0.005

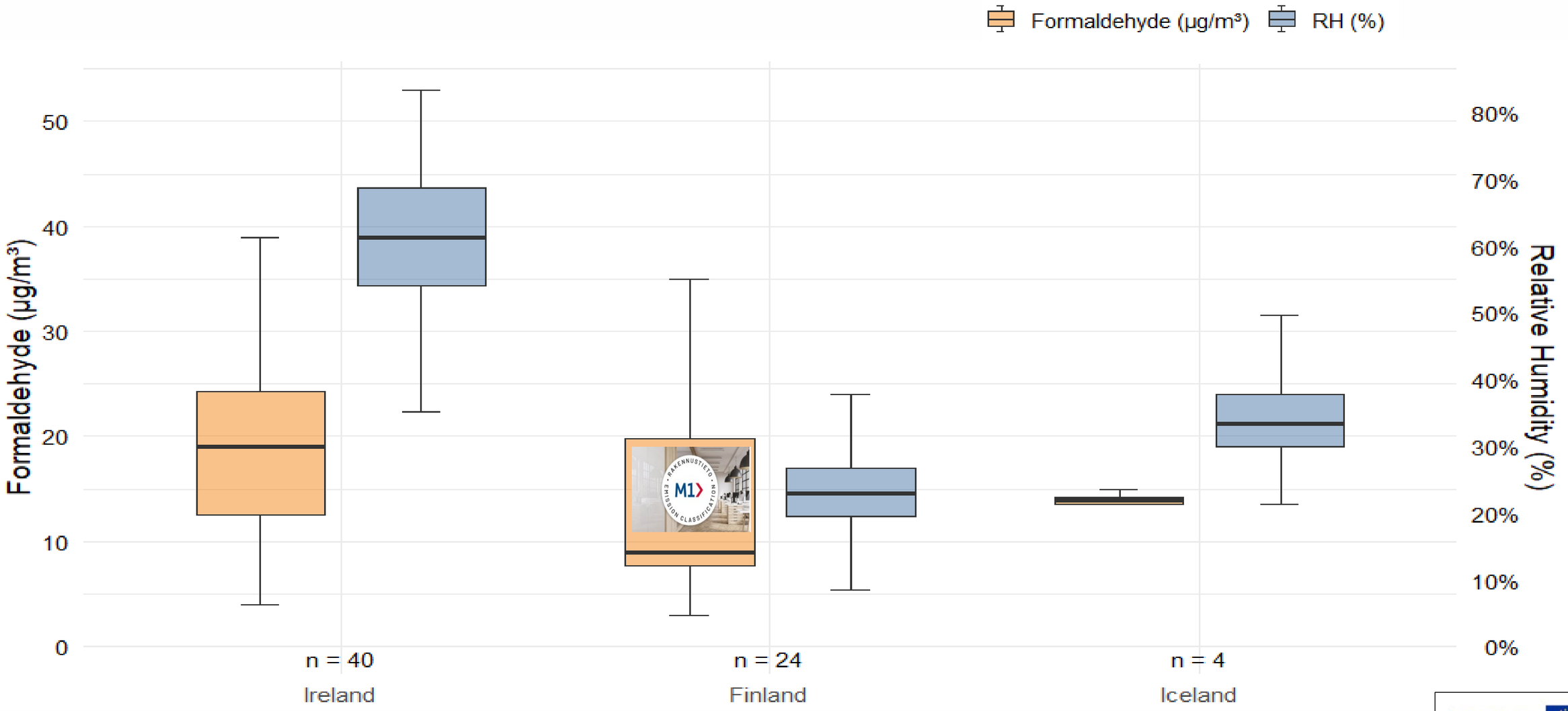
Case Study 2

BER A2 | A2W



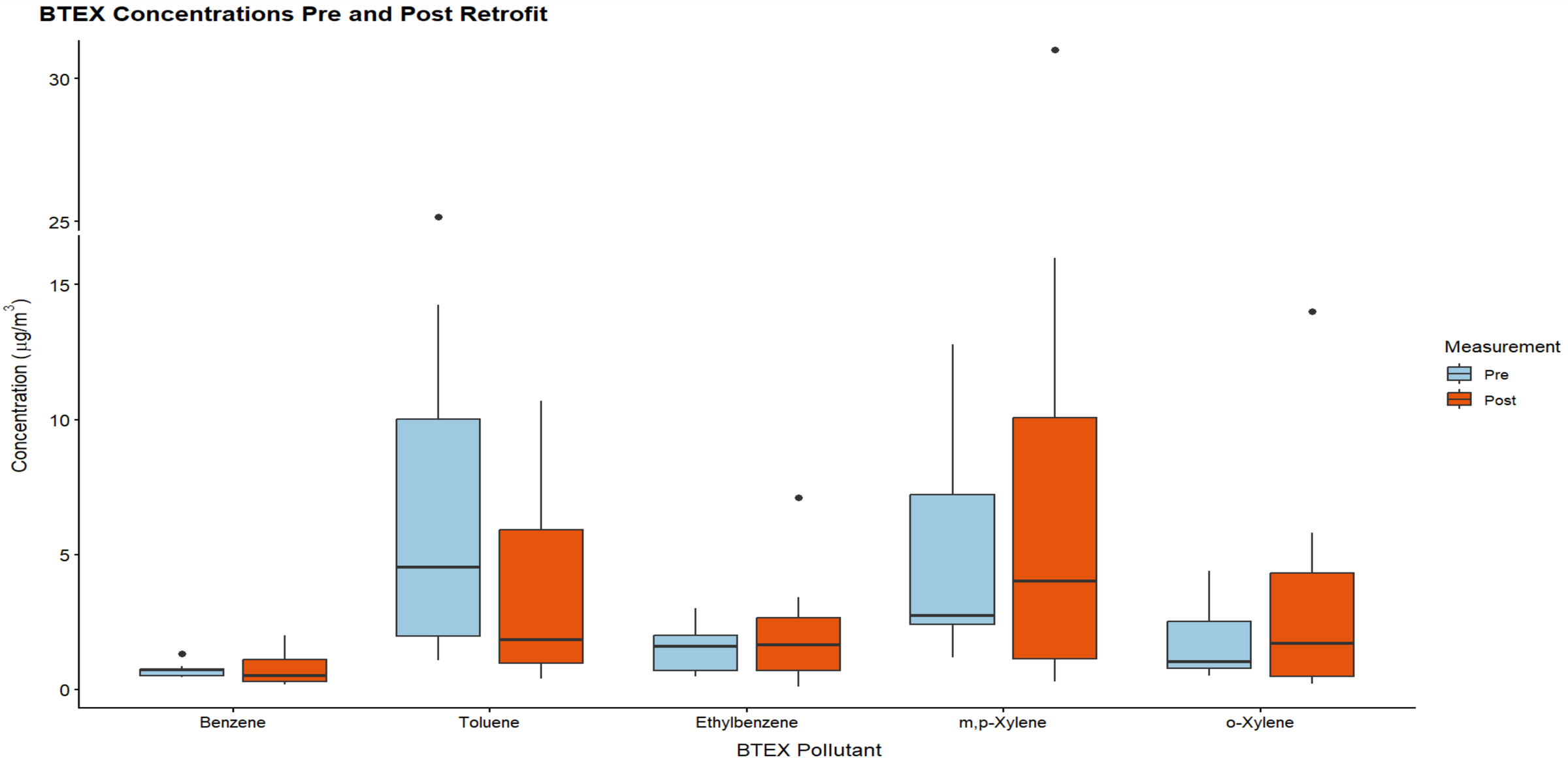
https://www.shutterstock.com/image-photo/editorial-use-only-bungalow-attic-conversion-1111593074

Indoor Formaldehyde concentrations (µg/m³) pre residential retrofit –Irish, Finnish, Icelandic homes

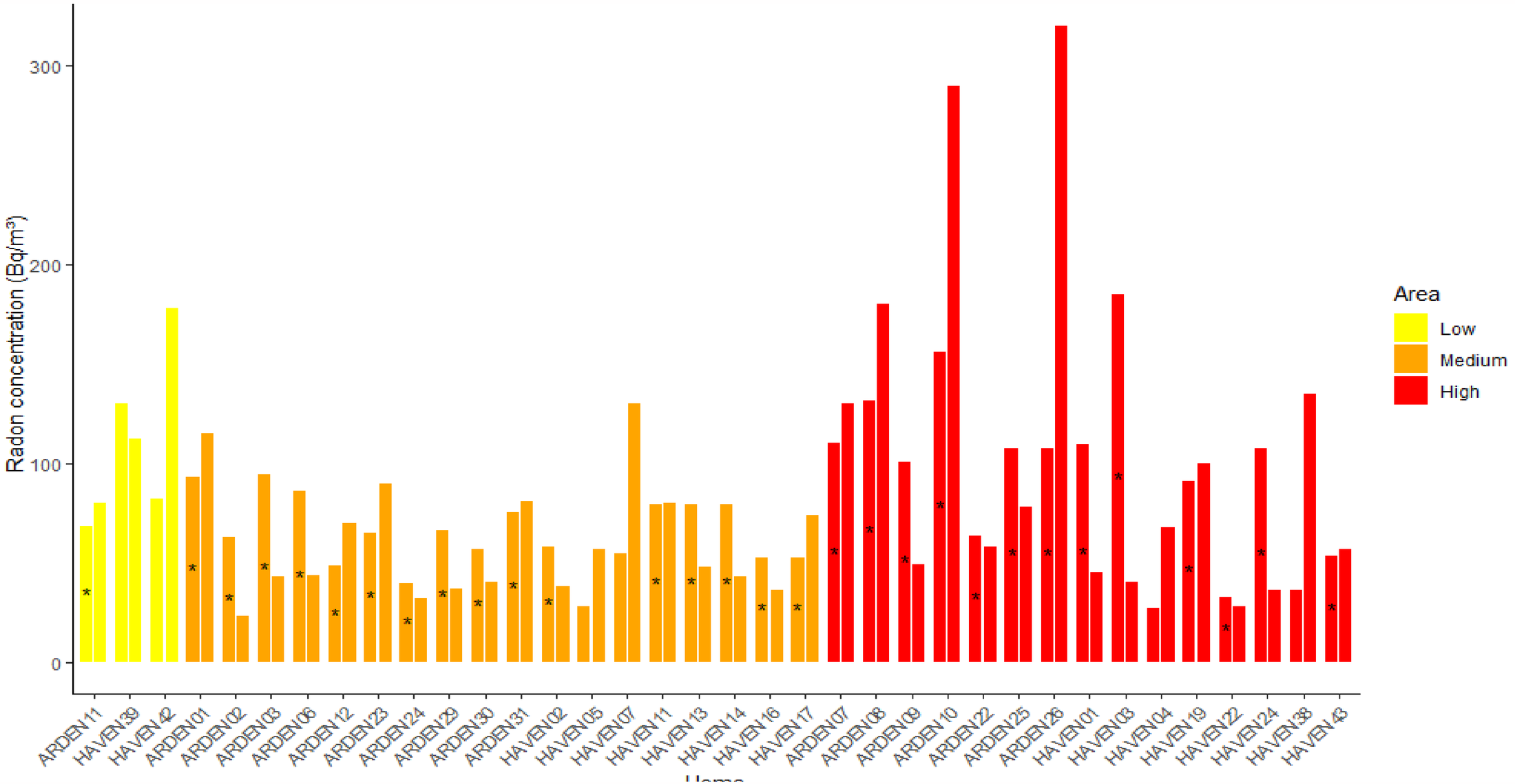


Interreg
Co-funded by the European Union
Northern Periphery and Arctic

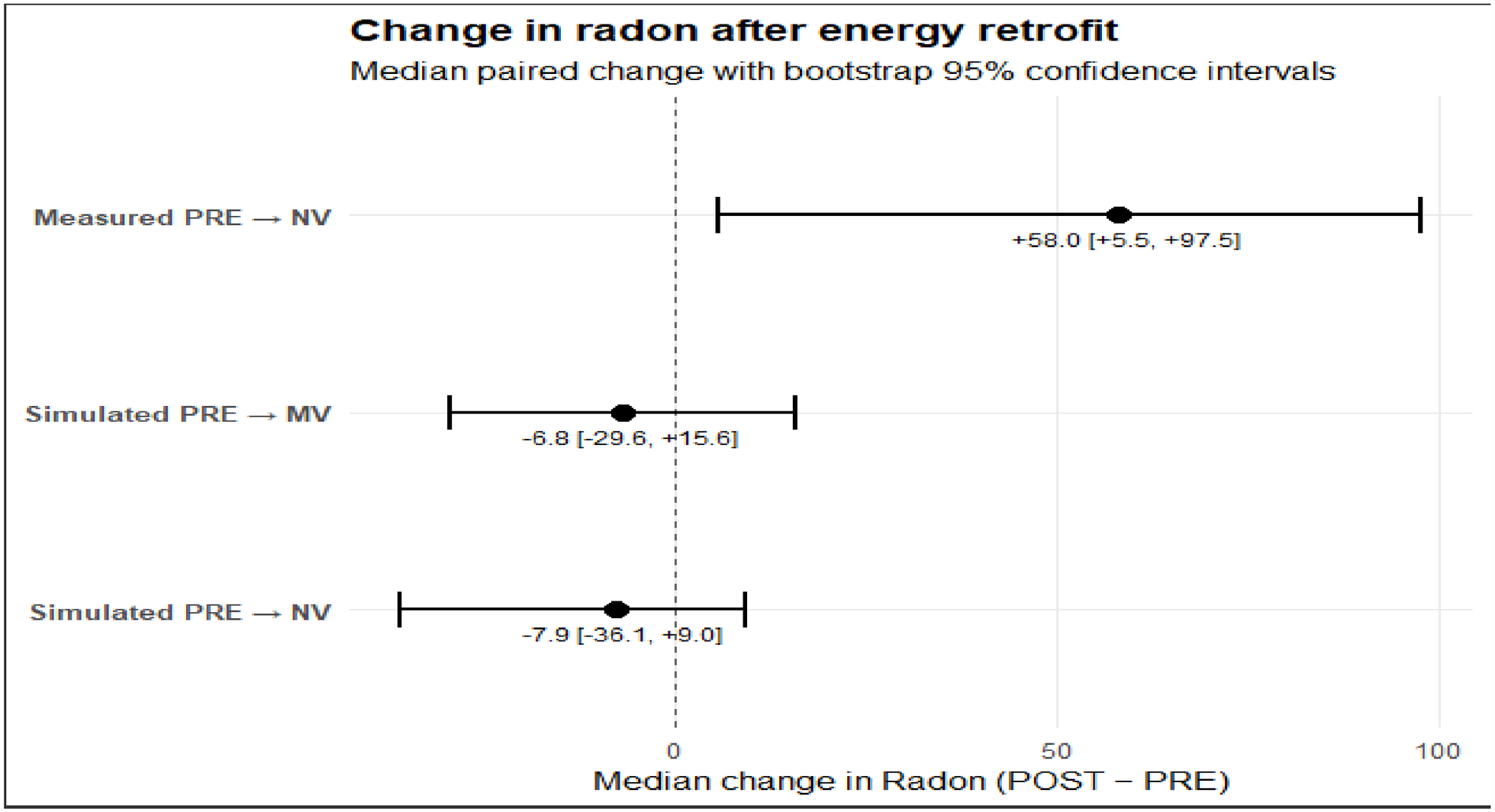
Indoor BTEX concentrations (µg/m³) pre/post residential retrofit –Irish homes



Radon (Bq/m^3) pre/post residential retrofit –Irish homes



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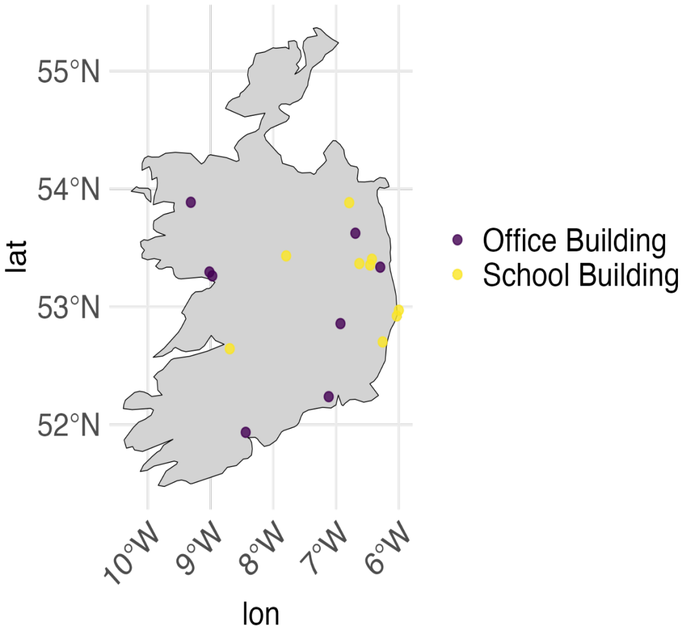


BENEFIT project: a pre- and post-retrofit IAQ study of classrooms and offices

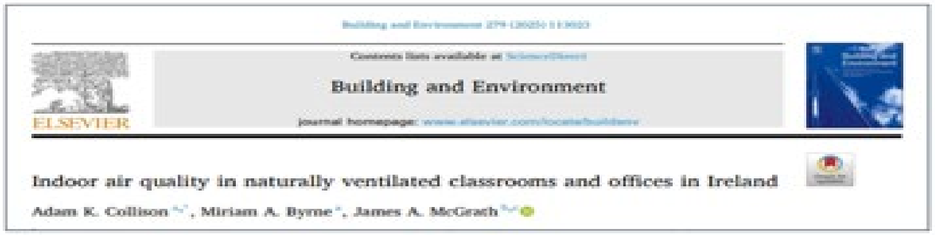
17 Irish public-sector buildings (8 office buildings, 9 schools; 51 rooms), naturally ventilated before retrofit. Retrofit: insulation, airtightness, glazing, heat pumps; dMVHR (typically F7 filters) in the retrofitted schools and one office building.

Pollutants monitored:

Parameter	IARC	Sampler / analysis
Formaldehyde (µg/m³)	1	UMEx 100 badge, HPLC (MDHS 102); **7-day average**
Benzene (µg/m³)	1	Anasorb badges, GC (MDHS 88); Tenax tubes, GC–MS (ISO 16000-6); **7-day average**
Toluene (µg/m³)	3	
Ethylbenzene (µg/m³)	2B	
Xylene (µg/m³)	3	
PM2.5 (µg/m³)	1	TSI SidePak photometer; **daily mean, occupied hours**
NO_2 (µg/m³)	-	Gradko diffusion tubes, UV–Vis; **4-week average**
Radon* (Bq/m³)	1	Airthings Wave Plus, continuous; **seasonally corrected room mean**

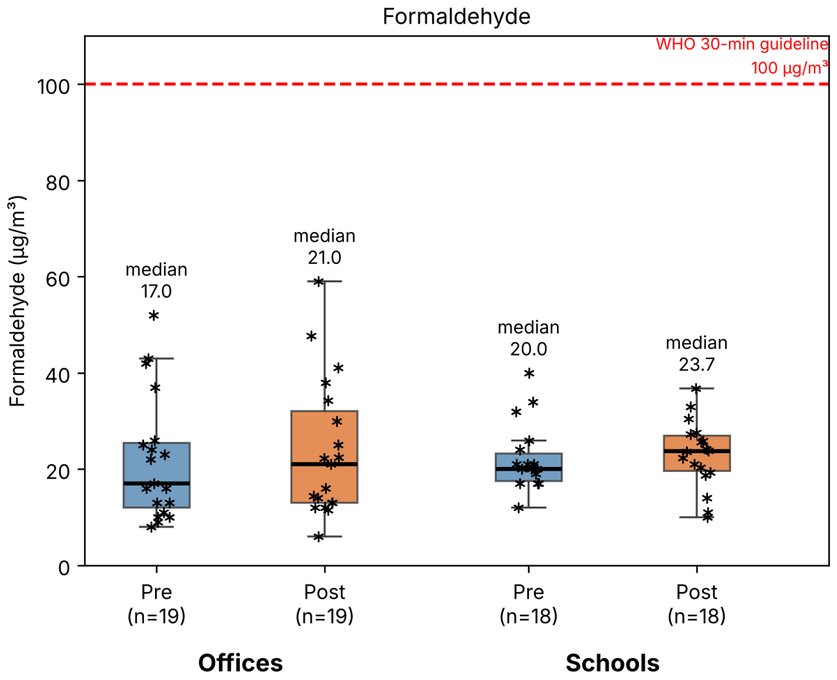


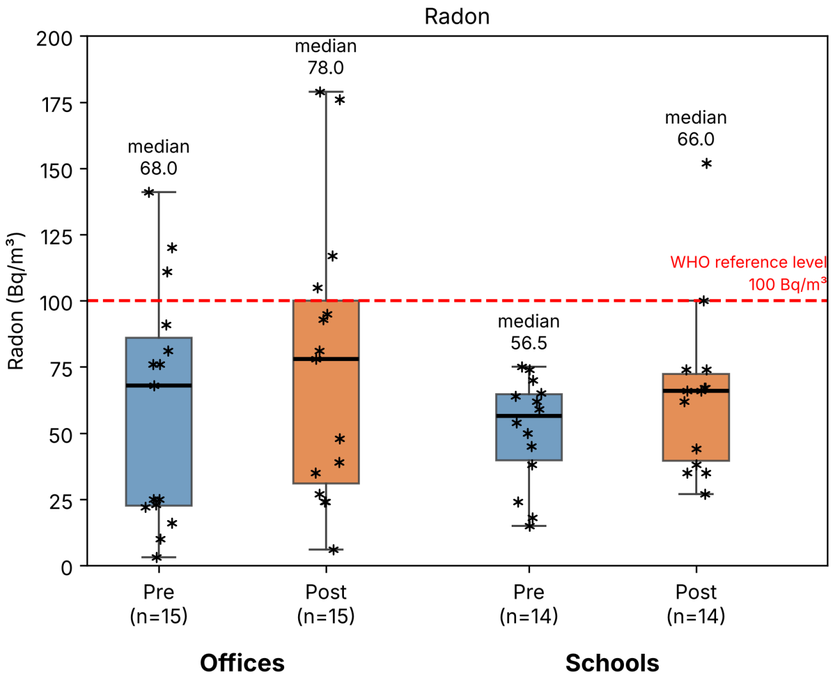
Also measured: CO_2, TVOC, temperature, RH.





BENEFIT project: Some key findings





Key points

- PM2.5 fell by 27–30%, consistent with airtightness and filtration;
- NO_2 stayed below the WHO annual guideline in every room and lower than previous studies in these settings.
- Benzene mostly < 10 ug/m3, 16 – 23 ug/m3 in three schools.
- Ethylbenzene mostly < 10ug/m3, higher concentrations in 6 offices (12- 304 ug/m3)
- Formaldehyde medians increased marginally.
- Radon increased in most rooms (median increase +16 Bq/m³) post-retrofit

Retrofits and indoor air quality

Warmer homes



Inadequate handover
Ventilation aspects



can suffer



Educate, increase awareness

Occupant behaviour and material choice matters



Acknowledgements

All the homes owners who participated in our research

ARDEN: Hala Hassan Asit Kumar Mishra (University of Galway), Hilary Cowie (Institute of Occupational Medicine Edinburgh)

HAVEN: Daniel Norton, Vicky Hogan, Medeina Macenaite, Ciaran Maher, Nina Wemken, Asit Kumar Mishra, Declan Foster (University of Galway), Hilary Cowie (Institute of Occupational Medicine Edinburgh)

RIAQ:D.Coen[1],M.Coggins[1], D. Norton[1], V. Hogan[1], M. Hajdukiewicz[1], A.Kumar Mishra[1]
F.Fedorik[2], J.Härkönen[2],V.Lappalainen[3], L. Chen[3], M. Täubel[4], C. Chokwitthaya[5], W. Lu[5], D. Sigurðardóttir[9], S.Dögg Sigurjónsdóttir[6], , U.Haverinen-Shaughnessy[7] [1]University of Galway, Ireland, [2]University of Oulu, Finland, [3]The Arctic University of Norway, Norway. [4]Finnish Institute for Health and Welfare, Kuopio, Finland [5]Umeå University, Sweden.[6]University of Iceland, [7]Verkvist, Iceland

BENEFIT: Adam Collison et al. University of Galway

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