

Indoor Environmental Quality in Irish Energy Efficient Dwellings

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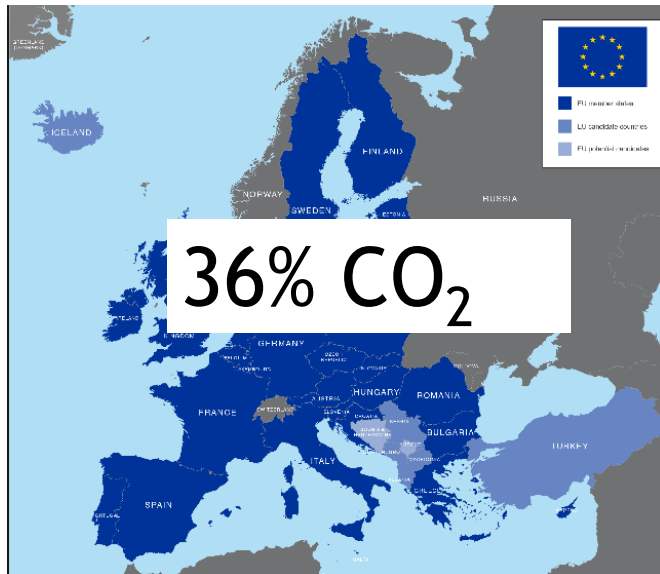
NUI Galway
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Ionad Aeráide agus Truicillíú Aeir
Centre for Climate & Air Pollution Studies



EU challenges – Built environment

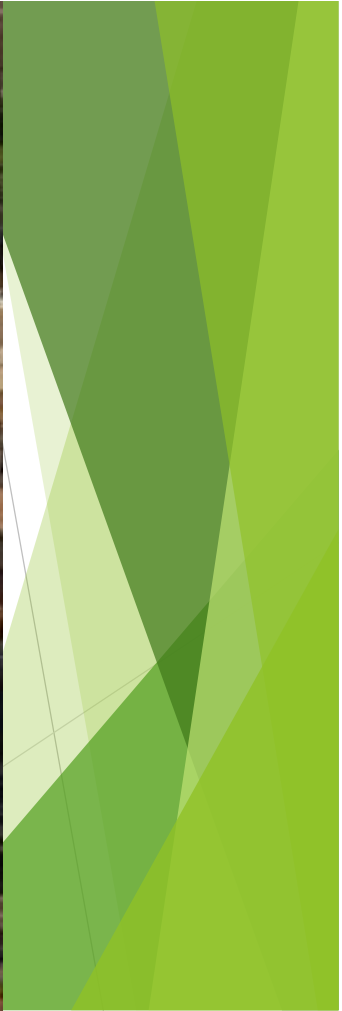


40% of energy consumption

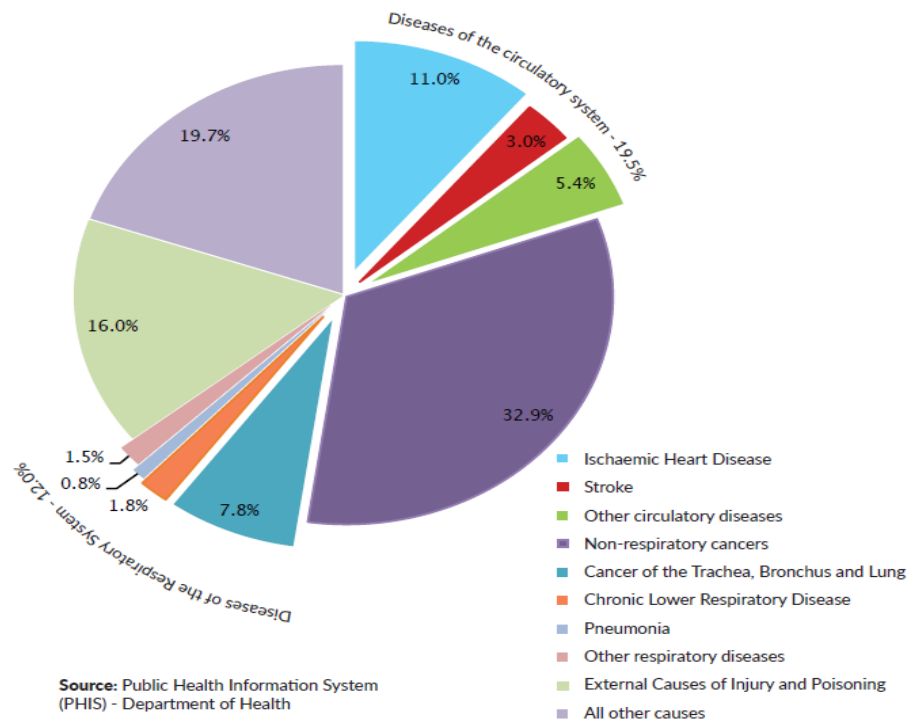


**Energy
efficient**

**Healthy
homes**



Ireland - Deaths by principal causes 2017 ages 0 - 64



Chronic illnesses on the increase



4th highest prevalence of asthma in the world



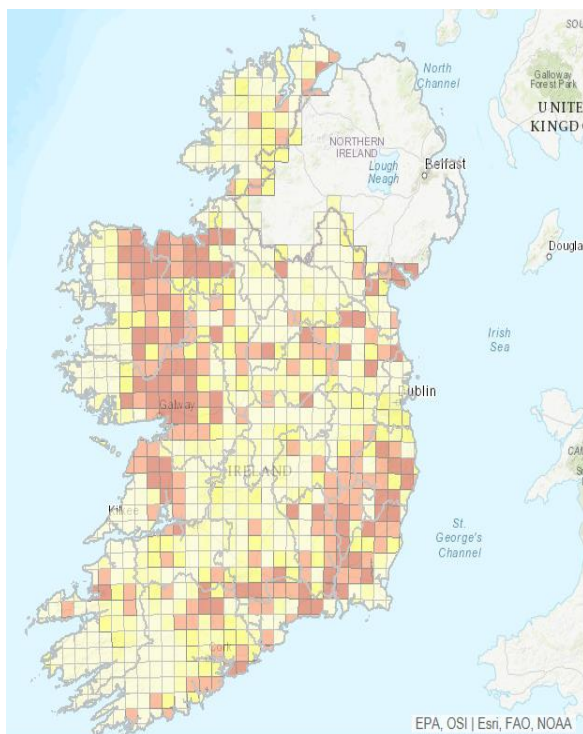
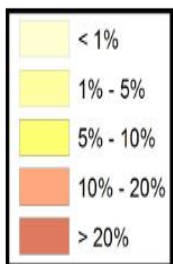
3rd highest rate of COPD in Europe
Respiratory disease 1/3 emergency hospital admission
mortality rate 113.6 / 100,000 v's EU 28 average 85.2



Lung cancer leading cause of cancer death in Ireland, 1 in 10 due to radon exposure

Specific Irish challenges – Radon

Estimated percentage of homes above the Reference Levels

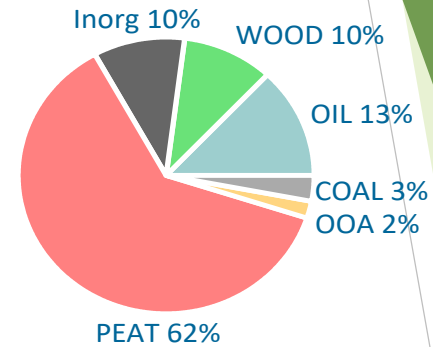
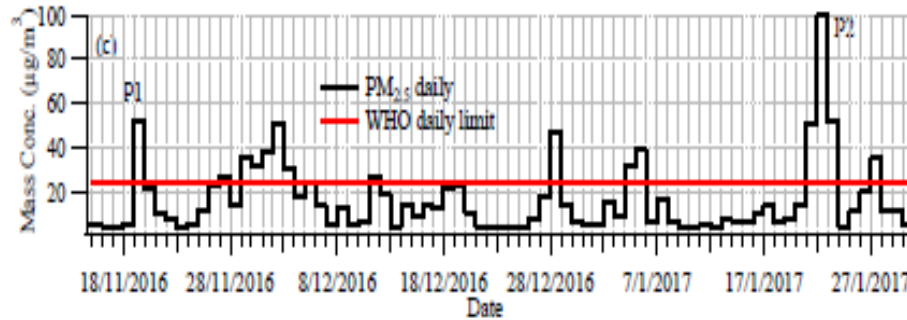
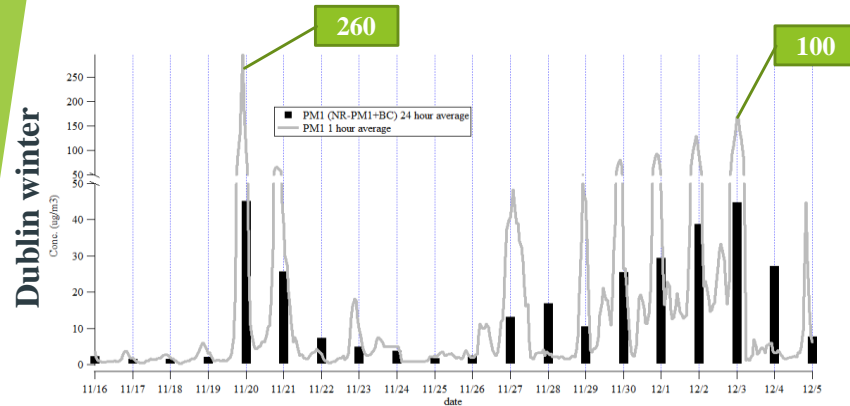


200 bequerel per cubic metre (Bq/m^3).

Irish homes $77 \text{ Bq}/\text{m}^3$ v's worldwide average of $39 \text{ Bq}/\text{m}^3$

300 lung cancer cases /yr

Outdoor PM



ANALYSIS

<https://doi.org/10.1038/s41893-018-0125-x>

nature
sustainability

Extreme air pollution from residential solid fuel burning

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NUI Galway
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Ryan
Institute



C-CAPS



epa

▶ Energy Efficient home

- ▶ Comfort, mental health and wellbeing
- ▶ Quality ventilation is the key to achieving low energy healthy buildings
 - ▶ Outdoor sources
 - ▶ Indoor occupant sources
 - ▶ Natural source



Research Projects at NUI Galway funded under the SEAI RD&D 2018 call

- ▶ Indoor **A**ir, Ventilation and comfo**R**t in Irish Domestic dwellings post **DE**ep Energy re**NO**vations – **ARDEN**

- ▶ Assessment of **V**entil**A**tion effectiveness via a **L**ongitudinal indoor environmental study in ‘**A**’ rated **I**rish **D**wellings: **VALIDate**

Funded by Sustainable Energy Authority of Ireland (SEAI) - 2018 National Energy Research, Development & Demonstration Funding Programme





Indoor Air, Ventilation
and comfort in Irish
Domestic dwellings pre
& post **DE**ep Energy
re**N**ovations – **ARDEN**

Pre & post @ 12 and 18 months



Home Selection Criterion

- ▶ SEAI Deep Retrofit Team

- ▶ Criteria
 - ▶ Detached, semi detached
 - ▶ Floor area approx. 130m²
 - ▶ Cavity walls
 - ▶ Non-smoking



Pollutants of interest

24 hour - 3 months monitoring period

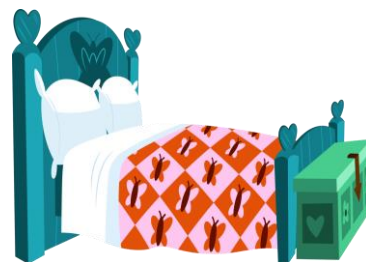
- ▶ Particulate matter (PM_{2.5}) Total volatile organic Compounds (TVOCs)
- ▶ Carbon Monoxide (CO) Carbon Dioxide (CO₂)
- ▶ Formaldehyde Radon
- ▶ BTEX (benzene, toluene, ethylbenzene and xylene) Nitrogen Dioxide (NO₂)
- ▶ Temperature and Humidity



Where will monitoring will take place within the home?

2/3 of our time at home

living room and the bedroom



Contextual information

- ▶ Field visit
 - ▶ During construction
 - ▶ Building materials
 - ▶ Refurbishments



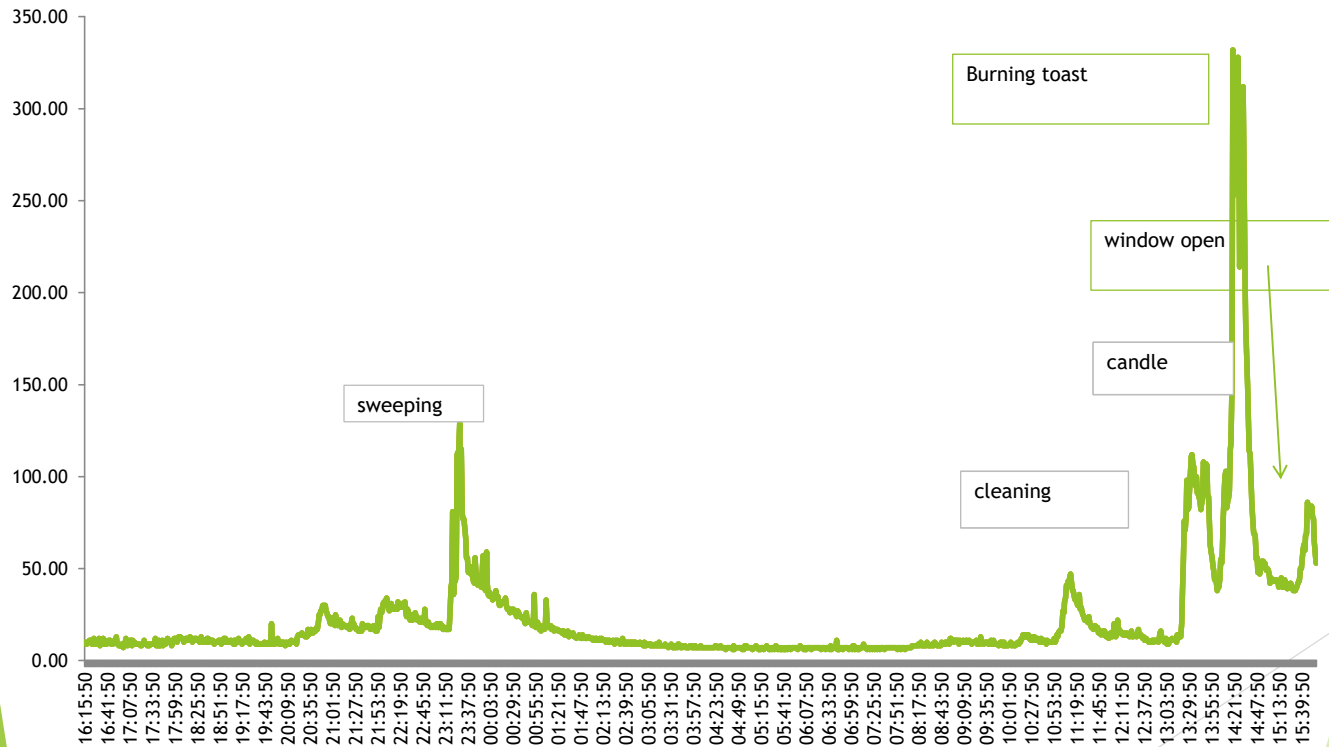
Contextual information

- ▶ Time activity diaries
 - ▶ before and after retrofit

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								



24 hour time series of PM_{2.5} (ug/m³) concentration – post shallow retrofit BER C1





www.nuigalway.ie/ARDEN





VALIDate
Project



Rationale



The impact of user behaviour on the control of indoor air quality



Determination of occupant expectations of highly energy efficient buildings in relation to indoor air quality



Identification of pollutants of concern especially in highly energy efficient buildings.



The purpose of this study is to investigate the indoor environmental quality within homes that have 'A' rated Building Energy Rating (BER) certification



Evaluate the temporal and spatial variations in indoor air pollutant concentrations



Collect occupant feedback relating to thermal comfort, potential mould growth, knowledge of ventilation system and satisfaction



Conduct computational simulations examining the energy and operational performance of the ventilation system with a particular emphasis on the control category



Determine the effectiveness of ventilation systems and obtain important information surrounding the implementation of building regulations and national strategies



Measurements

Thermal Comfort (Temperature and Humidity)

CO2

Radon

VOCs

Air Pressure



A Longitudinal Study

- ▶ Monitor environmental quality over two heating season and a cooling season
- ▶ Provide an accurate representation of the effectiveness of whole-house ventilation
- ▶ Long-term measurements as opposed to snapshots of individual rooms and periods
- ▶ Questionnaires will be administered concurrently with the monitoring data to capture information on occupants awareness of their ventilation system



Methodology

▶ Low cost sensors

- ▶ 18 months
- ▶ Contextual information

▶ 4 rooms

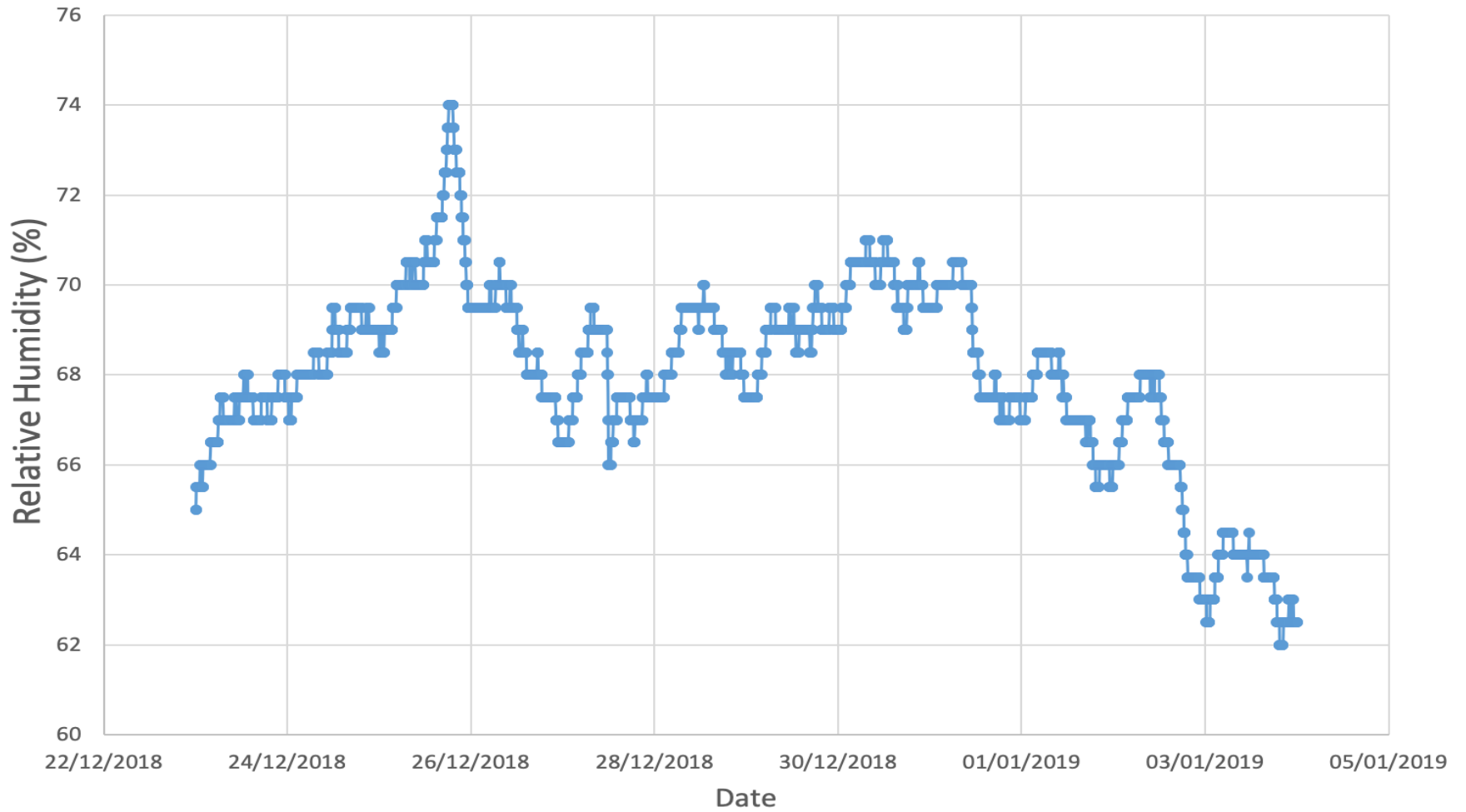
- ▶ Kitchen
- ▶ Living room
- ▶ Master Bedroom
- ▶ Bathroom

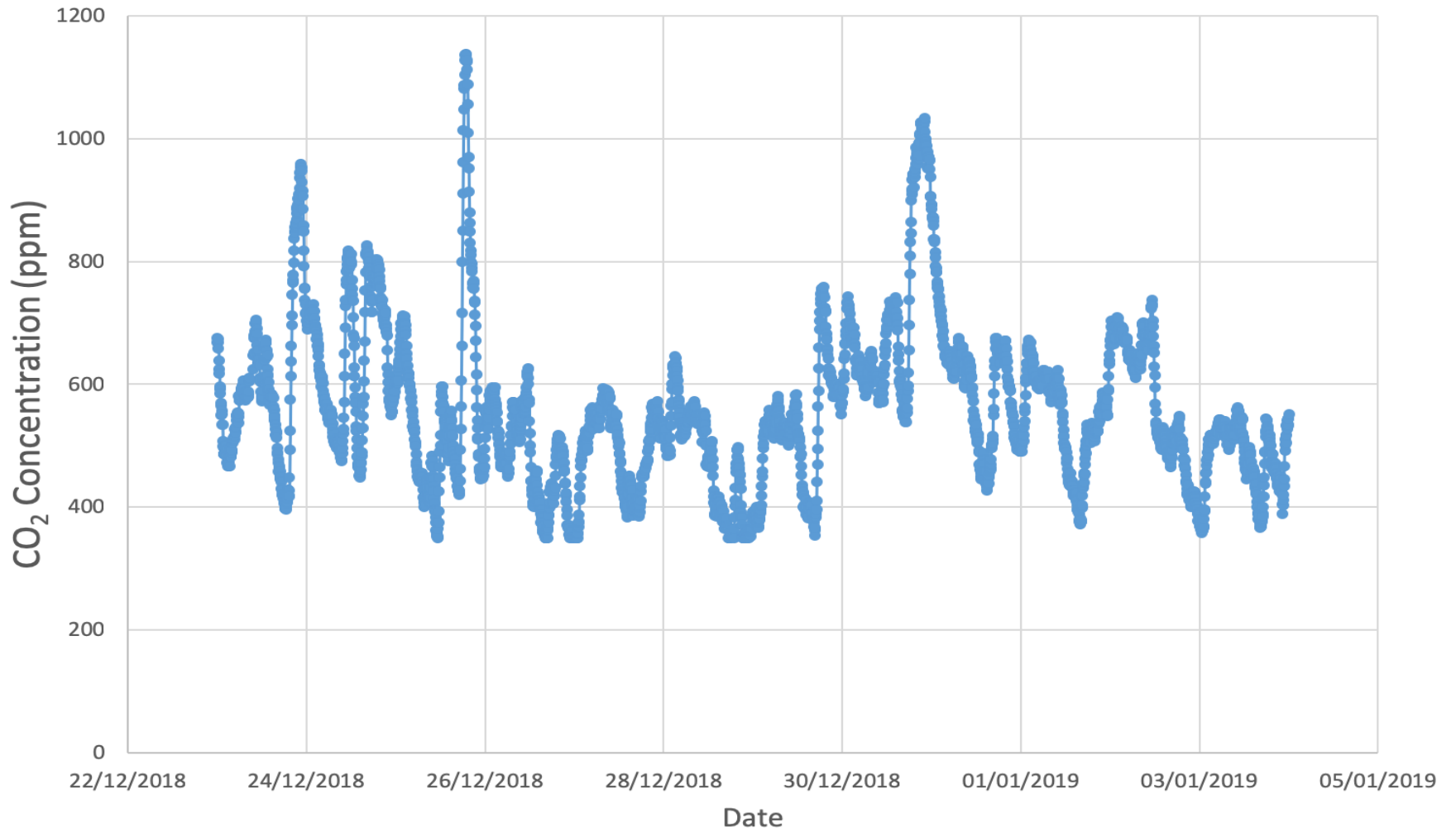


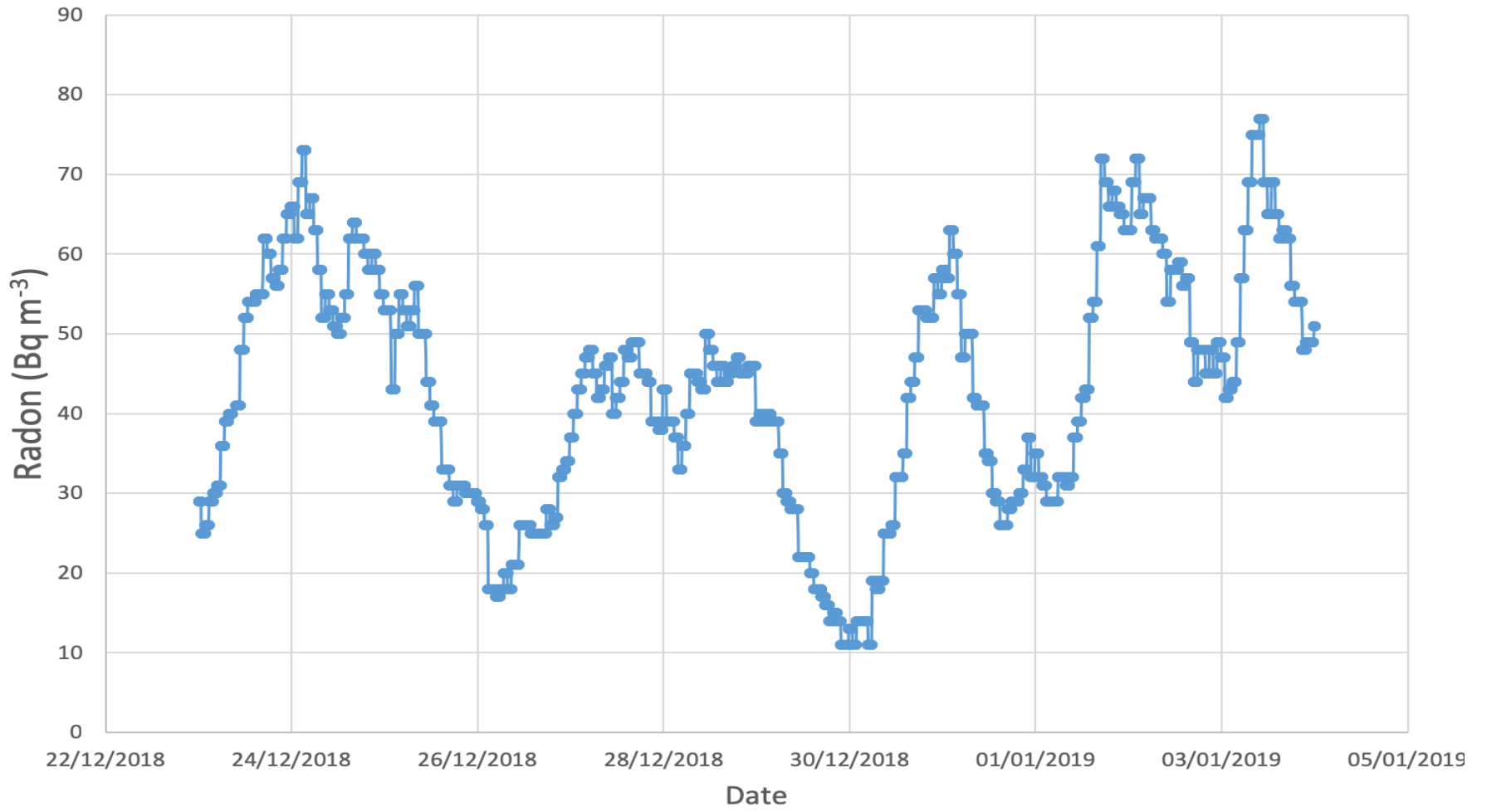
Table 2: MVHR Systems: Minimum extract rates

Wet rooms	Minimum extract rate (l/s)
Kitchen	13
Utility room	8
Bathroom	8
Sanitary accommodation (no bath or shower)	6 ¹









Expected outputs

▶ ARDEN

- ▶ First Irish dataset on IAPs in domestic dwellings post deep retrofit
- ▶ Linked to contextual information & occupant activity diaries
 - ▶ Identify pollutant and potential indoor sources
 - ▶ Concentrations during occupied and unoccupied periods
 - ▶ Insight into interaction between occupants and their interaction with different 'exposure controls' ventilation systems provided as part of the retrofit

▶ VALIDate

- ▶ 300 million time-series data points - data over 2 heating seasons and a cooling season
- ▶ Identifying the temporal and spatial variations in indoor air pollutant concentrations
- ▶ Assessment of the effectiveness of the ventilation system
- ▶ Conduct computational simulations examining the energy and operational performance of the ventilation system with a particular emphasis on the control category

Acknowledgements

- ▶ Indoor **A**ir, Ventilation and comfo**R**t in Irish Domestic dwellings post **DE**ep Energy re**N**ovations – **ARDEN**
 - ▶ Marie Coggins (NUIG), Andrew Apsley (NUIG), Miriam Byrne (NUIG), Hilary Cowie (IOM), Stephanie Long (EPA)
- ▶ Assessment of **V**entil**A**tion effectiveness via a **L**ongitudinal indoor environmental study in ‘**A**’ rated **I**rish **D**wellings: **VALIDate**
 - ▶ Miriam Byrne (NUIG), James McGrath (NUIG), Alison Connolly, James O’Donnell (UCD)

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Thank You



Deep Energy Renovation

Upgrades the energy efficiency of a home to an **A-rated energy efficient home**. The renovation takes a holistic approach to this by considering multiple energy efficient measures together.

- ▶ Wall insulation, attic insulation
- ▶ Replacing windows and doors
- ▶ Air tightness and ventilation (DCV/MVHR)

