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A hole in the wall

or

Energy and air quality implications of ventilation practice in Irish social housing

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Overview

Background

Methodology

- Field testing and occupant surveys
- Computer modelling

Summary

Conclusions

Background

Buildings use a lot of energy

EU Energy Roadmap: 80 to 95% reductions in CO_2 emissions by 2050

Buildings in the EU are responsible for:

- 40% of energy consumption, and
- 36% of CO_2 emissions

80% of occupied buildings in 2050 have already been built.
-United Nations Environment Programme (2009) Buildings & Climate Change

The energy-efficiency retrofit of the EU building stock is key to meet energy and carbon targets.

European Commission https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

SEAI Energy Efficiency Schemes

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Better Energy Programme

- Better Energy Homes (everyone)
- Better Energy Warmer Homes (fuel poor)
- Better Energy Areas and Communities
- Social Housing Investment Programme

Total of 1.65 million homes in Ireland

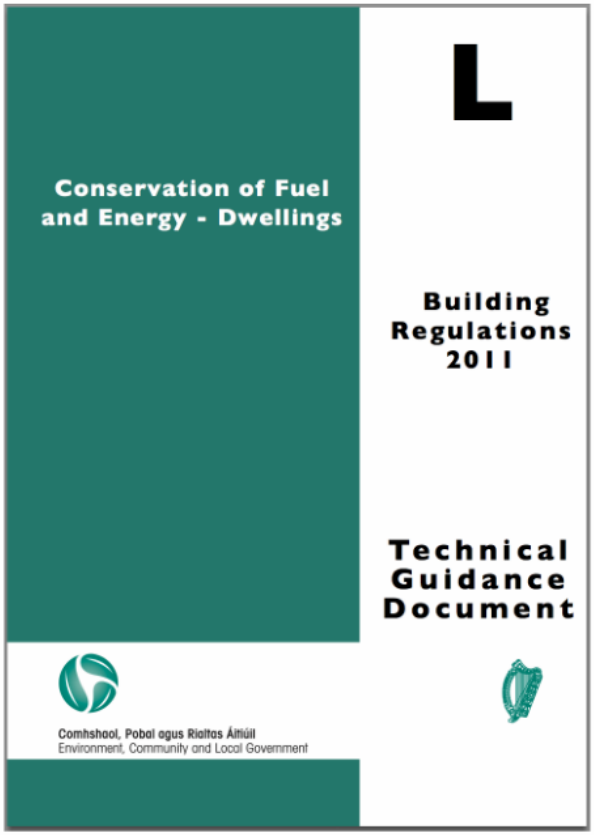
Social housing accounts for approximately 10%

Retrofits include insulation and some draught proofing

Social housing in Ireland is undergoing energy-efficiency retrofit to reduce energy consumption and CO2 emissions

Dept. of Environment, Communities and Local Government (2014) *Social and affordable housing statistics.*
Irish Council for Social Housing (2013) *Pre-budget submission*
Central Statistics Office (2011) Profile 4- The roof over our heads.

Irish building regulations



1.3.4 Building envelope air permeability

1.3.4.1 To avoid excessive heat losses, reasonable care should be taken to limit the air permeability of the envelope of each dwelling. In this context, envelope is the total area of all floors, walls (including windows and doors), and ceilings bordering the dwelling, including elements adjoining other heated or unheated spaces.

High levels of infiltration can contribute to uncontrolled ventilation. Infiltration is unlikely to provide adequate ventilation as required in the correct location. It is important as air permeability is reduced that purpose provided ventilation is maintained.

But ventilation is important…

Building Regulations - The Requirement

Part F of the Second Schedule to the Building Regulations 1997 is amended to read as follows:

Means of ventilation. F 1

Adequate means of ventilation shall be provided for people in buildings. This shall be achieved by
a) limiting the moisture content of the air within the building so that it does not contribute to condensation and mould growth, and
b) limiting the concentration of harmful pollutants in the air within the building.

Poor indoor air quality can lead to…

- Reduced mental concentration and productivity (from increased CO2)
- Lung cancer (from exposure to Radon and Volatile Organic Compounds)
- Dampness – mould growth
- Asthma
- Allergies
- Respiratory infections
- Sick Building Syndrome
- Bad odours

[Sundell (2004) *On the history of air quality and health*]

- Dampness can lead to “plague of leprosy”

[The Bible, *Leviticus 14, 34-57*]

So how should we ventilate?

Building Regulations - The Requirement

Part F of the Second Schedule to the Building Regulations 1997 is amended to read as follows:

Means of ventilation. F 1

1.2 DWELLINGS

1.2.1 General

1.2.1.1 In this Subsection guidance is given on approaches to meeting the ventilation objectives as set out in Subsection 1.1 through the use of

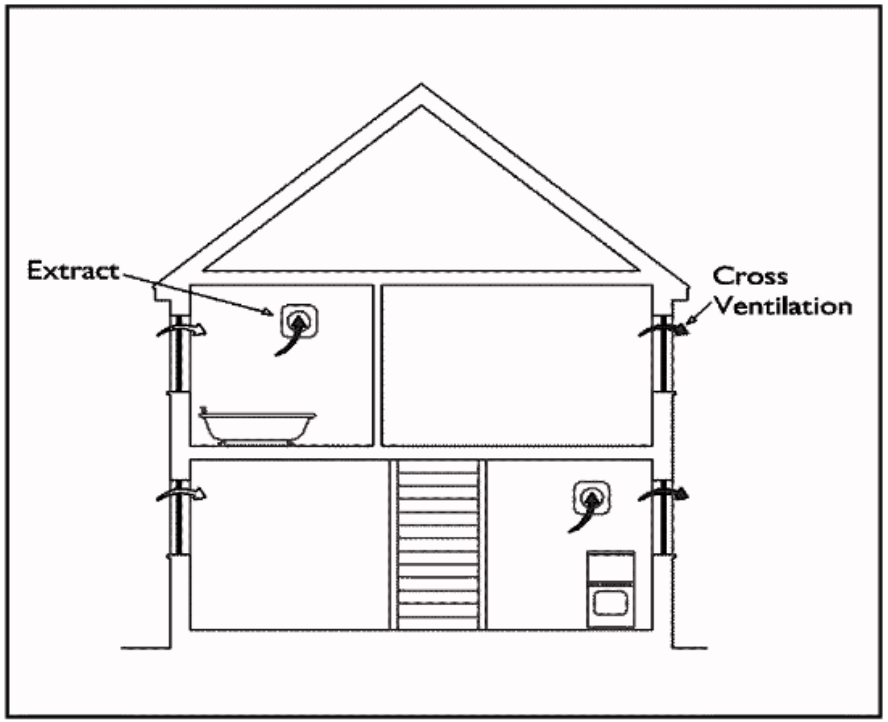
Standard practice in Ireland →

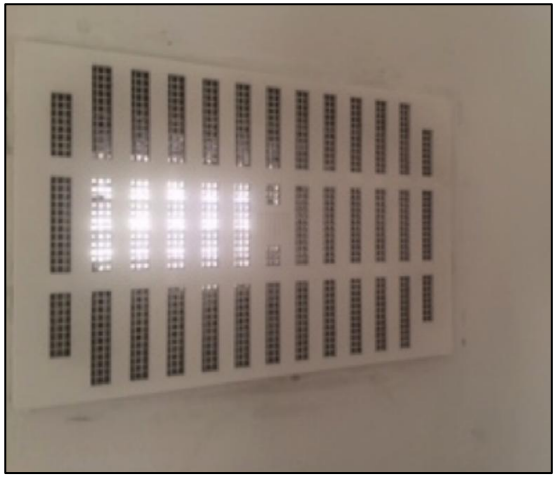
a) natural ventilation with specific provision for extract ventilation (Subsection 1.2.2); and

b) mechanical ventilation with heat recovery (Subsection 1.2.3).

“Background ventilators”

Diagram 1: Natural Ventilation with mechanical extract

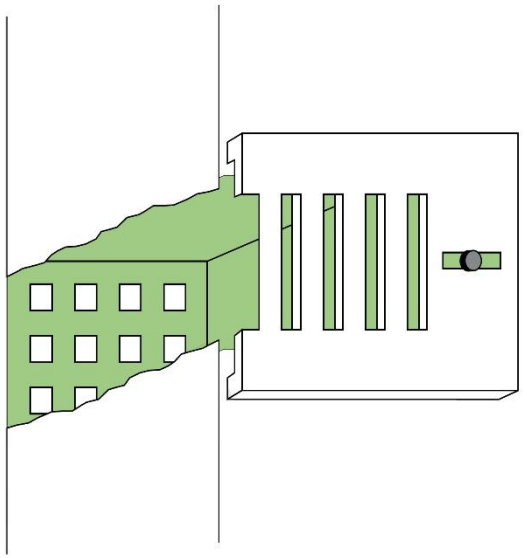




Airflow through vents driven by natural pressure differences (Diagram from Part F 2009)

Equivalent areas of vents…

Minimum area per room type	
Habitable rooms:	5000-mm^2
Kitchens:	2500-mm^2
Utility rooms:	2500-mm^2
Bathrooms:	2500-mm^2



Total household equivalent area of vents:
30,000-mm^2 plus 5,000-mm^2 for every 10-m^2 of floor area over 70-m^2.

45,000-mm^2 is approx. 0.5 sq. ft.

Project aim:

Investigate the impact of meeting Part F by installing background ventilators in Irish social housing

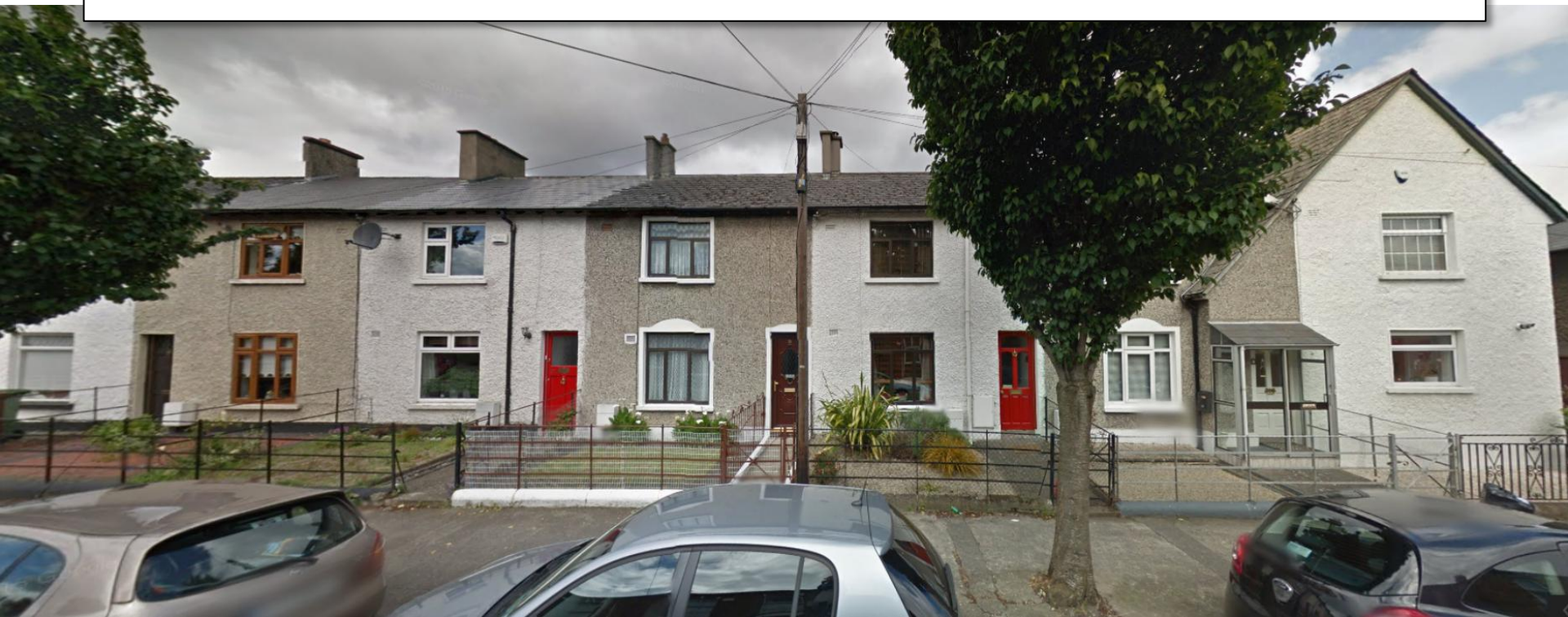
Impacts include:

i. Indoor air quality (health)
ii. Energy consumption
iii. Occupant comfort

Methodology 1:
Field testing and occupant surveys

Case study homes

- Nine houses investigated over one heating season
- Located in Co. Kilkenny
- Social Housing Investment Programme
- Terraced
- Built circa 1982
- Floor areas between 45 and 90-m^2



Case study homes

Two-stage retrofit carried out

- Thermal retrofit
- Ventilation retrofit (to meet Part F)

Thermal retrofit:

- Full-fill wall cavity insulation
- Attic insulation
- Open fires replaced with wood-burning stoves
- Draught stripping around attic hatch and windows
- (Some) windows and doors replaced

Ventilation retrofit:

- Background vents installed in all rooms (or cleaned if already present)
- Mechanical extract fans installed in bathrooms

Airtightness measured before and after retrofit

Dwelling	Classification	Floor Area Area m^2	Orientation	Pre- Upgrade Measured, Q_{50} $[m^3/h.m^2]$	Post- Upgrade Measured, Q_{50} $[m^3/h.m^2]$	
A	2[4], T[5]	80.6	E - W	17.1	13.6	LEAKY
B	2, S	89	E - W	12.7	10.2	
C[2]	2, S	76.9	E - W	19.7	13.8	
D	2, T	87.7	E - W[6]	9.6	7.7	
E[3]	2, T	75	N - S[7]	6.5	5.3	TIGHT
F	2, S	76	N - S	10.2	8.3	
G	2, T	79.8	N - S	10.1	6.3	
H[1]	1, S	46.2	N - S	6.4	5.6	
J	1, S	49.8	N - S	3.9	4.4	

Airtightness measured using a blower door. Background vents have to be closed during blower door testing. ATTMA (Air Tightness Testing and Measurement Association) Technical Standard

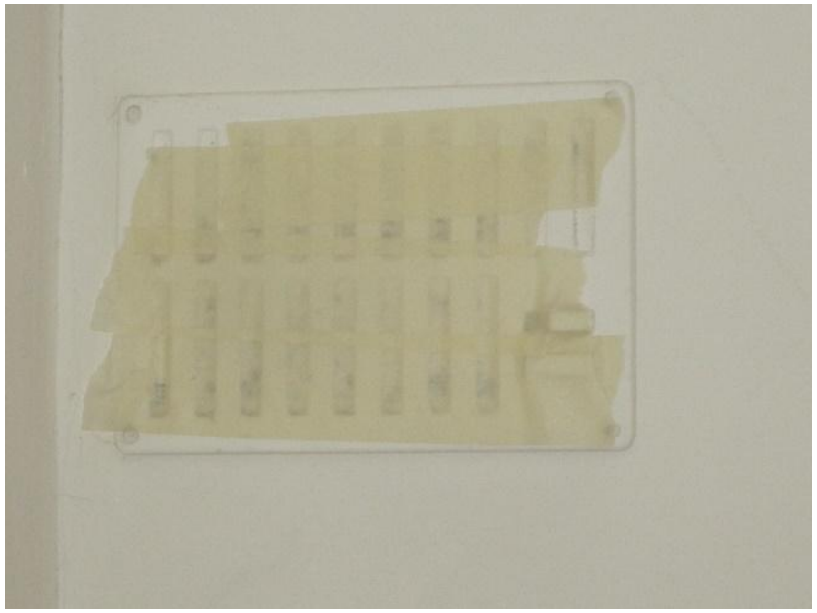
Occupant survey results

Post retrofit:

- Responses broadly positive
- Occupants felt homes were warmer and easier to heat
- However, 6 out of 9 homes reported occupant discomfort…

> **"*My bedroom is now freezing*"** due to installation of background vents
>
> **"*The [background] vents cause draughts*"**
>
> **"*It is freezing sitting under the [background] vent in the sitting room*"**
>
> **"*There are draughts across our feet*"** from the background vents
>
> **"*I can't enjoy the television*"** due to noise of breeze from the background vents
>
> **"*Street noise is very annoying*"** from background vents

The net result…



Occupants carried out adaptive actions to remedy source of discomfort

Methodology 2: Computer modelling

Two versions of one home studied in detail

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Airflow and energy modelling:

1. The house with a **tight** building envelope (5.3-$m^3/h/m^2$)
2. The house with a **leaky** building envelope (13.8-$m^3/h/m^2$)

Floor area = 90-m^2
End-of-terrace

Two modelling scenarios

Scenario 1. Post-thermal retrofit

Scenario 2. Post-ventilation retrofit

Background vents installed. Equivalent areas sized to meet Part F.

Airflow modelling – CONTAM

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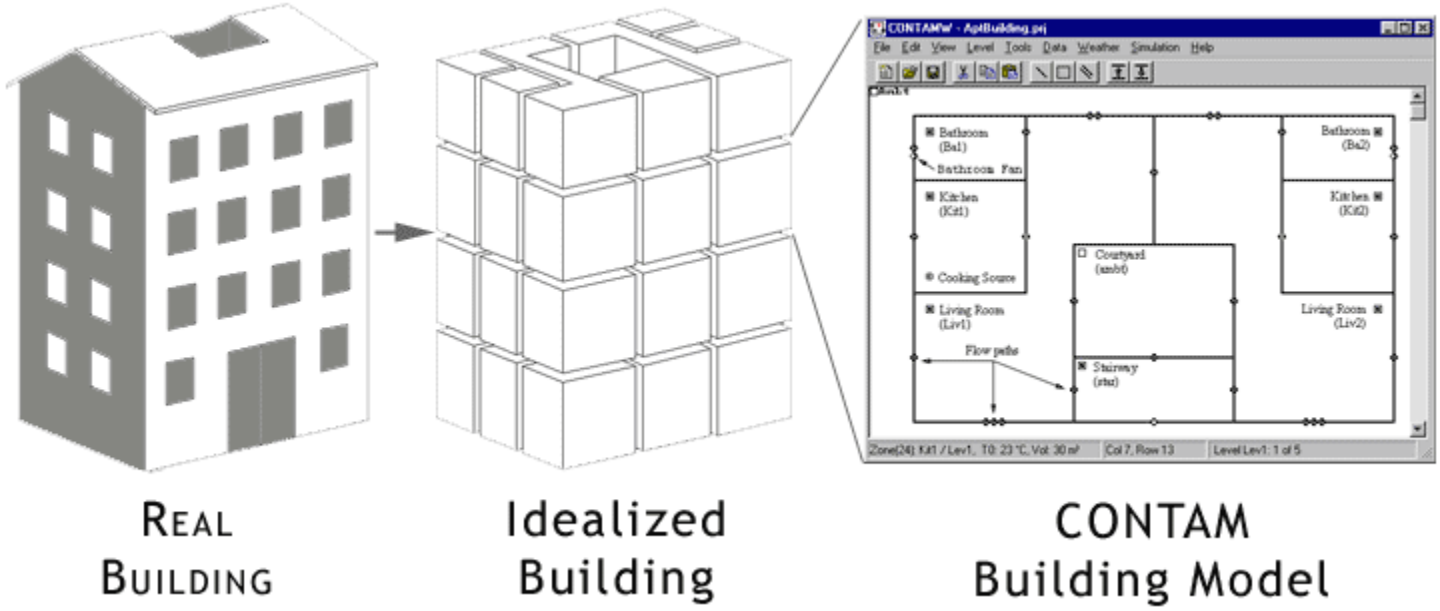
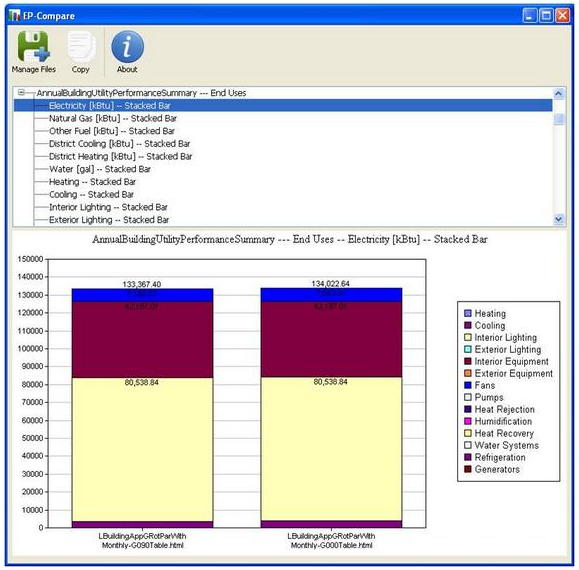


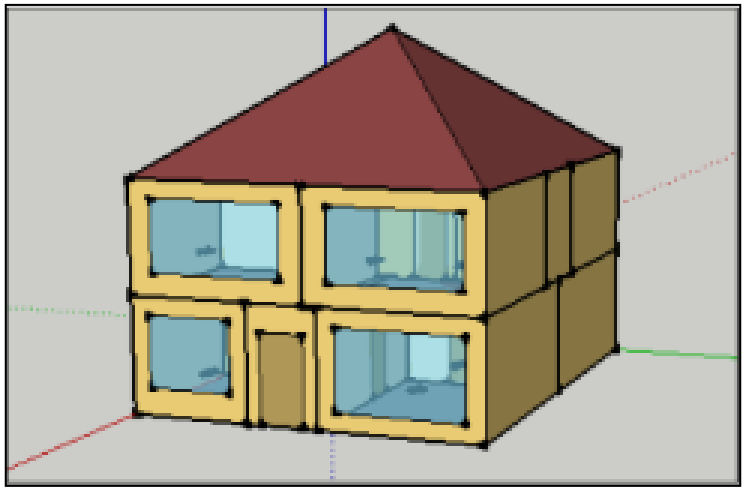
REAL BUILDING | Idealized Building | CONTAM Building Model

What is CONTAM? "CONTAM is multi-zone airflow and contaminant transport analysis software."

NIST National Institute of Standards and Technology U.S. Department of Commerce

Energy modelling – EnergyPlus

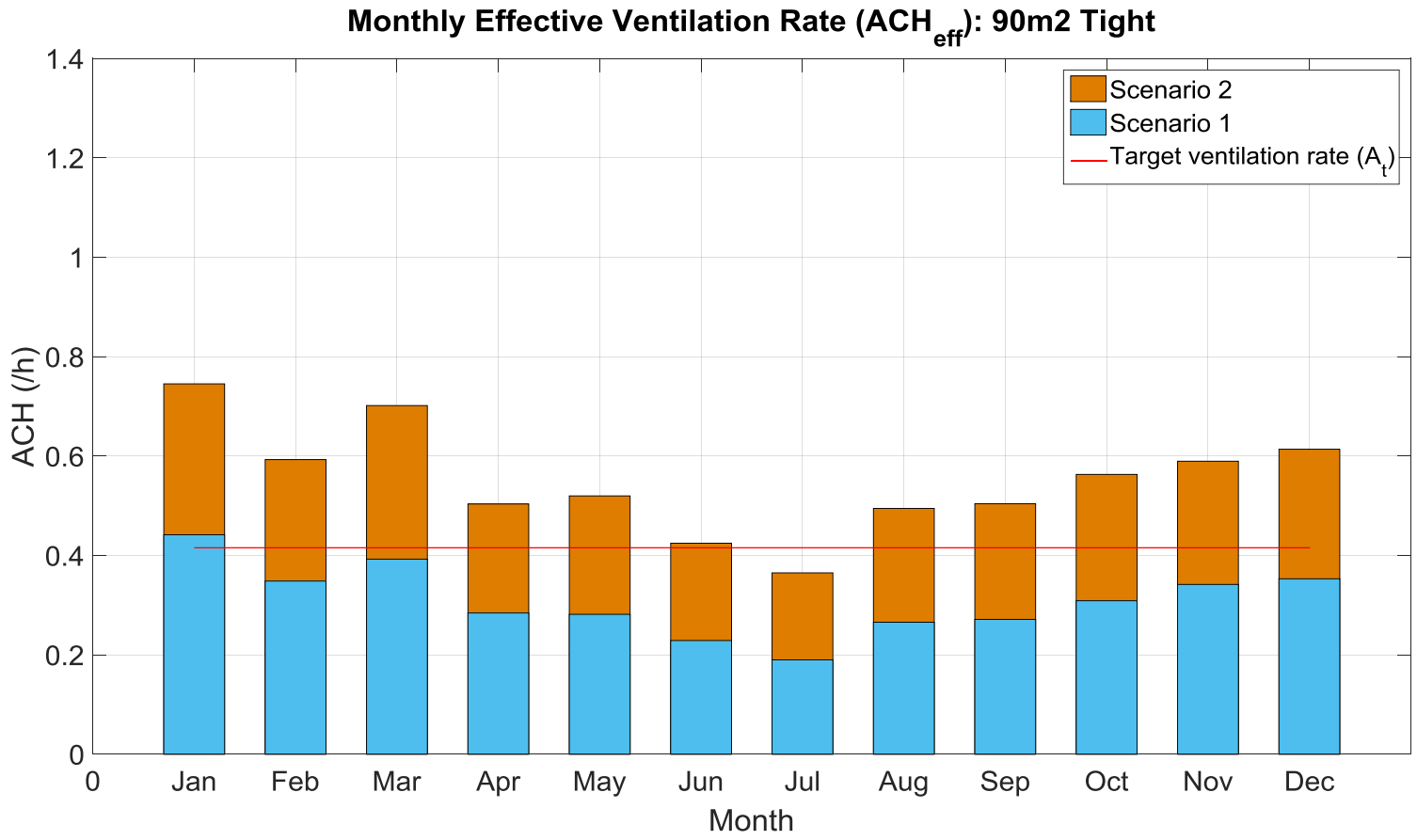




From Neu et al. (2014)

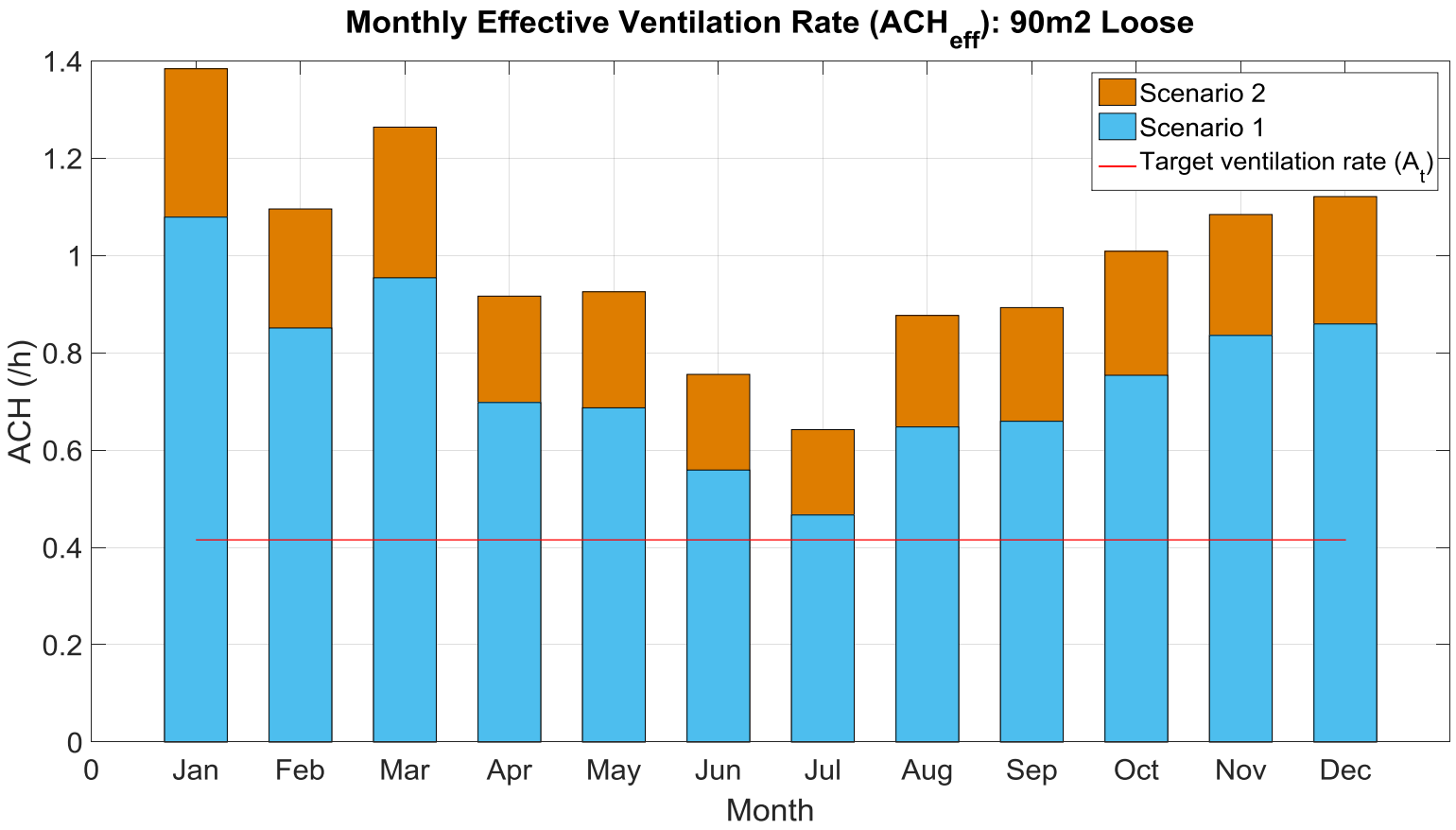
What is EnergyPlus? "EnergyPlus is a whole-building energy simulation program that engineers, architects, and researchers use to model energy consumption."

Airflow: House 1 (Tight)



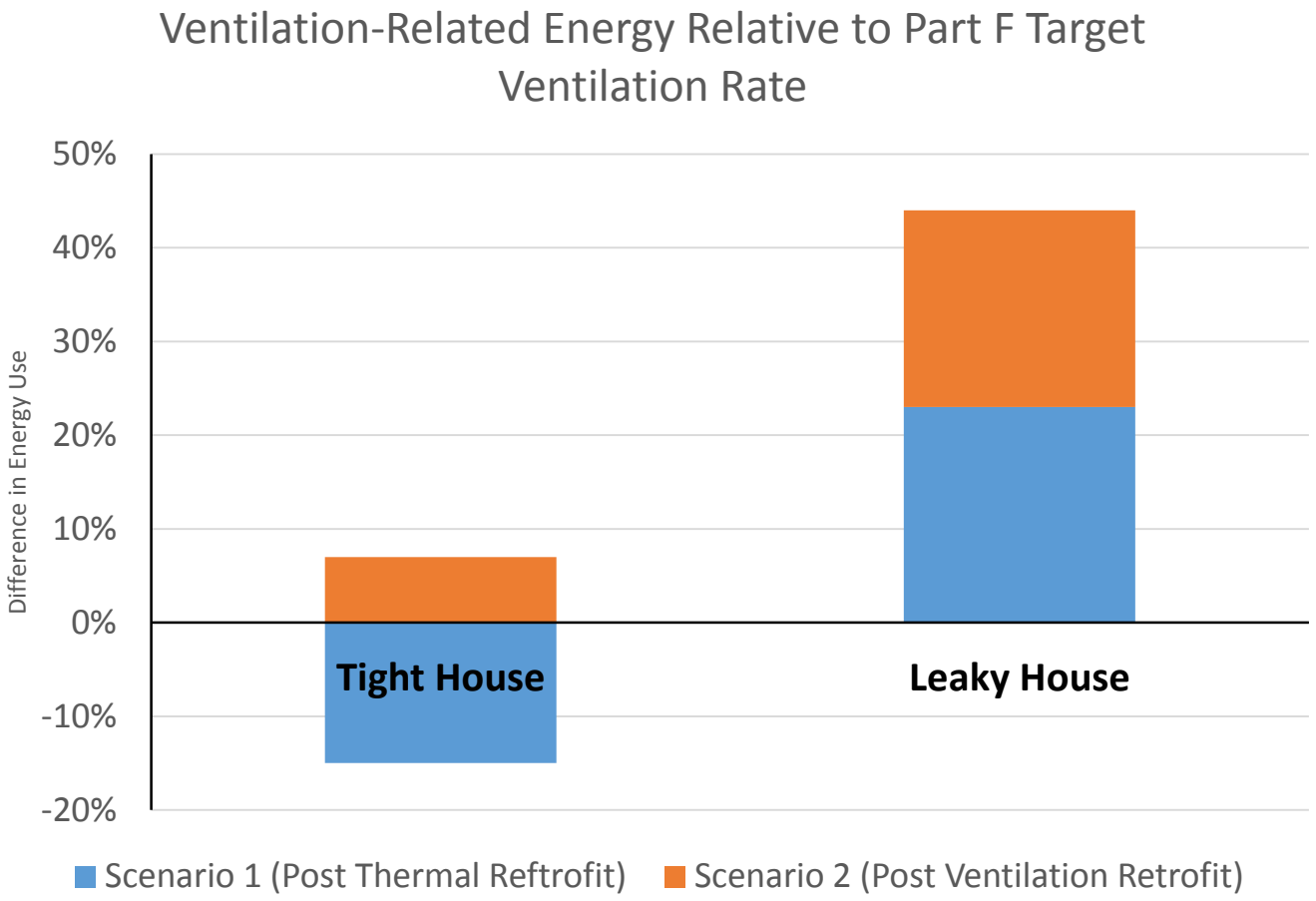
Home is over-ventilated by 16% after installation of background vents.

Airflow: House 2 (Leaky)



Home is over-ventilated by 107% after installation of background vents.

Energy…


Ventilation-Related Energy Relative to Part F Target Ventilation Rate
Difference in Energy Use
50%
40%
30%
20%
10%
0%
-10%
-20%
Tight House
Leaky House
Scenario 1 (Post Thermal Reftrofit)
Scenario 2 (Post Ventilation Retrofit)

To summarise…

- Social housing is undergoing thermal retrofit to save energy and CO2
- Background ventilators are being installed to ensure good indoor air quality
- In **tight buildings** these vents are necessary for good indoor air quality
- However, occupants are sealing these vents due to cold draughts and noise pollution – **health implications**
- And in **leaky buildings** these vents are unnecessary and can increase energy consumption by 45% - **energy implications**

Conclusion

We need a better approach to ventilate Irish social housing!

Current approach inadequate from health and energy perspectives.

Next steps…

Investigate alternative ventilation strategies!

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A hole in the wall

or QUESTIONS???

Energy and air quality implications of ventilation practice in Irish social housing

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Reserve slides

1.2.3.2 The minimum capacity of a Mechanical Ventilation with Heat Recovery system should be based on the calculated general ventilation rate, adjusted to allow for air infiltration due to permeability of the building fabric. The calculated general ventilation rate is determined as the greater of

a) 5 l/s plus 4 l/s per person, e.g. 25 l/s for a five person dwelling. This is based on two occupants in the main bedroom and a single occupant in all other bedrooms. This should be used as the default value if a greater level of occupancy is expected, then add 4 l/s per occupant.

Or

b) 0.3 l/s per m^2 internal floor area, e.g. 30 l/s for a 100 m^2 dwelling.

The adjustment to the calculated general ventilation rate to allow for air infiltration is 0.04V (l/s), where V is the gross internal volume of the dwelling in m^3.

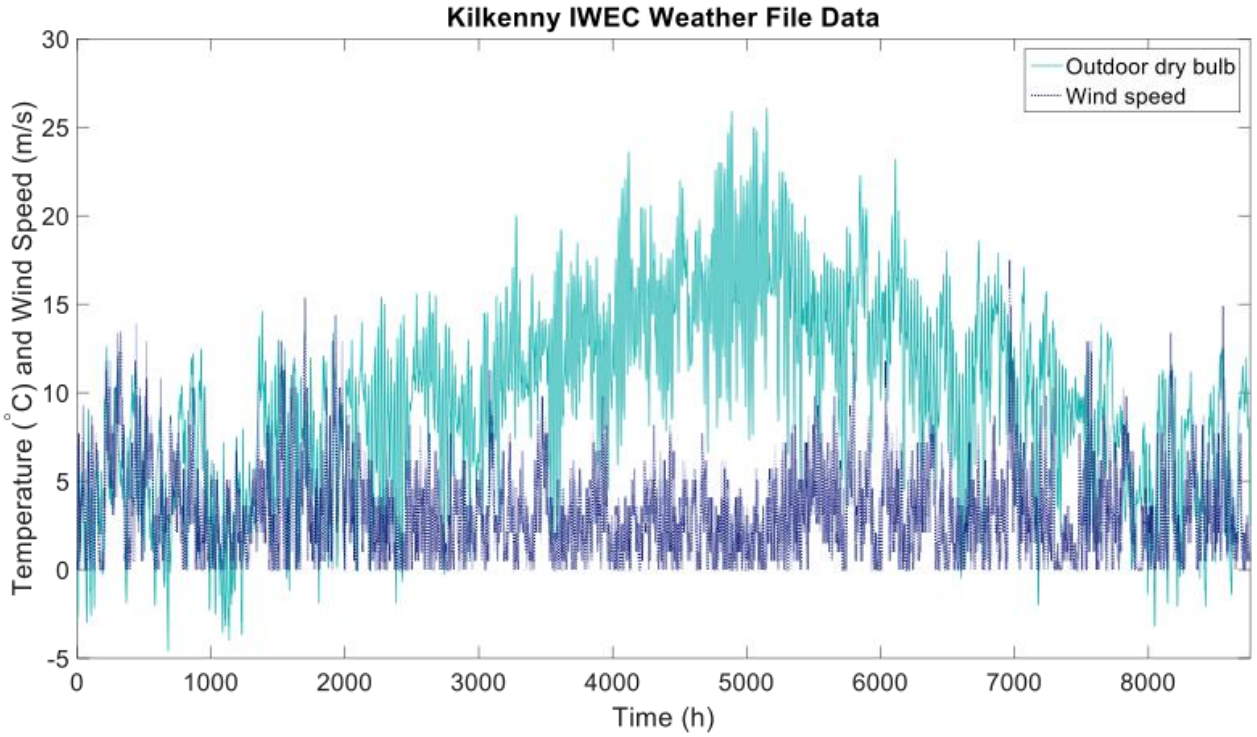
Where the air permeability is $5m^3/(h.m^2)$ or greater, the adjustment is deducted from the calculated general ventilation rate to give the minimum capacity of the Mechanical Ventilation with Heat Recovery system. Where the air permeability is less than $5m^3/(h.m^2)$ no deduction is made.

Target ventilation rate

Two key EU policy documents to legislate the reduction of building energy consumption:

1. Energy Performance of Buildings Directive (EPBD)
2. Energy Efficiency Directive

Kilkenny weather file (IWEC)



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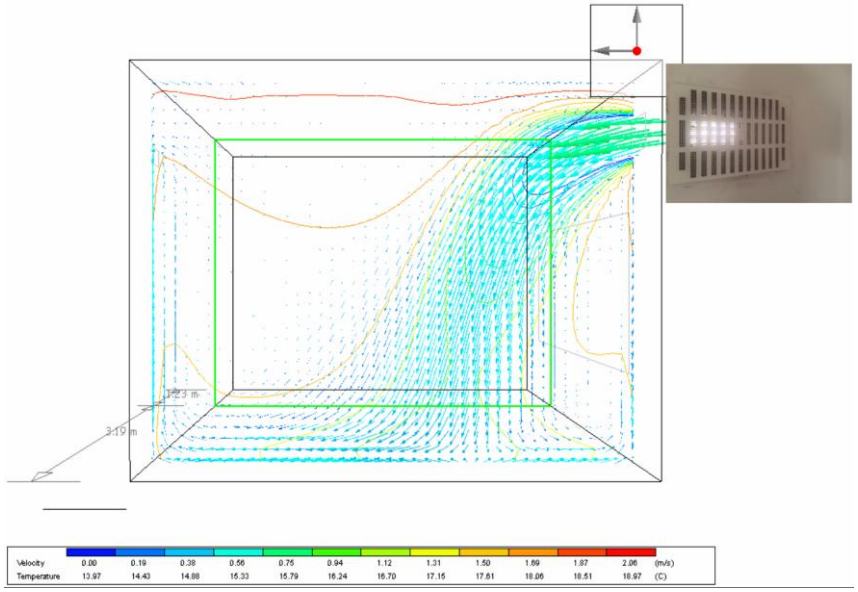

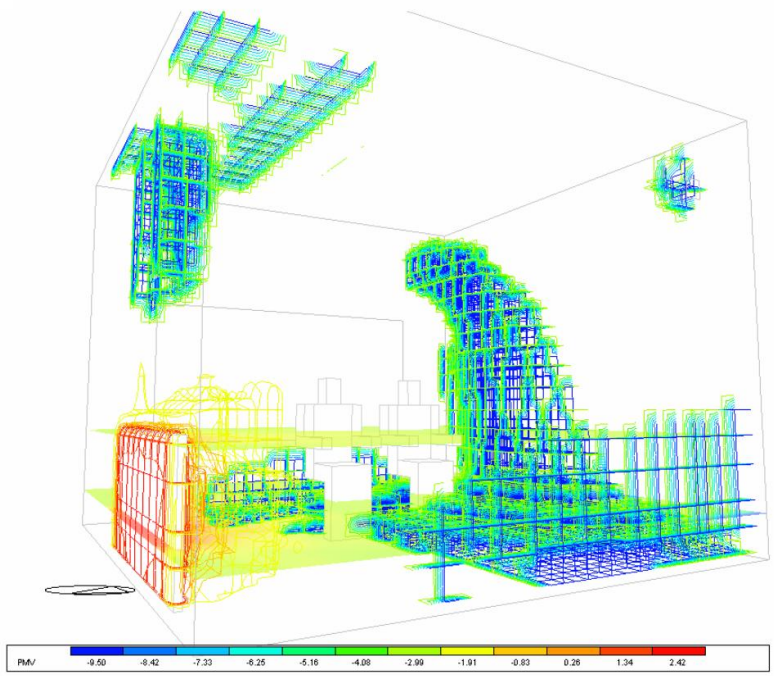

Irish building regulations

Part J - The Requirement

Part J of the Second Schedule to the Building Regulations 2014, provides as follows: -

Air supply.	J1

A heat producing appliance shall be so installed that there is an adequate supply of air to it for combustion, to prevent overheating and for the efficient working of any flue pipe or chimney serving the appliance.

Airflow measurements