VENTILATION AND INDOOR AIR QUALITY

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1. Energy and buildings

- Building sector provides biggest potential to mitigate climate change [1]
- This can be achieved through reducing heat loss due to uncontrolled infiltration
- However important to maintain requirements for adequate indoor air quality

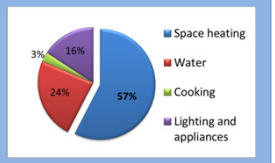

Fig 1: Typical home energy use [2]

2. Towards energy efficient buildings

- All new homes to be zero-carbon by 2016 in UK[3]
- Progressive tightening of Building Regulations – e.g. significant improvements in U-values[4]

(lower U-values mean better thermal insulation therefore reduced heat loss through the building fabric)

- Passive House (PassivHaus) design focussed on reducing need for space heating by employing higher degree of air-tightness.

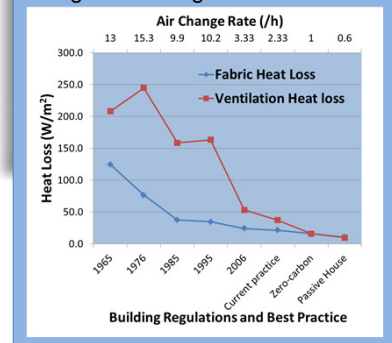

Fig. 2: Improvements in building standards

Reduced heat loss means less energy required for space heating.

An idealised zone (room) with a floor area of 20m² and 10 occupants, under steady state environmental conditions, was used in the calculation.

Fig. 2 shows the impacts of improving building regulations and corresponding air change rates achieved in dwellings[5-7].

Fig. 3 shows the effect of decreasing air change rates on indoor pollution levels and the progression of diseases.

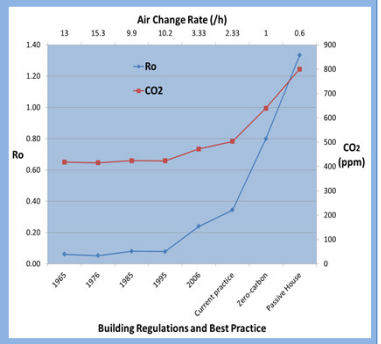

Fig. 3: Impacts of changing ventilation rates

Ro – reproductive ratio of an infection [8] – e.g. common cold

- Ro<1 – disease will die out
- Ro>1 – disease outbreak

3. Ventilation and indoor air quality

Sources of indoor pollutants include temperature, moisture, CO_2, radon, formaldehyde, particulates and odour.

Results from research implies that there is an economic benefit from providing and ensuring good indoor air quality in offices due to improved performance.

With increased air-tightness are our ventilation systems providing good IAQ?

Table 1: Impacts of IAQ parameters on occupants [9-12]

IAQ measures / Outcomes	Increasing ventilation rates	High CO_2 levels	Particulates e.g. NO_2
Students in school			
Performance test	↑	↓	
Risk of asthma			↑
Attendance			↓
Workers in office			
Performance test	↑		
Attendance	↑		

↑/↓ - Increase/Decrease in beneficial outcome

4. PROBLEM

CAN MANUALLY OPERATED WINDOWS PROVIDE ADEQUATE IAQ?
What environmental changes induce window opening?

Use of windows play a significant role in providing ventilation and controlling IAQ, especially in naturally ventilated buildings. This makes it important to understand occupant behaviour in window use.

5. HOW DO PEOPLE CONTROL THEIR INDOOR ENVIRONMENT?

Results from previous field studies on window use and occupant behaviour suggest that occupants will open windows in response to thermal discomfort [13-15].

What about other indoor air quality parameters such as CO_2 – do occupants respond to increase in pollutant levels in a room?

A pilot study will be carried out to observe how occupants in a naturally ventilated room control their indoor environmental conditions.

The study will be carried out in a controlled, single occupancy office with operable windows. The environmental conditions at which an action is carried out on a window or door will be recorded.

Table 2: Parameters to be measured

Parameter	Recommended range[16-18]	Impacts of poor IAQ due to these parameters
Temperature	Min – 16°C Recommended – 21°C – 23°C	Overheating, increased energy used in heating/cooling
CO_2	600 - 800 ppm	Sleepiness, headache, drowsiness, indicator of low ventilation rates
Relative humidity	40 – 70%	Stuffiness, dust mites growth, mould growth

6. IMPLICATIONS OF STUDY

- To provide an introduction to manually operated window behaviour as a function of IAQ with particular focus on indoor pollutants.
- Model indoor air quality in naturally ventilated buildings to answer the question of whether manually operated windows can be used to achieve adequate IAQ.
- Understand the implication of window use on energy consumption in buildings to help bridge the gap between design and actual energy performance in buildings.

REFERENCES

[1] IPCC (2007). Mitigation of Climate Change. 4th Assessment Report.
[2] DECC (2010). Energy consumption in UK – Domestic data tables
[3] Pre-Buget Report (2006)
[4] CLG (2010). Part L of the Building Regulations
[5] Low Carbon Housing Learning Zone – Air-tightness in UK Housing
[6] Zero Carbon Hub (2009). Defining a Fabric Energy Efficiency Standard for zero carbon homes.
[7] BRE. PassivHaus Primer.
[8] Noakes, C. et al., (2006). *Epidemiol. Infect.*, 134 (5): 1082–1091.
[9] Coley, D.A. & Beisteiner A. (2002). *International Journal of Ventilation*, 1 (1): 45–52.
[10] Hulin, M. et al. (2010). *Indoor Air*, 20 (6): 502–514.
[11] Wargocki, P., et al. (2001). *Proceedings of Healthy Buildings*, 1, 635–640.
[12] Milton, D.K., (2000). *Indoor Air*, 10 (4): 212–221.
[13] Rijal, H.B. et al., (2007). Energy & Buildings, 39 (7): 823–836.
[14] Haldi, F. & Robinson, D., (2008). Building & Env., 43 (12): 2163–2177.
[15] Dutton, S. & Shao, L., (2010). 4th National Conf. of IBPSA. New York.
[16] CIBSE Guide B (2005). Heating, ventilation, air conditioning and refrigerating
[17] ASHRAE (2001). Ventilation for Acceptable Indoor Air quality.
[18] CIBSE Guides A (2007). Environmental Design