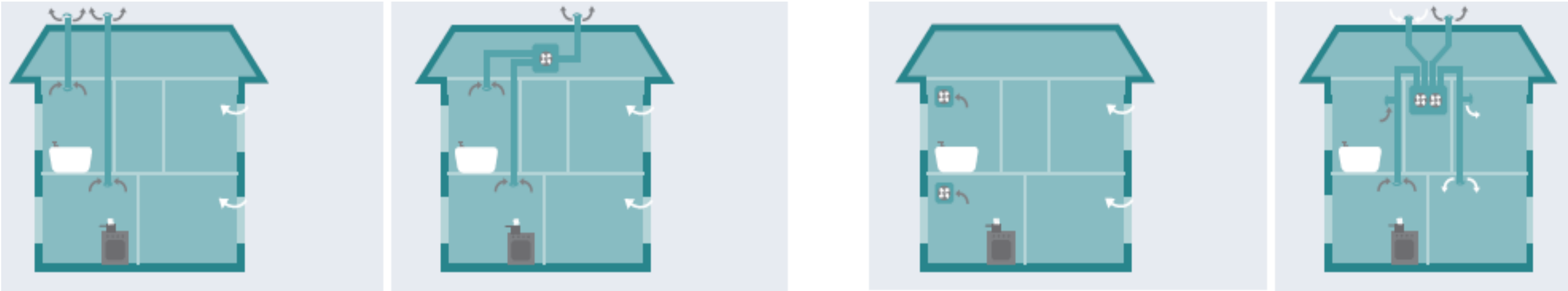

Moisture: Developing a simplified method for evaluating ventilation performance in dwellings

An initial study

Presented by Ian Mawditt | May 2018 | High Wycombe

UK IEG Indoor Environments Group

Ventilation, Indoor Air Quality and Human Health

UKIEG 2018 CONFERENCE

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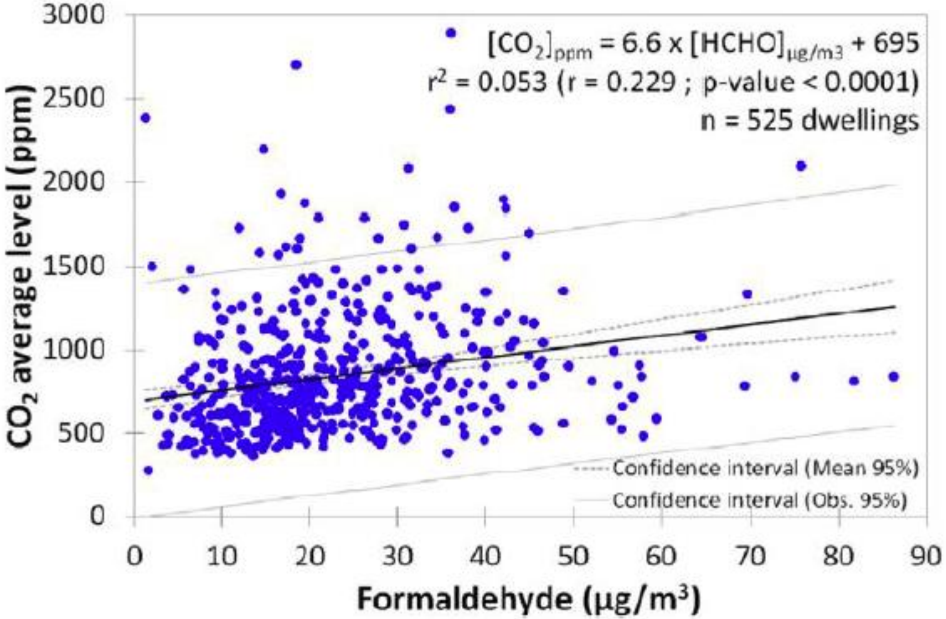
Inspiration for this presentation

- A lot of focus is still on dwelling airtightness and fabric performance: not enough on ventilation, IAQ and health
- IAQ metrics becoming more confusing – there's a lot of discussion around CO_2, VOCs, PMs, etc. Which should we lead on?
- Previously involved in a number of IAQ and building performance field studies, giving a portfolio of building data for re-analysis
- Can we develop a simplified approach (using measured data) that acts as a 'catchall'?
- Currently investigating a possible solution for a simplified approach using moisture vapour as the metric and applying to existing standards.
- Wish to share preliminary findings with conference

Ventilation in dwellings: CO_2

- Recent years has seen the development and introduction of sensors to control ventilation on CO_2 and VOCs – CO_2 considered a marker for performance
- Correlation CO_2 with other pollutant is okay some of the time, but CO_2 concentrations are highly variable. Limiting CO_2 concentration is not enough to prevent exceedances to occur



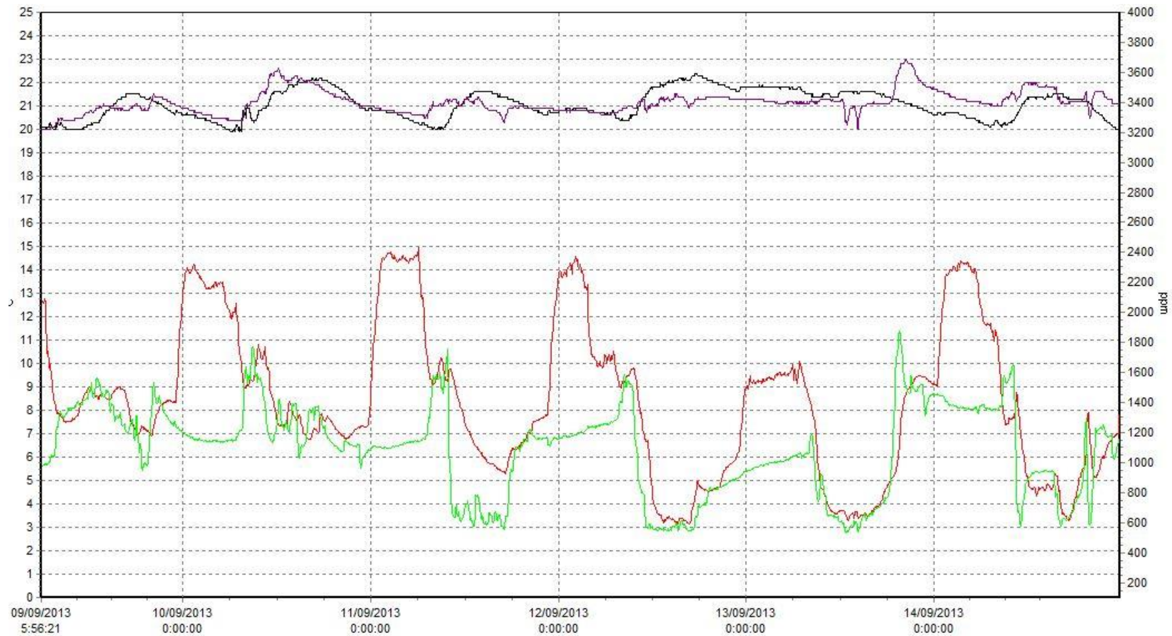
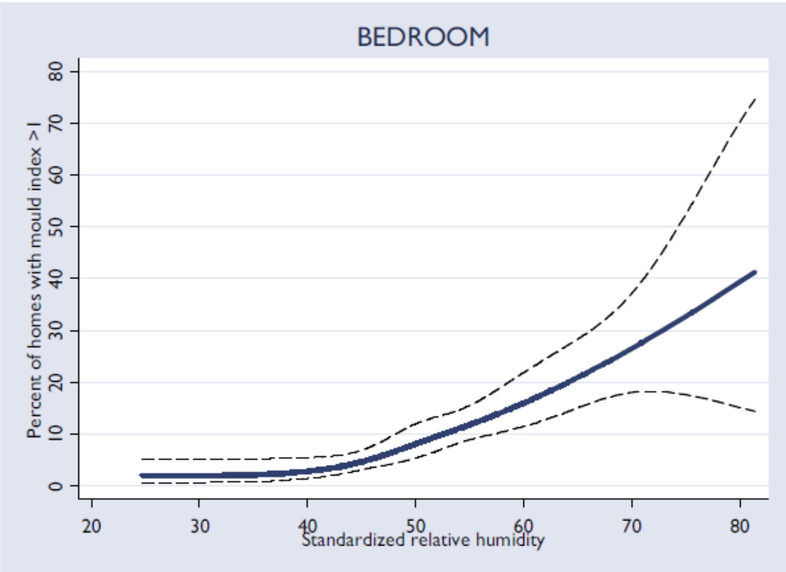


Chart source: Ramahlo O, et al 2015

Ventilation in dwellings: moisture

- Moisture has been considered to be the dominant pollutant in dwellings for quite some time
  - Relative Humidity (%RH) has been the adopted ‘language’ for moisture
  - %RH useful for understanding risk related to surface condensation, mould, HDM, etc.



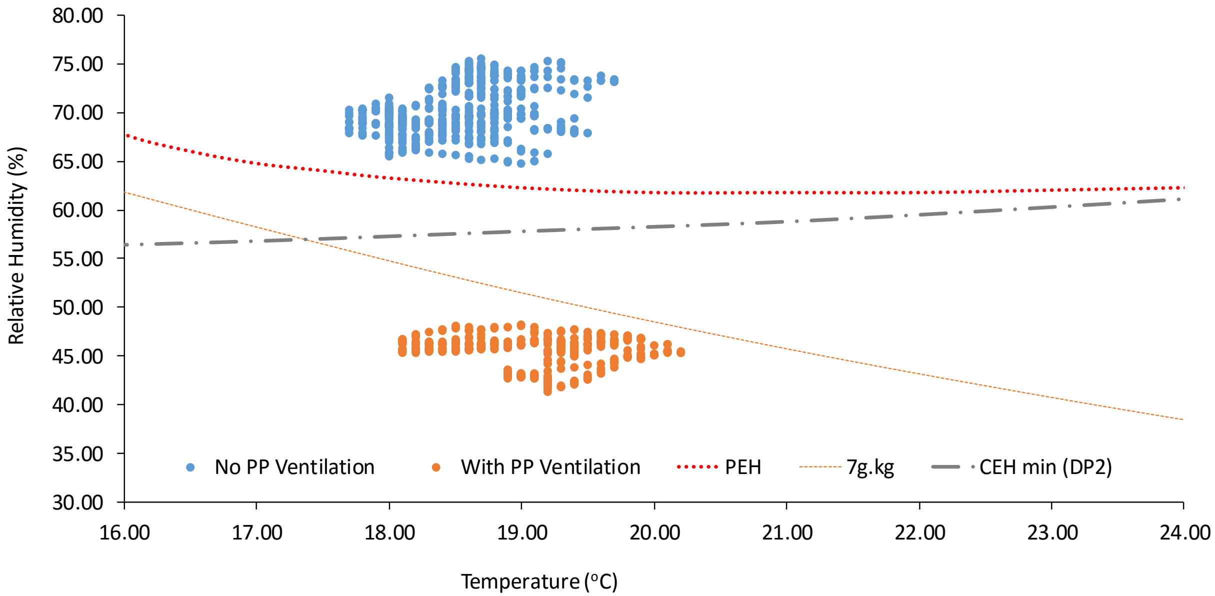
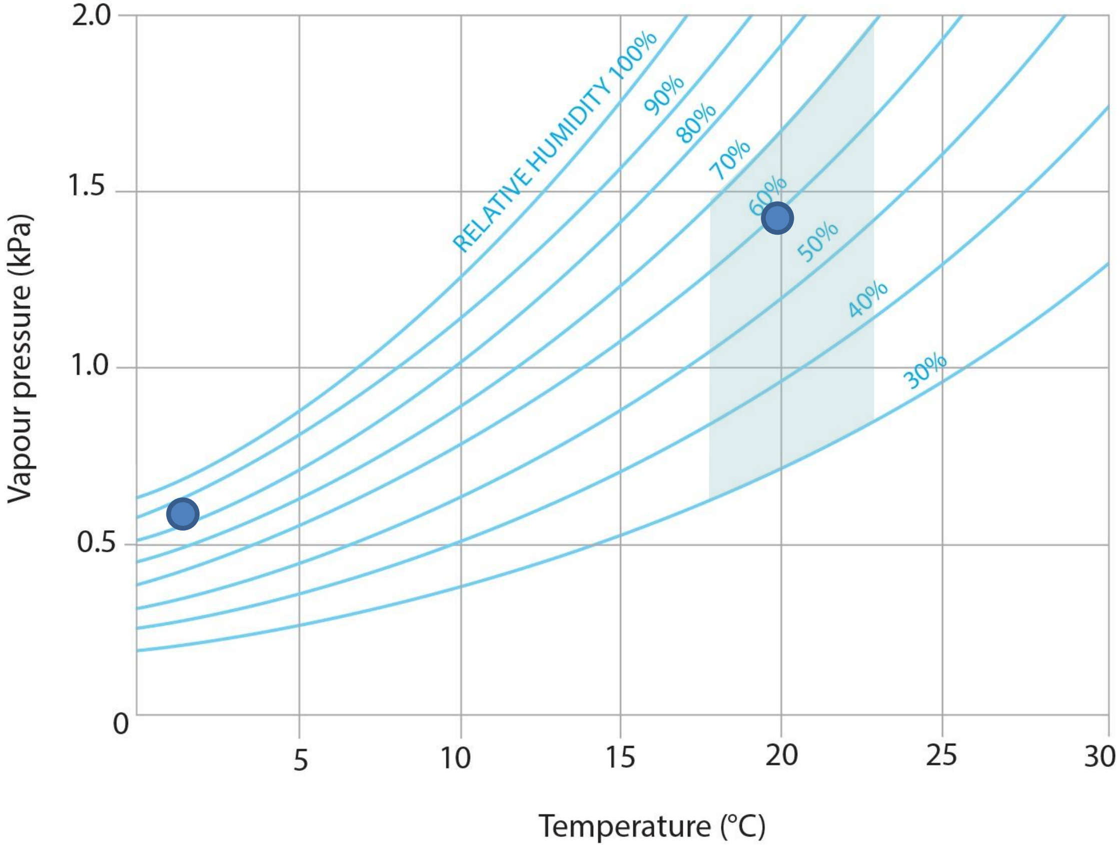


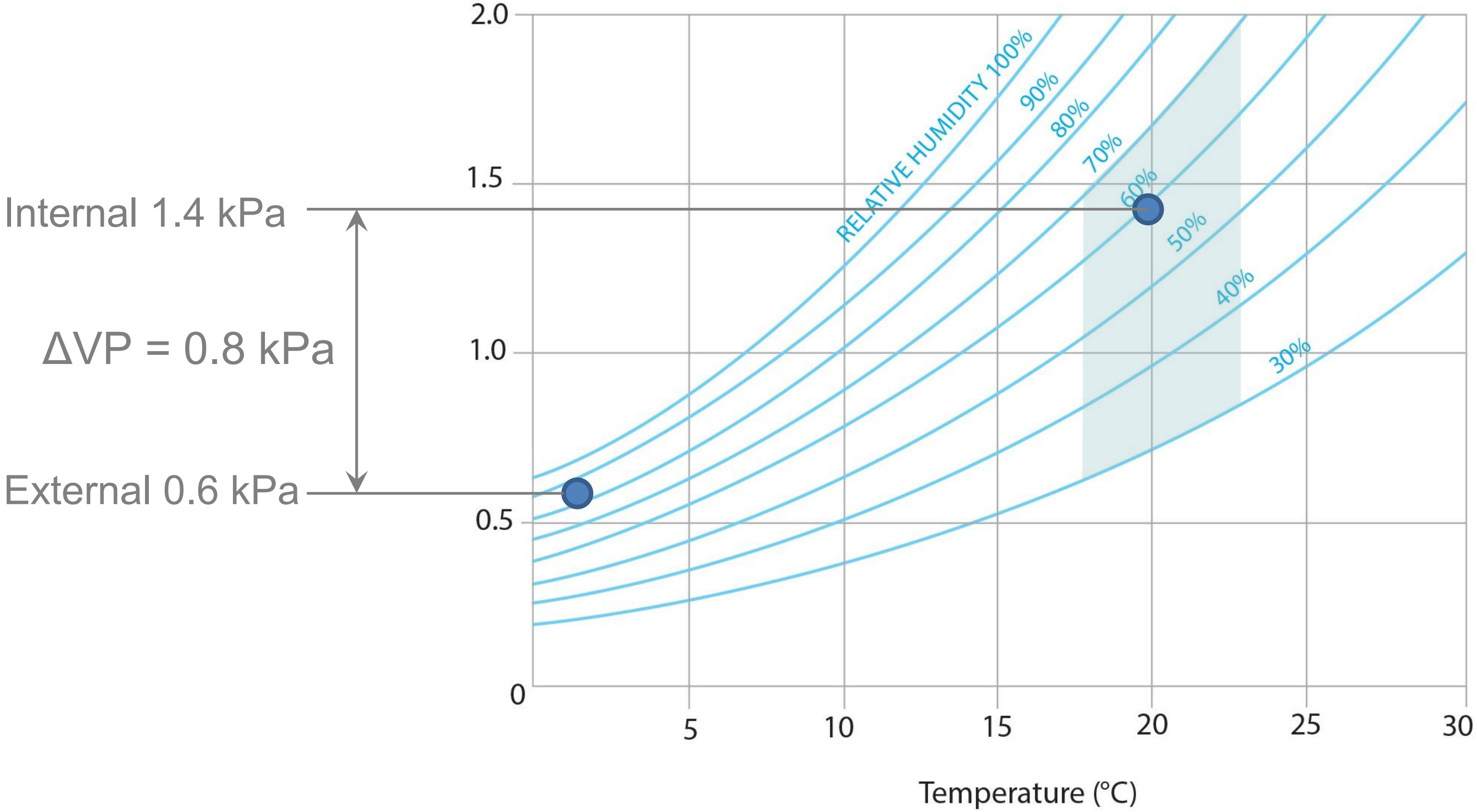
Chart source: Oreszczyn T, et al, UCL

Ventilation in dwellings: moisture



%RH non-linear and relates to meteorological & internal moisture

Ventilation in dwellings: moisture

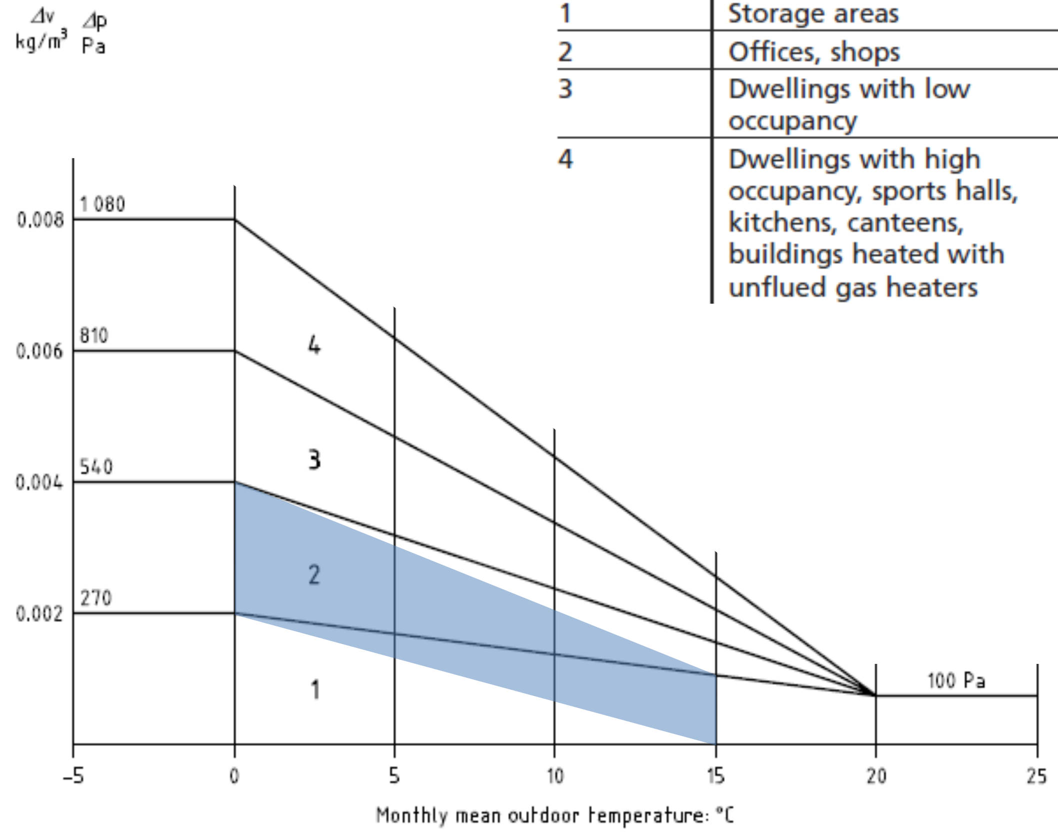


ΔVP assumes difference between internal and external vapour pressure, represents the internal humidity load.

Excess value depends upon the amount of moisture produced within the building and the ventilation rate.

BS 5250:2011

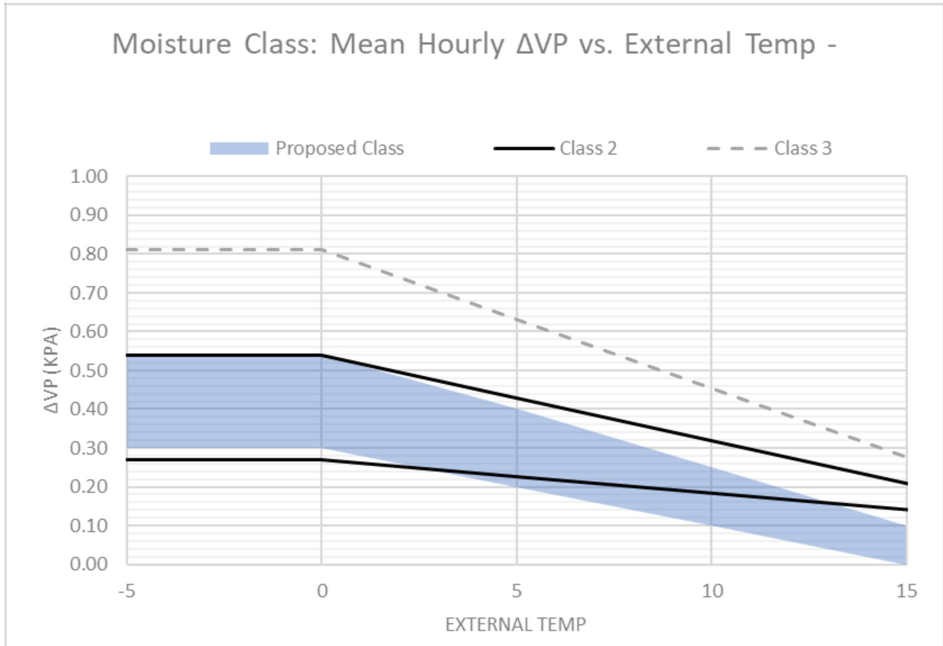
Humidity class	Building type	Relative humidity at internal temperature		
		15 °C	20 °C	25 °C
1	Storage areas	< 50	< 35	< 25
2	Offices, shops	50–65	35–50	25–35
3	Dwellings with low occupancy	65–80	50–60	35–45
4	Dwellings with high occupancy, sports halls, kitchens, canteens, buildings heated with unflued gas heaters	80–95	60–70	45–55



Suggested moisture class for dwellings

Blue band indicates a 'proposed' average range. It represents the moisture conditions in 70% of dwellings from a sample of 1600 monitored homes from the Warm Front study. (Ridley I. et al 2007, UCL)

Moisture vapour in bedrooms



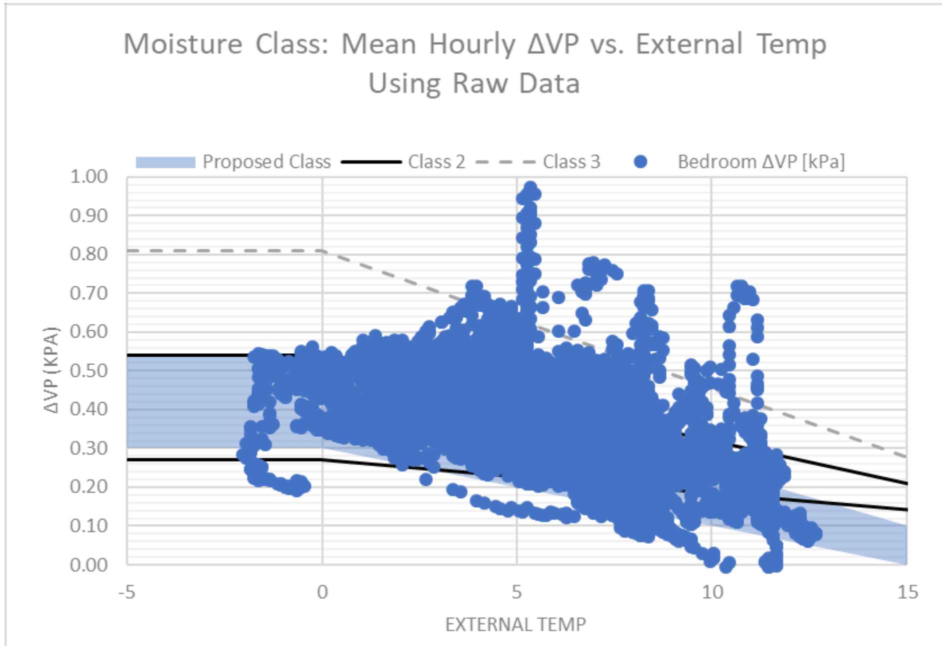
Template based upon BS5250 Class 2 and 3 (Class 4 considered too high for dwellings)

BS5250 does not offer a methodology for application of the chart (originally intended for condensation risk analysis)

Proposed 'Average' Class added based upon Warmfront study by UCL

Suggest that vapour pressure excess conditions be within or below Class 2 or Proposed 'Average' Class

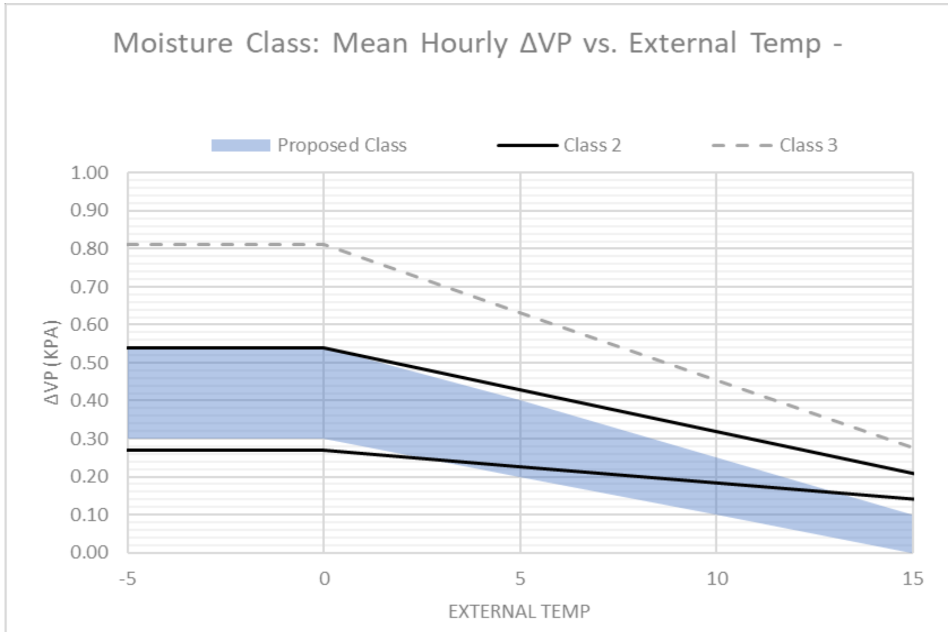
Moisture vapour in bedrooms



Using raw measurement data not particularly useful (except for regression analysis)

Sometimes data is within expected class; sometimes outside. Example chart shows property spanning 4 moisture classes

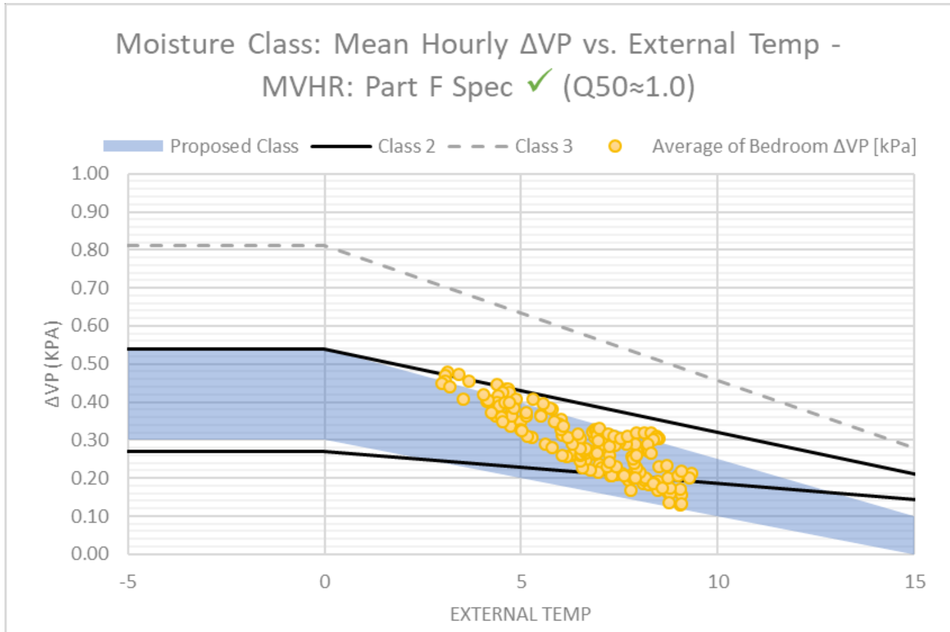
Moisture vapour in bedrooms – case studies comparing ventilation types



Case studies focus on:

- Dwellings with known ventilation performance, and where ventilation is used as intended
- Dwelling airtightness <6.0 $m^3/h.m^2$@50Pa
- Bedrooms – as these have the most consistent occupation pattern (and occupants tend not to alter environment)
- Double occupancy bedrooms for similar metabolic moisture generation
- Bedroom doors slightly ajar
- Typically 4 weeks data (November or January)

Moisture vapour in bedrooms – a comparison of ventilation types (winter condition) #1/4

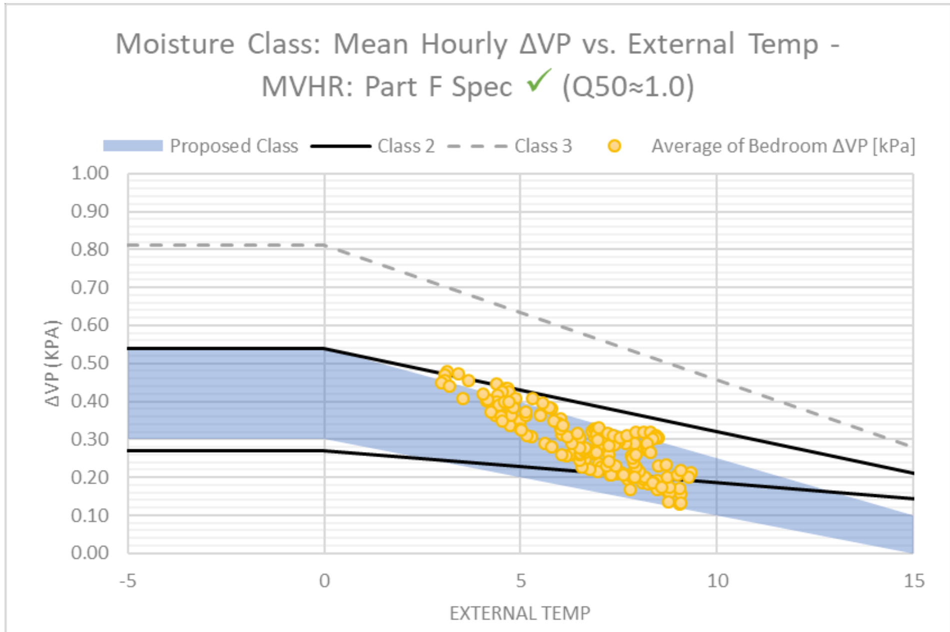


Using hourly means for each day of the week to normalise conditions, it is possible to grade properties according to expected humidity class.

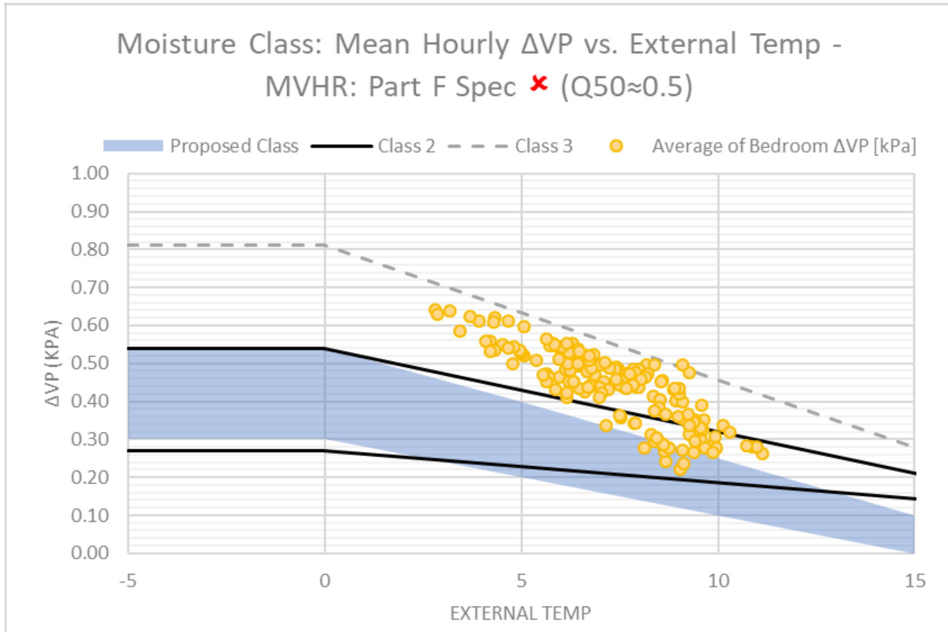
Offers a visual guide for assessing how internal moisture levels are being managed

MVHR
correctly commissioned

Moisture vapour in bedrooms – a comparison of ventilation types (winter condition) #1/4

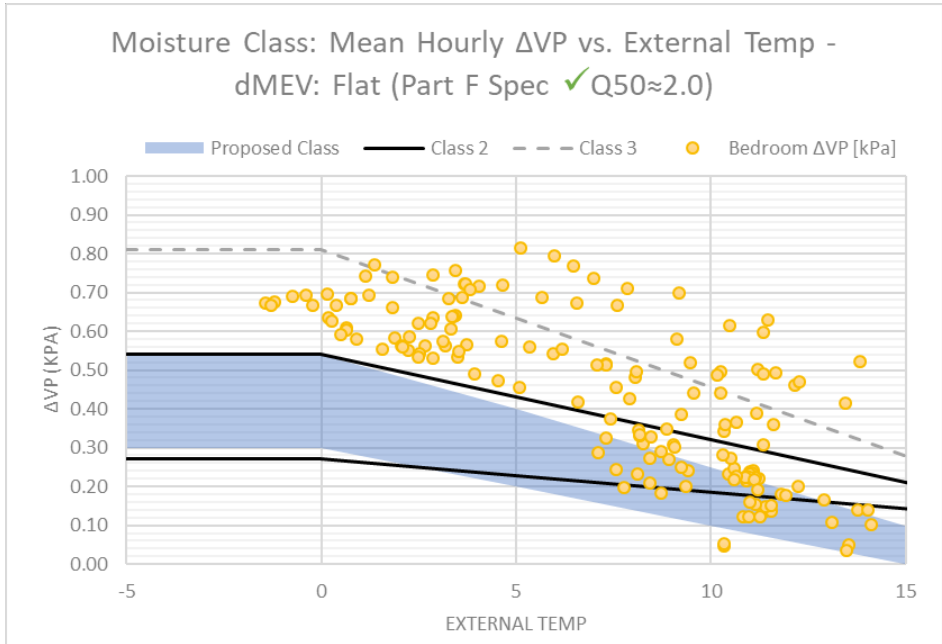


MVHR case study
correctly commissioned

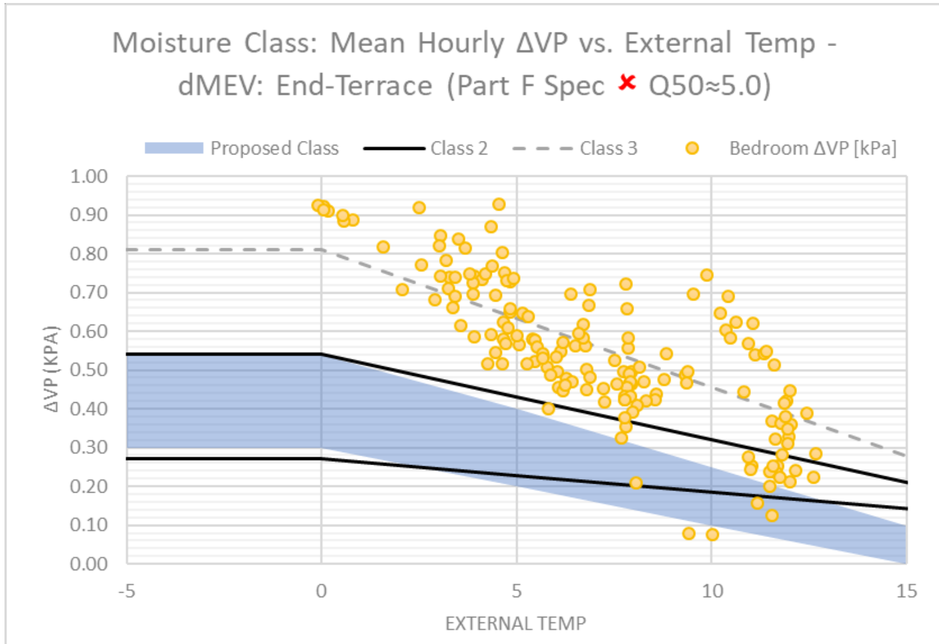


MVHR case study
sub-optimal operation

Moisture vapour in bedrooms – a comparison of ventilation types (winter condition) #2/4

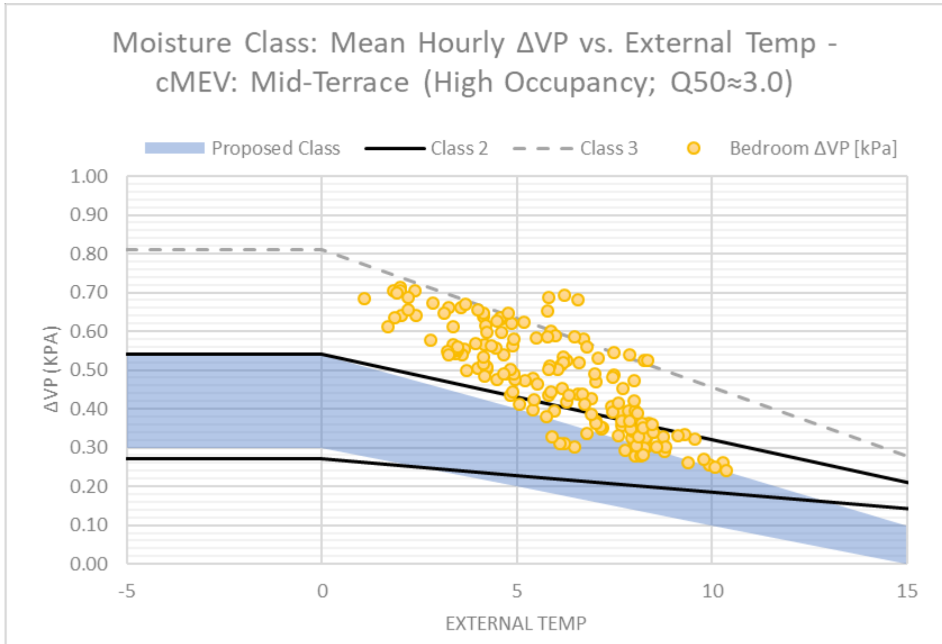


dMEV case study
correctly commissioned

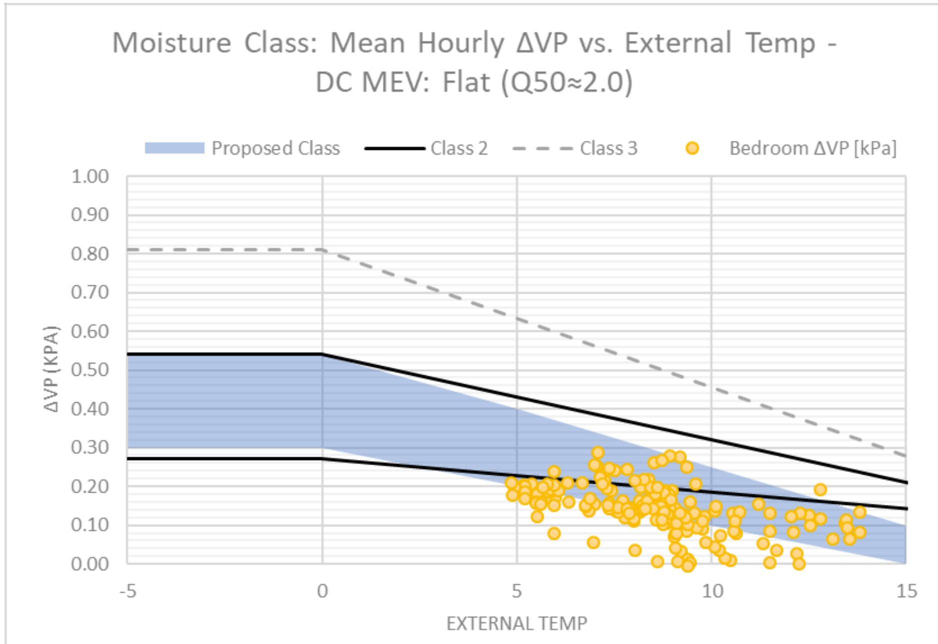


dMEV case study
incorrectly commissioned

Moisture vapour in bedrooms – a comparison of ventilation types (winter condition) #3/4

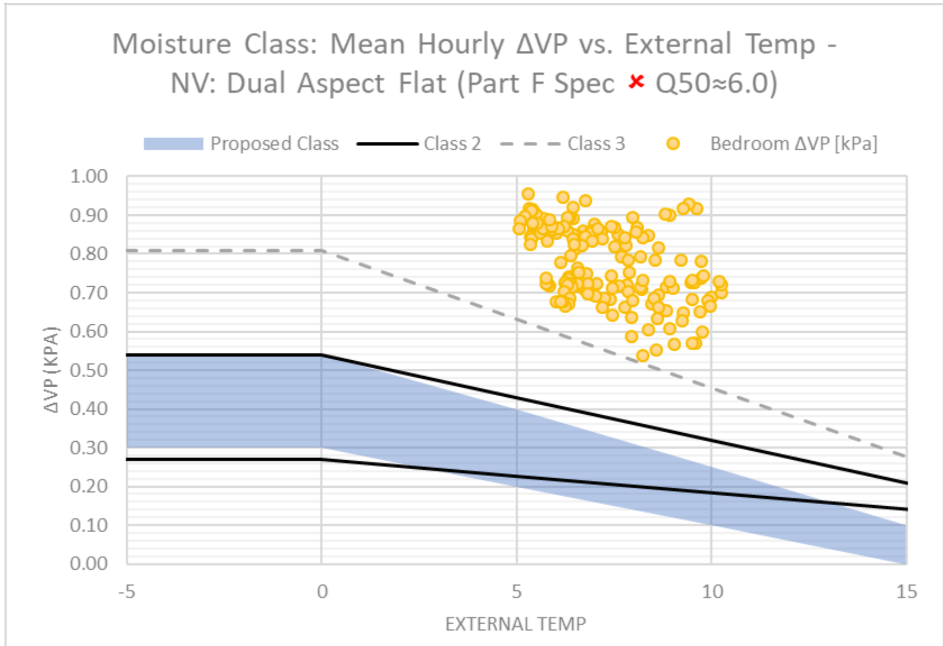


cMEV case study
correctly commissioned

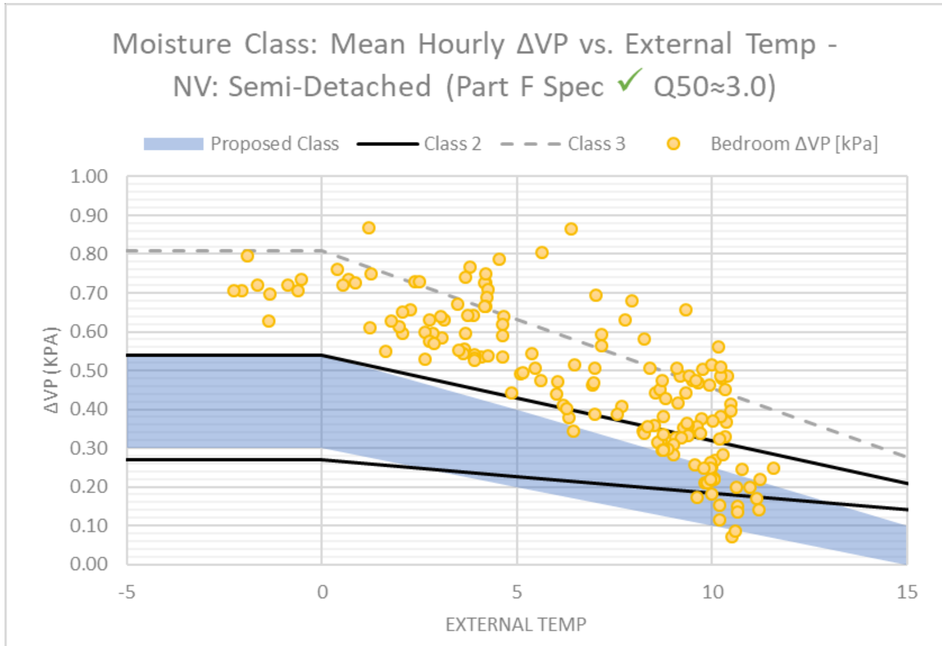


Demand Control cMEV case study
correctly commissioned

Moisture vapour in bedrooms – a comparison of ventilation types (winter condition) #4/4



NV – no cross-vent capability
background vents ok; poor intermittent fans



NV – with cross-vent capability
background vents ok; intermittent fans ok

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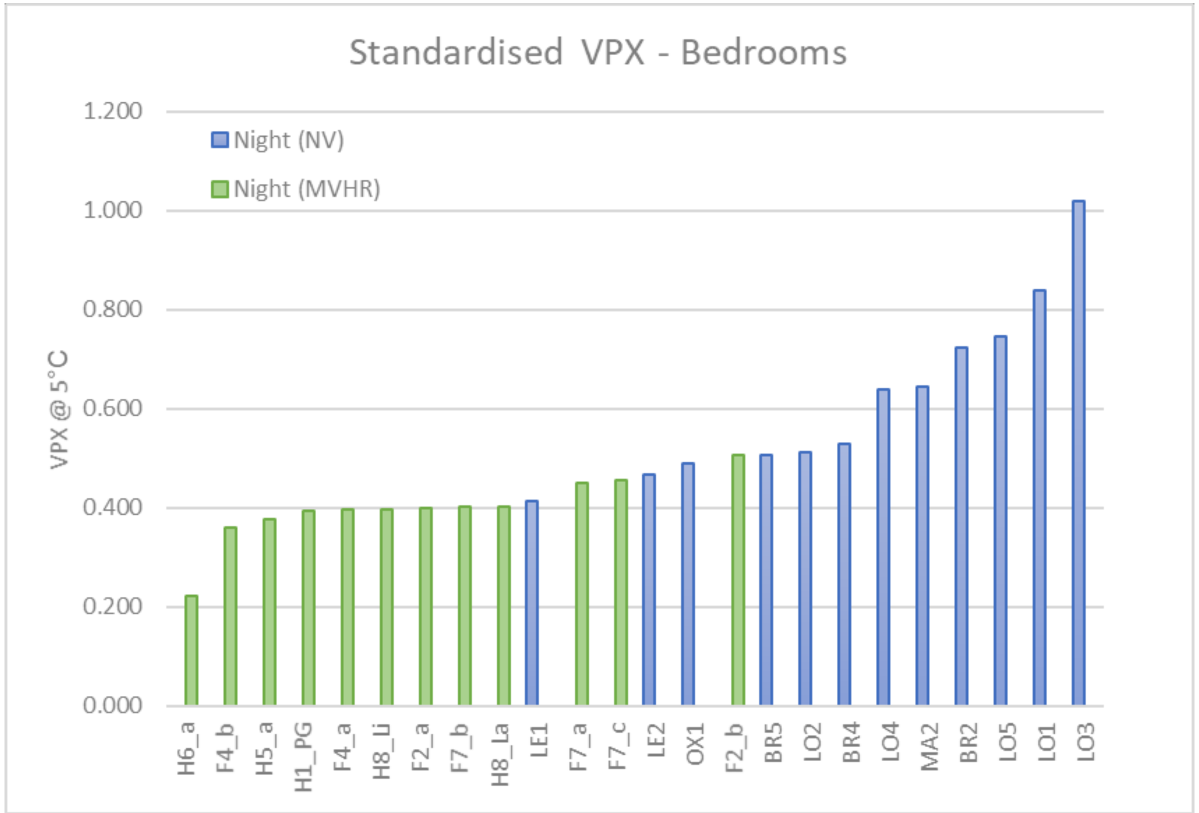
Standardised moisture vapour in bedrooms overnight – a comparison of NV and MVHR (winter condition; APT<6.0)



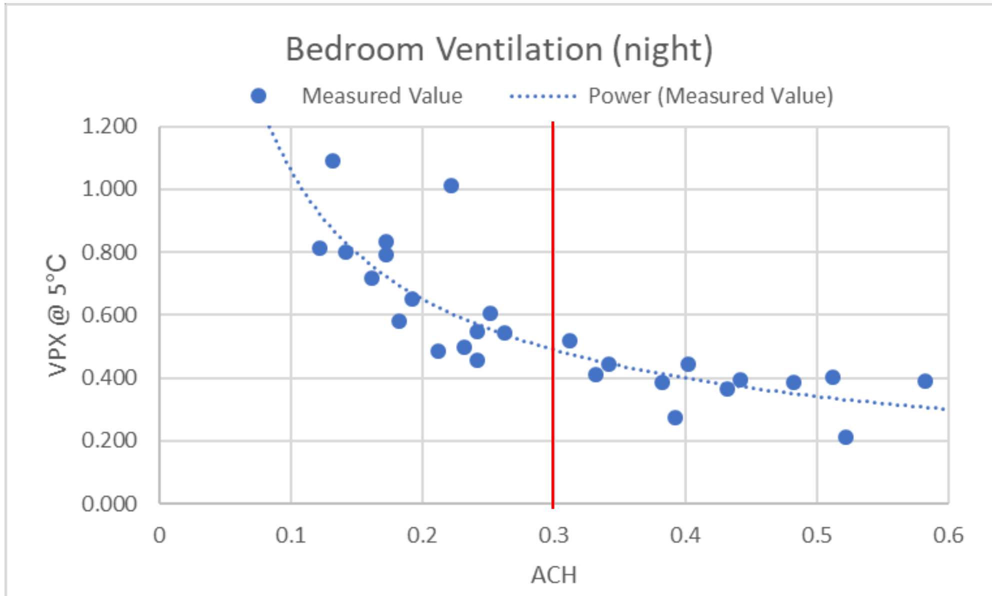
Summary results (means):

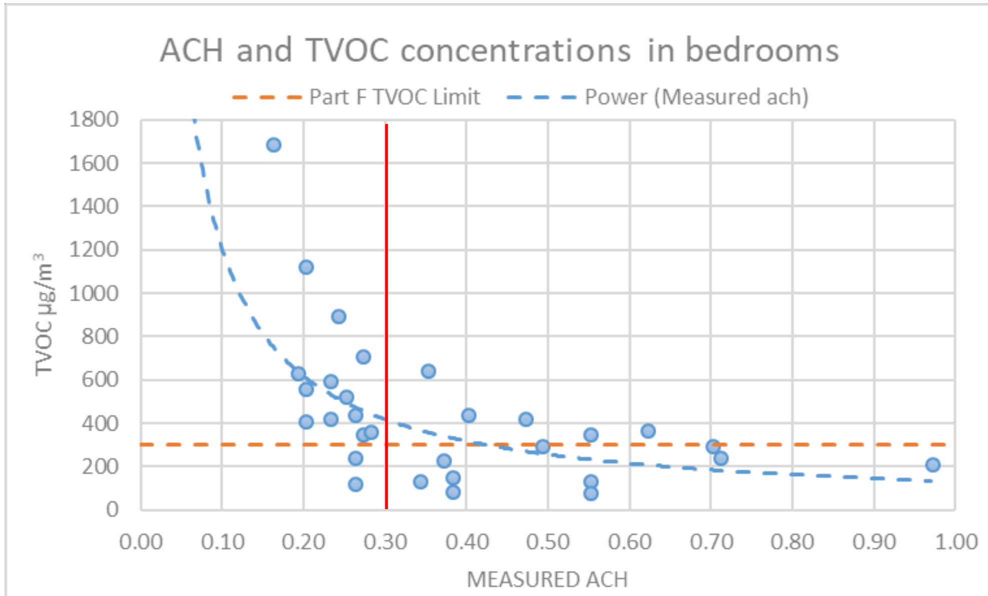
24 homes (12 NV; 12 MVHR) prevailing conditions when external conditions are 5°C, 85 %RH

	MVHR	NV
Standardised VPX (kPa)	0.420	0.627
Standardised internal temp (Ti°C)	20.4	20.8
Standardised internal RH (%)	56.3	63.9

Air exchange rates: moisture and TVOC concentration

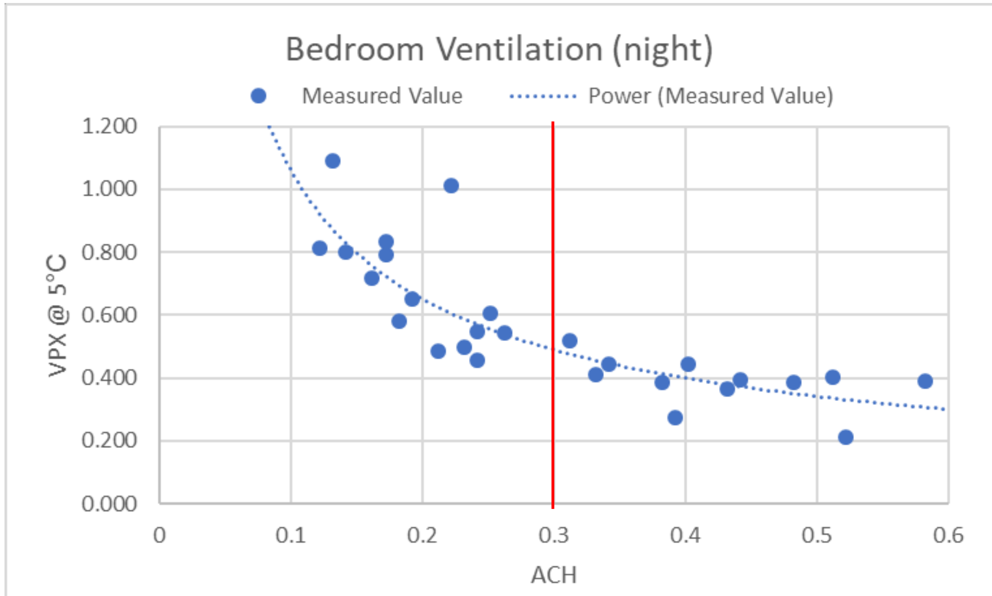
- Rise in VPX observed below 0.3 ach^{-1}
- Rise in TVOC concentrations appears to increase below 0.3 ach^{-1}

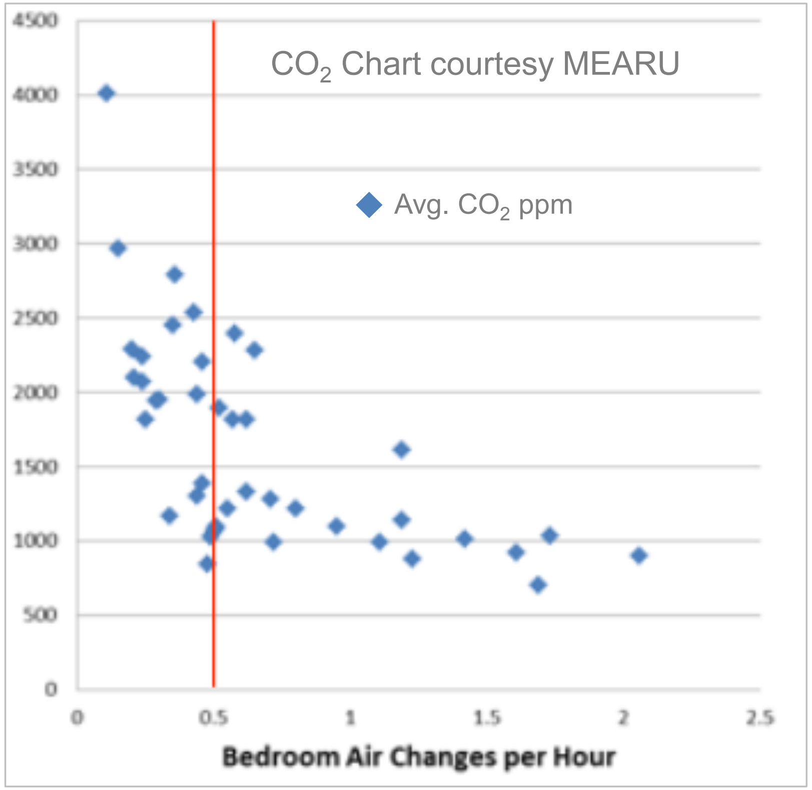




Air exchange rates: moisture and CO_2 concentration

- Rise in VPX observed below 0.3 ach^{-1}
- Increase in CO_2 concentrations as air change rate reduces below 0.5 ach^{-1}





Summary (and further thoughts) 1/2

- Initial study is based upon relatively small case studies and considers only bedrooms. Many more case studies needed
- Case study scale-up preferred – context about building use and ventilation is vital. Large-scale studies (data, no context) less useful for developing methodology
- Safe backstop for background ventilation needs to be established. Preliminary observations suggest not below 0.3 ach^{-1} (dwellings should not ventilate below this level even when unoccupied)
- Increased ventilation rates of >0.5 ach^{-1} could be considered to deal rise in metabolic CO_2 (preferably on a per room basis). Increased ventilation rates in wet rooms should remain
- What 'class' of performance should be specified in dwellings?:
  - Basic – class 3 (appropriate to NV)
  - Enhanced – class 2 (appropriate to MV)

Summary (and further thoughts) 2/2

- Advantage with moisture vapour:
  - Cheap to collect (whereas CO_2 ££; VOCs £££)
  - Potentially available on large scale (e.g. smart thermostats, IoT devices)
- Disadvantage of moisture vapour:
  - Language can be confusing: vapour pressure; absolute humidity; moisture content
  - Need a common metric for non-tech audience (that is different to RH)
- Similarly, we should define appropriate and consistent ventilation terminology. Commonly used in dwellings:
  - Volume flow rates: litres per second (Par F) or cubic metres per hour (PHPP)
  - Unit area flow rates: litres per second per m^2 floor area (Part F)
  - Occupant air flow rates: litres per second per person (CIBSE, ASHRAE, etc)
  - **Air change rate:** relates to the volume of conditioned space (relegated to literature not generally used in standards)

Next steps…

1. Develop into a simplified methodology for widescale evaluation of ventilation effectiveness for managing pollutants in dwellings
   - Useful benchmarking tool for ventilation performance?
   - If developed into a tool, it could be useful for understanding if higher VPX observed is due to under-ventilation or atypical moisture generation
   - Potential: performance criteria check for Part F?
2. Support proposal for new moisture classification for dwellings
   - Further studies into moisture (and other pollutants) to identify appropriate thresholds/ bands for air exchange rates in dwellings
3. Get some funding!

If interested either to support (incl. supply of data) or to participate then please get in touch

Thank you – questions?