CIBSE
Homes for the Future Group

Ecobuild, London 8th March 2017

Modelling for real life performance: Practical tools and guidance for future homes

Chair:

Ashley Bateson, Partner, Hoare Lea & Chair, CIBSE Homes for the Future Group

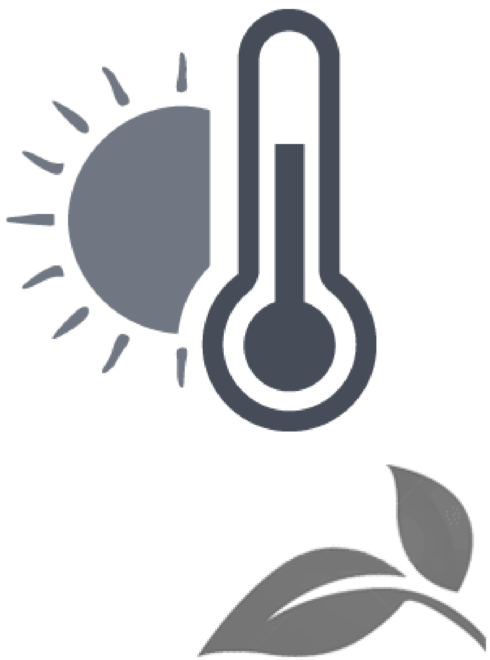
Speakers:

1. **Overview of the new CIBSE guidance in the design of homes**
   Tom Lelyveld, Regional Director, AECOM

2. **A new methodology for assessing overheating risk in homes**
   Susie Diamond, Partner, Inking LLP

3. **Interaction between energy efficiency measures and air quality in homes**
   Marcella Ucci, Senior Lecturer in Environmental and Healthy Buildings, UCL Institute for Environmental Design and Engineering

Environmental challenges for future homes



- Energy efficiency
- Performance gaps
- Thermal comfort / overheating risk
- Resilience to climate change
- Air quality
- Health and wellbeing

Residential construction rates

- 25 million existing homes in UK
- Approx. 140,00 new homes built last year
- Government target: approx. 250,000 new homes per annum (equivalent to replacing 1 % of housing stock every year)

Predicted climate change impacts on housing

"The number of heat-related deaths is projected to increase from 2,000 per year currently to 7,000 per year by the 2050s."

(Source: The Committee on Climate Change, 2015)

Getting the balance right
– we need to assess the risks and options

IPCC predicts huge worldwide residential demand to keep cool as temperatures rise

● Growing middle-class now able to afford technology

The warming climate – allied to improved economic circumstances – will drive rocketing demand for air conditioning, according to the UN Intergovernmental Panel on Climate Change (IPCC).

A growing international middle-class able to afford mechanical cooling will spend more money on the technology to offset the impact

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Good practice in the design of homes

A new CIBSE Technical Memorandum

Tom Lelyveld, Regional Director

8th March 2017

Agenda

1. Introduction/ Agenda
2. Why a new Technical Memorandum for Homes?
3. Development of the Guide
4. Intended audience
5. The structure of the TM
6. Introductory sections
7. Core Content
8. Key Messages
9. Case Studies
10. Next Steps

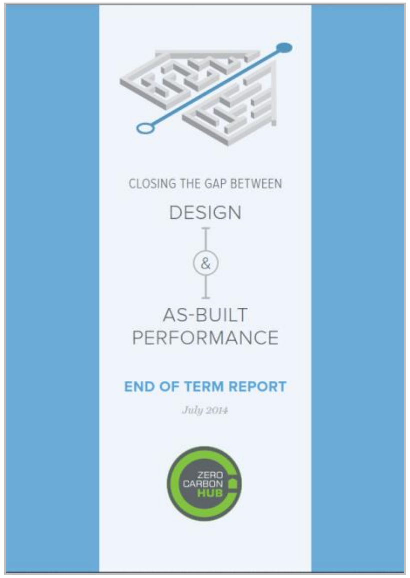
Why a new TM for Homes...

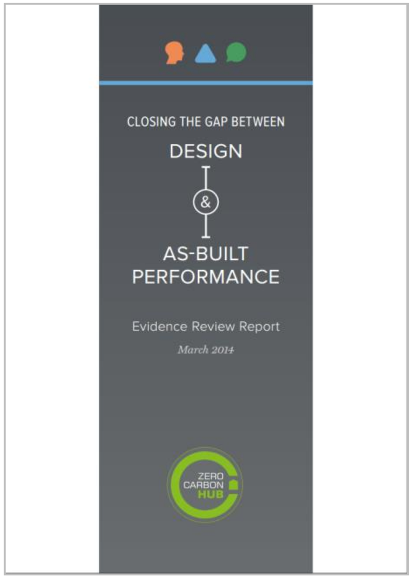
Growing awareness of the Performance Gap between design intent and performance in operation, particularly in homes

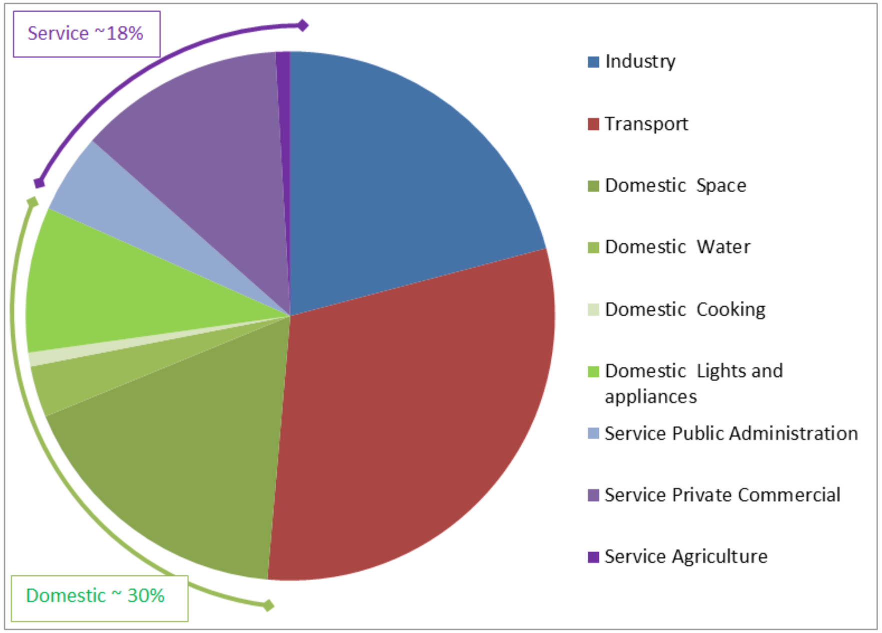
- Domestic Homes ~ 30% of UK CO_2 emissions
- Private Commercial % Public Administration together <18% UK CO_2 emissions

CIBSE Homes for the Future Group:

- Identified a focus of CIBSE Guidance on non-residential buildings.
- Recommended CIBSE commission a Guide/ TM on best practice in the design of homes







Development of Technical Memorandum – Good Practice in the design of Homes

CIBSE Homes for the Future Group developed outline scope for a ‘Best Practice Design Guide for Homes

AECOM – commissioned to produce guide after competitive tender

HFG Steering Group – comprised mix of architects, engineers, housing associations, developers, academia and a Local Enterprise Partnership (LEP).

Development process involved:

- **AECOM Editorial team** – set out structure, drafted core content, consistency of tone
- **AECOM Subject Experts** – provided specific subject area input and chapter review
- **CIBSE HFG Steering Group**– reviewed TM content and provided further, broader expert input and advice from wider industry
- **CIBSE Appointed Peer Reviewers** – independent review of final guide against standard CIBSE review questions

AECOM

Purpose of the new Technical Memorandum

'to help building services engineers and other professionals working on the planning, design and construction of homes to:

- *Understand and demonstrate good practice.*
- *Understand the relevant guidance, tools and other resources available.*
- *Contribute to delivering good practice as part of a wider design team.*

… 'Good Practice' is defined as:

'the design and delivery of homes that are fit for purpose, resource efficient, low carbon, comfortable, healthy, and easy to operate and maintain'

Audience

TM has been written mainly for **Building Services Engineers working on residential projects in the UK.**

It is also intended to be relevant to:

- **Clients when setting a design brief,**

and subsequently:

- **Architects & designers,**
- **Contractors and others in the supply chain**

Scope

Guidance covers both new and existing homes, and aims to be of relevance to all types of residences.

However - non-domestic guidance should also be referred to for certain types of home, such as care homes.

Structure of TM

Section	Content
1	Introduction
2	Context - *relevant policies, regulations and standards, and potential risks*
3	Appointment, project briefs and design development
4	Design and compliance tools
5	Key design considerations
6	**System Design** – more detailed guidance for each service
7	Installation, commissioning and handover .

TM is designed to be a **reference document** so there is some repetition between content sections

Case studies are interspersed throughout the TM. References to key sources of additional guidance are given in the text and at the end of the TM.

Context

– Policies, Regulations and Standards

- Signposting core regulations, policies and standards for UK

– Residential Assessment Methodologies

- Home Quality Mark, BREEAM New Construction and BREEAM Domestic Refurbishment
- PassivHaus, Enerphit

– The Performance Gap

- *Building services engineers should **work closely** with clients and the design team to reduce the gap between design intent and As-Built performance.*

– Climate Change Adaptation

- *Building Services Engineers should consider whether their design will be fit for purpose both now and in the future. If not they should advise on **reasonable design changes** to deliver a building that will be **fit for the purpose in the future**, or that will **enable the retrofit** of passive and active measures to manage predicted climate impacts.*

AECOM

Appointment, project briefs and design development

– Utilising the expertise of a building services engineer

- Building services engineers and other design team members should offer good practice advice, *even if they are not explicitly required to do so .*
- The **earlier that building services engineers are involved** in a project the **greater the positive impact they are likely to have**

– Project Brief

- Delivering good practice design begins at project conception and the setting of the brief. The benefits of delivering good practice should be considered as early as possible, ideally prior to the formal project inception.

– Design Development

- Provides an overview of the stages of design development and describes important factors to be considered by engineers at each stage

Key design considerations

– Fitness for purpose

- The delivery of homes which are fit for their purpose is **integral to good practice** in the design of homes.
- As well as current needs, **potential future needs** of occupants should be taken into account when designing homes.

– Integrated design

- Design strategies for individual building services should be **integrated** with the design of the building fabric, of other services, and of occupant needs.

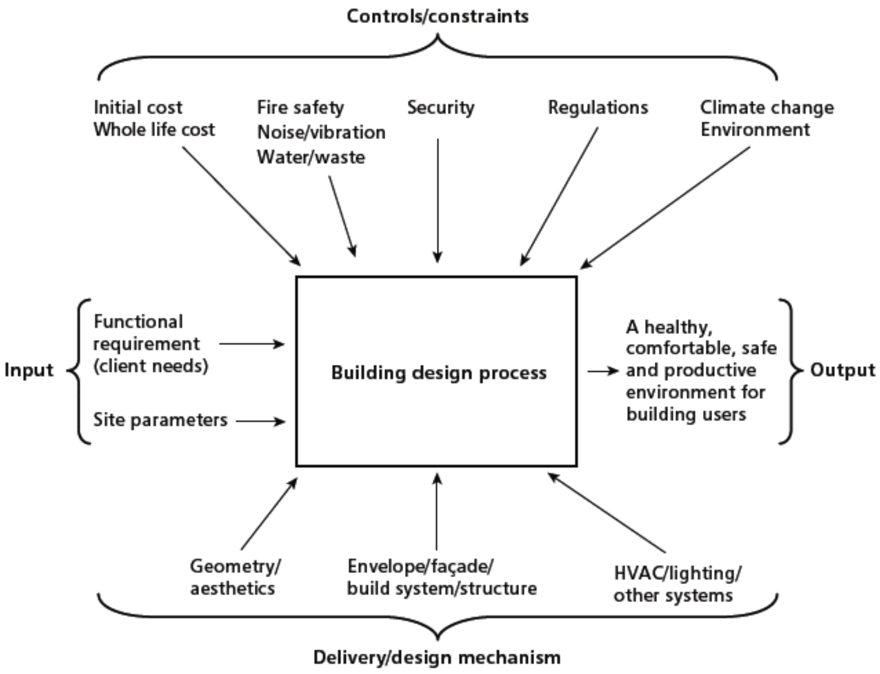


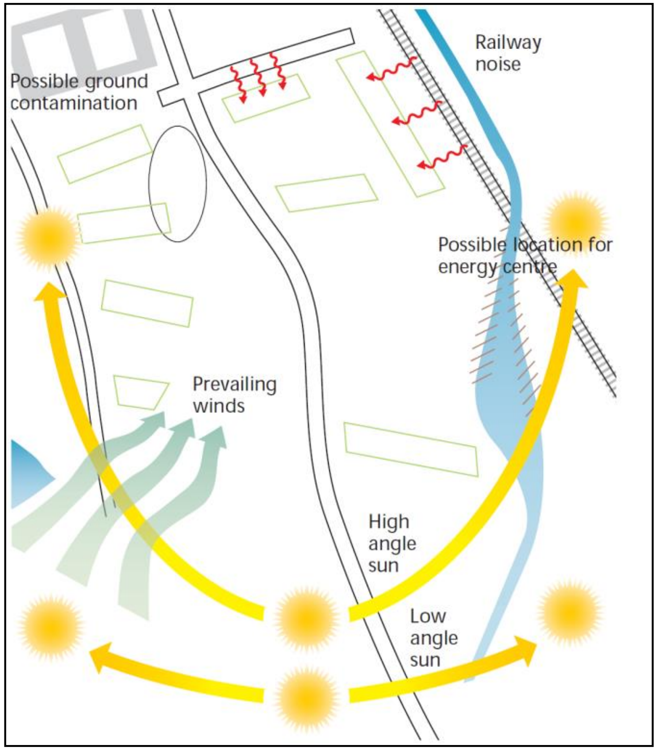
Illustration of integrated design.
CIBSE Guide A (CIBSE 2016b).

Key design considerations

– Site planning and passive design
  - Prioritise the use of fabric design and site planning to
    - reduce energy demand and;
    - take advantage of useful natural light, ventilation and solar gains.

– Life cycle performance and costs
  - Engineers should consider life cycle performance and costs as well as the initial performance and capital cost.
  - Life cycle performance will often be challenged during value engineering

– Retrofit considerations
  - Undertake detailed building surveys to gather key information before design



Site opportunities and constraints. *CIBSE Guide L*

Core Content

Section 6 comprises the core content of the guide:

- Space heating,
- Water heating,
- Ventilation,
- Cooling,
- Electricity,
- Lighting,
- Renewable electricity,
- Water and waste water
- Controls.

Each Section considers:

- System selection
- System sizing
- System optimisation
- Integration of design (with other services and other disciplines)
- Summary of key messages

Key Messages

Each section of the guide ends with a summary of the key messages for the reader to take away e.g.

Section 2 Context: *'Building services engineers and their clients must understand, and design to avoid, the contributing factors to the performance gap.'*

Section 6.2 Space Heating: *'When selecting and designing heating systems, building services engineers* ***should consider*** *whether occupants or others (e.g. landlords) are likely to be* ***able to use and maintain the system as required for it to operate effectively and efficiently****.*

Section 6.3 Ventilation: '*The consequences of poor practice in the design, installation, commissioning and operation of ventilation systems can include impacts on* ***occupant health*** *and* ***damage to the building fabric,*** *with potential* ***financial*** *and* ***reputational costs*** *for those responsible.*

AECOM

Case studies - Examples of good practice to illustrate guidance

Clapham Retrofit, London Borough of Lambeth

Deep retrofit of a 170-year old Grade II listed Victorian townhouse. As **best practice**, before design proposals were developed: airtightness testing, thermographic surveys, U-value measurements and interstitial moisture monitoring were undertaken.

Works included:
- Improved insulation
- a new ventilation system (as air leakage was reduced from 9.6ach to 1.8ach @50Pa).
- LED lighting,
- solar thermal panels, and
- Stelrad radical radiators

During installation, workmanship and airtightness detailing were monitored and wireless sensors were fitted.

Occupants benefit from decreased energy bills.

CIBSE's 2016 Building Performance Awards - residential project of the year

Prince Regent lane, London Borough of Newham

Demonstrated the benefits of an integrated design team

From inception the client, architects and engineer worked together to develop the scheme ensuring that room layouts integrated simple routing of services minimising pipe and duct lengths and minimising dead legs.

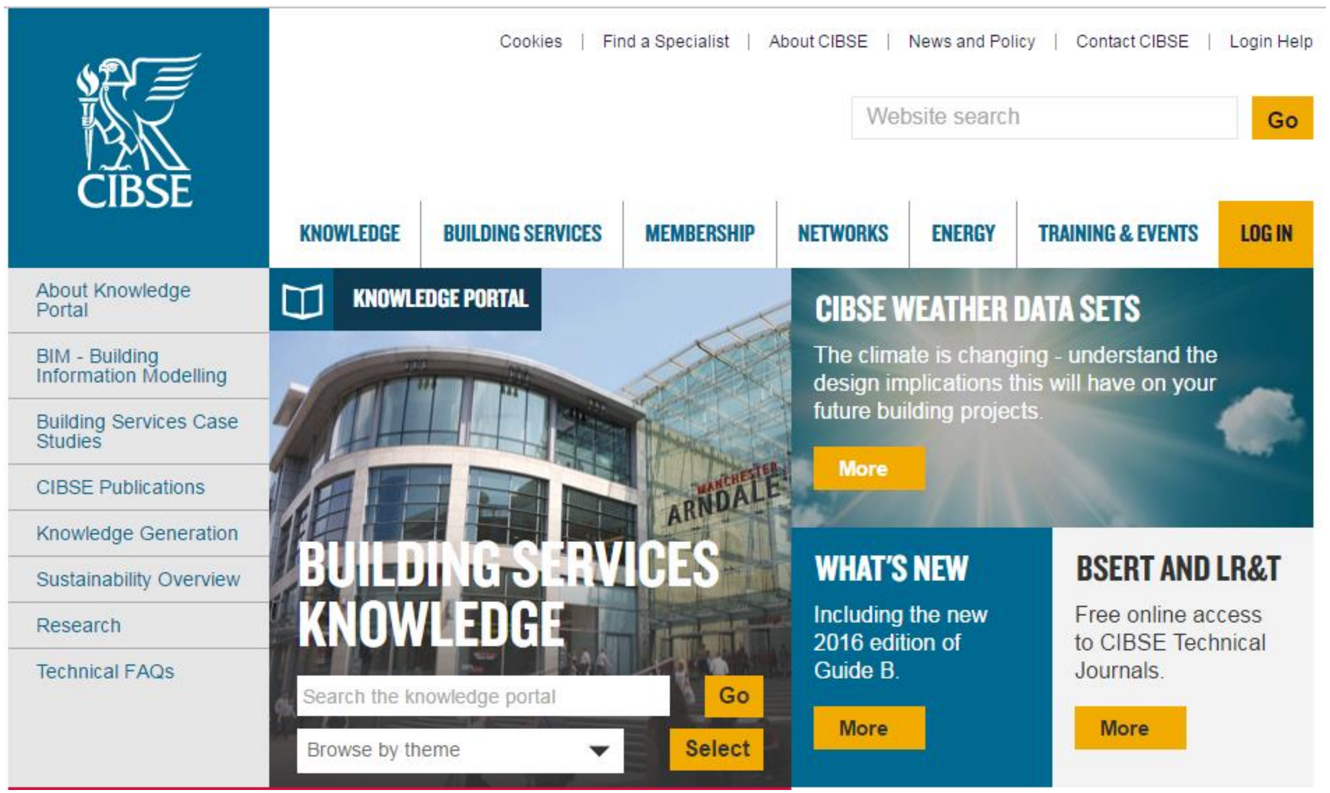
Photovoltaic panels were installed at an optimal orientation facing due south over a green roof.
Design of the homes included high levels of fabric insulation, gas condensing boilers, and mechanical ventilation with heat recovery.

Large south facing windows were set back within projecting boxes to provide winter daylight access and summer shading

Next Steps

TM is currently going through final stages of peer review

Then ~ 2-3 months with CIBSE editorial team before final approval and publication.



Thank you

tom.lelyveld@aecom.com
0777 097 7144

AECOM

PREDICTING OVERHEATING RISK IN HOMES – A NEW METHODOLOGY

Susie Diamond – Inkling

Modelling for real life performance

8th March 2017 - Ecobuild

About Inkling

- Building Physics Consultancy
  - Susie Diamond
  - Claire Das Bhaumik

- Services
  - Design stage overheating risk assessments for all building types
  - Thermal performance and TM54 analyses
  - Modelling in support of BREEAM, WELL, LEED
  - Advanced HVAC modelling
  - Part L2A compliance modelling and advice
  - EPC assessments
  - Research

Domestic overheating

Article by Liza Young
CIBSE Journal August 2014

CIBSE JOURNAL

NEWS CIBSE NEWS TECHNICAL CPD JOBS CASE S

Using weather data to make buildings climate proof

Climate change means CIBSE's updated weather files are imperative for building energy and overheating risk analysis. Liza Young explains the new data sets and finds out whether the methodology for applying them is up to the task

Posted in May 2016

Two summers ago, *CIBSE Journal* received a memorable letter from Ben Cullen about life in his sweltering flat in Milton Keynes. He described how his single-aspect apartment became so hot that the 'killer views' alluded to in the sales brochure were more likely to come from his lack clothing, which consistently breached broadcasting standards. (See '***Tickled pink***', *CIBSE Journal*, September 2014).

Article by Liza Young
CIBSE Journal May 2016

HOUSING OVERHEATING

HOME IS WHERE THE HEAT IS

As global temperatures rise, overheating is becoming an urgent problem for the residential sector. With no government-enforced sanctions on maximum temperatures and little incentive for developers, **Liza Young** finds out what can be done to keep cool

The consequences of climate change are not a problem for future generations – they are an immediate threat. Already, there is growing evidence of overheating in homes. According to the Committee on Climate Change (CCC), one fifth of domestic properties could be overheating, even during a cool summer. Flats, which make up 40% of new dwellings, are especially vulnerable.[1]

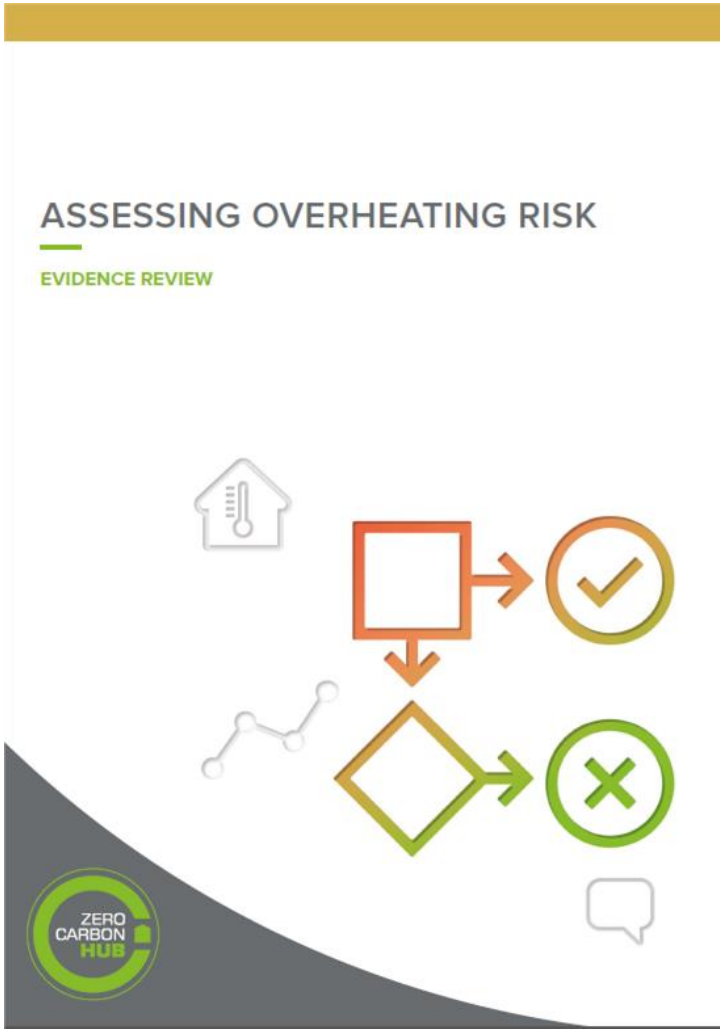
By the 2040s, half of all summers are expected to be as hot, if not hotter, than in 2003, when temperatures of up to 38°C led to more than 2,000 excess deaths in the UK. A recent CCC adaptation sub-committee report predicts that annual deaths caused by high UK temperatures will triple to 7,000 on average by the 2050s.[2]

Yet at the same time, we are designing and building for winter energy efficiency,

> We've forgotten how to design for natural ventilation in dwellings – we've lost the art
> **Michael Swainson**

Assessing Overheating risk

- Zero Carbon Hub publication
- Co-authored by Inkling and Anastasia Mylona (ARCC and CIBSE)
- Part of report series and ongoing research



What is overheating?

- No one definition fits all
- Comfort is subjective
- Depends on both environmental and human factors
- Duration/ timing of high temperatures is important
- Very high temperatures > 35°C lead to **Heat stress**
- High bedrooms temperatures (>26°C) can impair sleep

Image from ZCH *Overheating in homes - Where to Start - An introduction for planners, designers and property owners*, 2013

Key overheating risk factors in homes

- Single aspect
- Large areas of glazing
- Limited ventilation
  - Restricted openings
- City centre locations
  - Noise and/or air pollution limiting natural ventilation
  - UHI effects
- Community heating

Existing Methodologies

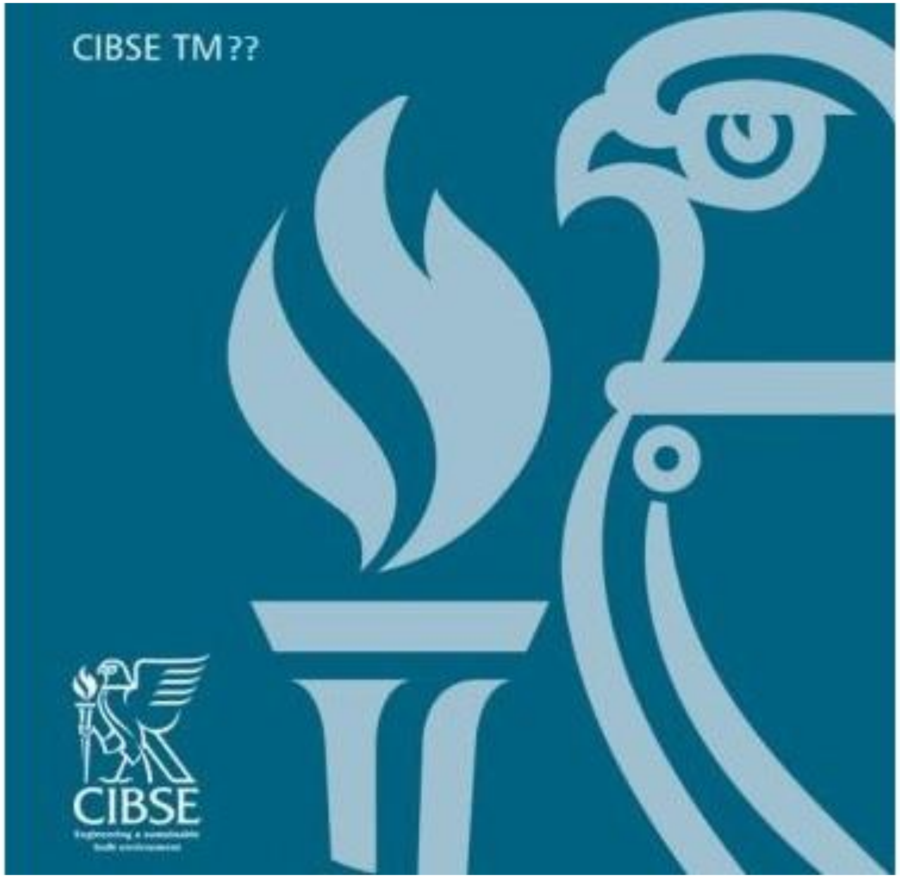
- SAP (Appendix P)
  - Single calculation for June, July and August using monthly averages for weather data
  - Single zone model
  - Easy to fudge
- CIBSE Guide A 2015
  - Follows TM52 – adaptive thermal comfort
  - Based on commercial buildings - advice for dwellings is limited
- PHPP
  - Passive House Planning Package
  - Spreadsheet based
  - Uses bespoke internal gains but similar calc to SAP
- Dynamic Thermal Simulation
  - Powerful software, but inconsistent application as no defined methodology

What do we need?

- A stakeholder agreed methodology to follow that is:
  - Reliable
  - Cost-effective
  - Flexible
  - Understandable
- Not as easy as it first appears, but do-able

Introducing CIBSE TM XX

- Due to be published in the next few weeks



CIBSE TM XX Overview

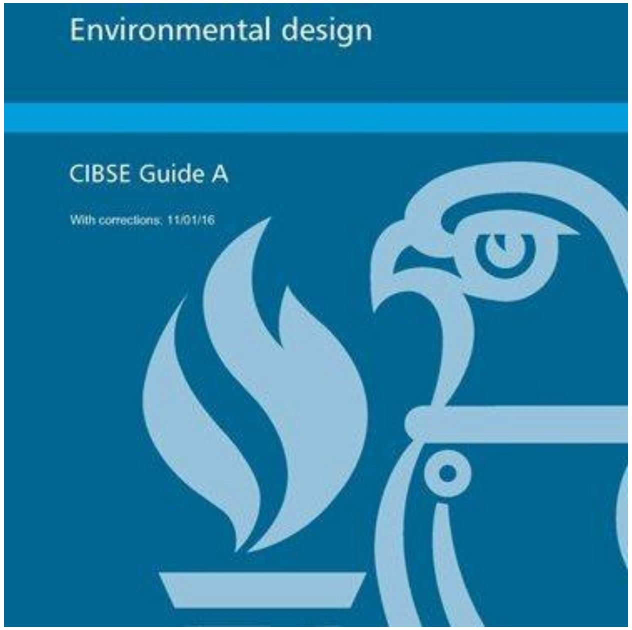
- Focuses on naturally ventilated (free running) homes
- Draws from TM52 AND CIBSE Guide A
  - TM52 criterion 1 used for all occupied spaces (including bedrooms)
  - CIBSE sleep criteria used in bedrooms
  - Bedrooms must pass both requirements
- Gain profiles for occupancy, lights and equipment are provided
  - These include 24/7 occupancy of bedrooms (worst case)
  - Profiles must be adopted for the test
- Weather files
  - Requires local 2020s (high emissions, 50th %ile) DSY1 for test
  - Recommendation to run for DSY2/3 or 2050/2080s data but not required to pass

CIBSE TM52

- Developed for ‘free-running’ commercial buildings
- Provides a definition of overheating and pass/fail criteria
- Based on BS EN Standard 15251:2007
- Sets three criteria against which designs should be assessed:
  - Criterion 1: Hours of Exceedance
  - Criterion 2: Daily Weighted Exceedance
  - Criterion 3: Upper Limit Temperature

CIBSE GUIDE A (2016)

- Advises that sleep quality may be compromised at temperatures above 24°C
- Recommends that peak bedroom temperatures should not exceed an absolute threshold of 26°at night



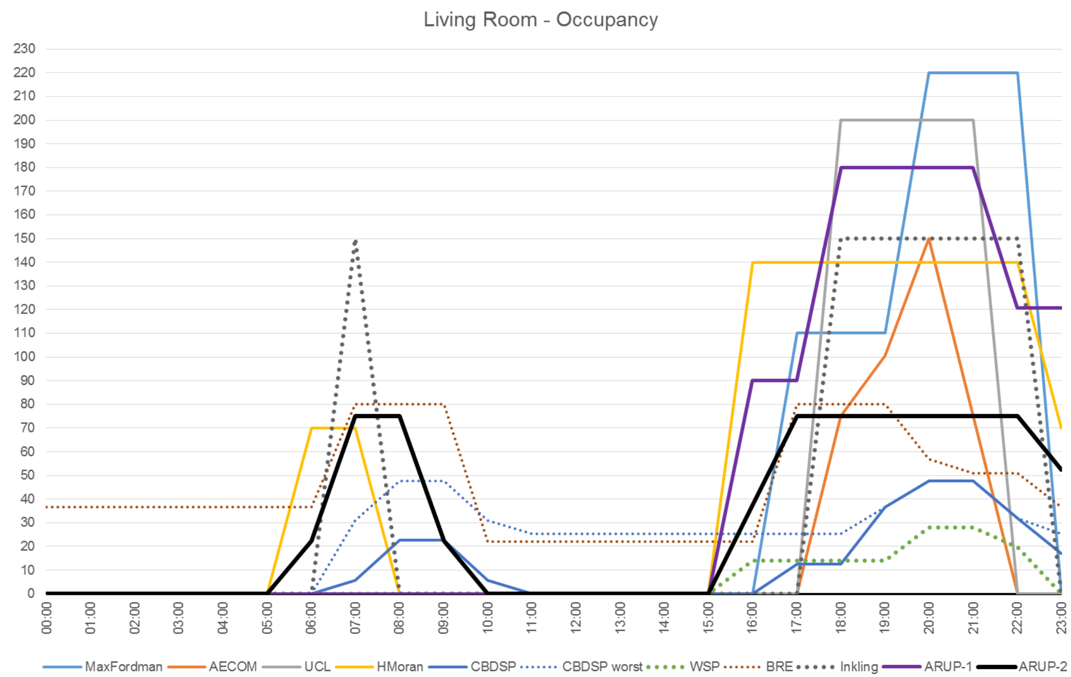
What is included in the TM?

Guidance on

- Gain profiles to use
- Sample size
- Weather file selection
- Modelling opening windows and doors
- Infiltration and mechanical ventilation
- Use of blinds/curtains
- Heat loss from pipework, HIU and heat maintenance tape
- What to include in the report

Gain profiles for methodology

- Profiles were compiled based on suggestions from range of sources
- Lighting and equipment gains linked back to annual electrical consumption for homes
- Significant testing



This image shows the collated profile for living room occupancy gains. There is significant correlation, but also variation..

Key points

Blinds

- If blinds form part of the mitigation strategy then these must be included in the base build, and results without blinds must be included in the report
- Blinds should not interfere with the free area of opening windows, or of they do this reduction should be taken into account

Vulnerable residents

- Care homes and accommodation for vulnerable occupants should assume Type I occupancy (see CIBSE TM52 for description).

Window opening

- Open areas should include any restrictors, and take into account any security, noise or air quality issues which reduce opening area
- Windows should only be modelled as open when rooms are scheduled to be occupied, unless secure openings are provided

Key points

Community heating

- Heat losses from pipework, HIUs and heat maintenance tape should be included for community heating systems, and/or where heat maintenance tape is used

Suggested Reporting Requirements

Including:

Site location and orientation.

Images of the model and internal layouts

Construction types including U- and g- values and thermal mass

Ventilation strategy - including details of window openings, infiltration rates and any mechanical flow rates.

The weather file(s)

The results of the analysis

Authors

Cecilia Bonfigli, ARUP

Marguerita Chorafa, Principal Engineer, AECOM

Susie Diamond, Partner, Inkling LLP

Chris Eliades, Mechanical Engineer, ARUP

Anastasia Mylona, Research Manager, CIBSE

Becci Taylor, Associate Director, ARUP

Dane Virk, UCL, CIBSE sponsored EngD

Testers

Claire Das Bhaumik, Partner, Inkling LLP
Marcus Haydon, Inkling LLP
Marguerita Chorafa, Principal Building Physics Engineer, AECOM
Alexandros Kyrkopoulos, AECOM
Cecilia Bonfigli, ARUP
Chris Eliades, Mechanical Engineer, ARUP
Ed Cremin, Etude
Leon Tatlock, Etude
Ashley Bateson, Partner, Hoare Lea
Owen Boswell, Sustainability Consultant, Hoare Lea
T Brown, Hoare Lea
Tom Spurrier, Associate, Hoare Lea
Zsolt Bako-Biro, Director, GT Advanced
Narguess Khatami, Sustainability Consultant, Hilson Moran
Gabriela Costa, Senior Sustainability Consultant (Architectural), Sweco
Juliana Moreira, Energy & Sustainability Engineer, WSP
Dane Virk, UCL, CIBSE sponsored EngD

Limitations

- Cannot guarantee that people will always be comfortable, regardless of how they act
- Modellers will need to use common sense and professionalism
- Continued testing and feedback from monitoring will feed into future updates

The End

Thank you for listening!

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EcoBuild March 2017 – Performance Lab Programme

Modelling for real life performance:
practical tools for excellent design of homes

Interaction between energy efficiency measures and air quality in homes

Dr Marcella Ucci

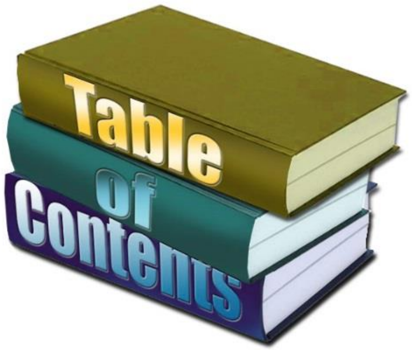
m.ucci@ucl.ac.uk

MSc HEALTH, WELLBEING AND SUSTAINABLE BUILDINGS

ucl.ac.uk/bartlett/environmental-design

Outline

1. Background: evidence on health and housing
2. Indoor air quality, energy efficiency and health
3. Examples and recommendations



Ranking of Housing Hazards (existing dwellings)

Domestic Health and Safety Hazard	Category	Risk Index
Hygrothermal conditions	A	83
Slips, trips and falls on the level		78
Particles and fibres		78
Radon		78
Environmental tobacco smoke		72
Slips, trips and falls on stairs, ramps and escalators		71
Security and the effects of crime	B	70
Noise		70
House dust mites		69
Burns and scalds		68
Fires in buildings		67
Carbon monoxide		66
Fungal growth		62
Lighting		62
Space and crowding		62
Lead		61
Slips, trips and falls from windows, balconies and roofs	C	60
Oxides of nitrogen		60
Toilet facilities		60
Volatile organic compounds		59
Collision/entrapment involving doors		59
Sources of infection other than toilets		58
Electrical hazards		56
Drowning		56
Collision/entrapment involving windows	D	50
Sulphur dioxide		50
Cockroaches		48
Structural collapse and falling objects		48
Explosions in buildings		48
Land contamination including landfill gas		41
Biocides		26
Collision/entrapment involving lifts and escalators		14
Electromagnetic fields	NBRA	

Note: This is the Risk Index with a focus on existing dwellings in England and Wales.
The rating may be different in other countries.

CLG, (2008), *BD 2518 Review of Health and Safety Risk Drivers*, Communities and Local Government, www.communities.gov.uk

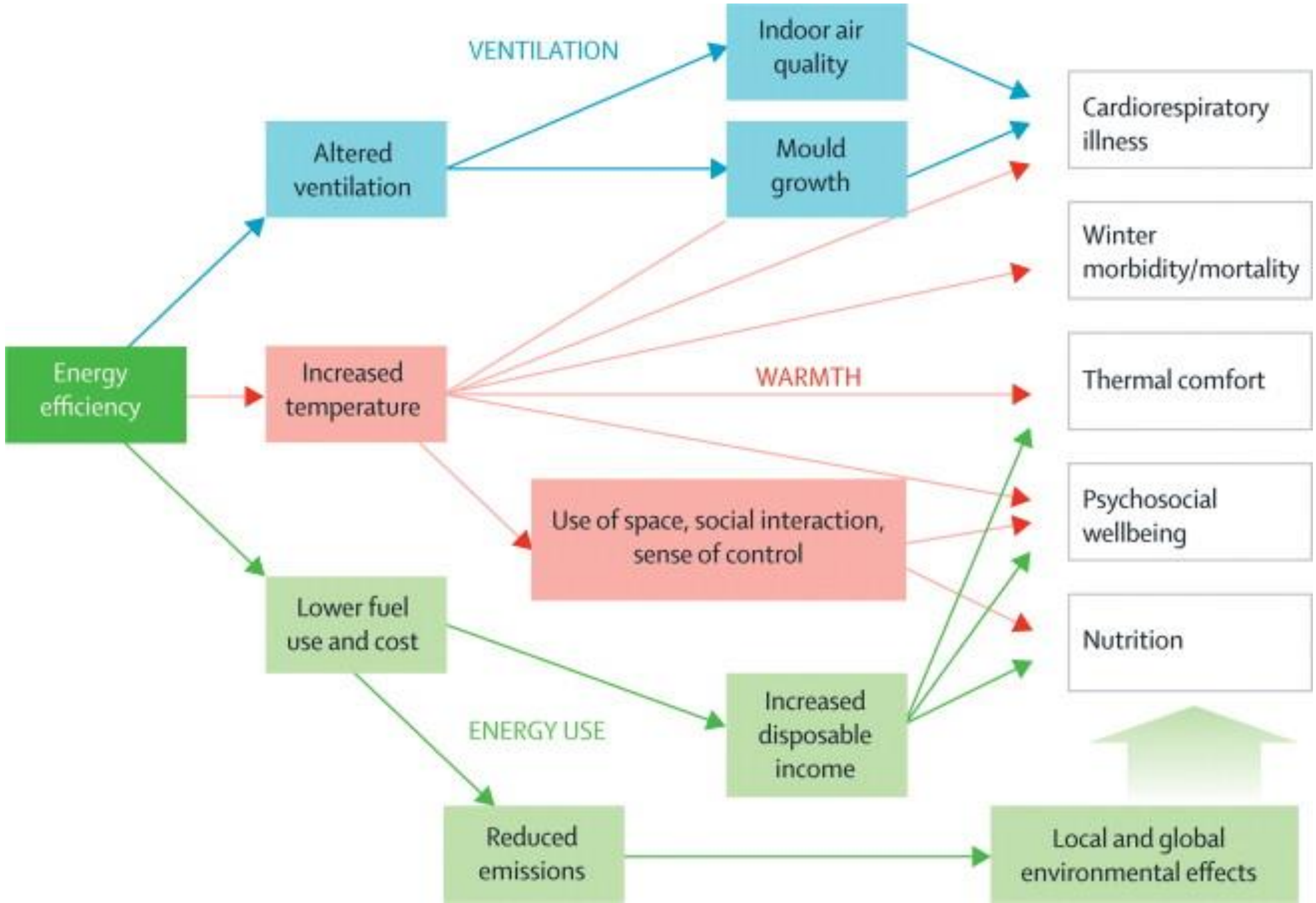
Ranking of Housing Hazards: how could hazards be affected in new energy efficient dwellings?

A. Physiological requirements**
- Damp and mould
- Excessive cold
- Excessive heat
- (Asbestos & MMF)
- Biocides
- CO & fuel combustion
- (Lead)
- Radiation
- Uncombusted fuel gas
- VOCs

B. Psychological requirements
- Space & Crowding*
- Entry by intruders*
- Lighting*
- Noise*

C. Protection against infection
- Hygiene, sanitation and water etc.

D. Protection against accidents
- Falls*, fires, collapse etc



Wilkinson et al., (2007), *Energy, energy efficiency and the built environment*, The Lancet, 370 (9593):1175-1187

Evidence and Examples

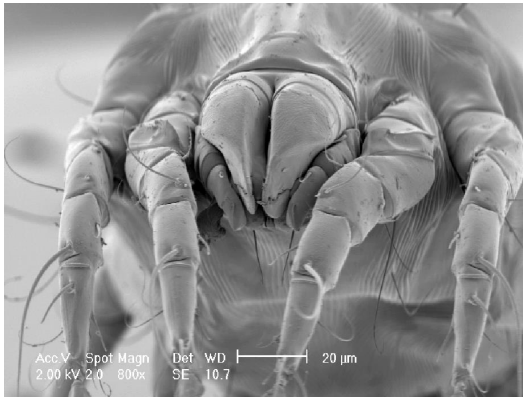
1. Modelling and fieldwork studies
2. Examples about overheating and air quality (moisture)
3. (Remember role of outdoor pollution too)

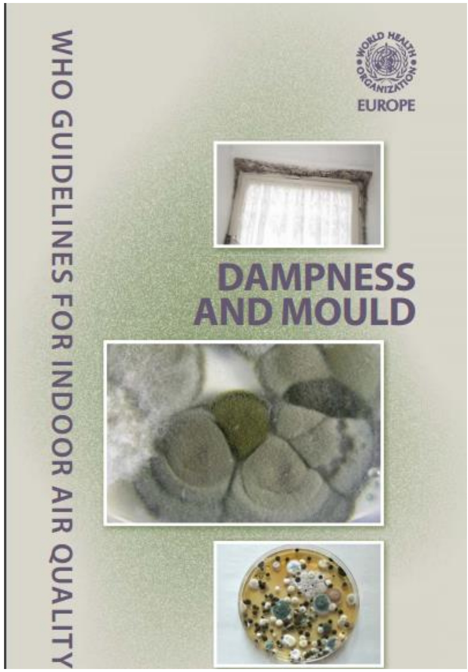
Example 1: Meta-analysis of new buildings & overheating

- Temperature data recorded at five-minute intervals in 60 dwellings across 19 demonstration projects (2012–14)
- 27% of living rooms exceeding 28° C during August.
- 57% of bedrooms and 75% of living rooms had at least 5% annual occupied hours > 25° C.
- 30% of living rooms exceeded the adaptive comfort threshold of > 3% occupied hours $\Delta T \geq 1$ K
- The higher minimum and average summertime temperatures observed in mechanical ventilation with heat recovery (MVHR) homes ($p < 0.05$) and lower temperature range ($p < 0.001$) suggest the need for greater attention to adequate summertime ventilation provision in airtight homes.

McGill et al., (2017), Meta-analysis of indoor temperatures in new-build housing, Building Research and Information, http://dx.doi.org/10.1080/09613218.2016.1226610

Example 2
Energy Efficient Housing:
Increasing Dampness, Mould and/or House Dust Mite Infestations?





Fieldwork Studies: Contradictory Evidence

- Good: Oreszczyn et al (2006) low income households in England - mould severity index decreases with SAP rating.
- Bad: Sharpe et al. (2015) postal questionnaire of social housing in Wales - a unit increase in household Standard Assessment Procedure (SAP) rating was associated with a 2% increased risk of current asthma. Also found higher SAP associated with less mould.
- Good : Woodfine et al (2011) - randomised controlled trial of tailored housing improvements (ventilation and temp.) of homes of children (5-14 years) with moderate/severe asthma in Wales. Found positive impact.
- Good: Spertini et al. (2010) – cross-sectional study with case/control. Found lower levels of Der F1 in low energy buildings.
- 'Ish': Grey et al. (2017) – Welsh energy efficiency retrofit programme Arbed, low income areas. No improvements in short term (1-10 months) self-reported physical and mental health or respiratory symptoms. Improved subjective wellbeing and psychosocial outcomes (e.g. thermal satisfaction, reduced social isolation). Intervention is external wall ins., heating systems upgrades.

Scenarios modelling: house dust mite infestations in mattress, base case flat in London compliant with 2006 Building Regs

Table 8. Scenarios modelling results ordered by the sum of predicted mites for the three mattress cells (results presented as ratios in relation to base-case results).

No.[a]	Scenarios	Mite predictions (total of cell A, B, C)	Energy consumption
14	Moisture: 5 kg/day	0.02	(1.0)[b]
9	Thermostat: 22°C	0.03	1.20
3	Permeability: 20 m^3/m^2h	0.08	1.58
18	Boundary conditions: best case	0.10	(1.0)[b]
7	Extract fan, longer use	0.45	1.07
1	*U*-value: 1.6 W/m^2K	0.65	1.27
5	Windows open all night	0.75	1.02
11	Heating period: plus 2 h	0.94	1.05
6	Windows closed	1.03	1.00[c]
2	*U*-value: 0.25 W/m^2K	1.10	0.97
10	Thermostat: 18°C	5.40	0.80
8	No extract fan	5.49	0.89
12	Heating period: minus 2 h	5.59	0.94
13	Moisture: 14 kg/day	7.08	(1.0)[b]
19	Boundary conditions: worst case	10.10	(1.0)[b]
16	MVHR, option 2	20.40	0.33
15	MVHR, option 1	159.53	0.31
4	Permeability: 3 m^3/m^2h	269.03	0.55
17	*U*-value 0.25 W/m^2K and permeability 3 m^3/m^2h	312.63	0.52

[a]Scenarios Number (from Table 7).
[b]No changes expected.
[c]Very small energy reduction.

Ucci et al., 2011, Application of a transient hygrothermal population model for house dust mites in beds: assessment of control strategies in UK buildings, Journal of Building Performance Simulation, DOI: 10.1080/19401493.2010.532235

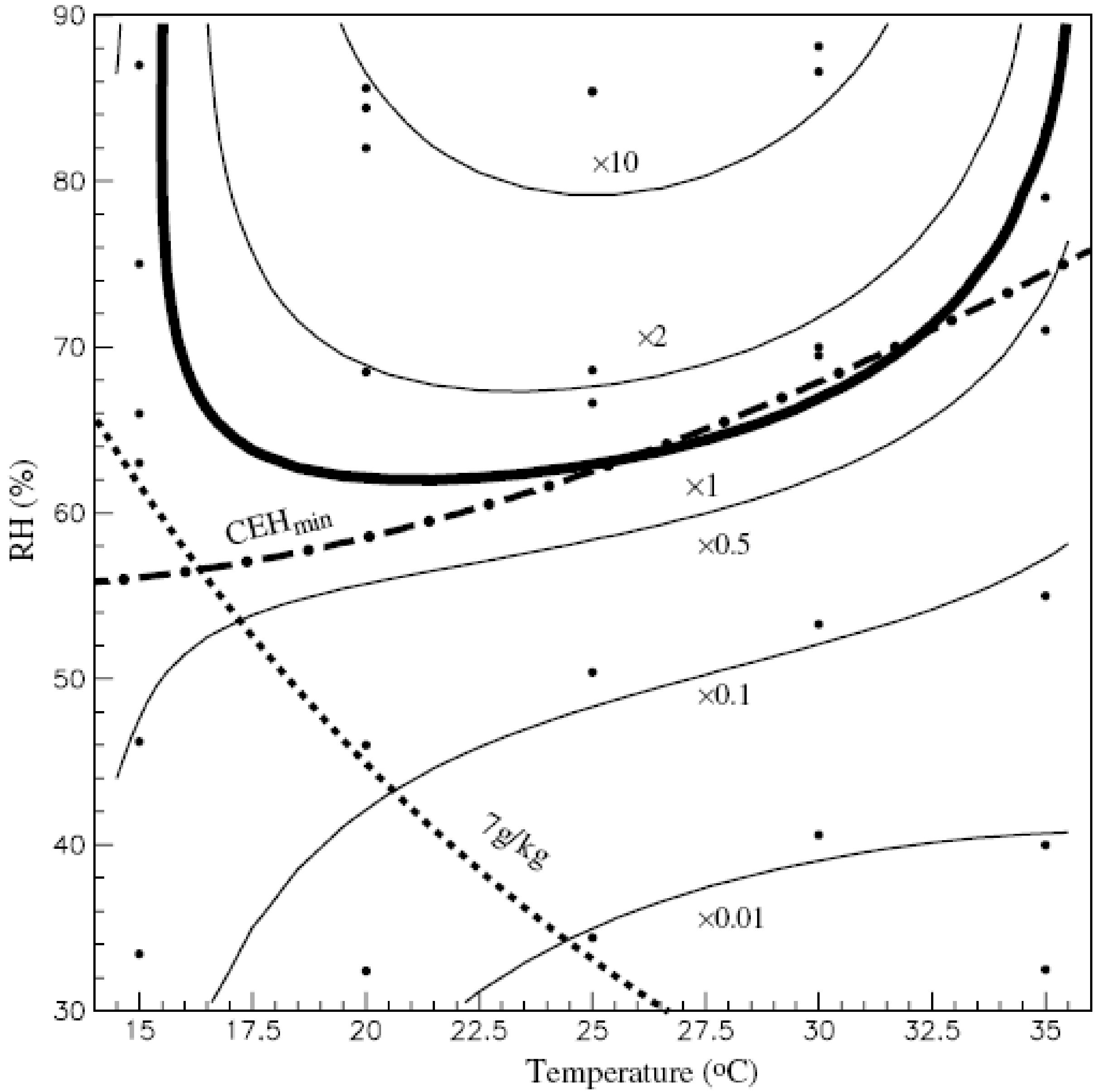
Scenarios: Ranked Results

No.~	Scenarios	Mite Predictions (total of cell A, B, C)	Energy Consumpt.
14	Moisture: 5 kg/day	0.02	(1.0) #
9	Thermostat: 22° C	0.03	1.20
3	Permeability: 20 m^3/m^2h	0.08	1.58
18	Boundary conditions: best case	0.10	(1.0) #
7	Extract fan, longer use	0.45	1.07
1	U-value: 1.6 W/m^2K	0.65	1.27
5	Windows open all night	0.75	1.02
11	Heating period: plus 2 hours	0.94	1.05
6	Windows closed	1.03	1.00*
2	U-value: 0.25 W/m^2K	1.10	0.97
10	Thermostat: 18 ° C	5.40	0.80
8	No extract fan	5.49	0.89
12	Heating period: minus 2 hours	5.59	0.94
13	Moisture: 14 kg/day	7.08	(1.0) #
19	Boundary conditions: worst case	10.10	(1.0) #
16	MVHR, option 2	20.40	0.33
15	MVHR, option 1	159.53	0.31
4	Permeability: 3 m^3/m^2h	269.03	0.55
17	U-value 0.25 W/m^2K and permeability 3 m^3/m^2h	312.63	0.52

~Scenarios Number (from Table 7); #No changes expected; *Very small energy reduction

Simple Tool: MPI Model*

To be used solely as initial indicator



Crowther et al., 2006, *Experimental and Applied Acarology*, 39: 127-148

Conclusions: Highlights

- Overall, energy efficiency in buildings can be beneficial to health and wellbeing, especially considering potential effects of cold
- Unintended consequences can arise – most can be avoided by good design (& commissioning), adopting integrated design principles and addressing at the onset building operation and the flexible/variable needs of buildings users.
- Reduction of emissions, and extraction at source, must go hand in hand with adequate ventilation.
- Ventilation affects not only concentrations of air pollutants indoor but also temperature, which in turn affects directly and indirectly moisture-related pollutants.
- For air quality, one should consider both outdoor and indoor sources.

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Thank-you

Any Questions?

ashleybateson@hoarelea.com