MONITORING OVERHEATING
HOUSING ASSOCIATION CASE STUDIES

Purpose

The Zero Carbon Hub has been working with Government and industry partners over the last year to understand the extent of the issue of overheating in homes in England and Wales and what more Housing Providers, including housing associations, can do to mitigate this risk.

Our preliminary report "Overheating in Homes – The Big Picture" was published on 16 June 2015. You can find this, and other booklets and publications on overheating at **www.zerocarbonhub.org**

A second phase of the project is due to begin this summer, aiming to make recommendations to industry and government decision-makers about what policies or changes to frameworks may be needed to tackle the issue in a systemic way.

What does this booklet cover?

We know that overheating in homes is a growing problem, and that it is likely to become more prevalent as the climate changes. Furthermore, housing associations could face particular challenges due to the larger proportion of residents vulnerable to effects of excess heat living in social housing.

Consequently a number of housing associations are choosing to investigate how thermally comfortable their housing stock is by monitoring temperatures in homes and surveying the occupants to check their perceptions.

This booklet summarises the experiences of four housing associations, with their kind permission. It discusses why they carried out monitoring projects, how they carried out the work, some of the results and importantly, how the results are being used within their organisations. Practical issues related to monitoring, highlighted by the case studies, are included in annexes at the end. However this booklet is not intended to be technical guidance, and detailed construction specifications have not been provided. The aim is to share experiences and for readers to consider whether similar research may be useful for their organisation too.

What monitoring can tell us

By monitoring internal temperatures in different rooms in homes, it is possible to understand whether and how often a home is overheating. Collecting temperature data in sample developments across housing portfolios as a whole can also show whether particular types of property are more susceptible to overheating.

Ideally, monitoring data should be coupled with occupancy surveys, which ask occupants how comfortable they find the temperatures in their homes. Surveys can also ask questions about occupants' lifestyle and behaviour, for example, are they at home during the day, can/do they open windows, what appliances do they have and how much do they use them. All these things can affect the likelihood of overheating.

Example survey question

Is your home ever too warm?
(Please tick one)

- O *Never*
- O *Occasionally*
- O *Sometimes*
- O *Often*
- O *Always*

If so, when? (which season? What time of day or night?) Which room(s)?

How does it affect you?
(e.g. can't sleep, don't cook)

Do you try to make yourself cooler? How?

Box 1. **Defining 'overheating'**

There is no universally agreed definition of overheating within the domestic sector. Housing Providers use many different ways to define and assess the risk of overheating. These include:

CIBSE's fixed temperature thresholds, Guide A, Environmental Design (2006)
This design guidance states that, over the course of a year, temperatures should not exceed thresholds of 28°C in living rooms and 26°C in bedrooms for more than 1% of the hours during which the rooms are occupied.

CIBSE adaptive comfort criteria, Technical Memorandum 52 and Guide A (2015)
This guidance sets limits on how warm non air-conditioned buildings should be compare d to recently occurring external temperatures. The calculation is more involved than simple thresholds. CIBSE is planning more research in order to be able to apply this method to domestic bedrooms.

Standard Assessment Procedure (SAP) Appendix P
A simple overheating 'check' for new dwellings, underpinned by Part L1A of Building Regulations.

Passive House Planning Package (PHPP)
This guidance states that, over the course of a year, internal temperatures should not exceed a fixed threshold of 25°C for more than 10% - and ideally less than 5% - of the time the building is occupied.

Housing Health and Safety Rating System (HHSRS)
Notes that temperatures over 25°C can increase the risk of occupant ill-health and fatalities.

Further details of assessment methodologies can be found in the Zero Carbon Hub's *"Assessing Overheating Risk Evidence Review"*.

"The definition is very difficult…there isn't one single definition that will fit all circumstances."

HOUSING ASSOCIATION

CASE STUDY A

Location
Suburban site on England's south coast.

Monitoring period
Initial monitoring took place from January 2012 to September 2013, and was later extended into 2014. Overheating analysis was carried out for the year-long period October 2012 to September 2013. This period included the warmer than average summer of 2013. From 3 to 23 July 2013 there was a heatwave, bringing very warm weather across the UK.

The Development

- 24 new-build flats in two identical low-rise blocks completed in 2011.
- One block was built to Code for Sustainable Homes level 3, and the other to the higher Fabric Energy Efficiency Standard (FEES).
- Achieved high airtightness (less than 4 m^3/m^2h @ 50 Pa).
- Used a Mechanical Ventilation with Heat Recovery (MVHR) ventilation system with an occupant-controlled summer bypass mode to allow the pre-heated air to be turned off.

Why was the development monitored?
The Technology Strategy Board's (now Innovate UK) Building Performance Evaluation (BPE) programme funded two occupant surveys and the initial period of monitoring. The first user survey was undertaken just after the occupants had moved in. The second, in March 2013, showed that some residents found their flats uncomfortable even in the cooler summer of 2012. Particularly in the smaller, single-aspect dwellings, even though they were able to open the windows. Consequently, an additional monitoring period was undertaken to allow a more detailed investigation.

How was the monitoring done?

11 flats in the two blocks were monitored, covering the three different build typologies:

- 3 one-bed single-aspect units, facing south
- 2 two-bed single aspect units, facing south
- 6 two-bed triple aspect flats with a small south-facing façade, larger north-facing and east/west facing facades

Sensors located in the living room and the main bedroom recorded internal temperature and humidity data every 5 minutes.

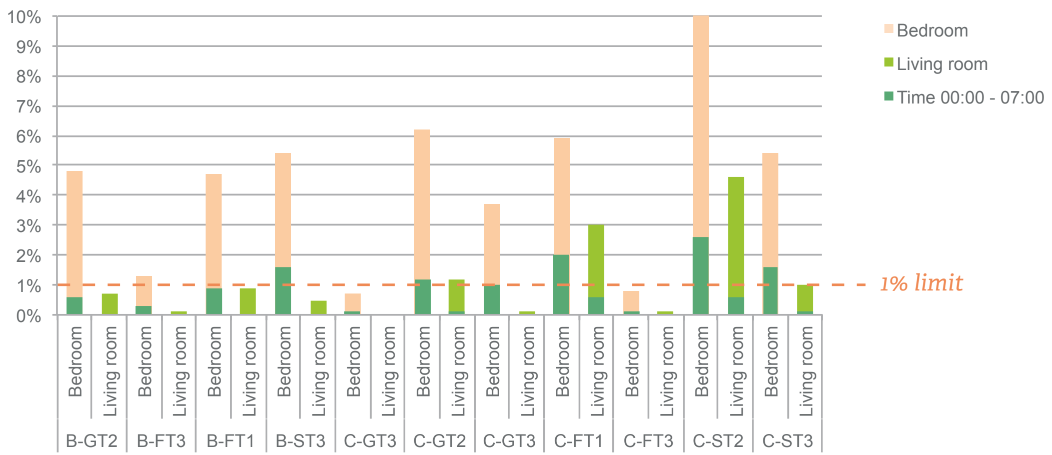
Energy use monitoring in a smaller number of flats and structured surveys of occupants provided additional information about occupant lifestyles and behaviours. External temperature and humidity sensors recorded the local weather conditions.

What did the monitoring find?

Two different definitions were applied to the monitored temperature data to assess whether the flats were overheating.

Figure 1. **Percentage of hours over CIBSE fixed temperature thresholds (26°C for bedrooms and 28°C for living rooms). Hours between 00:00 and 07:00 during which the bedroom is assumed to be occupied - are highlighted**

OCT 12 - SEP 13 DATA



Using CIBSE's fixed temperature thresholds (Figure 1)

- 8 out of the 11 monitored flats overheated – assuming they were constantly occupied 24 hours a day.
- 5 out of the 11 monitored flats overheated during night-time hours.

Against CIBSE's adaptive comfort criteria, which take into account people's ability to adapt to recent external temperatures, one top floor, small, single-aspect apartment was found to overheat. This flat was the only one to fail both the overheating tests applied to the monitored data. Overall, the flats most susceptible to overheating were small, single-aspect units, especially those located on the top floor.

Outcomes and lessons learnt

The ventilation units in three flats were tested in July 2013 and problems were identified with all three. Surveys found that many occupants were unaware of the need to manually switch their MVHR units to summer-bypass mode and had not done so. As a result the housing association took steps to educate occupants. They advised them when it was best to open windows in order to cool down their homes and also how to use the MVHR system correctly in summer.

Following this project and a result of resident complaints at other sites, the housing association has now extended monitoring to other properties in their portfolio.

> "Overheating was a new phenomenon for us. Residents were saying they were hot so we needed to take our responsibility as a landlord seriously and try to understand the extent of the problem. Monitoring has helped us identify the problem properties – usually single-aspect flats – where measures might be needed. Our insights are helping our thinking and showing how we need to improve our design guides."

HOUSING ASSOCIATION

CASE STUDY B

Location
Suburban site in England (West Midlands).

Monitoring period
The monitoring period included three consecutive summers: 2011, 2012 and 2013. For each summer a minimum of one months' data was collected. Four months data was collected for summer 2013.

Variable weather was experienced during the monitoring period. The summers of 2011 and 2012 were both cooler than average, whereas the summer of 2013 was warmer than average. There was a heatwave from 3 to 23 July 2013, bringing very warm weather across the UK.

The Development
- Small development of 5 houses and less than 20 flats.
- All social housing units.
- Built to Passivhaus standards and completed in 2011.
- Mechanical Ventilation with Heat Recovery.

What did the monitoring find?
This study focused on sensors installed in all habitable rooms within each dwelling recoding a range of environmental data (e.g. temperature, humidity, CO_2, air-quality, Volatile Organic Compounds, and light levels). The approach enabled an in-depth analysis of how each dwelling was occupied and how design elements of passivhaus such as MVHR and night-time passive ventilation were being used. It also highlighted where external environmental conditions had an influence on occupier behaviour, irrespective of the internal environment of the dwelling being recorded.

Both the Passive House Planning Package (PHPP) and the CIBSE adaptive comfort criteria were used to examine overheating risk. The adaptive comfort assessment included both standard and vulnerable occupants. A number of flats were deemed to fail the overheating criteria using either category of occupant, but – as would be expected – more flats overheated when using the stricter criteria for vulnerable occupants. The results of all three overheating risk assessments are summarised in Table 1.

Table 1. **Overheating in monitored Passivhaus flats**

Year	Number of flats monitored	Fail PHPP overheating risk assessment	Fail CIBSE adaptive comfort criteria	Fail CIBSE adaptive comfort criteria: vulnerable occupants
2011	11	8 (73%)	3 (27%)	4 (36%)
2012	9	5 (56%)	5 (56%)	5 (56%)
2013	5	5 (100%)	3 (60%)	5 (100%)

Outcomes and lessons learnt
Despite being part of the same development, there is considerable variation in the internal conditions in different flats. Statistical analysis for each flat helped to determine whether this was due to the external weather conditions or to occupant behaviour. User behaviour was considered to have the most impact on increasing or decreasing risk of overheating.

The team concluded that it was important that occupants are helped to understand how their actions affect the temperature and other environmental conditions within their homes. This included recognising the importance of providing appropriate and long-term support and guidance to occupiers through targeted education packages to help them maximise the design elements of the building.

CASE STUDY C

Location
Urban site in Newport (South Wales).

Monitoring period
February 2011 to February 2013. The summers of 2011 and 2012 were both cooler than average. 2011 was the coolest summer since 1993. Summer 2012 was exceptionally wet with almost double the average rainfall.

The Development
- Small two-bed, two-storey, end-of-terrace house occupied by three adults.
- Constructed in the 1980s.
- Retrofitted during summer 2010 aiming to achieve 80% carbon emissions reductions.
- Included improved insulation, triple-glazing and on-site renewable energy generation.
- Achieved improved air-tightness of 7.73 m^3/ m^2 h @ 50 Pa.
- Whole-house MVHR system without summer bypass.

Why was the development monitored?
This was an Innovate UK funded "Retrofit for the Future" project. Post-occupancy evaluation and monitoring of the completed retrofit formed an essential part of the project.

How was the monitoring done?
Sensors were located in the living room and both bedrooms.

What did the monitoring find?
Using CIBSE fixed temperature thresholds, the living room did not overheat. Temperatures only exceeded 28°C for 0.1% of the time. However, the temperature exceeded 26°C for 1.4% of the time in the first bedroom (west-facing) and for 9.8% of the time in the (east-facing) second bedroom. Both bedrooms were more prone to overheating during the summer, although the second was overheating throughout the year. It was suspected that this was due to heat losses from the hot water tank cupboard sited in this room, suggesting the need to think about the position and the level of insulation.

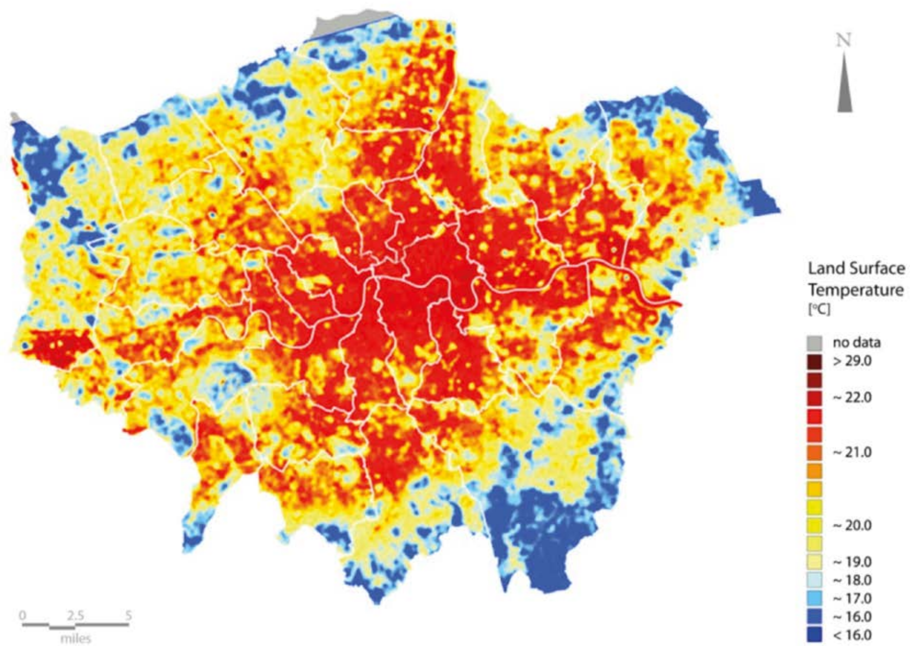
CASE STUDY D

Location
Large urban redevelopment site in inner London.

Monitoring period
Late 2012 to early 2014, including summer 2013. Summer 2013 was warmer and sunnier than average and there was a heatwave from 3 to 23 July 2013 bringing very warm weather across the UK. This site is within the Urban Heat Island so external temperatures would be higher than surrounding rural areas (Figure 2). Mean daily external maximum temperatures in inner London in July 2013 exceeded 26°C.

The Development
- Mid-rise medium sized social housing block.
- Built during the first decade of the 21st century.
- Individual MVHR ventilation units with boost function.
- Communal heating system provides site-wide heating and hot water.

Figure 2. **By way of example, land surface temperature in London's Urban Heat Island increasing from the outskirts to the centre of the city in London at 21:00 on 12 July 2006 (LUCID project)**



Why was the development monitored?

The developer wanted to measure the performance of a large number of apartments on a scheme typical of construction in the 2000's in London, to develop an insight into recently built housing and to bridge the gap between design and performance by understanding important features such as:

- Real energy consumption and energy performance
- Whether overheating occurs
- Occupant experience and satisfaction
- Efficiency of the communal heating system

How was the monitoring done?

Three flats were monitored for over a year using:

- Battery-powered temperature and humidity sensors in the bathrooms and bedrooms
- Mains powered temperature, humidity and carbon dioxide sensor in the living rooms

External temperature and relative humidity were also measured, as well as:

- Monthly electricity and heat usage figures for 20 flats, including the 3 monitored flats
- Appliance monitoring in 12 flats, including the 3 monitored flats
- Occupant surveys to which almost half the flats responded

What did the monitoring find?

Overheating was assessed on a month-by-month basis using CIBSE fixed temperature thresholds, assuming the bedrooms were occupied from 10pm to 8am and the living rooms from 8am to 10pm.

All three monitored flats experienced periods of overheating during summer 2013. All of the rooms in each of the three flats exceeded the acceptable levels of overheating in July and August 2013, except one bedroom, which overheated only in July but not in August.

The overheating was attributed to several potential factors:

- The large proportion of glazing
- Insufficient ventilation
- No summer bypass installed in the MVHR system
- Heat losses from the communal heating system distribution pipes into the communal corridors, subsequently dissipating into the adjoining flats

Outcomes and Lessons learnt

Residents were given feedback on:

- Their electricity, heating and water use
- Potential reasons for their relatively high energy consumption
- Use of the MVHR system and its maintenance

As some of this information was given to residents part way through the study, the monitoring team was able to assess whether this changed occupant behaviour, for example use of the MVHR system. Overall, monitoring has strengthened relationships with residents who felt that the developer was making an effort to monitor the quality of the homes and services.

Issues were identified with the communal heating system. The early plant design was not adjusted properly to accommodate changes as the site design evolved, resulting in it being oversized. Different design approaches are now being adopted, in which 100 to 300 apartment developments are treated differently to larger developments (1000 or more apartments).

More detailed design specifications are being considered and steps taken to avoid future problems with installation and commissioning. The developer is now moving towards adopting the ECA – NES Y50 enhanced insulation standard for pipework.

Overall, temperature monitoring provided the opportunity to highlight issues and improve processes and procedures for future projects. For example to:

- Improve plant energy efficiency and ensure good practice/quality of installation
- Improve handover of the building to owners and occupants, communicating relevant information on how to use and maintain their asset
- Integrate the maintenance regime as a critical element in the design and take maintenance procedures over the life span of the building into account

OBSERVATIONS

Best practice

Alongside the Zero Carbon Hub, organisations such as the Good Homes Alliance, BRE, and the Homes and Communities Agency view the post-occupancy monitoring of properties as good practice. Monitoring allows housing associations to check that their developments and schemes achieve thermal comfort (and other) design aspirations when in use. However, it is recognised that resources need to be found to conduct such research.

Motivations

Most monitoring study results shared by housing associations with the Zero Carbon Hub were undertaken as part of Innovate UK's Building Performance Evaluation (BPE) programme and/or in response to reports or complaints of overheating from tenants or occupiers.

Which properties to monitor

If monitoring only takes place when overheating is already suspected or perceived by occupants, the results could skew the housing association's understanding of the scale of any overheating problem. Broader programmes of monitoring or Post Occupancy Evaluation provides a truer reflection of the overheating risk profile across housing stock as a whole.

Need for good design

Monitoring should not be viewed as a substitute for giving serious consideration to overheating risk when designing dwellings or carrying out retrofit works. It is usually more difficult to find practical, passive solutions to overheating once building work is completed and the property is occupied. For example, the orientation of the building or total glazing area would be extremely difficult to fundamentally change. In some severe cases, where the health of the occupants was at risk, housing associations have had to take emergency measures to install air-conditioning, in the absence of other alternatives.

Design Lessons

Monitoring, alongside overheating risk assessments, can help identify elements of the design that make homes particularly susceptible to overheating, so that housing associations can avoid problems when commissioning future developments.

Checking mitigation strategies

Monitoring can help to demonstrate whether an overheating mitigation strategy is working, provide a sense of the changing risk profile of the organisation's housing stock as a whole, and can reveal to technical teams how severe an overheating problem is once it is happening.

Ongoing monitoring and home management

One option raised by stakeholders during the ZCH's Overheating Project is to install indoor temperature sensors as a permanent fixture in new properties and in any existing homes deemed to be at a higher risk of overheating. This would inform both occupants and housing managers about the temperatures in their homes and potentially provide an "early warning system" enabling them to take action.

ANNEX A
MONITORING METHODS

Placement of temperature and humidity sensors

Mini data loggers fixed to the wall of a property record internal air temperature and humidity at fixed time intervals.

Aim to locate sensors within the main habitable spaces, i.e. the living room and the bedroom(s). This usually requires consent from the occupants.

Fix at an appropriate height to measure the temperatures the occupant experiences.

Do not expose to any factors which could distort the measurements, e.g. position out of direct sunlight and away from radiators.

Communal spaces in blocks of flats can also be monitored to see whether heat is building up there, which could eventually penetrate into the surrounding dwellings.

How long should monitoring be carried out for?

In order to identify potential problems with overheating, monitoring is normally carried over the course of at least one whole summer, and longer if possible, over multiple seasons, to check for anomalies.

The external weather conditions, especially air temperatures, have a large impact on the risk of overheating. High external temperatures increase the chance that properties will overheat. On the other hand, monitoring during a cooler summer may not identify all properties which are at risk.

Ideally monitoring should take place over several summers in order to build up a reliable picture of the overheating risk.

Some homes are hot all year-round and it is important to identify if this is the case. Also, a number of the overheating risk assessment methods used by the construction industry, for example the CIBSE fixed temperature thresholds (Guide A 2006) or Passive House Planning Package (PHPP), consider internal temperatures over the course of a whole year.

Technical considerations

Certain questions need to be considered in designing a monitoring study. Examples include:

How are the sensors powered? Battery or mains?

How will the team know if there is a problem with the sensors?

How will the data be downloaded? Wireless or hardwired?

How will the data be stored and managed?

It takes time to gain consent to access residents' homes. You need to plan when to install the sensors so that they are ready in time for the summer season, and also when to collect them.

Sensors can sometimes break or may be removed by residents. In communal areas, you can reduce the risk of this happening by putting the sensor inside a secure ventilated casing. It is important to have quality checks on the data to ensure that it is giving an accurate measurement of the conditions experienced inside the home.

ANNEX B
CONTEXTUAL CONSIDERATIONS

Many factors can affect the propensity of a dwelling to overheat. To understand if and why overheating is occurring in a particular property, the factors summarised in this section also need to be considered.

External weather data

Overheating is more likely to occur in a hot summer. External temperatures and humidity should be recorded on site if possible. Alternatively, weather data or information about local weather patterns can be obtained from sources such as the Met Office.

When residents are at home

Data loggers record internal conditions 24 hours a day even when the occupants are not present in the home, or in individual rooms within the home. A key question is whether occupants are comfortable when they are present in the property. Some tenants may be at home most of the time, for example if they are older, disabled or unemployed.

Window opening

Including window sensors as part of a monitoring programme can add additional information to the temperature data gathered, shedding light on window opening patterns.

However, most window sensors only identify the times at which the windows are open and not how widely they are opened. It can sometimes be more practical to ask occupants about their window opening habits as part of the occupancy survey.

Lighting and appliance use

Lighting and electrical appliances generate heat, which make homes hotter than they otherwise would be. Lighting and appliance usage varies widely between occupants. Monitoring energy use and auditing appliances as part of a structured occupant survey can help determine which appliances are generating the most excess heat.

How hot people feel does not depend only on temperature

Most data loggers measure the air temperature within the space. How hot or cold occupants feel also depends on other sensations, for example air movement, such as a breeze through open windows, the humidity and how relatively hot or cold the walls, floor and ceiling are.

Temperature will vary throughout a room. Sensors should be placed where they will measure air temperatures as the occupant experiences them.

Occupants who are elderly, very young and/or disabled are more likely to be vulnerable to the effects of excess heat.

Since our formation in 2008, the Zero Carbon Hub continues to work with Government and industry to identify risks, remove barriers to innovation and help demonstrate that energy efficient, healthy new homes can be delivered by the mainstream house building industry and in advance of the introduction of Nearly Zero Energy Homes from 2020.

Get in touch to find out how we can assist you

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