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BRE Client Report

Resilience of new developments to high temperatures and flooding

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Executive Summary

The Building Research Establishment (BRE), was commissioned to conduct this research project on behalf of the Adaptation Sub-Committee (ASC) of the Committee on Climate Change. The aim of this research is to help to better understand the costs, benefits, drivers and barriers (real and perceived) that designers and builders associate with making buildings fit for the future climate. The research paid particular attention to the management of the risks of, and resilience to, flooding (river and coastal) and overheating as these are both risks that must be managed today and are likely to be exacerbated due to climate change in the future.

An online survey was designed by BRE with feedback from the ASC and administered using the online ‘Survey-Monkey’ software. A pilot version of the survey was created and piloted, but it was found to be too complex to enable sufficient response. Therefore the final version of the survey was shortened to allow it to be completed by a single respondent. In total 123 responses were received, of which two thirds were substantially completed for flooding and/or overheating.

A series of (23) telephone interviews were then arranged involving survey respondents who indicated that they would be willing to take part, to explore issues associated with adapting to climate change in more detail. Following on from the initial online survey and follow-up telephone interviews, two focus groups were held which built upon their findings.

The respondents to the online survey were spread across all areas of England, although a significant proportion were located in London and the south east. The focus groups ensured that there was a geographic spread through events being held in the north and south of England. The majority of respondents were involved as designers and consultants in new buildings, with a lesser number involved as developers.

The full findings for all parts of the survey work are detailed in the main report. The conclusions are set out below.

<u>Flood resilience</u>

The following points are concluded from the surveys, interviews and focus groups:

- **Costs of flood resilience**
    - Costs of adaptation: a variety of responses were obtained in the surveys, although most respondents thought that there were either significant or high costs to design and build in flood resilience.
    - Build in versus retrofitting: The costs of designing and building in as new as opposed to retrofitting measures was typically thought to lead to lower overall construction costs by respondents.
    - Planning: developers and their consultants are directed in flood risk areas towards the raising of the floor level through either land raising of a site or introducing a ‘sacrificial’ ground floor. The additional costs would vary depending on the actual site or building design. The application of flood resilience measures in building design and construction was limited.
    - Type of flooding: the surveys addressed river and coastal flood risk, but a number of respondents included surface water management measures within new developments, which was also indicated to add to the construction cost.

- **Benefits**
    - Planning permission: the respondents indicated that securing planning permission was a major benefit from including flood resilience measures. The benefits of using flood resilience

measures in order to satisfy planning requirements was further highlighted within the interviews.
  - Reputational gains and property values: were generally found to be less of an issue for respondents to the survey.
  - Achieving a level of design quality and certification: these factors figured highly in the responses as benefits by respondents.
  - Consumer demand: there was a mixed response, although there were more respondents who viewed it as a benefit than did not.

- **Drivers**
  - Planning permission: was seen to be the most effective driver for flood resilience and indeed the only driver that would be considered to be legislative and subject to relevant regulations.
  - Building regulations: the introduction of relevant building regulations in England would drive flood resilience within the design and construction of the building fabric and services.
  - BREEAM: Adaptation to climate change (including flooding) is set out in this standard (and the Home Quality Mark) and this was considered to drive flood resilient adaptation by some developers.
  - Insurance: its availability, and affordability, for new developments was considered to be a potential driver of flood resilience.

- **Barriers**
  - Developer responsibility: the liability for new development often falls to the owner rather than the original developer who may simply sell on the property, therefore they have no incentive to add cost by including resilience measures. The developer would not necessarily obtain the benefit from installation of measures through an increase in property value.
  - Public awareness: lack of awareness on flood risk and therefore the use of resilient measures is a barrier; this lack of awareness results in poor client demand.
  - Skills: the various surveys highlighted the capacity of planning departments as being a barrier to implementing flood resilience measures.

The following points are concluded from the three forms of survey with regards to the adaptation of buildings for overheating:

- **Costs**
  - Additional costs: in only a limited number of cases did respondents consider that the adapted building design would result in substantially higher costs, unlike flood resilience the overheating measures mainly involve building fabric and services related costs.
  - Built in versus retrofitting: the situation was quite different with regards to the retrofitting of measures into the property to adapt for climate change. In this case there was more likely to be a high cost involved.
  - Simple design and construction solutions: the interviews and focus groups highlighted simple, low cost, assessment of overheating potential may be sufficient to derive suitable measures and this may add virtually nothing to the overall cost. Good design and a limited additional cost to fully assess issues such as orientation will reduce the need for expensive adaptation.

- **Drivers**
  - London Plan: required an assessment of overheating and achieving the planning permission for a development was therefore indicated as a significant driver (note that the requirements only apply in London).
  - Reputation: the survey respondents indicated that some developers were concerned with reputation and would take measures to deal with overheating.
  - Industry standards: the surveys indicated that designing and building to Passivhaus was a driver for domestic properties to account for overheating. Other drivers are BREEAM (non-

domestic) and the Home Quality Mark (HQM), where credits are awarded for adaptation to climate change.

- **Benefits**
  - Granting of planning permission: despite the lack of national requirements, respondents often viewed the granting of planning permission as being a benefit. Developers and consultants found that dealing with overheating at the planning stage resulted in better responses from planners.
  - Quality of product: the public does not expect problems such as overheating to arise; where the building manages the risks then problems are less likely to occur.
  - Industry standards and certification: achieving the criteria set out in BREEAM, Home Quality Mark, Passivhaus and standards were all viewed as benefits by respondents.

- **Barriers**
  - Absence of building regulations: the regulations do not currently address overheating and this is viewed as a barrier; in the absence of regulation developers will not take measures to address resilience.
  - Lack of client demand: including both developers and the public, meant that even when the issue was raised by consultants or others that cost savings in projects often resulted in such measures being removed at a later stage.
  - Uncertainty over future conditions: there is an inherent uncertainty of the scale and intensity of the future impacts of climate change and it is therefore difficult to recommend appropriate solutions.
  - Application of research: whilst good research has been conducted on the issue of overheating it can be difficult to apply these findings to a building and make the link to increased risk due to climate change as there are many different factors that can exacerbate overheating.
  - Skills and knowledge: these were considered to be lacking on overheating across building professionals in the focus groups. Most university architecture courses do not consider issues of overheating, often climate change adaptation is either not covered, or is covered inadequately as a side issue.
  - Lack of application of simple rules: there is a need for simple rules of thumb for passive approaches as effective solutions, if such simple rules can be applied then it may encourage cost effective measures to be taken.

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1 Introduction

Context

The Building Research Establishment (BRE), was commissioned to conduct this research project on behalf of the Adaptation Sub-Committee (ASC) of the Committee on Climate Change. The aim of the research was to help to better understand the costs, benefits, drivers and barriers (real and perceived) that designers and builders associate with making buildings fit for the future climate. The research paid particular attention to the management of the risks of, and resilience to, flooding and overheating as these are both risks that must be managed today and are likely to be exacerbated due to climate change in the future.

The Adaptation Sub-Committee of the Committee on Climate Change reports to Parliament as an independent assessor of the UK Government's progress in implementing the National Adaptation Programme. This research will help to form the evidence base for the Committee on Climate Change to report to Parliament in June 2017.

According to the UK Climate Change Risk Assessment (2017), the risks of overheating and flooding are expected to rise due to the observed and projected increases in global temperatures, and these present some of the most significant risks to the built environment and its inhabitants. Approximately 1 in 10 homes have been built in Flood Zone 3 in recent years (House of Commons, Briefing Paper, 2016). Climate change is expected to increase the likelihood, frequency and severity of heavy rainfall, putting more properties at risk. The average number of hot days per year has also been increasing in the UK since the 1970s. By the 2040s, under a medium emissions scenario a typical summer is expected to be as hot as the heatwave in 2003 when temperatures reached the mid-30s°C.

Previous analysis undertaken by the ASC has considered the social costs and benefits of a range of adaptation measures for buildings including property-level flood protection, permeable paving and passive cooling measures. This research considers further evidence to support its analysis on the broader perceived costs and benefits specifically for designers and builders to including resilience measures in new developments (homes and public/commercial buildings) to manage overheating, internal flood damage, and surface water drainage issues.

Risks to people through flooding and overheating in the built environment were two of the ASC's top priorities in its first report on the National Adaptation Programme to Parliament in 2015. The report found that even in the best case scenario, 45,000 more homes and other properties in England are expected to fall in to the highest flood risk category by mid-century (i.e. at a 1-in-30 annual chance of flooding or greater). Planning policy is ensuring that three-quarters of new development in the floodplain is located in low risk areas. However, each year 1,500 new homes are built in areas of high flood risk and 3,100 homes per year in areas of medium flood risk (at a 1-in-100 annual chance of flooding or greater). The uptake of property-level flood protection measures appears to be low, in both new and existing developments. In terms of heat, evidence from various sources suggests 20% of homes in England may already overheat, even in relatively cool summers. In addition, policies to increase air tightness and the insulation of homes could, if unmitigated, increase the risk of overheating in new and existing homes. In the absence of additional action, the number of heat-related deaths could increase from a UK annual average of around 2,000 currently to 7,000 by the 2050s, due to climate change and population growth.

Building design and construction is of variable complexity depending on the size and type of the development. The initial planning stages are important with regards to decisions on achieving higher standards than required by planning and building regulation requirements. For example, the use of BREEAM or similar standards will be decided by the client in association with architects and consultants.

At the early stages of planning and design the architect may incorporate plans to manage climate related risks through resilient features. However, subsequent changes may remove some of these features as a result of cost cutting.

At present flood risk needs to be assessed at the planning stage of a development. The Government's National Planning Policy Framework (NPPF) and the accompanying online Planning Practice Guidance (PPG) on Flood Risk and Coastal Change sets "sequential" and "exception" tests and thresholds to protect property from flooding which all local planning authorities (LPAs) are expected to follow. Where these tests/thresholds are not met, new development should not be allowed. The planning system has an assumption that flood risk areas will not be developed. However, developers who include floor level raising, or resistance and/or resilience measures may be able to develop a site. The incorporation of flood resilience into design and construction is primarily a planning issue with the details of the design meeting good practice requirements rather than statutory.

For the purposes of applying the NPPF, "flood risk" is a combination of the probability and the potential consequences of flooding from all sources, including from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems, and from reservoirs, canals and lakes and other artificial sources.

There are no national planning or building regulation requirements that refer to the need for resilience to overheating. However, those set out in the London Plan do specifically require overheating risks to be assessed and managed in the building design and construction. The delivery of resilience to overheating is a good practice as opposed to a regulatory requirement across the country.

Building regulations in England do not have requirements for either flood resilience or overheating. As such any design measures to address these issues and make buildings more resilient would be above minimum building regulation requirements. The absence of building regulations for flooding has been a topic of discussion (Pitt Report, 2008), but as yet it has remained a planning requirement only.

British Standard BS85500 provides advice for designers and developers on flood resilience and resistance measures for new buildings. This standard was only published in late 2015 and therefore its impact amongst the building professions so far is limited. It is a voluntary code of practice rather than having any statutory status.

The UK Government introduced the Housing Health and Safety Rating System (HHSRS) as a defined approach for the evaluation of the potential risks to health and safety from any deficiencies in dwellings. The underlying principle of the HHSRS is that 'any residential premises should provide a safe and healthy environment for any potential occupier or visitor'. The HHSRS is in itself not a standard, however since it was introduced under the Housing Act 1985, s604, as amended by the Local Government and Housing Act 1989, judgements about the lack of safety of a dwelling are enforceable under the Act. The HHSRS covers those matters which can be considered the responsibility of the owner or landlord.

Study methods

This research has taken the form of an online survey and a series of follow-up telephone surveys aimed at professionals through the building supply chain, including architects, consultants and housing developers. Two focus groups (one in Manchester, one in London) involved in-depth discussions built around the results of the telephone interviews to further develop an understanding of building professionals' perceptions of climate change adaptation.

For the purpose of this research, flood resilience refers to any strategy that increases the resilience of a building to flooding, including the use of existing defences; avoidance strategies (avoiding flood water by raising the level of the building); resistance strategies (keeping water out of the building); and resilience strategies (accepting water will enter the building and waterproofing the inside to minimise recovery time).

The main targets for the survey, interviews and focus groups were architects, consultants and developers.

The architects were in larger multi-disciplinary practices and also small firms. Design architects (or project designer in some firms) are responsible for the aesthetics and sometimes the overall plan of the project. A technical architect usually is more involved in detailing and producing the drawings and (maybe) specifications. The surveys attracted a mix of architectural experience, including heavy involvement in planning processes as well as detailed design. The developers included both private house builders and social registered landlords.

Construction consultants will take on detailed design or construction activity in a development. The size of firms involved in work in the UK is variable from sole practitioners to large organisations.

2 Surveys, interviews and focus groups

This section of the report describes the methodology undertaken for the surveys, interviews and focus groups. It also provides the details of responses and the different types of organisations that took part. The detailed findings with regards to flood resilience and overheating are then set out in Sections 3 and 4 respectively.

2.1 Methodology

2.1.1 Online survey

An online survey was designed by BRE with feedback from the ASC and administered using the online 'Survey-Monkey' software (see Figure 1).

A pilot version of the survey was sent to 25 organisations and individuals. The pilot version of the survey consisted of over 60 questions, covering the issues of overheating and flood resilience. Feedback from this pilot showed that the original survey was too complicated, making it difficult for a single person to answer efficiently. As the initial target was to achieve a response from 100 organisations and individuals the questionnaire needed to be revised to achieve this goal.

Therefore the final version of the survey was reduced to allow it to be completed by a single respondent. Questions focused on the types of developments that the respondent was typically involved in; types of measures used to mitigate against flooding and overheating; the strategies used to ensure these measures are effective; and the costs associated with these measures. The final version of the survey is included in Appendix A.

The online survey was targeted at a variety of professional organisations involved in the building process. These professionals included housing developers and builders; housing associations; architects and architectural technologists; engineering and sustainability consultants; surveyors; and BREEAM assessors.

All responses were treated in strictest confidence. A mixture of direct and indirect communications channels were used to reach professionals to complete the survey, including the following:

- Directly to the 'BRE Centre4Resilience' mailing list, which consists of parties affiliated with and interested in the output of the BRE Centre for Resilience.
- Directly to other relevant BRE contacts.
- Directly to a number of Housing Associations.
- Directly to RIBA members selected from their directory (approximately 1500 contacts).
- Survey link was 'tweeted' multiple times on the Centre4Resilience and Committee on Climate Change twitter accounts, as well as retweets by followers (see Figure 2).
- National Housing Federation newsletter, who put a link to the survey in their newsletter.
- Adaptation and Resilience in the Context of Change (ARCC) network, who put a link to the survey in their newsletter.
- Posted the survey link on several relevant LinkedIn groups including 'UK House Building Network'; 'Social Housing, Construction and Infrastructure'; and 'Resilient Cities'.

This approach far exceeded the targeted 250 direct contacts, however the targeted response rate of 40% was not achieved initially, hence the increased circulation of the survey through multiple means. A total of 123 responses were ultimately collected.

In order to ensure a mixture of respondents, the survey was targeted at people from a range of different geographic regions where possible. For example, the RIBA chartered Architect directory is filtered by address, so it ensured that the survey link was sent to an equal number of people from each geographic region. All passive communications were unaffected by potential regional bias.

2.1.2 Telephone interviews

A series of telephone interviews involving survey respondents who indicated that they would be willing to take part was arranged, to explore issues associated with adapting to climate change in more detail.

The aim of the Flood Resilience part of the telephone interview was to understand if buildings built in areas at risk of flooding are built to be resilient to flooding in a cost effective way.

The aim of the Overheating part of the telephone interview was to understand if overheating was considered in building design and construction. If overheating was not considered then to understand the barriers to its consideration.

The content of each telephone interview was to use a set of questions tailored to the survey responses of the interviewee.

2.1.3 Focus groups

Following on from the initial online survey and follow-up telephone interviews, two focus groups were held which built upon the findings of the telephone interviews. It was not possible to acquire a sufficient level of detail from the online survey alone as any such survey would have been too long and difficult for a single person to answer. The telephone interviews yielded much more in-depth answers, which were used to inform the structure of discussions in the focus groups.

The focus group format allowed more in-depth discussions to be held between building professionals, who were able to engage in open dialogues that may have been unlikely to take place otherwise. The discussions focused on the costs, benefits, barriers and drivers associated with adapting buildings.

To ensure more people from a greater geographic area could attend, one event was held at the University of Manchester whilst a second event was held at the offices of the Committee on Climate Change in London. Invitations were sent to all professionals who took part in telephone interviews, as well as a selection of other professionals who may not have been able to answer the online survey but who it was considered would contribute to the discussions. In order to encourage maximum participation from all attendees, the focus groups involved between 10 and 15 delegates.

Each focus group was split equally between the topics of overheating and flooding. A 15 minute presentation introducing the risk of overheating was followed by a 45 minutes roundtable discussion involving all of the delegates. A similar format was used for the flooding section, with a 15 minute presentation followed by a 45 minute discussion.

The questions posed by BRE in the workshop were the same for each topic and built upon the responses collected in the online survey and the telephone interviews. The questions were as follows:

- Can a new building be ‘future proofed’ against flooding in a cost effective manner?*
- What resilience measures are reasonable and meet the needs of people as well as designers and builders?
- What are the barriers and how do they interact?
- What are the solutions?
- * Note that respondents generally did not think that ‘future proofing’ of buildings was the key issue, as the problems exist now and therefore it is a current problem and not just one for the

future. Although it was accepted that climate change would introduce greater uncertainty in the future.

2.2 Response

2.2.1 Online survey

A total of 123 responses for the online survey were collected. Of these responses 69 were of sufficient completeness to be useful for the study. The other responses were only partially completed by respondents, often only completing their details but not addressing the detailed questions. Of the 69 respondents 44 had experience of adaptation for flood resilience and 68 has experience in overheating.

All percentages given in this section are for the number of responses for the given question, as not every respondent answered every question. For example, not every building professional had experience of managing the risks of both flooding and overheating, so several did not answer one of those question sets. Similarly, within each section not every question was answered by all survey respondents. This is a product of the decision that not requiring a mandatory answer for every question would increase the response rate, as respondents may be more likely to stop their response part way through if they are locked in to answering every question.

The survey sought information on the professional background of the respondents, see figures 2 and 3. The main respondent groups were architects and consultants, 44 and 43 respondents respectively (87% of the sample). Four others identified themselves as engineers and only three as developers/housing association. However, 19% (22) were identified as other, which included contractors (firms that carry out the building works), material suppliers, facility managers and other housing professionals (note that not all respondents in this category identified their profession). The respondent group as a whole is referred to as 'building professionals' throughout this report.

The low numbers of developers responding to the survey meant that there was a bias towards the opinions of architects and consultants. The precise role of individual respondents or their firms in construction projects was difficult to determine, although the interviews and focus groups demonstrated the breadth of knowledge across the needs of planning, design and construction. Respondents therefore answered questions in the survey where they were able or otherwise left them blank.

The spread of respondents on a geographic basis was assessed by the areas in which they had experience of working. London had the greatest number of professionals with project experience in that area (66.4% (77)) whilst the North East had the fewest professionals with experience on projects in that region (26.2% (28)), as shown in Figure 4.

2.2.2 Interviews

A total of 20 telephone interviews were held, those taking part had knowledge of either flood or overheating adaptation, but a number had addressed both issues.

Of the 20 people interviewed, 13 had experience of developing in areas at risk of flooding and managing the risk of flooding, whilst all 20 had experience of overheating adaptation measures.

2.2.3 Focus groups

Two focus groups were run on 7th and 8th March 2017, in Manchester and London respectively. Following short scene setting presentations about overheating and flooding, delegates were invited to discuss several questions. The discussions were structured using a series of questions in order to address the costs, benefits and barriers. Delegates to both events covered flood resilience and overheating.

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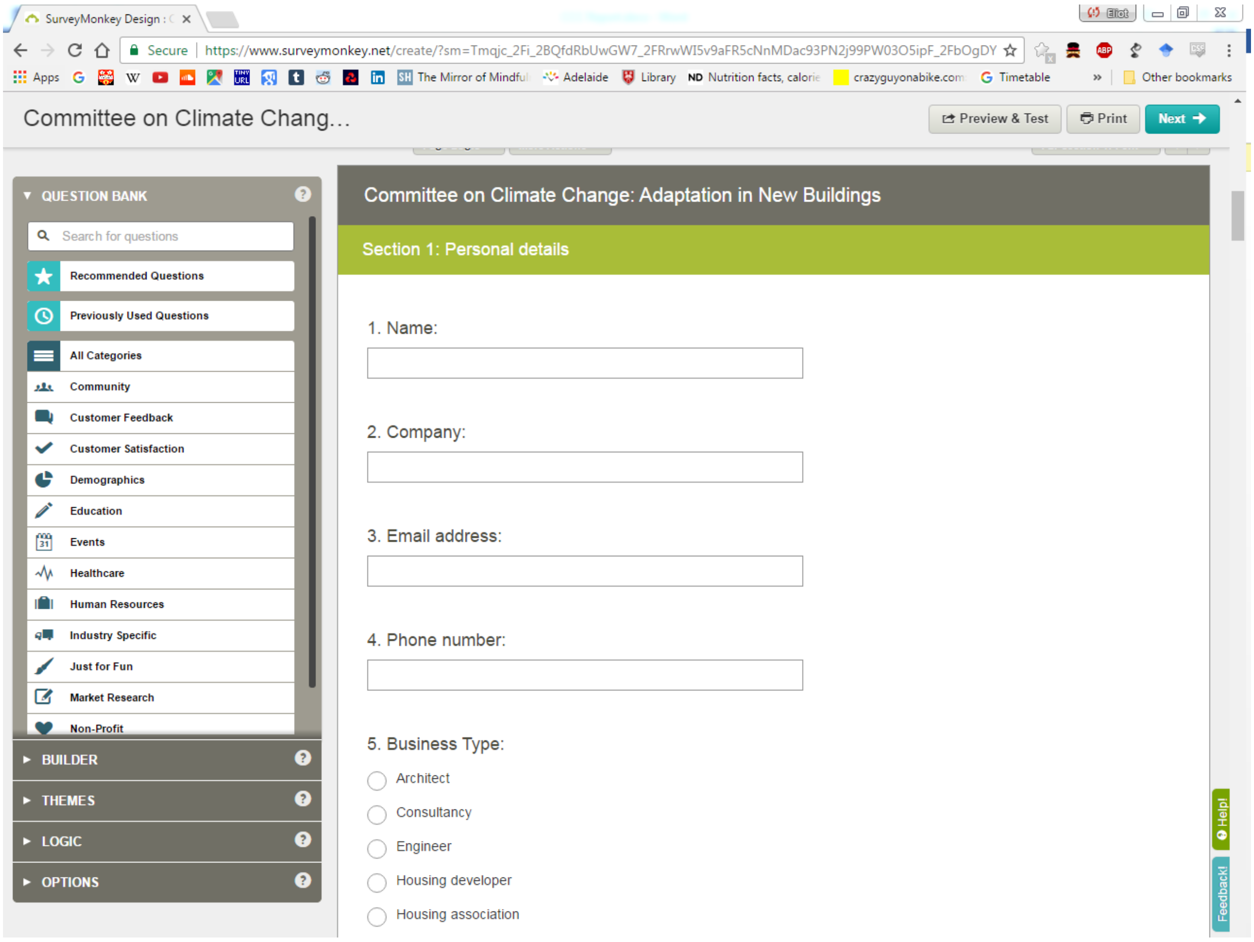

Figure 1: The survey was designed and managed using the ‘Survey-Monkey’ web based software

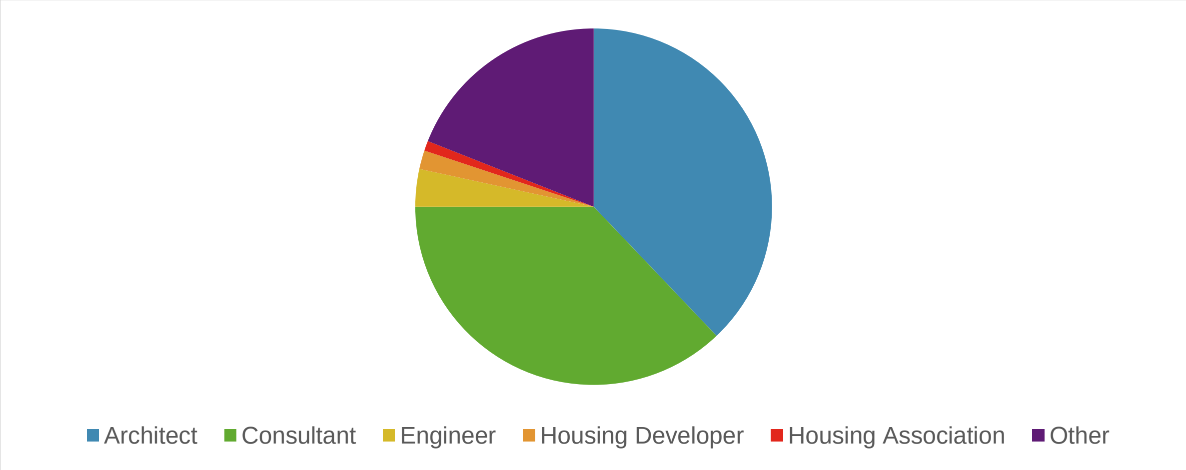

Figure 2: Response by type of building profession

Building Profession	% responses (number)
Architect	37.9 (44)
Consultant	37.1 (43)
Engineer	3.4 (4)
Housing Developer	1.7 (2)
Housing Association	0.9 (1)
Other	19 (22)

Figure 3: Survey responses by building profession (numbers)

Figure 4: Survey responses by experience of operating in geographic area

Geographical Area	% survey responses with experience operating in area (number)
North West	29.9 (32)
North East	26.2 (28)
Yorkshire and the Humber	29 (31)
West Midlands	29.9 (32)
East Midlands	30.8 (33)
South West	29 (31)
South East	48.6 (52)
East of England	35.5 (38)
London	66.4 (71)

3 Flood resilience

In this section of the report the results of the online survey, the interviews and the focus groups are reported with regards to flood resilience (figures are located at the end of the section).

3.1 Online survey

In the survey, building professionals were asked if they have had experience developing buildings in areas at risk of flooding; 64.6% (73) of respondents had experience of developing in flood risk areas, whilst 35.4% (40) did not (Figure 5).

Building professionals were asked which types of measures they implemented in their projects to manage the risk of flooding and how frequently they did so (Figure 6). The most frequently used strategies were found to be as follows:

- 'avoiding flood water reaching living/usable spaces' (83% (44) of professionals 'often' or 'always' used this strategy on their projects
- 'relying on existing defences' (66.6% (35) of professionals 'often' or 'always' used this strategy on their projects).

The least frequently used strategies were found to be 'relying on planned flood defences paid by others' (70.8% (34) of professionals 'rarely' or 'never' used this strategy on their projects); 'contributing towards new flood defences' (71.4% (35) of professionals 'rarely' or 'never' used this strategy on their projects); stopping flood water from entering living/usable spaces (64.6% (31) of professionals 'rarely' or 'never' used this strategy on their projects); and making living/usable spaces flood-resilient (62.5% (30) of professionals 'rarely' or 'never' used this strategy on their projects). Other strategies to which were reported in the comments section include the use of SuDS and onsite attenuation.

Building professionals were asked why they implemented measures in their projects to manage the risk of flooding and how frequently they did so in their projects for the different types of projects (Figure 7). The most frequent reasons for implementing measures were as follows:

- to secure planning permission (92.5% (49) 'often' or 'always' implement measures for this reason);
- to complying with 'building regulations' (75.5% (37) 'often' or 'always' implement measures for this reason);
- to achieve a level of design quality to meet a certain level of certification (72% (36) of professionals 'often' or 'always' implement measures for this reason).

The least frequent reasons for implementing measures were 'achieving higher property values' (54.9% (28) of professionals 'rarely' or 'never' implement measures for this reason); and for 'reputational gains' (48.9% (24) of professionals 'rarely' or 'never' implement measures for this reason).

In the comments section, it was also reported 'to be indefensible to do anything else' and 'rarely down to consumer demand, generally down to our recommendations.'

Building professionals were asked how they ensure that measures to mitigate the risk of flooding were effective (Figure 8). The most common response was 'relying on consultant's experience', with 96% (36) of respondents 'often' or 'always' doing so. The respondents are likely to implement the measures that the consultants said were the most effective to obtain planning permission. The use of standards (76.6% (36) responding 'often' or 'always'); certification (72.3% (34) responding 'often' or 'always'); and successful previous experience (79.1% (38) 'often' or 'always' doing so) also were frequently used to ensure measures are effective.

Testing of materials and products (57.8% (36) responding ‘rarely’ or ‘never’); and post-construction inspections (52.2% (34) responding ‘rarely’ or ‘never’) were least commonly used to ensure the effectiveness of measures.

Survey respondents were asked to give an indication of the costs associated with adapting buildings for flooding (see Figure 9a and 9b). Generally it was found to be more cost effective to design flood resilience into a new build compared to retrofitting an existing building to be flood resilient. Although a similar number of respondents reported that the cost can be ‘significant’ for both new builds (51.1% (22)) and retrofits (52.7% (19)), for new builds more professionals reported ‘little to no cost’ (39.5% (17)) compared to retrofits (13.8% (5)), whilst fewer reported ‘very high costs’ for new builds (9.3% (4)) compared to retrofits (33.3% (12)).

However several respondents mentioned in the comments section of the survey that a general estimate of costs for their projects is difficult as a large number of factors influence the overall cost, including the size and type of development; the type of measures implemented; the source, duration and depth of flooding; local topography and the client’s budget.

Respondents often found it difficult to answer detailed questions about cost, as the majority of them were not typically involved in the costing of solutions. As the question referred to their experience over a number of projects they were not typically able to generalise on actual costs, but could comment on their perception and general costs.

One respondent wrote the following comment:

> “I get the impression that the consultant reports are designed to satisfy the planning requirements or to achieve the necessary BREEAM credits/certification rather than to actually determine if building in such a situation is sensible or not - I have never seen a report that says 'don't build here' (i.e. in a flood risk assessment). Despite the consultant reports, assessments etc. the homes get built and they then flood…"

This type of comment was also made by other respondents and it was therefore followed in the interviews and focus groups.

Have you developed in flood risk areas	% Response (number)
Yes	64.6 (73)
No	35.4 (40)

Figure 5: Have you developed buildings in flood risk areas

Type of measure	How frequently is this type of measure used to manage flood risk in your projects? (% responses) (number)			
	Never	Rarely	Often	Always
Rely on existing flood defences	9.8 (5)	21.5 (11)	47 (24)	21.5 (11)
Rely on planned flood defences (paid for by others)	35.4 (17)	35.4 (17)	18.7 (9)	10.4 (5)
Contribute towards new flood defences	44.8 (22)	26.5 (13)	28.5 (14)	0.0
Avoid flood water reaching the living/usable spaces (e.g. raising the building above the predicted flood level, sacrificial ground floors etc)	1.9 (1)	15.1 (8)	54.7 (29)	28.3 (15)
Stop flood water from entering the living/usable spaces (e.g. flood doors and/or windows, walls and floors membranes, non-return valves)	41.6 (20)	22.9 (11)	27.1 (13)	8.3 (4)
Make living/usable spaces flood-resilient (e.g. water-proof floors and walls, raise services and resilient fittings/fixtures)	33.3 (16)	29.1 (14)	27.1 (13)	10.4 (5)

Figure 6: Which measures have you implemented to manage flood risk

Why do you implement and select these measures?	How frequently? (% responses) (number)			
	Never	Rarely	Often	Always
To secure planning permission	0.0	7.5 (4)	56.6 (30)	35.8 (19)
To achieve higher property values	25.4 (13)	29.4 (15)	37.3 (19)	7.8 (4)
To comply with building regulations	10.2 (5)	14.3 (7)	36.7 (18)	38.7 (19)
To achieve a level of design quality to meet a certain level of certification	18 (9)	10 (5)	48 (24)	24 (12)
Reputational gains	24.5 (12)	24.5 (12)	34.7 (17)	16.3 (8)
Consumer demand and satisfaction	14.2 (7)	22.4 (11)	44.9 (22)	18.3 (9)

Figure 7: Why do you implements and select these measures?

How do you ensure measures are effective?	Frequency of responses (%) (n = x)			
	Never	Rarely	Often	Always
Standards for materials and products	12.7 (6)	10.6 (5)	42.5 (20)	34 (16)
Certification of materials and products	14.9 (7)	12.7 (6)	28.3 (18)	34 (16)
Testing of materials and products	28.9 (13)	28.9 (13)	26.6 (12)	15.5 (7)
Installed by approved contractors	14.9 (7)	12.7 (6)	53.2 (25)	19.1 (9)
Consultants experience	1.9 (1)	1.9 (1)	49 (25)	47 (24)
Post-construction inspection	15.2 (7)	36.9 (17)	28.2 (13)	19.5 (9)
Previous experience of successful use	4.1 (2)	16.6 (8)	62.5 (30)	16.6 (8)

Figure 8: How do you ensure that these measures are effective against flooding

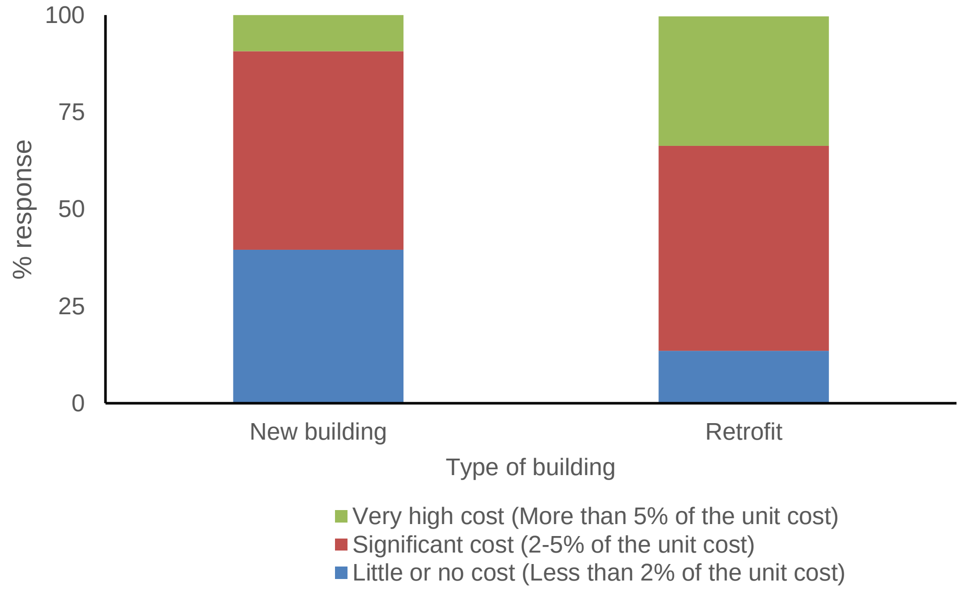

Figure 9a: Cost indications for flood resilience measures

Type of building	Little or no cost (Less than 2% of the unit cost)	Significant cost (2-5% of the unit cost)	Very high cost (More than 5% of the unit cost)
New building	39.5 (17)	51.2 (22)	9.3 (4)
Retrofit	13.9 (5)	52.8 (19)	33.3 (12)

Figure 9b: Percentage increase in cost (per unit) for including measures to increase flood resilience (number in brackets)

3.2 Interviews

Of the 20 people interviewed, 13 had experience of developing in areas at risk of flooding and managing the risk of flooding. Although the questions asked were tailored to the survey responses of the individual interviewees, the main aim of the flood resilience section of the telephone interview was to understand if buildings built in areas at risk of flooding are built to be resilient to flooding in a cost effective way, with the associated benefits and barriers.

3.2.1 How many properties have been developed in flood risk areas

This question drew a mixed response. Some respondents had significant experience of developing in flood risk areas (>80% of their projects were in areas of medium to high risk flooding) whilst others had little (one off development) or no experience of developing in areas at risk of flooding. The geographic location of the professional may help to explain this aspect with many working around London and the south east, where development in flood plains is often undertaken.

One respondent suggested that in the future, many more new builds will be developed in areas of flood risk, due to the increased risk of flooding due to climate change. They also suggested that some properties that they had developed in the past could be at increased risk due to climate change; possibly not at risk now, but will be in future; or were currently at risk, but at even greater risk in future.

Flood risk assessments were carried out for any new development, which was standard practice. There are different sources of flood risk information that can be used by developers and their consultants, often combined with assessments of the future allowance that should be made for climate change.

3.2.2 When you do build in a flood risk area, how is it approved during the planning process

All interviewees reported that if the development is at risk of flooding, there will be planning conditions set by the Environment Agency and local planning departments that must be met to allow the development to be built.

The majority of respondents reported that flood risk is considered on all their developments, either in the form of a basic assessment or a full flood risk assessment where the risk is higher. Flood risk assessments are performed by flood risk consultants, who prepare a report making suggestions for appropriate measures to mitigate any risk of flooding. The consultant may recommend different solutions with differing levels of complexity, from which the developer can select based on their budget. If the development is in a high flood risk area then there are planning restrictions.

Requirements often include attenuation measures to pre-development levels to ensure provision of the same volume of flood space is designed into the development for on-site attenuation. Permeable surfaces and SuDS are typically employed for this reason in larger developments. Although these measures are to manage surface water risk they often were included as requirements across a range of flood risk. Sites often had not only river or coastal risk, but also surface water or groundwater.

The most common measure to manage the risk from river flooding was reported to be raising the level of the building. This was achieved either by raising the ground level or building a ‘water sensitive’ ground floor and having the principle living level and other occupied spaces on the first floor and above. Other measures typically taken are described in Section 3.2.4.

3.2.3 Do flood risk assessments include climate change allowances

Several respondents reported that designers do not routinely consider climate change when designing buildings, as it is not a building regulation requirement. However, projections for increased risk of flooding due to climate change were included in flood risk assessments. The flood risk assessment was considered to be a specialist aspect of a project that was undertaken by a consultant and not all respondents knew exactly how it was undertaken. Where flood risk exists on a site then resilience measures would include climate change allowances.

The Environment Agency planning guidelines for flood risk assessments and strategic flood risk assessments have climate change allowances for increased peak river flow for the different major river basins, with projections for increased peak flow for the 2020s, 2050s and 2080s. Several interviewees reported that these allowances have recently been updated (in 2016), but most reported using the older allowances of +300mm for all river basins. It was reported that when SuDS systems are designed, they are designed with allowances for climate change.

It was stated that it was more common for larger project, such as critical infrastructure, to include allowances for climate change. It was reported that some industries have relevant guidelines, such as the utility industry and that on these types of projects this issue is always considered. However, it was unlikely to be addressed in smaller housing developments.

One consultant reported that they run a series of regular climate change adaptation workshops to help to educate clients and designers of the increased risks and the importance of designing with these in mind, which helps to embed resilience in their projects. Some respondents reported that BREEAM awards credits for Adaptation for Climate Change, which includes consideration of future increased flood risk.

3.2.4 What particular measures do you use to manage the risk of flooding and why

Telephone interviewees were invited to further elaborate on the measures that they use to manage the risk of flooding on their developments (see Figure 6 for online survey responses regarding this issue). In particular, why they selected the particular measures they do and the advantages and disadvantages of different measures.

All interviewees suggested that measures were typically selected based on a bespoke site specific assessment to ensure they are appropriate, following the completion of a flood risk assessment. The measures are then selected based on recommendations of a suitably qualified consultant; either the interviewee themselves, an in-house consultant or an external consultant. A combination of cost effectiveness, the requirements of regulatory bodies (local and national) and build-ability all inform the type of strategies selected.

Housing developers suggested that first having calculated the risk to a property and the source of flooding they then select the most cost effective solution from a bank of measures predetermined to be appropriate to that level of risk. Although it was also suggested that if at all possible to avoid building in the flood plain.

Raising the level of the building, either by raising the building on foundations or a platform, raised earthworks and/or having a sacrificial ground floor designed that was not to be a living space (e.g. a car park) was a common response. There was a mixed response on how this affects the project capital costs but several interviewees suggested that it was less expensive the earlier it is integrated into the design process.

Interviewees try to use simple, passive design features where possible and avoid relying on active measures, such as temporary flood barriers. The use of measures that require manual intervention increases the risks involved. The fitting of a demountable flood barrier requires someone to receive a warning that a flood is likely to occur and then being in a position to fit the item. There are a number of things that can go wrong and as such any measure that eliminates manual intervention was viewed as favourable.

Resistance and resilience measures were not widely mentioned. Some interviewees were not overly familiar with these strategies and suggested they were relatively uncommon. Others suggested that typically only the bare minimum and most cost effective solution were implemented; if raising the building above the Environment Agency's recommended flood level is deemed as suitable risk management, then it is unlikely that internal spaces will be designed to be extensively resilient. Indeed ground floor level raising was the recommended approach from the Environment Agency, thereafter if the floor level cannot be raised above the estimated flood level plus climate change then resistance and resilience measures would be used. Despite this guidance a number of respondents did mention that they specify the interior of some buildings to be resilient (selecting appropriate materials for insulation, fixtures and fittings) and resistant (e.g. using flood doors and non-return valves).

Some of the less common but interesting strategies that were mentioned during the telephone interviews include the following:

- Integration of a hydropower system into a flood wall and landscaping to combine flood resilience with onsite energy generation.
- Floating and amphibious houses could be built in high flood risk locations.
- Raising existing building (more common in Australia and New Zealand where lightweight timber framed properties are very common); not common in the UK due to a prevalence of brick and block construction types.
- Geotechnical solutions such as grouting the earth underneath buildings to improve their resistance to groundwater flooding.
- Raising the level of wiring, services to be above the 1 in 100 year flood level.

One interviewee commented that innovative measures might not be well received by clients due to their inherent risk aversion; they want cost effective, tried and tested solutions. Another respondent reported that a catchment based approach to flood risk management should be favoured over building level measures. This respondent noted that the current practice of raising defences and buildings is rather futile and that studies are required into water management over a catchment rather than over an area subjected to flooding. Problems could be solved by management of the water long before it reaches populated areas.

Although the interviews focussed upon the aspects of flood risk in river and coastal situations the use of Sustainable Drainage Systems (SuDS), sacrificial green space to allow flooding to take place in designated areas of the development and integrative design of landscaping and hardscaping was reported. Several interviewees reported that these resilience measures are included in the majority of their projects. Types of SuDS that were mentioned include: rainwater harvesting systems; infiltration systems; swales; pervious/permeable pavements and hard standings; attenuation storage tanks; ponds and planting of trees. However other interviewees reported that green infrastructure is often one of the first aspects of a project to be reduced in scope or cut altogether if budget constraints arise. The wider benefits of green space were recognised and taken forward by more ‘forward-thinking’ clients.

Green and blue roofs were reported to be more commonly specified in densely populated urban environment with fewer permeable surfaces. One interviewee reported that they regularly advised clients on the use of green roofs to offer both stormwater attenuation, but that they found that this measure was often cut from a design due to budget constraints.

3.2.5 Who requires these measures and is there a process to check that appropriate measures have been implemented post-construction

Where requirements or conditions to mitigate the risk of flooding were made as part of a successful planning application, there is usually a requirement from the planning authority to show that such measures have actually been built as designed. Evidence should be provided, for example by submitting drawings and photographs. However this is not necessarily just to prove that measures to mitigate against the risk of flooding have been installed. Instead it is a requirement where any planning conditions have been set, before being signed off.

There was no mandatory formal inspection process. One respondent reported that buildings are unlikely to be investigated unless there is a complaint associated with planning conditions not being met.

3.2.6 To what extent is there consumer demand for flood resilience

Many respondents argued that flood resilience is not a major factor in client briefs or something that is brought up, other than to satisfy existing regulation, which is argued to be relatively weak.

Others argued that there is demand for flood resilience but more in the sense that people just expect their properties not to flood rather than it being a factor which they would consider when purchasing or renting property. Estate agents were said not to raise the issue of flooding as this could affect the value or saleability of a property. Although it is a requirement to have a flood risk assessment as part of the searches for the property transaction.

Some interviewees had the opinion that the public are not generally well informed on flooding as an issue and have 'short memories'. Areas that have recently been subject to major flood events, such as Cumbria, were argued to have flooding higher up in the public consciousness, though respondents couldn't quantify how this manifested itself in client briefs in these areas.

Some clients do have greater awareness towards risks and specify measures to mitigate the risk. These clients, including housing associations, universities and health care facilities, are more likely to include resilience in their briefs. The main motivator for this is the desire to prevent valuable assets from being stranded.

One respondent described how over 55% of UK pension funds are invested in real estate and that as an awareness of the risks to these assets develops, resilience is increasingly specified by clients to help protect the value of such assets.

Some clients have an expectation that risks that could be mitigated against through resilience strategies are actually covered by insurance and therefore no investment would be required at the construction stage.

Some respondents found it hard to comment as designers and consultants are not typically in touch with the end user, so there isn't much feedback regarding what the end user wants, other than that which is specified in the client brief.

For commercial developments, it was argued that there is a demand for flood resilience only to the extent that insurers require them to do so, if at all.

One respondent commented as follows:

> "Clients are not necessarily complacent but want flood resilience to be implemented as cheaply as possible."

Another respondents commented as follows:

> "Most housing developers simply do the minimum that regulators allow them to get away with, at the cheapest cost possible. They don't care if a house will flood in 10 years, as long as they can sell it on for a profit in the short term. This coupled with an apathy towards or lack of awareness regarding resilience from clients, or generally lack of appetite to spend money on such things means that resilience is not high on the agenda."

3.2.7 Can a building or development be 'future-proofed' against flooding in a cost effective manner

This was difficult to comment on for some respondents whose work ranges from single residential buildings to large housing developments, hospitals, university buildings, for which the costs are significantly different.

All respondents argued that the earlier that measures to manage the risk of flooding are designed into the building, then the less impact there is on cost. It was argued that if measures are 'tacked-on as an afterthought' then this increases the cost and reduces the options for different types of measures. However it may be difficult to compare the cost of a resilient and non-resilient house in the same location, as measures to manage the risk of flooding are a requirement of planning, rather than being optional.

Some interviewees mentioned that the regulatory requirements on some sites were too onerous to allow them to come up with a cost effective solution and so the development was abandoned. However, interviewees argued that it would be cost effective when compared to the cost of repairing the building if it does flood. Retrofitting was also argued to have far fewer options and is much more expensive. Housing developers indicated that measures are rarely over-engineered above and beyond planning requirements as this reduces profit margins.

Several respondents mentioned that they were not directly involved in the specific costs of measures and that this was the job of quantity surveyors, commercial departments or other professionals.

Several respondents raised the issue of insurance and whether or not it was cost effective if resilience is adequately rewarded in insurance schemes. The most significant costs were argued by different parties to be as follows:

- In the design of buildings to remove non-resilient materials and products.
- The raising of building levels through groundworks.

Although not strictly relevant to managing river and coastal flooding SuDS were argued to be an effective solution for surface water management, but a cost side effect being that they reduce the total usable space of a development, reducing up front profits as fewer buildings can be built in the same site, or those that are built must be made smaller. They also involve issues over who is responsible for their adoption and therefore maintenance costs.

3.2.8 What are the main existing drivers for the implementation of measures to improve flood resilience

Interviewees were asked what, in their opinion, acted as the main existing drivers for the implementation of measures to mitigate the risk of flooding. Similar themes were raised by more than one interviewee as follows:

- Existing planning and legislation requirements at both the national and local level when building in areas at risk of flooding is argued to be the most effective current driver; although debate surrounding the effectiveness of that which currently exists was entered into by seven interviewees.
- Existing certification schemes such as BREEAM were argued by three interviewees to be drivers of flood resilience to some extent as they award credits for management of surface water, use of SuDS and flood resilience. However, this only applies to non-residential buildings. It was suggested that the Home Quality Mark (HQM) could act as a driver for flood resilient construction in the future, although this depends on the extent of its uptake.
- Risk of loss of reputation, designers and engineers don't want their own designs or buildings to be damaged by flooding was raised by three interviewees.
- Three interviewees referred to the risk of lack of coverage by insurance for properties built in a vulnerable manner in high flood risk areas.
- Improved awareness of the issue, especially in areas that have recently been affected by flooding according to six interviewees.
- One interviewee stated that existing guidance regarding the current risk of flooding and the need for climate change adaptation e.g. UK Climate Change Risk Assessment; albeit how to implement on a local level was still seen as an issue.

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- Resilience measures would be a way of mitigating against the risk of 'stranded asset' that could not be sold or would lose value, as stated by one interviewee.
- Higher level legislation such as the Climate Change Act and the UNFCCC Paris Accord were argued to be drivers for climate change adaptation measures by two interviewees.

3.2.9 What are the main existing barriers to the implementation of measures to improve flood resilience

Interviewees were asked what, in their opinion, acted as the main drivers to the implementation of measures to mitigate the risk of flooding. The following comments were raised:

- A common response was the client's resistance to the potential increased costs associated with the addition of flood resilience measures. There was no financial or altruistic imperative to build in resilience, especially for volume housing and commercial developers. There was a need to educate clients, whether they are developers or indeed the purchaser of the property (housing or commercial).
- Some respondents considered that there was a lack of care by developers and private homeowners about the issues, unless it was a way to provide more usable space thus increasing the value of the property. Typically householders are unwilling to spend much money on improving the resilience of the development and individual choices are driven by "it won't happen to me".
- Developers want to maximize number of properties on a single site and flood resilience often requires lower density development.
- There is a perception from home owners that flood resilience is not rewarded adequately by the insurance industry and therefore is not worth investing in. Some clients just assume that insurance covers risk so no need to make buildings resilient. Thus there is apathy and no major desire for flood resilience, rather consumers just assume their homes will be fine (in project briefs).
- A flood resilient property may take more time to construct, e.g. for raising earthworks, pulls time away from building, preventing efficient development of a site.
- The problem of managing flood risk may not be easily resolved by taking action to make the development more resilient. Instead planners need to take a whole catchment scale approach. It is difficult to address the flood resilience of one development if problems exist elsewhere in the catchment.
- Although planning regulations exist they are seen as weak and are often ignored or bypassed in favour of the imperative for new development. Local plans amount to effectively different planning requirements in different areas.

There is a lack of leadership on flood resilience in the construction industry. There is also a lack of awareness of the benefits of measures to create resistance or resilience approaches with some interviewees not familiar with these approaches, preferring to raise the building threshold. There is a significant skills and knowledge gap through industry, including designers and builders, education is needed but this can require technically complex engineering expertise. The industry is not specialised as contractors will build in areas that are both at risk of flooding and those that are not. They are unlikely to gain significant expertise as only some proportion of their projects will be in flood risk areas, so they are less likely to learn from the past.

There is uncertainty over what to design for, for example the following:

> "inherent uncertainty of scale and intensity of future impacts of climate change therefore difficult to recommend appropriate solutions. More research and guidance is required for this issue; for example what does 2 degrees, 4 degrees (temperature increases) actually mean, what is the expected flood level in each scenario; local impacts vs generic country level impacts."

Solutions could be technically complex and will require engineering expertise. Complex issues require the input of multiple specialists to tie together all the design issues. At present there is not adequate capacity in the supply chain. It was noted by some interviewees that flooding doesn't always occur in predictable ways that might be expected, e.g. land can flood on a hill due to surface water runoff. Measures are often tacked onto the end rather than integrated into the design from the beginning.

Communication to developers and the public was considered to be necessary. This requires better metrics to easily communicate risk to the public. Innovators in this sphere often market their solutions to flood resilience poorly, or need help to increase their influence. Assistance with developing resilient solutions that can be achieved cost effectively is required.

3.3 Focus Groups

The focus groups were provided with a presentation of the issues of flood resilience. A series of questions were then used to lead the discussion.

3.3.1 Can a new building be 'future proofed' against flooding in cost effective manner

At the start of the discussion, it was correctly pointed out that the use of the term 'future proofing' was problematic, as although flooding will likely be exacerbated by climate change, the risks of flooding are present today. Therefore buildings need to be 'present-proofed' rather than just 'future-proofed'; put differently this means that sufficient resilience measures need to be designed and built in now rather than simply left to a later adaptation of the existing structure.

The general consensus of the discussion was that buildings can be made flood resilient cost effectively if measures are designed in early enough. It was also agreed that retrofitting buildings would be more expensive and with fewer possible options. However several of the delegates reported that they were not typically involved in financial aspects of their projects.

A discussion arose around who should pay for flood resilience. The government, housing developers and the building owners themselves were all argued to be partly responsible for ensuring the resilience of buildings to flooding.

One delegate reported that "there is an urgent need for exemplary case studies of cost effective solutions that work, to showcase different ways to work with water, with different sources of flooding". Another delegate described how "SuDS can be difficult to justify in costs, as they add to the capital costs of a development and are often one of the first features to be cut in a project with a tight budget. Developers aren't interested in the wider benefits associated with SuDS such as amenity provision". Raised earthworks were argued to be an effective but an expensive solution to reduce the risk of flooding to the property development.

Non-domestic buildings were argued to be much better at addressing flood risk than residential properties. However, some types of buildings such as storage facilities are particularly vulnerable due to the losses experienced by a flood event. In addition, small businesses are more vulnerable to flooding and many are forced to go out of business when impacted by a flood.

3.3.2 What resilience measures are reasonable and meet the needs of people as well as designers and builders

One delegate argued that the best way to avoid flooding is to avoid building on the floodplain altogether, and that guidance to this effect is regularly ignored in favour of development on the floodplain. The delegate questioned whether designing and retrofitting buildings to be resilient to flooding was just a way of justifying development on a floodplain and getting around planning restrictions. This question was countered by arguments that rigidly sticking to planning rules would take out development in large areas of the country, including established settlements. This would be a detriment to local economies and that locations not currently at risk of flooding will be in future, so building in resilience today is prudent.

Another delegate suggested that "people like living near water, so we should make it feasible for them to live nearby water in the future." It was argued that for new buildings flood resilience can be a simple matter resolved through the property and site design. There are design tools available to use, but a lot of the designed in resilience measures are removed as it moves from planning to the actual construction.

The delegates agreed that passive resilience measures should be designed with how the end users will use them in mind. It was argued that protective measures must be passive, as flooding is a random event that is a function of climate. Buildings need to be resilient without the input of people who may not be able to respond to a threat of flooding if they are asleep, not in the building at the time or if they simply don't know how to use the protection measures correctly. Back-up generators and batteries for sump pumps are likely to fail if not properly maintained.

The aesthetics of flood resilient buildings were also discussed, with one delegate stating: "It is important that these buildings don't look like public toilets, which some designs and products have in the pasts, otherwise people will not want to live in these kind of buildings."

3.3.3 What are the barriers and how do they interact, and what are the solutions

A number of barriers were discussed, largely around the issues of planning, building regulations, costs, methods of incentivising, insurance, poor communication and lack of data.

Planning regulations were discussed. Despite the existence of regulation, planning permission was argued to be too negotiable to effectively help manage the risk of flooding. Planning departments are typically under resourced so many aspects are not thoroughly addressed. Planning officers, who are responsible to the planning committee, are not trained experts and are not taught the importance of every single aspect of regulations. There is no guidance on what is a 'hard line' that should never be crossed, and 'soft lines' that are more up for negotiation.

Planning rules are often compromised in favour of development. One delegate gave an example of a specific site as follows:

> "(a site was) completely unsuitable for development, but developers bought it speculatively. They brought in several consultants who said it is not viable, until they found a consultant to come in and say it is fine, probably for a price. The planning permission was only denied through a concerted effort by local people, and then only by a single vote."

The 'broken housing market' was also argued to be at blame for the lack of resilience of buildings. Private developers build as cheaply as possible to maximise profits or prioritise types of developments that command a high price over affordable housing. As ventured by one participant "developers don't want this [flooding] to come into the debate so they hire a consultant to not even raise the issue."

One delegate argued that "the younger generation, who increasingly rent privately instead of owning properties, are much more aware of the risks of climate change and are more interested in thinking in the long term and better quality homes", which could help to push a resilience agenda through client driven demand.

Another delegate argued that in private rented and council properties, there is a greater incentive to invest money to ensure that issues will not arise. Tenants may be more likely to demand such measures compared to private homeowners who must invest in the measures themselves.

It was widely agreed that even though flood resilience can be cost effective, it must be much better incentivised as 'currently no-one is willing to pick up the tab'. Some possible funding mechanisms were discussed, including the following:

- Community retrofit plans to embed resilience into neighbourhood plans; use civil payments to effect positive change in area.

- Incentivising mortgage payments by giving a better loan rate if resilience is built into the development.
- Rewarding developments further up in the catchment that prevent flooding to a development further down in the catchment.

The wider context of a development was argued to be important when managing the risk of flooding and by taking a catchment based approach, the level of protection required on site can be significantly reduced. There must be better communication and quantification of the wider benefits of green infrastructure so that local authorities and developers invest in green infrastructure and wider catchment area solutions. It was argued these should be a greater priority for government and local authority spending.

There was wide consensus amongst the delegates that resilience must be better incentivised for it to have a wider uptake. Some innovative approaches to ensuring resilience were proposed, as follows:

- A regular procedure for homes, analogous to a car MOT, to ensure that they are well maintained to minimise risks and to ensure that all resilience measures are working properly. Not just for flooding, but for general maintenance and other resilience matters.
- A standardised process for the handover of buildings to new buyers, including how to use resilience technologies in the form of some kind of digital housing manual. This would contain detailed instructions on maintenance, documentation of improvements that have been made, how to use implemented building measures; in the future this could be linked to BIM.

The role of insurance was discussed. There were numerous problems with the current approach to resilience by insurance companies, not least the no betterment approach whereby only like for like replacements were made. Although, one delegate argued that some insurance companies will pay for low or no cost improvements, e.g. re-wiring above the predicted flood level.

It was argued that there should be rewards for people who invest in resilience measures. The example of Scandinavia was given, whereby certified trades are linked to insurance, e.g. wet room tradespeople have personal certification (and personal liability if something goes wrong). If a bathroom is installed by a certified tradesperson, then lower cost insurance is provided. Insurance programs in the USA provide credit points based on the use of certified architects, engineers and other building professionals. The British insurance industry has a lot fewer links with industry, but it was argued that the industry should move closer to the Scandinavian model.

Insurance is against betterment as the market demands that people shop around annually for insurance. As there is no loyalty insurers do not spend extra money on a property that may not be theirs to insure beyond the current year.

However, it is recognised that the insurance market increasingly wants to acknowledge resilience giving rise to the question of how can insurers make money and protect their risk using a resilience approach? Insurers and underwriters don't see it as protecting their risk. Is a new financial/business model required for a resilience approach compared to 'traditional' insurance models.

Educating the general public was argued to be crucial for embedding resilience in the built environment as there is a lot of misunderstanding and miscommunication surrounding the issue of flooding. Some specific comments were as follows:

- "Don't tell everyone we can completely stop flooding, inform them that we have to live with it"
- "Do homeowners fully understand the risks of flooding? Do they understand what a 1/100 risk actually means? Would argue not and also that it is not a factor widely considered when purchasing a property. If they buy a property in an at risk area which is yet to flood they may be initially able to get insurance, but if and when it floods this may not be possible."

- "Some people are condemned to living in high flood risk areas and can't escape their non-resilient homes as they can't get insurance on them or can't sell them."
- "Is there a responsibility for the developer to communicate the risk? They build and sell property now that they know are at risk."
- "A lot of people think it [resilience] is not their problem, instead it is that of the government."

One delegate posed the following question:

> "How would the situation change if people were fully aware and demanded resilience? Simple effective measures already exist, but why are they not widely implemented? Where resilience is implemented how is it reflected in the price of the building, if at all? Will the end consumer be charged more?"

Another delegate suggested that "innovative ways of communicating the risk of flooding are required". A number of further requirements that would enable a wider uptake of flood resilience measures were identified, including the following:

- Guidance on flood resilient design details, such as junctions and elements.
- Standards and guidance for adapting buildings to the risks of flooding and embedding resilience into the design and build.
- Certification of buildings, products and installers.
- Better trained surveyors who can assess a whole house and take a holistic approach to resilience – not necessarily just flooding.
- Better data and hard research on the performance of measures, with evidence based fully costed metrics for comparing options. Further research in this area and the development of metrics could help to better inform designers, planners and local authorities.

3.4 Summary

The adaptation of building design and construction has been addressed through online surveys, interviews with practitioners and focus groups. Of the respondents to the online survey 64% had experience of developing in flood risk areas, particularly existing floodplains, either greenfield or brownfield development. The interviews provided further data on practitioner experience with one interviewee indicating that over 80% of their projects were in flood risk areas (medium and high), whilst others had little or no experience, possibly just one-off relevant project experience only.

3.4.1 Costs of flood resilience

The types of measures involved were to rely on existing defences through to taking resilience measures involving changes to the design and construction of the building. The majority of respondents and interviewees indicated that reliance on defences and/or avoidance strategies were adopted. As regards avoidance this was focussed on preventing water from reaching the living level of the building via land raising in the floodplain, raising the building level or making the ground level of lesser sacrificial use.

It was noted that over 50% of respondents would never rely on contributing to the costs of new flood defences, with less than a third often relying on this approach. Uncertainty about whether or not such defences would be built or would be adequate was a drawback for most designers and developers.

The online survey found the following:

- For new buildings, 15 of the total or 39.5% of respondents indicated that measures to improve the flood resilience of buildings has little or no increase (0% to 2%) on the unit cost of the building.
- For new buildings, 19 of the total or 50.0% of respondents indicated that measures to improve the flood resilience of buildings had a significant increase (2% to 5%) on the unit cost of the building.
- For new buildings, four of the total or 10.5% of respondents indicated that measures to improve the flood resilience of buildings had a very high increase (>5%) on the unit cost of the building.

- For new buildings, 39.5% of respondents indicated that measures to improve the flood resilience

As the online questionnaire asked questions regarding the general costs, rather than fully costed works it was difficult to precisely relate the measures taken to the cost increase. The cost issues were indicated in the interviews and the focus groups to be highly project and site specific rather than being possible to generalise the measures against the cost. The building professionals that responded to the online survey were often not those with a direct involvement in the actual costing exercises and decision making that was undertaken on a project. Whilst there was an overall appreciation of flood resilience and the need to take additional measures the actual resilience measures and costs were not always well known by respondents. Indeed in the interviews a number of the interviewees indicated a lack of knowledge of measures such as resistance and resilience. This was considered to be common across the industry where lack of awareness and gaps in education were noted as being likely to mean these measures would not be used.

Flood risk management was an accepted part of the planning process. The response of developers to manage river and coastal flood risk was typically a mix of reliance on flood defences combined with floor level raising. The raising of the floor level through either land raising of a site or introducing a 'sacrificial' ground floor might be viewed as an avoidance approach rather than adapting the building design and construction through the resilience of the fabric and services. The application of resilience measures in the building design and construction was limited. The measures (defences and floor level raising) used to manage flood risk were indicative of a planning driven approach as opposed to those driven by building regulations which focus on the building design and construction itself.

The costs of designing in measures as opposed to retrofitting measures at a later stage was indicated as generally being lower. The category of significant costs (2% to 5%) were however thought by about 50% of respondents to apply no matter if measures were designed in or were retrofitted after construction. At the higher end more respondents considered that there was more cost associated with retrofitting (38.7%) as opposed to building in (10.5%).

In the interviews this difference was further examined and it was generally agreed that retrofitting resulted in higher costs than designing in from the start. However, it was noted that the design and construction costs under a retrofitting approach need to take account of additional costs, such as relocating people during works, or indeed the costs associated with litigation actions. Although it was noted that there appeared to be less litigation with regards to flood risk than overheating. In flooded buildings as long as the owner is insured then they are considered to be covered and litigation is unlikely to arise. In the longer term more issues with insurance affordability and availability in flood risk areas may arise for new development.

In the interviews the cost effectiveness of measures was addressed further. Once again the absence of consistent data across a range of sites gave interviewees difficulty with making estimates of the actual costs associated with flood resilience adaptation. The costs were often associated with groundworks involved in land raising, and essentially determining that seeking solutions for the site would not raise issues elsewhere. Interviewees were generally less well versed in the costs associated with resistance and resilience measures, although some considered that they would not be a specific hindrance to new development.

Other potential solutions such as SUDS were considered cost effective. However, the loss of a number of houses or floor space in any one house to enable their implementation would offset a good effective measure being implemented.

3.4.2 Benefits

The benefits of including flood resilience measures in new building development was addressed through the different surveys. In the online questionnaire a number of choices were given in order to develop land at flood risk.

The respondents indicated that securing planning permission was a major benefit to include flood resilience measures. Over half of respondents often did so and around 40% always did so. Interestingly none of the respondents 'never' included measures to secure planning permission, i.e. planning was frequently a factor for site development. The resilience measures delivered were often those associated with land raising or building (living level) raising. The implication is that if the building itself is vulnerable to damage by flooding that it is raised above a certain level, which is in accordance with current planning requirements. However, the interviews also showed that whilst this was a common approach that designing for future flood depths was not straightforward. There was concern from respondents over the uncertainty of climate change and whether or not the floor level raising or flood defence designs were sufficient. The concerns were raised more prevalently by architects and developers involved in building design and delivery rather than those involved in consultancy.

Other benefits such as achieving reputational gains or improving the property values were generally found to be less of an issue for respondents to the survey. The property value has probably much greater dependency on location, size and type of property rather than if resilience measures have been included. However, it was still be seen as a benefit either often or always by around 43% of respondents.

Achieving a level of design quality and certification figured highly on the responses with around 70% of respondents either often or always indicating that they addressed thought it was a benefit. The impact of consumer demand was mixed with 60% thinking that it often or always was used for this purpose, whilst 40% thought resilience was either never or rarely used for this purpose.

The benefits of using flood resilience measures in order to satisfy planning requirements was further highlighted within the interviews. The role of consultants in determining the appropriate measures was set out. Often this starts by considering a range of measures, but what can be implemented will be restricted by the developer's budget. On site flood spaces, attenuation and the use of sustainable drainage were all seen as flood resilience measures.

The interviews also addressed the issue of consumer demand for flood resilience, including developers, large holders of built assets and the public. There was a divide in the response that reflected experience of these different client groups, on the whole there however appeared to be a lack of demand from clients and that this was often driven by an expectation that new property will not flood. Whilst this finding is not perhaps surprising ("why would anyone expect a new property to flood") the overall impression is of a lack of knowledge amongst the client groups including the risks involved on some sites.

Overall it would seem that at present flood resilience measures for new build properties cannot readily be identified with benefits directly to the clients and consumers. Lack of acceptance of flood risk by those ultimate users of buildings combined with the developer focussing on securing planning permission works against extracting a higher value from resilient properties.

It is often considered that people value living and working in areas that overlook the sea or a river. However, it is clearly thought that the risk of flooding is being managed or there is a lack of awareness of the risks even if defences are in place. The benefits of including resilience measures are not well enough known to register highly amongst the client groups.

3.4.3 Drivers

The drivers for the inclusion of flood resilience in design were also addressed through the surveys, with further information being sought through the interviews and the focus groups.

The issue of planning permission arose and was seen to be the most effective driver for flood resilience. This was the only driver that would be considered to be legislative and subject to relevant regulations. The guidance associated with planning is however limited with respect to any detailed resistance and resilience measures. Therefore, respondents and interviewees were left unable to assess the effectiveness of the planning requirements. Planning as a national requirement through the National Planning Policy Framework should lead to consistency of approach across England.

In addition to planning the issue of building regulation was covered by the interviews and focus groups. The interviewees and delegates generally expressed the opinion that incorporation of flood resilience within building regulations would be the main driver that could be made by the government, using legislation and regulation. The incorporation of a suitable regulation within supporting guidance of the Approved Documents and reference standards could drive change effectively. The detail of what was required was limited within the discussions, however, several models of delivery through regulation might be possible. The options would include the following:

- The incorporation of a regulation and guidance within an existing part of the building regulations.
- The creation of a new part to the building regulations.
- The dispersing of mandatory measures and guidance across the existing range of relevant regulations.

The interviews and focus groups provided specific feedback on the types of measures that were actually taken in new developments. Whilst the approach was often to raise land or the height of the lowest living level of the buildings, there was also a range of passive building design measures that could be taken. If good examples of resilient design could be shown that work in a predominately passive manner then this would act as a driver for further flood resilient projects to be realised. Some of these measures are effective at no additional cost such as the height at which electrical sockets, meters and fuses are located. The important aspect is to raise the location of services on a ‘sympathetic’ basis to the building. Designers should avoid simply locating electrical sockets half way up a wall on an ‘eye line’ when someone is sitting in a room. Instead using building features to ‘blend in’ the sockets themselves and how they are used would be beneficial. Employing flood resistant doors and any low level windows would be beneficial for any property in a flood risk area no matter if the land or building ground floor height is raised. The experience of consultants was a substantial driver to adaptation for flood resilience.

Further drivers related to meeting the intent of the United Nations Framework on Climate Change agreements, particularly that from Paris in 2015. Although such agreements address the needs of the mitigation of further greenhouse gas emissions, they also recognise that even restricting global temperature increase to 2°C will result in greater flood risk. Adaptation to climate change (including flooding) is set out in BREEAM and the Home Quality Mark. Ensuring that the adaptation aspect of such voluntary standards is strengthened over time will contribute to greater uptake of resilience. In addition, rewarding flood resilience rather than simply flood risk assessment within the standard could potentially result in greater interest in implementing resilience measures. Further area based planning and building related incentives, e.g. the London Plan, can result in greater uptake of resilience. However, as the issues are national then changing planning and introducing building regulation requirements would be much more of a driver than area based approaches.

The availability of insurance, including its affordability, for new developments was considered to be a potential driver of flood resilience. As FloodRe will not cover properties at high flood risk built after 2009 then any new build must take measures or risk subjecting those developments to blight. Where insurance cannot be obtained then its overall value may be affected and also the availability of mortgages. The insurance driver was not clearly agreed amongst respondents and interviewees, although it was clear that it could drive behaviour amongst developers and the public.

3.4.4 Barriers

The barriers to greater uptake of adaptation for flood resilience measures in new buildings were addressed through the various surveys. The online survey and the interviews strongly indicated the lack of building regulations with regards to flood resilience measures in flood risk areas was highlighted as the main barrier.

As flooding can occur years after a property has been built then the liability for such development falls to the owner.

The additional cost of property flood resilience measures to the developer were often considered to be such that even when they are designed into a new property that they are often removed during value engineering at a later stage. Adaptation measures that include resilience in the building fabric and services are not readily checked by planners, whereas where floor level raising is used then such works can be identified during site visits. The result is that developers can change designs and building materials rather than using the resilient design measures.

The developer would not necessarily obtain the benefit from installation of measures through an increase in property value. The developer is not considering the whole life costs of the property, but focussed upon the capital costs only. There are a few examples of domestic properties that have been commissioned by individuals for their own use and in such cases it is more likely that long term resilience measures will be retained. The same applies to non-domestic property where the client has directly commissioned the building.

The lack of awareness of the public in flood risk and therefore the use of resilient measures is a barrier. In effect there is a lack of client demand. Whilst the focus groups and interviews did highlight that the public is generally more informed on energy efficiency and some other aspects of sustainability that they are not currently expecting to buy or invest in a property that might flood. The public perception is that the government looks after flood risk through defences and drainage and as a result they do not accept their own risk and responsibilities. The online survey did indicate that client demand was an influencing factor in encouraging flood resilience, but it was still not fully engaged by developers.

The skills and capacity of planning departments was raised as being a barrier to implementing flood resilience measures. The loss of experienced staff from local authorities has resulted in a skills gap. The precise impact will be variable across the country, but it may result in the existence of defences being the main route by which the developer achieves planning permission rather than being required to take property flood resilience measures into the design and build.

4 Overheating

In this section of the report the results of the online survey, the interviews and the focus groups are reported for overheating. The results are described and figures and tables of results are presented (figures are located at the end of the section).

4.1 On line survey

Survey respondents were asked whether or not they generally consider overheating as a risk in new build projects (Figure 10). Overheating was typically considered a risk, with 85.9% (79) of respondents reporting that they either 'always' or 'often' consider overheating as a risk in new build projects.

Survey respondents were asked what, if anything, had ever stopped them from considering overheating at the design stage of a project (see Figure 11). A mixed response was found with this question (apart from 'not my organisations responsibility' which was reported as 'never' for 58.2% (39) of responses) with 'never', 'rarely' and 'often' yielding an almost equal split of response for each of the factors.

Survey respondents were asked how their assessments of overheating are performed (Figure 12). A mixed response was found with this question, with 'SAP appendix P', 'dynamic modelling' and 'simple assessment based on design characteristics' all yielding relatively similar results (52.7% (29), 62.9% (39) and 67.2% (43) responding 'often' and 'always', respectively).

Building professionals were asked which types of measures they implemented in their projects to manage the risk of overheating and how frequently they did so (Figure 13). Natural ventilation was the most commonly used measure (94.5% (69) responding 'often' and 'always'), followed by mechanical ventilation (76.4% (55) responding 'often' and 'always'); solar shading (78.1% (57) responding 'often' and 'always'); building orientation (72.2% (52) responding 'often' and 'always'); and thermal mass (64.8% (46) responding 'often' and 'always'). Passive cooling systems (68.6% (48) responding 'rarely' and 'never') mechanical cooling systems (68.1% (47) responding 'rarely' and 'never'); local urban planning (76.1% (51) responding 'rarely' and 'never') and green and/or blue roofs (57.9% (40) responding 'rarely' and 'never') were much less commonly reported.

(Note: Passive cooling is cooling achieved without the need for mechanical means; this means without mechanical cooling and therefore includes natural and mechanically driven ventilation systems. Mechanical cooling is refrigeration based cooling included in a system, may include ventilation or not, which could be a split or a full AC system.)

Building professionals were asked about the benefits of including measures to mitigate against the risk of overheating are (Figure 14). A 'desire to produce a high quality product' was the highest reported reason, which was reported by 71.6% (53) of respondents. This was followed by 'achieving a level of design quality to meet a certain level of certification' which was reported by 67.6% (50) of respondents. 'Achieving higher property values' was the least reported reason, with 24.3% (18) of responses reporting this as a benefit of including measures to mitigate against the risk of overheating.

Some further comments regarding the benefits of including measures to mitigate the risk of overheating were made as follows:

- "Regulation is weak in this subject. Other than good design skills there is little to ensure overheating is avoided"
- "Clients want to lower energy use / carbon footprint"
- "Some clients wish to demonstrate their commitment to sustainability"
- "Clients want easily managed, functional buildings."

- “Being associated with overheating is damaging to a brand”
- “We apply Passivhaus methodology to all our new build projects even if this is not a requirement of the contract as our experience indicates that this is the most reliable method of getting the building to perform as designed. This method only permits a simple evaluation of overheating and if we feel this needs to be considered further then a dynamic thermal model will be used. We do not work to BREEAM, CfSH or HQM, as it is not always necessary to evaluate overheating. For Passivhaus projects it is mandatory.”

Building professionals were asked if overheating had ever been identified as an issue after completion of a project (Figure 15). The responses indicated that 21% (16) of respondents reported that it was ‘never’ reported after the completion of a project, while 35% (26) reported that it was identified ‘rarely’, and 9% (7) ‘often’. Approximately one third of respondents (34.7% (26)) did not know if problems had been reported after completion.

Building professionals were asked if post-construction remedial works were required where overheating had been identified as an issue after completion of a project (Figure 16). One third (34.2% (13)) of respondents reported that remedial works had been required, compared to 65.8% (25) of respondents who said this was not the case.

Respondents were invited to comment on the type of remedial works required. The reported remedial works include the following:

- Removing window restrictors (2)
- Additional solar shading (3)
- Additional blinds (2).
- Education of occupants on use of building features, including mechanical ventilation systems or how best to utilize passive systems (2).
- Mechanical ventilation (2)
- Additional comfort cooling (3)
- Natural ventilation (2)
- Extra insulation on hot water pipes and fittings and HIU (1)
- Solar control film to roof lighting in passive shop building (1).

Survey respondents were asked to give an indication of the costs associated with adapting buildings for overheating (Figure 17). Generally it was found to be more cost effective to design overheating resilience into a new build compared to retrofitting an existing building to be resilient. Although a similar number of respondents reported that the cost can be ‘significant’ for both new builds (47.5% (29)) and retrofits (48.2% (28)), for new builds more professionals reported ‘little to no cost’ (47.5% (29)) compared to retrofits (17.2% (10)), whilst fewer reported ‘very high costs’ for new builds (4.9% (3)) compared to retrofits (34.5% (20)).

However several respondents mentioned in the comments section of the survey that a general estimate of costs for their projects is difficult as a large number of factors influence the overall cost, including the size and type of development; the type of measures implemented; the source and level of risk of overheating; and the client’s budget.

Finally, survey respondents were invited to make any further comment regarding the strategies they typically use to manage the risk of overheating and the challenges they face when doing so, yielding the following comments:

> “It is hard to beat the 5% of floor area rule. If this opening area is provided with cross flow there is unlikely to be a problem.”

"Domestic hot water circuits commonly installed in current apartment buildings can often lead to overheating the common areas where the circulation pipes run. This is a technology, planning and carbon content problem not related to climate adaptation."

"Building Regulations are inadequate in reducing/designing out overheating risk. Developers cannot be relied on to address overheating beyond the requirements of Building Regulations. Occupiers are unaware of the risk and not technically equipped to assess it when purchasing or leasing, therefore the market does not demand higher standards."

"It is very difficult to make a generalised assessment of costs as the range of options vary enormously from little cost in orientation of new buildings to complex cross cooling of existing and between building types e.g. houses v hospitals"

"Overheating is not a problem if buildings are designed by qualified professionals. Generally an issue when developers try to short change their customers."

"There is very little organised feedback from clients about building performance to the original design team."

"Enlightened clients assist in delivering sensitively designed projects which operate through all seasons."

"My one-off housing architecture work breaks down to two basic approaches - one for clients and the other for me. Both small scale. For me two cases studies have been built so far - one in 1996 and the other in 2014 - with a third case study now at design stage. For clients adaptation design is inevitably very low [almost zero] priority - with mitigation design a high priority. In my own case studies adaptation design and mitigation design are of equal and high importance. Natural cross and natural rising ventilation is considered carefully in my case studies but clients are not prepared to spend money or focus on adaption approaches [overheating is just one] on their own projects."

"As designers it can sometimes be difficult to say how our buildings perform in operation. Mechanical systems often mitigate risk of overheating. Feedback is rarely received by the design team unless a Post Occupancy Evaluation undertaken. We do analysis on the majority of our jobs so maybe that's why overheating is not much of an issue. Architects definitely need training in this field."

"Overheating would typically be assessed using Dynamic Simulation. Doing Dynamic Simulation can be very time consuming and for many projects is excessive in relation to the fee, especially when using natural ventilation. For these projects simple steady state calculations are completed and designers experience used however this does not allow an overheating risk to be properly assessed."

"Difficult to assess with basic tool such as SAP, which is not intended to be a design tool in the first place. If cooling is added in SAP it appears to make no difference to the overheating. Planners dislike the use of external shutters which can be highly effective. Urban planning relies on streets with opposite facing sides of the road - rather than all dwellings being able to face the same way. Ground floor flats and bungalows are significant issue because of lack of window opening."

"Overheating risk should always be modelled for naturally ventilated buildings."

"Most of the overheating we have is based on low temperature hot water boiler heat loss not common parts, overheating by solar gain is never an issue as mitigation is easily designed in."

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Do you generally consider overheating as a risk in new build projects?	% Responses (number)
Always	41.3 (38)
Often	44.6 (41)
Rarely	8.7 (8)
Never	1.1 (1)
Don't know	4.3 (4)

Figure 10: Do you generally consider overheating as a risk in new build projects

What factors stop overheating being considered at the design stage?	% Response			
	Never	Rarely	Often	Always
Overheating not considered to be a risk	35.9 (23)	32.8 (21)	29.7 (19)	1.5 (1)
Client has not requested measures related to thermal comfort	33.8 (22)	24.6 (16)	33.8 (22)	7.7 (5)
Lack of regulatory or other drivers to ensure it is included	28.1 (18)	28.1 (18)	34.3 (22)	9.4 (6)
Costs of designing in measures is prohibitive	28.1 (18)	35.9 (23)	32.8 (21)	3.1 (2)
Overheating measures would conflict with other aspects of the project	29.7 (19)	43.7 (28)	25 (16)	1.5 (1)
Not my organisation’s responsibility	58.2 (39)	28.4 (19)	2.9 (2)	10.4 (7)

Figure 11: What, if anything, has stopped you from considering overheating at the design stage of a project

How was overheating assessed	% Response			
	Never	Rarely	Often	Always
SAP appendix P	25.5 (14)	21.8 (12)	29.1 (16)	23.6 (13)
Dynamic modelling	22.6 (14)	14.5 (9)	41.9 (26)	20.9 (13)
Simple assessment based on design characteristics of the build	18.7 (12)	14 (9)	51.6 (33)	15.6 (10)

Figure 12: Where an assessment of overheating was performed, how was this assessed

Type of measure	% Response (number)			
	Never	Rarely	Often	Always
Natural ventilation	0.0	5.5 (4)	71.2 (52)	23.3 (17)
Mechanical ventilation	2.7 (2)	20.8 (15)	69.4 (50)	6.9 (17)
Air conditioning	21.4 (15)	34.3 (24)	40 (28)	4.3 (3)
Solar shading	2.7 (2)	19.2 (14)	63 (46)	15 (11)
Building orientation	5.5 (4)	22.2 (16)	50 (36)	22.2 (16)
Thermal mass	8.4 (6)	26.7 (19)	53.5 (38)	11.2 (8)
Passive cooling systems, e.g. evaporative cooling, thermally active building systems	28.6 (20)	40 (28)	27.1 (19)	4.3 (3)
Mechanical cooling systems, e.g. earth tubes, district cooling, exhaust air heat pump	30.4 (21)	37.6 (26)	28.9 (20)	2.9 (2)
Local urban planning	31.3 (21)	44.8 (30)	20.9 (14)	2.9 (2)
Green and/or blue roofs	11.6 (8)	46.4 (32)	39.1 (27)	2.9 (2)

Figure 13: Which of the following overheating mitigation measures have you used in any of your projects

Benefit of including measures	% Response (number)
Achieving higher property values	24.3 (18)
Securing planning permission	54.1 (40)
Complying with standards	59.5 (44)
Achieving a level of design quality to meet a certain level of certification (e.g. BREEAM, Code for Sustainable Homes, Home Quality Mark)	67.6 (50)
Reputational gains	48.6 (36)
Consumer perceptions of design features where these value the incorporation of adaptation measures	43.2 (32)
Desire to produce a high quality project	71.6 (53)
Other (please specify)	13.5 (10)

Figure 14: What are the benefits of including these measures

Overheating identified as an issue after completion	% Response (number)
Always	0
Often	9.3 (7)
Rarely	34.7 (26)
Never	21.3 (16)
Don't know	34.7 (26)

Figure 15: Has overheating ever been identified as an issue after completion of a project

Were any remedial works required?	% Response
Yes	34.2 (13)
No	65.8 (25)

Figure 16: If overheating has been identified as an issue after completion of a project, were any remedial works required

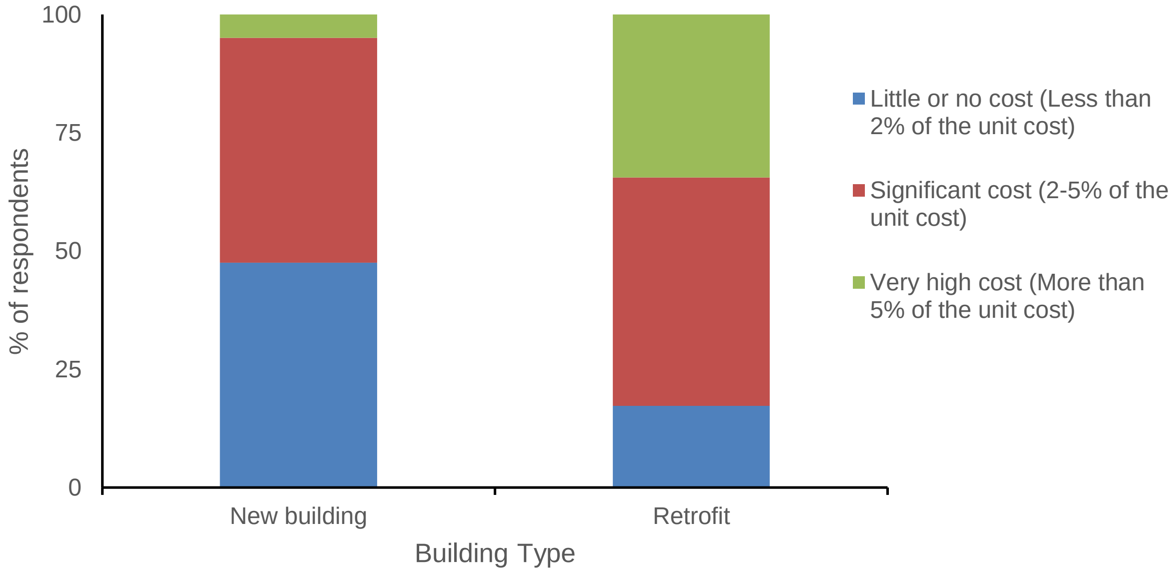

Figure 17a: Costs indicators for overheating resilience

Type of building	Little or no cost (Less than 2% of the unit cost)	Significant cost (2-5% of the unit cost)	Very high cost (More than 5% of the unit cost)
New building	47.5 (29)	47.5 (29)	4.9 (3)
Retrofit	17.2 (10)	48.3 (28)	34.5 (20)

Figure 17b: What increase in cost (per unit), if any, do building professionals associated with including measures to mitigate overheating

4.2 Telephone interviews

The aim of the overheating part of the telephone interview was to understand ‘where overheating is considered, and are companies successful at dealing with it at low cost?’ Alternatively if overheating is not considered at the design stage, what are the specifics about the barriers in question (e.g. specific costs, conflicts, perceptions)?’

Of the 20 people interviewed, all 20 had experience in managing the risk of overheating.

4.2.1 Who performs the assessment of overheating and how is it done

A variety of different professionals perform assessments of overheating, including building service engineers; mechanical and electrical engineers; building physics consultants; sustainable design consultants; energy assessors; and PhD students, depending on the organisation. Some organisations had in-house modelling teams, whilst others outsourced this service.

SAP assessment for new housing (Part L of the building regulations) is used, but it is argued by a number of respondents to be ineffective with insufficient focus on overheating risk and resilience.

Overheating assessment is performed to different levels as follows:

- Detailed for high risk properties, involving design consultants using thermal modelling.
- Adaptation checklists for lower risk properties.

Where an initial assessment of the risk of overheating is determined to be low, then it is not typically modelled further, especially for residential properties.

Where the risk is indicated to be higher, and for larger developments or buildings, a more detailed assessment of the risk of overheating is performed, typically in the form of dynamic thermal modelling. Factors that were reported as influencing the need for dynamic thermal modelling include the following:

- Developments with extensive glazing, especially south facing glazing
- Larger non-residential developments
- Highest risk urban developments
- Developments in densely populated urban environments most likely to be affected by the urban heat island effect
- If the building is in a high risk location, or deemed to be at risk, more detailed analysis is undertaken. This might involve development in an inner city urban location rather than a rural house.

Rules of thumb for ventilation were argued to be adequate for managing the risk of overheating in many development types by several interviewees.

It was noted by some respondents that BREEAM has requirements for calculating overheating, therefore commercial and public buildings may have an assessment of overheating as well as specified measures to address risk. For Passivhaus projects there is the use of a Passive House Planning Package (PHPP) tool to calculate overheating risk as part of the design process.

A barrier to more thorough and widespread assessments of overheating was identified by one respondent as the need for better, quicker and more accurate tools. A housing developer described how they use an adaptation checklist, which considers the risk of flooding and water shortages, as well overheating based on a checklist of factors including for coastal, fluvial, greenspace, urban, rural. Depending on these factors the checklist gives a set of requirements for resilience, which informs to what extent overheating should be considered a risk and to what extent it is modelled further.

One consultant reported that energy modelling and overheating are tested post-construction with onsite monitoring to compare predicted performance with operational. Factors including temperature, carbon dioxide emissions, humidity, ventilation, air-flow and air tightness are all measured. However this was not widely reported and it is not common practice.

Further reference documents for overheating were cited, as follows:

- CIBSE Guidance A and TM 52
- Building Regulations Part L.

4.2.2 Are measures to mitigate the risk of overheating mandatory for securing planning permission

Respondents largely agreed that there were no mandatory requirements within the planning system to ensure that buildings do not overheat and therefore the planning process does not currently act as a driver for managing the risk of overheating.

Some respondents reported that there was variable attention to overheating across planning authorities and that some planning officers consider it a more important issue, so in these local authorities requirements might be more stringent, but largely it wasn't considered mandatory. A housing developer reported that there is a tension in developments between building as cost effectively as possible (and therefore generally avoiding adherence to non-mandatory regulation) and protecting customers by providing healthy and comfortable buildings.

CIBSE advice was used as a guideline threshold in planning, including maintaining bedroom temperature at no more than 26°C.

4.2.3 Are assessments of overheating based only on current risk or do they also consider the increased risk due to climate change over the life cycle of the building

Interviewees reported that for any development where dynamic thermal modelling is not performed, the increased risk of overheating over the life cycle of the building due to climate change is unlikely to be fully considered. Several argued that this was not commonly the case as developers build for onward sale and profit in the short term, and have no incentive to 'future-proof' buildings. It is difficult to perform such a calculation of increased risk where dynamic thermal modelling has not been performed.

For projects where dynamic thermal modelling is performed, several respondents referred to the use of CIBSE TM 52 Future Weather Files, which allow the impacts on the building, including overheating, of increased temperatures due to climate change. Some local authorities specify the use of future weather files for certain projects, such as larger developments or those perceived to be at higher risk, but this is not widespread.

The Prometheus research project used a probabilistic approach to climate change data to future-proof design decisions in the building sector'. This was referenced by some respondents as another useful resource that they use for future climate-driven weather files.

The London Plan acts as a driver for developers to consider overheating issues, but this only applies to London and cannot be used effectively elsewhere. BREEAM also acts as a driver for overheating to be managed in certain types of commercial and non-domestic properties, in the future the Home Quality Mark may impact on the housing sector across the country and lead to further consideration of overheating and climate change risks. The London Plan, BREEAM and the Home Quality Mark all require some consideration of the need to adapt for climate change, but as yet these aspects are not given the priority of other sustainability and resilience measures.

Some argued that if current risks are sufficiently mitigated against it may still not be sufficient for the future climate over the remainder of the century. Whilst consideration of climate change adaptation has become more common in past few years it is still not widespread.

The balance between designing for an increase in the average temperature and for more frequent heatwave events that will result from climate change has still not been adequately covered in regulation and guidance.

4.2.4 Is thermal comfort typically considered as a requirement of a client brief

In particular types of development, such as care homes, schools and healthcare facilities, i.e. buildings with 'vulnerable' users, thermal comfort is a requirement of client briefs. It is based on a maximum number of days above a certain temperature, though respondents differed on what this maximum temperature is, >20°C was argued by some respondents, >25°C by others. The modelling of thermal comfort based on CIBSE guidelines to test and make adjustments to the design is the approach normally taken by consultants.

The residential sector is argued to be much more varied with regards to requirements for thermal comfort. The requirements are based on the risk of overheating perceived by the developer and the extent of future issues that are likely to occur.

For Passivhaus projects, a calculation of thermal comfort is inherent to calculations in the PHPP tool and is therefore calculated as part of the design.

One housing developer described how they have recently set a commitment to develop an approach for ensuring thermal comfort in all future developments, based on a review of industry research, including guidance from the Zero Carbon Hub and CIBSE guidance.

One consultant referred to their ‘Well-briefing’ tool, an in-house tool focusing on improving occupant health and wellbeing, including thermal comfort, which they use to inform the design process.

A number of respondents described how thermal comfort is increasingly on the agenda for commercial buildings as organisations realise the negative effects on health, wellbeing and productivity.

Interviewees cited the lack of requirements in national planning requirements and building regulations. Although SAP includes aspects of overheating there is no building regulation associated with overheating. However, the ‘Metric Handbook: Planning and Design’ data was reported as a useful guidance in this area by one respondent.

4.2.5 What strategies do you typically select to manage the risk of overheating

A wide variety of measures were reported by respondents as being used to manage the risk of overheating, however a number of common themes emerged.

The majority of respondents reported that they use a fabric-first, passive approach to managing the risk of overheating wherever possible. Openable windows were widely reported as a favoured strategy, however they are considered unsuitable in some areas, such as noisy inner city areas with low air quality. However, this depends on the building type and its use as well as location.

The fabric-first approach involves low-energy passive measures to manage the risk of overheating wherever possible, though this depends on the user. Passive measures are relatively cheap, especially over the life cycle of the building, but only if included at the early design stage. It was acknowledged that for some types of buildings, such as large offices with high internal heat gains, or highly airtight buildings that natural ventilation alone may be inadequate.

The following measures were reported to be used to manage overheating:

- Openable windows and/or balcony doors
- Other types of natural ventilation e.g. trickle vents
- Solar shading
- Building orientation
- Building layout and location of rooms
- Multiple aspect with cross ventilation
- Thermal mass
- Labyrinths
- Chimneys
- Dynamic façade
- Phase change materials
- Green and blue roofs
- Green walls
- Trees
- ‘Bioclimatic design’.

One respondent reported that several useful rules of thumb exist for managing the risk of overheating, for example to use the 5% to 10% openable window to floor area ratio.

Interviewees reported that they avoid the use of mechanical systems and air conditioning where possible, as using carbon intensive systems to manage overheating is a ‘vicious circle’. They produce carbon emissions which will exacerbate overheating due to the contribution to climate change. It was also noted that the use of air conditioning contributes to the urban heat island effects in cities.

A wide range of different opinions, both positive and negative, were recorded regarding mechanical ventilation systems, including Mechanical Ventilation with Heat Recovery (MVHR) systems, as well as comfort cooling or air conditioning. Specific comments on MVHR include the following:

> “Try to avoid mechanical systems where possible, for numerous reasons - extra costs of design and installation; increased running costs; customers don’t like mechanical systems, don’t know how to use them or need to be trained how to use them; requires regular maintenance unlike passive systems.”
>
> “Difficult for occupants to use – doesn’t work well unless properly set up and controlled.”
>
> “Carefully controlled mechanical systems help to minimise uncertainties; giving a guaranteed airflow over a given period - important for large buildings with internal, large blocks of flats.”
>
> “Works with a well-designed Passivhaus building; as long as ventilation, airtightness and overheating are all considered holistically then mechanical systems work effectively.”
>
> “MVHR systems are difficult to appropriately size, specify and install.”
>
> “Openable windows are not always appropriate in developments at high risk of overheating, especially in high rise buildings, buildings with high internal gains, high density developments and marginal sites. The reasons include noise pollution, air pollution and high external air temperature from the urban heat island effect rendering natural ventilation less effective. Therefore these buildings require mechanical systems and/or comfort cooling.”
>
> “Offer a safety net for the times that natural ventilation doesn’t provide the performance required for the building.”
>
> “It is very difficult and expensive to retrofit MVHR.”

One respondent reported how they try to design in space to allow future flexibility into their buildings, providing space so that if mechanical systems are required in the future to manage increased risk of overheating, they can be more easily retrofitted in.

It is recognised that mechanical ventilation and air conditioning are quite different things. However, due to the issues that emerged surrounding combination of ‘passive vs mechanical’ methods for mitigating the risk of overheating, it was felt to be appropriate to combine these to manage thermal comfort on a number of properties.

4.2.6 Have you ever found that measures to mitigate overheating conflicts with other aspects of the project

The most commonly argued possible conflicts, either real or perceived were as follows:

- Some interviewees argued that high airtightness, to improve energy efficiency and reduce carbon emissions, is actually a cause of overheating by reducing ventilation. However other interviewees argued that if the building is designed holistically then there is no reason for an airtight building to overheat. Passivhaus in particular was argued not to have this problem, as the design and testing tools have checks for overheating. Airtightness is generally associated with no natural ventilation, especially openable windows.
- The trend away from openable windows, which is a reliable way to prevent overheating.

- Lots of glazing, which is popular for aesthetic reasons and for internal daylighting, but causes significant solar gains is another significant cause of overheating. This is particularly problematic with south facing glazing and high rise developments. Similarly, the lack of consideration of the effects of orientation.
- The use of mechanical systems, such as air conditioning is carbon intensive, which adds to the climate change problem and in turn increases the risk of overheating.
- Mechanical ducting systems take up a large amount of space, reducing the usable and liveable space in a size constrained development.
- District heating is argued to be susceptible for overheating particularly in higher density developments where corridors don't have any external facing and therefore have a tendency to overheat.
- Generalist engineers might not understand the fire risk to buildings of mechanical systems.
- Conflicts between what the architect and M&E engineer want from a design and completed building often arise. These professionals don't typically work together closely enough, examples given concerned window design, pipe layouts and wiring locations.
- Summer time ventilation requirements versus the rest of year; how many days of risk do you need to design for is often not known at the start of a project.

4.2.7 Has overheating ever been identified as an issue after completion of one of your works

The following problems and corresponding remedial works were reported as having been required in projects where overheating had been identified post-construction:

- Improved insulation of hot water pipes which were causing overheating was necessary on a number of projects, particularly where 'district heating' was used. Some interviewees indicated that there were industry wide problems of overheating in corridors due to district heating, where hot water circulates through the building and heat escapes into flats.
- Solar glazing film was included to reduce the effects of solar gains, which was seen as a relatively cost effective measure, although the film will need to be replaced periodically.
- Mechanical systems were poorly maintained and set to the wrong settings, which needed to be reconfigured.
- Air ducting systems which were not properly installed, needed to be addressed.

Overheating has been caused by mixture of design issues, material choices, building orientation and occupant behaviour. It is the subject of ongoing research studies, but there is still much to understand and solutions to determine.

Overheating was widely reported to be more likely to occur in buildings where dynamic thermal modelling was not conducted. One respondent reported that where SAP, an 'oversimplification of an extremely complex issue', is incorrectly used as a design tool, overheating is likely to occur and remedial works are likely to be required.

It was reported that highly efficient, airtight buildings are difficult to retrofit. Therefore if remedial works are required on such buildings they can be expensive.

There is almost no feedback loop between designers, consultants and end users of buildings. Therefore, decision makers in design and construction rarely hear of problems that later arise in buildings.

Post occupancy analyses are rare and one respondent reported that housing developers actively resist this kind of monitoring.

4.2.8 Costs

Interviewees were asked to give an indication of the costs associated with adapting buildings for overheating. The majority of respondents said that they found this difficult to report on, as few of the people interviewed are regularly involved in cost decisions. This, coupled with the fact that it is was also difficult to report on costs on a general level, as numerous variables impact the cost of mitigating the risk to a development, make any such generalized assessment of cost of limited use.

Several respondents suggested that if measures to mitigate against overheating are included from the early design stage, then the increase in cost per unit may not be significant. Many respondents argued that the cost of designing measures is just part of the design process and is absorbed by the design firm fees. Whilst others reported that extra design and consultancy fees might be accrued compared to a build that didn't fully consider the risk.

Respondents were asked about the most significant aspects of the costs associated with the risk of overheating. Materials and technology were generally agreed to be the most expensive aspect, although the actual cost impact depends heavily on the type of measure selected; for some passive measures there is unlikely to be much of a cost impact. Increased labour costs were also suggested as an increased expense, but again these vary significantly depending on the types of measures selected.

High specification glass, with shading measures and triple glazing is expensive (although prices are slowly falling) and can be extremely costly in buildings with lots of glazing.

A number of specific comments were made with regards to costs, as follows:

- Measures to manage overheating are perceived to be expensive by housing developers.
- Opening windows were considered to be expensive, particularly for certain types of buildings.
- There was some perception that measures are more likely to have money spent on them if they help to earn BREEAM credits.
- Designing a structure to have space helps to future proof for climate change.
- Higher up front capital cost to invest in overheating resilience measures can reduce retrofit.
- Passive measures such as building orientation and room arrangements often have no impact on the price but can have a significant impact on whether the building overheats or not.
- It can be difficult to persuade housing developers that overheating is a major issue in smaller dwellings, so measures are less likely to be invested in.
- If the risk of overheating is considered from the early design stage, it was argued that this should not have a significant impact on the balancing act with other requirements.
- The most expensive aspect of mechanical systems with large amount of ducting is the loss in potential profit due to reduced floor space.
- The perception of costs by developers; including that openable windows are costly, but the right window can be a simple solution to overheating.
- There was little fully costed research produced to help inform the selection of cost effective solutions.
- A well designed Passivhaus with measures to mitigate against the risk of overheating designed in early by an experienced team can be cheaper than a typical structure designed to 'meet building regulations' with no holistic consideration of the risk of overheating.

4.2.9 What are the main drivers for the implementation of measures to manage the risk of overheating

Interviewees were asked what, in their opinion, acted as the main drivers to the implementation of measures to mitigate the risk of overheating. The following responses were recorded:

- Human health, wellbeing and comfort (e.g. sleep deprivation, productivity) were affected by overheating, this is known and good designers and consultants want to manage out risk.

Thermal comfort, particularly in buildings where users are more vulnerable to negative health effects associated with schools, care homes and hospitals.

- Chartered Institutes and Professional Bodies are raising awareness of the importance of climate change adaptation and this impacts on the design to manage overheating.
- BREEAM and Home Quality Mark roles were noted as drivers by some, but the response was mixed. Some interviewees argued that this was a major driver for certain types of projects, others argued that they were not so significant.
- The 'green credentials' of buildings were acknowledged to include overheating design, which should be managed appropriately.
- Passivhaus homes are designed using a specific methodology, not just selecting certain measures to focus upon, this approach can drive good practice. However, the take up on Passivhaus so far is limited. Government initiatives, such as the former Zero Carbon Homes, can also act as a driver, but they need to be consistent and have commitment.
- UNFCCC Paris Agreement was argued to be a (perhaps indirect) driver on the issue, as more forward thinking designers might consider this and it should shape government policy.
- CIBSE technical guidance and standards can be used by designers and consultants and can provide demonstration of good practice.
- 'The London Plan: The Spatial Development Strategy for London' & 'London Climate Change Adaptation Strategy' goes beyond Building Regulations.
- Thermal comfort good practice, involving assessment and modelling was more likely as a driver in schools than homes.
- Overheating management can be linked to reducing greenhouse gas emissions, reducing energy consumption and running costs, but this requires awareness raising and education.
- Cost implications of having to remediate a building post-construction that is overheating. This can include the risk of liability being raised with litigation if the building significantly overheats. Developers are increasingly aware and want to avoid customers' complaints to maintain reputation. Further there is a risk of stranded assets; asset managers must consider impacts of climate change, e.g. approximately 55% of UK pension funds are tied up in real estate, asset managers can't risk loss of value due to the impacts of climate change.
- On occasions consideration of overheating is client driven, although what they define as thermal comfort can be subjective. There is a desire to produce a high quality product with environmentally conscious design becoming more common.
- There are wider benefits of landscape design and green infrastructure, which as well as helping to manage overheating provides many other benefits to a development.

4.2.10 What are the main barriers for the implementation of measures to manage the risk of overheating

Interviewees were asked what, in their opinion, acted as the main barriers to the implementation of measures to mitigate the risk of overheating. The responses can largely be grouped into a number of areas such as regulations, cost, competence of professionals, demand and lack of incentives.

Respondents indicated that there were no mandatory requirements in planning or building regulations with regards to overheating and its management. Therefore, it has not formed a core consideration for developers. Regulation does not include adaptation to climate change so even if the design considers overheating, future risk management is not considered. There is therefore uncertainty regarding what future climate will occur and how this will affect individual developments.

Consultants in the interviews indicated that they often found it difficult to make the business case for adaptation. If building regulations are not introduced then this situation will not change.

There was a perception amongst a number of interviewees that overheating is costly to deal with, although cost is more a consequence of poor design than good design. Developers are motivated by maximising profits seeking to reduce up-front costs and developing as many properties as possible on a site. They are looking to build as cheaply as possible on a site; not motivated by life cycle costs, environmental impact or resilience or future proofing. The situation represents a failure of market forces in housing.

The competence of professionals was raised in different ways by the interviewees, with the following issues discussed:

- There is an education, skills and knowledge gap throughout the building industry that affects designers, developers and contractors. The issues of resilience, sustainability and climate change adaptation are not embedded in the education of experts. As there was no incentive for future proofing buildings against climate change there was no incentive for busy professionals to upskill.
- Buildings are often not designed holistically using different experts who don't work together or tackle issues such as overheating, which are impacted by each of their disciplines. There is a disconnection between disciplines working on the same projects. Different professionals have different priorities; this silo effect prevents some issues being properly covered. There is a lack of a feedback loop between designer and occupant.
- The professional 'silo effect' prevents some issues being properly covered e.g. the architect focuses on window design whilst the engineer focuses on pipes and wires, but neither necessarily takes ownership of the issue of overheating and the approaches can conflict; professionals often don't fully understand the consequences.
- There is a lack of competent people checking design work, post construction studies to check measures work e.g. on site auditing and post construction occupancy evaluation are not carried out. There was no enforcement of planning requirements for overheating and the lack of planners with the right skills is an issue that needs to be addressed.
- There is poor feedback between the designer and the ultimate occupant. The former often carries out design work years in advance of the project being built and occupied. Therefore, interviewees considered that handover of buildings was important as well as the provision of longer term support. Users often don't understand the technology installed in their building, e.g. mechanical ventilation systems. Overall there was poor communication of the issues, nobody wants to raise risk aspects of new developments. There was often an over reliance on 'high tech fix versus low tech fix', which made matters difficult for the user. Thus the burden of managing overheating is passed onto someone else with the effects of poor design not felt by decision makers.
- There was a lack of accountability for overheating. It is not the responsibility of the building control authorities or planners. The designer may be implicated, but not if the designed in measures are removed at a later stage.
- Professionals had an over-reliance on simulations and modelling, which have many assumptions, rather than using their own experience and expertise.
- It was difficult to apply effective rules of thumb required for building density, traditional building layouts and occupancy are not always fully considered by designers and consultants when selecting measures.
- There was a lack of simple design tools and a lack of guidance that could be used by those involved in design and construction. There was some good research and guidance, but less focus on how to implement measures on a bespoke building level. More bespoke weather files, with projections for climate change, could empower designers if combined with the correct tools and guidance.

The interviewees acknowledged that there was a lack of demand, either from developers or the public. Over-reliance on air conditioning, and mechanical ventilation which exacerbates the problem by being a carbon intensive strategy was thought by many clients to be the only solution to overheating. There was misinformation regarding the effectiveness of different strategies which prevents them being implemented on a wider scale, e.g. natural ventilation was not always used in a situation in which it could be effective.

There were shortcomings in client briefs which reflects on their priorities and values. If these issues were not included in the initial brief, then they are not given enough attention. Clients had a short term focus as opposed to long term thinking. Users were often unwilling to pay for a service engineer for ventilation and mechanical systems. The end users (the general public) do not understand how a building works, essentially people don't demand better design and they don't realise how easy it is to produce a good building.

There was a trend for buildings with lots of glazing to be required by clients. However, they do not understand how these are likely to impact on overheating and thermal comfort.

The lack of drivers and incentives was discussed in the context of being a barrier in the interviews, the following issues were raised:

- Human health, wellbeing and comfort do not act as drivers to the extent that they should do at present, the design team and developer are not aware of the impacts of poorly performing buildings.
- Developers and the public want 'normal buildings' and if solutions are not aesthetically acceptable then the clients do not accept the solutions.
- Clients can be risk averse and therefore unwilling to try innovative solutions.
- Homeowners rarely take on responsibility for adaptation, but they have an important role to play in adaptation, as well as designers and developers.
- The building regulation compliance checks such as SAP are simplistic analyses and should not be used as a design tool, which they routinely are by professionals. There are therefore unintended consequences where buildings are not designed holistically, conflicting factors can lead to overheating e.g. airtightness with poor ventilation.

4.3 Focus Groups

A number of similar questions were used in the overheating discussion as for flood resilience. The use of the term 'future proofing' was considered problematic, as although overheating will likely be exacerbated by climate change in future, the risks of overheating are present today. Therefore buildings need to be 'present-proofed' rather than just 'future-proofed'.

4.3.1 Can a new building be 'future proofed' against overheating in a cost effective manner

The general consensus of the discussion was that the risk of can be managed in a cost effective way. Relevant comments were as follows:

- "Resilience can be designed in cost effectively. There can be an assumption that it costs more, but if designed in early on this does not need to be the case."
- "The risk of overheating can be cost effectively managed. Measures to prevent overheating must be designed in now, otherwise the building will overheat now. Understanding the whole building as a system is extremely important; all internal and external gains and the measures used to remove these gains must be considered as part of this system. If using MVHR it must be appropriately sized, controlled and used all the time."
- "Investing in good design might cost more up front, but could save you money over the lifetime of the building."
- "Consultants time costs money for doing work properly with good recommendations. As people are often not willing to pay for a suitable consultants then resilience solutions cannot be delivered."

The role of flexible design was discussed. It was argued to be cost effective as this way features can be retrofitted in future if and when the risk of overheating increases, with a lesser impact on upfront costs. This solution was suggested as possibly more favourable to housing developers who would have to spend less money up front, although allowing extra space for future flexibility does reduce profits as it may reduce liveable floor space.

Some specific comments made were as follows:

- "In the longer term, not designing in resilience can be very expensive, but expensive for who? The developer doesn't pay, it's the end user who has to deal with the consequences of poor design. The person who causes the problem doesn't suffer the consequences of their decisions."
- "We are starting to see sale value increase for buildings designed to Passivhaus."
- "The way that projects are costed is not set up for resilience, if a financial appraisal was conducted with resilience in mind, the value of land should be changed to allow resilient homes to be put in mind."

The Stern Report (The Economics of Climate Change: The Stern Review, 2007) was also mentioned, whereby the cost of inaction far exceeds the cost of taking actions to mitigate against the impacts of climate change.

4.3.2 What resilience measures are reasonable and meet the needs of people as well as designers and builders

The delegates agreed that there are many different effective resilience measures that work well, but they are not widely implemented. Such measures include optimising building orientation, use of thermal mass and ensuring effective cross ventilation.

It was suggested that green infrastructure, including landscaping, green walls, green roofs, tree planting, roof gardens, can be an effective strategy for increasing resilience of the built environment to both overheating and flooding, as well as providing amenities and other community benefits. One of the main barriers to implementation of green infrastructure is the question of maintenance and the fact that it is not conducive to high density developments. Green infrastructure has been implemented successfully in cities such as Chicago, Berlin and Malmo and perhaps there are lessons to be learned from these success stories. The knowledge of an open minded client is key to properly implementing a fully integrated green infrastructure strategy.

4.3.3 What are the barriers and how do they interact, and what are the solutions

It was suggested that the role of building regulations is widely misunderstood by many in the construction industry. They are simply minimum legal requirements and they are not a set of design tools or advice; too often buildings are 'designed to building regulations'. There is discontinuity between different sections of building regulations, which have knock on effects on everything. For example, Part F doesn't deal with summertime ventilation properly. As there are no requirements for resilience in existing legislation, problems such as overheating are not often not dealt with in a holistic manner.

One delegate commented that housing builders have been trying to deregulate as much as possible, however if a top-down legislative approach is not taken, why would they bother designing buildings for resilience. It was argued that the skills and competence levels of local authorities must increase in order to be effective at assessing planning applications and the specialist nature of overheating resilience. Currently planners are often overwhelmed by the volume of applications received and do not have the resources to assess all aspects. The planning system should have the capacity to analyse and monitor detailed specialist areas such as overheating, otherwise the planning system will not be effective.

The consensus of the discussion was that more stringent planning regulation, as well as looking at the role of building regulation, would have a major impact on the management of overheating.

Specific comments covering a number of barriers were as follows:

- “There needs to be more research into what increase in temperature over what time will give what impacts – and then build that into building regulations.”
- “It's important that resilience is driven through several channels, starting at planning, followed through at building regulations and then closing the loop to make it difficult for people to avoid compliance.”
- “If we mandated an overheating risk assessment, it would transform the market and would force developers to incorporate measures to manage the risk of overheating.”

The importance of building performance modelling was also discussed. Some delegates argued that a minimum level of modelling of building physics should be applied to all buildings and the findings related to overheating should then inform the design process. Others argued that that it is unnecessary to model everything as modelling is not always effective, as factors such as the microenvironment and the urban heat island effect can’t be taken into account. Some delegates suggested that "a spreadsheet approach is often more powerful than a dynamic simulation model."

Another delegate suggested that modelling smaller residential properties is ‘totally unnecessary’. If design rules of thumb are applied to the building then it will not overheat. They suggested that the 5% to 10% openable window to floor area ratio, with cross ventilation will more than adequately deal with the risk of overheating in the UK. A design guide of these simple rules of thumb could act as a driver for better design.

The discussion then focused around how the desire for spending less money and time causes common sense solutions to be ignored. It was argued that the vast proportion of buildings are not well thought out and that the question is often asked what is the cheapest building regulation compliant solution rather than preventing problems such as overheating that can easily be designed out with some foresight.

An example was provided of local authority and planning departments are increasingly accepting single aspect developments, which are prone to overheating. Double aspect flats with cross and/or rising ventilation would solve this issue, but this simple solution is ignored because fewer double aspect flats can be squeezed on a plot of land compared to single aspects flats.

One delegate argued that the UK is afflicted by its mild climate. In more extreme zones or zones with more variable climates houses are better designed than in the UK. The UK climate is not enough of driver in itself as few people consider that overheating is a risk to them. There is an opportunity to learn from other countries.

One delegate suggested that for housing developers, keeping their reputation intact is not such a motivator to make buildings more resilient as was suggested by other delegates. People don’t buy a house because it was made by Berkeley or any other developer, so why would the developer spend more money on a dwelling. However, others suggested that the risk of litigation does act as a driver, although perhaps not as much as it might.

Delegates argued that the skills gap throughout the whole supply chain was a major barrier to adaptation. They described the need to educate designers properly on how best to holistically tackle the problems requiring adaptation and what the design rules of thumb are; contractors need to know why it is so important to follow the design correctly and not make changes. One delegate described how the current situation is ‘a perfect storm of a whole lot of things catching us out.’

The importance of better educating the general public on issues of resilience was widely discussed. Some comments from that discussion include the following:

- “People need to interact with their homes more; buildings doesn’t just look after themselves but people don’t understand how their buildings work”
- “People should be educated from an early age of the importance of climate change, buildings and resilience with simple and interesting courses”

- “Do people buy a building based on their resilience properties? Is it a decision that influences their choices? If not, how can the end user be educated to see the benefits of resilience?”
- “Who is the audience, who should we be communicating resilience to? People who are being ‘screwed’ by the system, they are the audience we should be talking to - resilience should be presented to them as a lifestyle choice”
- “End-users don’t know what to ask for and salespeople don’t know how to describe it”
- “The language of overheating is a bit abstract for residents. How can we change the language we use to communicate the issue better?”
- “People don’t generally realise a building overheats until they move in”
- “End-users don’t always associate overheating with poor design, just think that it is something that happens on hot days.”

4.3.4 How can resilience be rewarded, and how can resilience measures add to the overall attraction of a property

Delegates discussed that the best ways to remove the complex barriers to adaptation are not well understood. Unless the barriers are understood and what might drive the change, then the problem cannot be tackled effectively. Sometimes policies that don’t seem likely to make a difference, can act as significant drivers for change.

One delegate suggested that an important solution is for the government to take the issue seriously, which in their view is currently not the case.

Delegates discussed that there might be the need for some kind of shock for adaptation policy to come to the fore. A UK heatwave similar to Paris 2003 might have to happen before action is taken at government level. Examples of adaptation in France post 2003 era were discussed, including that any flat roof over certain size that is capable of taking a sufficient load must be a green roof. Elderly people with poor social networks were amongst those most badly affected by the Paris heatwaves and so embedding social resilience can also help to mitigate against the risks climate change poses.

Another issue discussed was that to make resilience attractive, there is a need to somehow monetise the benefits, which are not currently incentivised.

4.4 Summary

The findings with regards to overheating are discussed using the same format as for flood resilience.

4.4.1 Costs

The online survey findings indicated the following:

- For new buildings, 24 of the total or 42.86% of respondents indicated adaptation for the risk of overheating in buildings has little or no increase (i.e. 0% to 2% increase) on the unit cost of the building.
- For new buildings, 29 of the total or 51.79% of respondents indicated adaptation for the risk of overheating in buildings has a significant increase (i.e. 2% to 5% increase) on the unit cost of the building.
- For new buildings, three of the total or 5.36% of respondents indicated adaptation for the risk of overheating in buildings has a very high increase (greater than 5%) on the unit cost of the building.

The results are interesting in that in only a limited number of cases did respondents consider that the designed building would result in substantially higher costs. The range of measures involved such as natural or mechanical ventilation will dictate the cost involved, but in terms of measures there was a strong preference towards natural ventilation rather than mechanical methods, including refrigerated cooling.

The situation was quite different with regards to the retrofitting of measures into the property to adapt for climate change. In this case there was more likely to be a high cost involved. In addition, only a few responses indicated little or no cost were likely to result from the need for measures to be used post construction. The interviews and focus groups showed that there was likely to be a greater tendency towards mechanical ventilation systems post construction than for designed and built in. It was noted by some involved that this may be the only measure that could be successfully applied retrospectively for some projects. Some options such as thermal mass is not a realistic option for retrofit, but that use of phase change materials may provide some similar performance. However, the focus groups discussed that even where thermal mass was present that it is still necessary to use effective ventilation to remove excess heat from the property.

The assessment of overheating potential was clearly included within the overall cost impact of overheating resilience measures. This was particularly the case where dynamic simulation modelling was used for more complex buildings. The additional consultant cost may not be welcomed by developers, however, the result may simply be changes in design, materials, layout or orientation that has little impact on the overall cost of the building. As such the impact would be little on the overall development cost, but the risk would be managed over the lifetime of the building potentially saving costly retrofitting of measures. In some cases a simple, low cost, assessment of overheating potential may be sufficient to derive suitable measures and this may add virtually nothing to the overall cost.

4.4.2 Drivers

The existing drivers are somewhat limited, with the evidence from surveys, interviews and focus groups supporting this being that resilience to overheating is not mainstream and many buildings currently overheat or will be at increased risk of overheating due to climate change. At present planning requirements may be set with regards to resilience to overheating. Interviewees and participants to the focus groups cited that the London Plan required an assessment of overheating and demonstration that it had been properly managed. Achieving the planning permission for a development was therefore indicated as a significant driver in the online survey with just over 50% of respondents indicating this factor.

The survey respondents indicated that developers were concerned with reputation and would take measures to deal with overheating. However, there was greater indication that developers would just build to building regulations rather than addressing other risks.

All types of surveys indicated that Passivhaus was a driver for domestic properties to account for overheating. In fact in this housing methodology assessment and management of overheating is essential. A passive house is a building which is designed using a set of standards to achieve comfort levels inside the building and as well obtaining a minimal energy cost. The building fabric is designed in such a way that heat loss is minimized and internal heat gains are maximized.

Only careful passive house design allows it to achieve the best thermal comfort level and reduces the energy cost. This is achieved by considering certain criteria during construction such as super insulating walls, floors and roofs, increasing the air tightness in order to minimize heat loss from the building, introducing thermal mass to maintain the heat inside the building, usage of MVHR (mechanical ventilation heat recovery system) to increase the air quality and maintain internally the dispensed heat, using best quality windows such as triple glazing to avoid heat losses and improve heat gains.

The map of Passivhaus properties in the UK shows its application across the UK (http://passivhausbuildings.org.uk/passivhaus.php). However, the numbers of Passivhaus properties built each year is probably around 250 in the UK at present, whilst this may increase in the future it is unlikely that it will represent a major part of the total UK housing output, at least not for many years. Therefore, whilst Passivhaus is a driver its penetration into the market place will limit its impact.

Other drivers that are voluntary from the industry are BREEAM (non-domestic) and Home Quality Mark (domestic). In this respect BREEAM has a well-established position in the market place. Overheating is addressed to ensure that appropriate thermal comfort levels are achieved through design, and controls are selected to maintain a thermally comfortable environment for occupants within the building. Dynamic thermal simulation software packages currently provide the facility for building designs to be assessed under external climatic conditions specific to geographic location. Industry standard weather data for the UK is available in the form of Test Reference Years (TRYs) and Design Summer Years (DSYs) provided by CIBSE. This weather data enables thermal analysis of building designs under current climatic conditions, yet no account is taken of the projected variations in weather data that will occur during the building's life cycle as a result of climate change. The probabilistic DSY weather data files should be used to establish the projected climate change environment against which the design is evaluated.

No specific aspect of BREEAM is mandatory and therefore designers and developers may seek to improve other areas. No specific measures are required to achieve the BREEAM credits.

The Home Quality Mark (HQM) has not been in existence for as long as BREEAM and therefore its penetration into the housing market is limited. In the future this situation may change and it will be a more significant driver. HQM is intended to be a tool for homeowners to be better informed on all aspects of their building's performance. HQM can be used by developers and designers to demonstrate the quality of their designs and buildings. As the problems of overheating become better known and the awareness of the risk is increased then this driver for resilience measures should be increased.

4.4.3 Benefits

In this section of the report the benefits of resilience measures for overheating are discussed. The online survey addressed the benefits and this was supported by further discussion in interviews and focus groups. There was cross over between the benefits and the drivers, and indeed a relationship between barriers and benefits.

Developers and their consultants often viewed the granting of planning permission as being a benefit. Therefore, consideration of overheating at this stage and then designing in measures would reduce time spent in achieving permission and this could then save money. The inclusion of relatively low cost measures was considered possible and would allow developers to achieve an insignificant increase in capital costs.

The findings of the surveys indicated that developers and their consultants did consider that the desire to produce a quality final product was a key benefit. In fact this was the main choice of those who responded to the question. More aware and educated respondents were able to sell the idea of resilience to their developer client and indeed to reassure the public that the issue has been addressed. On the opposite side there was an opinion that the public does not expect problems such as overheating to arise. This was reflected in the lower response to consumer perceptions (and demand) for such resilience features. Although a significant body of opinion indicated that there was some customer demand in general this was viewed more as a barrier. In short it is difficult to sell houses and indeed other buildings on the basis of avoidance of overheating.

Other benefits were more obvious such as achieving the criteria set out in BREEAM, Home Quality Mark, and Passivhaus standards. As regards standards there was no building regulation that covers this area and instead industry standards are more relevant with regards to overheating. The CIBSE guidance on thermal comfort and dynamic modelling for non-domestic buildings are perhaps the main standards to achieve. Greater use of dynamic modelling or the use of simple rules would be beneficial to consultants and developers in achieving a better end product.

4.4.4 Barriers

The most important barriers that repeatedly arose in the comments sections of the online survey, the telephone interviews and the focus groups are discussed in more detail.

The absence of building regulations that actually cover climate adaptation and more specifically overheating is a major barrier. This was raised by respondents in the online survey, but it was considered further and the impact of a lack of regulation was reinforced in the interviews and focus groups. A number of delegates to focus groups commented that in the absence of regulation that developers will not take measures to address resilience.

The lack of client demand, including both developers and the public, meant that even when the issue was raised by consultants or others that cost savings in projects often resulted in such measures being removed at a later stage.

A number of interviewees and delegates noted the unintended consequences of improved energy design that promotes carbon reduction and energy efficiency. The consequence was that airtightness of buildings is higher and therefore the leakiness of buildings cannot be used in order to remove excess heat from buildings. However, whilst this was viewed as a barrier by some professionals others argued that the two issues are not counterproductive if a building is designed holistically and properly.

Uncertainty over what future conditions to design for was a barrier to designing for climate change. There is an inherent uncertainty of the scale and intensity of the future impacts of climate change and it is therefore difficult to recommend appropriate solutions. For example, what does an average global temperature increase of 2°C or 4°C actually mean for the risk of overheating in buildings in the UK. Delegates questioned should buildings be designed with the ‘new normal’ average temperature in mind or be designed to be resilient extreme weather events. The impact of regional and local differences in temperature changes is difficult for designers to address without the models and tools to help them assess risk over the whole life of the building.

Whilst good research has been conducted on the issue of overheating it can be difficult to apply these findings on a building design and construction in practice. The surveys reinforced that overheating and the removal of excess heat from buildings is a current issue and not just a future one. The likelihood of greater extremes such as heatwave frequency was not viewed as a particular barrier rather it was the day to day management of heat that is important.

Although it is an inherently uncertain issue, it was argued by several interviewees that more research and ultimately guidance is required for this issue.

The lack of skills and knowledge on overheating across building professionals was identified within the focus groups as a major barrier. Most university architecture courses do not consider issues of overheating, often climate change adaptation is either not covered, or is covered inadequately as a side issue. It was commented that universities teach ‘green building’ issues inadequately. One respondent described how all new graduates (engineers and architects) at their organisation have to be trained on these issues at work and they have limited understanding after graduation. Although there are many knowledgeable consultants there is significant scope to raise awareness and train across the industry.

The perceived cost of resilience measures was discussed, where building clients do not consider any measure that will add to the capital cost of a new development. Whilst the solutions for overheating may be affordable there is a need for simple rules of thumb for passive approaches, e.g. to have 5% openable windows on each side with cross ventilation will provide more than adequate ventilation. If such simple rules can be applied then it may encourage cost effective measures to be taken.

5 Conclusions

BRE has undertaken surveys of construction industry sectors with regards to the climate change adaptation of buildings to enable resilience to flooding and overheating. These issues are widely recognised as among the main impacts that are likely to arise from climate change for people and the built environment, with the impacts expected to worsen over the remainder of the century. At present there are national planning requirements in England related to flood risk management, but no such planning requirements related to overheating. There are no building regulations related to these issues and indeed resilience overall is given little if any consideration. The surveys addressed how the industry views the costs associated with adaptation, as well as the benefits and barriers that arose.

In this section of the report the findings with regards to flood and overheating resilience are discussed. The respondents to the online survey were spread across all areas of England, although a significant proportion were located in London and the south east. The focus groups ensured that there was a geographic spread through events being held in the north and south of England. The majority of respondents were involved as designers and consultants in new buildings, with a lesser number involved as developers.

5.1 Flood resilience

The following points are concluded from the surveys, interviews and focus groups:

- **Costs of flood resilience**
    - Costs of adaptation: a variety of responses were obtained in the surveys, although most respondents thought that there were either significant or high costs to design and build in flood resilience.
    - Build in versus retrofitting: The costs of designing and building in as new as opposed to retrofitting measures was typically thought to lead to lower overall construction costs by respondents.
    - Planning: developers and their consultants are directed in flood risk areas towards the raising of the floor level through either land raising of a site or introducing a 'sacrificial' ground floor. The additional costs would vary depending on the actual site or building design. The application of flood resilience measures in building design and construction was limited.
    - Type of flooding: the surveys addressed river and coastal flood risk, but a number of respondents included surface water management measures within new developments, which was also indicated to add to the construction cost.

- **Benefits**
    - Planning permission: the respondents indicated that securing planning permission was a major benefit from including flood resilience measures. The benefits of using flood resilience measures in order to satisfy planning requirements was further highlighted within the interviews.
    - Reputational gains and property values: were generally found to be less of an issue for respondents to the survey.
    - Achieving a level of design quality and certification: these factors figured highly in the responses as benefits by respondents.
    - Consumer demand: there was a mixed response, although there were more respondents who viewed it as a benefit than did not.

- **Drivers**

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    - Planning permission: was seen to be the most effective driver for flood resilience and indeed the only driver that would be considered to be legislative and subject to relevant regulations.
    - Building regulations: the introduction of relevant building regulations in England would drive flood resilience within the design and construction of the building fabric and services.
    - BREEAM: Adaptation to climate change (including flooding) is set out in this standard (and the Home Quality Mark) and this was considered to drive flood resilient adaptation by some developers.
    - Insurance: its availability, and affordability, for new developments was considered to be a potential driver of flood resilience.

- **Barriers**
    - Developer responsibility: the liability for new development often falls to the owner rather than the original developer who may simply sell on the property, therefore they have no incentive to add cost by including resilience measures. The developer would not necessarily obtain the benefit from installation of measures through an increase in property value.
    - Public awareness: lack of awareness on flood risk and therefore the use of resilient measures is a barrier; this lack of awareness results in poor client demand.
    - Skills: the various surveys highlighted the capacity of planning departments as being a barrier to implementing flood resilience measures.

5.2 Overheating

The following points are concluded from the three forms of survey with regards to the adaptation of buildings for overheating:

- **Costs**
    - Additional costs: in only a limited number of cases did respondents consider that the adapted building design would result in substantially higher costs, unlike flood resilience the overheating measures mainly involve building fabric and services related costs.
    - Built in versus retrofitting: the situation was quite different with regards to the retrofitting of measures into the property to adapt for climate change. In this case there was more likely to be a high cost involved.
    - Simple design and construction solutions: the interviews and focus groups highlighted that simple, low cost, assessment of overheating potential may be sufficient to derive suitable measures and this may add virtually nothing to the overall cost. Good design and a limited additional cost to fully assess issues such as orientation will reduce the need for expensive retrofitting.

- **Drivers**
    - London Plan: required an assessment of overheating and achieving the planning permission for a development was therefore indicated as a significant driver (note that the requirements only apply in London).
    - Reputation: the survey respondents indicated that some developers were concerned with reputation and would take measures to deal with overheating.
    - Industry standards: the surveys indicated that designing and building to Passivhaus was a driver for domestic properties to account for overheating. Other drivers are BREEAM (non-domestic) and the Home Quality Mark (HQM), where credits are awarded for adaptation to climate change.

- **Benefits**
    - Granting of planning permission: despite the lack of national requirements, respondents often viewed the granting of planning permission as being a benefit. Developers and consultants

found that dealing with overheating at the planning stage resulted in better responses from planners.
  - Quality of product: the public does not expect problems such as overheating to arise; where the building manages the risks then problems are less likely to occur.
  - Industry standards and certification: achieving the criteria set out in BREEAM, Home Quality Mark, Passivhaus and standards were all viewed as benefits by respondents.

- **Barriers**
  - Absence of building regulations: the regulations do not currently address overheating and this is viewed as a barrier; in the absence of regulation developers will not take measures to address resilience.
  - Lack of client demand: including both developers and the public, meant that even when the issue was raised by consultants or others that cost savings in projects often resulted in such measures being removed at a later stage.
  - Uncertainty over future conditions: there is an inherent uncertainty of the scale and intensity of the future impacts of climate change and it is therefore difficult to recommend appropriate solutions.
  - Application of research: whilst good research has been conducted on the issue of overheating it can be difficult to apply these findings to a building and make the link to increased risk due to climate change as there are many different factors that can exacerbate overheating.
  - Skills and knowledge: these were considered to be lacking on overheating across building professionals in the focus groups. Most university architecture courses do not consider issues of overheating, often climate change adaptation is either not covered, or is covered inadequately as a side issue.
  - Lack of application of simple rules: there is a need for simple rules of thumb for passive approaches as effective solutions, if such simple rules can be applied then it may encourage cost effective measures to be taken.

Appendix A: Online survey

Introduction

This survey is being undertaken by the Building Research Establishment (BRE), on behalf of the Adaptation Sub-Committee (ASC) of the Committee on Climate Change. The aim of this survey is to help the ASC to understand the costs and benefits that designers and builders associate with making buildings fit for the future climate. The ASC will use the results in its next progress report to Parliament.

According to the UK Climate Change Risk Assessment (2017), the risks of overheating and flooding are expected to rise due to the observed and projected increases in global temperatures, and these present the most significant risks to the built environment and its inhabitants. Approximately 1 in 10 homes have been built in areas of significant flood risk in recent years. Climate change is expected to increase the likelihood, frequency and severity of heavy rainfall, putting more properties at risk. The average number of hot days per year has also been increasing in the UK since the 1970s. By the 2040s, a typical summer is expected to be as hot or hotter than the heatwave in 2003 when temperatures reached the mid-30s°C. As such this survey pays particular attention to adaptation measures aimed at protecting residential properties against these risks.

The survey is anticipated to take 10-15 minutes to complete. It is split into five sections; section one concerns your personal details; section two concerns the types of building developments you are typically involved in; section three concerns flood resilient design and measures for new builds; section four concerns overheating; and the final section is an opportunity to add any further comments. If you do not have any experience related to the contents of sections three or four, please move on to the next section.

All responses will be treated in strictest confidence. Your feedback is valuable and we thank you for taking the time to complete this survey.

Section 1: Personal details

1. Name:

2. Company:

3. Email address:

4. Phone number:

5. Business Type:

- ◯ Architect
- ◯ Consultancy
- ◯ Engineer
- ◯ Housing developer
- ◯ Housing association
- ◯ Other (please specify)

6. Business size:

- ◯ Micro or self-employed (<10 employees)
- ◯ Small (<50 employees)
- ◯ Medium (<250 employees)
- ◯ Large (>251 employees)

Section 2: Housing development types

7. In which geographical area(s) do you typically operate? Please select all that apply.

- [ ] North West
- [ ] North East
- [ ] Yorkshire and the Humber
- [ ] West Midlands
- [ ] East Midlands
- [ ] South West
- [ ] South East
- [ ] East of England
- [ ] London

8. Which type of development site are you typically involved with? Please select all that apply.

- [ ] Cities
- [ ] Towns
- [ ] Rural
- [ ] Other (please specify)

* 9. Which type of building do you typically commission, design or build? Please select all that apply.

- [ ] Residential properties
- [ ] Offices
- [ ] Hospitals
- [ ] Schools
- [ ] Care homes
- [ ] Other (please specify)

10. Which size of development do you typically commission, design or build? Please select all that apply.

- ☐ Minor development (less than 10 units/1 hectare)
- ☐ Major development (10 units/1 hectare or more)

Section 3: Flood resilient design and measures for new buildings

* 11. Have you developed buildings in flood risk areas?

- ◯ Yes
- ◯ No

Section 3: Flood resilient design and measures for new buildings

12. Which measures have you implemented to manage flood risk?

	Never	Rarely	Often	Always
Rely on existing flood defences	○	○	○	○
Rely on planned flood defences (paid for by others)	○	○	○	○
Contribute towards new flood defences	○	○	○	○
Avoid flood water reaching the living spaces (e.g. raising the building above the predicted flood level, sacrificial ground floors etc)	○	○	○	○
Stop flood water from entering the living spaces (e.g. flood doors and/or windows, walls and floors membranes, non-return valves)	○	○	○	○
Make living spaces flood-resilient (e.g. water-proof floors and walls, raise services and resilient fittings/fixtures)	○	○	○	○

Other (please specify)

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13. Why do you implement and select these measures?

	Never	Rarely	Often	Always
To secure planning permission	○	○	○	○
To achieve higher property values	○	○	○	○
To comply with building regulations	○	○	○	○
To achieve a level of design quality to meet a certain level of certification	○	○	○	○
Reputational gains	○	○	○	○
Consumer demand and satisfaction	○	○	○	○

Other (please specify)

14. How do you ensure that these measures are effective against flooding?

	Never	Rarely	Often	Always
Standards for materials and products	○	○	○	○
Certification of materials and products	○	○	○	○
Testing of materials and products	○	○	○	○
Installed by approved contractors	○	○	○	○
Consultants experience	○	○	○	○
Post-construction inspection	○	○	○	○
Previous experience of successful use	○	○	○	○

Other (please specify)

15. What direct costs does these measures add, as a proportion of the unit cost?

	Little or no cost (Less than 2% of the unit cost)	Significant cost (2-5% of the unit cost)	Very high cost (More than 5% of the unit cost)
When designed into a new building?	○	○	○
When retrofitted into an existing building?	○	○	○

16. If you have any further comments regarding flooding, please specify below:

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Section 4: Overheating management design and measures for new build

This section considers adaptation measures related to reducing the impact of climate change on overheating. Efforts to improve energy efficiency and reduce carbon have also led to the new buildings that are better insulated and more airtight. However these design features have in some cases inadvertently increased the risk of overheating in new buildings and the need for ventilation. These issues are also explored in this section.

* 17. Do you generally consider overheating as a risk in new build projects?

- ◯ Always;
- ◯ Often;
- ◯ Rarely;
- ◯ Never;
- ◯ Don't know

18. What, if anything, has stopped you from considering overheating at the design stage of a project?

	Never	Rarely	Often	Always
Overheating not considered to be a risk	◯	◯	◯	◯
Client has not requested measures related to thermal comfort	◯	◯	◯	◯
Lack of regulatory or other drivers to ensure it is included	◯	◯	◯	◯
Costs of designing in measures is prohibitive	◯	◯	◯	◯
Overheating measures would conflict with other aspects of the project	◯	◯	◯	◯
Not my organisation's responsibility	◯	◯	◯	◯

Other (please specify)

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Section 4: Overheating management design and measures for new build

19. If you have ever assessed overheating risk, how was this assessed at the design stage? Please select all that apply.

	Never	Rarely	Often	Always
SAP appendix P	◯	◯	◯	◯
Dynamic modelling	◯	◯	◯	◯
Simple assessment based on design characteristics of the build	◯	◯	◯	◯

Other (please specify):

20. Which of the following overheating mitigation measures have you used in any of your projects? Please tick all that apply.

	Never	Rarely	Often	Always
Natural ventilation	◯	◯	◯	◯
Mechanical ventilation	◯	◯	◯	◯
Air conditioning	◯	◯	◯	◯
Solar shading	◯	◯	◯	◯
Building orientation	◯	◯	◯	◯
Thermal mass	◯	◯	◯	◯
Passive cooling systems, e.g. evaporative cooling, thermally active building systems	◯	◯	◯	◯
Mechanical cooling systems, e.g. earth tubes, district cooling, exhaust air heat pump	◯	◯	◯	◯
Local urban planning	◯	◯	◯	◯
Green and/or blue roofs	◯	◯	◯	◯

Other (please specify):

21. What were the benefits of including these measures to the designers, builders and consumers? Please select all that apply.

- ☐ Achieving higher property values
- ☐ Securing planning permission
- ☐ Complying with standards
- ☐ Achieving a level of design quality to meet a certain level of certification (e.g. BREEAM, Code for Sustainable Homes, Home Quality Mark)
- ☐ Reputational gains
- ☐ Consumer perceptions of design features where these value the incorporation of adaptation measures
- ☐ Desire to produce a high quality project
- ☐ Other (please specify)

22. What direct costs does these measures add, as a proportion of the unit cost?

	Little or no cost (Less than 2% of the unit cost)	Significant cost (2-5% of the unit cost)	Very high cost (More than 5% of the unit cost)
When designed into new building?	○	○	○
When retrofitted into existing building?	○	○	○

23. Has overheating been identified as an issue after completion of any of your organisation's projects?

- ○ Always
- ○ Often
- ○ Rarely
- ○ Never
- ○ Don't know

24. If overheating has been identified as an issue after completion of a project, were any remedial works required?

- ○ Yes
- ○ No

If yes, please specify which post-build alterations were required:

25. If you have any further comments regarding overheating, please specify:

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Section 5: General comments

26. If you have any further comments, please specify below:

* 27. Please indicate if you would be willing to take part in a telephone interview or round table focus group discussion on adaptation costs:

- Yes
- No

Appendix B: Telephone interview template

This survey is being undertaken by the Building Research Establishment (BRE), on behalf of the Adaptation Sub-Committee (ASC) of the Committee on Climate Change. The aim of this survey is to understand further how designers and builders assess the costs and benefits of measures to increase the resilience of new buildings to overheating and flooding; what these costs and benefits are; and how they influence decisions on the extent to which these measures are incorporated into new buildings.

The results of this survey will inform the Adaptation Sub-Committee's understanding of incentives and barriers for adaptation measures to be incorporated into new builds, and will be used to inform the second progress report to UK Parliament.

This interview is expected to take approximately 30 minutes. All of your responses will be taken in confidence. The interview questions are based on your responses to initial questionnaire [where this has been completed].

Your survey responses have indicated that you have experience in (issue they know more about: Flooding/Overheating) the main part of the interview will focus on how you adapt buildings for this issue. After that I'd like to clarify a few points on your experience, if any, with dealing with (issue they know less about: Flooding/Overheating).

On behalf of the Committee on Climate Change and BRE I would like to express my gratitude for your valuable time and insights.

First of all, I'd like you to confirm the following responses from your survey:

- Profession;
- Business Name;
- Business Size;
- Typical Building Type;
- Typical Development Site and Size;

Flooding

Aim: To verify if buildings built in areas at risk of flooding are resistant and resilient to flooding

If the interviewee has developed in a flood risk area

How many properties have been developed in flood risk areas?

When you do build in a flood risk area, how is it approved during planning? Any special requirements?

Do any of the Flood Risk Assessments conducted for your projects include assessments of projected future flood risk due to climate change? Where would you get this information from?

If you have included flood resistance and/or resilience measures, from whom did these requirements come from?

Who checks that the specification embedded in the planning application is followed and that appropriate measures have been implemented?

Have you ever seen the specification being changed during the construction phase? e.g. they were not implementable/the project was late or over budget. How was this resolved? Were the original planning requirements met?

Which particular avoidance/resistance/resilience measures were selected? Why? What are the advantages and disadvantages of these measures?

Are these generic solutions or are they selected based on a bespoke assessment?

To what extent is there consumer demand for flood resilience?

Who would typically maintain the installed measure(s)?

Have you used ever used SuDS to manage the risk of flooding on a site? Which particular types?

How do you ensure that these measures are effective against flooding? Which standards, certification or testing protocols?

What is the most significant aspect of the costs? Materials, labour etc. Are life cycle costs taken into account?

How does cost influence the solutions chosen to manage flooding, where a risk is identified?

What are the main drivers for the implementation of measures to improve flood resilience?

What are the main barriers to the implementation of measures to improve flood resilience? Suggested options:

What might be a solution to these barriers?

If the interviewee has not developed in a flood risk area

Have you consciously avoided developing in areas at risk of flooding? Why?

What are the barriers to developing in areas at risk of flooding? e.g. did planning requirements prevent you developing there? Was the client unwilling to pay the extra?

Overheating

Aims:

What stops people from considering overheating at the design stage including what are the specifics about the barriers in question (e.g. specific costs, conflicts, perceptions)?

Where overheating is considered, are companies successful at dealing with it at low cost?

If overheating is not considered

Where one of the factors described in Question 18 has stopped you from considering overheating at the design stage of a project, why was this the case?

What are the main barriers to preventing overheating?

Has overheating ever been identified in projects post-construction, if it was not identified as a risk initially? How

Where overheating is considered

Are climate change projections included when considering overheating as a risk? E.g. SAP Appendix P

If thermal comfort is not considered as a requirement, can you explain why it does not fall under an assessment of occupant health and wellbeing?

Have you ever found that measures to mitigate overheating conflicts with other aspects of the project, or vice versa? How so? What are the trade-offs?

If the costs have been found to be prohibitive, can you elaborate on what these costs were and at what stage of the design process they were estimated?

Who typically performs the assessment of overheating?

Is this based only on current risk? What about increased risk due to climate change over the lifetime of the building?

Why are these specific strategies selected? Are they generic or bespoke? Advantages and disadvantages of chosen measures?

If including measures to mitigate against overheating were included: (a) is it mandatory for securing planning permission? How does it help? (b) Why do property values increase? By how much? (c) Which standards/certification does this help to achieve? How? (d) How does it help to improve reputation?

What is the most significant aspect of the costs? Materials/labour etc? How does any initial increase in costs weigh against life costs?

Did you find it difficult to get these measures through to the build stage because of the additional cost? If so, in what way?

If overheating has ever been identified as an issue after completion o one of your organisations projects, what was the cause of the overheating? Were any remedial works required?

Was the property assessed for overheating pre-construction? Was a risk was identified? Was anything done or were the implemented measures ineffective? Why? Why did these measures fail? Were there any repercussions

Has designing your building for carbon reduction/energy efficiency ever exacerbated overheating? If so, how was this managed?

What are the main drivers for the implementation of measures to mitigate against the risk of overheating?

What do you see as the main barrier(s) to implementation of measures to prevent overheating?

Thank you that concludes this interview.

Once again behalf of BRE and the Committee on Climate Change I would like to express my gratitude for your valuable time and insights.

Would you be interested in joining a focus group in early March? Either Manchester or London.

Report Ends