# Incorporating Climate Change Projections into Building design: A Qualitative Study

Mehreen Gul*, Gill Menzies, Phil Banfill

*Urban Energy Research Group, School of Built Environment, Heriot-Watt University, Edinburgh, UK*
** Corresponding author. Tel: +44 1314514637, E-mail: M.Gul@hw.ac.uk*

**Abstract:** The UK climate of the future cannot be predicted with certainty and this is reflected in the current UK Climate Projections (UKCP09), which are probabilistic in nature. It is anticipated that the conventional approaches to building design will not adequately represent the effects of future warming and therefore guidance is required to overcome future overheating of a building by making it thermally more comfortable. The study presented here relates to a qualitative investigation and aims to draw out the needs and preferences of building design professionals to develop an easy to use formulation for adequately sizing Heating, Ventilation and Air-Conditioning (HVAC) plants. It will serve as an interface between professional building services engineers and the research team working on probabilistic weather data and a building simulation package. This investigation deploys a qualitative research approach of *Methodological triangulation*, which refers to the use of more than one method for gathering data. Herein, the three strands of research that will be used are the questionnaire, semi structured interviews and focus groups. This work is ongoing and the analysis is due for completion in 2012. This paper focuses mainly on some of the initial findings of the qualitative approaches mentioned above for domestic buildings only.

***Keywords:*** *Qualitative investigation, Future climates, Focus groups*

## 1. Introduction

In the absence of formalised design requirements that take account of climate change, there is a need for pragmatic guidance on pro active design measures to ensure that the construction of new, and the refurbishment of older buildings avoids unacceptable problems or failures in the future. There has been growing concern that the trend towards hotter drier summers will lead to a reduction in the quality of the internal environment within buildings. Potentially this could lead to a wide range of health problems for occupants, and a significant deterioration in comfort conditions. In particular there is a concern that the overheating of buildings during the summer months could become an issue within the UK. [1]

The UK climate of the future cannot be predicted with certainty and this is reflected in the current UK Climate Projections (UKCP09) [2], which are probabilistic in nature. It is anticipated that the conventional approaches to building design will not adequately represent the effects of future warming and therefore guidance is required to inform adaptation decisions i.e. the adjustments required to overcome future overheating of a building by making it thermally more comfortable.

The Low Carbon Futures Project, as part of the Adaptation and Resilience to Climate Change (ARCC) programme in the UK, integrates UKCP09 into dynamic building simulation calculations [3]. The study presented here relates to a qualitative investigation and aims to draw out the needs and preferences of building design professionals to develop an easy to use formulation for adequately sizing Heating, Ventilation and Air-Conditioning (HVAC) plants. It will serve as an interface between professional building services engineers and the research team working on probabilistic weather data and a building simulation package [4]. Interaction with building professionals will ensure that the approach taken leads to a practitioner-focused rather than an academic outcome.

This work is ongoing and the analysis is due for completion in 2012. This research output enables the project team to tailor a design tool module that might potentially be integrated with existing building simulation packages to assess the overheating risk for future climates. The project is looking at domestic and non-domestic buildings but this paper is focusing only on domestic buildings and will present the results of initial qualitative investigation.

## 2. Methodology

A holistic overview of the HVAC building design process was undertaken. The initial questions were constructed after reviewing steps in the design process from statement of need to the final solution. The questions are based on issues of current and future overheating assessment, climate change impact, building performance metrics, adaptation techniques and probabilistic climatic data for the future. The aim was to get feedback and advice from the user community to understand the current practice of building design process and the measures required to combat changes that may occur due to changes in the future climate.

Since the project is reliant on feed-back from user groups to tailor the outcome of this project, this investigation deploys a qualitative research approach of *Methodological triangulation*, which refers to the use of more than one method for gathering data. The use of more than one approach to the investigation of a research question enhances confidence in the ensuing findings. Since much social research is founded on the use of a single research method and as such may suffer from limitations associated with that method or from the specific application of it, triangulation offers the prospect of enhanced confidence. By and large, researchers viewed the main message of the idea of triangulation as entailing a need to employ more than one method of investigation and hence more than one type of data. Social scientists are likely to exhibit greater confidence in their findings when these are derived from more than one method of investigation. Of course, the prospect is raised that the two sets of findings may be inconsistent, but such an occurrence underlines the problem of relying on just one measure or method [5].

Herein, the three strands of research that will be used are the questionnaire, semi structured interviews and focus groups. The results of each will be 'triangulated' to provide additional confidence in the conclusions – ideally, findings in each strand will help to support findings in the others.

**Questionnaires** are used in a wide range of settings to gather information about the opinions and behaviour of individuals. Questionnaires are objective and gathered in a standardised way thus providing an initial indication of the trends behind the current building services design process.

**Semi-structured Interviews** This type of research is valuable for an in-depth examination of people's attitudes and beliefs, and will provide insight into some of the reasons behind the decisions made. These interviews confirm what is already known and can provide reliable and comparable qualitative data.

**Focus Groups** can provide a dimension that is simply unavailable with a traditional survey as the interaction between participants can lead to new issues being identified. The combined effort of the group will produce a wider range of information, insight, and ideas than the responses of a number of individuals when these replies are secured privately. A bandwagon effect often operates in a group interview situation, in that a comment by one individual often triggers a chain of responses from the other participants. A signature aspect of a focus group

is the objective to better understand the group dynamics that affect individuals' perceptions, information processing, and decision making. [6]

## 3. Results and Discussion

### *3.1. Questionnaire*

A questionnaire was designed with the main focus on highlighting the current process of building design, importance of different design variables, factors affecting thermal comfort, overheating and adaptation methods to mitigate the climate change for future years. The questions were orientated to gauge the differences between the typical practice and the best practice for HVAC design.

Normally, to limit the population surveyed, a sample is drawn to reflect the characteristics of the total population. By using a carefully drawn sample, there is an assurance that potential respondents have been selected in a standard, scientific manner. In this research the survey population was the Building Industry. The questionnaire was distributed via the fortnightly electronic newsletter of a building services professional body to all of its members. The resulting drawn sample therefore attempts to reflect the characteristics of the total population involved in the designing, structuring and engineering of buildings.

In this instance a total number of 42 people actually responded to the survey but as expected it was a diversity of professionals consisting of Architects, Electrical/Mechanical Engineers, Technical Directors, Energy Consultants and Sustainability Engineers. Although the responses were self selected and few in number, they still appear to suggest some trends within the Building Industry. The distorting effect of differential response rates has long been recognised as a limitation on inferences drawn from questionnaires in social research. Bias may arise even where the response is 100% and it is commonly understood that even where questionnaire response is poor, correlational studies are affected only by loss of degrees of freedom or precision [7]. In instances where the response rate is low or non neutral with regard to the topic of investigation, it is held that the conclusions suffer only from an increased sample variability, rather than from a substantial problem of bias. Increasing the response rate does not necessarily improve the precision of survey results [8]

Fig. 1 shows the hypothesis that emerged from the 31 responses to one of the questions of the questionnaire. It can be seen that the most important drivers in HVAC design are those of Building Characteristics, Available Budget, Comfort Criteria and $CO_2$ Emissions. Weighted scoring of these responses provides a method for evaluating the priority level of an individual at a glance. Weightings with values of 4, 3, 2 and 1, corresponding to very important, important, least important and not considered, respectively, were assigned to the columns. It can be seen that the Building Characteristics and Available Budget are the top rated parameters, followed by Comfort Criteria, Life Cycle Costs and $CO_2$ emissions. Plant Space and Ease of Installation are the least voted parameters.

Thermal comfort in a room is determined mostly on the basis of room air temperature, followed by external temperature and occupant activity. When asked about the incorporation of summer conditions of future climates into the design process, 77% of the professionals admitted including it, but only 33% implemented any measures to overcome future summer overheating. It emerged that adaptation is not always a part of the designing process but in some instances where it is, window opening, moveable internal blinds, air-conditioning and occupant control are highly regarded. It is also seen that beyond meeting Building Regulations and the requirement of Energy Performance Certificates, Good Practice Guides

and Building Research Establishment Environmental Assessment Method (BREEAM) are gaining priority.

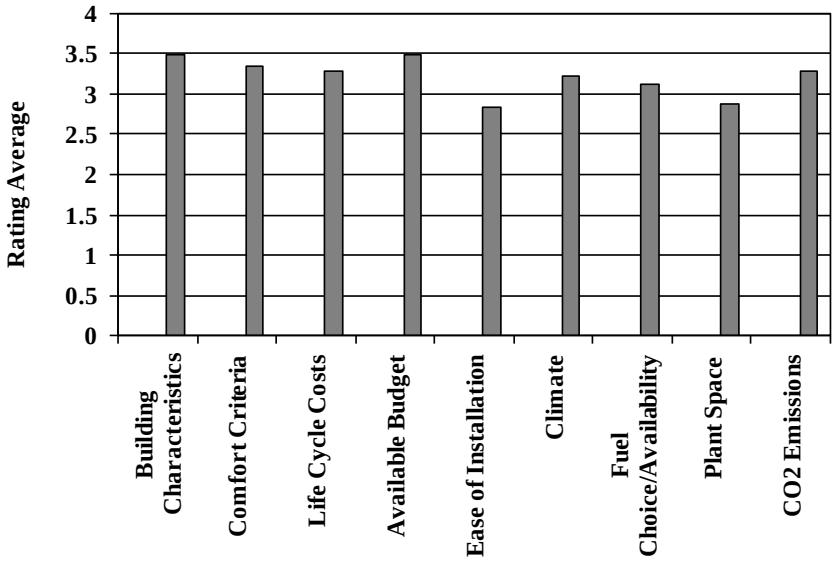


*Fig. 1. Most important drivers in HVAC design*

### *3.2. Semi-structured Conversation*

The project team plans to hold at least 18 semi structured interviews, 6 of which will be undertaken for domestic and 12 for the non domestic sector (6 for offices and 6 for schools). The first round of these interviews will take place in early 2011.

There have been 2 Focus Groups held so far (see Section 3.3) where opportunities to speak to participants were fully utilized. Each Focus Group had 6 participants comprising of architects, building surveyors, building services engineers, property managers, environmmental consultants and sustainability officers. Prior to commencing the actual Focus Group sessions, a semi structured discussion ensued when an initial task was set where the participants were provided with a list of 9 factors (same as shown in Fig. 1) from which to choose, in their opinion, the 3 most important drivers for HVAC design. On selection, the participants were asked to provide the reasoning behind their choices based on their experiences.

The results of these semi structured conversations are included in this section. The generic message was that there are obvious design features that could and should be optimised to ensure efficient HVAC systems. These include Building Characteristics such as location and the orientation of buildings on a site, thermal insulation levels, glazing type, the use of shading and the use of exposed thermal mass in the structure to moderate temperature extremes. Some of the comments are quoted below.

> *''The main one that stands out probably is the Building Characteristics - absolutely getting the fabric of the building right whether that's working on an existing building or a brand new building''*

> *''HVAC design- design it out as far as possible so Building Characteristics''* (is the most important factor)''

The design process seems to rely heavily on the Available Budget as some respondents agree

that money is usually the driving force behind the decisions made and other issues are only secondary.

> *''If we have all the money in the world we could do everything but we can't - so Available Budget restricts it all''*

> *''Available Budget, I spend all of my day discussing designs with different developers to minimise spend on budget''*

> *''Available budget because there is precious little of it''*

Most of the professionals agree on $CO_2$ emissions to be the most important driver as it is seen as a significant problem currently and in the future. Different councils have different $CO_2$ emissions criteria and designers have to follow it by choosing fuels source that will produce minimal emissions. Some people are of the view that buildings are for people and whichever way the buildings are designed, comfort should be the main priority.

> *''$CO_2$ emissions because it seems to be a significant problem we are going to have in the future''*

> *''As the designers we have responsibility towards a cut in carbon emissions because the way we use buildings accounts for nearly half of all are national emission."*

> *''Comfort Criteria - we are designers and we are designing to know the person and always take that into account whether it's an office building or an individual's requirement''*

> *''Comfort is becoming very important in the long term especially with questions over what the future climate is doing''*

### *3.3. Focus Groups*

There will be 6 focus groups throughout the UK, 2 for the domestic and 4 for the non domestic sector (schools and offices). To date, 2 Focus Groups on overheating in the domestic sector have been held as explained in section 3.2. Focus Groups were conducted in Edinburgh and in London to ascertain the differences in regional and climatic variations that would have an impact on the attitudes and experience of the participants. There is no magic number and more is not necessarily better, although holding 2 focus groups with similar group characteristics may place the results on firmer ground in relation to the patterning of the data. This is because it would suggest that the differences observed are not just a feature of a one-off group, but are likely to be related to the different characteristics of participants reflected in the selection [9]. A total of 6 research questions were explored in detail in these sessions but only some of the main themes that emerged are included in this paper and are as follows:

There is general agreement that the UK is in a comparatively good position as far as overheating in dwellings due to climate change is concerned. From the quotes given below one can observe the difference in trends due to regional variation. It is clear that there is little or no concern of overheating in Edinburgh (Scotland) whereas, although not regarded as an important issue in London (South England) it is nevertheless borne in mind that with suitable measures, this problem can be prevented.

*"Currently, Overheating is not necessarily seen as a problem as we do not tend to install air conditioning in to domestic buildings as a norm''* (Edinburgh Focus Group)

*''The UK is really in a privileged position as far as Overheating is concerned, with suitable interventions one can get both cooling in the summer and heating in the winter''*(London Focus Group)

No significant attention is being paid to future overheating in the domestic sector. Strategic decisions from the outset are essential. Getting the fabric of the building absolutely right for both existing buildings and brand new buildings is imperative thus dealing with what you can within the building characteristics/fabric and then looking at what you need to add in to the building to overcome any overheating problems. Typical comments are:

*''Building Characteristics top of my list because we are trying to make (these) strategic decisions from the outset''*

*''Building Characteristics obviously dictate whether you need HVAC for the start, whether you have to work from where you are or where you want to be"*

*"You have to get more mass into buildings to try and soak it up and redistribute it at times of the day when it's more beneficial''*

*''Some house builders have kind of set parameters for a fabric designed solution for reducing carbon and energy output"*

*''Building Characteristics - that's the most important - it's about reducing mechanical ventilation in the building - to maximise the way that natural ventilation can work well and also simply without being overly complex''*

For normal domestic developments the envelope design is deemed critical and construction elements seem more of a concern to future climate than overheating. Improvements in windows are required as double glazed windows still let in and let out substantial heat. By moving to a proper standard triple glazed passive house window, conditions can be maintained where no matter the external temperature, internal conditions can remain stable. Experience dictates that the main driver in people to overcome overheating will be legislation. A full impact will only be achieved if stipulated in Building Regulations.

*''Until we have to do it we won't do it, the money is not there and nobody is going to spend over the top"*

***''**We are driven by legislation in terms of what criteria we have to actually meet and our question is whether legislation is actually accurate where it's driving us to''*

*''If there is no legislation saying that you have got to do it at the moment you just have to use the latest national calculation methodology software and that's got a bit of overheating and that's all people will do''*
*''Every time we build one of these buildings we are almost building a little experiment based on legislation''*

There is a fundamental need to inform the user. Building Regulations can change and

buildings can become more and more efficient but it is imperative to also educate in order to change user habits. Habit means that thermostats are set at the same level even though a reduction of a couple of degrees would also be perfectly acceptable.

> *''Our behaviours have got to change- The barrier is actually the values of our society and the literacy of our society to the changing climate as much as it is about regulations''*

> *''We can change the Building Regulations and buildings can become more and more efficient but people don't change their habits so how much of this energy is going into the building fabric needlessly?''*

> *''We are technical people, we come up with technical solutions and we are forgetting that there are people living in these places who may not understand''*

All participants agree that the weather will get warmer in the future, which although alarming is ignored, as it is not considered an issue at the moment. Some participants said that they preferred to keep their 'heads in the sand' in the hope that it can be avoided until it is no longer their problem. The prevalent feeling is that probability is the only way forward to deal with future predictions otherwise people will want proof. If a tool is to be provided, that specifies the overheating risk of a building, as part of an overheating analysis based on probabilistic climate projections, it needs to be really simple and understandable.

> *''There is no intrinsic value to creating a better building or a more energy efficient building at this moment in time''*

> *"Yes it's going to get warmer but not in my lifetime so I don't need to bother about it - it's my children's problem they can deal with it"*

> *''Climate Change and Overheating is actually quite difficult at the moment to calculate anything on but the construction element is even worse - how can we design better buildings and better details''*

> *''The Probability aspect is probably the only way that you can model it - you have to have those variables and perhaps some kind of benchmarks.*

> *''The Tool needs to be a form where you can add it to the way you model the building as it stands''*

## 4. Conclusions

The Low Carbon Futures project relies on feedback from the Building Design Community to design a tool that can predict the risk of future overheating in buildings. This paper presented the initial findings of a qualitative investigation performed to gain insights into some of the decision making process. An important aspect of this study was to get the feedback of the Building Industry, surrounding aspects of HVAC design. As with any other branch of science, the validity and reliability of the measurement tools, needs to be rigorously tested to ensure that the data collected is meaningful. Depth of qualitative information may be difficult to analyse for example, deciding what is relevant and what is not. This investigation has therefore adopted the triangulation approach to analyse the resulting data from 3 modes: A questionnaire, semi- structured conversations and focus groups.

The Questionnaire results have suggested that the Building Characteristics and Available Budget are the top rated parameters, followed by Comfort Criteria, Life Cycle Costs and $CO_2$ emissions. Semi-structured Conversation with 12 experienced professionals indicated that the reduction of $CO_2$ emissions is the lead factor as it is a regulatory requirement. The majority agreed that many problems could be solved if a building is designed properly taking into account Building Characteristics. Available Budget and Comfort Criteria also play a key role in this aspect. Analysis of the Focus Group discussions revealed that the initial decision needs to be made on the building characteristics and then what is to be added in to the building to design the HVAC system needs to be addressed. There is a need to get the fabric of the building absolutely right whether that is working on an existing building or a brand new one.

The Triangulation methodology adopted herein seemed successful in validating the suggested hypothesis from the questionnaire by confirming it with the findings of the focus groups and the semi structured conversation. Since this is an initial analysis, these issues will be fully explored and on a larger scale with the semi- structured interviews taking place in early 2011 and with more focus groups.

After the initial questionnaire and focus groups there is a strong suggestion that currently overheating is not considered as a critical element when designing or refurbishing new and existing domestic buildings. However, the use of probabilistic climate information has been heard with interest inferring that a probabilistic approach may be the way forward to tackle the unpredictable nature of the weather in the coming years. The unanimous belief was that until the building industry is forced to consider climate change they will not do it. It is also accepted that a tool, based on probabilistic predictions, that is a simple add on to existing techniques will be well-received.

**References**

[1] Good Building Guide 63 (GBG 63), Climate change: Impact on building design and construction. BRE press 2004, pp. 1-6

[2] P.D. Jones et al., UK Climate Projections science report: Projections of future daily climate for the UK from the Weather Generator, available from http://ukclimateprojections.defra.gov.uk

[3] Adaptation and Resilience in a Changing Climate Network (ACN), Programme website http://www.ukcip-arcc.org.uk/content/view/605/519/

[4] S. Patidar, D.P. Jenkins, G. Gibson, and P.F.G. Banfill, Statistical techniques to emulate dynamic building simulations for overheating analyses in future probabilistic climates, Journal of Building Performance Simulation, In Press, 2010

[5] A. Bryman, Quantity and Quality in Social Research. Routledge, 1988, pp. 131-134

[6] D. W.Stewart, P.N. Shamdasani and D.W.Rook, Focus groups Theory and Practice, 2nd Edition, Sage, 2007, pp. 1-16

[7] R. J. Bowden, Self-Selection Biases in Correlational Studies Based on Questionnaires, Psychometrika 51, 2, 2010, 1986, pp. 313-325

[8] W. Jones and J. Lang, Sample composition bias and response bias in a mail survey: A comparison of inducement methods. *Journal of Marketing Research* 17, 1980 pp. 69-76

[9] R.Barbour, Doing Focus groups, First Edition, Sage, 2007, pp. 57-60