Adaptation to weather and climate in office buildings in Manchester

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EcoCities is a joint initiative between the School of Environment and Development, at The University of Manchester, and commercial property company Bruntwood. The project looks at the impacts of climate change and at how we can adapt our cities and urban areas to the challenges and potential opportunities that a changing climate presents.

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## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summary</strong></td>
<td>7</td>
</tr>
<tr>
<td><strong>1 Introduction</strong></td>
<td>9</td>
</tr>
<tr>
<td><strong>2 Methodology</strong></td>
<td>11</td>
</tr>
<tr>
<td>2.1 The office buildings</td>
<td>11</td>
</tr>
<tr>
<td>2.2 Social survey</td>
<td>12</td>
</tr>
<tr>
<td><strong>3 Office buildings and weather</strong></td>
<td>15</td>
</tr>
<tr>
<td>3.1 Buildings’ characteristics</td>
<td>15</td>
</tr>
<tr>
<td>3.2 Impact of weather on the buildings</td>
<td>16</td>
</tr>
<tr>
<td>3.2.1 Low temperatures</td>
<td>16</td>
</tr>
<tr>
<td>3.2.2 High temperatures</td>
<td>17</td>
</tr>
<tr>
<td>3.2.3 Rain and wind</td>
<td>18</td>
</tr>
<tr>
<td>3.3 Current and potential adaptation measures</td>
<td>19</td>
</tr>
<tr>
<td>3.3.1 Perceived need for adaptation</td>
<td>19</td>
</tr>
<tr>
<td>3.3.2 Heating systems</td>
<td>19</td>
</tr>
<tr>
<td>3.3.3 Cooling systems</td>
<td>21</td>
</tr>
<tr>
<td>3.3.4 Windows</td>
<td>22</td>
</tr>
<tr>
<td>3.3.5 Building fabric</td>
<td>25</td>
</tr>
<tr>
<td>3.3.6 Rainwater storage/drainage</td>
<td>25</td>
</tr>
<tr>
<td>3.3.7 Internal layout and fittings</td>
<td>26</td>
</tr>
<tr>
<td>3.3.8 Building surroundings</td>
<td>27</td>
</tr>
<tr>
<td><strong>4 Issues affecting the physical adaptation</strong></td>
<td>28</td>
</tr>
<tr>
<td>4.1 Conservation value of buildings</td>
<td>28</td>
</tr>
<tr>
<td>4.2 Cost of adaptation measures</td>
<td>28</td>
</tr>
<tr>
<td>4.3 Reactive versus preventive maintenance</td>
<td>29</td>
</tr>
<tr>
<td>4.4 Opportunities for adaptation</td>
<td>30</td>
</tr>
<tr>
<td>4.5 Division of responsibilities between the landlord and tenants</td>
<td>32</td>
</tr>
<tr>
<td>4.6 Tenants’ characteristics and preferences</td>
<td>34</td>
</tr>
<tr>
<td>4.8 Policy and standards</td>
<td>36</td>
</tr>
</tbody>
</table>
5 Interactions between weather, the office and the people

5.1 Impact of weather and temperature on people working in offices

5.1.1 Lateness or attendance at work

5.1.2 Productivity

5.1.3 Health

5.1.4 Tensions over temperature

5.2 Issues affecting thermal comfort in offices

5.2.1 Space organisation

5.2.2 Control over temperature and ventilation

5.2.3 Gender

5.2.4 Dress code

5.2.5 Work mode

5.2.6 Transport to work

5.2.7 Expectations regarding the office environment

6 Response to temperature and extreme weather

6.1 Changing what people wear

6.2 Changing the space organisation

6.3 Adapting working times and locations

6.3.1 Home working

6.4 Reducing the use of heating and cooling

6.5 The role of the landlord

7 Conclusions

7.1 Recommendations

7.1.1 Recommendations for office building owners and managers

7.1.2 Tenant companies

7.1.3 Policy makers and the industry

8 References
List of Figures

Figure 1. Differences in perceived winter temperature between the two buildings 17

Figure 2. Differences in perceived summer temperature and comfort between the two buildings 18

Figure 3. Difference in glare from sun and sky between Buildings A and B 23

Figure 5. Comparison of the impact of the building’s environmental condition on productivity at work between the Buildings A and B 40

Figure 6. Associations between the self-assessed health in the building and the perceived comfort of temperatures in winter and summer 42

Figure 7. Comparison of level of control over heating and cooling between Buildings A and B 46

Figure 8. Spearman’s rank correlations between the level of control over heating, cooling and ventilation and the self-assessed productivity and health 48

Figure 9. Differences in level of control over heating, cooling and ventilation between offices of different size 49

Figure 10. Differences between men and women under 30 years old in the perceptions of temperature in winter and thermal comfort in the summer 52

Figure 12. Percentage of male and female respondents considering control over ventilation as important 54

Figure 13. Percentage of office workers changing their behaviour in response to the environmental conditions in the buildings 59

Figure 14. Umbrella storage (left) and umbrella wrapping machine (right) in the lobby of an office building in Nagoya, Japan 70

Figure 15. Green roof on Chicago City hall: air conditioning vents and vegetation in harmony 71
List of Tables

Table 1. Opportunities for linking the adaptation solutions to the planned changes in the two buildings 31
Table 2. Spearman’s rank correlations between the level of control over temperature and ventilation and the perceived thermal comfort 47
Summary

This EcoCities report analyses current use and the perceptions affecting the potential future use of the physical and behavioural climate change adaptation measures in commercial office buildings.

The case study considers two different types of office building common to Greater Manchester. One is a listed building dating from the early 20th century and the other is a modern 1960s high-rise building. Both buildings are owned and managed by a property management company, and the individual office suites are rented out to tenant companies.

A mixed-method approach is used. A quantitative analysis of building occupant survey data, collected by Arup Manchester with the use of Arup Appraise methodology, is complemented by two series of semi-structured interviews with building management teams and representatives of the tenant companies.

The report considers physical adaptation measures in the current climate that affect the interactions between the weather and climate, the buildings and the people working in the offices. It draws out the key issues that affected the use of physical adaptation responses by building users. It also investigates perceptions of office workers on the impact of weather and temperature; what affects their thermal comfort and how behavioural changes could be promoted at the level of individual, company and the landlord.

The buildings investigated here are also subject of a report aiming to estimate the changes in expenditure on energy associated with heating and cooling under different climate change projections (see Cavan and Aylen 2012).
1 Introduction

We spend most of our time in buildings; in our homes and workplaces (Lader et al 2006). We know that the built environment is already affected by the weather and the changing climate. Between 1947 and 2008, 54 extreme weather events were recorded in Manchester that affected the built environment. The damage predominantly came from floods and storms (Carter and Lawson 2011). Even when the built environment itself is not directly affected by extreme weather events, such as heatwaves or low temperatures, by protecting people inside from the external conditions, it can either decrease or exacerbate the weather impacts to occupants.

The future projections of Greater Manchester’s (GM) climate suggest an increase in extreme weather events. Temperatures may rise and heatwaves become more frequent. Since these conditions are not common to GM’s currently moderate climate, adaptation will be required (Cavan 2011). While some new developments consider the future climate, over 80% of existing buildings will still be in use in 2050 (Boardman 2007). Therefore, it is necessary to consider whether existing buildings are adapted to both the current and future weather and climate in order to maintain comfortable living and working conditions.

This paper focuses on the commercial office buildings. They are an important workplace; 78% of the UK workforce is employed in the service sector (D’Agostino et al 2006), where offices are commonly rented to house their workers. Although technology has developed sufficiently to allow remote work, the majority of service industry jobs remain office-based. GM has a high concentration of these, particularly relating to the public sector and financial and business services. Combined, they account for 58% of the GM’s economic output (GVA 2011: 1). Many of these office buildings are located in urban centres meaning that they may be affected by the urban heat island (UHI) effect raising the temperatures (McEvoy et al 2006).

Approximately 55% of commercial office spaces in Manchester city centre were constructed before 1970; a proportion roughly similar to the average across the region (Nathaniel Lichfield and Partners 2010: 38). Many of these are inadequately suited to the current climate even before considering future changes (Roaf et al 2007). Technical solutions can improve the thermal comfort of people in the building; for example, air conditioning is increasingly considered
the norm rather than a luxury (Sanders and Phillipson 2003; Hacker et al 2005). However, air conditioning is not always considered to be sustainable; either environmentally, due to generating carbon emissions, or financially, due to increasing energy prices (Hacker and Holmes 2005; Smith and Levermore 2006; Cavan and Aylen 2012). Other physical options are being explored that respond to this, as described in an EcoCities literature review on the physical adaptation of commercial office buildings (Connelly 2011).

Technical strategies will help buildings adapt to the changing climate. However, human expectations, preferences and behaviour influence the functioning of these systems. Even the most sophisticated natural ventilation system will not operate properly if a building’s occupants do not know how and when to open the windows or if they prefer to use air conditioning. Considering behaviour change is a new direction in climate change adaptation. To some extent, it is explored in relation to risk perceptions (for example in the case of flooding; Bichard and Kazmierczak 2011). Yet it remains undeveloped in the more mundane aspects of everyday life and work.

Planning and implementing adaptation in the office buildings can be complex because of tenancy agreements, office turnover and ownership patterns. Typically, a building is owned and managed by one entity, and sub-divided into individual office suites that are rented by organisations of different size, needs and business types. This results in an interesting dynamic of responsibilities and expectations between tenants and landlords that further complicates the physical and behavioural aspects of adaptation.

This EcoCities paper brings all of these considerations together by investigating the social aspects of climate change adaptation in two different kinds of office buildings in Manchester. To supplement technical concerns, we unravel the views of tenants and landlords to explore social aspects of climate change adaptation; the perceptions, expectations and behaviour of people in relation to climate change adaptation Section 2 looks at the current impacts of weather conditions. Section 3 covers user perceptions of current and potential adaptation measures while section 4 investigates the issues that influence the implementation of these. Section 5 focuses down on interactions between the weather, the office space and the people using it. Following this, section 6 explores the way in which behaviour could be changed to minimise the negative impacts of the weather and climate on office workers. We conclude by making several recommendations aimed at commercial property owners, businesses and policy makers.
2 Methodology

2.1 The office buildings

This case study is based on two types of commercial premises in Manchester. These buildings are owned and managed by the same property development company who lets office suites out to various organisations. The buildings were constructed at different times and to dissimilar designs and can be considered as representative for a significant proportion of the varied commercial building stock in GM. Their contrasting character and arrangement of internal spaces means that conclusions can be drawn about the behaviour of people and adaptation responses in different types of space.

Building A was constructed in the early 1960s with one major refurbishment in the mid-1980s which included external recladding. It is one of the tallest office buildings in Manchester city centre. East and west elevations incorporate continuous windows above precast concrete panels. The north and south gable walls of the structure do not currently have any window openings present. It provides rented office accommodation and serviced office suites. The gross floor area is almost 16,000m². Building A is served by a landlord and tenant electricity system as well as a gas supply to space heating boilers and gas fired domestic hot water generators. The office suites are predominantly ventilated naturally while the toilets are served by a mechanical ventilation system. The building has a flat concrete roof.

Building B is an Edwardian Grade II listed building that is over nine storeys high. Originally designed as the head office for a prestigious professional association, it has subsequently undergone a series of refurbishments and currently provides rented office suites of different sizes with retail units at ground floor. Building B has a net lettable area of just over 26,000 m². The average weekday occupancy is between 1,200 to 1,300 people. The building has an extensive curtain wall single glazing system on rear elevations with a neo-classical front elevation to a busy thoroughfare. Heating is provided by a combination of radiators served by central gas fired boilers and refrigerant heat pump systems. The building was originally naturally ventilated by floor-by-floor mechanical ventilation systems.
Approximately 70% of the treated floor area now includes comfort cooling systems. The building is divided into four 'blocks' separated by lightwells.¹

2.2 Statistical analysis of the Arup Appraise data

Between December 2010 and January 2011, Arup Manchester carried out a questionnaire survey of building users in Buildings A and B. This was done with the use of Arup Appraise; a building performance evaluation service which provides a unique view of building performance by considering user needs and workplace performance. It is both quantitative and qualitative; combining industry standard survey methods with empirical benchmarks, and also drawing on the observations of building users. Arup Appraise is licensed to Arup and is protected by Intellectual Property rights. It includes questions relating to the thermal comfort of the building users, their perception of the building and a number of socio-demographic questions. 120 questionnaires were collected in Building B (c. 80% response rate) and 47 in Building A (c. 30% response rate).

The data was analysed using the following statistical methods: Spearman’s rank correlation ($r_s$); Mann-Whitney test (U); and chi-square ($\chi^2$). See Box 1 for the explanation of the statistical terms.

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¹ Information on both buildings was provided by Arup Manchester.
Box 1. Explanation of statistical terms and graphs used in the report.

Spearman’s rank analysis is used to analyse the associations between two variables measured on an arbitrary scale, rather than measured scale (i.e. satisfaction with workplace or perceived thermal comfort). The correlation coefficient \( r_s \) can vary in value between -1 and 1. It. If there is a perfect linear relationship between two variables with a positive slope (i.e. low values of variable A match low values of variable B), the correlation coefficient is 1; if there is a perfect linear relationship between two variables with a negative slope (i.e. low values of variable A match high values of variable B), the correlation coefficient is -1. A correlation coefficient of 0 means that there is no linear relationship between the variables. The closer the coefficient \( r_s \) values are to 1 or -1, the stronger the correlation.

Chi-square (\( \chi^2 \)) test is used for categorical data, which cannot be presented on a scale (e.g. men or women; Buildings A and B). It is used to test whether distributions of categorical variables differ from one another; i.e. whether the number of cases differs significantly between categories of data.

Mann Whitney test (U) is used for variables measured on arbitrary scale and it compares two mutually exclusive groups of results (e.g. for Building A and Building B) in order to assess if there is a significant difference between them (if the values in one group are higher than in the other). The data for both groups is ranked from smallest to the largest and U relates to the average of the rank values.

In all statistical tests, N refers to the number of observations (sample size) in a given test. The p value relates to the statistical significance of the test, i.e. the probability of the result being true. Significance levels show you how likely a result is due to chance. If p<0.05, the finding has less than 5% chance of not being true; there is a 95% chance of it being true. The lower the value of p, the higher the probability of the result being true; when p is larger than 0.05, the results are considered not statistically significant.

Box plots are used to compare the median values between two or more mutually exclusive groups of results:

- **Values Values >1.5 IQRs but <3 IQRs from the end of a box are outliers (marked as circles); values more than three IQRs are extreme outliers (*).**

- **The median value**
  - The interquartile range - IQR (values higher than the lowest 25% and lower than the highest 25%)
  - The full range of results (whiskers show minimum and maximum values in the sample)

- **The variable, whose values are being compared between the groups**
- **Temperature in winter**
- **Too cold**
- **Neutral**
- **Too hot**

- **Building A**
- **Building B**

- **The groups that are being compared**
2.3 Qualitative social survey

In order to complement the findings of the quantitative Arup Appraise survey, semi-structured interviews were carried out in both buildings. These included, firstly, a series of four semi-structured interviews with the landlord’s customer service and facilities management teams, carried out in August 2011. The questions asked during these interviews investigated the impact of weather on buildings; how the maintenance of both the physical structure of the building and of customers’ expectations is carried out; and what their perceptions were of the potential adaptation responses.

Secondly, ten semi-structured interviews with senior managers from tenant companies residing in the building were carried out between September and November 2011. We targeted participants who had an overview of the issues relating to their office. These interviews included questions about the characteristics of the office they are using, impacts of weather on their office space, behaviour of people in relation to weather and climate and the company practices associated with managing the impacts of weather and climate on their offices and staff.

Participants were drawn from a range of business types including built environment professionals, investment companies and recruitment agencies. They ranged in size from 4 to 200 staff (an average of 63 people per business). One group receives a large amount of visitors and, therefore, although it only employs 80 staff their office spaces can host up to 700 visitors at any one time.

All interviewees in both series of interviews gave their informed consent to the interviews. With the permission of the participants, the interviews were audio-recorded and transcribed by a professional transcription company. The interviews were then coded under a number of themes using NVivo 9 software. All of the interviews were anonymised although quotes throughout the document indicate what building an interviewee was based in.
3 Perceptions of office buildings and weather impacts

3.1 Buildings’ characteristics

The interviewees described Building A as basic, ‘nothing flash’, a ‘normal modern building’. Nevertheless it was seen as ‘nice’. On the contrary, Building B was generally assessed favourably in terms of its aesthetics and design. The respondents used emotive words such as ‘fantastic’, ‘impressive facade’, ‘lovely’, ‘wonderful’ and ‘stunning’. People working in the building identify themselves with it and call it ‘my building’. The traditional character of Building B was particularly appreciated but it was also observed that age is causing breakdowns, that the building is antiquated, constrained by its layout and inefficient in terms of energy performance.

Building B’s unique characteristics are one of the reasons why many companies renew their tenancy period even when they change size. The facilities management consider it to be one of the ‘best retention buildings’ (Interviewee B.7). However, despite the enthusiastic response to Building B in the interviews, there were no significant differences in the rating of design between Building A and Building B by the respondents to the Arup Appraise survey.

The main advantages of Building B quoted by the interviewees were the large floor space enabling open-space working even for companies employing 200 staff. In Building A, a smaller floor plate means that larger companies are spread across different floors: for some companies this is a reason to move, confirming that stairs are an obstacle when it comes to communications.

Spacious Building B was thought to provide plenty of natural light, even in offices facing the internal light wells rather than the outside. The amount of natural light and sun glare in both buildings differed depending on their exposure to the sun and to the floor that the

...the orientation is quite good for us ... [however] we do tend to get late afternoon sun coming in at a horrible angle. Interviewee B.3.
tenants were on. It was observed that the lower floors of Building A have reduced insolation due to the shade provided by surrounding buildings. Similarly, the lower floors in Building B were shaded by the light wells (resulting in low levels of natural light in some offices). However, in other locations in the same building, glare was considered a problem, in particular during specific seasons and times of day.

For both buildings, the central location was regarded as a prestigious advantage with only one interviewee reporting dissatisfaction with long journeys and expensive city centre food prices. Proximity to public transport links was beneficial, given the limited number of parking spaces available to people using the buildings, particularly with businesses who reported high numbers of visitors. The combination of Building B’s age and proximity to key transport links meant that it was regarded as a sustainable building to work in.

3.2 Perceived impact of weather on the buildings

Interviewees observed that recent weather, particularly snow events and extreme heat and cold, occurred more frequently. It was also observed that these extremes of weather have the largest impact on the buildings. Low temperatures were the greatest challenge identified for both buildings by the facilities management staff, followed by high temperatures. Wind and rain were less significant, and snow was only considered in the case of the disruption to travel.

3.2.1 Low temperatures

Tenants from Building A did not express many concerns about low temperatures in winter. On the contrary there were numerous complaints from Building B’s tenants regarding low temperatures. The analysis of the Arup Appraise data confirms that Building B was assessed by the office workers as significantly colder in winter than Building A (figure 1).
3.2.2 High temperatures

In both buildings, high temperatures in summer were a source of concern to the interviewees. The predominant reason for overheating was solar gain through the large windows. The problem was particularly felt in offices facing south, which were described as ‘absolutely boiling’ and ‘like an oven’ (interviewee A.3). Lack of appropriate ventilation (in particular in the light wells of Building B but also in parts of Building A) also added to the stuffiness of the air and general discomfort during high temperatures.

Analysis of the Arup Appraise data indicates that there were no statistically significant differences in the summer temperature and summer comfort between the two buildings. However, the comparison of median values shows that respondents to the Arup Appraise survey were feeling hotter...
and less comfortable in Building B during summer (figure 2). In terms of both variables (the perceived temperature and comfort), the median value of answers for Building A was at the comfortable, or neutral, level.

In both buildings, temperatures were raised by a considerable amount of internal heat gain associated with the presence of people (especially for large companies), lights and IT equipment.

**Figure 2. Differences in perceived summer temperature and comfort between the two buildings (based on Arup Appraise data).**

![Figure 2](image)

See Box 1. Explanation of statistical terms and graphs used in the report. for guidance how to interpret the results in the box plot.

**3.2.3 Rain and wind**

In the opinion of the interviewees, the buildings were not significantly affected by rain or flooding. Yet some leaks and minor flooding were experienced as a result of heavy rainfall, in particular on the top floors of both buildings. These problems were quickly addressed by the building managers.

According to the interviewees, the impact of wind was considerable. Due to its height, substantial noise from strong winds occasionally affected Building A. In Building B, the traditional windows could be draughty in windy weather resulting in lower temperatures. Some of the windows in Building B could even open or become damaged under the pressure of wind.
3.3 Current and potential adaptation measures

3.3.1 Perceived need for adaptation

During the interviews, it was observed by tenants and facilities managers that the increasing occurrence of extreme weather events, combined with building’s designed without due consideration of the warming climate, may require a change in management practices at both building and office level.

When hot weather occurred unpredictably outside of the typical period in 2011 (June to October), no air conditioning was the only adaptation measure used, and the discomfort associated with high temperatures was considerable, thus indicating the need for other solutions. It was also noted that current and projected changes in climate, for example concentrated rainfall, may increase roof leaks or expose the inability of drains to cope with the volume of water, particularly if these issues remain unaddressed. The following sections cover existing and potential physical adaptation measures.

3.3.2 Heating systems

In Building A, no problems with heating were reported by the majority of the respondents. On the contrary, there were a number of complaints that Building B’s central heating was too cold and inadequate. The ‘antiquated’ system of central boilers and wet radiators was not seen as satisfactory. The ‘single pipe’ heating system results in some areas being colder than others. The interviewees observed that the system is prone to airlocks, which means that the higher floors may experience problems with heating. These problems are exacerbated by the low water pressure in the pipes:

On the ninth floor, it takes some oomph to get it from the boiler room up. So without exception, when the heating comes on each year, we do have...
periods of time when it just simply isn't getting along our leg (Interviewee B.3).

In both buildings, the heating system is strictly regulated on seasonality, turned on between October and May, irrespective of the weather. It is turned off at weekends. This results in fluctuating temperatures throughout the week; Monday mornings in both buildings were thought to be cold. It was also observed in both buildings that the temperature tends to vary during the day, due to the heating being switched off at night.

A number of interviewees opined that the heating system should be more flexible to allow for changes in heating intensity according to the weather, season and time of day. It was also observed that several heating systems serving selected parts of the building, rather than one heating system for an entire building, would be much more efficient and customer-friendly. At present, companies who work weekends face the choice of either using a cold space or paying the charge for the entire building. Heating systems servicing individual offices or floor levels could ameliorate this.

In addition to the normal heating system, temporary heating solutions are often invoked in both buildings. The landlord provides portable heaters for their own staff at reception and for tenants if the temperature in the building drops below a designated comfort threshold (for example, due to very low temperatures or outside the heating season). Tenants are supposed to return the heaters when they do not need them anymore, but they tend not to in order to be able to use them as and when they wish. Consequently, temporary heating measures incur costs in assets (the heaters) and work hours spent organising them.
Many companies provide temporary plug-in heaters for their staff. Some workers bring their own portable heaters in. Across the board, they are not considered to be the best solution. For some companies the use of personal heaters goes against company policies on sustainability and energy use; others are concerned about the considerable extra expenditure on electricity. However, the decision to use them is driven by staff well-being. Also, one office manager observed that sometimes using a small number of heaters to keep individual people warm was more feasible than heating the entire office space.

3.3.3 Cooling systems

In both buildings most heating is centrally provided. Mechanical cooling provision is somewhat varied; some offices are not serviced at all. Tenants in poorly ventilated offices observed that temperatures can get very high without air conditioning. Predominantly, office suites are partially covered and have air conditioning in meeting rooms only. A few office suites service the majority of their space. The extent of the area provided with air conditioning depends on a tenant’s list of requirements when the suite is refurbished for their use; and also when it was refurbished last. It was expected by the building managers that the future rise in temperatures is likely to make air conditioning the standard equipment for office. Even those companies who do not currently use it would need to have climate control systems installed. They also observed that the system already has a heavy load leaving little room for manoeuvre in the future when temperatures are likely to get higher.

Differing client requirements, levels of tenancy turnover and the varied and uncertain use of the space (division into offices; number of people expected) make it difficult to retrofit a system that would be fit for future purpose:

When it’s been retro-fitted sometimes... it’s basically like a bolt-on, so you’ll get an air conditioning piece of equipment put into a room, and that might be fit for purpose for that one room at a certain point in time. Then you’ll get a customer move out and another customer move in. We sell it as an air conditioned room and they’ll put 20 people in a room this size. So the air-conditioning system that’s already installed can’t cope (Interviewee A.4).
Similarly, as in the case of heating, in-built air conditioning is supported by temporary cooling solutions, such as desk fans. The temporary measures are used where the air conditioning is not available or not efficient and where the natural ventilation is not possible. The landlord provides fans for tenant companies and some individual companies equip their staff with fans too. Cost is an issue, as in the case of temporary heating measures. Natural means of ventilating office spaces is also employed effectively for cooling purposes. This is discussed in the next section on windows.

### 3.3.4 Windows

Windows are the major point of contact between the internal and the external environment. Their quantity and quality affects the thermal comfort due to the solar gain, their poor insulation qualities causing cooling and draughts, and the possibility to use them for natural ventilation.

Improving windows to adapt to the weather and climate can include measures such as draught proofing the frames, installing double glazing, providing reflective film or blinds in order to reduce the solar gain and glare, and changing the type of windows to enable/improve natural ventilation.

Building B’s windows received the most complaints due to their characteristics: single glazing and large panes of glass with old metal or wooden frames that are prone to warping and cause draughts. They cause heat loss in cool weather and solar gain in sunny conditions.
The landlord has provided the windows in Building A with reflective film. In Building B, one tenant applied the film to their office windows under their own initiative. However, the acceptance of such film is variable: some of Building A’s occupants mentioned that the film uncomfortably reduced daylight. The tenants differed in opinion whether this adaptation measure actually reduces solar gain or glare.

According to the *Arup Appraise* survey, the tenants in Building A are significantly less affected by the glare from the sun than the occupants in Building B (figure 3). This could be the result of differing design characteristics (larger windows in Building B) or their surroundings (tall buildings around Building A shade the lower floors). Equally, it could be that reflective film is proving to be an effective adaptation solution.

**Figure 3. Difference in glare from sun and sky between Buildings A and B (based on Arup Appraise data).**

![Box plot showing the difference in glare from sun and sky between Buildings A and B.](image)

See Box 1. *Explanation of statistical terms and graphs used in the report.* for guidance how to interpret the results in the box plot.
Some interviewees considered blinds to be a reasonable solution to control glare, albeit a more expensive option than reflective film. Yet, in both the Arup Appraise survey and the interviews, respondents revealed that where blinds were installed, they were not working very well and whilst they reduced glare, they did not reduce the heat gain.

Windows can also be used for natural ventilation. They are a sustainable option for future cooling. Many respondents also emphasised the advantage of fresh air over mechanically cooled air. However, there are problems with naturally ventilating Building A. Design issues prevent the windows being used such as no bottom panel to the windows, they do not open on the top floor and suspended ceilings often cut across the top window panel. Noise is also a drawback of natural ventilation; from wind (mainly on higher floors) and from a nearby transport hub. However, some tenants reported that they leave their windows open at night during the summer to facilitate night-time cooling. Combining air conditioning and natural ventilation as a mixed mode cooling system for different times of the year was considered to be a viable option and had already been trialled by other tenants.

The radiators, the ventilation and the cooling, you know, we can do something about and, I mean, we limit the amount that we use our cooling and, you know, we trialled, this year, turning the air handling units off (...) and people didn’t complain, people didn’t realise.

Interviewee B.2

The layout of Building B (with some offices facing light wells rather than the outside) limited the possibility for using natural ventilation for some tenants; others were constrained by an inability to open all the windows or some that could not open sufficiently wide enough to provide airflow. However, for others, a more sophisticated, ducted system of natural ventilation as an alternative to the air conditioning for most part of the year was considered to be an attractive possibility.
3.3.5 Building fabric

Building fabric plays a crucial role in regulating indoor temperatures (Hacker et al. 2005). Due to its thick walls and high thermal mass, the older building (B) was considered by its tenants to be able to maintain more stable temperatures inside and, consequently, had the potential to be prepared for future climate change. However, a 1960s extension to the top floor that has a lower thermal mass that impacts on the ability of this part of the building to retain temperatures. This limits the potential of any installed heating and cooling systems to work properly. As one user of this office observed:

...if they [the landlords] turned around and said to us (…) we've got the solution, we're going to plug in some air conditioning units from front to back and that'll keep the temperature absolutely spot on, I think we would just go no, we don't want that. It's going to be a huge amount of energy, it's going to be a complete waste, because all you're doing is warming or cooling the space, for it just to leak away. (Interviewee B.3)

Thus, parts of Building B are similar in characteristic to the more modern Building A, which has an overall lower thermal mass due to its light construction. The replacement of cladding in Building A is under consideration and may offer an opportunity for insulating the building. The facilities manager described the idea:

I think what they would look to do would be to take the existing cladding off, because I believe the insulation under the cladding is quite thin: pack it out, re-insulate, it then re-clad it etc. with something that again has thermal glare...reduced thermal glare properties. (Interviewee A.4).

3.3.6 Rainwater storage/drainage

It was observed that the current drainage system in the older building (Building B) may not be capable of dealing with an increased amount of rainfall in the future. This may also result in a need to service the roof to prevent leaks. The possibility of water storage was not discussed extensively. It was seen as a reasonably suitable solution; however, problems
were envisaged with retrofitting the building with the system and in particular finding a location for the rainwater storage tank. However, retrofit solutions of rainwater storage tanks are usually suitable in larger and older buildings with generous ceiling heights. Any revenue lost in accommodating them may be somewhat recouped from reduced maintenance bills.

3.3.7 Internal layout and fittings

These corridors are quite protected. Because of the light wells we don’t get a lot of daylight, so they don’t heat up, they don’t cool down...so they do tend to stay at a constant temperature, which is good. In the really hot weather, it’s always cool on this corridor.

Interviewee B.1

The organisation of internal spaces importantly mediated occupant’s perceptions of weather and climate. For example, in Building A, the risk of overheating was reduced by the desks in the reception area being located away from the windows and by the considerable height of the reception area. According to one interviewee in building B, the combination of an open layout, the presence of corridor spaces and draughty windows created a constant airflow through the building. Another claimed that having internal corridors facing light wells helped to maintain stable temperatures.

Companies with technical knowledge of the built environment have introduced their own changes to the organisation of their office space to improve thermal comfort. This included taking the suspended ceilings out and exposing the soffits to benefit from thermal mass in addition to the enhanced floor-to-ceiling heights.

Thermal comfort needs to be considered when organising rooms with large numbers of computers because of their contribution to heat gain. Even seemingly minor changes in the fittings, such as use of timed lights and halogen rather than energy-efficient light bulbs have an influence on the internal heat gain and, consequently, thermal comfort.

Some of the rooms that we’ve got are computer suites ... if it’s a hot room and a hot day and you’ve got thirty computers on at the same time...you know, when it’s really, really hot that’s what I really worry about.

Interviewee B.4

For the tenants with large numbers of visitors, rainy days posed a challenge due to large quantity of wet garments present in confined spaces:
...you end up with a lot of wet bodies coming through, you know, lots of coats and lots of bulk and everything, so that’s the problem then because they’re just sticking their coats on the back of their chairs aren’t they which is not ideal but we can’t have a cloakroom for seven hundred people. (Interviewee B.4)

3.3.8 Surroundings

Both buildings are surrounded by a limited amount of green space. There is no green space around Building B and Building A is accompanied by a small green space with grass and several large trees. The use of this space is not encouraged due to concerns about littering.

Both buildings have flat roofs. In theory, these could provide green spaces. A green roof could provide additional insulation, reduce the threat of leaks and limit stormwater runoff. In Building B, a large roof is present and facilities staff observed that the space could be utilised for either vegetation or solar panels. In Building A, the majority of roof space is currently used for lift motors and air conditioning vents, reducing the potential for green space. If used, the space could provide an attractive addition for the next tenant on the 21st floor.

Neither of the buildings is directly at the risk of flooding. This is partly because both buildings are raised above the street level by a flight of steps. Both buildings have a canopy protecting the entrance from the rain; it is more extensive in the case of Building A.
4 Issues affecting the physical adaptation

4.1 Conservation value of buildings

Building B is Grade II listed, a constraint on any dramatic changes to the building’s fabric and appearance. The requirement to retain the historical character of the facade and windows limits potential adaptation measures. Conservation value even affects the organisation of the internal space by tenants much to their frustration; for example, room partitions cannot cross windows.

The building managers recognised that some of the adaptive solutions that are consistent with the protection of the building character may have a negative impact on other adaptation issues. For example, providing secondary glazing behind the existing windows limits the opportunities for natural ventilation and increases the reliance on air conditioning for cooling, or requires a provision of complicated ducting systems.

Where there are regulations that affect changes to the building other institutions, such as English Heritage and the local authority, should take the lead in discussing how to improve the efficiency of the building without compromising its aesthetic and conservation value.

4.2 Cost of adaptation measures

It was observed that the adaptation measures can be very expensive. For a large building like Building B, with extensive exterior glazing, the cost of replacing the windows was considered by the building managers as ‘massive’; they cited a figure of £70,000 associated with servicing the windows in the past (Interviewee B.6).

In addition, the replacement of old boilers for the heating system was estimated to be £160,000 to 200,000. This needs capital investment, according to the facilities managers, since the cost is too high to be covered in one financial year and may need to

We need to be looking at changing these boilers in three or four years’ time. We’ll start to collect the money now. So the customers don’t see a spike. They should see a flat line and that’s the challenge trying to keep that flat line as flat as possible. Interviewee A.4
be distributed over the years. It was noted that it is important to manage the customers’ expectations of the service charge by saving money in advance to do the essential big changes.

4.3 Reactive versus preventive maintenance

Partly due to the cost of the adaptation measures, and partly due to the division of responsibilities between the property owner’s head office and the local building management team, a large proportion of the adaptation measures in the buildings in question are reactive.

Tenants observed that the local teams are very good at responding to requests. However, the ability to respond in a more sustained manner (by making permanent changes to the building) is constrained by budget and by responsibility for this type of decision lying with head office. The focus on reactive maintenance may lead to the perception by tenants that things are just being patched up rather than resolved. On the other hand, from the owner’s point of view, not resolving temporary issues whilst waiting for a more substantial maintenance to take place may also lead to tension with tenants. In addition, large scale building works can severely disrupt the day-to-day functioning of individual offices and needs to be planned in advance.

It was observed that the temporary thermal comfort measures (heaters and fans) are a significant financial burden for the building management teams and it would be useful if provision of these could be avoided. It was firmly recognised that planned preventive maintenance, involving actions such as replacement of the boilers and windows, in long term is much more cost effective than reactive maintenance aiming at improving the thermal comfort.
An example how permanent measures can eliminate the provision of temporary measures was replacing the sliding doors by revolving ones in the reception to eliminate draught:

5200 people a day use the building so the buildings during peak times are literally just open all the time ... Everything we can try and do we did, but it was still freezing. ...So we’ve put a revolving door in now, and at a stroke that solved the problem. (Interviewee B.7)

The building management teams reported that they used to be overwhelmed by the amount of reactive work they needed to do and changes were made to address it. However, the intervention of head office has helped to improve the efficiency of running of the building: two teams were provided per building – one focused on the physical maintenance of the building, the other focused on managing customer expectations and meeting their requirements. Close collaboration between the teams has been essential to redressing the balance between the reactive and preventative maintenance, allowing proactive solutions such as regular servicing of the air conditioning kit.

4.4 Opportunities for adaptation

A considerable amount of work related to adaptation to weather and climate has already been carried out in the two buildings. Previous changes in Building A include recovering and insulating the roof, recladding the entire structure in the 1980s, and providing reflective film on the windows to prevent solar glare and solar gain (as section 3.3.4 suggests, with some effect). In Building B, some windows had catches and latches replaced to make them more functional. Better thermostatic valves systems were put in on the radiators; the windows were made draught-proof but not replaced.

There will be more opportunities for change in the future, according to the building managers. These expected areas of work could be linked even more strongly to climate change adaptation measures such as those outlined in table 1.
Table 1. Opportunities for linking the adaptation solutions to the planned changes in the two buildings.

<table>
<thead>
<tr>
<th>Building</th>
<th>Planned work</th>
<th>Weather-related problems</th>
<th>Proposed solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (1960s)</td>
<td>Window replacement scheme</td>
<td>Glare; solar heat gain; need for artificial ventilation</td>
<td>Operable top and bottom window panels; reflective film on parts of windows only; internal heat-reducing blinds.</td>
</tr>
<tr>
<td>Re-cladding of the elevation</td>
<td>Low and high temperatures</td>
<td>Provide insulation under the cladding</td>
<td></td>
</tr>
<tr>
<td>B (1910s)</td>
<td>Secondary glazing along the elevation</td>
<td>Low temperatures; wind; solar gain and glare; need for natural ventilation.</td>
<td>Additional provision of internal blinds; provision of ducting for natural ventilation or ensure operable windows.</td>
</tr>
<tr>
<td>Upgrading the drainage system</td>
<td>Intense rainfall</td>
<td>Take into account the climate projections and the maximum rainfall in planning the drainage; consider green roof and rain storage systems.</td>
<td></td>
</tr>
<tr>
<td>Replacing the heating system in (removal of perimeter heating; replacement of the boilers)</td>
<td>Low temperatures in winter</td>
<td>Improve the flexibility of the heating: spatial – controllability in different parts of the building; temporal – possibility to turn on outside the heating season.</td>
<td></td>
</tr>
</tbody>
</table>
Whilst these changes provide one-off opportunities for changes to the entire building, the opportunities for adapting the individual office suites are associated with the tenancy turnover. Office suites are refurbished before a tenancy commences according to the expressed preferences of the customer. This provides an opportunity to implement adaptation measures at the office level in a way that takes into account the way that the office is used and any specific issues that may arise from its location in the building: for example, selective use of reflective film in Building A or internal insulation of walls in the extension to Building B.

### 4.5 Division of responsibilities between the landlord and tenants

The responsibility for physical aspects of the building and the individual offices, including those relating to sustainability or the environment was generally seen to lie with the landlord. It was stated that the landlord takes care of maintenance, the provision of, and the information about facilities (e.g. for recycling). However, tenants should focus on using the supplied facilities or controlling their business-related activities:

*Well, the landlord needs to make sure that the facilities are available, which they have done in terms of having recycling or, you know, letting us know if there's something, greener energy or something that they can provide for us, that we could look into. And then we have a responsibility to make sure we use the facilities that are in place. I would say it's probably 60/40 because there's very little we can do, if we don't have the facilities to do it. But if they're there, then it's our responsibility to use them. (Interviewee B.5)*

This means that the tenants thought they could not do much in terms of the physical adaptation measures. In addition, the tenants observed that if they made any changes to their offices they would have to pay to reinstate them, which was considered a significant barrier to making physical changes to improve the thermal comfort. Also, the cost of replacement of the cooling system present at the time of moving into the suite was prohibitive. Only minor physical changes have been made by some tenants, for example, those particularly suffering from draughts have...
installed additional doors to solve the problem.

The tenants also commented that if they do not request the changes to the offices before they move in, they have limited opportunities to request changes to the layout of their offices. Whilst some of the companies interviewed were aware of the space organisation issues that improve the comfort, other lacked this knowledge. This is clearly demonstrated in the description that one interviewee provided on their approach to organising the space:

*When we decide space and layout you’re not thinking about where the air conditioning units are, you’re thinking about what’s the right place and then afterwards you might find out, oh actually, you know, someone’s sat directly underneath one, someone’s nowhere near one. One of the problems that we’ve found recently is we’ve only just renovated this reception area to make it more open plan which we thought brilliant, but we hadn’t actually realised how hot it gets out there near the lifts, because there’s no windows, there’s no natural ventilation or anything there.* (Interviewee B.4)

Some tenants were frustrated by their lack of power to change their offices without major costs. Some expressed a willing to contribute financially to the physical changes to their offices. For some it could mean considerable financial savings in the long term due to less need for temporary cooling and heating measures.

The division of responsibilities may be even more complicated when large organisations, particularly public sector bodies, are tenants in the building. Often, they can only rent or maintain properties using centrally approved suppliers. This means that an intermediary is introduced between the landlord and the tenant. As one office manager stated: *‘if anything goes wrong in our accommodation we effectively ring [our sub-contractor] to fix it, and that’s another story in itself’* (Interviewee A).
4.6 Tenants’ characteristics and preferences

It emerged from the interviews that the organisations in the buildings varied enormously in their number of employees, business type and their perceptions of environmental issues, which in turn influenced their opinion on adaptation to weather and climate.

The size of the companies had a strong influence on the issues associated with thermal comfort and adaptation measures. Our interviews suggest that larger companies have more money to spend for example on air conditioning units. Also, the temperature of their offices is influenced by the heat generated by a larger number of bodies, which in turn influences their requirements for heating and cooling. Thus, the larger the company, the more significant the issues they face in terms of the thermal comfort due to the organization of space and the number of people. These issues are discussed further in section 5.2.

Small companies were more likely to be careful about the costs – both in terms of the service charge and their electricity bill. They are less likely to be concerned about the climate change and sustainability issues. A report on climate change adaptation by Ipsos Mori (2010), undertaken for Defra, confirms this. Their findings suggest that larger companies are more likely to have undertaken steps towards climate change adaptation than the smaller ones. This is due to the absence of economic case for adaptive action for small organisations (Ipsos Mori 2010)

We’ve got very comprehensive sustainability plans and sustainability strategies, from an organisational point of view and from a business point of view. (...) But, I’m not aware that we’ve got anything relating it directly to the offices that we occupy. Again, I think, that’s, probably, because, you know, the climate change predictions for the North West are one to two degrees C rise by 2030 and most businesses don’t plan more than five years ahead. (...) So, it’s too far away, even though, you know, it’s one of our key areas, as a business, is sustainability.

Interviewee B.2

Tenant firms that are local offices of national or international organisations may not be directly responsible for covering the service charges and the utilities bills, thus be less inclined to introduce either physical or behavioural changes that would reduce these.

The preferences of customers are shaping the rental market of commercial properties. A problem
with promoting solutions such as mix-mode buildings is that there is a broad expectation of air conditioning in office buildings, which can be controlled at the office level. For some companies interviewed where sustainability was not a concern, air conditioning was considered to be the only choice as an adjustment for hot weather (Interviewee A.5). For others, sustainability issues ruled out mechanical cooling (Interviewee B.3). In general, the engineering and architectural companies we interviewed tended to be more aware of, and interested in, the sustainable solutions, as they apply them in their own business. They were likely to save the energy for its own sake rather than financial reasons; for example, these companies made a conscious choice of not using the air conditioning. Nevertheless, even these companies had not applied significant effort or thinking in adapting their offices to weather and climate beyond addressing the sustainability agenda.

The awareness of climate change issues amongst tenants may be seen as being reflected by the presence (or not) of strategies they have in place in relation to environmental issues or business continuity. The interviews suggested that only three of the companies did not have any such strategy in place. Whilst these plans can provide a good springboard for adaptation planning, the findings of the Ipsos Mori (2010) research suggest that in general the business continuity plans do not take into account climate change.

The companies following the code of conduct of the larger, national-level organisation tended to have not only business continuity plans but also energy saving plans, corporate social responsibility events or environmental statements. One employee explained that:

...one of the suggestions that we make is why don’t you try and travel to work on public transport today or travel together or anything like that. But other than those occasions I don’t think it’s something that we’ve really done a great deal.(...) I wouldn’t say that climate change is something that’s specifically addressed. (Interviewee B.4)

4.7 Landlord’s characteristics

According to the interviewees, the landlord has a large property portfolio and is particularly keen to promote the reduction of carbon footprint, increase recycling and implement green roofs. The green credentials tend to attract customers who
are interested in climate and sustainability, but also may be successful in influencing tenants who have not previously expressed interest in these issues.

Advantageously, the landlord owns the buildings that they manage and so have the opportunity to make the changes to them. It has been observed by building managers that making adaptation changes to their building stock, ensuring that the buildings are efficient, safe and comfortable under a variety of weather extremes, can attract new customers – particularly those concerned about business continuity. It could be concluded that weatherproofing the buildings can ensure that the landlord has a competitive edge over similar companies.

4.8 Policy and standards

Codes of conduct for landlord and tenants in relation to climate change in general, or climate change adaptation more specifically, are guided and influenced by legislation and policy. Section 1.1 discussed the limitations related to the adaptation of older buildings associated with their heritage status. This is covered in more detail in the associated EcoCities literature review (Connelly 2011).

One of the important guidelines cited by the interviewees was the minimum temperature of 16°C in offices provided in The Chartered Institution of Building Services Engineers guidance (CIBSE 2006). The landlord aims to stay above this legislative minimum. However, the interviewee also observed that currently there is no recommended maximum temperature in offices.

It was recognised by the interviewees that legislation reducing the carbon emissions has been an effective driver for change in relation to the public sector buildings, which need to comply with the standards. It was observed that the current actions by the politicians seem to promote that similar standards are applied to rented buildings. It was seen that
similar development in legislation is possible in relation to climate change adaptation.

The industry standards legislation affected some of the tenant companies. For example, the international Lexcel Standard, set by the Law Society for legal businesses, sets some requirements in relation to risk management.
5 Interactions between weather, the office and the people

5.1 Impact of weather and temperature on people working in offices

5.1.1 Lateness or attendance at work

From the interviewed employers’ perspective, the most crucial implications of climate and weather are those affecting the employees’ attendance at work. The impacts of weather on transport and services such as schools means that many employees cannot arrive at work due to disruption to transport or care duties. The main culprit in the recent years has been snow due to high numbers of schools being closed and the severe transport problems which forced some of the companies to close the office for a day. This results in loss of revenue.

5.1.2 Productivity

According to the interviewees, the perceived comfort of the work station can affect the efficiency at work, as office satisfaction and job performance are considered to be interlinked: ‘the most important thing is to make sure that everybody’s comfortable and works to their maximum and their best capacity’ (Interviewee A.3).

Indeed, the analysis of the Arup Appraise survey suggests that productivity at work is significantly correlated with thermal comfort in winter and summer (figure 4). Moreover, the self-assessed productivity of respondents in Building B was lower than the productivity of those working in Building A, due to environmental conditions (figure 5). This is consistent with the fact that Building B was considered less comfortable to work in due to extreme temperatures in both summer and winter (see figure 1 and 2).
Figure 4. Associations between the comfort in winter and summer associated with temperatures in the offices, and the self-assessed productivity of respondents (based on *Arup Appraise* data).

\[ r_s = 0.388 \]
\[ p < 0.001 \]
\[ N = 150 \]

\[ r_s = 0.396 \]
\[ p < 0.001 \]
\[ N = 137 \]
Figure 5. Comparison of the impact of the building’s environmental condition on productivity at work between the Buildings A and B (based on Arup Appraise data).

See Box 1. **Explanation of statistical terms and graphs used in the report.** for guidance how to interpret the results in the box plot.

A number of comments on the Arup Appraise survey and observations made by the interviewees suggested that extreme temperatures affect workers’ ability to concentrate. One respondent to the Arup Appraise survey said that ‘if I am too cold or too hot, or getting a draught from the window, it upsets my concentration’.

Alongside the lowered concentration, other impacts were also recognised. For example, rainy days meant that the workers spent some of the time at work time drying their garments:

_They could be soaked to the skin because some people don’t dress appropriately for the weather, and that’s when you’ve got everybody in the toilets with the hand dryers trying to dry their trousers and other things, sock and things, way over the radiators and things like that. (Interviewee A.3)_
5.1.3 Health

The direct impacts of weather on human health were reported to be particularly acute for snow and ice. Interviewee B.4 described their company’s concerns with health and safety, while another spoke of specific accidents occurring to members of staff inhibiting their ability to come to work (interviewee A.6).

Similarly to productivity, self-assessed health when in Buildings A and B is also significantly correlated with the perceived comfort of office temperatures in winter and – even more clearly – in summer (figure 6). According to the interviewees and respondents to the Arup Appraise questionnaire, high temperatures make people feel tired, sluggish, drained and cause headaches. However, whilst the climate control systems alleviate the problems associated with high temperatures, they also may have a negative impact on people’s self-assessed health (sore throats, dry eyes). Thus, the improvement of both productivity and health can be achieved by providing more suitable temperature in offices, particularly during the summer. However, it is essential to ensure that this is done in a manner that causes minimum negative side effects to people and the environment.

5.1.4 Tensions over temperature

A high number of comments made by the respondents to the Arup Appraise survey, and confirmed by the interviewees, suggested that the temperature in the offices had a significant impact on the mood of the people working there. Low temperatures made people ‘grumpy’. In relation to high temperatures, the respondents to Arup Appraise and the interviewees reported suffering from shortness of temper, which may lead to tension and conflicts.

I suppose people get a bit irritable, and we...you know, we try our best to let people take breaks and go outside. But, you know, it is a small office, so yeah, you can feel a bit, you know, irritable at times. 

Interviewee B.5

We also have feedback from everybody’s workplace assessments (...) and that [the climate control system] comes up all the time and its giving people sore throats, sore eyes, that sort of thing. Interviewee A.6
Figure 6. Associations between the self-assessed health in the building and the perceived comfort of temperatures in winter and summer (based on Arup Appraise data).

\[ r_s = 0.268 \]
\[ p<0.001 \]
\[ N=148 \]

\[ r_s = 0.445 \]
\[ p<0.001 \]
\[ N=136 \]
In addition to the mood changes caused by the uncomfortable environment, the perception of temperature is a highly individual matter, something the facilities management staff are particularly attentive to:

*Every office has got people that are hot and cold whatever you do, you’re probably never ever going to get it right for them because there are some people who feel the cold and some people who get hot and some people wear nothing in the cold.* (Interviewee B.7)

We have people who will argue within a section on whether they want it [a climate control system] at a certain temperature or not, so since it was installed it’s been the bane of my life basically. *Interviewee A.6*

The vast majority of the companies interviewed reported some tensions or conflicts regarding the temperature in their offices, ranging from the workers being disgruntled to making official complaints. In particular the integrated cooling and heating systems are causing plenty of arguments. This affects the productivity of the employees, as well as creates new issues for their managers.

5.2 Issues affecting thermal comfort in offices

5.2.1 Space organisation

The organisation of internal spaces is an important factor influencing people’s comfort in offices (Morgan and de Dear 2002; Steemers 2003). The majority of investigated companies operate from open plan offices. Firms operating in a team-based environment, such as the built environment professionals, organised their space predominantly as open plan with separate meeting rooms and individual offices for senior management. A similar system was used by most of the large companies. Only the smallest company’s space consisted of two offices for two people each.

The analysis of the *Arup Appraise* data suggests that there were no statistically significant (p<0.05) differences between the large and small offices in relation to the perceptions of temperatures in summer and winter and the self-assessed productivity and health. However, people working in offices larger than 8 people (which can be assumed as open-plan spaces) reported feeling less healthy when spending time in the office building than those based in smaller offices (figure 7).
Figure 7. The impact of the environmental conditions of the building on self-assessed health: differences between offices of varying size (based on Arup Appraise data).

See Box 1. Explanation of statistical terms and graphs used in the report. for guidance how to interpret the results in the box plot.

Interestingly, the analysis of the Arup Appraise results did not indicate statistically significant differences between people sitting by the window and away from the window in terms of their perceptions of summer and winter temperatures. Yet, during the interviews it was observed that the perception of temperature is different by individuals sitting by the window and close to the air conditioning in comparison to those sitting further away from these, which may again cause conflicts over the thermal comfort. The interviewees observed that whilst people complain about the cooling devices, they are reluctant to change their location:

The people who are hot or anything tend to complain too much, but the people who are underneath it are ‘Oh the room’s always freezing’ they always sit underneath the air con and then complain about it! Interviewee B4.
5.2.2 Control over temperature and ventilation

As discussed in section 3.3.3, cooling via the air conditioning systems is controlled within the individual office suites; however, a higher number of offices in Building A were reported as fitted with air conditioning units than in Building B. In both buildings the main heating system is controlled by the landlord, but the tenants have some flexibility in terms of controlling the heating, i.e. using the thermostats on the heaters (mainly in Building B). In Building A, central heating is currently used but it is being phased out. Individual climate control systems will be installed for offices in Building A. Thus, unsurprisingly, the respondents to the Arup Appraise survey in Building A, compared to those from Building B, said that they had more control over heating and cooling (figure 7).

Who controls the heating, cooling and ventilation varies between the offices. In some offices there is an appointed member of staff who manages the system’s settings. In other companies, one person was supposed to be in control of regulating the temperature and ventilation; however, their co-workers tended to change the setting when this person is not around. In other places, some of the settings can be adjusted by all office workers, but the regulation of the functioning of the main climate control system is limited to certain individuals. In the majority of the offices, however, everyone has access to the temperature controls (generally one set of controls per room, or one per zone in bigger open-plan offices) meaning that ‘you constantly see people turning the thermostat on and off, as they go around the office’ (interviewee B.5). Some interviewees believed that giving people too much control over the system is not an appropriate choice. However, whilst common access to temperature and ventilation controls was observed to have negative impact on the levels of energy use, or cause spikes in temperature, some interviewees observed that having control over the temperature and ventilation in the office has a big impact on how satisfied individuals feel with their environment.
Figure 7. Comparison of level of control over heating and cooling between Buildings A and B (based on Arup Appraise data).

See Box 1 for guidance how to interpret the results in the box plot.
Indeed, the results of the Arup Appraise survey suggest that the more control people had over the heating, cooling and ventilation, the more comfortable the temperatures were for them (table 2). Interestingly, the strongest correlation was present between the perceived comfort of temperatures in summer and the ability to control the natural ventilation. This is consistent with the preferences for fresh air expressed by many of the interviewees.

**Table 2. Spearman’s rank correlations between the level of control over temperature and ventilation and the perceived thermal comfort.**

<table>
<thead>
<tr>
<th>Level of control</th>
<th>Spearman’s rank coefficient (rs)</th>
<th>Temperature in winter – comfort (N)</th>
<th>Temperature in summer – comfort (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>0.201* (160)</td>
<td>0.163* (158)</td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
<td>0.255** (160)</td>
<td>0.192* (157)</td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>0.286*** (161)</td>
<td>0.465*** (158)</td>
<td></td>
</tr>
</tbody>
</table>

* significant at 0.05 level; ** significant at 0.01 level; *** significant at 0.001 level.

According to the results of the Arup Appraise survey, the level of control over heating, cooling and ventilation is also directly associated with productivity and health of office workers (Figure 8); the higher the level of control, the higher the self-assessed productivity and health in relation to the environmental conditions in the building. In particular, the correlation between ventilation and self-assessed health is strong; this further emphasises the need for fresh air in offices rather than air conditioning.

It was observed during the interviews that having full control over the functioning of air conditioning can be affected by the size of the room and the internal heat gains associated with a large number of people in the office: ‘we do experience problems when we have open plan offices, I don’t think the air con is always tweaked to that’ (Interviewee A.1). Also, it was noted that people sharing offices with fewer co-workers find it easier to compromise over the temperature than those based in large suites (Interviewee B.2).
Figure 8. Spearman’s rank correlations between the level of control over heating, cooling and ventilation and the self-assessed productivity and health (based on Arup Appraise data).

$r_s = 0.300; p<0.001; N=151$

$r_s = 0.202; p<0.05; N=151$

$r_s = 0.255; p<0.01; N=152$

$r_s = 0.364; p<0.001; N=138$

$r_s = 0.349; p<0.001; N=138$

$r_s = 0.368; p<0.001; N=139$
Figure 9. Differences in level of control over heating, cooling and ventilation between offices of different size (based on Arup Appraise data).³

See Box 1 for guidance how to interpret the results in the box plot.

³ The offices with 3-5 people have been excluded due to low number of answers and the fact that the responses came from one office.
The analysis of the results of the *Arup Appraise* survey suggests that, indeed, the lowest levels of control over heating, cooling and ventilation were consistently expressed by those located in the largest offices (figure 10). However, interestingly, the smallest offices did not score the highest. This may be associated with the opinion expressed by some of the interviewees that smaller spaces gain heat quicker than larger ones and, thus, are more difficult to control.

The interviews suggest that there is a strong tendency among the office users to alternate between the extremes of temperatures when trying to adjust the settings of the heating and cooling systems. This not only results in spikes in temperature, and lowers the comfort of people, but also puts a strain on the heating and climate-control system.

However, the absence of control can also lead to the misuse of the climate control system. Simultaneous use of the air conditioning and opening the windows; or use of heating and opening the windows; or even the use of heating and air conditioning at the same time has been reported. In addition, if the individuals are unable to control the cooling system, they may try to stop it from working:

> You'll go round our accommodation and you'll find some of the vents that people have stuck cardboard to stop the vents. Because of the fact that they're in a draft. (...) And other people are turning the whole system off so that then affects cos the heat goes up, so then it starts to cool down in another zone. (Interviewee A.6)

### 5.2.3 Gender

There was a general perception among the interviewees that women tend to feel colder than men. The interviewees mainly linked this to the biological differences, such as metabolism, rather than the dress style. One made the
important observation that older women can suffer from hot flushes and tend to feel too warm rather than too cold (Interviewee A.3).

This is reflected by the results of the Arup Appraise survey. Whilst the differences between men and women in terms of their perception of the temperature in the offices in winter were not statistically significant for the entire sample, when only the age group under 30 years old is considered, the differences in perception of temperature become larger. Not only do younger women feel colder in winter than their male counterparts; they also feel more comfortable in the summer (Figure 10). It was observed that the latter could be related to the greater flexibility women have in terms of their dress. This is further discussed in section 5.2.4.

Interestingly, the analysis of the Arup Appraise survey also suggests that women in comparison to men had more control over heating and cooling (figure 11). This could potentially be associated with the fact that women have been seen as those bringing to the office portable fans and heaters: 'the secretaries linked to each team (...) feel that they have a right to an electric heater, under their desk’ (Interviewee B.2).

Whilst the Arup Appraise survey suggests that there were no significant differences between men and women in terms of the level of control over ventilation, for men, control over ventilation was considered more important than for women (figure 12).
Figure 10. Differences between men and women under 30 years old in the perceptions of temperature in winter and thermal comfort in the summer (based on Arup Appraise data).

See Box 1 for guidance how to interpret the results in the box plot.
Figure 11. Differences between men and women in control over heating and cooling (based on Arup Appraise data).

See Box 1 for guidance how to interpret the results in the box plot.
5.2.4 Dress code

The clothes that people wear affects their perception of temperatures. If a number of people in a room are wearing different garments (which may the case in particular for companies with large numbers of visitors):

one will say it’s cold and one will say it’s hot and it is quite difficult, isn’t it, just to regulate the temperature in the rooms. (Interviewee B.4)

The dress code among the interviewed tenant companies varied from very formal to fully casual. Staff wearing uniforms have limited possibilities to adjust what they wear to different temperatures:

If it’s very, very hot and the consultant is not going out of the office, they don’t necessarily have to sit around wearing a tie or a jacket but, yeah, certainly if there were... Unfortunately we can’t allow very much leeway there because obviously we have to make sure that if going to meet with [external parties] that people are dressed appropriately. Interviewee A.5
You know, it would have to be the point where it was uncomfortable for us, to take the jackets off. (...) And it has to be all or nothing, we all take the jackets off or none of us do. (...) We wouldn't wear fleeces ... unless it's really unbearable. (Interviewee A.1)

The formal dress code in some companies was mainly associated with the presentation of the employees to the external parties; thus some companies allowed staff to make minor changes to improve their thermal comfort in the office. Nevertheless, it was observed that a very strict dress code may be ‘stifling’ in hot weather (Interviewee B.4) or, during cold spells, ‘look nonsensical’ with warm garments like fleeces (Interviewee B.3). Therefore, it would make it more difficult to adjust dress style to regulate thermal comfort than those wearing casual styles.

In some companies, mainly those specialising in the built environment, it was left up to the staff to come in their own choice of presentable garments, rather than formal attire. Even though this allows some flexibility to adapt to higher temperatures, the line was firmly drawn at shorts and flip flops.

Some of the companies with a stricter dress code adopted a policy of dressing down on Fridays. They reported that people did not drastically modify their garments to take the weather in the account:

I don’t think it really makes a difference. Most people tend to wear a blouse, and then they’ve got a jacket, or a jumper, or cardigan on their chair, so if they’re not warm enough they can put their jacket on. And the same with dress down day, most people tend to wear two layers. (Interviewee B.1)

It was emphasised by the interviewees that personal preferences in relation to dress code, such as following trends in fashion, take precedence over adjusting to the weather. This was particularly expressed in relation to women, who ‘want to be able to wear the same clothes all the year round’ (Interviewee A.2).
5.2.5 Work mode

Sedentary work makes it more difficult to adjust to the low temperatures in the office; however, it was also seen to reduce the opportunities for going to cooler parts of the offices in hot weather.

Interviewees also observed that the use of electrical appliances, such as computers and overhead projectors, exacerbates thermal discomfort in hot weather:

we use like computers you know and tablet PC type things, and so the tutor has got the heat of that coming off as well. Which I think that sometimes lands some problem in that you don’t realise that the students are actually cold, because you’re not, because you’ve got the heat from the computer (Interviewee B.4).

5.2.6 Transport to work

The interviewees stated that most of the employees in their companies (as much as 75 – 80%) commuted to work by public transport, cycling or walking. This was mainly due to the location in Manchester city centre with close proximity to transport links. Also, due to the limited and expensive car parking space in and around the buildings, travelling by car was limited. Whilst the Arup Appraise survey showed no statistically significant differences in the thermal comfort between those travelling by different mode of transport, it was observed during the interviews that those travelling by car require a more constant temperature.

Mode of transport to work also affects what people wear. Those travelling by car tended to be dressed appropriately for the temperature in their car, house or the office rather than the weather. One employee who drove to work described their experience:

If you’re in your car, you’ll go from your air conditioned house to your air conditioned car, to your air conditioned office. You have no idea what’s going on outside. Interviewee A.2

I think that the people who drive here are perhaps more demanding, I don’t know. I drive in everyday (...) I think it’s important that the temperature is at a certain level. Interviewee A.5
I mean there's days when I've forgotten my coat, because all I've done is I've gone out to the car and it's reasonably temperate, it's got to lunchtime and it's pouring down and I've neither my umbrella nor my coat with me. (Interviewee A.6)

In contrast, those travelling either by public transport, or cycling or walking to work tended to be better prepared for the weather.

In relation to extreme weather events, particularly snow, interviewees observed that cars and public transport tended to be affected, mainly the former. This causes lateness and problems with attendance at work. Those travelling to work by foot are the most reliable:

So the trains are the worst hit, buses next, and then probably runner up is the tram. But the couple of people that physically walk, not really at all, never an issue. (Interviewee B.3)

5.2.7 Expectations regarding the office environment

It was observed that the - frequently unrealistic - expectations of people regarding their office environment are a crucial aspect in climate change adaptation:

To me, the whole climate adaptation thing, a lot of it is not about the buildings, it’s about the people in the buildings, and change in their expectations. (...) It’s only a problem if you expect it to be 22°C all year round, irrespective of what’s happening outside (Interviewee A.2).

It was observed that expectations regarding office environment are shaped by the conditions in their homes:

So if you’re at work and you’ve got your heating on all the time and you come to work and you come to a 19ºC building, you’re going to find it freezing cold, but if you...
never use your heating you’re going to find it hot (Interviewee B.6).

In addition, employees of tenant companies may have unrealistic expectations regarding the functioning and efficiency of the climate control systems. It was said that there was an expectation that the system can provide temperature that fits everyone’s preferences, and that the system is tailored to immediate cooling or heating.

In Building B, due to the attractive design and historical character of the building, there was a higher tolerance of the extremes of extreme temperatures: ‘People, just, genuinely, like the building and, again, it’s that thing, there’s a forgiveness factor, if people like something, they’ll forgive it, yes, it’s old, well, what do you expect from an old building’ (Interviewee B.2).
6 Response to temperature and extreme weather

Respondents to the *Arup Appraise* survey observed that people working in office buildings changed their behaviour in response to weather conditions and the thermal control inside the building. The results of the *Arup Appraise* questionnaire suggest that significantly more people change their behaviour because of the conditions in Building B than in Building A (figure 14), which may be due to the more extreme temperatures in this building.

**Figure 13. Percentage of office workers changing their behaviour in response to the environmental conditions in the buildings (based on *Arup Appraise* data).**

![Bar chart showing percentage of office workers changing their behaviour in response to the environmental conditions in Building A and Building B.]

\[ \chi^2 = 6.666 \]

\[ p < 0.01 \]

\[ N = 144 \]

The following sections explore how the employees of Building A and Building B change their behaviour in response to weather and the conditions in the building, and how these are influenced by the organisations that they work for and by the landlord.

### 6.1 Changing what people wear

Changing what one is wears is one of the most logical responses to uncomfortable conditions, and it was seen as such by many of the interviewees, irrespective of the dress code:
...there are still people who come in with lightweight clothing or insufficient clothing and they complain it’s really cold and we say, well, you know, there needs to be some adaptation. Interviewee B.2.

The respondents to the Arup Appraise survey, particularly in Building B, commented on wearing numerous layers of clothing in winter to keep warm and adjusting to the changing temperatures as the building heats up. This was confirmed by the interviewees of Building A, some of whom said they kept extra garments in their drawers, and some advised their staff to resort to very warm garments (Interviewees A.1 and A.3).

In the hot weather, companies with no strict dress code allow their employees for an adaptation to temperatures. Some respondents to the Arup Appraise survey reported wearing short-sleeved shirts and taking their shoes and socks off when sitting at the desk to keep cool. For these companies it was seen as important to challenge employees expectations of the office environment and office wear with one commenting that: 'It’s hot, don’t wear a suit!' (interviewee A.2). Even companies with a stricter dress code or a uniform allowed for some adaptation.

We explored whether the companies residing in the building would be willing to provide their employees with warm garments, such as fleeces or jumpers to improve their thermal comfort during work hours and reduce the need for heating. However, it was not considered a sensible option: partly due to a strict dress code in a number of companies; but mainly out of respect for the personal preferences of their employees.

6.2 Changing the space organisation

Section 3.3.7 highlighted that the organisation of office spaces has an impact on the thermal comfort of workers. Changing the layout of an office or moving people around can be considered as a low-cost adaptation option.
However, the experiences of the interviewed companies suggest that people only rarely move around the office due to the temperature in certain places (mainly associated with the position close to an air conditioning unit or windows) or sun glare. Space limitations, or working in teams, can be obstacles to moving people around. Nonetheless, if the employees are really unhappy, most of the companies will try to meet their needs.

### 6.3 Adapting working times and locations

The majority of the companies we spoke to had been affected by severe snow and ice in early 2010 and 2011. Some of the offices had to close. Others cancelled meetings and other operations and allowed their staff to leave early. Some companies were guided by their code of conduct in dealing with the situation, such as treating the days off due to the weather as paid leave. One of the interviewees described monitoring the weather in order to decide how to proceed. In other places the senior management decides on the day how to deal with the situation:

> Usually the partners will decide what’s going to happen on that particular day, in those particular circumstances, and then people will be contacted or an email will go round to say, ‘Due to the weather conditions, we’re closing the office at four o’clock today’. (Interviewee B.1)

The companies with a number of offices across the region or country have the flexibility to offer their employees the possibility to work from different places. In other companies, employees living nearby, and who walked to work, have additional duties assigned in order to keep the business running during unforeseen circumstances (Interviewee A.3).

Adjustments to working hours were not made in relation to weather events other than snow. Wind and rain were downplayed as typical for Manchester, and the heat was not seen as a reason to change the working hours drastically. However, more frequent breaks were reported by a small number of
interviewees, particularly when sunny, attributable to a general lift in mood or ‘that summer feeling’ (Interviewee B.7).

6.3.1 Home working

A particular strategy that can be used when the offices are not comfortable due to high or low temperatures, or when the weather prevents the employees from arriving at work, could be home working. Home working was allowed by half of the companies interviewed. However, while some organisations accepted home working, it was not particularly encouraged. A common attitude was: ‘If you genuinely have stuff that you can do at home then do it, don’t make too much of a habit of it because obviously you need to kind of be in’ (Interviewee B.4). For some companies the only reason to encourage home working would be associated with the possibility to make savings by reducing the office space. In others the practice of allowing people to work from home has been very recent, and seen as a supplement to other flexible working practices:

It’s not been going so long but, yes, they do, they can work from home, only certain people and you have to have certain permissions to get a special thing to work from home (...) it’s just starting now to let people, because we’re very good now at being flexible with the hours, with the days they’re working. (Interviewee A.3)

Nevertheless, past extremes of weather conditions persuaded some companies to accept home working as an emergency option to maintain business continuity. It was understood that in the future, if extreme weather events occur more frequently, home working could become a more widespread option:

...if we could predict that there was going to be, say, significant snowfall every single winter, then we may make working from home available to more of our staff (...) And that's probably something that we would look into, if it was going to be that every year, we were losing, you know, three or four days' worth of business (Interviewee B.5).

Technology made the opportunity for home
working realisable. The work of many companies interviewed was fully computer-based character. The provision of laptops, widespread internet access at home, access to company servers, video-conferencing facilities and the possibility to redirect phone calls to the home number all made home working a viable option.

Another opportunity for making home working a valid option in one of the larger companies was found by pairing up office based staff with regular home worker (who had access to all necessary equipment) so that they could work at their home in exceptional circumstances.

The main barriers to home working were recognised as the need for interaction with co-workers, clients and visitors. In particular, it was observed that ‘if you’re a manager, you lose the ability to manage, yes, you can do it by phone, you can do it by video conference, but it’s not the same’ (Interviewee B.2).

Another barrier was posed by companies who deal with sensitive data that should not be taken out of the office. Other companies worked with large files or complicated software that current home internet provision cannot deal with sufficiently quickly or else with data in a format that does not make it practical to use outside the office. There was also issue with trust that employees will work within due protocols when not based in an office:

> You have to have a huge amount of faith in your employees, because if you’re giving them total access outside of work to everything about your business, all the servers, all the documents, you know, you have one disgruntled person and the whole thing could just, you know, implode. (Interviewee B.3)

It was observed that working from home may make it difficult to maintain work-life balance and also that some houses may equally be less comfortable in extreme temperatures than the office building, thus defeating the objective of permitting home working to make employees feel more comfortable.

> If you live in a post-1985 home, you know, they overheat horrendously in summer. (...) It’s only if you live in a pre-1930s home, that it is, actually, comfortable to be in and, potentially, as comfortable as here (Interviewee B.2)
6.4 Reducing the use of heating and cooling

Many interviewees recognised that behaviour change was crucial to adapt to the changing climate. Some of them quoted the examples of behaviour change relating to energy saving. This can be seen as an important common area between climate change mitigation and adaptation: reduced use of heating and cooling not only limits the carbon emissions but also allows for more creativity in adapting to weather and climate.

In some companies, senior management had been educating the employees on the rational use of the climate control units: ‘So it’s a constant telling them; you’ve got to work between twenty and twenty two degrees and just leave it’ (Interviewee A.3). One interviewee tried to reduce the use of air conditioning by providing a simplified instruction starting from the question ‘do you really need it?’ and explaining how to adjust the temperature in winter, summer and autumn/spring by using natural ventilation when possible (Interviewee A.3). The instructions reminded employees to switch the air conditioning off at night. The company also provides an energy chart, showing the cumulative use of energy; monthly energy usage; and the decrease of energy use in comparison to the previous year.

It was observed that it is very difficult to persuade the office workers or visitors to comply with the strategies aimed at reduced use of heating, air conditioning or energy: ‘no matter what signs you put up – don’t touch the air con, don’t switch the lights off, [the visitors] always take it as a challenge – alright, yeah here we go!’ (Interviewee B.4). Nevertheless, pressure from senior management on office staff to change their behaviour with regards to the use of heating and cooling was seen as effective.

Some of the interviewees and respondents to the Arup Appraise questionnaire observed that alternative approaches to improving the thermal comfort of people in offices can also reduce the need for cooling and heating:
On all the floors we have a special water fountain for everybody with filtered water. But you do notice when it’s the cold weather that we go through milk like you wouldn’t believe because everybody’s making hot, milky drinks. And in the winter also we supply cordials, three different types of cordials, because if you have that hot doctors recommend that it does help to keep the cold bug down. (...) The heatwave, well, sometimes the boss will buy ice creams and things like that. (Interviewee A.3)

6.5 The role of the landlord

Whilst managing the expectations of the office environment and actually controlling it are largely the responsibilities of the individual companies, the company that owns and manages the building can also exert some influence. The accepted practice in both buildings is for the building management team to visit those offices that complain of low temperatures and take temperature readings. If the temperature is inadequate, the building managers provide temporary heating. However, in many cases, the readings indicate that the temperature is within the reasonable range. The customers are also informed of the cost of the heating:

so in the winter, the problems we have as a customer will phone up at the moment and say ‘it’s too cold in the suite we want the heating up’ and at the moment we have to put that temperature up. What we’re trying to do next winter, is re-educate the customer (...) Rather than saying ‘No’, we’ll say ‘These are the consequences of us putting the heating up’. (Interviewee B.6)

It was observed at building management level that simply putting notices up promoting turning the lights off and other pro-environmental behaviours was not always effective:

You can put as many posters up as you like to make sure people turn the lights off and turn the air-conditioning systems off when they leave rooms. I think people still see it... I suppose generally users of the buildings still see it as, it’s not my problem. (Interviewee A.4)

This may suggest that individual employees are more likely to respond to demands from their employers than the landlords who they are not in daily contact with. However, a few of the companies said that they would like to receive more information about environment and sustainability from the landlord:
We would consider [the environment] if we were more aware of it, I suppose. It’s certainly not something that I could relate to all (...) so maybe, yeah, if we knew more about it, maybe we would. (...) The building owner probably would be quite good. They’re very good at notifying us of various other things that are going on. Everyone takes a note of it, so maybe the information should come from them. (Interviewee A.7)

The tenant companies were generally very satisfied with the level of activity by the landlord, particularly its responsiveness to issues they were facing in their offices and its pro-environmental attitude. Currently the landlord organises regular one-to-one meetings with customers as well as a general forum to discuss various issues relating to the buildings. These may provide a future platform for discussion about the weather and climate impacts. The one-to-one meetings could be used to explore issues relating to particular offices.
7 Conclusions

The analysis of the interviews and the Arup Appraise questionnaire data indicates that while most customers are generally happy with their office spaces, there is a discernible need to adapt the buildings to climate change. Discomfort is felt during current weather extremes and, especially if they become more frequent, adaptation will be mutually beneficial for all parties. Given that the construction characteristics of the two buildings considered in this report are found across Greater Manchester, the results suggest that the issue of poor adaptation to current weather extremes and future will be problematic to many buildings in Manchester.

Raised summer temperatures already influence the health and productivity of office workers in this study. At the same time, winters pose a threat of discomfort due to cold snaps and, as experienced in recent years, increased snowfall. This indicates the need to adapt to all weather extremes. More details about the future climate projections for Greater Manchester can be found in a study by Cavan (2011).

While both buildings considered in this research had advantages and disadvantages, the older building was particularly affected by extreme temperatures and intense rainfall. Incorporating adaptation into the long-term maintenance strategy and making planned changes in advance offer an opportunity to adapt buildings to cope with the impacts of extreme weather events. In both buildings, the windows were the weakest link, allowing for transfer of heat, cold and glare into the building. Windows should be the target of the most urgent adaptation actions. Out-dated heating systems, such as that in the older building, could also be improved especially considering that supplementary temporary heating was thought to be too costly and inefficient for both tenants and the landlord. More detailed recommendations are provided in section 7.1.

In general, the landlord was regarded as responsible for the physical changes to the building, and the tenants for adjusting their behaviour. The main constraints for implementing physical adaptation measures by the landlord are the costs associated with adaptation measures as well as the conservation value of Building B. The main opportunities were thought to lie in adding to the green credentials of the landlord and the possibility of savings in the long-term.
Behavioural adaptation measures were affected by the common reliance on air conditioning and the different size, code of conduct and know-how of the tenant companies. Issues such as the size and organisation of the office space, transport to work, gender, work mode, fashion sense and the perceptions of temperature by the individuals affected the expectations of and satisfaction with the office environment in terms of thermal comfort (Steemers 2003).

People already adapt their behaviour to the conditions in buildings (Haldi and Robinson 2008; Haldi and Robinson 2009; Zhang and Barrett 2012). The interviews showed that he office workers adapt what they wear and lobby for changes in space organisation in order to improve their thermal comfort. The level of control over the temperature and ventilation in offices has emerged as crucial for office employees’ comfort, health and productivity. On the other hand, democratically allowing each person the possibility of adjusting heating and cooling systems frequently results in their misuse. It results in damage to the system and does little to improve overall thermal comfort. Companies can also adjust their working hours in extremes of weather events; however, there is still a certain level of resistance against home working, which is seen as a last resort. More detailed recommendations considering changes in people’s behaviour are provided in section 6.1.

Both the landlord and tenants can bridge the gap between physical and behavioural adaptation by raising awareness amongst their employees and, thus, increasing their preparedness to deal with weather extremes. Using common points with energy-saving actions can help to make the issue of adaptation more relevant to office workers. Good relationships between landlord and tenants, similar to those described in this study, can help to achieve this.

Based on two office buildings and a small sample of tenant companies, this research has provided some indication of the current state of the physical and behavioural adaptation to climate and weather in office buildings. Further research could explore the importance of thermal comfort in relation to other aspects of the office environment, and the perceived priority of adaptation to weather and climate against other issues. An experimental, longitudinal research would be of interest, recording the workers’ perceptions of their comfort in different environmental conditions in their office, and investigating the success of individual and organisational adaptation measures in improving the comfort without compromising sustainability.
7.1 Recommendations

7.1.1 Recommendations for office building owners and managers

It is important to mainstream adaptation planning into the physical changes to the buildings (see examples in table 1 and Connelly 2011). Draught reduction could reduce the heat loss in Building B and other similar 20th century building stock in Manchester. The replacement of window frames and the possibility of double-glazing should be investigated as priority issues.

In both buildings, improving the opportunities for natural ventilation is crucial in order to help maintain low temperatures in the summer whilst reducing the use of air conditioning. Where possible, in line with health and safety issues, providing windows with operable bottom and top panels (in particular in Building A) in order to improve the possibilities for natural ventilation should be investigated. Also, ducted natural ventilation systems could be an option explored in Building B, if future double glazing does not allow for the windows to open. In Building A, natural ventilation options that help to reduce the outside noise would be preferable, for example, only using the windows at night outside of normal working hours to cool the building for the following day.

With regards to the heat gain through windows in Building A (a typical 1960s building type in Manchester) the impact of removing the reflective film from the top window panel on the amount of daylight, glare and heat gain should be investigated. If thermal comfort and glare are not compromised, the film could be partially removed to allow more daylight in. The cost of internal blinds with heat-reducing properties and introducing external shading could be explored in both buildings. In order to reduce internal heat gains, timed lighting should be introduced wherever possible.

The top floor extension to Building B requires insulation, confirmed by the tenants. In Building A, insulation under the cladding could be provided during the next cycle of major refurbishment.

Improvements to or replacement of the heating systems should take into account the projected increased unpredictability of the weather. Thus, the heating season and heating times should be more flexible and building teams should be able to turn the heating on and off when needed, or adjust the
temperatures to the current weather. In addition, the system should be flexible enough to correspond with the requirements of the individual office suites in the building; it should be made possible to turn the heating on for companies who use the building in the evenings or at weekends without heating the entire building.

When there is intense rainfall, roofs should be serviced more regularly to prevent leaks. The capacity of the drainage pipes needs to be expanded to cope with future rainwater volume, as specified in the climate change projections (Cavan 2011). The possibility of installing a rainwater storage system, and the reuse of rainwater in the buildings, should be investigated as it provides an opportunity for linking the adaptation agenda to broader sustainability issues. Internally, measures to prevent the hazard of wet floors, such as providing umbrella storage and wrapping (figure 15), cloakrooms or a facility to dry the rain-soaked garments (in particular considering the current climate in Manchester and the future projections) could be an unique selling point for commercial office buildings.

Figure 14. Umbrella storage (left) and umbrella wrapping machine (right) in the lobby of an office building in Nagoya, Japan. Photograph © Aleksandra Kazmierczak.
In the surroundings, extending the existing canopies over an entrance to the building and also above the pavement leading to bus stops could significantly improve the comfort of the people using the building in high temperatures and intense rainfall. These types of solutions are used extensively in tropical countries, such as Singapore.

Greenspace around buildings, such as that in Building A, could be maintained and/or expanded where possible as cooling assets. The possibility of promoting the use of the greenspace around Building A (e.g. provision of benches, tables, litter bins) could be explored to allow people the opportunity to cool down outside of the building. Providing green roofs on both buildings could be considered; an accessible green roof in Building A could improve the thermal comfort of the company based on the top floor and provide a selling point for this office. Figure 16 shows an example from Chicago, where the green roof surrounds the air conditioning vents.

**Figure 15. Green roof on Chicago City hall: air conditioning vents and vegetation in harmony. Photograph © Aleksandra Kazmierczak.**
The incorporation of ‘adaptation thinking’ into physical changes is also important at the office level. It is recommended that a compilation of information about the impacts of the organisation of office spaces on internal temperature and thermal comfort could be undertaken or commissioned by the landlord. The customer service and facilities staff could be trained to assess the potential thermal comfort of different types of office suites (dependant on their location in the building, building fabric and size) and advise organisations moving into the buildings on solutions relevant to their office space and business type.

Similarly, existing customers who are planning to extend their tenancy could be informed about the changes they could make to improve the comfort of their offices. A system of co-financing these changes by the tenant and the landlord, particularly the measures which could be retained for the future use (e.g. additional doors; internal insulation; heat-reducing blinds), could be discussed.

The communication of the landlord with the tenants is necessary; it helps to ensure that the tenants have the understanding of how the cooling and heating systems should function, and what thermal performance can be expected from the building. Customers should be informed about the long-term plans for replacement of the boilers or windows as it may positively affect their decision to remain in the building.

It is recommended that the landlord collates information about the types of the companies residing in the building (size, area of expertise, interest in and knowledge of environmental issues) in order to choose the most suitable communication strategy. Smaller companies may need more information about environmental issues, and their buy-in could be achieved by directly linking the adaptation and sustainability issues to the economic issues and human comfort. Larger companies could be informed how the adaptation of their offices in the face of changing climate could be utilised as part of their environment/sustainability/CSR strategy. The communication between landlord and tenants should be two-way as some of the tenants in the investigated buildings have a considerable know-how in relation to the built environment; the feasibility of their ideas could be explored by the landlord. The tenant – landlord relationship in this study can facilitate this communication. The existing forum and meetings could be used to promote an understanding of mixed-mode cooling systems, i.e. reduced air conditioning and increased natural ventilation.
Adaptive measures can be promoted through planned preventive maintenance as it is more cost-efficient in the long-term than reactive or temporary solutions. In this study, the division of responsibilities between the customer service team and the facilities management has been essential to improving the balance between the ‘fire-fighting’ and planned maintenance. It is recommended that this two-pronged approach to building management is promoted in other buildings.

However, reactive improvements to thermal comfort in response to sudden changes in weather are unavoidable. As temporary heating and cooling measures were recognised to be a significant strain on budgets, mainly due to the low recovery rate from tenants, more financially feasible options could be introduced. For example a system of deposits for the heaters and fans linked to the service charge or a ‘rent to buy’ system.

Ensuring that adaptive actions complement mitigation issues that the landlord currently promotes, such as energy-saving, recycling and greening, will further build their profile as a sustainable and forward-looking organisation. Expanding the portfolio of pro-environmental actions to adaptation, in close collaboration with the tenants, may add a competitive edge. This may mean that the landlord considers the development of long-term visions beyond the present five-year plans. This can take account of GM climate change projections in order to protect the sustainability and feasibility of investments.

The landlord has the potential to lead by example in GM by retrofitting its stock for the purposes of adaptation. Further, the landlord can lobby the industry and the policy-makers for a clearer recognition of the need to adapt office buildings to climate change. Due to the historic character of Building B, representative of a considerable proportion of buildings in Manchester and other post-industrial conurbations, the landlord should explore, in partnership with agencies such as English Heritage, non-invasive and easily reversible solutions that could be used as best-practice examples.

### 7.1.2 Tenant companies

It is recommended that an internal, informal survey is carried out by the tenant companies in order to learn about people’s individual preferences for temperature in the office. This could enable re-organisation of office spaces in a
way that allows those who tend to feel cold to sit in warmer spaces and those who feel warm in cooler areas; or even grouping the individuals according to their preferences. This could limit the number of temporary heaters and fans currently in use by serving more than one person at a time.

When planning climate control in the office and the organisation of space, it may be important to consider the gender and age of the employees. Young women were found to be more likely to require warmer settings, whilst young men were found more likely to require natural ventilation. Thus, particularly in male-dominated environments, it is recommended to provide a good level of control over natural ventilation. The access to windows should not be blocked and any faults with the windows preventing them from being opened should be reported to the landlord.

The perceived level of control over heating and cooling by the individuals could be improved by allowing them to adjust the temperature nearby their work station. This could be achieved by splitting the office space into a number of units with separate climate-control areas. However, in order to avoid the spikes in temperatures and the breakage of the climate control system, the controls regulated by individuals could be adjusted to cover a narrow range of temperatures, e.g. 19 – 23ºC. The larger range of temperatures should only be accessible to dedicated individuals, who will be able to adjust the temperature beyond the usual settings only in extreme circumstances.

The communication between office management staff and employees is key to improving overall staff satisfaction with the environment. The office staff and visitors should be informed about the expected temperature range in the building. Thermometers could be provided in the offices to demonstrate that the temperature is within the expected range. Other advantages of the building that compensate for the lower thermal comfort could be emphasised. The office staff should be educated about the functioning of the cooling and heating systems, and that the aim of the climate control in the offices is to maintain stable temperature and not respond quickly or respond to the preferences of individuals. Whilst it is easy to assume that everyone knows how to operate an air conditioning unit, it may be useful to provide a ‘guide for dummies’ next to the controls, which could also emphasise that air conditioning may not always be the best solution in given conditions.
Educating office workers about the adaptation to weather and climate could be linked to the energy-saving agenda. It is important to find common points (e.g. switching the computers and lights off will result in reduction of the internal heat gain, and reduced need for cooling) rather than simply using air conditioning intensively. People who remember to switch their appliances off regularly could be incentivised with, for example, permission for casual clothing on Fridays.

Organisations should analyse dress codes and explore the opportunities for making changes to adjust to the weather, which would not contradict their image. Managers could advise staff about what is appropriate and what weather conditions permit exceptional dress. To further reduce the need for artificial cooling and heating as well as to ensure workers’ productivity, hot and cold drinks can be readily provided.

It may be beneficial to introduce tasks for the sedentary workers which allow them to move around the office to cool down or warm up. For example, one of the companies in Building B requires the workers to type in a code in a printer after sending the job to the printers; this not only requires movement but also reduces the amount of paper used in the office as only the most essential documents are completed.

The use of public transport, cycling and walking not only reduce the carbon emissions but also force the office staff to dress appropriately for the weather and may reduce the need for heating and cooling in the office. Sustainable transport should be promoted amongst staff and, where possible, to provide or ask the landlord to provide improvements such as showers or lockers, bike payment schemes to encourage different modes of transport to work.

Considering the impact of weather on offices and staff, climate change and extreme weather events should be included in the business continuity and contingency plans of each organisation. Providing facilities to enable home working in extreme circumstances is an important option to consider.

**7.1.3 Policy makers and the industry**

In light of the changing climate, there is an increased need for the development of the standard describing the upper limit of the temperature in the offices,
similar to the minimum temperatures set by CIBSE (2006). Currently, there is
no statutory limit to the upper temperature in workplaces. The Workplace
(Health, Safety and Welfare) Regulations 1992 (Statutory Instrument 1992 No,
3004) require only that: 'During working hours, the temperature in all
workplaces inside the building shall be reasonable.' The CIBSE suggests for
offices that the temperature range for comfort should be 21 – 23ºC in winter and
22 – 24ºC in summer. The latter range applies to air conditioned buildings. Higher temperatures may be acceptable in non-air conditioned buildings.

There is also a need for a better balance between the need for conservation of
the historic character of buildings and the need for ensuring the sustainability of
these buildings under the changing climate. This could be seen as a continuation
of the work undertaken so far by the English Heritage (2008).

Another potential area of work for the Government is in their own procurement.
The mediating property companies that Government Agencies are permitted to
rent their space from should be fully briefed and able to deliver on climate
change mitigation and adaptation actions. In this way, Government agencies can
set example for others how to develop an energy-efficient and well-adapted
office environment.

Climate change adaptation, or adaptation to extreme weather events, did not
feature strongly in the business continuity plans of the interviewed companies.
Thus, it is recommended that the relevant industries set standards for the
organisations to take climate change into account and develop appropriate
contingency plans.

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4 Section 1 (Environmental criteria for design) of CIBSE Guide A: Environmental design.
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8 References


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