

Technical Note

Summary Buildings are designed for a specific climate yet they often have a lifetime of 100 years. Climate change may require a building to operate over a range of climatic conditions as a result of the impact of global warming. This effect is compounded by the fact that much of the climatic data currently used for design purposes is some 30 years old. This paper investigates the impact that climate change over the last two decades may have on the design and performance of buildings by examining the specific impact that changes in temperature and solar radiation have had on one particular design variable, energy use. The results indicate that the temperature and solar radiation in the London region of the UK has changed significantly in the last 15 years and that the climatic data currently being used for energy design calculations leads to inaccuracies in predictions of energy use. It is concluded that the climatic data used in these calculations should be urgently reviewed as it may be leading designers to adopt solutions which will be inappropriate for future use.

The impact of climate change on the environmental design of buildings

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1 Introduction

One of the fundamental requirements of buildings is the protection of the people who live and work within them from the weather. The objective of environmental building design is the creation of a comfortable yet energy efficient internal environment. The successful design of buildings relies on an appropriate understanding of the climate. It is no longer acceptable to rely solely on building plant to supply the internal conditions that we require. Buildings are increasingly being designed to utilise passive techniques and have evolved so that they adapt to the climate.

The recent publication of a government report⁽¹⁾ on global warming has led to a great deal of controversy within the industry as to what impact these changes will have on buildings. We are told that global warming will radically change our climate. Plant and animal life is slowly migrating northwards in search of cooler climes at the same time as it is predicted that our south coast will become likened to the Mediterranean in the very near future.

Although there is a general consensus that global warming is occurring, predicting how it will impact on a small island like the UK, which is so dependant upon the Atlantic Ocean currents for its climate, is difficult. The question is, what will be the impact of these changes on our buildings and are we designing them for the correct climate? Research undertaken as part of a Masters degree in Environmental Design and Engineering at the Bartlett by Stephen Pretlove⁽²⁾ suggests not.

2 Use of climatic data in building design

The study identified six *basic* building design calculations which rely on climatic data for their calculation. Computer simulation calculations which incorporate climatic data were not included in this study since they are generally not used for building design calculations at the moment. The six basic design calculations and the climatic variables which are required for their calculation are indicated in Table 1.

The collection of the data for this study was governed by the availability of free data. Due to the nature and scope of the study it was realised that the analysis could only be carried out for a single geographical region in the UK. This region is loosely referred to as the Thames Valley although the sources of data are from different locations within this region.

The climatic data collected for the study includes degree day data for the Thames Valley (1976 to 1995), mean monthly temperatures from Heathrow (1981 to 1995) and monthly solar radiation data from Bracknell (1981 to 1995).

3 The analysis of climatic data collected

The initial analysis of the collected data involved identifying and quantifying trends over the past two decades. Figure 1 indicates the collected degree day data to a base temperature of 15.5 °C for the Thames Valley region for the last 20 years. The centre moving average of the data is included on the chart so that longer term trends can be identified. A trend line has been determined during this period which is assumed to be linear for this study. There is clearly a reducing trend in average degree day data during the period studied. During the last 20 years the average monthly degree day

value has decreased by some 11%. Similar analysis of seasonal degree day data over the same period indicates an even greater reduction of 14%.

Figure 2 shows the collected mean monthly temperature data together with similar moving average and linear trend lines. The results of the analysis show that mean annual temperatures measured at Heathrow over the last 15 years have increased by 0.6 °C which represents an increase of 6%.

Figure 3 shows the collected solar radiation data. The results of the analysis show that the solar radiation has been changing during the period but not at the same rate as the other measured parameters. The average annual solar radiation has increased by 3% during the 15 year period.

4 The application of the climatic data collected to design calculations

The climatic data collected was applied to three building energy design calculations; the CIBSE Building Energy Code calculation, The Government SAP energy rating calculation and the BREDEM-8 monthly energy rating calculation.

Each of the three design calculations had the collected climatic data applied to it for each year during the 15 year collection period so that a comparison could be made between the collected data results and the design method data results.

The results for each of the three design calculation methods showed very similar results. Figure 4 shows the results of the CIBSE Building Energy Code calculations carried out on a standard heated and naturally ventilated office building.

The results for each of the three design calculations are summarised below:

Over the 15 year period studied:

- The CIBSE Building Energy Code has over-estimated the thermal demand of buildings in the Thames Valley region by an average 8%
- The Government SAP rating has over-estimated the space heating requirement for a traditional dwelling in the Thames Valley by an average 17%
- The BREDEM 8 has over-estimated the space heating energy requirements by an average 7%

5 Actual and predicted gas consumption in UK dwellings

For further validation of the findings of this study, a comparison of actual gas consumption⁽³⁾ against gas consumption predicted using energy design calculations was carried out. If the previous analysis were correct then one would expect a considerable reduction in energy use in UK housing during the last twenty years due to the effect of climate change. Analysis of gas consumption over the last 20 years indicates a smaller than predicted using the SAP model. Figure 5 shows the domestic

annual gas consumption against seasonal degree days for the period 1975 to 1995. The two lines on the chart illustrate gas consumption for the average UK dwelling. The top line indicates actual gas consumption during the period and the bottom line indicates the BREDEM predicted gas consumption for the average UK dwelling.

Both actual and predicted gas consumption results show that as climate becomes milder the consumption of gas decreases. However, the difference between actual and predicted consumption increases as the seasonal degree days reduce. This suggests that as the winters become milder people tend to increase their levels of comfort instead of reducing gas consumption. We can conclude from this that global warming may not produce the CO₂ reductions predicted. To what extent this factor occurs in modern well-insulated dwellings is not known at this stage since there is little available data on actual gas consumption for this type of dwelling.

6 Conclusions

There are a number of conclusions that can be made from the results of this study:

1. Significant changes have taken place in the Thames Valley region of the UK during the last two decades:

Annual degree days have reduced by 250 in 20 years (11%).

Seasonal degree days have reduced by 280 in 20 years (14%).

Mean annual temperatures have increased by 0.6 C in 15 years (6%).

Mean seasonal temperatures have increased by 1.0 C in 15 years (15%).

Annual solar radiation has increased by 3 W/m^2 in 15 years (3%).

2. The use of historical climatic data significantly overestimates building energy requirements:

The CIBSE Building Energy Code and BREDEM 8 calculation over estimates the energy requirements by 8% and 7% respectively.

The SAP rating calculation over estimates the energy requirement by 17%.

This can be partly accounted for by geographical location.

3. Climatic data used for building design calculations should be regularly reviewed and updated otherwise its use may result in buildings not suitable for the next millennium.

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References

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DESIGN CALCULATION	CLIMATIC VARIABLES REQUIRED
<p><i>PLANT SIZING</i> Heating and cooling plant design</p>	<p>Seasonal external temperature Seasonal wet and dry bulb temperatures</p>
<p><i>ENERGY USE</i> Simple energy design (steady state)</p> <p>Energy rating: BREDEM 8</p> <p>Energy rating: BREDEM 9 and 12</p> <p>Energy monitoring CIBSE Building Energy Code LT method Easichack</p>	<p>Seasonal external temperatures Seasonal solar gains through glazing Historical degree day data Mean monthly external temperature Mean monthly solar radiation Solar flux through glazing Variable base degree day data Current degree day data</p>
<p><i>CONDENSATION</i> Surface and interstitial</p>	<p>60 day mean external temperature 60 day mean external vapour pressure</p>
<p><i>NATURAL VENTILATION</i> Temperature driven ventilation Wind driven ventilation</p>	<p>Mean external temperature Mean external wind speed</p>
<p><i>SUMMERTIME OVERHEATING</i> The admittance method</p>	<p>Mean and alternating solar gains Mean and alternating air temperatures</p>
<p><i>DAYLIGHT</i> Daylight availability</p>	<p>Unobstructed external illuminance</p>

Table 1 - Basic design calculations relying on climatic data

Monthly degree Day data to base 15.5C for Thames Valley 1976 to 1995

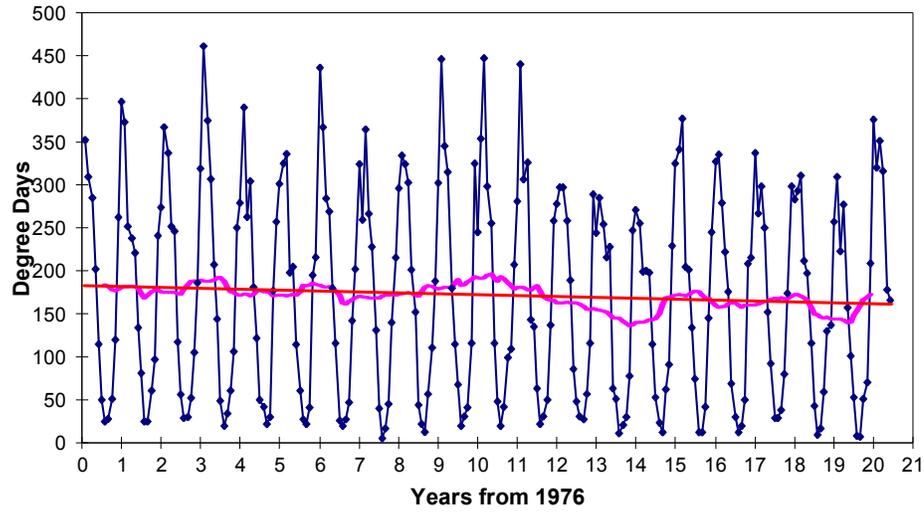


Figure 1

Mean monthly temperatures for Thames Valley (Heathrow) 1981 to 1996 with CMA of order 12

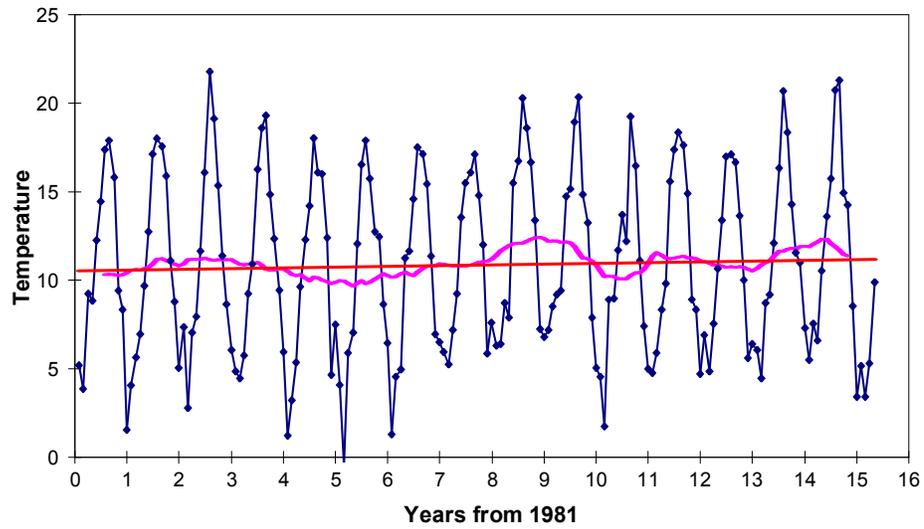


Figure 2

Average Total Solar Radiation (W/m²) for Bracknell 1981 to 1995

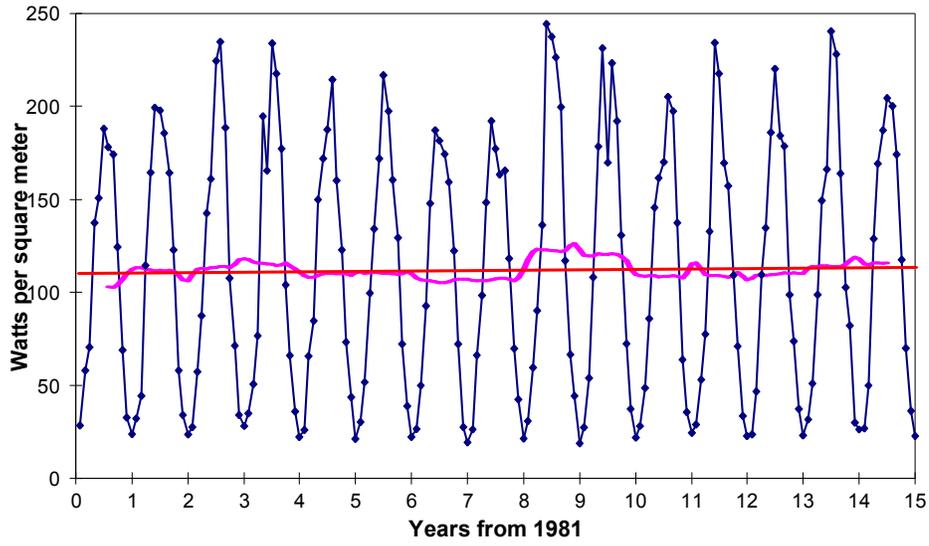


Figure 3

Comparison between measured climatic data 1981 to 1995 and CIBSE Building Energy Code original data

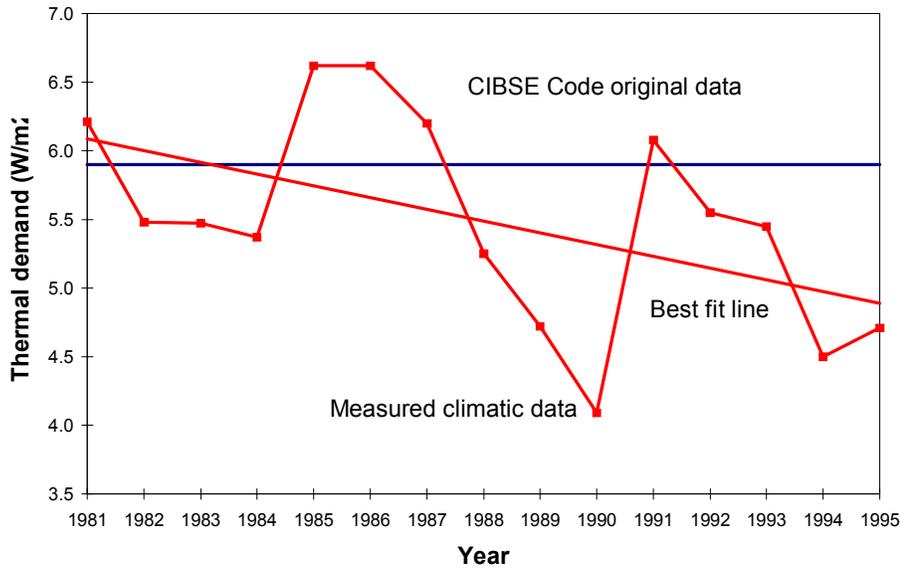


Figure 4

Domestic annual gas consumption against seasonal degree days 1975 - 1995

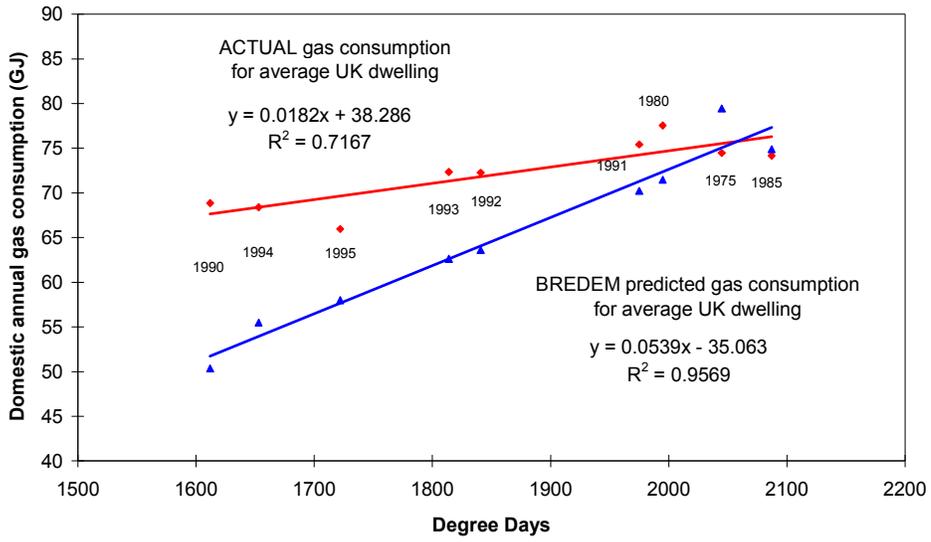


Figure 5