

# A Study on the Intensive Use of Air Conditioning in Large Retail Stores

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**Summary:** *In addition to an increase in greenhouse effect emissions the intensive use of air conditioning in the retail sector can eventually carry implications on the health of some of those directly exposed to sudden cooling particularly in hot summer days. This paper reports the results of an experimental study conducted in the summer of 2005 in the United Kingdom investigating air conditioning frequency of use and the indoor air temperatures of air conditioned premises. It was found that in some large retail stores indoor air temperatures could be set higher improving thermal comfort and contributing towards the environment.*

**Keywords:** *Air conditioning use in shops, indoor environmental quality, indoor environmental factors*

## 1 Introduction

Increasingly, there is evidence that the global climate is changing quite considerably and that such change is in part due to anthropogenic emissions of greenhouse gases, a significant proportion of which are a consequence of burning fossil fuels for electricity generation. Nevertheless, and as in most developed countries, there has been in the UK a steady increase in the air conditioned area and intensity of use of Air Conditioning (AC) in the retail sector.

The UK has a temperate climate without large seasonal extremes of temperature, i.e. summers are cool and winters are mild. However, eight out of the ten warmest years recorded in England happened in the last 16 years [1]. AC usage in the UK's retail sector is a relatively recent phenomenon but as climate is globally warming up the sudden growth of air conditioners usage is something to be concerned about. It is known that AC use in some sectors of the UK's non-domestic building stock, is increasing rapidly but statistical data is scarce. Since the early 1970s the rate of growth in UK energy consumption in the service sector, i.e. commercial and public buildings, has increased by approximately 30% compared with a 25% increase in the domestic sector [2]. It is important to know if rising AC use is one of the reasons for such an increase and if energy efficiency measures are being used effectively to limit the power required by AC systems. These systems exist primarily for the comfort of customers and staff, also for stock in case of food, but the same effect can be achieved with much less energy use, particularly in temperate climates such as in the UK. Typical measures in the retail sector may include more efficient use of display lighting, more and non-arbitrary setting of cooling temperatures combined with self closing doors or air curtains.

A broad survey with comparatively low data depth has been carried out of 700 retail premises to determine the frequency of AC use and the rate of

growth. The street surveys involved walking around areas which contained significant numbers of non-domestic buildings and noting HVAC systems by visual inspection of the accessible parts of the building and, where possible, by casual internal inspection.

In addition, to assess the intensity of cooling energy use a sub-sample of about 20 retail premises was also probed for temperature and relative humidity on a hot summer's day (outdoor temperatures ranging from 25-27 °C).

## 2. Research approach

The street surveys were all carried out in a busy commercial district in central London. The capital of the United Kingdom is located in the Thames Valley region where the greatest concentration of air-conditioning is found. Being in the South East of England its climate is largely influenced by the continental proximity and the added urban heat island effect. Summer temperatures can occasionally climb up to more than 30 °C. The shops surveyed were either part of a chain or local and were selected based on their size; location and type of activity (see Table 1).

Shop	Type of shop	Size	Survey duration (minutes)
A	Household Furnishing	Large	7
B	Department Store	Large	7
C	Department Store	Large	12
D	News Agent	Medium	6
E	Supermarket	Large	12
F	Supermarket	Large	7
G	Electrical Supplies	Medium	11

H	Department Store	Large	12
I	Household Furnishing	Large	5
J	Multimedia Centre	Medium	6
K	Multimedia Centre	Large	5
L	Supermarket	Large	10
M	Designer Clothes	Large	11
N	Pharmacy	Large	8
O	Record Store	Very Large	6
P	Book Store	Very Large	8
Q	Sports Store	Large	5
R	Gifts	Medium	6
S	News Agent	Medium	5
T	Multimedia Centre	Large	5

Table 1- Shops' description data

index in judging indoor comfort under cold conditions and thus was considered a good indicator of cooling intensity. To record Temperature and Relative Humidity (RH) two portable environmental dataloggers were used. These were carried inside of a well ventilated bag hanging from the surveyor's hand. The probing time was dictated by the response time of the loggers. As it took about 3 minutes for the loggers to record 90% of the actual temperature reading the surveys had to be conducted for at least 5-10 minutes. The response time for RH was much faster which revealed to be very useful in determining the exact period of time the surveyor was indoors. The loggers were programmed to record readings every 5 seconds.

### 3 Analysis of experimental results

Figures 1.a and 1.b show the evolution of indoor air temperature and RH over time for half the shops surveyed. The survey started just after the surveyor left an air conditioned room hence the low temperature recorded before shop A being surveyed followed by an increase when indoors. As should be expected, periods indoors of intensively air conditioned premises are generally characterized by a sharp drop of temperature and RH. By contrast, the

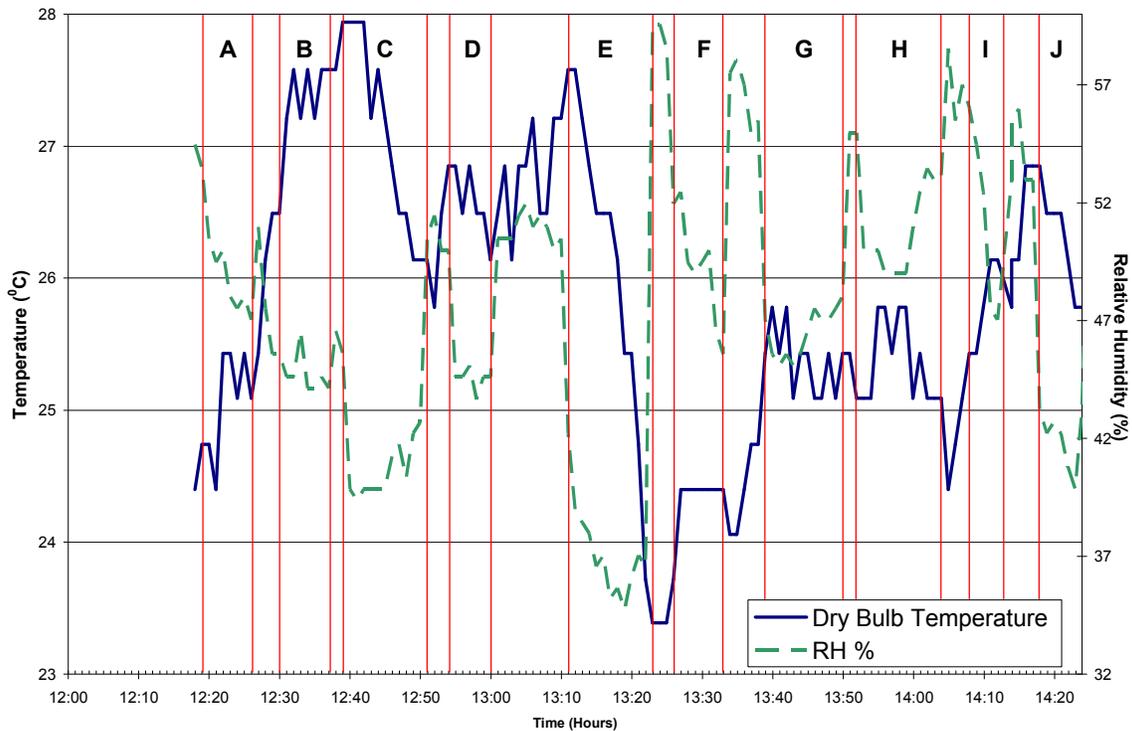


Figure 1.a - Air temperature and RH variation

Medium to very large size shops were elected not only because of the greater likelihood of being air conditioned but also because the surveyor could probe the environmental conditions for longer time without being too conspicuous.

Dry- bulb temperature is perhaps the most practical and simultaneously the most revealing environmental

periods spend outdoors are also generally characterized by a rise of temperature as might be expected. For ease of interpretation of the results the periods spent indoors are labeled with an uppercase letter on top of the two delimiting vertical lines, designation which has correspondence with that in Table 1.

The chart analysis shows that in some shops there is not a very marked temperature change from outdoors. This is primarily due to not all shops being air conditioned, having air conditioners set for ventilation only or having doors wide open without using air curtains. In others though there is a noticeable temperature drop, like in shop E. Recorded shop E temperature shows no signs of stabilizing during the period the surveyor stayed indoors suggesting that it would eventually drop still further. It should also be noted that of all those surveyed only four shops kept the cold in using automatic doors. Eleven shops had air curtains installed but actually only three had them operating. An assumption can thus be made that the recorded temperatures could even be lower if these facilities were in use. Interestingly the continuous downtrend of indoor and outdoor temperatures, seen in Figure 1.b, is due to the fact that all shops after shop N were located in a different street, which due to its orientation received much less direct solar radiation throughout the day than the former one.

with chronic respiratory diseases, e.g. bronchitis or emphysema, increase in colder environments. Moreover a study performed in the USA [3] revealed evidence of cold sensitivity in asthmatics.

The study carried out had the primary aim of investigating the level of indoor air temperatures existing in air conditioned premises. As a result it was also found that some supermarkets registered the lowest indoor air temperatures relatively to outdoor temperature presumably due to the combined cooling effect of the AC system and of open display fridges. This may be eventually designed to slow down the decay of perishable goods like vegetables and fruit ensuring a longer shelf life whilst retaining ready access to the displayed goods.

The study carried out in the summer of 2005 was a fairly small survey of UK retail premises therefore much larger follow-on surveys are to be conducted during the next few years. Of additional interest, are the longitudinal possibilities of such a survey, whereby once most of the database is populated the

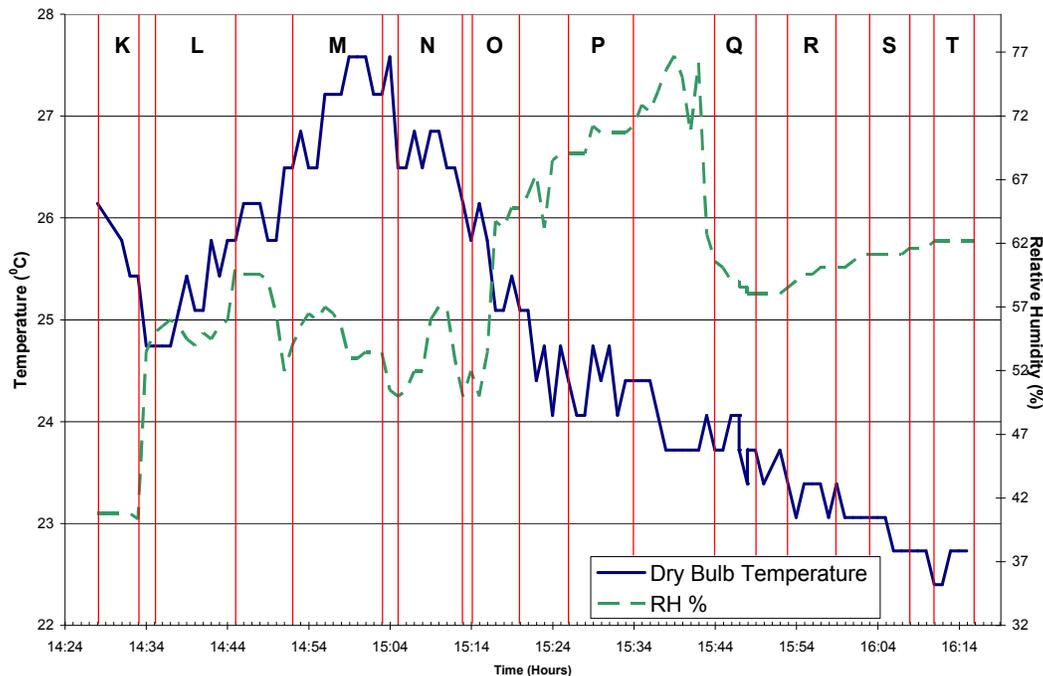


Figure 1.b - Air temperature and RH variation(cont'd)

#### 4 Conclusions and future work

Thermal comfort is perceived in different ways by different subjects and a vast amount of literature has already been published throughout the years on this subject. However, there are no known studies on the issue of people walking out from a warm into a much cooler environment, or vice versa, as often happens. Also the health implications of a sudden exposure to a much cooler environment are still pretty unclear but anyhow out of the scope of this paper. Yet, it is well known and documented that symptoms of patients

same sites can be re visited in the next years, and the frequency and intensity of AC use examined year on year. Future research will investigate the implications to energy consumption of the practices observed. So as well as examining this growth, the energy efficiency measures applied will also be assessed. This work will include obtaining floorspace data for the surveyed premises and modeling energy use to estimate incremental energy consumption. Logging equipment with enhanced features will be used as well as Infrared Imaging which is already being tested.

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