EXECUTIVE SUMMARY

The cooling market, in particular air-conditioning, has been growing rapidly in the UK. People now want more comfort and control of their indoor environment. Simultaneously, climate change models predict uncomfortably hot summers towards 2050. This report investigates how comfort levels and climate change will influence the demand for cooling, and policy options to address UK demand that avoid energy intensive solutions. Particular attention is paid to the residential market because it is expanding fastest.

Rising temperatures

Historical temperature trends show a sustained rise in Central England Temperature of about 1°C since 1980, whilst it has remained approximately stable for the previous 200 years. **South England, already the warmest region, will face the highest temperature increases; between 1-1.5°C in 2020, to 2-3°C in 2050, and 3.5-5 °C in 2080**. If emissions are high, SW England in 2080 could expect daily average temperatures to exceed 30°C about once every ten days with peak daytime temperatures reaching 42°C twice a week.

Whilst cooling degree days are offset by reduced heating degree days the Tyndall Centre found that reduced carbon emissions from heating are far outweighed by the increase in emissions from cooling. **They conclude that technical solutions to managing cooling energy consumption will not be enough, and suggest that further research into adaptive responses to comfort is required**.

Rising air-conditioner use

The air-conditioning market is growing, especially in the domestic sector where there are no precise figures. This is a major barrier to confident policy making. Evidence from the Institute of Refrigeration estimate approximately 10% of non-domestic floor space and less then 0.5% of domestic floor space to be air-conditioned. Forthcoming, **figures from the Market Transformation Programme predict a growth of approx 7% a year to 2010**. Forecasts further forward to 2020, predict cooling to use 25 TWh.

The domestic sector is growing faster than non-domestic and could conceivably change more significantly. **Mobile units are expected to dominate the residential market**. They are likely a 'distress' purchase' – bought during a heat wave or similar – for homes and small businesses, and once bought are likely to be used whenever the temperatures rise, rather than only at the previous peak which brought on the distress factor.

Modelling residential air-conditioner use

A new model was developed to predict residential cooling demand and subsequent energy consumption. Based on four Comfort Scenarios developed by Shove and Chappell, the model predicts the effect of unconstrained growth and possible savings resulting from adaptive responses.

i. **The comfort zone extends** – People are comfortable in a much wider range of indoor temperatures.

ii. **Indoor climates diversify** – There is no demand for any control of indoor climate.

iii. **Standardised efficiency** – In this case conventions of comfort and clothing stabilise and are provided efficiently.

iv. **Escalating demand** – Comfort will be even more demanding than those of today. People expect to be even warmer during the winter and even cooler during the summer.

From experience in Western USA, it is expected that the baseline comfort level will be scenario III or IV.

Four population groups are used to estimate the groups who are likely to consider buying air-conditioning. Population group A is the entire South England population

and the worst case. Each scenario is assigned a threshold temperature at which cooling is demanded by the population.

Group A whole pop^n	Scenario I (26°C)		Scenario III (22°C)		Scenario IV (20°C)	
Year	Energy /TWh	Emission /$MtCO_2$	Energy /TWh	Emission /$MtCO_2$	Energy /TWh	Emission /$MtCO_2$
2020	3.8	1.6	7.6	3.3	11.0	4.9
2050	4.6	2.0	9.1	3.9	14.0	5.9

Energy and carbon impact

If there was unconstrained growth of air-conditioning to meet all cooling demand, by 2020 domestic energy consumption increases by 11 TWh (shown above). Adaptive comfort levels could reduce this to just 3.8TWh under Comfort Scenario I, without low-energy options in place. The Building Regulations in the domestic sector are predicted to save 5.5 $MtCO_2$ (1.5 MtC). **Air-conditioning carbon emissions by 2020 could negate 15% to 90% of the domestic Building Regulations savings**.

The model developed in this research makes many critical assumptions and should be considered a first step. Further work is needed to solidify what is assumed and develop the model further.

Across the whole air-conditioning market, **increased emissions from 2000 of 4.3 $MtCO_2$ by 2010 negate over half of the 7.7 $MtCO_2$ projected savings from the combined 2002 and 2006 Building Regulations**. This is also much larger than 0.85 $MtCO_2$ (0.23 MtC) of cost effective savings by 2020 calculated by Pout *et al.*

Zero energy refurbishment is possible

Furthermore, **Energy consumption can be reduced to almost zero using passive measures**. Hacker *et al*'s dynamic building modelling found the most successful measures were:

- Shading from the sun
- Providing controllable ventilation during the day and high levels of ventilation at night (without compromising building security)
- Using heavier-weight building materials combined with night ventilation, to enable heat to be absorbed and released into the building fabric
- Improving insulation and air-tightness so that undesirable heat-flows can be controlled.

Passive measures can maintain a house in comfortable, but warm, conditions in London until 2050, at which point supplemental air-conditioning may be needed. Installing these measures keeps maximum temperatures below 28°C and net carbon dioxide emissions only exceed the current levels in the 2080s.

Recommendation

Revise Building Regulations

Building Regulations in England and Wales and proposals in Scotland already include a methodology to determine the risk of excessively high indoor temperatures. However, these are only guidelines. Because houses built now are expected to still be standing in 2050, **in South England, mandatory Building Regulations are needed for new dwellings and refurbishments that assess cooling performance, alongside heating, based on future climates**.

Recommendation

Better information about alternative cooling options

In conjunction with refurbishment standards, **better information about alternative cooling options need to be provided**, such as those mentioned earlier. Passive technical measures must take strong priority over active solutions which could be supported through a universal cooling energy efficiency label, comparing technical solutions against each other. The information must also be easy to find, eg on websites and in stores. In particular, energy labels were still not ubiquitous on websites even though they are required legally. **Stores should ensure energy efficiency, sizing guidelines, and best practice operation and maintenance information, are displayed prominently.**

Recommendation

Remove inefficient air-conditioning from the market

Where air-conditioning is needed, it is essential to ensure high efficiency units are used. **Minimum Energy Performance standards (MEPs) have been applied to gas boilers under Building Regulations and need to be applied to cooling appliances**. The IEA recommend Least Life Cycle Cost analysis to determine the optimal MEP which balances manufacturer, consumer and environmental concerns. Using 'regulatory best practice' is another option. This uses the best international regulation to set the MEP.

Recommendation

Engaging public and shifting attitudes

However, these implicitly assume that active measures will be used and ensures scenario III is maintained. **Achieving Comfort Scenario I or II will require more innovative approaches to engage the public**. Possible solutions that can be explored include changing fashions, particularly office attire, and reducing air-conditioning in cars and offices which may encourage residential purchases. To realise maximum savings, better awareness of personal carbon use that brings a stronger message home is needed to create a widespread shift in attitudes to comfort. Personal carbon trading or even carbon taxes might be needed to achieve this.

The policy recommendations are summarised in the figure below. The Comfort scenarios are placed in the four sectors defined by comfort temperature and the cultural or technical influence creating the initial attitude. Expectations and practices must be changed first from bottom up (shown in green) to achieve the desired comfort attitudes. Technical solutions can then be applied from top down (shown in blue) to match the Comfort Scenario.