Evidence to the House of Lords Select Committee on Science and Technology:

Energy Efficient Buildings

by
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The UK building stock is directly responsible for approximately 50% of UK's energy use and carbon emissions. This paper suggests the following:

1. The government should clearly state that the primary motivation for energy efficiency is reducing carbon emissions. It should therefore clearly brand its various instruments under this single banner and rationalise the bodies charged with delivering a low carbon future.
2. A major secondary motivation for improving efficiency is to reduce UK dependence on fossil fuels, which in the future will increasingly be imported. With appropriate planning, there need be no conflict between these two aims.
3. Improving the energy efficiency of the built stock is only possible in the long term. This goal therefore requires long-term policy instruments backed by significant and sustained research support.
4. Monitoring of the energy performance of the built stock should be based more on real delivered energy and stock data rather than inferred data. Energy efficiency should aim to provide an absolute reduction in carbon emissions and not simply a reduced rate of growth.
5. Trends in energy consumption should be monitored and policy instruments put in place rapidly to control the unnecessary use of energy. This will probably require the development of new instruments.
6. Energy efficiency alone can stimulate energy use and it is essential that a better understanding of social technical links are developed and then implemented in policy.
7. Significant and sustained research support that is in our view required to deliver a low carbon future, requires the brightest brains from the full range of disciplines to be excited by and stimulated to work in this area.
8. The UK should fully embrace the European Building Performance Directive and resist the temptation to discharge it responsibilities under this Directive in a perfunctory way. In this way the UK can lead Europe into a low carbon future. This will require the development of the UK Building regulations to be properly resourced. The government should also provide appropriate financial support to demonstrate the practicality of future regulation well in advance of introduction and at a scale that is capable of delivering statistically significant results.
9. Utilities should be mandated to collect reliable energy data (read not estimated), to provide appropriate feedback to customers on their energy performance relative to similar building types and occupancy and, while taking account of the associated ethical and data protection issues, provide access to this data to researchers.

A clear and long term focus

The last 30 years of energy efficiency in buildings in the UK has seen a range of different policy instruments applied to the Built Environment motivated by a desire to improve security of supply, improve health and comfort, save money and energy and most recently, reduce carbon emissions. There has been no really consistent long term policy focus in the UK until the most recent publication of the White Paper *Our Energy Future* (DTI 2003).

In the past there has also been confusion as to exactly what programmes are trying to achieve, is it energy efficiency (is this system efficiency or appliance efficiency), is it lower costs, use of less primary energy? Hence we have had, save energy, save monergy, conserve energy and energy efficiency campaigns. In terms of institutions and instruments, we have the Energy Saving Trust, The Carbon Trust and Building Regulations which are associated with Conservation of Fuel and Power. We have had regular rebranding of schemes with similar goals – Home Energy Efficiency Scheme then Warm Font, Energy Design Advice Scheme and now Design Advice. In research we currently have the Carbon Visions programme, Tyndal Centre and the UK Energy Research Centre. This is confusing to both professionals and the public and yet all of these bodies are broadly aiming to achieve a low carbon future. The government has a long term commitment to reduce carbon emissions by 60% by 2050. It needs to put into place coherent long-term instruments to achieve this. Long term stability can have many benefits.

1. **Industry can plan for change**: It can take industry three or four years to gear up to major changes. Once made, investments associated with preparation for such changes must then be given time to pay back[1]. Industry is an essential partner of government in the battle to drive down CO_2 emissions. Sudden and unplanned changes in instruments such as the Building Regulations can be a major inconvenience for industry and, by compromising the credibility of government, risk making subsequent change more difficult to implement. It is correspondingly essential that government actions do not compromise the trust of industry.
2. **Cost savings can occur.** The setting up of new or rebranding of existing schemes is expensive, taking money away from the scheme delivery.
3. **The impact and usefulness of research can be improved**. The collection of real energy data and the monitoring of trends become feasible and useful when these activities are embedded within a long term programme. For example, the research community is capable of supporting the development of building regulations through strategic studies to evaluate and demonstrate the effectiveness of regulatory proposals and possible responses. But this approach has rarely been attempted, in part because the long term perspective has not in place. Demonstration projects such as Stamford Brook, which has been of considerable value over the last year in the context of the Part L review, have occurred almost by accident. The seeds of this particular project were sown in a report written in 1998. The project itself received the funding go ahead in 2001 and the project is expected to finish in 2006. This shows the long lead times required to establish such projects, which in our view have

[1] A.N. Whitehead's (1911) observation that, "Operations of thought are like cavalry charges in a battle - they are strictly limited in number, they require fresh horses, and must only be made at decisive moments", is surprisingly appropriate to major initiatives in energy policy. One might add that it helps if successive initiatives in policy, like cavalry charges, generally point in the same direction.

been further extended due to the lack of clear direction and understanding of their strategic importance.

4. **Stability and clear direction can attract more researchers,** and encourage the use of better technology allowing the UK and UK industry to develop a world lead in low carbon technology where previously it has followed other countries.

Theoretical versus actual energy use

Despite thirty years of research in this area we have very little hard knowledge of how people actually use energy in buildings. The main information we currently have is the total delivered energy to the built stock, i.e. to the domestic and other (Digest of UK Energy Statistics). From this national data, delivered and useful energy demand is inferred from a range of data about the stock (such as the English House Condition Survey and floor space data from the Valuation Office) and computer modelling of energy flows in buildings. The UK has had a world lead in such computer modelling through the development of Building Research Establishment Domestic Energy Model (BREDEM) and subsequently the Standard Assessment Procedure (SAP) in the domestic sector and the development of simulation models in the non-domestic sector. However there is a real dearth of hard data with which to validate these models and take account statistically of variations in occupant behaviour. The reason for this is that it is always cheaper and quicker to model energy performance than measure it. In addition, energy models with large numbers of unknowns can be easily manipulated to provide the answers you want. This difficulty in getting real data has produced an over reliance on theoretical predictions. When this is combined with the fact that many research, consultancy and government programmes have carbon reduction targets to meet and the fact that people are generally only interested in hearing good news, one can very quickly build a fictitious world of carbon reductions which will never on their own result in real carbon savings. 'In theory, theory and practice are the same, but in practice, they're not' (Santa Fe Institute quoted in von Weizsäcker et al 1997).

Government funding must allow the reporting of things that do not work as well as those that do, so that lessons can be learnt and communicated. Schemes such as PROBE (Bordass et al 2001) which provide feedback to designers and building owners should be encouraged and, if need be, financially supported. Interestingly, very little data from the key domestic monitoring studies over the last thirty years has been widely distributed outside a small and select group of researchers and government departments. The consequence is that myths about energy efficiency abound, and are propagated from one generation of designers to the next with little or no reference to empirical data. Hopefully the Freedom of Information Act will increase the dissemination of publicly funded research[2].

If implemented correctly, the European Building Performance Directive (EBPD) will require building owners to display both theoretical and actual performance. This should very quickly identify discrepancies between the two.

[2] We are reminded of a sign displayed in a seminar room at a department of physics. "In God we trust. All others bring data."

Improvements in monitoring technology mean that it is now far cheaper to collect real data than it was a couple of decades ago although it is still more expensive than modelling. Cheaper monitoring combined with improvements in national data about the stock provide the opportunity to start to both undertake interesting research and provide useful feedback to building owners. For this to occur, it is critical that researchers can get access to utility energy data and hence open up research into Carbon Epidemiology. However obtaining access to utility data has become more complex since deregulation. The Regional Energy Consumption Statistics produced by the DTI are starting to make utility data available. However, for the purpose of research and with appropriate safeguards, it is critical that this data be able to be tracked back to individual premises where it can be linked to fabric, services and occupant data. Clearly such combined data, which is being sought under a Carbon Visions funded project[3], would not only be a major boost to research, particularly when trying to understand social technical links, but maybe also to occupants. For example, this would enable utility bills to compare a particular occupant in a particular type of dwelling with the average – normalised for floor area and other variables. This would provide a stimulus for occupants to take action and the data to enable them to do so effectively. Such developments may need the support of government departments - in particular DTI, ODPM and OfGem to ensure that this data is of good quality (in particular that it is not compromised by excessive estimated data). The technology for achieving this is developing. In our view, utilities should be obliged to collect good quality data and to make it available to the research community in an easy to use format. The costs would be relatively small and the potential benefits large. The barriers are largely institutional and departmental.

It is useful in this context to reflect on the parallels between energy research and medicine. The most important step made by medicine in the 19th Century was that it became evidence-based. The foundations of this transition were provided by a combination of experimental work in hospitals and universities and epidemiology. The latter was, and is, based on records of births and deaths, medical records and a wealth of circumstantial evidence. While the scientific underpinnings of medicine have advanced beyond the dreams of its founders, medicine remains empirically based. The thought of returning to non-evidence based medicine or of doing without epidemiology are both absurd.

This is however, very largely the position that energy researchers have occupied for the last thirty years, as a result of being denied access to basic data on energy use[4]. Clearly there are ethical considerations associated with allowing access to such data particularly if it is linked - as it must be ultimately be - to specific properties and their fabric and services; however these issues could be overcome if procedures analogous to those that apply to medical records were put in place. Indeed, they appear largely to

[3] Carbon Visions, funded by the Carbon Trust and EPSRC, has a new buildings programme "Building Low Carbon Communities" which includes one project called CaRB. This involves longitudinal monitoring of energy use in the buildings stock. One of its major outputs will be a detailed and spatially based model of energy use in the non-domestic stock. Another is an innovative approach to behavioural aspects of domestic energy use based on Bayesian Belief Networks.

[4] The exception has been a modest number of small studies, where the cost of data collection has been very high

have been overcome in countries such as the United States, where mandatory utility data collection has been carried out.

Longitudinal studies are for the first time being planned in the UK under the Carbon Visions programme. To avoid being crippled by inadequate data and high data collection costs, these studies will need to face, head-on, the issues laid out above.

Increasing use of energy. Despite a 30% reduction in domestic heat loss and a 30% improvement in the efficiency of domestic heating systems, energy delivered to UK dwellings has increase by 30% over the last 30 years (Shorrock and Utley 2003). This is because the demand for heat, light and other electricity in dwellings has doubled over the same time period. Whereas the average temperature maintained in dwellings 30 years ago is thought to have been 13°C it is now 18°C and could easily rise to 21°C over the next decade. We increasingly have air conditioning at work and there is already a small market in domestic air conditioning. This could grow significantly with the introduction of electric heat pumps which can provide both heating and cooling.

It is now recognised that the theoretical energy savings predicted very rarely materialise as a result of improved comfort and other changes in occupant behaviour. This is often called the "comfort factor" or "take back". Energy economists refer to the phenomenon – which was first recognised by Jevons in the late 19th Century - as the Brookes-Khazzoom effect (Saunders 1992). Estimates of the take-back for improvements to thermal insulation and heating systems have been hard to arrive at with so little monitored data but are thought to be in the region of 50%. However in some cases the proportion taken back may be greater than 100% (see below).

Energy efficiency can stimulate energy use. We appear to have an almost innate ability to come up with new and novel ways to use energy even if we know it is bad for the planet. This is similar to our desire to eat more than is healthy for us and become obese. Over the last thirty years the proportion of a family's expenditure on fuel, light and power has decreased by a factor of more than two - from 6.3% in 1970 to 2.9% in 2001 and we know spend more on alcohol than we do on energy (Graggs 2004). Partly stimulated by this cheapness of energy and facilitated by improvements in energy efficiency technology we are now using energy in ways not previously considered. One of the simplest examples of this is the domestic conservatory which when it was a single glazed leaky building was just used as a buffer space in autumn and spring. Now, however, 90% of conservatories are heated either directly or indirectly and those that are double glazed are heated twice as much as single glazed conservatories (Oreszczyn 1993). This is because the improvements in energy efficient technology have allowed people to use conservatories as habitable spaces. In addition to heating conservatories some companies also give away free cooling units when you buy a conservatory!

It is not only in domestic conservatories that energy efficiency improvements have resulted in increased energy use, many atria and glazed walkways have been designed to be energy efficient buffer spaces but then occupied and fully conditioned. Also, improvements in air conditioning and building design plus the low cost of energy have enabled us to build indoor ski facilities which maintain artificially made snow at -2°C inside even during the hottest day. Also, energy efficient lighting has meant that

we can light the Fourth Railway Bridge. One of the biggest challenges facing society will be to decide which of such high carbon emitting activities will be permissible in the future. At the moment it is very much left to governments to take such decisions through instruments such as the Building Regulations. However, such instruments may not be the most appropriate – particularly for rapidly developing technologies such as electrical appliances. Also government is not necessarily best placed to determine which are the priority areas that society needs to use its carbon quota on.

Market based instruments – the simplest and in our view most effective of which of which is carbon pricing - need to be investigated as alternatives. It is clear that if energy prices rise at a rate that offsets efficiency improvements, the Brookes-Khazzoom effect is largely neutralised. In the short term the UK can probably get away without addressing the issue of energy price, but in the long term, if it is not addressed, proliferation and intensification of end uses will always outstrip efforts to control and regulate existing end uses.

Skills Shortage: There is a real energy skills shortage at all levels of education in the UK. There are very few academics now left in this area, most researchers involved in current projects are overseas as are most postgraduate students. Undergraduates are taught relatively little about this subject. Although increased research funding through the UK Energy Research Centre and Carbon Visions etc will improve the situation slightly it will not tackle the large number of energy auditors etc that the UK will need to implant the EBPD for example. The situation is just as bad in the relevant practical trades that will be required to implement the necessary technology over the coming decades. Therefore a big government education programme is required in order to implement the necessary instruments and technologies.

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