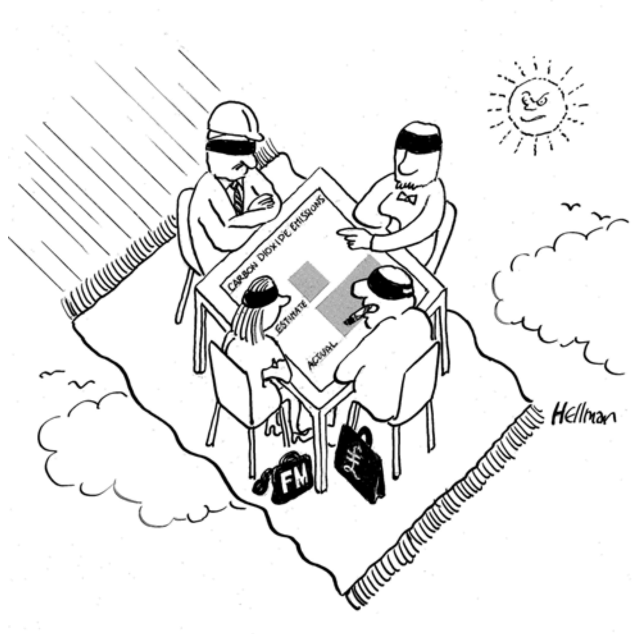
Association for the
Conservation of Energy

EEASOX

Energy Efficiency Advice
Services for Oxfordshire

FLYING BLIND

Everything you wanted to know about energy in commercial buildings but were afraid to ask



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FLYING BLIND? Everything you wanted to know about energy in commercial buildings but were afraid to ask

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The author

With a PhD in physical chemistry, Bill Bordass pursued an interest in buildings and joined the multi-skilled design practice RMJM to help with technical support and briefing. He also worked on the environmental assessment of planning and transportation projects (where he became interested in energy strategies at the regional scale) and coordinating building services into architectural projects. 1975 he became Associate in charge of building services, environmental design and energy efficiency at RMJM London.

He found that his main interest was not in design but in understanding how buildings really work in use. In 1984 he set up William Bordass Associates (WBA), which undertakes energy surveys, research management, monitoring and troubleshooting and takes the messages back to clients, designer, occupiers and government. WBA has undertaken major studies of energy use in offices, reducing carbon emissions from non-domestic buildings, and is a member of the Probe team, which since 1995 had undertaken post-occupancy surveys of recently-completed buildings and published them in Building Services - the CIBSE Journal and elsewhere. He is particularly interested in the interactions between people and technology, and particularly the usability and manageability of buildings and their environmental control systems.

In the 1980s Bill was founder chairman of the London Energy Group, chairman of the Energy Conservation and Solar Centre, and professor of building at University College London. He is currently on the RIBA Sustainable Futures Committee, English Heritage’s Research and Advisory Panel, the academic advisory board of University College London’s Centre for Sustainable Heritage, and the committee of the multiprofessional ginger group “The Edge”. He has also been advising the international Green Building Challenge team on the environmental assessment of existing buildings. In 2001 he was made an honorary fellow of the RIBA for his work on building assessment.

Acknowledgements

In writing this report, I have been much helped by Bob Lowe, David Olivier, Adrian Leaman and John Field. Thank you also to many others who have commented on drafts at various stages: I cannot name you all, for fear of leaving someone out. I hope you will be able to see the improvements you have made, I certainly can. Most of all, thanks to EEASOX for conceiving and funding this project and to ACE for supporting and publicising it.

BACKGROUND TO THIS WORK

EEASOX - Energy Efficiency Advice Services for Oxfordshire

The Trustees of the charity EEASOX commissioned this report from Bill Bordass in order to make a constructive contribution to the debate about UK building standards. This report is the second in a series.

Between 1993-9, the Trustees set up and managed the Oxfordshire Energy Efficiency Advice Centre, one of the first such centres set up with funding from the Energy Saving Trust. Its aim was to improve the energy efficiency of homes and small businesses in Oxfordshire. During the course of its six-year life, the Centre advised many thousands of households, and raised the profile of energy efficiency in the county. It worked with six local authorities in Oxfordshire. The Centre was closed in 1999.

The Trustees hope that this report will stimulate a debate about the energy performance elements of non-domestic buildings. The energy performance of commercial buildings is important in its own right – but also because their longevity causes high energy consumption to be locked in unnecessarily for decades.

The Trustees

Brenda Boardman was for eight years the Powergen Energy Efficiency Fellow at Oxford University. She now manages Lower Carbon Futures at the University's Environmental Change Institute. She has conducted many studies into the efficient use of energy by households; the best known of these are related to the energy efficiency of electrical appliances and fuel poverty.

Liz Reason is a director of ILEX Energy Consulting, specialising in the energy markets. With her husband, in 1991, she commissioned a low energy home, sited in a conservation area - a feature which required it to be of very conventional appearance. Their experience demonstrated that, given proper supervision of both the architect and the builders, it is perfectly possible to construct a well-insulated draught-free building, with a low energy demand, at average Housing Corporation yardstick costs.

Eileen Pirie (formerly Polgreen) was Chairman of the West Midlands Gas Consumers' Council from 1984 until 1992. Her recent experience of renovating a Victorian house taught her in no uncertain terms that neither architects nor builders had sufficient knowledge, let alone practical expertise to improve the energy efficiency of an existing building nor did they see it as being their responsibility.

EEASOX can be contacted via its Chair Eileen Pirie at:
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ACE – Association for the Conservation of Energy

The Association for the Conservation of Energy (ACE) is a lobby organization which also carries out policy research on energy conservation. The Association recently piloted the Home Energy Conservation Act through Parliament, and continues to maintain a high level of parliamentary activity. ACE was formed in 1981, with a remit to encourage a positive national awareness of the need for and the benefits of using energy conservation in buildings, to help establish a sensible and consistent national energy efficiency policy and programme, and to increase investment in all appropriate energy saving measures.

Membership of ACE is limited to twenty-four UK based companies which have substantial interest in energy conservation equipment and services. Current members include controls manufacturers, energy service companies, and manufacturers and distributors of insulation materials. ACE produces a free newsletter called The Fifth Fuel, copies of which are available on request, as is its publication list.

ACE spends much time researching these ideas, assessing how they would work in the UK, and then presenting the arguments for energy conservation at Westminster to MPs and Parliamentary Select committees, to the gas and electricity industries, to the European Commission, and to the public, through TV, radio and the press. We also liaise with other organizations who are working in the field of energy conservation and climate change from professional institutes to environmental and social NGOs, trade unions, local authorities and other housing providers.

ACE has successfully kept the issue of energy conservation in the forefront of the national media, and maintains close working relations with politicians, bureaucrats and other key decision-makers. It has been acknowledged to be one of the most vocal lobby groups in the UK, and will continue to exert pressure at home and in the European Parliament to ensure that energy conservation - the fifth fuel - is not overlooked.

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FLYING BLIND? Everything you wanted to know about energy in commercial buildings but were afraid to ask

PREFACE

This report was commissioned in September 2000 and completed in draft in early 2001. At the time, it was to be aimed at the DETR - which had departmental responsibility for buildings and their energy use.

With the upcoming election, the publication was placed on hold. However, the aftermath of the election in June 2001 brought more changes than we had imagined. The DETR was abolished and its responsibilities split between at least three ministries. At first this looks like a move away from joined-up to jumbled-up government, at least as far as buildings are concerned. However, we hope that it will lead to a clearer division of responsibilities, perhaps with:

- DEFRA making clear the importance of rapid environmental improvement, and changing the culture to recognise that the economy is a wholly-owned subsidiary of the environment;
- DTLR revising the rules of the game through advanced planning and building regulations and government procurement practices;
- DTI making sure that we have an efficient, competitive industry, focused on delivering increasingly sustainable buildings and on managing and improving the existing building stock effectively.

All these efforts will need to be linked by good information on how buildings actually perform.

Even before the DETR was abolished, energy efficiency and climate change responsibilities previously within its Energy Efficiency and Waste Directorate were beginning to move to the new Carbon Trust. The management of the Energy Efficiency Best Practice programme was also being reorganised. As we go to press, the implications of all these changes are still not entirely clear.

We hope that, as the different departments and agencies explore their new responsibilities, they will take account of the arguments in this paper to inform their future policy-making and implementation.

EXECUTIVE SUMMARY

Commercial buildings account for about one-sixth of the UK's carbon dioxide emissions. The proportion has been growing. If emissions from the commercial sector are not to prejudice the UK meeting its Kyoto target, massive changes are required in the way that buildings are commissioned, designed, built, marketed and operated.

In spite of the stark global issues and the need for urgent action, the market's response has been at best sluggish and often downright contradictory. This report exposes a just-in-time commercial world with increasingly short time horizons responding only to the perverse and contradictory incentives which currently operate.

The main lessons from this report are that there is a huge potential for demand reduction – as demonstrated by case studies going back over two decades. However, much of the improvement that is possible has not been delivered owing to little serious market interest and insufficient understanding of achieved performance by all the players - clients, designers, occupiers, agents, managers and government. It is the case that:

- The supply side of the building industry does not always serve its customers well, as it does not know enough about how its products perform and what really needs to be improved;
- Design estimates can be unreliable: it is not uncommon for a completed building – particularly a highly-serviced one - to use twice as much energy as anticipated, at least for some end-uses;
- Feedback from experience of actual buildings into building regulations on energy performance has not been sufficiently rapid and direct.

Recommendations

Radical and effective improvements are technically possible. It is possible to: virtually eliminate heating requirements; often avoid refrigeration cooling; improve the efficiency of ventilation, lighting and equipment; upgrade design, control and management to avoid the growing tendency for systems to default to ON. To achieve low energy commercial buildings in the UK:

- Government needs to make a clear and unambiguous statement about long-term (i.e. out to 2050), environmentally-realistic goals (such as the Royal Commission on Environmental Pollution's recommendations or better) for energy use and carbon emissions in the UK economy, and a commitment to continuous improvement;
- the entire system of building procurement, design, construction, commissioning and subsequent management needs to be motivated to deliver radically lower energy use and carbon emissions as part of a national programme;
- performance – both anticipated and achieved - needs to become an explicit market criterion for buildings;
- achieving good energy/carbon performance needs to become a badge of good design, good building and good management;
- there must be a clear, common language which is capable of being used to describe buildings and their energy use at all stages in their life cycles;
- everyone (clients, designers and managers) will need to do their bit. The language must therefore help each player to own their share of the problem, and to compete to do better;
- there must be direct feedback from performance of real buildings into improving client requirements, professional standards, and regulations.

In short, we must stop "flying blind" and make energy performance clearly visible and actionable by all parties concerned.

INTRODUCTION

The UK's target under the Kyoto Protocol is to reduce greenhouse gas emissions to 12.5% below 1990 levels by 2008-2012. The government has a more ambitious domestic goal: for carbon emissions in 2010 to be at least 20% lower than in 1990. In 2000, the Royal Commission on Environmental Pollution called for a cut of 60% by 2050, i.e. a linear continuation of the 1990-2010 cuts - 10% of 1990 levels per decade.

In the 1990s, Britain made a good start in meeting these targets. However, this was largely achieved by one-off reductions in the carbon intensity of the electricity supply industry. Since the underlying growth in electricity demand remained, emissions have recently begun to creep up. To bring them down over the next decade will be much more difficult.

Meanwhile, the stakes have been raised. The Intergovernmental Panel on Climate Change has found that greenhouse effects may trigger much faster environmental change than had previously been thought; and that only emissions reductions of 60% or more will stop carbon dioxide concentrations rising in the future. For some years, experts have been arguing that we will have reduce carbon emissions (at least per unit of production) by factors of between 4 and 10 by the end of this century. It now looks as if we must aim to reach these targets as quickly as possible.

Commercial buildings account for about one-sixth of the UK's carbon emissions. The proportion has been growing, owing not just to building design, but to technical, social and structural change. In spite of the stark global issues and the urgency of action, the market's response has been at best sluggish and often downright contradictory. Much energy waste occurs in new and old buildings alike. Many people seem to be ignoring the situation, but this is not unusual early in a revolution. The market does not sufficiently reward energy efficiency, because the true costs are borne at the societal level; and the polluter is paying nothing like the going rate.

This report touches upon a range of issues which affect carbon emissions associated with energy consumption in commercial buildings. For example, how buildings are procured, how they are valued and traded, what goes into them, and how they managed. It exposes a just-in-time commercial world with increasingly short time horizons, with the leaders increasingly requiring space and services not buildings, and prepared to pay unnecessarily high - but for them quite affordable - energy costs in order to buy flexibility, comfort and convenience.

Can commercial buildings be turned from a problem into part of the solution? We have the technical and management skills to slash their energy demands and to lessen their dependence on supply-side measures including nuclear power. But these skills are not yet focused: few can tell you how their buildings are performing, even in the simplest terms. Many would have you believe that performance is far better than the actual, real world situation. Even if they would like to, the supply side of the building industry does not always serve its customers well; as it does not know enough about how its products perform and what really needs to be improved. In short, many are **flying blind.**

To move forward we need to **make performance visible**, with:
- greater awareness of how buildings use energy and cause carbon emissions
- better understanding of the components which contribute to performance, and how they interconnect;
- clear ownership of problems in achieving good results; and
- encouraging all parties involved to do their bit in striving to achieve better performance.

To provide incentives and to underpin this visibility of performance, we need:
- A clear policy commitment by government.
- Energy and carbon efficiency to become a badge of good management for clients, designers, builders, occupiers and service providers.
- A clear language to describe buildings and their energy use, which can be applied consistently at all stages in the life cycle, from inception, through design and construction, and into use, maintenance and refurbishment.

The draft European Directive on the Energy Performance of Buildings, published in May 2001, will give us a great opportunity to build the infrastructure to support this exercise.

Buildings, carbon emissions and climate change

DO CARBON EMISSIONS REALLY CAUSE CLIMATE CHANGE?
First agreed politically at Kyoto, the scientific case is now much clearer. The Royal Commission on Environmental Pollution's report [2] recommends a 60% cut by 2050. Other experts have advocated larger reductions, by factors of 4 or even 10 per head, or certainly per unit of production [3]. The recent IPCC report [41] has raised the stakes, demonstrating that forcing effects are likely to make climate change much faster than previously estimated. In spite of George W Bush's reservations, slashing emissions is no longer a precaution, but an imperative[1]. A lot will have to change.

SO IT IS IMPORTANT TO MEET THE 2010 REDUCTIONS TARGETS?
Yes, indeed - and as part of a strategy to achieve ambitious long-term targets. Too often people aim at, not beyond, a target. We need constant improvement, not just - as so often happens - stopping once we reach benchmark levels. Energy and carbon efficiency are such important pre-conditions for a sustainable future [4] that we must do the very best we can.

CAN BRITAIN REALLY MAKE MUCH OF A DIFFERENCE?
Britain produces less than 3% of world emissions, but per capita this is 2.5 times the global average. We must set an example. We must make space for developing countries' rising emissions, whilst also helping them to level off. This is also in our best interests. If we cut emissions, we reduce risks - to ourselves and the world - and develop priorities, local and exportable skills, industries and infrastructure (including buildings) for a more sustainable future. We move away from crude profits - which do not take proper account of externalities - to the "triple bottom line" [5] of economic, social and environmental benefits.

HASN'T BRITAIN DONE QUITE WELL OVER THE LAST TEN YEARS?
In headline terms, it looks like it. In the 1990s the UK's greenhouse emissions fell by 13.5% and carbon emissions by 8%. However, as the Royal Commission said [2], the carbon emissions drop "was largely fortuitous", primarily the result of the collapse of the coal industry, the "dash for gas" in electricity generation, and the decline in manufacturing. With underlying upward trends, it is going to be much more difficult to produce similar results in the current decade, as the detail in the UK Climate Change Programme (UKCCP) [1] shows.

ARE BUILDINGS THAT IMPORTANT?
Yes. Buildings are the single largest source of carbon emissions. The energy used to operate them[2] causes 46% of UK carbon emissions, from fuels burnt on site or in power stations[3]. Housing accounts for 23% of the UK total, and commercial buildings 16% [6], excluding industrial plant. Buildings last a long time (the underlying trend is for new construction of about 1% of the stock annually and major refurbishment 2.5%), so what we build and alter now casts a long shadow into the future. However, commercial building refits are more frequent. We must use these opportunities to secure efficiency improvements - enhancement is much more cost-effective when combined with other work than in isolation. Energy waste does not only occur in old buildings. New ones are often more energy-intensive and can be profligate, poorly assembled, wastefully equipped and carelessly managed. They need radical improvement - fast!

HOW DO COMMERCIAL BUILDINGS FIT IN?
Commercial buildings include the service sector (offices, shops, hotels and leisure facilities), factories and warehouses. Although public buildings are regarded as a different sector, in fact private and public sector cultures are converging: both make increasing use of rented buildings and outsourced services; and both are becoming part of the 24-hour economy. Building types are also becoming more similar, for example with more and more tasks in all sectors done by people working with information and communications technology (ICT) in office and hotel-like environments. While some information will be specific to a sub-sector (offices for example), it is important to retain a coherent perspective, to seek out widely-usable approaches and to avoid mixed messages.

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1 *Cutting greenhouse gases is as optional as breathing* - A Simms, Guardian (6 August 2001).
2 For heating, hot water, ventilation, cooling, lighting, computers, appliances and so on (but not industrial plant).
3 Building construction, alteration and maintenance adds to this (the construction industry accounts for 8% of GDP [44]), as does unnecessary transport between badly located buildings; but that is another story.

Energy use in the service sector

IS SERVICE SECTOR ENERGY USE DECLINING?

No, its primary energy consumption is going up; and it will be a big job to turn round. The proportion of delivered energy which is electricity (37% in 1998) [2] is the highest in any sector, and rising. This underlying growth has been obscured by:

- People reporting "total delivered energy"[4], even though electricity often costs about five times as much as gas and has 2.5 times the carbon intensity[5].
- Major reductions in carbon intensity of electricity generation in the 1990s.

WHY IS ENERGY CONSUMPTION RISING?

Upward trends include more buildings (owing to structural changes in the economy); changed work patterns; more intensive use with longer operating hours; more electrical equipment; and more air-conditioning (AC) for both comfort and equipment. Downward trends include more efficient plant and equipment, better controls, and low-energy lighting. For electricity, upward trends dominate, particularly as equipment is increasingly left on permanently. This constant drain really mounts up, as does "leaking electricity" from devices on standby, or which "vampire" it even when "OFF"[6]. Heating needs are coming down, owing to better insulation, plant, controls, milder winters, and heat gains from all the electrical equipment, but AC can increase heating energy use substantially.

WHERE DOES THE ENERGY GO?

You can get lots of information from the Energy Efficiency Best Practice Programme. Too much, perhaps. Segmenting the market into sectors, technologies, and target audiences has produced a deluge of publications, but which sometimes lack underlying consistency. This is aggravated by a government which has increasingly fragmented its research management in relation to buildings and energy, outsources work in ever-smaller tender packages, and keeps those who do it at arm's length and with little ability to contribute to policy-making [9]. Consequently it has been difficult to maintain the integrity of the underlying methods and principles, or to see the wood for the trees.

WHY ALL THIS AIR-CONDITIONING?

AC is often demonised, but there can be good technical reasons: environments for sensitive objects, equipment and processes; high internal heat gains from people and equipment, deep plan forms, comfort, and of course global warming! AC also has powerful commercial drivers, including:

- Demand by international companies for the air conditioned space with which they are familiar.
- It is easier to design a crude building and use AC to sort out the environment than it is to prepare an integrated design. Cooper [10] describes how this happened in the USA. The Egan quest for more standardised approaches to UK construction may well do the same thing.
- The need for flexibility and adaptability to meet uncertain and fast-changing occupant needs, supported by a widespread philosophy of "layering" building designs into shell/services/ space plan/ scenery/sets [11]. This can militate against integrated energy strategies [12].

AC tends to increase electricity use considerably, particularly with inefficient systems which default-to-on - the scourge of modern buildings. Widely neglected antidotes are low-capacity "gentle engineering", intrinsically efficient equipment, and effective and usable controls, well-managed.

WHAT ABOUT THE PROPERTY MARKET?

In offices, high specification tends to mean high valuations [6, 9], at least on sites where the market can stand them. This increasingly includes AC. With AC on valuers' and agents' checklists, and investors' fear of the unfamiliar, even clients who do not want it are told they must have it, or their buildings will not be saleable. Owner occupiers have had more freedom and procured imaginative low-energy buildings, but in today's accelerating and globalising economy they are less sure how long they will need a building: to make it tradeable, they often get "locked-in" to market norms too!

BUT WON'T PEOPLE PAY MORE FOR AN ENERGY EFFICIENT BUILDING?

Not yet, certainly in the speculative market. A common problem is that features that add value for users and the environment are not yet valued in the marketplace. They are either:

- Not much thought about, for example poor airtightness, even though it leads to discomfort, high heat losses, larger plant, and much higher energy consumption. Process improvement trends to prefabricated components; and splitting of contracts into a cluster of individually-tendered work packages (but with no interface package!) have tended to make airtightness worse. However, this essential feature can be regarded as unaffordable, see table 1, item 4.
- Perceived as risky. Some developers of low-energy offices have found them a drag on the market; or saw tenants slapping-in AC [13] sometimes unnecessarily but to reduce business risks - perhaps less for themselves as for their advisers' fear of blame for any overheating!

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4 The simple sum of purchased fossil fuel and electricity consumption.

5 Research for DoE in the early 1990s [7, 8] set down energy reporting principles, but these are not yet consistently applied, even in the government's own publications.

6 George Bush has required (1 Aug 2001) Federal Agencies to purchase devices which "vampire" no more than 1 Watt.

Energy costs: who cares?

WHY DOES THE SERVICE SECTOR HAVE SO LITTLE INTEREST IN ENERGY?
Many organisations would prefer not to think about buildings, let alone their energy efficiency and carbon emissions. Hence the trend to outsourcing, with rapid growth in facilities management companies in the 1990s. More recently organisations (e.g. Inland Revenue, Abbey National and BT) have been getting out of property entirely and renting back not buildings but serviced space.

BUT SURELY BY SAVING ENERGY THEY WOULD SAVE MONEY?
Yes, but people buy energy to save effort. So if fuel is available and affordable, who cares? In the service sector, energy costs are typically 1% or less of outgoings (including staff costs), so they hardly figure in management decisions, particularly as energy is also a chargeable pre-tax expense.

BUT HASN'T GOVERNMENT BEEN ENCOURAGING PEOPLE TO SAVE ENERGY?
Yes, ever since the oil crisis in 1973 - and if this hadn't happened carbon emissions would be much higher now. However, in the early 1980s market dogma switched the agenda from saving energy to saving money ... and then fuel prices promptly drifted down, reducing the economic incentive! With gas and electricity privatisation in the 1990s, organisations were able to slash their fuel bills at a stroke of a contractual pen, so why bother with laborious technical and management measures[7]?

WHAT ABOUT ENERGY MANAGEMENT?
The situation described above, plus a trend to outsource non-core services, has made the energy manager - never the most secure of beasts - a vanishing species, more often spotted in the public sector. Some organisations - for example supermarkets and high street outlets with large and fairly standard portfolios of stock - have outsourced this function (sometimes together with bill-checking). However, this can become a routine and disconnected exercise with not enough review on the ground. Development of automated diagnostics may help to improve the situation. Facilities and maintenance management might be expected to undertake energy management ... but usually they don't [14]: often it isn't in their contracts. Even where it is, it can be difficult to do: in a tightly-run building people are more likely to complain than in one where everything is left running just-in-case.

ARE ENERGY EFFICIENT BUILDINGS COMFORTABLE?
In recent years, service has taken precedence over economy. Managers say they must run systems liberally to make people comfortable, or lost customers or disgruntled staff would cost far more than the energy saved. Conversely, some people claim that energy-efficient buildings are automatically more comfortable. In fact, neither energy wastage nor energy efficiency guarantees comfort; but a good design makes it possible to be more comfortable using less energy. The magic formula is for a client really to want their building to be **both** comfortable and energy efficient (and cost effective too), to find designers who can work together to deliver it, and take enough care in procuring **and** in managing it to achieve it [15]. The (sadly rare) exceptions that prove the rule include the Elizabeth Fry Building at the University of East Anglia [16][8] (1995); and One Bridewell Street - an AC office occupied in 1987 [17] - with energy performance that has seldom been bettered[9]. Why?

WHAT HAPPENS IN RENTED BUILDINGS?
Since commercial valuations and rent levels take no account of energy efficiency, developers and landlords have no incentive. Nor do they get revenue benefits as the energy costs - high or low - all get passed on in the service charge. Perversely, there are some upward incentives, e.g. valuations favouring AC, managing agents' fees set at a percentage of the service costs, and landlords enjoying bulk purchasing rates and re-selling energy to tenants at a profit! If that were not enough:

- Tenant fitout is usually driven by cost, time and appearance. It often takes little account of energy efficiency, and can easily ride roughshod over the good intentions of the designers of the base building, for example for daylight, natural ventilation and effective control.
- Lease arrangements often militate against mutually beneficial upgrading.
- In multitenanted buildings, there may be no submetering of individual tenants[10].
- In managed - particularly multitenanted - buildings, operators find it much easier to leave systems running liberally (to avoid complaint) than to fine-tune them to tenants' exact needs.

ACE [18] has reviewed some of the issues. It proposes legislation to oblige owners to build energy efficient premises; bring existing ones up to acceptable levels; and do energy audits every 5 years.

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7 An attitude reinforced by the buccaneering price-driven approach of the fuel industry regulators who, for example, in the early 1990s emasculated the Energy Saving Trust by getting agreed major fuel levies for energy saving withdrawn; and are currently messing-up the economics of renewable energy supplies and of Combined Heat and Power!

8 Tellingly, the case study of Elizabeth Fry in the Royal Commission's report [2, page 95] was all about its technical features and did not mention the client and team commitment, monitoring and fine-tuning that really made it work!!

9 One Bridewell Street's excellent energy performance was sustained well into the 1990s [45]. However, in 1999 the facilities/energy manager who had been responsible left. We understand that consumption has subsequently risen.

10 Proposed revisions to the Building Regulations Part L [21] begin to address this.

What are clients and designers doing?

WHAT ARE CLIENTS DOING?
The easiest way to turn energy performance into an objective for everyone on the supply side (for a new building, an existing one, for alterations, or for equipment purchase) is for clients to say this is what they want. Clients are becoming more aware of green issues, but so far it has been difficult to bring about real change in a rented sector driven by a valuation system which regards green features as a risk, instead of the foundation for a sound, long-term, sustainable investment. Inroads have been made into avoiding over-specification, for example by the British Council for Offices [30].

WHAT ARE DESIGNERS DOING?
If a client wants it, will designers follow it up? Many are interested, but not always well informed, or able to overcome inertia in the system and to apply what they do know [9]. Impediments include:

- Tortuous procurement paths. An architect may do a masterplan which sets key parameters like orientation and building depth; another team may do the sketch design which is then handed over to a contractor to detail and build. Finally, a completely different team fits it out to occupier requirements. It is not easy to maintain continuity of vision through such a maze.
- An emphasis by some architects on spatial and visual aspects, not on achieved performance. But spending on extravagant gestures (e.g. wind towers or large areas of glass) can make it impossible to afford simple measures that work, e.g. integrity of insulation and airtightness.
- Building services engineers can also be happier doing the design (and sometimes also adding complication) than influencing strategic decisions on the building; questioning the standards; reducing loads; and applying principles of gentle, efficient engineering and effective control.
- Cost plans tend to be based on historic information. However, past practice often does not embody, for example, good insulation integrity, low air infiltration, intrinsically efficient plant and usable controls. One is then told that these essential features "cannot be afforded"!
- Contract specifications seldom mention any explicit energy efficiency criteria, so site changes and substitutes made by contractors can undermine design intentions (and BREEAM ratings).
- Energy arguments are often "soft", and difficult to sustain against hard cost and time criteria. Later I discuss how one might make performance more visible.

If you need some cases to drive these points home, look at Table 1. This throws light on situations where things have gone wrong on recent projects. None of these examples is at all unique.

COULD NEW ENERGY SOURCES MAKE MEASURES IN BUILDINGS UNNECESSARY?
The trend is away from large, centralised power generation systems to more local and networked solutions - owing to the changing economics of power generation [31] and some buildings being their own generators, e.g. with combined heat and power (CHP), photovoltaics and wind power. However, it is most unlikely that green energy sources will be so cheap and abundant that they will deliver the UK's required carbon savings by themselves: they need to go hand-in-hand with radical cuts in demand by buildings, systems and equipment (i.e. do more with less energy, and make that energy more carbon-efficiently). There is huge potential for demand reduction, for example:

- Some buildings (mostly overseas) have used siting, insulation, solar gains, natural ventilation and thermal capacity to reduce space heating loads drastically and to eliminate cooling loads.
- Some have made good use of natural light, efficient luminaires, and effective controls to slash lighting energy consumption. When free to select light levels, many people also opt for much less than the recommended industry standards, reducing lighting energy use still more.

It is important to get the demands down first. If not, the cost and complexity of building-integrated renewables may even distract expert attention from the fundamental business of making the building work simply and effectively. In inexpert hands, overall performance might even get worse.

FLYING BLIND?
The supply side of the building industry does not routinely go back into the buildings it creates and alters to obtain feedback on achieved performance, including energy performance. Such an "open loop" system makes it difficult to learn and to improve. Even where energy efficiency was the aim, there can often be large discrepancies between intentions and achieved results. Even though sophisticated computer models are increasingly used, their input assumptions can bear little relationship to what happens on the ground. This can lead to major underestimates, for example:

- Assumed operating hours are often shorter; fabric integrity (insulation and airtightness) and plant efficiency higher; and control strategies more effective than in the completed building.
- Design predictions often concentrate on HVAC and lighting in the principal spaces. Less important spaces often get overlooked, as does energy consumption by computer rooms and their AC, appliances, kitchens, communication systems, outdoor lighting and so on[11]. Yet energy savings are claimed in relation to benchmarks which include these, like ECON 19 [19]!

Hence it is not uncommon for actual energy use - particularly of more highly-serviced buildings - to be twice the design estimates (at least for some end-uses); and few people seem to know or care[12].

11 These can account for up to half the carbon emissions from an office building, sometimes more.
12 See examples 7 and 8 in Table 1 and papers on the Probe surveys [33, papers 3 and 5].

TABLE 1: SOME TELLING EXAMPLES

1 BRIEFING AND PROCUREMENT
In 1995 an English university procured an energy-efficient building and carefully monitored its performance, achieving excellent results. In 2000, when the university sought a similar building under the Private Finance Initiative, the building providers would only commit themselves (at reasonable cost) to targets for using twice as much energy as had been demonstrably achieved by its predecessor, designed to normal cost levels seven years beforehand!

2 DESIGN
In air-conditioned buildings, the fans can use more electricity than anything else, particularly in laboratories where air-change rates can be extremely high. In four laboratory designs, the engineers were asked to state their targets for specific fan power and annual energy use by the fans. All four designers reassured their clients that they were working to good practice levels, but no targets or estimates were ever produced.

3 DETAILING, SPECIFICATION AND BUILD QUALITY
In the eight leading nondomestic buildings pressure-tested in the Probe studies [33, paper 2], only one came close to the standard air leakage index of 5 m^3 per hour per m^2 of exposed envelope area at 50 Pascals imposed pressure. Three (all claiming to be low-energy naturally-ventilated buildings) had indexes between 27 and 35; and gas consumption no better than typical levels. An index of 5 is regarded as good practice for mechanically-ventilated offices in the UK and best practice for naturally-ventilated offices [35, table 1]. As discussed in Report 1 [32], in Scandinavia and parts of Canada much better standards have been routinely achieved for many years.

4 THINGS WHICH ADD VALUE ARE NOT VALUED IN THE MARKETPLACE
At a design review of a speculative office, an expert asked what steps had been taken to ensure airtightness. This was a new issue to the team, but they went away to explore it. At the next meeting, the Quantity Surveyor reported that airtightness would cost £ 20 more per m^2 of gross internal area, and testing might scare contractors into pricing higher generally. The client said that they could not afford it: they would not gain any benefit from their investment; the letting agents wouldn't notice it; the tenants wouldn't pay extra rent for it, and the landlord wouldn't benefit from the reduced energy costs because - whatever their levels - they were all passed on to the tenants in the service charge.

5 LETTABILITY
The design team asked if they could consider a mixed-mode alternative to an air-conditioned speculative building. The developer agreed, subject to it meeting the same budget and technical criteria. A successful design was produced, with openable windows, tall exposed ceilings, and up-and-down lighting which questionnaires show occupants like. The design retained background mechanical ventilation and local fan-coil cooling units, but now to be operated on demand. The letting agents and the tenant's fitout design teams were dismayed at the unfamiliar design, the lack of suspended ceilings, the need for taller partitions, and the constraints they felt openable windows and suspended lighting placed on flexibility. The incoming tenants never expressed any interest in energy, and declined the developer's offer of free energy consultancy for their fitout. The developer said that next time they will provide a standard AC building.

6 FITOUT
Commercial buildings are often fitted-out by different teams from those who design them; and driven primarily by cost, time, appearance and sales revenue. The fitout designers often prefer bland, flexible interior space into which they can insert what they please. Their approach can be hostile to passive energy measures (as in example 5 above), energy efficiency, and the zoning and control of building services. Retail units are an extreme example: all-electric for simplicity, convenience, low cost to the developer, and ease of metering; doors left open (with electric heaters above) to attract shoppers; display lighting with high illuminance and low efficiency; and increasingly AC to take its heat out again! Reference [36] describes two similar stores for the same retailer: one had an installed lighting power density of 35 W/m^2 and the other 86 W/m^2. The perimeter display areas (about 20% of the total) were 73 W/m^2 and 315 W/m^2. A typical office is about 18 W/m^2 [19]; current good practice 12, and new buildings should aim for well under 10!

7 MANAGEMENT
An operational centre for a leading British corporation was completed in 1994. A survey in 1996 criticised facility and engineering systems management. In 1997 a new FM contractor was appointed, with a strong engineering background. Although it had undertaken some energy-saving measures, when visited in 2000, it had never seen (or asked for) a single fuel bill! Bills were sent by the utilities to a consultant who checked and consolidated them and sent them to the corporation's head office. Although the designers had included submeters, the contractor had never read them, nor had the meters ever been connected up to inputs the designers had specified on the building management system (BMS) computer. Not surprisingly perhaps, a consultant identified opportunities for 21% energy cost savings at no or low cost, with an overall payback period of 4 months - so easily recoverable within a year's utility budget. In spite of this, to our knowledge the recommendations have not been implemented.

8 PEER REVIEWS
A recently-completed office won a national environmental award. Another, more modest in size and appearance, did not reach the shortlist. A year later, energy and occupant surveys were undertaken in both. The winner used 2.7 times more gas (worse than a typical benchmark) and 3.5 times more electricity (still similar to a good practice head office benchmark) than the designers had predicted. Not all the discrepancies were due to poor design, but to shortcomings in commissioning, control and management; and to energy-consuming systems present on the site but not included in the design estimates. The building which had been eliminated proved very energy efficient, using 22% as much gas and 28% as much electricity as the winner! Fortunately, both buildings had high levels of occupant satisfaction.

9 INTEGRATED DESIGN
At an early design team meeting for a "leading-edge" energy-efficient building, an expert suggested integrated design process, following the rules and stages developed in Canada's C-2000 Programme. Everyone seemed to agree that this was an excellent idea. Three months later, it became apparent that the terms of the architects' original appointment by the client made this proposal impossible to follow, and that there was no chance of changing it in time.

10 BENCHMARKING
In visiting a building which claimed to be low-energy, a journalist enquired about the boiler power per m^2 of floor area. The designers had never calculated this, but it turned out to be 200 W/m^2. A rule-of thumb benchmark for a 1990s building might be 100 W/m^2. The Elizabeth Fry building [2, page 95] had a boiler power of 22.5 W/m^2. In Sweden's colder climate, new non-domestic buildings reportedly have an average boiler power of 50 W/m^2.

What about the construction industry?

WHAT IS THE EGAN REPORT?

The construction industry is changing faster than ever, owing to commercial pressures, changed procurement methods, skills shortages, technological development and mechanised production. The Egan Report "Rethinking Construction" [23] expressed concern at its widespread underachievement and said that it must sort itself out to meet the needs of clients and government. The report urged:

- committed leadership, customer focus, integrated teams and processes, a quality-driven agenda, and commitment to people;
- integration of design and production: product development, project implementation, partnering the supply chain and producing components[13];
- a culture of performance measurement and continuous improvement in seven areas: cost, time, predictability, defects, accidents, productivity and profitability.

Government-funded projects will soon be required to show commitment to Egan principles, but I fear that the principal driver may not be quality improvement but Treasury cost-saving!

WHAT IS THE MOVEMENT FOR INNOVATION?

The Movement for Innovation (M4I), initiated to take Egan forward, has been more successful than expected, and is feeding its lessons into the Construction Best Practice Programme. It has launched Key Performance Indicators (KPIs), but none yet on the in-use performance of the product[14].

DOESN'T THAT SOUND GREAT?

Yes and No. Clearly the industry must improve, but Egan had little to say about:

- Design (other than exhorting designers to get closer to product; and clients to appoint early).
- Building performance in use (apart from meeting client requirements & avoiding defects)[15].
- The needs of building occupiers (clients who procure buildings often don't use them).
- Other stakeholders: the occupants, the local community, the public interest.
- Sustainability (apart from waste-saving in production). In 2000, DETR plugged this gap by stating that its twin aims were Rethinking Construction and Sustainable Development [24][16].

A TREND TO CORPORATISM?

Egan and M4I seem to hand power to the corporates, which government finds easier to talk to than smaller units; but whose agendas can be far from public and environmental interests [25]. Some small and medium-sized clients and builders have objected. We see four principal problems:

1. A concentration on the immediate needs of larger clients, who tend to want largely utilitarian buildings for their corporate ends and have had little interest in achieved energy outcomes.
2. The equation of buildings with the construction industry. In fact, once constructed, most buildings pass out of the hands of builders, sometimes for generations.
3. Constructors tend to be more interested in new construction than in looking after buildings.
4. Property providers - agents, builders, designers, cost consultants, and even management companies - often regard buildings as ends in themselves, not means to improve conditions for their occupiers, society or the environment. Few assess in-use performance of buildings, or in their work to date have demonstrated active concern about achieved energy performance.

Egan, in other words, reinforces the supply-side culture, and may make it even harder for demand pull to fit supply push. Which is, perhaps, why the larger firms are prepared to back it.

WHAT IS SO BAD ABOUT THAT?

In *Air-conditioning America*, [10], Gail Cooper outlines how commercial pressures to include air conditioning led to simplified and debased forms of building (and AC!) in order to make the technology affordable and to suit supply side interests in an industry in which the purchaser of the building is seldom the end user. It is now happening here, assisted by pressures of globalisation, layering, climate change, and a quest for flexibility. Egan-style industrialisation may twist the knife once more, in the quest for more standardised constructions which fit a wide range of contexts[17].

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13 There are, I think, some false analogies. *Technocrats are always on about building buildings like cars ... Ford is planning to become a design and marketing company and to outsource the production of cars to "subcontractors". While we want to be more like the car industry, it appears to want to be more like the building industry.* Ken Dixon, letter to "Building", 22 August 1999. See Also Charles Handy's book: *The Gods of Management.*

14 KPIs for sustainability have recently been announced, but for energy they still fail to make clear connections between design predictions and in-use performance.

15 Some of these points are made by the RIBA [26], which also states that the biggest improvement to be made is in systemising feedback and instituting post-occupancy evaluation.

16 DETR was abolished after the June 2001 election. DTI now runs the Construction Research and Innovation Programme. Its key policy aims are the triple bottom line of economical, social and environmental improvement.

17 See how rapidly air conditioning has become the expected standard in cars sold in the UK!

What can government do?

WHAT ABOUT BUILDING REGULATIONS?

Building regulations should ensure acceptable minimum standards. Unfortunately, however:

- Most buildings last 50-100 years and more, so standards - particularly for the fabric - need to be higher than might appear to be economically justifiable on a short term view.
- The standard becomes the norm; but where is the vanguard pushing standards forward, to explore and monitor leading-edge buildings?
- "Trade off" provisions allow people to continue dubious practices, as Report 1[32] discusses. How else would the highly-glazed offices which are so widespread have been permissible?
- Over-complicated procedures make life impossible for overworked Building Control Officers.
- Cost compliance calculations do not include the environmental costs of carbon emissions.

WHAT DO BUILDING REGULATIONS MISS?

There has been little direct feedback from performance of real buildings into regulations. This has made it difficult to pick up new trends and assess the impact of changed regulations. For example:

- Until the 1990s, the regulations were entirely about heating, not fast-rising electricity use.
- Despite its rapid growth since the early 1980s, AC is only now about to be included [21].
- Parallel growth in ICT and appliances is now very significant but is outside the scope of building regulations. So are their cooling systems, which can be very wasteful.
- Many premises are not metered, but metering proposals are only now to be introduced [21].
- Process aspects have been overlooked, for example commissioning, testing and management.
- Emergent problems were missed, for example dry construction undermining airtightness [4].

For regulations to keep pace, we must stop flying blind and have better real-time feedback.

HOW CAN WE ENGAGE THE MARKET?

Regulation could extend to many more aspects of design, construction and operation. However, given difficulties of implementation, civil liberties, and the uncertainties of building use, it may be best to stick to largely "fit and forget" attributes [34] which can be simply regulated, and use other mechanisms to reduce emissions further. The simplest way [4], with a wide impact would be:

- a large tax on carbon fuels to account for their damaging externalities[18];
- invest the proceeds in a programme to transform new buildings and upgrade existing ones;
- include schemes to overcome nasty transitional consequences, such as fuel poverty.

A full-blooded scheme is impossible politically at present. The climate change levy (CCL) makes a modest start, but it does not work in a very transparent way, nor is it a proper carbon tax! Recycling much of it into national insurance reductions[19] also perversely subsidises the labour-intensive service sector, which is the least concerned about its energy consumption levels!

WHAT IS MARKET TRANSFORMATION?

Traded goods account for 75% of the UK's electricity use [1]. MTP, the Market Transformation Programme, works with business, consumers and experts to steer the market to efficient goods and services by mandatory energy labelling, standard-setting and negotiated voluntary agreements. Its best known example is for domestic appliances. First there was labelling and consumer awareness for a few products. The labels then let customers choose and manufacturers compete. MTP then works to eliminate inefficient products from the market and improve the efficiency of the best.

WHAT IMPACT COULD SUCH LABELLING HAVE IN BUILDINGS?

Labelling can be applied directly to, say, office equipment; and building components like boilers, chillers, pumps and fans. When combined into a system, labelling becomes more difficult owing to context, for example an efficient fan in a bad duct system, with poor control, poor part-load performance, and which defaults to ON. Labelling whole building performance is more difficult again. A building is seldom standard and its energy use the outcome of the interaction of a many variables. Labelling systems already exist (e.g. BREEAM [20] includes an energy assessment of design-stage ambitions) but we need to make actual performance more visible, as discussed later.

WHAT ELSE IS CURRENTLY PROPOSED?

In addition to improved building regulations and the CCL, measures include [1]:

- Removing property market obstacles identified in reference [6].
- Improving procurement by government.
- Voluntary agreements with sector bodies[20], with targets and bi-annual reviews.
- Publications, helpline, and design and site energy advice.
- Corporate Commitment (MACC) by top-level management, with quantified targets.
- Implementation of environmental management systems and company reporting.

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18 Carbon trading is advocated by some as an alternative to carbon taxation. It might work at the corporate level, but to see it applying to individual buildings seems ludicrous: most buildings lack sufficient management as it is!

19 Some is also recycled into enhanced capital allowances (ECAs), but only for new single tradeable equipment. Not covered are systems, demand-reduction (e.g. insulation), bespokes, refurbishments or upgrades (other than renewals).

20 For example the Energy Efficiency for Commerce Partnership of the British Energy Efficiency Federation (BEEF).

Making performance visible

FLYING BLIND?

We have mentioned several times that many people seem to be flying blind:

- Clients who would like energy efficiency but do not get it.
- Designers who incorporate features but not necessarily performance[21].
- Design estimates which bear little relationship to reality.
- A property market which takes little interest.
- Facilities management which is often equally unmotivated; and
- an absence of feedback of achieved performance to designers and regulators.

We need to get actual energy performance on the radar, and link it through to investment decisions. The industry does not seem to have realised that interest rates are now at a 50-year low and falling.

HOW ARE DESIGN TARGETS SET?

When design targets are set, they are often at the whole-building level (e.g: in kWh/m^2 per year or kg CO_2/m^2 per year) in order to give designers freedom in the route they choose. In practice, this approach has not been very effective in delivering energy-efficient buildings. In particular:

- Targets have sometimes been set in total delivered energy (see footnote 4), which can be worse than useless. Its perverse effects include, for example, encouraging shifts from gas to the much more expensive and carbon-intensive electricity, and discouraging CHP.
- They tend to be very blunt instruments when fighting the inevitable battles which occur on most projects (e.g: between cost, size, appearance and energy performance).
- They are also of little direct help in the quest for continuous improvement. Having achieved a target or a BREEAM certificate, teams move on to something else and performance drifts.
- Seldom does anyone understand how the various individual features contribute to achieving (or missing) the target.
- The numbers are not readily accessible to, or understandable by, clients and occupiers.
- They cannot be verified until long after the building has been occupied. If inconsistencies are then revealed, extended operating hours and high equipment levels are the usual scapegoats

It is not easy to track these back to the design assumptions and to feed experience back to clients. designers, and modellers. In short, they are a variety of open-loop, not closed-loop control!

WHAT ABOUT PERFORMANCE INDICATORS?

Performance indicators used in energy management are often at the whole building level too. They say broadly how well one is doing, but do not get to the roots of energy consumption. I have been asked to report on a building regarded as highly energy wasteful, only to find over half its electricity was going into a computer room[22] which (on all but one occasion) was not submetered. Flying blind again! This sort of management information is essential to making performance visible.

CAN WE GET TO THE ROOTS?

A relatively quick way of getting down to the individual end uses is described in CIBSE TM22 [8][23]. Essentially it breaks the energy use of each subsystem into four components, splitting out the elements of energy consumption *and the parties responsible*

1 The requirement, e.g. heating load, light level or air change rate. *Client and Designer*
2 The efficiency with which it is achieved, for example W/m^2 of installed power. *Designer*
3 The annual requirement, in hours per year. *Occupier and System design*
4 The efficiency of control and management. *Operator, Maintenance, FM, & Control system*

The builder, suppliers and subcontractors are also responsible for meeting the design requirements.

CAN WE MAKE PERFORMANCE VISIBLE?

The EARM approach was designed not just for energy surveys, but to report energy performance in design, research, benchmarking, labelling, and in structuring databases of energy and related information. Its principles have been used in TM22, a number of EEBPp publications including ECON 19 [19], and it is referred to in the Building Regulations consultation document [21]. It could be developed in a much more central role as a common language in describing buildings, the elements of their energy use, and to help indicate where the prime responsibility for making savings lies. It can also provide a transparent link between predicted and in-use performance[24].

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21 Bob Lowe comments that some features of today's buildings have as much to do with actual environmental performance as the tail fins of a 1958 Chevrolet had to do with aerodynamics.

22 In others they have blamed the computers and the fans and humidifiers turned out to be the problem.

23 This in turn was based on EARM - the Energy Assessment and Reporting Methodology - a study of how to compare existing buildings and their energy use undertaken for DoE in the early 1990s. Prototypes of the TM22 method were used to undertake office case studies for BRECSU [37, 38], and in the Probe surveys [33, paper 3].

24 For example, in a "low-energy" office with continuous background mechanical ventilation, the designers expected the fans to use 2 Watts of electricity for every litre/second of air delivered. Since this was not specified, the contractor was able to cut costs by using a smaller AHU with a bigger motor. The as-built value was 3.5. Watts per litre/sec.

Making radical improvements

SHOULD WE BE MORE AMBITIOUS?
Massive changes are required, and are technically possible. Ways have already been demonstrated (mostly in other countries) for virtually eliminating heating loads through passive measures, making air distribution much more economical, and providing lighting more efficiently and responsively. Mechanical cooling can be reduced and sometimes eliminated using thermal mass and passive cooling methods. Appliances, office and catering equipment are often needlessly wasteful, but customer awareness and Market Transformation could change this rapidly, if the will is there ... but not in the current market/regulatory scenario.

WHAT SHOULD WE BE IMPROVING?
"Much energy consumption arises from the compounding of unnecessary loads" [21].
Effects multiply. In many existing buildings, and particularly the more highly-serviced ones:

- The fabric unnecessarily increases the need for, or the capacity of, the building services.
- Inefficient or wastefully used equipment within the building unnecessarily adds to these loads.
- Internal environmental standards are set at unnecessarily high levels, or applied too widely.
- The systems which service the above loads are unnecessarily wasteful and inefficient.
- They run at unnecessarily high proportions of their capacity, owing to shortcomings in design, control, management, operation or usage.
- Opportunities for carbon efficient energy supply, recovery or CHP systems are overlooked.
- Faults causing waste are not spotted and dealt with.

Such problems often occur because an issue was not identified in briefing and design; dismissed as too costly; or there was too much oversizing in a quest for flexibility. Occupant complaints, poor control and management then deliver the coup de grace, causing these inefficient systems to be operated for extended hours, using yet more energy unnecessarily.

CAN WE EXPLOIT THIS MULTIPLIER EFFECT?
Yes, indeed. With a clear strategy, perseverance, and an integrated approach the benefits compound too. A succession of relatively small measures (reduced demand, increased efficiency, better control, less waste, lower-carbon energy supply) multiply into substantial savings. Things which at first look expensive can then become useful and affordable, as discussed in reference [29], Chapter 6, "Tunnelling through the cost barrier". However, if the approach is not properly integrated, one only ever sees the first order effects - the multiplier is invisible.

HOW MUCH CAN WE DO BY BUILDING REGULATIONS?
Changes in Building Regulations can slowly modify what is *de facto* standard practice, raising the floor, so to speak. However, to get big leaps forward we needs carrots (R,D&D, and technology transfer programs like Canada's R-2000 and C-2000), not sticks. The UK is a little lacking here, both in the RD&D, and in the follow-through. Report 1 [32] identified the "forgetting curve", where the lessons from low-energy housing demonstrations in the late 1970s failed to become mainstream practice or even so-called "good practice". In commercial buildings it is even worse, because there are fewer proven good examples and they have been replicated less.

CAN WE ADVANCE PRACTICE AND ALSO CREATE ROUTES TO NORMAL PRACTICE?
Essentially we need:

- An openness to new ideas, and a commitment to follow them through.
- Research which is less constrained by today's commercial realities but clearly focused on long term environmental performance targets. This will need public funding.
- The need for RD&D to be layered, from cutting edge projects via advanced practice to good current practice. In the UK so-called "good practice" energy performance - which should be the starting point for most projects - is widely seen instead as a somewhat unattainable goal; whereas the ASHRAE 90.1-1999 energy standard *was* taken as the starting point for the Canadian government's C-2000 programme [40] and other commercial building programmes.
- Hence we need to engage the professions in pioneering advanced practice - for example through competitions to improve on established benchmarks - and then pulling it through into good practice by exhortation, communication, standards, and education. Once demonstrated and consolidated, proven improvements could then trickle down into building regulations.
- To recognise the limited role of advanced technology in its own right and the relative importance of improving the basics of the procurement process: briefing, design, construction, checking, commissioning and handover. This has been highlighted in the Probe studies and in the Canadian C-2000 programme.

CAN WE LEARN FROM OVERSEAS?
What goes on overseas seems to be of little concern to an internal UK ministry - certainly I have never been able to get support. However, there much to be learned if you dig deeply[25]. The relative isolation of national construction industries means that the study of overseas practice is a good way of understanding the differences between engineering, economic, procedural and perceptual barriers. For example, difficulties thought in one country to be economic (e.g. the use of low temperature radiators; or air leakage 10% of the UK norm) turn out to be perceptual (the whole building or heating system goes together differently in the other country). Since many countries spend much more on building energy-related research than we do, not to learn from them is folly.

CAN WE APPEAL TO PEOPLE'S BETTER INSTINCTS?
For most people energy is relatively cheap, so the Climate Change Levy (CCL) will not have a dramatic direct effect on consumption, though it will create more of an interest in carbon emissions and prepare the way for further reductions. In terms of the environment, one is pushing at an open door: most people feel that they should be doing something to help, but not necessarily very strongly when their convenience is threatened, their choices are limited, or extra cost is involved. As momentum builds up, it will become possible to enlist increased support of individuals and professionals.

CAN WE APPEAL TO MANAGEMENT?
The bigger buildings tend to be the better managed. They also tend to be the higher energy consumers per square metre, because they are often more intensively used, have more AC, and more avoidable waste. The size distribution of offices and shops [39] means you can influence half the space (and more than half the emissions) by getting at 5% of the premises, and a far smaller proportion of organisations[26]. However, for the most part, management has not been interested in energy efficiency. If we can change the culture to one in which carbon efficiency becomes a badge of good management, we could achieve rapid emission cuts in the commercial sector[27]. We will also need to develop complementary approaches for smaller buildings.

CAN WE MANAGE THE FEEDBACK?
A stream of managed feedback information is needed to improve awareness of the performance sought and achieved, the factors for success and the things that need doing better. If we create a language to describe buildings and their energy use, which can be used it at all stages of a project, from inception into use and alteration, it will be possible to "plug in" to this data at various stages to monitor and assess what is going on. For example:

- There could be a guide to normal rule-of thumb values in good and advanced practice buildings. These could be adopted at briefing stage and refined as the design progresses.
- Design teams would seek to maintain and improve on these values as the design and specification was developed.
- With these values explicit, environmental assessments like BREEAM can use them as input. This will streamline the process and help ensure that qualitative labels like "excellent, "good" and "fair" are traced back to their roots and mean what they say. They can be taken forward from the design assessment into the constructed and completed project, as outlined below.
- The information would be the input to building regulations energy and carbon assessments such as the Carbon Performance Rating CPR.
- They could form part of contractual requirements for the construction.
- They could be used to track the energy performance of components from specification through ordering, delivery, installation, commissioning and be "signed off" on completion.
- They would be included in the proposed logbook for the building, and available to inform the owner, the occupier, and prospective purchasers and tenants.
- They would be updated as necessary through the life of the building.
- They would be readily available to anyone undertaking a survey exercise, and for databases.

The final report on EARM in 1994 proposed a centre to develop the necessary standards and conventions and to manage the data collected by using them. As commonly happens, professional bodies and research sponsors - perhaps more interested in short-term initiatives - were unwilling to invest in the necessary infrastructure. Now is the time to get moving!

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25 Superficial comparisons can be misleading as national contexts vary.
26 Since large organisations own or occupy large numbers of the large buildings.
27 Time and again, energy surveys of air-conditioned office buildings reveal potential for carbon emission savings of 15-20%, often by better control and management of the heating, ventilation and air-conditioning systems alone. In spite of this, the findings are seldom acted upon!

Recommendations

1 STOP FLYING BLIND

Generally speaking, the history of energy conservation is the triumph of hope over experience ... largely because we don't learn from the experience. Market forces do not cause rational energy efficiency because of the perverse and contradictory incentives which currently operate: there are simply too many barriers and not enough drivers. As this report documents in detail, most people within the system are flying blind. This must stop.

2 ENSURE VISIBILITY OF ENERGY AND CARBON PERFORMANCE

Performance - anticipated and achieved, needs to become an explicit market criterion for buildings:

- **When they are procured or altered**, and particularly at the key points of decision: inception and briefing, scheme design, planning approval, detailed design, regulatory approval, specification, equipment selection, construction and completion.
  Achieving excellent energy and carbon efficiency must become a professional ethic.

- **When they are sold or let.** This will make the projected or achieved performance clear to the customer, who will then be able to value it properly and reward the building provider appropriately for the investment they have made. There will also be grounds for redress if the performance levels defined within the purchase or lease contract are not achieved.
  The potential for excellent energy efficiency must become a badge of a good building.

- **For their management**, including landlords and outsourced services.
  Achieved energy/carbon performance must become a badge of good management.

3 DEVELOP A COMMON LANGUAGE TO MAKE VISIBILITY WORK

Performance will only become visible if becomes easy to do so. We need **a clear, common language** (not the present Tower of Babel) which is capable of being used to describe buildings and their energy use at **all** stages in their life cycle, for example to:

- Summarise briefing and design criteria.
- Summarise outputs from energy use calculations, however simple or sophisticated.
- Provide input data for assessments such as Part L and BREEAM.
- Incorporate in specifications.
- Track through purchase, construction and commissioning.
- Include in proposed building log books.
- Pull together energy survey and management data.
- Allow feedback of information collected for research and statistical purposes.

4 GET EVERYBODY TO PARTICIPATE

If energy/carbon performance becomes a badge of good management, everyone (clients, designers and managers) will need to do their bit. The language must therefore help each player to own their share of the problem, and to compete to do better. For example:

- the commissioning client, the briefing requirements
- the design team, intrinsic efficiency of the design and specification
- the building team, the construction quality
- the manufacturer, installer and commissioning engineer, the plant operational efficiency
- the occupier, to require energy-efficient fitouts and alterations, and efficient plug-in equipment
- the managers and any outsourced service providers, to run and monitor things efficiently.

5 EXPRESS A CLEAR, VIGOROUS POLICY COMMITMENT

To get all this going, the entire system of building procurement, design, construction, commissioning and subsequent management must be motivated to deliver radically lower energy use and carbon emissions as part of a national programme. The missing factors are strategy and aspiration. To kick this off, we need **a clear and unambiguous statement from central government** about long-term (i.e. out to 2050), environmentally-realistic (RCEP [2] or better) goals for energy use and carbon emissions in the UK economy, and **a commitment to continuous improvement**.

ANNEX 1

Creating The Underpinnings - The European Directive

In May 2001 - after this report was initially drafted - Brussels issued a proposal for a European Directive on the Energy Performance of Buildings [42]. It refers to the EC's Green Paper [43], which confirms the high potential for energy savings in the service sector and the importance of efforts to be intensified. The Green Paper said that, in general, the Community programmes to support and promote new technologies had not brought about the application of new standards of energy efficiency in buildings in many Member States. It asked for more emphasis on concrete measures such as the establishment of a clear legislative framework to reduce growth in demand.

The Directive requires member states to implement, by 31 December 2003:

A) A general framework of a common methodology for calculating the integrated[28] energy performance of buildings.

B) Application of minimum standards on energy performance to new buildings and to certain existing buildings when they are renovated.

C) Certification schemes for new and existing buildings on the basis of the above standards, with public display of energy performance certificates and recommended indoor temperatures and other relevant climatic factors in public buildings and buildings frequented by the public.

D) Specific inspection and assessment of boilers and heating/cooling installations.

The Directive recognises the market imperfections which arise because the owner and the renter of a building have different interests. It feels that the best way to make investments in energy efficiency more attractive is to provide clear and reliable information to prospective renters. Energy certificates should therefore be available both for new and existing buildings; and should be available when they are constructed, sold and rented out.

It is important to remember that - particularly for commercial buildings - the outcomes are not just a matter for designers and builders, but are also very much affected by changes in occupation, use, equipment and in management. To close the loop properly, the proposed framework must:

- effectively integrate design predictions with in-use performance monitoring
- use a language which provides an integrated description of energy performance and at the same time allows client, design, construction, equipment (installed and non-installed), usage and management aspects to be separately identified and dealt with;
- relate clearly to quantities which can be measured, for example by appropriate sub-metering;
- provide incentives for management and service providers to improve operational performance.

We must grasp the opportunity for a thoughtful and effective response to this Directive, and to build the infrastructure to support it. We can then use it to *stop flying blind* and instead *make energy performance visible* and begin to reduce carbon emissions ... fast.

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28 The draft Directive requires the methodology to integrate the following aspects: orientation, insulation (of building shell and installations), heating and hot water supply, air-conditioning, ventilation and lighting.

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