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THE ENERGY-RELATED ENVIRONMENTAL ISSUES (EnREI) RESEARCH PROGRAMME

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ABSTRACT

The Energy-related Environmental Issues (EnREI) Programme was established in 1991 by DoE Construction Sponsorship Directorate and BRE, with the aim of reducing emissions of CO_2 and other greenhouse gases due to energy use in non-domestic buildings.

The UK is aiming to return its emissions of CO_2 and other greenhouse gases to 1990 levels by the year 2000, following the ratification of the 1992 Rio Climate Change Convention. The construction and building services sectors are a major area for action, since the construction and use of buildings account for about 50% of all UK greenhouse gas emissions.

The Programme addresses a range of key issues in the design and management of non-domestic buildings and their services. It covers nine main areas:

- A common energy targeting methodology for use at the early design stage;
- Passive and low energy cooling utilising thermal mass;
- Design and specification of air conditioning systems;
- Strategies for handling the phase-out of CFCs and HCFCs, including leak detection technologies;
- Natural ventilation of non-domestic buildings;
- Control of adventitious ventilation;
- Advanced management and control technologies employing artificial intelligence;
- Effective management and control of electric lighting and daylighting;
- Analysis of embodied energy in construction materials and products;

and includes some 21 different research projects, many of them in collaboration with industry, with a total annual budget of over £1.5 million for 1994/95.

In addition to the expected reduction in emissions, the programme promises important technical and economic benefits to the owners and users of buildings. Greater energy efficiency brings lower running costs, and almost always leads to improved management and control of the environment; in turn this brings greater comfort for the occupants, better health and increased productivity. Increasingly, it is energy-efficient buildings with good environmental control that are successful in the market place and enhance the corporate profile.

Industry will also benefit from the programme's study of innovative and advanced technologies. Details of their performance in realistic tests and guidance on their application in practice will give UK companies a competitive edge.

All the findings of the EnREI programme will be actively disseminated to the construction industry and building users through comprehensive published guidance and, where appropriate, will be incorporated in legislation, codes and standards.

This paper will describe the policy framework under which the programme has been developed, the research priorities, the collaborative links with industry and the university research community, and the applications strategy adopted to ensure effective impact.

INTRODUCTION

The Prime Minister signed the Climate Change Convention in Rio in June 1992. Ratification of this Convention committed the UK, along with other developed countries, to adopt policies aimed at returning emissions of carbon dioxide (CO_2) and other greenhouse gases to 1990 levels by the year 2000.

The UK's greenhouse gas commitment will have implications throughout the economy, and the Construction Sponsorship Directorate (CSD) of DoE has developed a strategy and supporting research programme to address the issues which are likely to arise for the construction and use of buildings. The Energy-Related Environmental Issues (EnREI) research strategy, was first developed in 1991 and was subsequently reviewed and revised in 1992 to place a greater emphasis on mechanisms for ensuring the research programme impacts on the industry and on building users.

The EnREI strategy makes the assumption, based on published DoE and DTI statistics, that to achieve the Government's greenhouse gas emission aims it would be necessary to reduce CO_2 emissions associated with energy use in buildings by 15% (37Mt CO_2) of that projected for the year 2000.

The effective application of the findings from the EnREI research programme should yield a significant contribution towards these savings by reducing non-domestic building-related CO_2 emissions. However, the realisation of savings will depend, in part, on the implementation of the programme's findings through other Government promotional/marketing initiatives, such as the Energy Efficiency Office's (EEO's) 'Best Practice' programme.

Any further call for reductions in building-related CO_2 emissions, which go beyond the levels proposed for the year 2000, would require a very substantial change in current attitudes to, and trends in, energy use, and the uptake of a variety of new and established technologies. The successful development and uptake of new technologies would require a substantial effort, and the potential for savings in emissions in the long term would need to consider the likely future availability of energy sources.

OBJECTIVES OF THE EnREI PROGRAMME

The EnREI Programme aims to:

- **minimise the impact of buildings on the global environment** (eg, to reduce CO_2 emissions associated with energy use in non-domestic buildings).

In serving the primary objective, the Programme also seeks to support CSD's policies relating to:

- **wealth creation**, by:
  - promoting and maintaining a competitive UK marketplace;
  - enhancing the competitiveness of the UK construction industry in international markets;

  through innovation and the application of new technologies and techniques.

- the Department's **statutory obligations** (eg under the Building Act and Regulations), by providing technical guidance with respect to:
  - the health and safety of people in and around buildings;
  - energy conservation;
  - the welfare and convenience of disabled people.

- the **quality and performance** of buildings by ensuring that national and European standards, and professional guides and codes adequately reflect the wider interests of the owners, operators and users of buildings.

RESEARCH PRIORITIES

Projected carbon dioxide emissions for the year 2000

In order to identify appropriate research priorities, estimates were made of the likely energy consumption and related CO_2 emissions, according to end use, for the building sector in the year 2000. These estimates were based on DoE data [1], supplemented by an additional BRE analysis of available data [2,3,4,5]. The use of the BRE data was required to enable properly targeted research requirements to be identified, based on a more detailed breakdown of energy projections according to end use.

Projected CO_2 emissions related to the transport sector are given in figure 1, together with a simple trend regression predicting future rises. In the short to medium term, the potential to reduce CO_2 emissions associated with transport is generally regarded by informed opinion as being considerably less than that for the buildings sector. Therefore, if the overall UK target for the year 2000 is to be achieved a greater onus must be placed on energy efficiency in buildings.

The DoE Climate Change report [1] forecasts a rise in CO_2 emissions related to energy use in both domestic and non-domestic buildings. BRE's analysis of this forecast suggests that CO_2 emissions associated with the building sector would have to be reduced by some 15% (37Mt CO_2) of that projected for the year 2000, if the projected overall building and transport-related emissions for the year 2000 are to be reduced to 1990 levels.

Projected carbon dioxide emissions for the year 2020

Considerable uncertainty must be attached to any prediction of likely CO_2 emissions for the domestic and non-domestic building sectors in the year 2020, as these would need to make assumptions about possible changes in climate. Total CO_2 emissions are also highly dependent upon power station generating mix.

Based on simple regressions of current energy use, linked to some simple constraints on future energy use, it would seem reasonable to suggest that CO_2 emissions from the building stock could be between, perhaps, 10-34% (24 to 81Mt CO_2) in excess of 1990 levels by the year 2020. By 2020, though, there may well be a shortage of certain fossil fuel energy sources (possibly natural gas). Such supply side limitations could have a profound impact on energy usage in buildings.

It is not clear whether a significant reduction in building-related CO_2 emissions will be necessary by the year 2020, but if savings of, say, 25-50% (60 to 120Mt CO_2) relative to 1990 levels are sought, it would require a very substantial change in current attitudes (and trends) to energy use, and in enabling the introduction of new attitudes, standards and technologies. The development and application of these new technologies is an area that would require more fundamental research than current "best practice" type programmes.

In order to reduce building-related emissions of CO_2 to 50% of current levels by 2020, new buildings commissioned after the year 2000 would need to be constructed to emit, perhaps, less than 50% of the CO_2 emissions associated with typical buildings constructed in 1990. A 50% cut in building-related CO_2 emissions by 2020 would be a major challenge. If targets of this order are sought, there would be significant implications for the development of the Building Regulations. This is an area where output from the EnREI programme could make an important contribution in future.

Targeting the non-domestic sector

The EnREI strategy and programme places a strong emphasis on the non-domestic sector. This is due to the following factors:-

- Although dwellings account for around two thirds of the total CO_2 emissions from all buildings, and as such are a major area of concern, energy efficiency in this sector is being addressed by DoE Housing Directorate's 'Greenhouse' programme.

- An analysis of trends to the year 2000 (see figure 2 and 3) shows that CO_2 emissions associated with the non-domestic sector are increasing at

Figure 1 Transport sector CO2 emissions

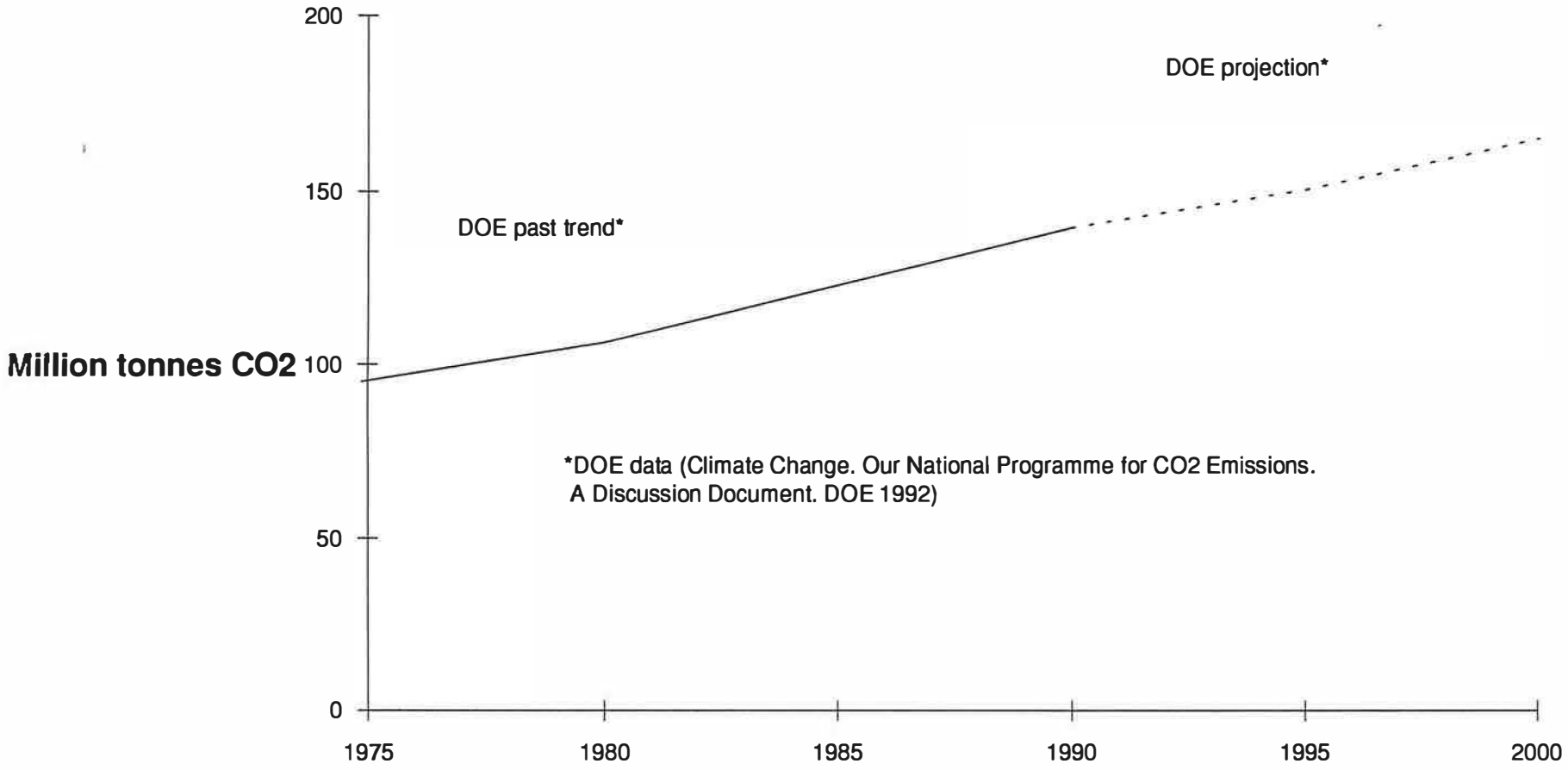


Figure 3 Domestic buildings CO2 emissions

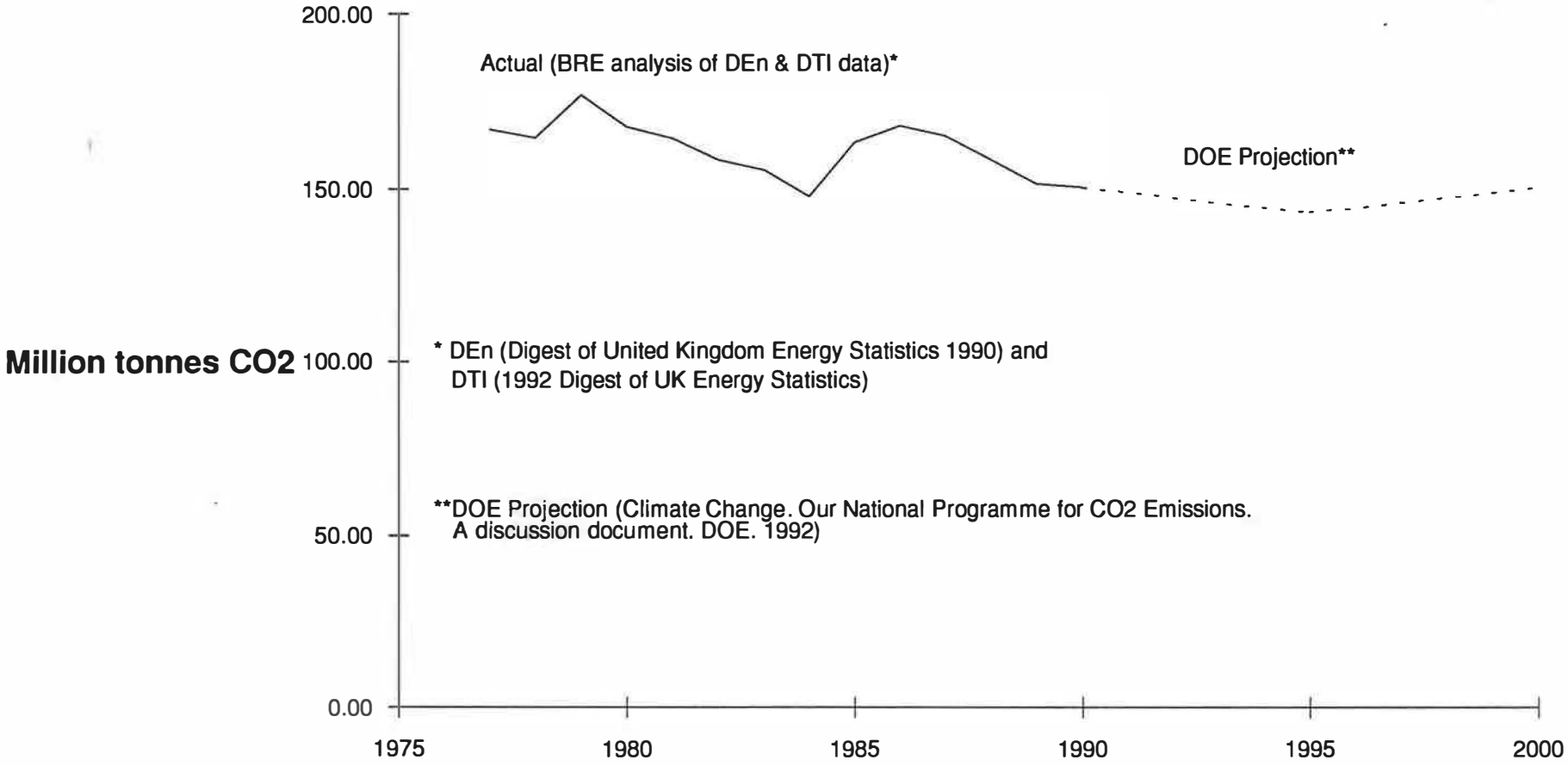
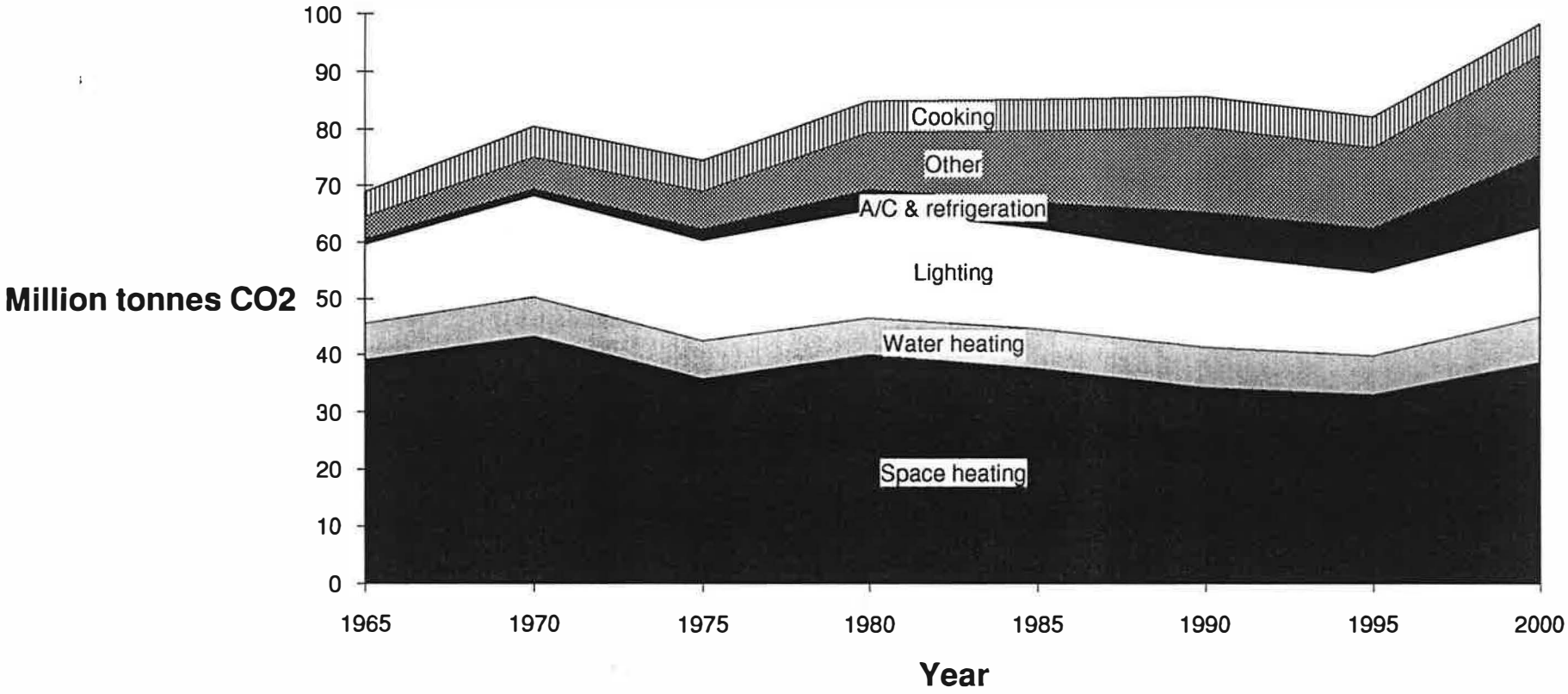


Figure 2 Non-domestic buildings CO2 emissions (excl. industrial)



Source: BRE analysis of EEO data (Energy use and energy efficiency in UK commercial and public buildings up to year 2000. EEO, HMSO, 1988), adjusted to DOE projection of CO2 emissions 1990 to 2000 (Climate Change. DOE, 1992).

a faster rate than the domestic sector, with a trend to more intensive servicing, including air-conditioning. Although this trend has undoubtedly been reduced or halted by the current economic recession, there is no reason to believe it will not return when we start to see a recovery.

- Generally speaking, the non-domestic sector is being refurbished and replaced at a greater rate than the domestic sector, and so it could be argued that the non-domestic sector has a greater potential for the uptake of energy efficient technologies and techniques. However, currently, many refurbishments lead to *increases* in CO_2 emissions.

- It could be argued that, since there are fewer decision makers in the non-domestic sector than is the case with dwellings, it easier to target the key influential people.

Current research priorities

If the designers, regulators and clients of non-domestic buildings are to assess the likely energy performance implications of various design options at an early stage in the design process, they will need access to a ***common energy targeting methodology*** which can address their different but inter-related, technical and policy needs. The development of such a targeting methodology is considered a high research priority within the EnREI programme.

Air conditioning accounts for a disproportionate, and growing, component of the total primary energy used in the office sector. Also, the CFC and HCFC refrigerants used in air conditioning can damage the ozone layer and are powerful greenhouse gases in their own right. Research priorities therefore include the development of guidance on the:

- the ***minimisation and avoidance of air conditioning*** through effective use of passive cooling techniques (eg thermal mass, evaporative cooling, mixed mode buildings etc);

- the ***design and specification of air conditioning systems***, including assessments of part load performance;

- replacement strategies for ***handling the phase-out of CFCs and HCFCs***, methods of ***minimising refrigerant leakage***, and issues related to the ***safety of refrigeration systems*** used for air conditioning in buildings;

- the ***design and specification of non-domestic buildings for natural ventilation***, including establishing consensus indoor thermal acceptability criteria.

With little prospect of a significant up-turn in new commercial office developments in the short to medium term, it is important to seek retrofit

opportunities for reducing energy in this sector. Research priorities therefore include the

- development of ***new control strategies*** which can be applied to new and existing environmental systems;

- application of ***advanced artificial intelligence techniques*** to environmental controls and BMS to improve performance and utilisation.

The UK currently holds a position of technical leadership in the field of environmental controls and the above priorities will serve to strengthen this lead.

Lighting constitutes a major, if not the largest, component of the primary energy used in office buildings. Research priorities therefore include assessments of:

- the performance of ***lighting control systems*** in practice and the development of guidance to enable the potential savings in electric lighting energy use to be realised;

- ***innovative daylighting techniques***, including the development of a mathematical/computer model of daylight availability and an assessment of the impact of daylighting on screen-based tasks.

International experience has shown that the ***control of adventitious ventilation*** can have a major impact on the energy used in space heating. Therefore, the development of design guidance on minimising heat loss through adventitious ventilation, including the development of a simplified method of measuring the 'leakiness' of non-domestic buildings is an EnREI research priority.

It has been estimated that the energy used in the processing and manufacture of building materials accounts for about 70% of the total required for building construction, and about 10% of the total energy required for UK industry. This major fraction of the energy used in construction, ie the ***embodied energy***, is therefore a research priority within the EnREI programme.

WORKING WITH INDUSTRY AND THE UNIVERSITY RESEARCH COMMUNITY

Over £600K of the £1.5M budget allocated to EnREI for 1994/95 will be used to fund work by industry and university contractors. Input from the industry under these contracts ensures the practical relevance of the programme, and, through the direct involvement of designers and specifiers, provides a highly effective application mechanism for the findings of the work. In the case of universities, the contracts usually take the form of EnREI research fellowships and studentships which bring academic rigour to the programme while feeding EnREI results back into the education of future building professionals. The close collaboration with universities also enables these bodies to gain access to BRE's

specialist research facilities such as the Air Conditioning Evaluation (ACE) facility.

Collaboration is not restricted to the UK and the programme has strong, well established links with European research agencies through EC research programmes and International Energy Agency Annexes.

Through BRE's input to the development of national and European standards, professional codes and guides, and participation in less formal industry fora such as BEPAC, the views of designers and specifiers are constantly being fed into the development of the EnREI programme.

MANAGEMENT OF THE ENREI PROGRAMME

A small steering panel has been established to ensure effective management of the programme. The panel has the remit to:

- monitor the quality of the research being carried out;
- assess the effectiveness of the programme in transferring results to the industry, and where necessary to make recommendations on measures to increase its impact;
- promote appropriate collaboration with other European research groups and programmes;
- review the strategy annually and advise on any necessary revisions in the light of available information, including economic trends, technological developments, changes in legislation, new research findings etc.

The panel consists of officials, representatives of industry and private sector users, the Chartered Institute of Building Services Engineers (CIBSE) and the Science and Engineering Research Council (SERC).

ACHIEVING IMPACT

If the EnREI programme is to achieve its stated aim of reducing UK non-domestic building-related CO_2 emissions, it needs to ensure that the results of the research are effective by disseminated and subsequently implemented by the designers, constructors, developers and owners of buildings.

The EnREI programme strives to achieve the desired impact by adopting a hierarchy of application routes. In order of effectiveness, these are:

(i) ***Legislation***. Where appropriate, the findings of the research are implemented as statutory requirements under the Building Regulations. Such an approach is highly effective but has limited scope:

(a) current government policy does not favour legislation as a mechanism for securing environmental objectives (a market-based approach is preferred);

(b) the Approved Document relating to energy (Part L) is currently under review and is likely to be published before any firm recommendations emerge from the EnREI programme.

(ii) ***Codes and standards***. Where findings from the programme are in a form which can be fed into the UK and/or European standards making process every endeavour is made to do so. Short of legislation, codes and standards represent the most effective mechanism for achieving impact. However, there are several disadvantages which should be borne in mind:

(a) standards tend to be product-related and therefore do not cover all aspects of the EnREI programme, in particular their relevance to existing buildings may be limited (codes, however, may relate to the application of products);

(b) they have long gestation periods;

(c) they are often subject to vested commercial interests.

(iii) ***Consensus guidance***. Many guides and codes issued by professional bodies (eg, CIBSE Guides and Codes) and by other technical authorities of national standing (eg, BRE - Digests and Information Papers, the EEO - Best Practice Guides, and DTI's EDAS), are recognised by consensus as representing good practice. It is a priority of the EnREI programme to ensure that where ever appropriate its findings are embodied in consensus guidance, since a failure to secure such recognition would cause many building professionals to shy away from adopting the proposals in fear of being accused of not following best professional practice.

(iv) ***The market place***. If developers of new buildings and owners of existing buildings are to adopt the findings of the EnREI programme they must be persuaded that the proposals are both technically and commercially viable.

When assessing technical viability, developers or owners will look to their professional advisers for advice. The advice they receive will be primarily influence by factors addressed in (i), (ii) and (iii) above, but the message can be greatly reinforced by targeted articles in professional/trade journals, seminars and demonstration projects. The EEO Best Practice Scheme represents a highly effective vehicle for seminars, while the EEO Offices of the Future and the proposed BRE Phoenix building should provide demonstration opportunities.

Promoting the commercial benefits to be gained by adopting the findings of the programme requires a carefully targeted approach. Directors, senior managers and their advisors (eg, investors, letting agents, project managers and management consultants) need to have the potential benefits drawn to their attention via appropriate articles in influential journals such as the Financial Times, Estates Gazette, the Economist etc. Having established a degree of awareness of the commercial benefits to be gained by their organisations, this message can be translated into commitment via follow-up seminars specifically aimed at educating this important group. Where possible BRECSU's existing links with the various target groups are exploited.

In addition to information relating to specific energy efficiency measures, the following general messages need to be emphasised:-

(i) Energy Efficiency can be achieved without sacrifices. There is still a myth pervading the construction industry that it is not possible to design an energy efficient building without sacrificing aesthetics, letable floor area or occupant comfort.

(ii) Research has shown that energy efficient buildings tend to have the highest levels of occupant satisfaction. While this is not a direct causal relationship, both are consequences of effective management. Energy efficiency should not be regarded simply as a means of reducing fuel costs, but as an essential attribute of a responsible, well-managed organisation, with value added benefits in improved amenity, organisational performance and corporate profile.

(iii) A naturally ventilated building which fully exploits daylighting, and provides occupants with a degree of control over their local environment, should not be regarded as a low-tech low prestige option. The successful implemental of these concepts required innovative design which is likely to yield a distinctive building with a comfortable and productive internal environment.

(iv) The current trend for major companies to adopt a "Green" corporate image is inconsistent with estates of "gas guzzling" buildings.

CONCLUSIONS

The EnREI research programme is a response to the challenge posed by the Government's commitment to return UK CO_2 and other greenhouse gas emissions to 1990 levels by the year 2000.

The programme is being managed by the Building Research Establishment for the Construction Sponsorship Directorate of the Department of the Environment. Its objectives seek an innovative approach to enhance the technology needed to sustain healthy and comfortable indoor environments, while reducing the detrimental effect that current technologies have on our global environment.

EnREI addresses a range of key issues in the design and management of non-domestic buildings and their services. It covers nine main areas:

- A common energy targeting methodology for use at the early design stage;
- Passive and low energy cooling utilising thermal mass;
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and includes some 21 different research projects, many of them in collaboration with industry, with a total annual budget of over £1.5 million for 1994/95.

Widespread application of its results is vital to the success of the programme. It is hoped that industry will become involved in the programme, as users, contributors or sponsors of the studies.

A brochure describing the EnREI programme and its constituent projects has been published [6] to inform building users of the objectives and nature of the programme, and to promote awareness within industry and the research community.

REFERENCES

1. DoE, 1992, "Climate Change: Our National Programme for CO_2 Emissions".

2. HMSO, DoE, 1990, "Digest of Environmental Protection and Water Statistics".

3. HMSO, DEn, 1989, "Digest of UK Energy Statistics 1989".

4. Shorrock L., and Henderson G., 1990, "Energy use in buildings and carbon dioxide emissions", BRE Report BR 170.

5. Herring H (Editor), 1988, "Energy use and Energy Efficiency in UK Commercial and Public Buildings up to Year 2000", HMSO.

6. BRE, 1993, "Energy-Related Environmental Issues in Buildings" - a brochure describing the EnREI programme and its projects.