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Energy Efficiency and Buildings

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Summary: This paper outlines the design of energy efficient buildings, presents some of the main national and international drivers for energy efficiency, introduces some initiatives taking place in Wales, and makes recommendations for the future.

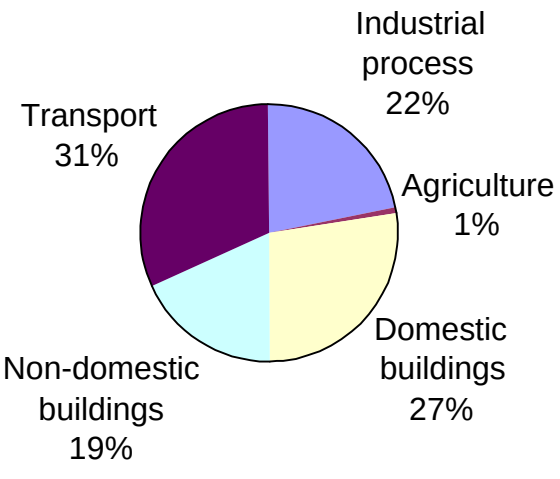
1.0 Introduction

People typically spend up to 90% of their time in buildings. It is therefore important that they enjoy a comfortable, healthy and safe internal environment. To support this, energy is used in buildings to provide thermal and electrical power for:

- Heating
- Cooling
- Ventilation
- Lighting
- Small power loads

These services should be provided with the most efficient use of energy, and in particular low carbon use, that is, energy from fossil fuel sources. Buildings account for about 46% of UK carbon emissions. This represents some 65mtC out of UK total energy use of 143mtC.

Breakdown of UK energy use
Some 46% of UK energy is used in buildings, with 60% of this total being used in the domestic sector. It has been estimated that 10 to 20% of UK energy can be saved in buildings by introducing cost effective energy efficiency measures.



The immediate priorities for the building sector are:

- To promote energy efficiency to reduce energy demand.
- To expand the role of renewable energy sources

However, there is also the need to recognise fuel poverty, and to provide affordable warmth for the elderly and low-income groups. So it is expected that some of the energy saving measures will result in improved comfort conditions in the home.

2.0 Energy efficient design of buildings

The main strategy for providing an energy efficient building is:

1. For a given use and occupancy pattern, to design the form and fabric of a building to respond to the local climate, making use of 'passive design' features,
2. To provide energy efficient means of heating, cooling, ventilating and lighting, where possible using renewable energy sources to power them.

2.1 The building form and fabric

Much can be done in the design of a building to reduce its energy demand. In fact, some buildings can be 'free running' for most of the time, maximising the use of natural daylight, and making use of solar energy and wind energy to provide heating and ventilation. This approach to building design is termed 'passive design'. It minimises the energy use through 'active' building mechanical services, for example, heating and air conditioning. Passive design involves attention to the following design parameters.

- Thermal insulation – maximise thermal insulation to reduce heat loss through the building fabric.
- Reduce air infiltration (unwanted air leakage) – to minimise excessive ventilation heat loss in winter.
- Control ventilation – to provide good control over the natural and mechanical ventilation systems, to reduce energy consumption and provide good air quality.
- Control solar heat gains – to make use of solar heat where and when needed but to avoid solar overheating which may result in the need for mechanical cooling.
- Use of thermal mass – thermal mass (that is, heavy weight construction materials) can be used to stabilise internal temperatures and reduce heating and cooling energy consumption.
- Maximise use of daylight – good daylighting will reduce the level of electrical lighting, which uses electricity directly and may also indirectly increase the heat load on the space, which may result in the need for mechanical cooling.

2.2 Building services

If the thermal loads on the space are reduced through careful design of the building using a passive design strategy, the thermal, ventilation and lighting systems can often be simplified and reduced in capacity. They then become easier to use and potentially more energy efficient. This involves attention to the following.

- Efficient systems – Heating, cooling, ventilation systems should be chosen so that their capacity matches the loads on the space. They should not be oversized to the extent that that they cannot respond to part-load operation, where they will

operate relatively inefficiently. They should have responsive controls to ensure they can quickly respond to the loads on the space, which may vary over time.

- Renewable and alternative energy sources – Where possible renewable or alternative energy sources should be used to replace traditional fossil fuels. This may be currently uneconomic in terms of capital cost and there may also be uncertainties in performance. Provision for future installation of renewable energy systems within the lifetime of the building should therefore be considered.

Buildings are replaced at about 1% per annum. Therefore attention has to be given to improving the existing building stock as well as to the design of new buildings.

3.0 National and International drivers for energy efficient buildings

3.1 Kyoto

In response to the Kyoto summit, the EU has agreed to make a 12.5% saving in carbon by 2010. The UK government's policy is to aim for a 20% saving by 2010 and a further 20% by 2020. It also aims to obtain 10% of its energy from renewables by 2010 and 20% by 2020.

3.2 Energy – the changing climate (Royal Commission on Environmental Pollution) June 2000

This calls for major reductions in carbon to minimise climate change impacts. It calls for a 60% reduction in carbon by 2050 and 80% by 2100. It suggests that drastic improvements in building regulations are needed to ensure that new buildings can begin to form the basis of a low (to neutral) carbon future.

3.3 UK Government strategies

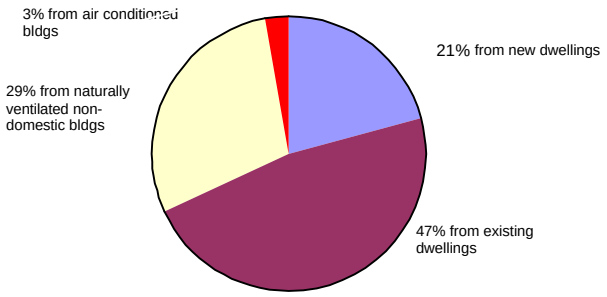
In response to the growing concern over climate change and other pollution impacts the government has published a number of reports outlining future strategies. Building a Better Quality of Life – A strategy for more sustainable construction (April 2000) identifies the need to improve energy efficiency in existing buildings and to extend the use of renewable energy sources. The recently published UK Energy Review (February 2002) reiterates the need to improve energy efficiency not only in response to climate change but also in relation to the future security of energy supplies. The 'Rethinking Construction' programme also includes attention to sustainability, together with other issues, such as improved quality and site safety.

3.4 Building regulations

The Building Regulations for England and Wales address energy efficiency under 'Conservation of fuel and power'; Part L1 (dwellings); Part L2 (other building types). They have recently been revised, requiring higher standards of thermal insulation, new requirements relating to energy use for air conditioning and mechanical ventilation, lighting and attention to improvements in existing buildings. These improvements are a significant part of the UK's strategy for reducing energy use.

Further improvements are planned in two stages in 2004 and 2008. The Building Regulations Advisory Committee (BRAC) is currently looking at how renewables can be included in the regulations and what can be done to improve the performance of existing buildings. The proposed EU directive on energy efficiency in buildings is likely to be a major driver for future improvements in the building regulations.

Predicted energy savings from new revisions to the building regulations (Part L). A total of 1.4mtC is predicted to result from the recent improvements. This represents 8% of the UK's target energy savings. Much of the savings will be achieved in existing buildings, mainly through replacement windows and boilers.



3.5 Home energy conservation act (HECA)

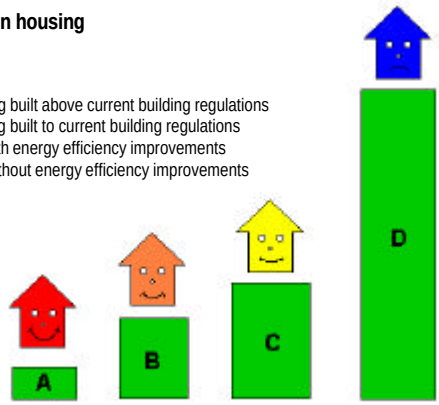
The HECA requires local authorities to plan for 30% reduction in energy use over a 10-15 year period. Housing accounts for about 60% of the energy used in buildings. There are therefore considerable savings to be achieved both in the improvement of existing dwellings and in the design of new dwellings.

Example

Energy saving potential for new and existing dwellings. New dwellings are compared for building regulation standards (B) and improved standards (A). Existing dwellings are compared for a typical older house (D) and houses that have undergone a package of energy saving measures (C).

Potential for energy savings in housing

A - New build semi-detached dwelling built above current building regulations
B - New build semi-detached dwelling built to current building regulations
C - Pre 1919 mid-terrace property with energy efficiency improvements
D - Pre 1919 mid-terrace property without energy efficiency improvements



CO_2 (kg/yr)	2,011	2,852	3,502	7,581
Cost per year (£)	288	322	411	749
SAP rating	71	66	69	40
Heating (GJ/yr)	22.7	34.2	50.7	133.6

3.6 European directive (draft 2001)

The EU is predicted, from current trends to become increasingly dependent on external sources of energy, from today's 50%, to 70% in 2030. It is also committed to reducing greenhouse gas emissions under the Kyoto protocol. It recognises the need to improve energy efficiency, especially in existing buildings. It proposes, a common framework for calculating energy performance of buildings, minimum performance standards for new and existing buildings, certification schemes for buildings, and regular inspection of buildings and their energy systems. The directive is likely to be implemented in 2004/5 and governments will have three years to comply.

4.0 Energy Efficient Building Initiatives in Wales

There is a number of national and local initiatives to encourage improved energy efficiency in the building stock. Some of these are listed below.

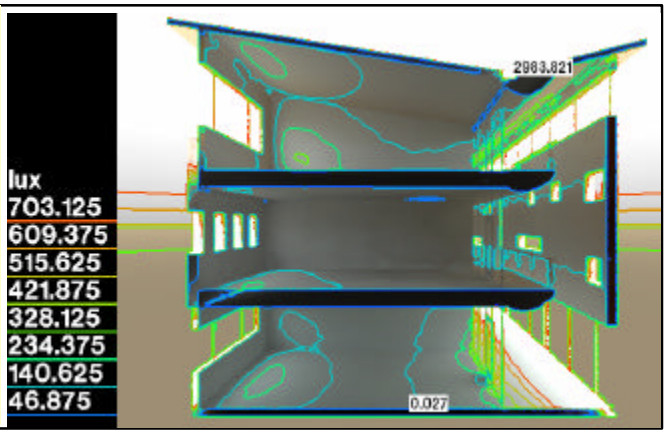
4.1 Design Advice

The UK government's Design Advice scheme provides building designers with a one day free advice on energy and sustainability aspects of new and refurbished buildings. It applies to buildings or groups of buildings with a total floor area greater than 500m^2. If further advice is needed on a particular scheme then a 30% grant is available.

In Wales this scheme is promoted by the **Design Advice Committee,** which is convened by the Welsh School of Architecture on behalf of the National Assembly for Wales. The committee comprises representatives from government, government agencies, the building industry and local authorities. It has promoted a number of sustainable building initiatives and events. It organised the analysis and exhibition of 'green buildings in Wales' at the international Green Building Challenge (GBC) conference in Maastricht (2000). It is planned to repeat the exercise for the next GBC conference in Oslo in October 2002.

Example

Office develoment at Llantarnum. The scheme was design by Stride Tregowen architects. They received **Design Advice** which included ventilation and energy advice, and daylight analysis (see right). Advanced computer modelling was used to assess the energy and ventilation design of the building and the results were used to modify the building to improve its performance.



4.2 Assessment methods

Environmental assessment methods have been developed to encourage the design of sustainable buildings, which includes improving energy efficiency. The main method used in the UK is BREEAM. This is a credit-based system, which allocates credits in relation to the buildings potential impact on the global, local and indoor environment. A building is awarded a rating from fair, good, very good to excellent.

Example

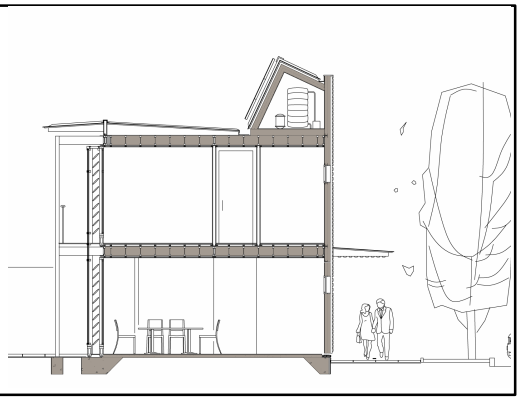
The Eco Factory on the Baglan Bay Energy park has building integrated PV's providing electricity and acting as solar shading devices. The building has high levels of thermal insulation, natural ventilation and maximised daylight. The building was awarded a **BREEAM 'excellent' rating** and it won the CORUS industrial building of the year design award (2000). Design partnership: Neath Port Talbot CBC and the Welsh School of Architecture.

4.3 Demonstration projects

There are a number of buildings in Wales that demonstrate energy efficiency and the use of renewables. Some of these have been funded under the governments best practice programme, others have been developed through European projects, for example, solar thermal low energy houses at Clase Swansea (developed by Gwalia Housing Group). The National Assembly for Wales current Social Housing Innovation Programme (SHIPS) is anticipated to produce houses that demonstrate low energy features.

Example

The Swansea **'Combi-house'** demonstrates innovation of construction techniques with low energy design and the use of renewables in the roof 'energy pack' and use of rainwater harvesting. It has been designed at the Welsh School of Architecture in collaboration with Gwalia Housing Group. The energy pack includes options for PV, Solar thermal and wind power. The design was recently exhibited by CORUS at the Building Exhibition in London.

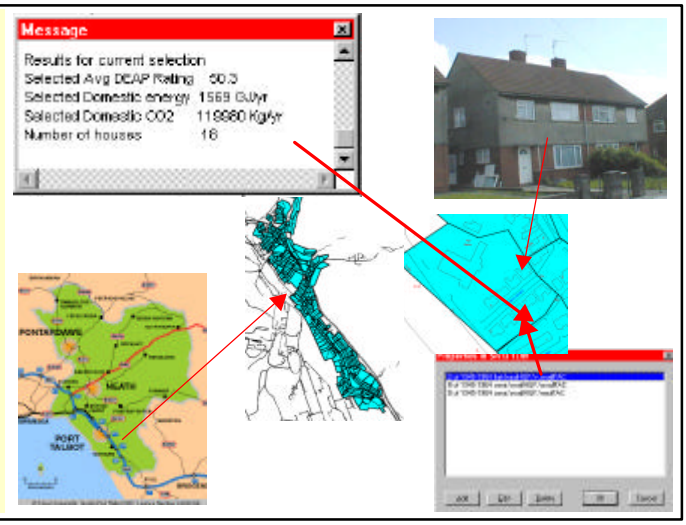


4.4 Local Authorities and energy efficient buildings

Improvements in energy efficiency of existing buildings is being addressed by Neath Port Talbot CBC using Geographical Information System (GIS) based energy and environmental analysis. This will help them to direct funds and information to those houses where the maximum benefits can be realised, not only to save energy, but also to address social related issues, such as fuel poverty. The Welsh School of Architecture in partnership with the Welsh College of Medicine and Neath Port Talbot CBC is using the modelling framework to investigate the impact of the built environment on public health, in particular, to reduce cardio-respiratory disease, injuries in the home, and mental health problems.

Example

The **Energy and Environmental prediction model (EEP)** is a GIS based environmental model for local authorities. It has been applied to Neath Port Talbot CBC to help assess the most beneficial energy saving packages for the existing building stock. The model is also able to assess traffic flow and industrial pollution. Recent developments with Welsh College of \Medicine are investigating links between the built environment and health.



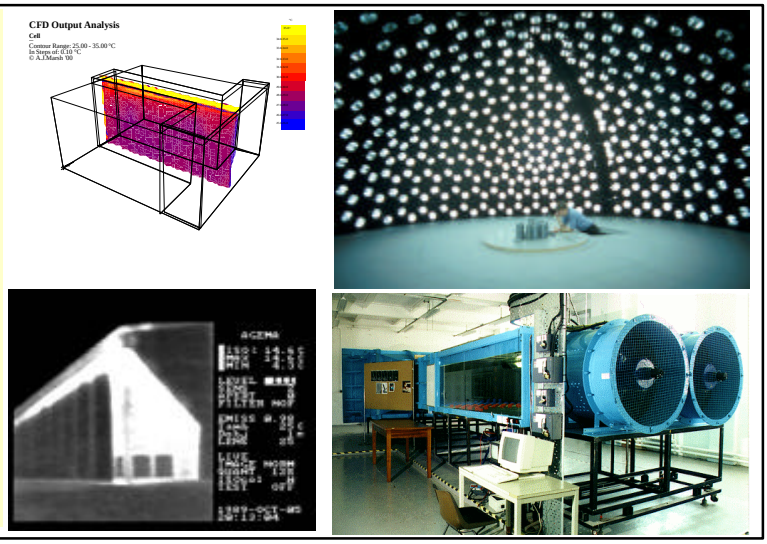
The Welsh School of Architecture and the Consortium of Local Authorities in Wales (CLAW) have recently formed a partnership to develop built environment research and training within the local authority sector.

4.5 Design Research Unit

The Centre for Research at the Welsh School of Architecture is designated by the Welsh Development Agency and a centre of excellence, in particular, in recognition for its work with industry. It has world class laboratory facilities and advanced computer models for low energy design. The Design Research Unit partners industry on design projects, either through specialised consultancy or through developing concept designs. In the recent UK Research Assessment Exercise (RAE) the Welsh School of Architecture achieved the highest research rating (5A) for UK Schools.

Example

The environmental laboratory at the Welsh School of Architecture has world leading facilities in scale modelling, computer prediction and site measurement. As a recognised Centre of Excellence (CETIC) for research in the built environment, it is increasing its work with industry. The facilities can be used by industry, for example through the Design Advice scheme.



5.0 Recommendations

5.1 To expand the Design Advice scheme in Wales. All public sector new build and refurbishment projects should be required to use the scheme.

5.2 To promote the testing of buildings on the completion of construction. Many buildings are not properly constructed and fail to provide their design performance. Such tests include pressure testing for air leakage and thermography surveys to check the installation of insulation.

5.3 To carry require regular checks on building energy performance throughout the building lifetime. Building 'MOT' checks should be carried out on all public sector buildings. This is likely to be a future requirement under EU directives.

5.4 To include environmental assessment as part of the design process. Public sector buildings should be required to achieve a BREEAM 'excellent' rating.

5.5 To encourage improvements in the existing building stock, for example, by increase grant aid for domestic and boiler and window replacement.

5.6 The wide-scale application of building integrated renewable energy systems will be difficult without grant aid and better buy-back rates of electricity by the electricity supply companies. If renewable 'green energy' can be sold back to the companies at

a premium rate then this would make investment easier. This should be investigated along with other aspects of 'smart metering'. Also, to support community schemes to develop renewable energy projects.

5.7 To support further improvements to the building regulations, relating to energy efficiency, and in particular for expanding their remit in relation to renewable energy and existing building performance.

5.8 To promote energy efficiency through a realistic programme of demonstration projects for improving existing building as well as new build. The projects should highlight potential problems as well as the benefits.

5.9 To promote energy efficiency through the planning process. Planners could become more proactive in improving energy efficiency, for example, orientation of buildings on site to maximise passive solar gains.

5.11 To support a programme of research and training. Wales has a strong research and training base in energy efficiency and environmental management. A research programme might include:

- Development of practical evaluation tools for sustainability, energy and environment performance, including life cycle assessment (LCA) methods an d embodied energy. Prediction methods will apply to individual buildings and whole local authority areas. Such tools should be able to be fully integrated into design and decision making procedures.
- To investigate barriers to energy efficiency and sustainable development. This would cover the institutional, social, economic and professional aspects of design. It would link to such initiatives as 'Rethinking Construction'.
- Investigation of appropriate materials for construction, for example, to provide non-toxic, fire safe options for insulation. Also, to investigate the use of suitable materials in relation to improving the performance of heritage buildings to extend their useful life.
- To investigate the implementation of the forthcoming EU directive on energy performance of buildings. This will impact all in the building construction industry as well as those who manage and occupy buildings. It is due to come into operation in 2004/5. Although governments will have up to three years to comply with the directive, it would be advisable to consider its impact and how it might be implemented at an early stage.

Professor Phil Jones is Chair of Architectural Science and Director of the Centre for research in the Built Environment at the Welsh School of Architecture, Cardiff University. This is one of the largest university based research groups of its kind in the UK. Professor Jones is a member of the UK Government Building Regulation Advisory Committee (BRAC) and chairs its Part L 'efficient use of power' working group. He also chairs the Wales Design Advice Committee. He sits on a number of professional committees relating to energy efficiency and environmental design of buildings. He was a member of the Built Environment Panel for the 2001 Research Assessment Exercise (RAE).
