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Building energy efficiency and the greenhouse effect

By George Henderson

Buildings account for about half of UK energy consumption and a similar fraction of carbon dioxide emissions to the atmosphere. Those emissions could be reduced significantly through applying energy efficiency measures which are cost-effective and use well proven techniques and materials.

In the last few years, it has become widely accepted that human activity is now on a large enough scale to affect global climate patterns through the greenhouse effect. Direct measurements show rapidly increasing atmospheric concentrations of the gases believed to cause the effect. Climatic change is more difficult to observe directly because of the considerable natural variability evident from past records.

Several different gases associated with human activity are contributing to the greenhouse effect including carbon dioxide (CO_2), methane, chlorofluorocarbons (CFCs) and nitrous oxide. CFCs are also blamed for damaging the stratospheric ozone layer which has an important role in filtering out harmful ultraviolet wavelengths from sunshine. Paradoxically, excess ozone being produced in the lower atmosphere is another significant greenhouse gas but does not compensate for the reduced concentration in the stratosphere.

CO_2, the most important greenhouse gas, is estimated to account for about half of the man-made component of the greenhouse effect. Most of this CO_2 originates from energy production through the burning of fossil fuels. Buildings are major users of energy, requiring heat, light and other services in order to function properly. In the UK, buildings are responsible for about half of all energy consumption and a similar proportion of energy-related CO_2 emissions[1].

Action to reduce emissions of greenhouse gases is likely to be undertaken on an internationally agreed basis since the problem itself is on a global scale. The problem is being examined by the Intergovernmental Panel on Climate Change (IPCC), set up by the United Nations Environment Programme and the World Meteorological Organisation. The IPCC is due to report in November 1990. It is appropriate therefore to examine how reductions could be achieved in the UK. In buildings, there are many opportunities for improving energy efficiency which will reduce energy consumption and, hence, CO_2 emissions. The EEO Buildings programme, managed by BRECSU, has shown that many such improvements are already cost-effective and can be carried out using well developed materials and techniques. BRE has analysed those opportunities for the housing stock in detail[2].

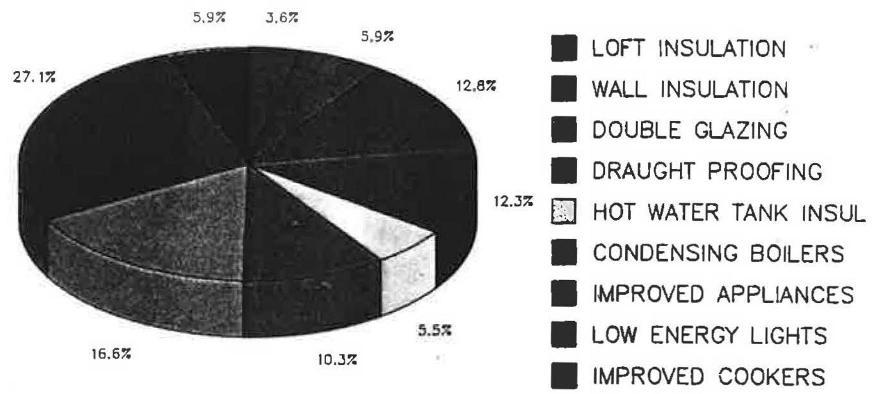
A proper understanding of the relationship between energy efficiency in buildings and CO_2 emissions requires an analysis which takes account of the fuels used and how they are attributed to the various uses of energy such as space heating, lighting and water heating. Particular energy efficiency measures apply to particular uses of energy and fuels, e.g. cavity wall insulation in a gas heated house would apply to that proportion of the gas supplied to the house which is used for space heating. This kind of analysis is necessary because different fuels produce varying amounts of CO_2 for each unit of energy they provide (see table 1). BRE has been able to take all those factors into account using the BREHOMES model of energy use in the housing stock when estimating the reductions in emissions that could be achieved through the application of cost-effective energy efficiency measures. A total reduction of 44 million tonnes of CO_2 per year was estimated, equivalent to about a quarter of the present level of emissions from housing and about 7 per cent of total UK emissions. A total reduction of 62 million tonnes was obtained when measures which are technically well proven but not usually cost-effective at present energy prices were included, solid wall insulation for pre-war housing.

TABLE 1

CO_2 emission associated with each unit of delivered energy (United Kingdom, 1987)

FUEL	*CO_2 EMISSION* (Kg/Gj)
Coal	92
Natural gas	55
Electricity	231
Oil	84

DOMESTIC SECTOR CO2 SAVINGS (MILLION TONNES) THROUGH COST-EFFECTIVE ENERGY EFFICIENCY MEASURES



TOTAL REDUCTION 44 MILLION TONNES

Figure 1 shows the relative importance of different measures that could be applied cost-effectively. About two thirds of the reduction in CO_2 is due to improved insulation, with cavity wall insulation and double glazing being the leading contributors. The other third is due to improved efficiency of heating systems, lighting and domestic appliances. The contribution from lighting and appliances is made more significant by the fact that the energy savings are all in electricity.

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Heat exchanger design prevents corrosion

Nitric acid is manufactured by burning ammonia in air to produce nitrogen oxide gases which are then absorbed in water to produce nitric acid. The reaction takes place at high temperature and produces considerable quantities of heat. As the absorption process must take place at ambient temperature or below, heat must be removed between the two stages. This heat is available for recovery and is usually used for steam generation.

Traditional nitric acid plants only recover heat to 2000°C because below this temperature there is the possibility of the nitrogen oxide gases condensing to form dilute nitric acid. Although this is not a problem in itself, if the temperature increases after condensation, evaporation causes concentration of the nitric acid which can, in turn, pose a serious corrosion risk.

By careful design of the heat recovery system, and in particular the design of the heat exchanger used to recover heat at the lowest temperature range, Kemira (formerly UKF Fertilizers) is recovering heat down to 140°C. The heat exchanger used at the low end temperature range has a complex internal arrangement which is designed to keep the tube surface wet, avoid re-evaporation and to avoid wetting the shell.

In terms of the benefits which the company is achieving, a detailed heat and mass balance over the plant has shown that an additional 5.3 tonnes steam/hour is being produced by the nitric acid plant. This has reduced the firing of a package boiler by 18 GJ an hour. Extrapolated over a typical year this is worth £290,000 a year to Kerima.

The total investment cost, including spare heat exchange capacity, was £620,000, giving a payback period of just over two years. Extensive thickness measurements have been taken and corrosion will be monitored. To date there have been no problems with the operation of the exchangers and the indications are that there has not been any severe corrosion. Kemira is very pleased with the results from the project and is considering similar modifications on one of its other nitric acid plants.

The Best Practice programme

Both of these projects received support under the Energy Efficiency Demonstration Scheme. However, the Energy Efficiency Office has replaced the Demonstration Scheme by the Best Practice programme which is aimed at advancing and disseminating impartial information to help improve energy efficiency. Results from the Demonstration Scheme will continue to be promoted but new projects can only be considered for support under the Best Practice programme.

In the chemicals sector, information will be targeted at specific parts of the industry, grouped by type of product and processing operation. An Energy Consumption Guide, providing information on current energy use, is to be compiled for the resins sector; more are planned for other parts of the industry. Guides, outlining good energy efficiency practice, are also planned for the key unit operations of drying, distillation and evaporation.

In addition, the EEO is actively looking to support collaborative R&D ventures of relevance to the chemicals industry. Further projects continue to be sought.

Further information

Alan Mercer, the ETSU Project Officer for chemicals, will gladly answer any queries regarding either of these projects or participation under the *Best Practice* programme for this sector. Alan can be contacted on 0235 433568.

Queries of a more general nature should be directed to the Energy Efficiency Enquiries Bureau, ETSU, Building 156, Harwell Laboratory, Didcot, Oxon OX11 0RA. Tel No: 0235 834621. Fax No: 0235 432923.

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BP to sponsor an award to excellence

For the second year running BP Oil are sponsoring an award to excellence with prizes worth £1000, the award scheme being administered by The Institution of Plant Engineers.

BP Oil are looking for that special Engineer, working in plant, works or maintenance engineering in any industry, whose contribution in engineering terms during 1989 has benefited his or her's organisation or the public at large.

Details

Details of the award, for which the closing date is 31 January 1990, can be obtained from Peter Tye, Assistant Secretary, The Institution of Plant Engineers, 138 Buckingham Palace Road, London SW1W 9SG. Telephone: 01-730 0469.

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At present, with most UK electricity generated by coal fired stations at an average efficiency of about one third, each unit of electricity consumed releases about four times as much CO_2 as an equivalent unit of natural gas. This relationship depends heavily on how the electricity is generated. For example, it would be quite different for France where most electricity is generated by nuclear power stations.

CFCs have already been referred to both as contributors to the greenhouse effect and as agents causing damage to the ozone layer. The Montreal Protocol, signed by the UK and most leading industrial nations, commits us to reduction in CFC production of 50 per cent of 1986 levels by 1999, while an EEC agreement aims at the complete phasing out by the year 2000 of all listed CFCs for which substitutes can be found. Present usage is connected with building energy efficiency in two significant ways. Firstly CFCs are widely used as working fluids in refrigeration equipment and it has been estimated that their replacement by non ozone-damaging fluids may cause a small increase in the energy used for refrigeration[3]. Secondly, CFCs are used as foaming agents for some types of insulating materials, notably extruded polystyrene and polyurethane foam. Again, substitution will have some associated penalty in energy efficiency. At the very least, the need to eliminate CFCs is going to put some constraints on the use of certain insulation materials.

Overall, it is clear that energy efficiency in buildings is strongly linked to the greenhouse effect. Significant reductions in greenhouse gas emissions are possible through the application of energy efficiency measures which are already cost-effective. Conversely, a desire to reduce emissions could provide a major new impetus for energy efficiency improvements.

References

[1] L D Shorrock, The greenhouse effect: CO_2 emissions attributable to buildings; *Building Services,* July 1989.

[2] G Henderson and L D Shorrock, The greenhouse effect: reducing CO_2 emissions through energy efficiency in the housing stock: *Building Services,* September 1989.

[3] J Bates, CFCs and energy use in refrigeration plant: *Energy Management,* August 1989.

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