Commercial in Confidence

REPORT PREPARED FOR THE

EUROACE - BUILDING ENERGY EFFICIENCY ALLIANCE

on the

ASSESSMENT OF POTENTIAL FOR THE SAVING OF CARBON DIOXIDE EMISSIONS IN EUROPEAN BUILDING STOCK

submitted by

CALEB MANAGEMENT SERVICES

Enquiries to:

Paul Ashford
Caleb Management Services
Arran Cottage
6 The Row
Aust
Bristol, BS35 4AY

May 1998

Tel. 44-(0)1454-633879
Fax. 44-(0)1454-633991

E-mail CalebGroup@compuserve.com

CONTENTS

1. EXECUTIVE SUMMARY

Concerns over the growth of carbon dioxide emissions in the developed world over the past thirty years have been given new focus by the emergence of Climate Change as a real and, apparently, tangible phenomenon. The Rio Summit in 1992 was the first sign of political response to the issue. However, the subsequent difficulties experienced by signatories in achieving some of the objectives set out at Rio only served to emphasise the problems which Governments will face in implementing policies and measures to curb such greenhouse gas emissions. The international community has since grappled with these problems and its activities culminated in the Kyoto Protocol which was agreed by the Parties in December 1997. The ratification of the Protocol will take place during the remainder of 1998 and has focused even greater attention on the need for appropriate policies and measures at national and EU level.

The workshop held in Brussels by the Dutch Presidency (May 1997) into the subject was able to focus attention on those areas where savings might be made with the key exception of those achievable in the building sector. Bearing in mind that buildings account for 40-45% of all energy usage in the EU[3], it was obvious that further work was required to quantify opportunities for savings. The insulation industry responded by enlarging the scope of a pre-existing study[1] on comparative insulation capabilities and was able to make some estimates. However, it was recognised that a more comprehensive derivation of potential savings was required.

Following inter-action between DGXI and EuroACE (an alliance of companies working in the building energy efficiency sector), it was agreed that an attempt should be made to collect together those strands of information from various sources which would allow a more complete estimate of potential savings to be made. This report represents that activity.

Whilst it has been found that there is a plethora of information and report data in the public domain on aspects of energy saving potential in the building sector, it has become singularly clear that the data set is nowhere near complete - particularly with respect to basic domestic dwelling and commercial property statistical data across Europe. This arises from the fact that buildings have not been viewed historically in a trans-boundary context despite the fact that emissions are clearly a trans-boundary issue. It must be said that the most complete data set to date has been found in the UK. However, this may reflect aspects of accessibility rather than a fundamental observation on available data.

Despite these short-comings and on-going concerns about data, it has been possible to make assessments about the potential for carbon dioxide savings which fit with the vast majority of published data and yet still provide a cohesive and non-contradictory analysis. The table below summarises the opportunities:

Measure	Sector of Application	Annual Saving by 2010
		(M tonnes CO_2)
Improve Thermal Insulation	Domestic	98 -120
	Commercial/Public	20
	Industrial	56
Improve Glazing Standards	Domestic (as per FIZ/CPIV Report)	94
	Commercial/Public/Industrial	25
Improve Controls	Commercial/Public	67
	Industrial	20

Improve Lighting Efficiency	All	50
TOTAL		**430 - 452**

The main conclusions of the report are therefore as follows:

- A search of the relevant literature on domestic building stock and its condition has shown that space heating savings of approximately 20% can be made through thermal insulation improvements amounting to savings in excess of 100 M tonnes per annum by 2010 in the targeted Member States alone.

- Thermal insulation measures are likely to be less effective in isolation in the commercial sector in view of the importance of glazing and energy control elements. Nonetheless, savings of approximately 20 M tonnes are anticipated from this sector.

- Substantial improvements can be made in the industrial sector by increasing high temperature thermal insulation requirements to optimise energy saving rather than just to cover personal protection as they do currently. Savings of at least 50 M tonnes are already predicted by this route with an additional 6 M tonnes being achievable through better insulation in normal space heating activities.

- A Europe-wide domestic window upgrading programme could save 94 M tonnes of carbon dioxide emissions but will require support to initiate. An additional 110,000 jobs could be created in the process (see below). Additional savings of 25 M tonnes can be achieved through similar measures in the commercial, public and industrial building sectors

- Energy management systems and control upgrades could have a significant further role to play in energy savings within the commercial building sector. Reductions in energy use of 20% could be achieved resulting in carbon dioxide savings of approximately 67M tonnes. Additional savings of 20M tonnes can also be targeted in the industrial sector.

- The reliance of lighting on electrical supplies makes it a significant contributor to carbon dioxide emissions. Moves from tungsten lamps to compact fluorescent lamps and improvements in the efficiency of traditional fluorescent tubes are expected to save between 30 and 35% in electricity usage in the sector, thereby reducing resulting carbon dioxide emissions by up to 50M tonnes across Europe.

- All of the measures identified in this report will require the support of the European Commission and member state governments if they are to succeed. It will be important for support schemes to be built into the policies and measures which follow from the Kyoto Protocol.

- Assuming that such support is gained, the potential for carbon dioxide emission saving could be in excess of 400 M tonne annually by 2010, representing 12.5% of the EU's current emissions.

- The introduction of such energy saving investments will create substantial employment opportunities. One estimate provided by the Environment Commissioner suggests 3.4 million job years between now and 2010[27].

There remain several areas of assessment which require further refinement in the light of additional data. The most obvious of these relates to the condition of domestic building stock in Member States. Also parallel information regarding the European industrial sector would be helpful to augment the data already available for the UK.

It is hoped, however, that this short analysis of existing data sets and previously published studies goes some way to filling a gap in the field of information by bringing together several existing sources and interpreting them in the light of a specific requirement from the regulatory community.

2. INTRODUCTION

2.1 Previous Work and Current Scope

This report follows-on from the work conducted in the preparation of 'Thermal Insulation and its Role in Carbon Dioxide Reduction'[1] which was completed and issued by Caleb Management Services in November 1997. Whilst the prime purpose of this earlier work was to compare the relative merits of different insulation solutions in respect of their CO_2 savings using Total Equivalent Warming Impact (TEWI) methodology, the report necessarily became involved in the potential savings that could be achieved through overall increases in insulation use within existing and new building stock across Europe. This was particularly an issue because of the lack of trans-boundary data and the subsequent failure of the initiatives set up under the Dutch Presidency in late 1996/early 1997 to identify possible CO_2 savings in the building sector.

Since this extension in scope was well beyond the original brief, the assessment of likely overall savings was based on the potential of insulation industry in Europe to grow its activities by 5% year on year for retrofitting purposes. It was assumed that there would be sufficient retrofitting targets amongst the existing building stock within the domestic, commercial and industrial sectors to support this approach. By making these assumptions, it was found that savings of the order of 350M tonnes of CO_2 per annum could be reached by 2010 from insulation and limited glazing measures alone. However, it was noted that retrofitting activities should be focused on those EU member states where either average CO_2 emissions from power generation were high or where energy efficiency measures were known to be weak and population weighting factors were significant. The relevant average figures for CO_2 emissions from power generation across each member state are shown below:

Member State	CO2 Emission Rate
	(kg/KWh)
Austria	0.22
Belgium	0.29
Denmark	0.84
Finland	0.24
France	0.09
Germany	0.61
Greece	0.98
Eire	0.70
Italy	0.59
Luxembourg	1.08
Netherlands	0.64
Portugal	0.64
Spain	0.48
Sweden	0.04
United Kingdom	0.64
	Source: ORNL

For the series of reasons outlined above, the list was reduced to the following countries as targets for a retrofit programme:

Germany
Eire

Italy
Netherlands
United Kingdom

However, since completion of that work, it has been noted that inclusion of Spain would also have been an appropriate target despite its slightly lower carbon dioxide emission rate of 0.48kg/kWh.

This report is therefore scoped to investigate the building stock in these countries in respect of their age profiles and likely levels of insulation in order to confirm that the estimates made in the previous report are valid. In addition, the opportunity is taken in Section 5 to review the incremental energy savings achievable through improvements in glazing, lighting and energy controls.

2.2 Sources of Information used and Limitations of this Current Report

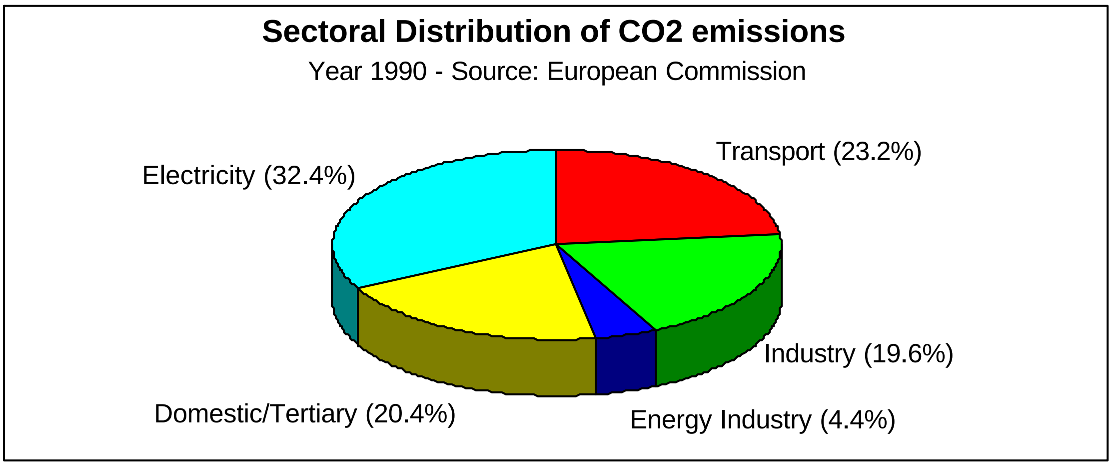
In seeking to address these additional aspects of the issue, it was never intended that Caleb Management Services should undertake new research into the building stock distribution across Europe. The prime objective of the project was to review existing sources and to extract information which is pertinent to the member states in question. In doing so, the project team has drawn on a plethora of reports which are available at national and European level.

In its research, Caleb has noted that there is considerably more information available on the domestic sector than on either the commercial or industrial sectors. In addition, the UK domestic sector seems to have been characterised to a greater degree than other European member states. This is particularly so in respect of insulation status in the domestic sector. Accordingly, this work has been used to extrapolate where necessary to other European member states. In doing so, the author attempts to ensure that factors such as the historic existence of insulation standards are taken into consideration.

------------ “ -------------

3. CHARACTERISATION OF BUILDING STOCK PROFILE

A guidance document[2] produced by the European Commission ahead of the Kyoto Conference noted that the following distribution of carbon dioxide emission sources within the Union existed at the base year of 1990:



European Carbon Dioxide Emission Sources - 3200M tonnes in 1990

One of the problems with this particular analysis is the difficulty in extracting the specific contributions relating to buildings and, in particular, the contributions relating to space heating. However, a further Commission document published in 1996 by DGXVII entitled "European Energy to 2020 - A Scenario Approach"[3] notes energy use in the residential and commercial sectors accounts for approximately 45% of all energy use in the Union' suggesting possible related emissions of up to 1440 M tonnes per year. This, of course, assumes that the CO_2 emissions from the building sector are proportionate to the respective energy use which may not be the case in every respect. In many space heating applications, gas is a preferred option and in the case of UK commercial buildings[4] space heating can account for 60% of energy consumption, but only 44% of carbon dioxide emissions. This is an extreme example in a country which is highly reliant on gas as an energy source. However, it might not be unreasonable to reduce the emissions allocated against the building sector by 5% to compensate for the bias towards gas in space heating. This would reduce the emissions assessment down to 1280 M tonnes per year.

The ability to make significant savings in the building sector depends on the split between domestic and commercial consumption on the one hand and the state of insulation and other energy saving actions being currently practised in the building stock. This, in itself, depends to a large extent on the age-profile of the building stock involved and this next section looks at the spread for some of the six countries being considered for domestic savings in this report.

3.1 Domestic by country and age profile

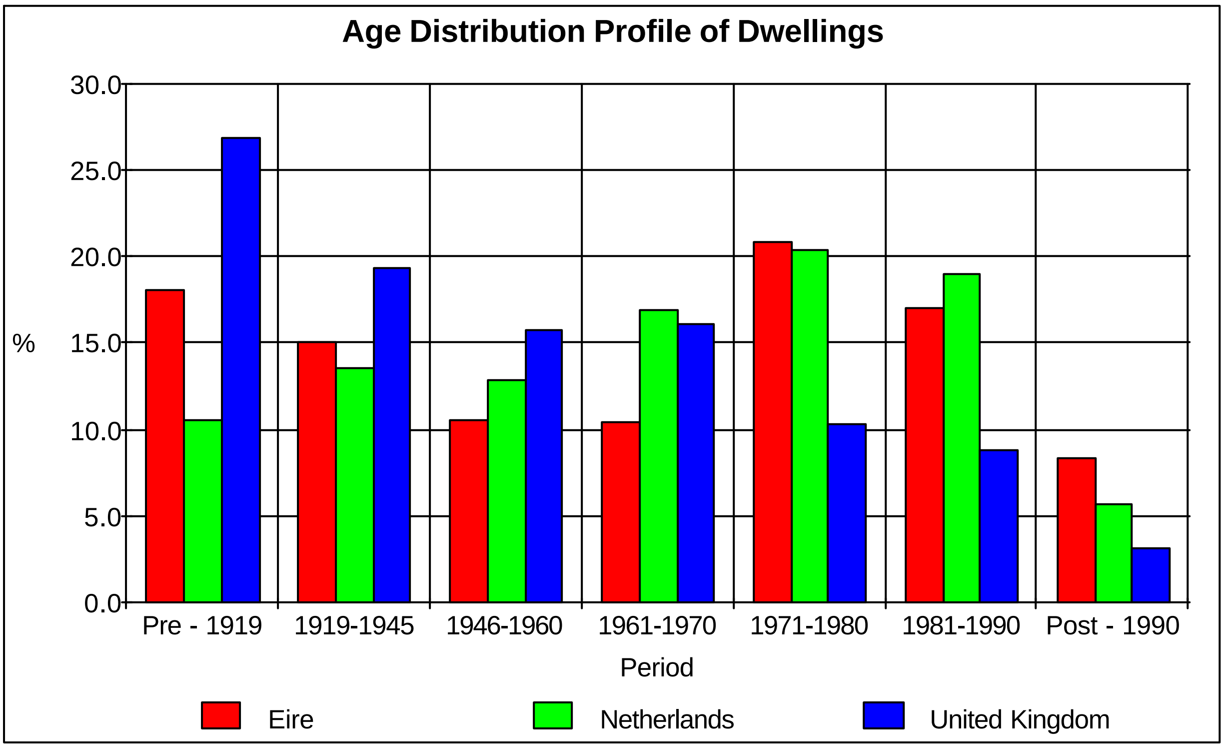
According to the 1996 Annual Bulletin of Housing and Building Statistics for Europe and North America[5], there are approximately 110 million dwellings in the EU excluding Spain, Italy and Greece where no absolute figures are available. In the same region, new dwellings are emerging at a rate of around 1.4 million per census period (typically 3 years). Over the same period there were decreases of around 175,000

relating to demolitions and changes of use. To fill in the gaps concerning the other European countries of interest, the number of 'households' reported[5] (not necessarily the same as the number of dwellings) in Spain is 11.74 million. For Italy, there is no comparative data but an average occupancy of 3 per household (as for Spain and Greece) would suggest approximately 19 million dwellings. This creates a total of just over 97 million dwellings in the countries of interest, equating to approximately 70% of the overall housing stock in Europe. The make-up of the targeted total is shown below:

Country	Dwellings ('000s)
Eire	1085
Germany	34988
Italy	19000
Netherlands	6195
Spain	11740
United Kingdom	24249
Total	97257

It is important to note that although only 70% of the European building stock might be targeted in a retrofitting programme, these countries cover 82% of the emissions[6].

The age profile of the dwellings for the countries relevant to the study and covered by the Bulletin are as follows:



It can be seen from the comparative bar charts that the age profile of dwellings in the UK is skewed towards older properties. This will reflect in the insulation assessment reviewed later in the report.
Bearing in mind that positive interest in the thermal insulation of dwellings began to emerge in the 1960s and was only fully established following the energy crises of the 1970s it can be seen that there is a substantial proportion of dwellings which would not have been insulated during construction. The table below illustrates the possible percentages for each of the countries considered above as taken from the age profile statistics in the Bulletin:

Country	% pre - 1960	% pre - 1970
Eire	43.5	53.9
Netherlands	36.9	53.5
United Kingdom	62.0	78.3

It would not be unreasonable to suppose, therefore, that over 50 million dwellings still existing in the targeted areas were originally built without insulation. However, this subject is dealt with in more detail under section 4.4.

With respect to the energy consumed in domestic buildings, the BRE publication ‘Future energy use and carbon dioxide emissions in UK housing: a scenario’[7] suggests a consumption in domestic dwellings of approximately 1950 PJ in 1991. A further BRE Information Paper ‘Greenhouse-gas emissions and buildings in the United Kingdom’[8] estimates that 1100-1200 PJ (56-62%) of this total was consumed in domestic space heating, although an alternative German paper suggests that this percentage for the domestic sector can be above 75%[26]. With respect to the BRE figure, the UK Climate Change Programme document[9] notes that the proportion of CO_2 emissions reduces to 50% because of the preponderance of gas used in UK space heating - a point noted previously in this section.

3.2 Commercial and Industrial Sectors

There is little published data on energy consumption profiles in the commercial and industrial sectors. In the UK, the Building Research Establishment (BRE) have published an Information Paper[4] detailing the energy consumption to the commercial buildings sector in 1991 as 812 PJ. As noted earlier in this section, a similar proportion of this energy can be apportioned to space heating (60%) as in the domestic sector, This figure is consistent with the UK proportion for domestics but lies below the 75% just noted for German domestics. For the sake of this paper, the figure used for the proportion of space heating in the domestic sector will be 70% across Europe and that in the commercial sector will be 60%. It should also be noted that in the UK the commercial and industrial sector consumption equates to approximately one half of the domestic consumption. Since there is no reason to suppose that the ratio of commercial to domestic energy consumption should vary substantially across Europe, this proportion will also be assumed within the calculations that follow.

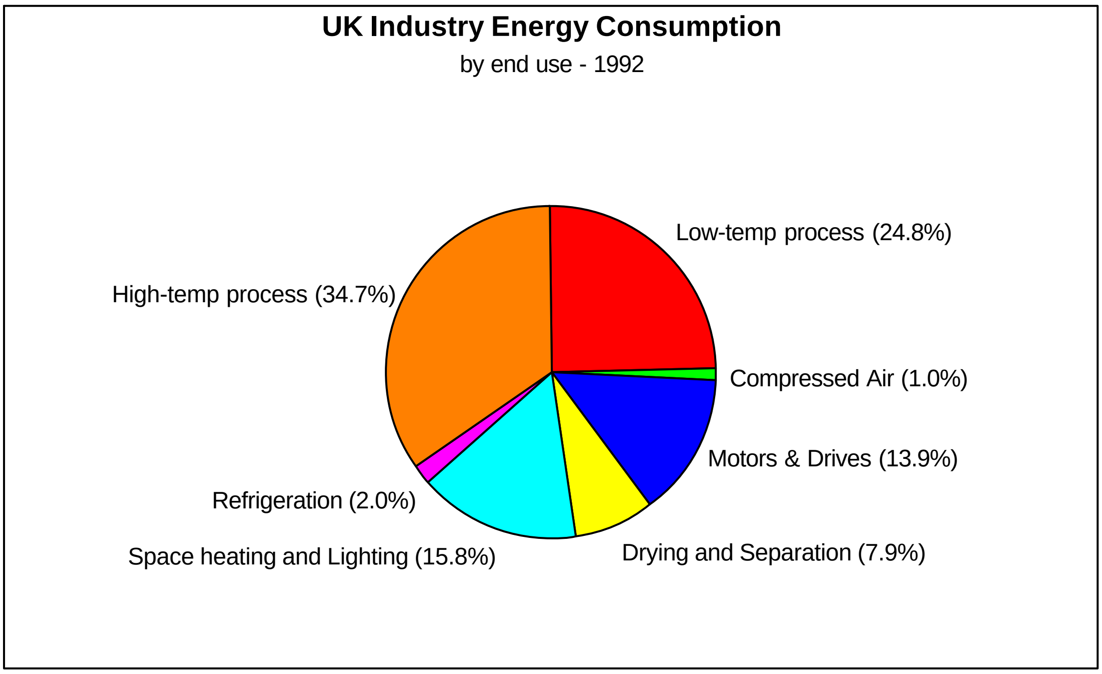
With respect to the age profile of the commercial sector, a paper presented by Mat Santamouris of the University of Athens at the 'Energy-efficient and environment-friendly building' Conference in Brussels, October 1996[10] notes that 'All office buildings need to be retrofitted, more or less thoroughly, at least a couple of times during their lifetime. Over 50 years, the changes in a building cost three times as much as the original building as a result of the cumulative effect of three generations of services and ten generations of plan changes.' This concept of continual change and update would seem to make age profile less important. It would also seem less likely that further substantive savings are possible in the commercial sector. However, the author notes that 'Important work has been carried out, by either architectural or engineering groups, to retrofit office buildings and to improve their energy performance. Results show that cost effective energy savings of the order of 20-30% can be achieved in office buildings, while there is evidence of greater savings resulting from major refurbishment projects.'

Experience under US EPA 'Energy Star' office programmes in North America support this potential saving. A presentation at the 1995 International CFC and Halon Alternatives Conference[11] cited average energy savings of 35% for 24 'showcase' partners. It was noted that a significant percentage of these savings arose from use and maintenance of appropriate controls within the HVAC system and, where necessary 'right-sizing'. This is consistent with Santamouris's paper which suggests as much as 50% of all electrical energy used in offices can relate to the HVAC system.

The sensible use of controls does not only provide improvements in efficiency but offers the possibility of being able to move away from the static equilibrium model (constant internal temperature) which is normally used to assess savings. For commercial buildings in particular, where occupancy is rarely over a twenty four hour period, it is possible to reduce overnight temperatures to levels which would not be tolerable for occupants. The minimum temperature is usually dictated by that required to avoid condensation. Bearing in mind that many offices are empty for over 50% of the time, this is a vital source of additional saving. Accordingly, there are many examples where controls can save approximately 20% of energy use on their own.

The corollary of this , is that thermal insulation per se is unlikely to contribute more than around 7.5% savings, even amongst office buildings in need of refurbishment.

In the industrial sector, the space heating requirement is even less well defined, since the focus is on heavy industry energy usage and the effects of the introduction of CHP. The inclusion of an industrial sector paper in the Dutch Presidency Workshop proceedings[12] made no overt reference to the possibilities for savings from space heating changes. This may well reflect the reality of priorities within this sector. However, a review of energy consumption in the UK by the UK Government Statistical Services cites space heating a lighting as 16% of industry consumption. The pie chart below gives the full breakdown:



Assuming that 12% of the total is specifically for space heating and similar saving patterns are achievable as in the commercial and public sectors. The insulation saving will equate to approximately 6 M tonnes, whilst savings from the better application of controls could amount to 15 M tonnes.

Additionally, thermal insulation could play a significant role in energy saving through the upgrade of high temperature insulation in the industrial sector from ‘personnel protection’ criteria to realistic energy efficiency targets. Work carried out by Rockwool[14] on this issue has suggested that up to 5M tonnes of CO_2 per year could be avoided within a six year period in the UK alone. Extended across the rest of Europe, a conservative potential of 50M tonnes savings per year would be achievable from this source by 2010 representing 10% of the overall emissions emanating from the industrial sector.

As a further point, the widespread use of compressed air is an important target for energy saving. The Statistical Office data[13] estimates suggest that 6% of all of all electricity consumption (1% of total energy) in the industrial sector is expended on the generation of compressed air. With leaks and other inefficiencies accounting for a substantial part of this consumption (up to 50%), the use of better controls can make savings of between 15-25% in overall energy usage in this sector. At best this could mean a saving of 2M tonnes of carbon dioxide emissions in its own right.

As a final point on controls, the introduction of better process systems can save approximately 0.5-1% on overall process energy usage. For the chemical industry, process uses represent over 70% of energy consumption (excluding compressors). This is probably higher than the industry average, but with the Statistical Office aggregated average of 60%, a further 3M tonnes of CO_2 could be saved.

4. THE POTENTIAL FOR SAVINGS THROUGH INSULATION

4.1 General Drivers

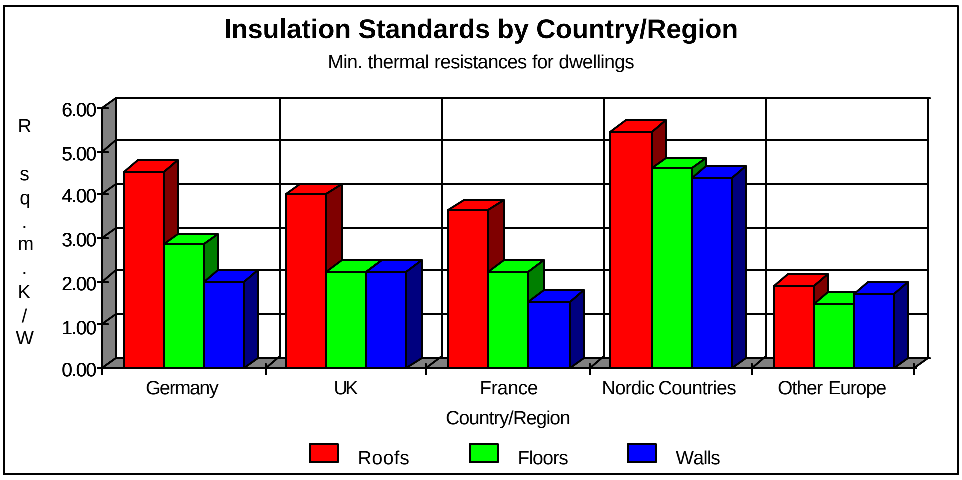
Historically, cost/benefit ratios and pay-back periods have been the key factors in dictating levels of insulation where specific minimum standards do not apply. Bearing in mind that only new installations have typically been covered by standards since the 1970s, the cost/benefit driver has remained a critical factor in the levels of insulation adopted in buildings throughout Europe.

A major problem to the insulation industry and to those promoting energy efficiency has been the steady decline in real terms of the cost of energy since the early 1980s. With continuing de-regulation and the absence of any energy-based tax of significance, this scenario is likely to continue into the next century. Attempts have been made to revise the cost/benefit calculation by the offering of grants for installation of additional thermal insulation. However, whilst these have been significant successes in themselves, they have not found anywhere near universal uptake. This is partly because of the perceived ‘hassle’ value on the part of many property owners of having to install insulation. Where access is relatively easy (e.g. lofts and some cavity walls), retrofit of insulation has been accepted to a larger degree. In areas of collective ownership (e.g. council housing, commercial premises etc.) more radical retrofitting has been possible with the inclusion of both internal and external cladding approaches amongst the measures adopted.

The emergence of the Climate Change issue and the need for absolute CO_2 savings has provided a new stimulus for energy saving. However, until the global and national targets are cascaded into specific policies and measures it is unlikely that widespread action will be taken in any area including the increased use of insulation. Even in this context, it is not expected that grant schemes will offer the solution in isolation. One of the issues which will inevitably influence Governments in the policies and measures they choose will be the cost per unit of CO_2 emission removed. It is believed that insulation in certain sectors (particularly retrofit) will fair extremely well against other options and an indication of cost effectiveness is provided for different scenarios in Caleb’s previous report[1].

4.2 Current Standards

The Institute of Building Control provides a regular update of national building regulations amongst member states[15]. An illustration of the comparative standards is shown graphically below:



The consistent emphasis on roof insulation is seen, as is the regional variation across Europe. As noted in Section 3, however, the issue affecting overall energy usage today is not so much related to the quality of the current standards as to the history and longevity of earlier standards. Olaf Smith-Hanson in his paper 'Energy Conservation in Danish Buildings 1972-2005'[16] has documented the progressive improvement of insulation standards from their initiation in 1961 and notes a further 33% decrease in energy demand required for new buildings by 2005. This activity has resulted in a constant energy demand of 810-830 PJ in Denmark since 1972. Of course, the gross domestic product has increased by 35% since 1972 and the unit decrease in energy consumption is estimated to have been approximately 25% since 1980. When space heating is separated out, the savings are even more impressive with unit consumption having dropped by 53% owing not only to energy saving measures but also to the introduction of more efficient supply-side activities such as district heating and CHP. Even then, this does not fully reflect the improvement in overall insulation standards, primarily because of the age profile of the building stock. In theory, overall savings of well over 50% will have been achieved once all of the building stock catches up. This will be important to Denmark since it has committed to a 20% reduction target in carbon dioxide emissions based on 1990 levels by 2005 and a 50% reduction by 2030. However, attainment of such targets will be partially dependent on building replacement rates and/or retrofit initiatives.

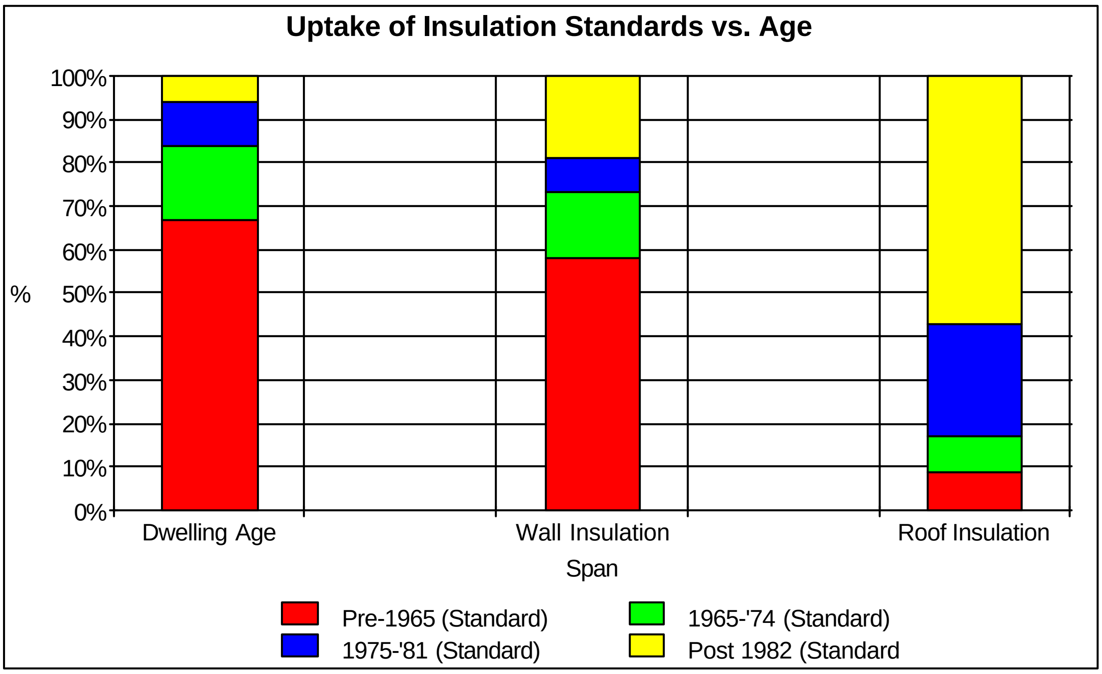
4.3 Building Stock Replacement Rates

In assessing the replacement rates in building stock it is important to realise that attention needs to be focused on the quantity of properties demolished or experiencing change of use. Focusing on new building will not provide the same data since it is the difference between new build rates and demolition/change of use rates which indicates the growth in the overall building stock.

From section 3.1, it is noted that the rate of demolition/change of use is as low as 175,000 over the census period of 2-3 years. This equates to less than 0.2%. Accordingly, a full turnover of building stock could not be envisaged for 500 years unless the rate of change were to be radically increased. The trend in demolitions has generally decreased since the 1970s in most countries and attention has more focused on renovation. There is, of course, an environmental argument for this in the saving of natural resources and the prevention of additional embodied energy burdens. However, the observation clearly points to the importance of renovation and retrofitting as key factors in building stock management. To gain a view on how successful renovation strategies have been, the following section looks at the UK experience on insulation.

4.4 The Experience of Retrofitting and Specific Factors affecting Improvements

The ‘English House Condition Survey 1991- Energy Report’[17] published in 1996 provides excellent information on the extent of use of thermal insulation in current building stock. An analysis is presented concerning the current status of the stock in relation to the various standards introduced in 1965, 1974 and 1982 for new housing. The impact of the 1991 revision, which includes reductions down to U values of 0.2 W/m^2K for roofs and 0.45 W/m^2K for walls and floors, is not evident in this analysis owing to the age of the data. Nonetheless, the analysis is extremely interesting as the graph below shows:



The graph clearly illustrates the fact that roofing insulation has been more easily retrofitted than wall insulation and that well over 50% of the total building stock and over 85% of that pre-1965 is without any wall insulation.

With respect to this latter observation, a further part of the analysis reveals that the uptake of wall insulation in the privately rented sector is substantially lower than in the owner occupied, local authority owned and housing association sectors. Additionally, approximately 31% of walls are solid masonry walls of either brick, block or stone. Levels of insulation on these walls are particularly low.

As an additional point, it is worth noting that roof insulation in its own right does not make massive changes to the conductive heat losses in a dwelling. The reason for this is the fact that traditional loft air, felt and tile constructions are relatively good insulators in themselves (U value 0.8 W/m^2K)[18]. Based on the Dutch domestic dwelling model (steady state) used in Caleb’s previous work[1], the following table illustrates the relative merits of various insulating options applied to existing structures:

Modification	Solid Wall Construction	Cavity Wall Construction

	Heat Loss W/K	% saving	Heat Loss W/K	% saving
Unchanged	740.26	0	608.77	0
Roof Insulation only	723.10	2.3	591.61	2.8
Wall and Roof Insulation	419.66	43.3	419.66	31.1

However, it should be noted that convection heat losses can increase roof losses to anything up to 35% of the total for poorly constructed systems. Nonetheless, with less than 10% of stock without some sort of roof insulation, it is clear that the additional benefits from focusing on roofs will be small. Retrofit wall insulation is, without doubt, the major target and could save substantial quantities of energy.

Assuming that the uninsulated proportion of the stock is balanced between cavity wall and solid construction in the same proportion as the overall stock levels (a conservative assumption), we can calculate the following average unit savings:

Average Savings = (Proportion of Cavity Wall Construction * % saving in Cavity Wall) +

(Proportion of Solid Wall Construction * % saving in Solid Wall)

= (0.63 * 28.3) + (0.31 * 41.0)

= 30.54%

Applying this figure to the uninsulated building stock figure of 58% gives an overall saving of 17.71% for the UK domestic sector on wall insulation alone, ignoring upgradings of additional insulation.

Although the age profile of stock in other member states indicates lower levels of aged stock, it is believed that the proportion of cavity wall construction is higher in the UK than elsewhere. With these factors off-setting one another, it could be expected that the overall saving across Europe's domestic building stock will be of the order of 20% from insulation alone.

4.5 The situation with respect to Commercial and Industrial sectors

The commercial and industrial sectors are broadly covered under section 3.2. From this review savings in the range of 20-30% in energy consumption for Public and Commercial buildings are targeted in the Santamouris paper. The US EPA Energy Star programme highlights an average saving of 35% in the United States, but this will take in more air- conditioned facilities in the southern states. Interestingly, the Environmental Technology Support Unit (ETSU) of the BRE suggests the highest of all possible savings estimates at 40-55% in 'Energy Use and Energy Efficiency in the UK Commercial and Public Buildings up to Year 2000' published by the Energy Efficiency Office in 1988[19]. Bearing in mind the savings which may have been made since that date, a reasonable target for the current stock is most likely to be in the 30-35% region with savings being biased towards controls rather than insulation or glazing upgrades for the reasons given in section 3.2.

5. OTHER SOURCES OF POTENTIAL SAVINGS IN BUILDINGS

5.1 Glazing Improvements

The potential savings available through the upgrading of dwelling units has been researched extensively within a DGXVII sponsored project conducted by FaschinformationsZentrum Karlsruhe (FIZ) and the Comite Permanent des Industries du Verre de la Communaute Economique Europeenne (CPIV). The report entitled 'Major Energy Savings, Environmental and Employment Benefits by Double Glazing and Advanced Double-Glazing Technologies' is published as part of the THERMIE Programme Action (B 154)[20].

The conclusions of the report are that::

- 60% of all windows in the EU remain single glazed
- The annual space heating savings arising from an upgrade programme of all units could save 1 billion gigajoules of energy
- The associated annual saving in carbon dioxide could amount to 94 M tonnes.

The problem in achieving these savings is that, at current rates of replacement, the major member states will take some considerable time to achieve such savings, as the table below suggests:

Country	Years to Full Replacement
Belgium	20
Denmark	0
Germany (former FRG)	20
Spain	60
France	32
Italy	100
Netherlands	20
UK	30

Accordingly, an accelerated programme is proposed for window replacement. A 10-year window upgrade programme is estimated to create 110,000 jobs across the EU and save ECU 11 billion on unemployment costs. Since the investment in windows will be spread widely between the public and private sectors, the costs will not fall solely on Governments. Accordingly forms of grant aid may be possible which still leave the whole project funds neutral for Governments.

5.2 Upgraded Controls

The potential value of upgrading controls and 'right-sizing' of equipment has already established within the US EPA Energy Star programme amongst others. These factors have been discussed already in section 3.2. The introduction of Building Energy Management Systems (BEMS) has been widely trialed and monitored in the public building sector through the CADDET programme, amongst others. In one example in a Dutch school scheme (16 schools) savings of the order of 20% in natural gas and 10% electricity were cited[21]. It is clear therefore, that savings in the range of up to 20% in space heating energy usage could be anticipated if wider use of BEMSs were made in the public and commercial sectors. Such reductions could amount to 67 Mtonnes of CO_2 on a Europe-wide basis.

The possibilities of energy saving within the domestic sector are less pronounced because of the higher potential periods of occupancy. Nonetheless, the domestic sector requires less sophisticated energy management systems and simple controls from thermostatic radiator valves to individual room controls or 'chronotherm' for an entire house are widely available and have demonstrated their effectiveness. Savings from these items are difficult to quantify but in Eastern Europe domestic savings as high as 20-30% have been achieved[22].

The upgrading of control systems in district heating and other multiple networks is a particularly efficient way of making improvements, targeting, as they do, both commercial and domestic sectors. In a recent upgrading project in Krakow, Poland[23] energy savings of 10-20% on the demand side and an additional 15-20% on the supply side were identified. In a further project with the municipal housing authority in Kostrama, Russia, two identical buildings of prefabricated panel-type block houses with six storeys and 40 apartments each were chosen for direct comparison[24]. One of the buildings was fitted with up-rated heating controls and both were monitored over a three month period. The total average saving measured was 21%.

5.3 Lighting

Because of its almost universal reliance on electricity, this sector is specifically of value in targeting energy savings. Additionally, the technology is available to make substantive in-roads into current energy usage figures.

According to a recent BRECSU report[25] covering the UK in 1994, lighting accounted for 20.3% of all electricity consumed which, in itself, constituted 33% of all energy used. Bearing in mind the higher than average carbon dioxide emissions associated with electrical energy, the emissions associated with lighting in the UK alone amount to 34.4 M tonnes.

The lighting figure varies considerably between the domestic sector (as low as 3% of total energy usage)[20] and the commercial/public sector (approx.10% of total energy usage)[4]. Bearing in mind the overall share in the UK of 6.7% this would an approximate 50:50 split between the two application areas.

For two parallel initiatives covering:

(i) the replacement of tungsten filament lamps with compact fluorescent lamps

and

(ii) the improvement of efficiency in linear fluorescent lamps

savings of 35.4% were noted as technically achievable with 32.1% being totally economically justified.

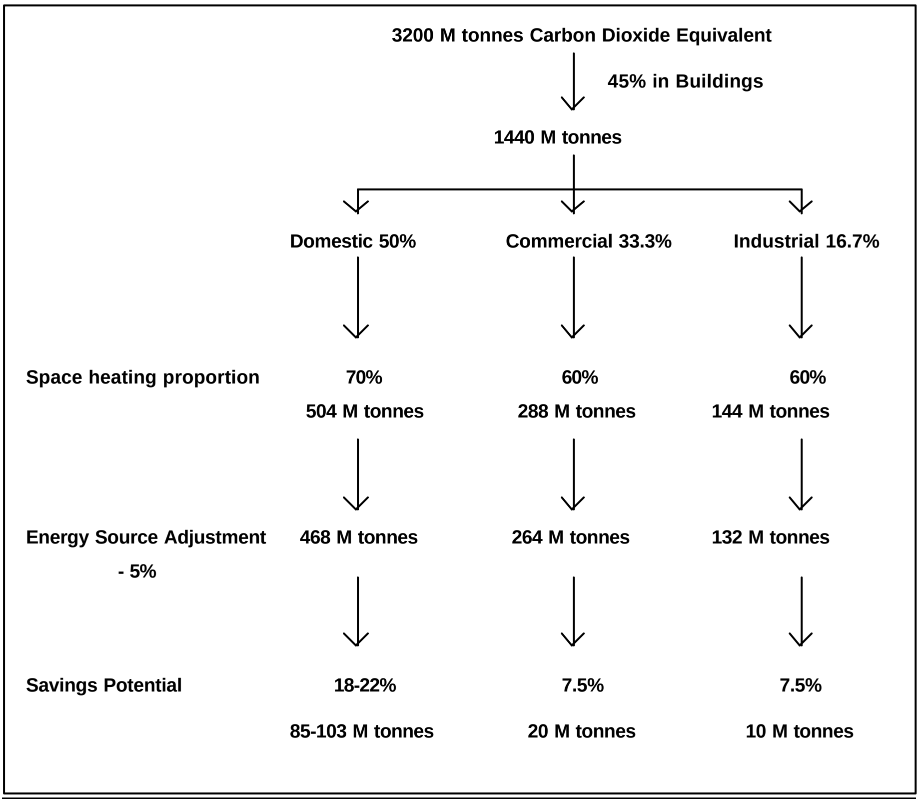
The implication for the UK would be a saving in CO_2 emissions of approximately 12M tonnes which if replicated across Europe could see savings of at least 50M tonnes.

6. OVERALL ESTIMATE OF PROJECTED SAVINGS

In collecting together the various projections made in this report, the following overall estimates for carbon dioxide savings from the building sector can be made as follows:

Insulation

The savings potential is summarised by the schematic diagram below



Other savings are as follows:

Glazing

Domestic (As per FIZ / CPIV Report)	=	94 M tonnes
Commercial /Public /Industrial (7.5%)	=	24 M tonnes

Controls

20% saving in Commercial/Public	=	67 M tonnes
Industrial Control Upgrades	=	20 M tonnes

Lighting

As above	=	50 M tonnes

In total, therefore, the building sector can rightly target in excess of 400 M tonnes of carbon dioxide emissions savings (12.5% of total EU energy use) by 2010 with the assistance and encouragement of Commission actions and member state activity.

7. CONCLUSIONS

The conclusions of this report can be summarised as follows:

- A search of the relevant literature on domestic building stock and its condition has shown that space heating savings of approximately 20% can be made through thermal insulation improvements amounting to savings in excess of 100 M tonnes per annum by 2010 in the targeted Member States alone.

- Thermal insulation measures are likely to be less effective in isolation in the commercial sector in view of the importance of glazing and energy control elements. Nonetheless, savings of approximately 20 M tonnes are anticipated from this sector.

- Substantial improvements can be made in the industrial sector by increasing high temperature thermal insulation requirements to optimise energy saving rather than just to cover personal protection as they do currently. Savings of at least 50 M tonnes are already predicted by this route with an additional 6 M tonnes being achievable through better insulation in normal space heating activities.

- A Europe-wide domestic window upgrading programme could save 94 M tonnes of carbon dioxide emissions but will require support to initiate. An additional 110,000 jobs could be created in the process (see below). Additional savings of 25 M tonnes can be achieved through similar measures in the commercial, public and industrial building sectors

- Energy management systems and control upgrades could have a significant further role to play in energy savings within the commercial building sector. Reductions in energy use of 20% could be achieved resulting in carbon dioxide savings of approximately 67M tonnes. Additional savings of 20M tonnes can also be targeted in the industrial sector.

- The reliance of lighting on electrical supplies makes it a significant contributor to carbon dioxide emissions. Moves from tungsten lamps to compact fluorescent lamps and improvements in the efficiency of traditional fluorescent tubes are expected to save between 30 and 35% in electricity usage in the sector, thereby reducing resulting carbon dioxide emissions by up to 50M tonnes across Europe.

- All of the measures identified in this report will require the support of the European Commission and member state governments if they are to succeed. It will be important for support schemes to be built into the policies and measures which follow from the Kyoto Protocol.

- Assuming that such support is gained, the potential for carbon dioxide emission saving could be in excess of 400 M tonne annually by 2010, representing 12.5% of the EU's current emissions.

- The introduction of such energy saving investments will create substantial employment opportunities. One estimate provided by the Environment Commissioner suggests 3.4 million job years between now and 2010[27].

8. REFERENCES

1. Thermal Insulation and its role in Carbon Dioxide Reduction, 1997, Caleb Management Services
2. Climate Change - The EU Approach for Kyoto, 1997,The European Commission
3. European Energy to 2020 - A Scenario Approach, 1996, DGXVII (ISBN 92-827-5226-7)
4. Energy Consumption in Public and Commercial Buildings, BRE Information Paper IP16/94, 1994
5. Annual Bulletin of Housing and Building Statistics for Europe and North America, United Nations, 1997
6. Own calculations, Caleb Management Services, 1998
7. Future Energy Use and Carbon Dioxide Emissions for UK Housing - A Scenario, BRE Information Paper IP 9/94, 1994
8. Greenhouse-gas Emissions and Buildings in the United Kingdom - BRE Information Paper IP 2/90, 1990
9. Climate Change - The UK Programme, UK Government, 1990
10. Energy Efficient Retrofitting of Offices, Santamouris M., 'Energy Efficient and Environment-friendly Building Conference' Proceedings, Brussels, 1996
11. Own notes from the 1995 International CFC and Halon Alternatives Conference, Washington, 1995
12. Workshop on EU Policies and Measures on Climate Change - Briefing Notes, Dutch Presidency, May 1997
13. Energy Consumption in the United Kingdom - Energy Paper 66, UK Department of Trade and Industry, 1997
14. Reduction of Carbon Dioxide associated with Mineral Wool Industrial Pipeline Insulation, Ralph N. & Bowdidge J., 1993
15. Review of European Building Regulations and Technical Provisions 1992-96, Institute of Building Control, 1997
16. Energy Conservation in Danish Buildings 1972-2005, Smith-Hanson O., Rockwool A/S, 1997
17. English House Condition Survey 1991- Energy Report - UK Department of the Environment, 1996
18. Practical Energy Saving Guide for Small Businesses, Energy Efficiency Office, UK DoE, 1994
19. Energy Use and Energy Efficiency in UK Commercial and Public Buildings up to the Year 2000, Energy Efficiency Office, UK DoE, 1988
20. Major Energy Savings, Environmental and Employment Benefits by Double Glazing and Advanced Double Glazing Technologies, FIZ/CPIV, THERMIE Programme, DGXVII, European Commission,1995
21. Heating System Control - Nijmegen, the Netherlands, CADDET Register Project No. NL-96-501, 1996
22. Written communication, Honeywell Controls, 1998
23. 'Krakow - City Network' District Heating Case Study, Honeywell Controls, 1998
24. 'Kostrama' District Heating Case Study, Honeywell Controls, 1998
25. Reducing Emission of Greenhouse Gases by 20% 1990-2010, BRECSU, UK DETR, 1997
26. Increased use of Renewable Energy, (Erneuerbare Energie verstarkt nutzen). Information booklet German Federal Ministry of Economic Affairs, Bonn, 1994

27. Employment and the Environment Conference, March 1997, European Parliament, Ritt Bjeragaard