Energy productivity to 2010 –
Potential and Key Issues

Contents

Executive Summary (long version)

1. This paper is based upon the assumption that the fact of atmospheric climate change has changed fundamentally the approach to energy efficiency. Over the last few years there has been a growing scientific consensus that
   (a) climate change is taking place
   (b) it is caused largely by the release of greenhouse gases, principally carbon dioxide, to the atmosphere
   (c) to contain the degree of climate change emissions of the main greenhouse gases must be dramatically curtailed over the next 50-100 years and
   (d) even with such curtailment there will be significant changes in climate and sea-level which will cause widespread disruption.

2. The paper takes the imperative arising from this consensus as given , as for example in "Climate Change: The UK Programme". It is also implicit in the UK commitments to reduce carbon emissions by 20% by 2010. And in the longer term low carbon futures described by the RCEP.

3. The paper is concerned with the domestic and business (industry, commerce and service) sectors, it makes no comment on the transport and agricultural sectors. The broad aims of the paper are to
   (1) establish the broad area of agreement on the technical potential for improved energy efficiency and the economic potential to 2010
   (2) document some of the new technologies that could start to have impact by 2010 but are probably more important in the longer term
   (3) review the work done in understanding why most households and businesses do not adopt the cost-effective energy efficiency opportunities available to them
   (4) review the policies that have been used in the UK and elsewhere to promote energy efficiency with a view to drawing lessons regarding what worked and why
   (5) highlight the key areas which require further policies
   (6) raise challenging questions about shared assumptions, goals and analytical frameworks used by most of those involved in the formulation of policy in this area.

Potential for energy efficiency

4. The *ultimate technical potential* for improving energy efficiency is determined by thermodynamics. Most uses of energy achieve only a few percent, often a lot less, of the theoretical minimum energy requirement.

5. The *technical potential* consists of all commercially available energy efficiency technologies. The *economic potential* as a sub-set of the commercially available technologies that pass some cost-effectiveness condition. In this paper we use a simple payback time of less than 5 years in the domestic sector and less than 4 years in the

business sectors. The *economic potential to 2010* is the part of the economic potential that can be realised, taking account of the capacity and capital constraints.

Domestic sector potential

6. There are currently 24.6 million households in GB. The number of people per household (in GB) declined from 3.01 in 1970 to 2.53 in 1990. This has an adverse effect on energy use per person since small households use more energy per person than larger households. The number of households in the UK is expected to increase from 22.1m in 1990 to 24.6m in 2000, 26.4m in 2010 and 28.1m in 2020.

7. The government has announced it plans to eliminate fuel poverty by 2010, largely by improving the energy efficiency of that part of the housing stock. The large numbers of households in fuel poverty is the main reason why government pursues low fuel prices and resists the use of fuel or carbon taxes in the domestic sector. The government will not meet its fuel poverty objectives without tackling solid wall properties.

8. The stock of domestic dwellings is the slowest changing stocks of capital that plays a major role in energy consumption. The energy efficiency of housing has been significantly increased by improvements in the Building Regulations (Part L) over the last twenty years. The proposed changes to the Regulations would further improve performance, by 30% immediately and 50% after 5 years. These improvements increase building costs by about 1%.

9. The efficiency of the existing stock has been improved by retrofitting insulation and improved heating efficiency. In the period 1990-2000 energy use in the domestic sector *increased* due to increased number of households (3.6MtC), improved levels of comfort/service (5.2MtC) and changes in external temperature (3.8MtC). It *decreased* due to improved insulation (4.1MtC), improved efficiency (4.3MtC) and reduced carbon intensity in the electricity supply industry (8.5MtC) and other carbon changes (1.0MtC).

10. Estimates of the potential savings (Mtoe) and reduced carbon emissions for improvements t o the domestic housing stock are shown in the Table below. The total is equivalent to more than 50% of domestic energy use and emissions. This is consistent with recent IPCC published figures.

Measure	**Mtoe**	**MtC**
Payback time 5 years or less		
Loft insulation	1.7	1.38
Cavity wall insulation	3.2	2.59
H/W cylinder insulation	0.4	0.32
Condensing boilers	6.5	5.26
Energy efficient lighting	0.6	1.13
Energy efficient appliances.	1.9	3.56
Controls	0.5	0.40
Payback time greater than 5 years		
Solid wall insulation	3.4	2.75
Double glazing(+low E)	2.1	1.70
Draught proofing	0.4	0.32
Solar water heating	2.0	1.62
Ground source HP	2.8	5.25
High performance glazing	1.5	1.21
Total	**27.0**	**27.50**
Percentage	*56%*	*64%*

11. The cost-effective potential savings are therefore 16.4 Mtoe (35%) and 15.9 MtC (37%). Taking account of changes in numbers of households and levels of service overall savings of about 5MtC are achievable in the domestic sector by 2010, but these will not be achieved without additional policies.

12. The government has taken the view that significantly increasing the cost of domestic fuels, to take account of the climate change externality, is not an option at present. Under these circumstances it needs to pursue other policies with considerable vigour to achieve the same level of carbon reductions that would be generated by the economic level of carbon taxation. In the longer term action is needed to deal with the existing stock, with assisting potentially significant technologies achieve full cost-effectiveness and working within the EU to improve standards for domestic appliances.

Commercial & Service sector.

13. Commercial and service sector buildings account for 80% of energy use in non-domestic buildings, the remainder corresponding to industrial buildings. Since 1970 the total floor area of offices has doubled, of retail outlets has increased by 54% and of warehouses has more than doubled. Together the non-domestic building stock accounts for 17% of total energy use and 19% of carbon emissions. Use of coal and oil has declined whilst use of gas and electricity has increased.

14. The pattern of energy use varies considerably, as one would expect for a sector covering offices, schools, shops, warehouses, hotels, hospitals and leisure centres. For the

service sector as a whole space heating accounted for 54% of energy use, water heating 9%, catering 6%, lighting 15%, cooling 6%, IT equipment 3% and all other uses 7%.

15. There is a large variation in the energy use per square metre across the whole sector. Within the Offices sub-sector the measured range of energy use varies from 0.2 $GJ/m^2/yr$ to 3.0 $GJ/m^2/yr$, for retail outlets the range is from 0.1 $GJ/m^2/yr$ to 2.0 $GJ/m^2/yr$. The range reflects different types of building, varying energy efficiency and good and poor management. The scope for insulation improvements is less than for the domestic sector.

16. The potential for energy savings using commercially available technologies is estimated to be 39% of energy use and 36% of emissions; this figure excludes technologies that will become available before 2010. The economic potential has been estimated to be 21%energy use and 23% of carbon emissions. About half this could be achieved by 2010. Assuming continued growth and no measures energy use is expected to increase by 27% between 1996 and 2010. The assumed savings by 2010 reduce the increase in energy use to 15.6% (and restrict carbon emissions to an increase of 3%).

17. This outcome reflects the fact that this sector is growing quickly and not subject to any specific policies to improve energy efficiency.

Industrial sector

18. Industry makes a falling, but still significant, contribution to UK energy use and CO_2 emissions. Major improvements in energy productivity in industry have been achieved since 1970. Although the rate of improvement has slowed in major years, a factor four improvement over the period 1970-2010 is achievable.
Changes in industrial structure have played a part, but most of the effect is increased energy productivity in individual sub-sectors. Changes in energy prices probably played a major role in the 1970s, but the relationship is not simple and there seems to have been a lag.

19. Many sub-sectors contribute significantly to energy demand and emissions. Key technologies may be divided into sector-specific process technologies and more widely used energy services. Process energy efficiency is closely linked to core business activities. Energy services (of which steam, space heating and motive power are the most important) probably offer larger scope for short-term energy efficiency improvement.

20. The scope for improving energy use in manufacturing industry by 2010 is estimated to be 20-30% over and above business as usual. This forms much of the basis for win-win climate policy options.

Frameworks for Energy Efficiency Decisions

21. Opportunities for cost-effective improvements in energy efficiency have existed for many years and have not been adopted by businesses and households. In order to increase the adoption of improvements it is essential to understand how businesses and households

take decisions regarding energy efficiency and devise policies to overcome any obstacles or barriers that inhibit adoption.

22. Both economists and technologists assume, for different reasons, that ‘rational’ agents would adopt cost-effective improvements in efficiency and presume that if this does not occur then barriers must exist to prevent it. Energy costs are sufficiently small that investments to reduce costs are rarely considered. Energy efficiency is not generally regarded as valuable in its own right. Thus both the economic and technological assumptions made about what motivates people are inadequate.

23. In order to understand how businesses and households perceive energy efficiency it is essential to take into account their individual perceptions, constraints and historical, organisational and cultural contexts. When the actor’s perception and context is fully understood then their behaviour and decisions are seen to be completely rational.

Decision making in business

24. The extensive management literature on decision making emphasises the *necessity* of using imperfect information and less than rational procedures in reaching decisions. This is embodied in the theory of ‘satisficing’ or ‘bounded rationality’ that emphasises the limited availability of *attention*. In addition organisations, and groups and individuals within them, have many different goals that will influence decisions differently depending upon context.

25. A wide range of market barriers has been identified. A recent study found that constraints on staff time, access to capital and bounded rationality were the major factors restricting adoption of energy efficiency in public and private organisations.

Decision making in households

26. Household decision making is subject to bounded rationality with additional issues involving trust, fashion (peer approval) and bargain seeking. Because energy efficiency is invisible and not experienced directly it is not perceived as providing a direct benefit.

27. Regarding energy efficiency expenditure as an investment is unattractive due to the loss of capital and uncertain returns.

28. Making decisions about energy efficiency expenditures have quite high risks associated with them due to

- Difficulties finding out reliable information on appliance performance and the effects of insulation measures
- Not knowing whether how to resolve the large differences in cost for apparently identical products
- Not trusting most of the obvious agencies including the fuel companies and sales staff
- Not trusting the tradespeople who will be involved in the installation.

Summary of Barriers

29. The most important barriers are lack of motivation coupled with bounded rationality. These are compounded by the low proportion of total costs spent on fuel and the invisibility of both energy and energy efficiency. To overcome these barriers energy efficiency policies need to gain attention of decision makers.

30. The other main barriers are

1. Split incentives, as in landlord-tenant and between departments in businesses.
2. Adverse selection where asymmetric information permits poor products to drive out better ones.
3. Access to capital, particularly in the public sector, the fuel poor and in organisations (where principal-agent problems exacerbate the issue).
4. Imperfect information.
5. Lack of credibility and trust, especially in regard to fuel companies.
6. Transaction costs, though the evidence suggests these pose at most a small transient barrier.

Energy productivity policies

31. There are five broad types of policy intervention possible

1. Regulation, as in Building Regulations and EU minimum standards for appliances.
2. Taxation, for example the Climate Change Levy.
3. Subsidy, as for example the cash-back schemes run by the EST.
4. Information, for example energy labels and disseminating best practice.
5. Market transformation, as for example using procurement or encouraging Energy Service Companies.

32. Examples of the successful application of policies using the above instruments to improve energy efficiency include;

A. Building Regulations that have substantially improved the energy efficiency of new housing in the UK over the last twenty years. The use of regulation overcomes split incentive and adverse selection barriers.

B. Green Lights in the USA which is a voluntary programme which has enabled a large number of organisations to invest in energy efficient lighting. It overcame split-incentives and principal-agent barriers by providing credible data at the decision making level within organisations.

C. Technology Procurement in Sweden has encouraged the development and sales of energy efficienct products in several sectors, including domestic appliances. It overcame several barriers by assembling a sufficiently influential group of buyers to persuade manufacturers to change product design to an improved specification.

D. Energy Star in the USA has transformed the energy efficiency of a range of office equipment, particularly computers, by a combination of voluntary participation in specifying standards of performance and Federal purchasing power.

E. HECAction run by the EST involves partnerships between Local Authorities and installers. The LA plays a key role in overcoming distrust of installers and the EST grant enables bulk-purchase to provide discounts to households, thereby providing them with a motive for proceeding.

33. The main conclusions for *future policy* are summarised as follows.

(a) Energy prices do affect the culture in which decisions are made and the common expectation (based on recent experience) that energy prices will fall is unhelpful in encouraging the productive use of energy. Energy taxes therefore have an important role in setting a long term framework. However, energy taxes alone will be of limited effectiveness in many sectors and certainly will not produce the large improvements in energy productivity that are possible and necessary.

(b) Regulation remains a very effective policy instrument, as it can address information barriers with more information. Product regulation is likely to be particularly effective in markets involving small users of energy, e.g. for houses and consumer products. Process or emissions regulation is more appropriate for large business users. To maximise the potential for effective responses, regulation needs to be clear and set out well in advance of implementation. Negotiated agreements may be used as an alternative, but are only likely to be effective where Government is clear that alternative policy instruments will be used in the event of failure.

(c) Regulation and market mechanisms are not in conflict. Energy labelling requires regulation, but is essentially a market mechanism. Similarly, emissions trading requires both regulatory controls and a market. Obligations on energy suppliers and others may be also more effective if they can be traded.

(d) The role of Government is essential as both regulator and fiscal authority. But Government can also play a key role as a promoter of innovation and market transformation, for example through its own procurement policies and by building partnerships with market players.

(e) Information can be effective, but only if it is carefully designed and targeted at the key decision makers. Industrial energy managers will require detailed information on technical performance. But for many consumers the simplest approach: ‘buy this – it saves you money’ may be the most effective.

(f) Information is more effective if it comes from trusted sources, and therefore there is a role for both local Government and the voluntary sector as partners in energy efficiency programmes.

(g) Subsidies can work, both by attracting consumer attention and altering prices. They will be most effective when cross-price elasticities are high, notably to differentiate efficient products from less inefficient goods providing the same energy service.

(h) Good marketing works and it is business that has big marketing budgets. Policies should therefore seek to involve businesses and to encourage them to sell energy efficient goods and services.

(i) Market transformation will tend to require a number of different instruments working together to address the different parts of the market.

34. Overall the examination of policies in the light of the analysis of potentials and barriers leads to the following general conclusions.

(a) Examination of policies that have worked demonstrates that by accident or design they do address the main obstacles and barriers identified in section 3. It is striking that the most successful schemes have addressed *all* the major obstacles, not just one.
(b) Policies designed to address just imperfect information are generally not successful. This is to be expected since most actors are operating under conditions of bounded rationality and will therefore already be rejecting much information that is available.
(c) The most successful interventions in transforming markets involve the voluntary or regulatory introduction of improved minimum standards. There are several excellent examples that can be used as templates in other areas.
(d) The market transformations that have not worked have failed because they did not appreciate the culture and perspective of key agents in the process of delivering improved products to consumers. (e.g. heating installers and condensing boilers, salesmen for low-e double glazing).
(e) Although policies need to be *justified* within a neo-classical framework that framework should not be taken as an adequate description of the ways in which the agents operate. Policies need to be *designed* by taking multiple perspectives of the context into account and should aim to address *all* the known barriers and obstacles involved.
(f) The Climate Change Programme has a wide range of policies, many of which will be effective in the ways designed. However there remain serious areas where effective policies are still to be developed. The most important areas are
    (i) the services sector, particularly commercial buildings and equipment
    (ii) small and medium sized businesses
    (iii) solid wall dwellings in the domestic stock
(g) In the industrial sector, the Climate Change Levy marks an important development away from a policy relying very largely on information. The effectiveness of the Levy looks likely to depend less on the simple price effect than the accompanying measures: exemptions for clean energy sources, greater Government support for energy efficiency, negotiated agreements and emissions trading.

1. Introduction.

How to reduce energy use without loss of economic performance has been of interest since the oil crises in the 1970s. There have been several changes in terminology and emphasis: energy savings, energy conservation, energy efficiency and now energy productivity. The changes in terminology reflect a significant change in both perception and goals. Energy saving, as characterised by the ‘Save It’ campaign was literally about reducing energy consumption and was a response to the need to reduce oil consumption in the wake of the price hikes and rationing in the 1970s. The advice to save energy included accepting reduced levels of energy services, for example by turning down thermostats and wearing warmer clothing. This evolved into a longer term programme to conserve energy, largely on the grounds that energy resources were regarded as in danger of exhaustion. Energy conservation did not involve any loss of energy service but rather emphasised that it was possible to achieve those levels of service using less fuel, principally by improvements in insulation. Energy efficiency was a natural development from the conservation ethic, with the advantage that “efficiency” implied a modernising ethos consistent with economic theory. It is worth noting that an economy or a household could continually become more and more energy efficient whilst continuing to use more and more energy. Energy saving, and to some degree energy conservation, implies an absolute reduction in energy consumption. Homes and appliances can become more energy efficient, but if we have more of them or their size increases then there may be a net increase in energy use.

Energy productivity is energy efficiency recast in the language of the economics of sustainable development. The recasting is significant because it is no longer the scarcity of energy resources that is driving interest and concern, but the unsustainability of carbon dioxide emissions. The change is also part of a larger movement to reconcile the needs of the environment with economic growth. Due to the deeply ingrained writing habits of the authors this paper is cast in terms of energy efficiency, but should be interpreted as dealing with energy productivity in the broader sense.

This paper is based upon the assumption that the fact of atmospheric climate change has changed the political climate, including the imperatives, targets and interests in energy efficiency. Over the last few years there has been a growing scientific consensus that

(a) climate change is taking place
(b) it is caused largely by the release of greenhouse gases, principally carbon dioxide, to the atmosphere
(c) to contain the degree of climate change emissions of the main greenhouse gases must be dramatically curtailed over the next 50-100 years and
(d) even with such curtailment there will be significant changes in climate and sea-level which will cause widespread disruption.

The scientific evidence for the new perspective is summarised in the recent reports from the Intergovernmental Panel on Climate Change (IPCC)[1]

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[1] See for example IPCC Working Group 1 Third Assessment Report, Jan 2001 available on www.ipcc.ch

The paper takes the imperative arising from this consensus as given and does not consider it an option to do nothing, nor even to simply carry on as before. This is consistent with the approach set out in detail in the government's Climate Change Programme[2], which sets out the policies to deliver the UK aim of reducing carbon emissions by 20% by 2010. Stabilisation of the climate will require much larger reductions in global emissions in the long term, for example along the lines set out in recent report Royal Commission on Environmental Pollution[3]. This low-carbon future implies dramatic changes to energy use, supply and infrastructures. Within this context, the paper sets out to review both the assumptions underlying policies and their goals.

The paper is concerned with the domestic and business (industry, commerce and service) sectors, it makes no comment on the transport and agricultural sectors. The broad aims of the paper are to

(1) establish the broad area of agreement on the technical and economic potentials for improved energy efficiency by 2010
(2) document some of the new technologies that could start to have impact by 2010 but are probably more important in the longer term
(3) review the work done in understanding why most households and businesses do not adopt the cost-effective energy efficiency opportunities available to them
(4) review the policies that have been used in the UK and elsewhere to promote energy efficiency with a view to drawing lessons regarding what worked and why
(5) highlight the key areas which require further policies
(6) raise challenging questions about shared assumptions, goals and analytical frameworks used by most of those involved in the formulation of policy in this area.

Section 2 describes the potential for improvements in energy efficiency in the domestic and business sectors to 2010. There is a broad consensus about the technical and economic potentials for the next decade. This section points to the factors that are likely to determine the longer term potential.

Section 3 reviews and examines the assumptions made about the ways in which householders, businesses and governments make decisions about energy efficiency. It is a central thesis of this paper that the change in circumstances created by global climate change requires a critical appraisal of the assumptions and theories that have informed the energy efficiency debate for the last 10-20 years.This section also summarises the main obstacles and barriers to the adoption of energy efficiency.

Section 4 reviews energy efficiency policies within the UK and elsewhere using the concepts and frameworks discussed in Section 3. The aim is to develop an understanding of what has worked, what hasn't and what were the significant differences in the policies involved. In this context the section also reviews the range of policies set out in the Climate Change Programme.

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[2] "Climate Change: The UK Programme". DETR, 2000 [exact web ref].

[3] Royal Commission on Environmental Pollution. "Energy the changing climate" [exact web ref]

2. Estimating the technical and economic potentials for energy efficiency to 2010

2.1 Framework

Between 2000 and 2010 there will be a number of changes in both the domestic and business sectors that significantly affect energy consumption. In the domestic sector there will be an increase in the number of households and continuing improvements in the efficiency of boilers, appliances and houses. In the business sector there will be increases in the value of output, improvements in efficiency of heating and other equipment and changes in the mix of output (particularly between manufacturing and the service sector). Without any deliberate policies these changes will lead to changes in both the quantities of energy used and the efficiency with which it is used. This is the base case, often referred to as "business as usual" or BAU, against which changes in energy use are evaluated.

The potential for energy productivity is difficult to define for a number of different reasons.

1. The *ultimate technical potential* for improving energy efficiency is determined by thermodynamics. A few industrial processes, such as the reduction of iron oxide to iron, are close to their theoretical limits. However most uses of energy achieve only a few percent, often a lot less, of the theoretical minimum energy requirement.
2. In line with most authors we restrict discussion of *technical potential* to commercially available technologies. There is some ambiguity about what is and is not commercially available. This distinction eliminates technologies in development, those that are known but not yet profitable enough to be in production and those yet to be discovered. The technical potential also includes all cases where a given technology could safely be applied.
3. Most authors also define *economic potential* as a sub-set of the commercially available technologies that pass some cost-effectiveness condition. This may be as simple as a payback time less than some period, or it may involve a net present value calculation using a discount rate and estimates of future energy prices. We shall generally use a simple payback time of less than 5 years in the domestic sector and less than 4 years in the business sectors. Since local circumstances may impose additional costs the economic potential of a given technology may also have a reduced scope compared to the technical potential for the same technology.
4. In any given time period there are also constraints on the *rate* of adoption of energy efficiency technologies. These maybe investment constraints, production capacity constraints or constraints imposed by the rate of turnover of capital equipment. The key to this aspect of potential improvements is to specify the time period involved. In this report we refer to this as the *economic potential to 2010*.

Thus in this report we have excluded active solar heating of domestic dwellings on the grounds that the technology is not commercially available[4], even though it has been demonstrated in a few cases. Solar water heating for domestic dwellings is included in the technical potential, but not in the economic potential since its pay-back time is in excess of 5 years. Cavity wall insulation is a technical and economic potential for a large proportion of the cavity wall dwellings in the UK. However the economic potential to 2010 is largely constrained by the installation capacity of the industry, and the need to build up and run down this capacity over reasonable periods.

2.2 The Domestic Sector.

The domestic sector accounts for about 28% of Final Energy demand (48.1 Mtoe) and about 23% (43 MtC) of greenhouse gas emissions (after reallocating the emissions and losses associated with fuel supply). Of this total space and water heating accounts for about 80% of the energy used in the sector and about 65% of the greenhouse gas emissions.

There are currently 24.6 million households in GB of which 16.7m(68%) are owner occupied, 2.7m(11%) private rented, 4m(16.5%) owned by Local Authorities (LAs) and 1.1m (4.5%) rented from Registered Social landlords (RSLs). Although the UK population is fairly stable, the number of households is increasing as the number of people per household declines. The number of people per household (in GB) declined from 3.01 in 1970 to 2.53 in 1990. This has an adverse effect on energy use per person since small households characteristically use more energy per person than larger households. The number of households in the UK is expected to increase from 22.1m in 1990 to 24.6m in 2000, 26.4m in 2010 and 28.1m in 2020.

Fuel Poverty

Depending upon the definition of fuel poverty used[5] there are between 6m and 4.4m households in fuel poverty. Fuel poverty contributes to the 30,000 excess deaths each winter and to the health problems of the households involved. The large numbers of households in fuel poverty is the main reason why government pursues low fuel prices and resists the use of fuel or carbon taxes in the domestic sector. Of the 4.4m (in the lower definition) in fuel poverty 2.3m are owner-occupiers, 0.7m are in private rented, 1.1m are in LA and 0.2m in RSL properties. The largest group of people in fuel poverty is pensioners, they account for more than 50% of the total. Single people, including

[4] In addition the costs of inter-seasonal heat storage are such as to preclude this technology from cost-effectiveness for the foreseeable future.

[5] The definition is that the household has to spend more than 10% of its income on achieving adequate warmth in the home. The difference in the figures arises from the definition of income. The higher figure excludes housing costs (which are not disposable to those on housing benefit) and the lower figure includes housing costs (which ensures those with high mortgage costs are excluded from the definition).

single parents, account for a further 26.4%. The remainder is split between adult households and households with young children.

Fuel poverty arises as a result of the interaction of three factors. The first is low income. The second is poor energy efficiency in the fabric and heating systems of the dwelling. The third is the size of the dwelling compared to the number of occupants. Many older people continue to live in a family home that is much larger then their needs and requires. The larger a property the more it costs to heat adequately.

The government has announced it plans to eliminate fuel poverty amongst vuknerable householdsby 2010[6], largely by improving the energy efficiency of that part of the housing stock. It is important to note that increases in fuel prices, whether by taxation or by changes in world prices, will significantly increase the numbers in fuel poverty. Any increases in fuel prices are also highly regressive. The *average* household expenditure on fuel (excluding transport) has fallen to 3.3% of total expenditure (from 5.1% in 1988). Currently the poorest 10% of households spend 9.9% of income on fuel, and the richest 10% spend about 2%.

Housing Stock

The rate of new house building varies with economic cycles, but averages about 180,000 new dwellings per year. There are also around 20,000 demolitions per year. Since the existing stock is 24 million the annual additions represent an increase of less than 1% and the demolitions a decrement less than 0.1%. The time for renewing the stock of dwellings is thus somewhere between 100 and 1000 years. This is therefore one of the slowest changing stocks of capital that plays a major role in energy consumption. Between 2000 and 2010 there will be about 2m new homes added to the housing stock, which is roughly the forecast increase in number of households.

The energy efficiency of housing has been significantly increased by improvements in the Building Regulations (Part L) over the last twenty years. The space heating energy use for a 3-bedroom semi-detached house (with well controlled gas central heating) of various vintages is shown in Table 2.2 below[7]. Note that the average SAP energy rating for UK housing is about 42.

[6] The UK Fuel Poverty Strategy: Consultation Paper, DETR Feb 2001
[7] Calculations done using NHER Builder, based on BREDEM-12, and a gas price of 1.2 p/kWh.

Table 2.2 Space heating requirements for 3-bed semi-detached house.

	SAP energy rating	Space heating (GJ/a)	Cost of heating (£/yr)	Carbon emissns[8] (t/yr)
Solid wall property (pre 1930)	35	105	350	2.0
1965 Regulations	55	60	200	1.3
1982 Regulations	65	40	135	1.0
1995 Regulations *(current)*	**78**	**32**	**110**	**0.8**
Proposed new Regulations. Phase 1	91	20	70	0.6
Phase 2	95	16	55	0.5
5 years ahead	110	10	30	0.3
NHER 10 includes condensing boiler	100	13	45	0.4

The last rows in Table 2.2 above indicate that space heating requirements can be reduced significantly further than the current Building Regulation standard with substantial savings in running costs, energy use and carbon emissions. The proposals for improving the Regulations are awaiting implementation and include proposals for improved standards 18 months and five years ahead. Providing advance notice of improvements has been welcomed by the industry.

The NHER 10 standard shown in the final row is currently compulsory for all new housing in Milton Keynes and English Partnerships (the controlling land-owner) are considering extending this to other new towns. It is a standard that all the volume builders can meet without any significant additional cost[9]. The NHER 10 standard is similar to the standard of the current Danish Building Regulations.

Houses with cavity walls (most properties post 1930) can be brought up to a standard close to the current Building Regulations or better by cost effective insulation measures and renovation of the heating system at the point of renewal (a condensing boiler can compensate for the lack of floor insulation).

This is not the case for solid wall dwellings, of which there are about 6 million. Either internal drylining or external cladding can insulate solid walls. Drylining reduces the internal space, which in smaller properties is unacceptable. It also requires complete redecoration of the property and is therefore only considered as part of a wholesale renovation scheme. External cladding is less disruptive, but changes the external appearance of the dwelling significantly. External cladding also improves the weatherproofing of the dwelling, but is the more expensive option. It has been estimated that about 4m of the 6m solid wall dwellings could be externally clad, at an average cost

[8] This is the carbon emissions from space and water heating as calculated within the SAP routine
[9] The Building Regulations consultation document estimates that the additional cost for the Phase 1 improvements to be between £500 and £800 per (semi-detached) dwelling with an additional £400 to £600 for achieving the phase 2 standards. This compares with construction costs in the range £50,000 to £80,000.

of £2350[10] per dwelling. The government will not meet its fuel poverty objectives without tackling solid wall properties.

Trends in Energy efficiency

The UK housing stock[11] has been significantly improved since 1970 by the addition of insulation, particularly loft insulation and double glazing, the increased ownership of central heating and the improvements in heating system efficiency. Ownership of loft insulation has increased from about 40% in 1970 to over 90%[12], although only 50% have 100mm or more. The economic optimum thickness is between 150mm and 200mm. Ownership of cavity wall insulation has increased from about 2% in 1970 to about 25%[13]. The ownership of double-glazing has increased from under 10% to over 60% in the same period.

There have been two major changes affecting heating system efficiency. The first was the switch from coal fires with efficiencies of about 25% to gas heating systems with efficiencies of 65%. The second is the significant improvement in gas boiler efficiencies following the introduction of the European Directive on boiler efficiency. Modern gas boilers have seasonal efficiencies in excess of 75% with condensing boilers achieving 85-90%.

L.Shorrock at BRE has recently analysed effect of government grant schemes on the take up of insulation measures. The position regarding loft insulation is summarised in Figure 2.1 below. Shorrock's[15] analysis of the data shows that grants dominated the acquisition of loft insulation prior to 1988. Since 1988 grants have had much less of an effect, in part because the ownership has approached saturation. Shorrock also estimates free-riders from the data, though to do so he has to make strong assumptions about the industries involved and the homogeneity of the market, both of which can be criticised. His data also excludes the impact of HECA and the HECAction schemes run by Local Authorities using grants from the EST (from 1995 onwards). These schemes will have promoted all
Figure 2.1. Acquisition of loft insulation and grants. The dark grey area shows the acquisitions supported by grants and the light area those not supported by grants
the measures analysed by Shorrock with significant discounts due to bulk purchase (not direct grants).

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[10] Cost taken from "A realistic strategy for reducing greenhouse gas emissions in the period 2000 to 2010 using improvements in energy end-use fficiency", Association for Conservation of Energy and Energy-Environment Research Group, Imperial College. October 1997 p.19

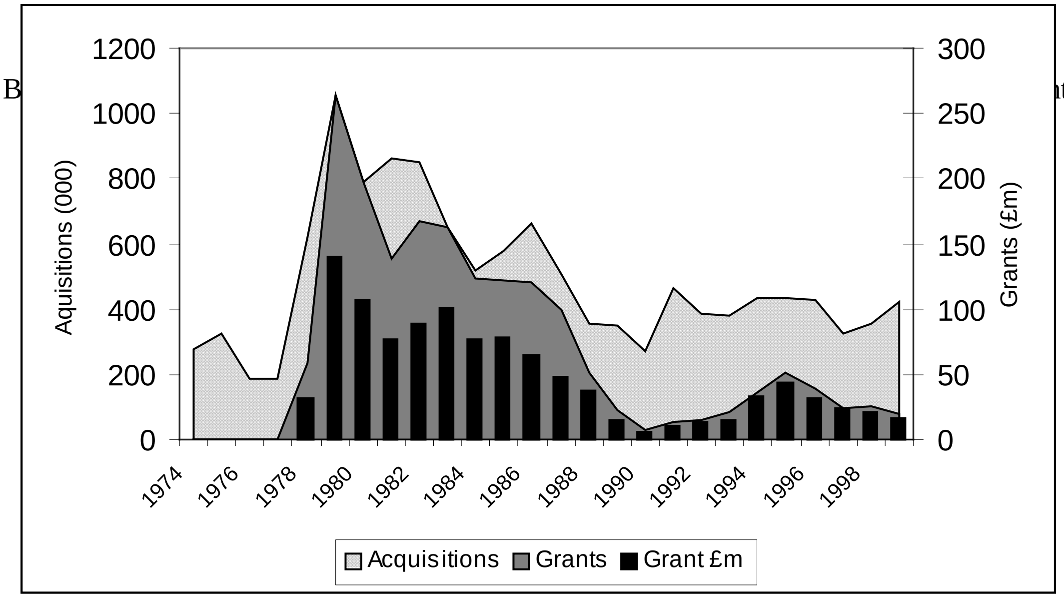
[11] All data on stock characteristics have been obtained from the BRE Domestic Energy Fact File series of publications.

[12] Note that this is a percentage of properties with accessible loft spaces.

[13] The percentage is of properties which have cavity walls that can be filled.

[14] However when double-glazing is selected over single glazing for windows which require replacement the payback time is far more attractive, 5-10 years.

[15] The initial analysis of loft insulation is presented in Shorrock, L.D. "An analysis of the effect of government grants on the uptake of home insulation measures", *Energy Policy* **27** (2000) p 155-171. Further analysis using later data and extensions to include cavity fill and condensing boilers are covered in a report to J.Penman, Global Atmosphere Division, DETR dated Feb 2001.



The analysis of the effect of grants on cavity wall insulation (CWI) and condensing boilers is less clear cut since grants for these have not been operating for as long. Nevertheless there is a strong effect with CWI acquisitions taking off significantly following the introduction of grants in 1994/95. The analysis of loft insulation shows that for every £1m spent on grants there were about 4100 additional acquisitions made. For CWI each £1m spent increases take up by 3400, and for condensing boilers the additional take up is 1790 boilers.

The analysis shows that the grant expenditures on loft insulation have been cost effective. The housing stock energy use is some 92PJ/yr. less, corresponding to 1.6MtC/yr. Cumulatively the grants have saved about 1490 PJ, 27 MtC and £8.7bn in fuel expenditure (these figures reduce to 900PJ, 16 MtC and £5.2bn when allowing for free-riders). The savings clearly outweigh the cost of the grants (£1.1bn) and produce a net cost per tonne of carbon saved of -£280/tC (-£253/tC with free riders). The position with CWI and condensing boilers is less positive since the grants have been operating for a much shorter period and the savings do not yet outweigh the expenditure.

It should be noted that the analysis also implies that without incentives it would take about 33 years before all lofts were adequately insulated and 72 years before all cavity walls were insulated.[16]

Shorrock has also analysed the factors that have influenced energy consumption and carbon emissions in the domestic sector for the period 1990-2000.[17] As noted in the Climate Change Programme (CCP) [18] the domestic sector has reduced its carbon emissions by 5.1MtC (8.4%) in this period. Shorrock's analysis shows that this is due to the interaction of several different factors. There have been *increases* in carbon emissions caused by increased number of households (3.6MtC), improved levels of comfort/service (5.2MtC) and changes in external temperature (3.8MtC). There have also been *decreases*

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[16] These estimates are surprisingly similar to those made in Danskin, H "SARUs Energy Demand Model", *Futures* December 1979 p 491-509
[17] Shorrock, L.D. Identifying the individual components of UK domestic sector carbon emission changes between 1990 and 2000", *Energy Policy* **28** (2000) p.193-200
[18] "Climate Change. The UK Programme", DETR Nov 2000

in carbon emissions due to improved insulation (4.1MtC), improved efficiency (4.3MtC) and reduced carbon intensity in the electricity supply industry (ESI) (8.5MtC) and other carbon changes (1.0MtC). It is important to note that energy efficiency improvements contributed as much as the changes in the ESI to the reduced carbon emissions.

The improvements in the ESI are expected to continue to 2010 but at a slower rate than for the period 1990-2000. The growth in the number of households is expected to continue, despite a stabilising population. This trend will increase the demand for dwellings and energy significantly. Improvements in insulation and efficiency could continue, their rate will be determined mostly by the level of government intervention (as indicated by Shorrock's analysis of the historical data).

Technical and Economic Potential

The estimates of the technical potential for improving energy efficiency used below consider only technologies that are currently commercially available. The estimate takes into account the number of suitable properties for each measure. . The estimates do not take into account any increase in the numbers of households, increases in the ownership of appliances or increases in levels of service required. The estimates do not include

(a) floor insulation which can be applied when suspended timber floors are replaced or refurbished. With approximately 9m dwellings with suspended floors and a saving from floor insulation of 0.08toe this corresponds to a large potential.
(b) flat roof insulation which can be applied externally or when the roof is refurbished (which usually occurs every ten years). There are approximately 2m dwellings with flat roofs. The saving per dwelling is about 0.14toe, so the overall potential is a further 0.28Mtoe.
(c) micro-CHP. This technology is currently in field trials and could substantially reduce carbon emissions by local generation of electricity at a very high effective efficiency.

The table below summarises the results from a number of sources, all of which have used slightly different criteria for estimating the potential. The BRE estimate is a technical potential estimate[19]. The NES data refers to a study of "new" energy efficiency technologies not yet regarded as economic but with substantial potential for energy and carbon savings.[20] The ACE, EST and ECU estimates are all based on economic potential by 2010. They are included for comparison purposes. The ACE estimate[21] does not take into account the savings that would have occurred over the period due to natural take-up, and reduces the savings from condensing boilers to account for interactions between the measures.The EST report is based upon economic potential to 2010.[22]. The ECU data refers to the DECADE publication entitled "2MtC" and deals explicitly with lights and appliances.[23] The overall figure is an assessment of the "most reasonable" estimates made

[19] Private communication H.Danskin, DETR Background paper responding to RCEP.
[20] "Innovative Energy Efficiency Technologies for UK Housing", Report to BRE, NES 1999
[21] "A realistic strategy for reducing greenhouse gas emissions in the period 2000-2010 using improvements in energy end-use efficiency". Report for EA, ACE 1997
[22] "Energy Efficiency and Environmental Benefits to 2010", EST 1997
[23] "DECADE, 2 MtC", Environmental Change Unit, Oxford 1997

and the carbon savings are based on these.[24] Note that the sum is only approximately correct since there will be interactions between the savings[25].

Table 2.3 Estimates of the potential savings (Mtoe) and reduced carbon emissions for improvements t o the domestic housing stock.

	Technical Potential		**Economic potential to 2010**			**Overall Technical Potential**	
Measure	BRE	NES	ACE	EST	ECU	Mtoe	MtC
Loft insulation	1.71		1.06	0.6		1.7	1.38
Cavity wall insulation	3.17		3.03	2.3		3.2	2.59
Solid wall insulation	3.35	2.7	3.56			3.4	2.75
Double glazing(+low E)	2.13		0.72	1.3		2.1	1.70
Draught proofing	0.41		1.15			0.4	0.32
H/W cylinder insulation	0.29		0.1	0.5		0.4	0.32
Condensing boilers	6.51		0.82	1.5		6.5	5.26
Energy efficient lighting	0.51		0.58	0.4	0.87	0.6	1.13
Energy efficient appliances.	1.93		1.06	0.5	1.59	1.9	3.56
Controls				0.5		0.5	0.40
Solar water heating	2	2				2.0	1.62
Ground source HP†		2.8				2.8	5.25
High performance glazing*		1.5				1.5	1.21
Total						**27.0**	**27.50**

† Replaceing some electric storage heating only
*U-value of 0.9 or less

The total potential for carbon saving represents 64% of the domestic sector emissions in 1990. Although there may be disagreements concerning some of the detail there is a broad consensus that currently available technology can reduce the carbon emissions in the domestic sector by at least 50%[26]. This estimate does not include any comfort factor or rebound effect, though that is likely to be small over the period required to achieve the full potential savings[27].

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24 Using 0.809 tC per toe saved (based on the average domestic heating fuel mix) and 1.876 tC per toe of electricity saved.

25 The savings from all insulation measures exceeds the sum of the components due to increases in internal temperature. The savings from heating are reduced once the dwelling is insulated. However energy efficient lights and appliances increases space heating requirements. Applying all the measures to a single property results in energy savings 5% less, and carbon savings about 10% less, than the sum of the components

26 For example IPCC Working Group III, 3rd Assessment Report (March 2001) estimates that the potential savings by 2020 in all buildings, including appliances, is between 60% and 66%.

27 See Appendix 1 for a discussion of the degree to which savings are taken back by consumers, referred to as the ‘comfort take’ or the ‘rebound effect’.

The technologies documented in table 2.3 that do not meet a five-year payback period are solid wall insulation, solar water heating, ground source heat-pumps and high performance windows. Some analysts question whether draught proofing is cost-effective and others question whether heating controls upgrades achieve the assumed savings. Excluding all these technologies the economic potential is 16.4 Mtoe (35%) and 15.9 MtC (37%). This agrees with the general consensus that the cost-effective potential is 30% or more.

It is unreasonable to assume that all these savings could be achieved within the next decade and this explains why some of the estimates by ACE, EST and ECU are less than the potential figures. The EST figures, which total 7.6 Mtoe (and saves 7.1MtC), are based upon a detailed appraisal of reasonable rates of installation over the period 1997-2010. Using the BREHOMES model Shorrock and Dunster[28] have demonstrated savings of 5 MtC by 2010 with further savings to 2015. The BREHOMES model takes into account factors such as the increase in number of households, ownership of appliances and so on that increase consumption. The forecast increase in consumption under BAU assumptions is 0.65MtC. It also takes into account trends in lights and appliances from the DECADE project[29], though since the policies assumed by that report have not yet been implemented the savings forecast could not now be achieved.

The CCP itself indicates that savings of between 4.5 and 6.0 MtC are achievable between 2000 and 2010 in the domestic sector. Without additional measures carbon emissions in the sector are expected to fall by 1.2 MtC. The policies specified for delivering the additional savings are

the Energy Efficiency Commitment (EEC formally EESoPs)	2.6 – 3.7 MtC
the new HEES	0.2 MtC
more efficient lights and appliances	0.2 – 0.4 MtC
new Building Regulations	0.9 MtC
and improvements to community heating	0.9 MtC

HEES and the part of EEC focussed on disadvantaged households(currently 50%) will not produce significant carbon savings in the short term since most of the benefit will be taken in improved comfort[30]. There is no commitment to EEC beyond 2005 and the assumed emissions reductions from in community heating are hard to justify. The CCP therefore appears to have an optimistic forecast of achievable savings based on current policies.

Overall there is a consensus that savings of about 5MtC are achievable in the domestic sector by 2010, but that this will not be achieved without additional policies.

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[28] Shorrock, L.D. and Dunster, J.E. "The physically based model BREHOMES and its use in deriving scenarios for the energy use and carbon dioxide emissions of the UK housing stock", *Energy Policy*, **25**(12) (1997) p.1027-1037

[29] see for example DECADE; 2 MtC by B.Boardman et al. Energy and environment Programme, Environmental Change Unit, University of Oxford. 1997

[30] See Appendix 1

Longer-term issues

Although new housing does not make a large impact in the next decade, it will be very significant in the next 50 years. Housing is the slowest changing capital stock that has a major influence on energy use. It is therefore crucial that new housing is built to much higher standards and incorporates measures that are extremely difficult to implement retrospectively, such as floor insulation. The proposals for new Building Regulations achieve these objectives and do so over a five year time period. They should be implemented as soon as possible. The case for applying some type of minimum standards to existing homes through Regulations could also be explored further.

The government will not achieve its fuel poverty targets, nor be able to upgrade a large proportion of the housing stock, without finding a method of improving the thermal performance of solid walls. Present systems are not cost effective and are either very disruptive or significantly change the appearance of the building.

Solar water heating, ground source heat-pumps and high performance windows are all potentially important technologies, all are widely used in other countries and all have a significant potential in the UK. However without some assistance[31] they are unlikely to generate enough business to achieve the necessary cost reductions.

The continuing decline in number of people per household is driving energy consumption per capita upwards. There needs to be a review of ways in which this might be mitigated.

The fastest growing area of energy use in the domestic sector is electricity use in lights and appliances. There is a very large potential for improvement in the energy efficiency of appliances, and in producing appliances that suit smaller households. This potential will not be achieved without intervention, and the most cost-effective intervention is at the design stage.

Micro-CHP, effectively the generation of electricity by domestic gas boilers, is not yet available commercially, but soon will be. It has a large potential for reducing carbon emissions provided that both regulations and systems accommodate distributed generation of electricity.

The government has taken the view that significantly increasing the cost of domestic fuels, to take account of the climate change externality, is not an option at present. Under these circumstances it needs to pursue other policies with considerable vigour to achieve the same level of carbon reductions that would be generated by the economic level of carbon taxation.

[31] Note that high-performance windows and heat-pumps were both successful outcomes of Sweden's technology procurement programme.

2.3 Commercial and Service Sector

Business energy use can be broken down and analysed in many different ways. One of the core divisions is between buildings and industrial processes. These energy uses have very different drivers, respond to different policies and have markedly different historical trends. However the available statistics on industrial energy use do not support an analysis on this basis so this paper uses the standard distinctions between Industrial, Commercial and Public Services.

Almost half the energy used in the UK is used in buildings, they also account for almost half of all CO_2 emitted. Domestic buildings account for 28% of energy use, non-domestic buildings for a further 17%[32]. Whilst domestic buildings account for 23% of greenhouse gas emissions the non-domestic stock accounts for 19%.

The energy use in all non-domestic buildings peaked in 1973 and has been fairly steady since 1980. Over the period there has been a significant substitution between fuels with declines in the use of oil and coal and growth in the use of electricity and gas. The overall effect has been a significant decline in carbon emissions for the entire non-domestic building stock, as illustrated below.

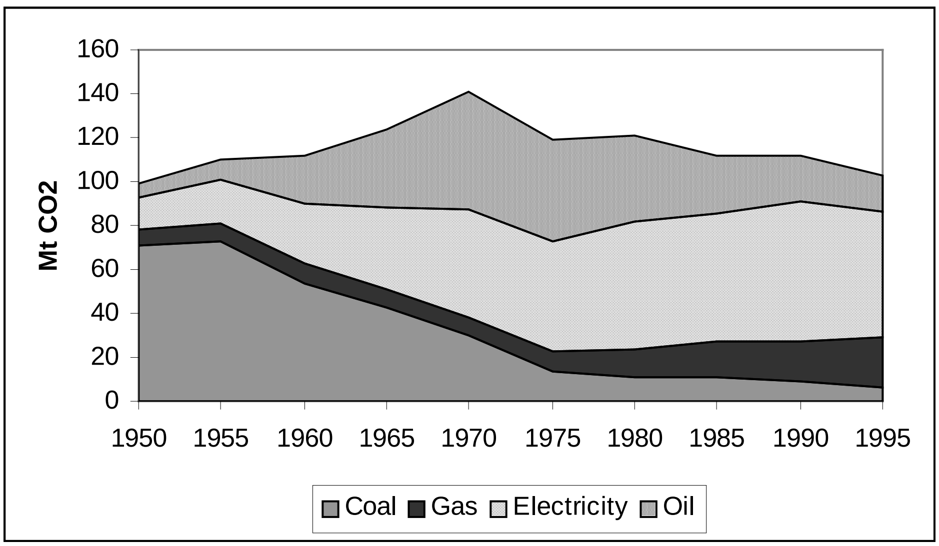

Figure 2.2. Trend in CO_2 emissions for the non-domestic building stock

The service sector includes both the commercial sector and public services and accounts for about 80% of energy use in non-domestic buildings, the balance occurring in industrial buildings. The trend in energy use in the services sector shows growth since 1950 with short declines at each downturn in the business cycle. The trend in carbon emissions from the service sector alone is fairly constant until the decline in the carbon intensity of the electricity supply industry from 1990 onwards. The services sector alone shows a much faster rate of growth in the use of electricity.

[32] Most of the data on the non-domestic stock has been obtained from "Non-Domestic Building Fact File", BRE, 1998 by C.H.Pout, S.A. Moss and P.J. Davidson.

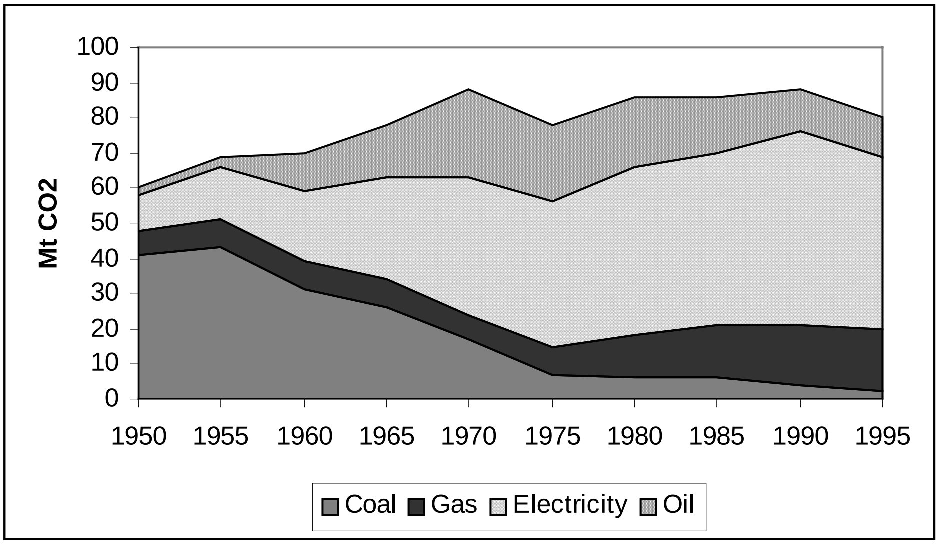

Figure 2.3 Trend in CO_2 emissions for the service sector.

Since 1970 the total floor area of offices has doubled, of retail outlets has increased by 54% and of warehouses has more than doubled. Since the total delivered energy has been more or less constant over the period there has been a corresponding improvement in energy efficiency. This has been driven by similar factors to those applying in the domestic sector, namely improved building regulations and improved heating efficiency due to switching from coal to gas.

The pattern of energy use varies considerably, as one would expect for a sector covering offices, schools, shops, warehouses, hotels, hospitals and leisure centres. For the service sector as a whole space heating accounted for 54% of energy use, water heating 9%, catering 6%, lighting 15%, cooling 6%, IT equipment 3% and all other uses 7%. For carbon emissions the proportion for lighting, cooling and IT equipment are larger since they use electricity. The table below sets out the proportions in sub-categories of the services sector.

Table 2.4. End-uses of energy by sub-sector [33]

End-use	Offices	Warehouses	Hotels	Education
Heating	47.4	28.1	46.5	73.3
Hot-water	5.0	4.3	21.4	5.5
Catering	5.6	1.4	17.6	6.6
Lighting	14.9	21.0	6.3	8.8
Cooling	10.2	30.9	2.5	
Small power	1.9	2.9	3.8	2.2
IT equipment	10.2	2.8	0.1	
Other	4.9	8.6	1.9	3.3

[33] Energy Consumption in the United Kingdom, Energy Paper 66, DTI December 1997

The averages for the sub-sectors also hide a very large variation in specific energy use within each sub-sector. For example in the retail sub-sector whilst a DIY supermarket uses more than 75% of its energy in space heating, clothing shops use just over 50%, with almost all the rest devoted to lighting and a chemist shop uses less than 25% for space heating with more than 75% in lighting. Similar variations are found between different office types.

There is also a large variation in the energy use per square metre across the whole sector and within sub-sectors. For example within the Offices sub-sector the measured range of energy use varies from 0.2 GJ/^{m2}/yr to 3.0 GJ/^{m2}/yr.[34]. This range reflects both a wide range of buildings, from converted houses to custom built head-office complexes, and a wide range in energy efficiency, both in fabric insulation and service efficiency. It has been suggested that adopting best practice management practices within offices can make substantial savings.[35] Similar ranges of energy use per square metre are found in other sub-sectors, as illustrated in Figure 2.4, below.

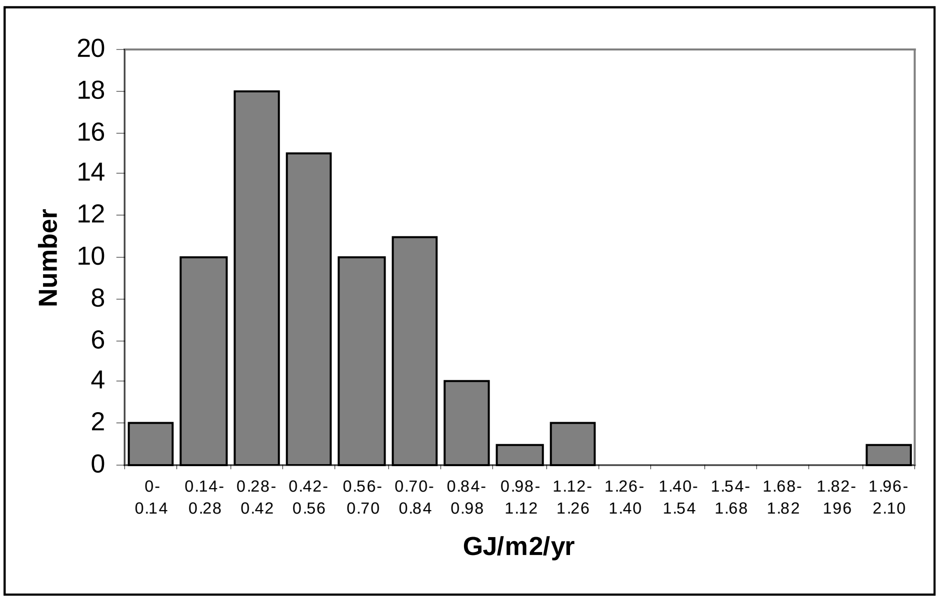

Figure 2.4. Frequency distribution of specific energy use for retail properties[36]

Energy Efficiency Technologies

There are three broad areas in which energy efficiency could be improved within the non-domestic building sector. These are improvements to the building fabric and its heating and cooling equipment, improvements to lighting and improvements in general office equipment.

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[34] Mortimer,N.D, Elsayed, M.A. and Grant, J.F. “Patterns of energy use in non-domestic buildings”, *Environment and Planning.B Planning and Design* **27** (2000) 709-720

[35] See “Energy use in Offices”, Energy Consumption Guide 19, DETR 1998

[36] Mortimer, N.D, Ashley, A, Elsayad,M, Kelly, M.D and Rix, J.H.R. “Developing a database of energy use in the UK non-domestic building stock” *Energy Policy* **27** (1999) 451-468

Building fabric insulation is not as important in the non-domestic sector for several reasons. First the built form of many offices precludes items such as loft insulation and cavity fill. Second a much larger proportion of the external envelope is usually glazed. Third the largest single heat loss from non-domestic buildings is usually through ventilation.

Non-domestic heating systems are generally larger and longer lived than their domestic equivalents. Historically there has not been much attention paid to heating efficiency, instead the emphasis has been on providing adequate service under the worst conditions. As a result many heating systems are significantly oversized and operate at relatively low annual efficiencies. There is significant scope for replacing older boilers with condensing boilers and for improving the controls both in the boiler room and in the building generally. Many smaller offices are equipped with electric heating, largely to reduce initial capital costs. Switching to gas room heaters can make significant carbon savings. Combined heat and power (CHP) is used in some commercial and public sector service buildings and provides a way to reduce carbon emissions. Its use is restricted to sites where there is a sufficiently large demand for heating, even in the summer, and for this reason is often associated with leisure facilities.

The proportion of air-conditioned buildings has risen from 2% in 1970 to 10% in 1994 – with 19% of retail outlets and 17% of offices now having air-conditioning. Particularly in offices the trend to increased use of air-conditioning is associated with deep-plan designs and increased use of IT equipment and lighting. Many air-conditioning systems run at low efficiency and in the worst cases both air-conditioning and heating systems operate at the same time.

Lighting is a major source of carbon emissions, particularly in the service sector. There are a wide range of measures that can be used to improve lighting efficiency including, improved day-lighting at the design stage, providing more local control of lighting, replacing tungsten with fluorescent lighting and replacing standard fluorescent lights with high-efficiency fluorescent lights.

Office equipment is of importance because (a) it has a very high growth rate (b) it often has low efficiency, especially when on stand-by and (c) it is a major reason for installing air-conditioning. Several schemes are available for labelling and improving the energy performance of office equipment, the most successful being the Energy Star programme in the USA (see the case study used in Section 4).

Technical and Economic Potential

There have been very few studies of the potential for energy efficiency in the commercial and services sector, in part reflecting the heterogeneity of the sector. The results described here are largely based upon those presented in a background paper prepared for the Royal Commission on Environmental Pollution by Fisher et al.[37] The analysis of the sector reported there is based upon the BRE ‘Non-Domestic Energy and Emissions Model’ (N-DEEM)[38] which is loosely based upon the BREHOMES structure. The model was used to identify 25 measures where there was sufficient data for a full cost-effectiveness analyses to be completed. In addition to these measures the Fisher study identified further savings available from CHP, office equipment (including air-conditioning) and improved housekeeping. This latter item represents savings achieved by managing building energy use better and its absence is believed to account for a significant part of the observed variations in energy use per unit floor area. The study made use of technologies currently commercially available and did not include any new technologies (such as solar PV, super-insulated windows, ground source heat pumps and so on)[39].

Table 2.5 Potential energy and carbon savings for service sector

Measure	Energy Saving (Mtoe)	Carbon saving (MtC)
25 costed energy saving measures	6.52	6.12
Office equipment (including air conditioning)	0.13	0.22
CHP use in service sector buildings	0.51	0.87
Energy management and housekeeping	1.0	1.0
Total	**8.16**	**8.21**
(1996 Service Sector energy use)	*21.1*	*23.0*
Total savings as percentage	*39%*	*36%*

The savings from CHP in the sector have been estimated as being between 0.9MtC and 3.4 MtC[40]. Using a set of 15 energy efficiency technologies Mortimer[41] has estimated the potential savings in the commercial sector as 2.8 MtC (note this estimate excludes the public service sector). It is not clear whether the measures used in the N-DEEM analysis include those made compulsory by the proposed new Building Regulations. The Building Regulation consultation document estimates savings of 0.4 MtC in the non-domestic sector for the proposed changes.

[37] Fisher,J,Blyth,W.Collings,S,Boyle,S,Wilder,J, Henderson,G and Grubb,M “Prospects for Energy Saving and Reducing Demand for Energy in the UK”, 1998. Available on http://www.rcep.org.uk/studies/energy/98-6063/fisher.html

[38] Put, C.H “N-DEEM: the national nondomestic buildings and emissions model” *Environment and Planning B: Planning & Design* **27** (2000) p 721-733

[39] Appendix B.3 of the paper identifies 13 new technologies likely to be available by 2010 and a further 6 sometime thereafter. No estimates are provided of the ultimate potential for these additional technologies. It is suggested that they could contribute 0.4 MtC by 2010.

[40] “Potential carbon savings from combined heat and power in buildings” by S.A.Moss and L.D.Shorrock, BRE IP4/96. The range corresponds to different discount rates and different fuels displaced in power stations.

[41] Mortimer,N.D, Ashlety,A, Moody, C.A.C., Rix, J.H.R. & Moss, S.A. “Carbon dioxide savings in the commercial building sector”, *Energy Policy* **26** (8) (1998) p.615-624

The Fisher paper also provides estimates of the cost-effective energy efficiency potential and the proportion of that potential it considers achievable by 2010. These are summarised in table 2.6.

Table 2.6. Economic and Realisable potential savings in Services Sector to 2010

	Economic potential		**Achievable by 2010**	
	Energy Saving (Mtoe)	Carbon saving (MtC)	Energy Saving (Mtoe)	Carbon saving (MtC)
25 costed energy saving measures	3.76	3.35	1.56	1.27
Office equipment (incl. air conditioning)	0.72	0.12	0.036	0.06
CHP use in service sector buildings	0.51	0.87	0.20	0.35
Energy management and housekeeping	0.8	0.8	0.6	0.6
Total	**5.14**	**5.14**	**2.4**	**2.28**
(1996 Service Sector energy use)	*21.1*	*23.0*	*21.1*	*23*
Total savings as percentage	*24*	*22*	*11*	*10*

Thus of the 39% energy saving potential some 24% is judged to be economic and 11% deliverable by 2010. The BAU projection for the Services sector has energy consumption increasing by 0.7% between 2000 and 2010[42]. Table 2.7 below summarises the net changes anticipated as a result of the BAU projection and Fisher analysis of energy savings but using EP68 projections (rather than EP65).

Table 2.7. Projections of energy demand and carbon emissions, service sector.

	1996 levels	2010 No measures	2010 BAU	2010 all economic	2010 all
Energy use (Mtoe)	21.1	26.8	24.4	21.7	18.6
Change (%)		*+27%*	*+15.6%*	*+3%*	*-11.8%*
Carbon emissions	23.0	26.0	23.7	20.9	17.8
Change (%)		*+13%*	*+3%*	*-10%*	*-22.6%*

This analysis indicates that on current projections the energy use in the services sector will increase to 2010, albeit slower than the historical rate of increase. The government has announced that it wishes public sector buildings to be exemplary in demonstrating energy efficiency and estimates that this will lead to 0.5 MtC savings for that sub-sector. It is relying upon the Climate Change Levy and the new Building Regulations as the policy vehicles for achieving the 2.28 MtC reductions in the sector as a whole (the savings documented in column 5 of table 2.6 and assumed to be realised in the BAU projection in column 3 of Table 2.7).

[42] Energy Paper 68. Cl and CH scenarios (see Table 4.9)

Most of the business sector policies in the UK Climate Change Programme essentially address the industrial sector. The service sector, in particular the sub-sectors in commercial services where emissions have been rising, have largely been neglected. As the price elasticity is low, the effect of the CCL will be limited in this sector. Apart from the Building Regulations there have not been any policies targeted specifically on the sector. This remains a major deficiency in the programme, and it is doubtful whether the 2.28 MtC target savings will be achieved without further policy measures. Two options for addressing the sector might be:

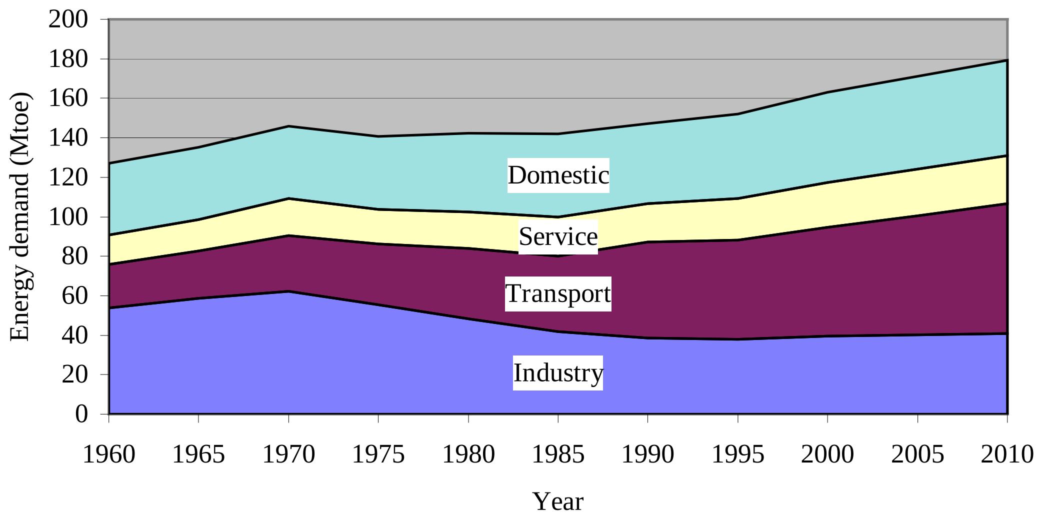
- use of obligations on energy suppliers (similar to the system of Energy Efficiency Commitments in the domestic sector), and
- agreements with (or obligations on) commercial sector landlords to improve the energy efficiency of their buildings.

2.4 Industrial Sector

2.4.1. Trends in Industrial Energy Use

Industrial energy demand has fallen continuously since the first oil crisis, quite rapidly until about 1990 and then more slowly. This has been more than offset by growth in energy demand in other sectors of the economy, most notably in transport, so that (with the exception of the 1970s) final energy demand in the economy as a whole has risen. Figure 1 shows the changes in energy demand in each of the major sectors of the economy since 1960 with projections out to 2010 based on DTI energy projections[43].

UK Final Energy demand, 1960-2010



Part of trend is the shift in economic output from manufacturing to services. But to ascribe the decline in industrial energy demand to de-industrialisation would be misleading. A breakdown of changes in industrial energy use over the period 1970-1996[44] indicates that there have been major increases in energy productivity within industry. The energy productivity of industry over this period has risen at an average rate of 3.4% per year. If the trend were to continue to 2010, **industry would achieve a factor 4 improvement in energy productivity over the period 1970-2010.**

Part of this change results from a shift between different industrial sectors (e.g. from energy intensive sectors, such as steel, towards less intensive sectors, such as food). But it is estimated that this is only 15% of the effect. The remaining 85% is due to energy productivity increases within each sector. There are two contributory factors:

[43] Department of Trade and Industry. Energy Paper 68. Energy Projection for the UK. Average of CL and CH scenarios

[44] Department of Trade and Industry. Energy Paper 66. Energy Consumption in the UK.

- shifts within sectors to higher added value products, and
- technical changes that increase energy efficiency.

The pace of energy productivity improvements has certainly slowed (and in some sectors stopped) in the 1990s[45]. This is commonly ascribed to changes in fuel prices, by both economic theory and anecdotal evidence. However, the price/demand correlation is not direct – there is no sudden change either at the point in time real fuel prices stopped rising (1982) or when the steep price reductions began (1985). Instead there is a gentle reduction in the pace of improvement, particularly in the 1990s.

What seems probable is that the oil shocks led to an expectation in industry of likely future price rises and stimulated technological change. These persisted well into the 1980s partly because the turnover of capital stock was sufficiently slow to ensure the effects took time to come through fully. Conversely, in the 1990s, the long period of falling process led to an expectation that industrial energy prices would not rise. This may have been exacerbated by the assumption of most opinion-formers that low prices are a ‘social good’, especially throughout the period of market liberalisation. In other words, the impacts of price changes can lag the price changes themselves, and expectations about future prices may also be important.

2.4.2. How Energy is Used

Energy use by sector is shown in Figure 2. Although some sectors are of key importance (notably steel and chemicals) a large number contribute significantly to overall demand. Policy needs to reflect this fragmentation. An analysis of the end use of energy in industry is summarised in Table 1.

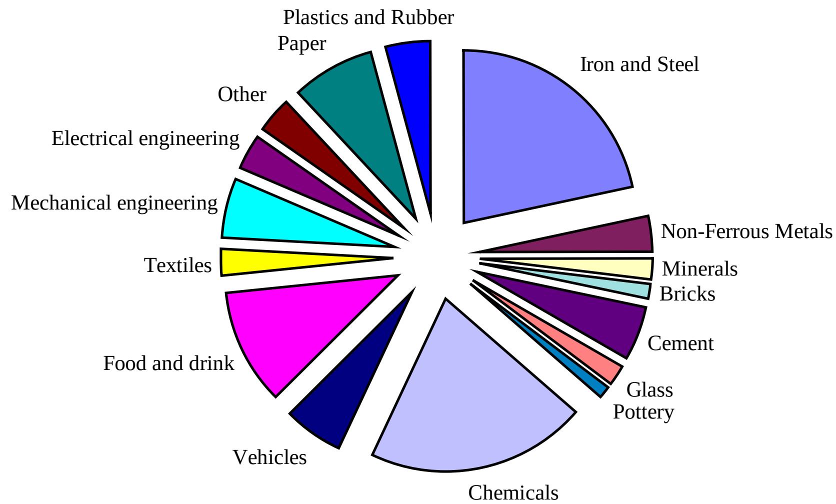
Table 1
End Use Applications of Energy in Industry

	Energy use (Mtoe/year)		
End use	Fossil fuels	Electricity	Total Energy
High temperature processes	11.2	0.8	12.0
Low temperature processes	7.9	0.6	8.5
Space heating and lighting	4.9	0.7	5.6
Motors and drives	0	4.7	4.7
Drying	2.7	0	2.7
Compressed Air	0	0.5	0.5
Refrigeration	0	0.5	0.5
Total	26.7	7.8	34.5

Figure 2

[45] ETSU. Industrial Sector Carbon Dioxide Emissions: Projections and Indicators for the UK. 1990-2020.

Industrial Energy Use by Sector, 2000



Processes are the major energy users of fossil fuels, in particular:

- high temperatures processes - largely smelting, furnaces and kilns - of which over 95% is in the metals and minerals sectors; and
- low temperature processes - steam based processes, over 75% of which is in the chemicals, food and paper sectors.

Space heating of buildings is the only other large user of (non-electric) fuels and this is largely in the light industrial sectors such as engineering.

Electricity has a smaller share of final energy demand. However, the cost, primary energy input and carbon emissions of a unit of electricity are more than double those of fossil fuels. Electricity demand is dominated by electric motors for pumps, fans and compressors, which use over 70% of industrial electricity. Lighting, aluminium smelting ,electric arc steel production and some chemical manufacturing processes are the only other large electricity users.

Key technologies fall into two broad categories: the major energy intensive processes, which are largely sector specific and energy services that are common to all sectors.

The major energy intensive processes are steel-making, primary aluminium smelting, foundries, cement kilns, bricks kilns, glass tanks, paper making, brewing, sugar factories, air separation and the manufacture of basic chemicals such as ethene, ammonia, chlorine and sulphuric acid. There are a number of common themes to energy efficiency improvement – insulation, heat recovery and improved process control. However, these are specialist processes, where energy efficiency improvement often has process and product implications. Where energy is a major factor of production, energy efficiency has historically been a major concern. In these cases major improvements will often require expensive capital replacement. Step changes tend to require major product and/or process innovation. (In the long term, more productive use of material resources may have a significant effect on demand for these processes. This will be investigated as part of future work on longer term changes.)

The main energy services are steam, hot water, space heating, lighting, motive power, compressed air and refrigeration. These are relevant across all sectors and the dominant energy consumers outside the energy intensive sectors. There are a number of important energy efficiency technologies, efficient boilers, CHP, high efficiency motors, motor speed and power controls and building energy management systems. In general, as in the domestic and service sectors, the low cost of energy compared to other inputs results in limited management attention. In many cases, low cost / no cost energy management measures (such as management systems for monitoring and targeting energy use) can yield worthwhile savings. Significant savings are generally possible at the point of capital replacement.

2.4.3. The Scope for Increased Energy Efficiency

The scope for improving energy use in manufacturing industry has been investigated over many years by the Government's contractor for the Energy Efficiency Best Practice programme, ETSU. Estimates of what might be possible by 2010 are given in Table 2[46]. Analyses like these underpin the Climate Change Levy negotiated agreements (see below).

Table 2
Projections of the Energy Efficiency Savings Potential in 2010

	Energy use (Mtoe)		Energy Savings Potential in 2010 (Mtoe)	
	Actual 1996	Projected 2010	Economic potential (industry criteria)	Technical Potential
Metals	9.2	10.2	2.2	3.2
Minerals and Ceramics	4.0	4.4	1.3	1.8
Chemicals	6.2	7.0	1.1	1.9
Food & Drink	4.2	4.7	0.7	0.8
Paper and Textiles	4.8	5.3	1.4	2.4
Engineering and Other	8.5	11.3	1.9	3.3
Total (% of 2010 total)	**36.9**	**42.9**	**8.6 (20%)**	**13.2 (31%)**

[46] Fisher,J., Blyth,W., Collings,S., Boyle,S., Wilder,J., Henderson,G. and Grubb,M. "Prospects for Energy Saving and Reducing Demand for Energy in the UK", 1998 http://www.rcep.org.uk/studies/energy/98-6063/fisher.html

Over the 14 year period, 1996-2010, there is a 20% potential for reduction, even using the criteria commonly used by industry for discretionary cost saving investments of this type (a simple payback period of 2-4 years). Under criteria more typical for public sector decision making, the number is 25% and the technical potential is over 30%. It should be noted that these are in addition to what is expected to be achieved under business as usual conditions.

There are differences between sectors; for example, the potential is lower in the chemicals sector where there have already been substantial efforts. However, there remains significant scope for improvements in all sectors, even without radical product or process change.

The existence of this 'energy efficiency gap' is the basis of much of the Government's Climate Change Programme for the business sector, as it provides much of the scope for win-win options in the medium term to address climate change. Similar analyses have been undertaken in other countries, with similar results, so that the existence of 'no regrets' policies for combating climate change is now established internationally[47].

This significant scope for cost saving may seem counter-intuitive to people unfamiliar with resource productivity issues. However, for energy use in particular, the issues have been thoroughly examined. There is no serious doubt that business decision-making processes lead to energy efficiency that sub-optimal by normal economic criteria. These are sometimes characterised as barriers to energy efficiency. The issue is examined in more detail in the next section. Addressing this economic potential is a critical issue for medium term policy.

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[47] http://www.ipcc.ch/pub/sarsum3.htm

[48] HM Treasury. Economic Instruments and the Business Use of Energy. A Report by Lord Marshall, 1998.

[49] http://www.environment.detr.gov.uk/ccl/index.htm

[50] http://www.hm-treasury.gov.uk/pub/html/prebudgetNov98/marshall.pdf

[51] Department of Trade and Industry. Shaping Change. The Energy Report, 1997.

[52] http://www.environment.detr.gov.uk/ccl/index.htm

[53] ETSU, 1999 Energy Technology Support Unit. Industrial Sector Carbon Dioxide Emissions: Projections and Indicators for the UK, 1990-2020.

[54] Department of the Environment, Transport and the Regions, 2000. UK Climate Change Programme.

3. Frameworks for making decisions regarding energy efficiency

> "For both firms and consumers, there is abundant evidence that highly profitable energy saving opportunities exist, yet the technologies embodying these opportunities have not spread universally throughout the economy. … The neo-classical profit-maximising firm … should invest in all projects having a positive net present value, using a discount rate for each project suitable to that project's riskiness. Yet undeniable evidence exists that some energy saving investments, using proven, low-risk technologies, show rates of return well in excess of 30% or more. Why have such improvements not been adopted by all firms."[55]

This quotation poses a question that has been the subject of many academic debates over the last decade. There have been many disagreements between technologists and economists on the key concepts to be used in understanding the issues and hence devising ways of overcoming the "efficiency gap". This is clearly a crucial issue if the energy efficiency potentials identified in the previous section are to be realised and provides the focus of this section.

The approach adopted is to start by questioning the assumptions that are made in formulating the issue in terms of an efficiency gap caused by barriers. Although the arguments between technologists and economists have improved both mutual understanding and each other's models of the world, there are also assumptions that they share and therefore do not question. Examining these shared assumptions leads to a broader concept of the range of influences on consumer and organisational decision making in this area. This provides the basis for a more holistic and systemic framework within which to examine the theories regarding barriers and decision making in the domestic and business sectors.

3.1 Developing a framework

Different ways of formulating a question invite one to make a certain set of assumptions and to adopt a particular perspective, sometimes a particular theoretical position. The idea that low adoption of cost-effective energy efficiency measures is due to the existence of barriers presumes that the actors involved are motivated, primarily or solely, by cost savings. As such it frames the question in terms of costs and savings and invites a certain kind of model of the behaviour of the actors involved. But what if cost savings did not motivate the actors? When a business is assessing a new product for market it does not start out with the assumption that the product is desirable and that there are barriers to its sale – it starts by finding out what its target audience actually wants! The opportunities for adopting cost-effective energy efficiency measures are numerous and have existed for decades – they have also been widely promoted by governments as well as businesses. So

[55] DeCanio, S. "The efficiency paradox: bureaucratic and organisational barriers to profitable energy-saving investments" *Energy Policy* **26** (1998) p441-454

it seems reasonable to start by questioning the framework in which such products are axiomatically regarded as desirable and good.

One of the reasons why consumers and firms may be disinterested in saving energy and money is that energy costs are generally a very small proportion of total costs or outgoings. For the average household in the UK expenditure on fuel (excluding transport) represents 3% of household income, less than is spent on alcohol. For businesses the average energy costs are 1.6% of operating costs, and if the energy intensive industries are excluded the average falls to less than 1% of costs. These are average figures and there are important exceptions, but they do indicate that cost savings are unlikely to have a high priority because the potential savings are so small compared to other costs. At home and at work, people at not able to optimise every aspect of decision making. So although economists have models of people and businesses as maximising utility and returns on investment these assumptions do not hold for energy use. For a neo-classical economist households and firms are behaving ‘irrationally’, although their behaviour is quite understandable.

Not only are energy costs small, for most actors energy itself is unseen – it is outside their way of perceiving the world. Technologists lose sight of the fact that energy is an abstract concept with which they have become familiar through years of professional training. To a householder or business manager there is very little relationship between the purchase of appliances and the direct debit used to pay the utility bills. What is more the householder is not actually interested in purchasing energy, nor even fuel, but really wants warmth, lighting, hot water and hot food. If energy is hard to perceive energy efficiency is invisible. Engineers and scientists have a deeply ingrained positive valuation of high efficiency and presume that this value is shared by others, but it is not. To an engineer it is a mixture of incompetence, stupidity and perverseness to have a system operating at anything but maximum efficiency – but to most people energy efficiency is not only unimportant, it is invisible and not fully understood.

Thus both the economic and technological assumptions made about what motivates people are inadequate. This is why both groups will agree that there must be barriers preventing the ‘rational’ behaviour their models presume. The fact that they are trying to correct different models explains why they vehemently disagree about the relative importance of types of barriers. In neither group is there recognition of the failure of deeply rooted assumptions and the consequent shortcomings of their own models of household and business decision making. The fact that the models are based on flawed assumptions does not mean that they cease to be useful models; almost all engineering is still done using Newtonian mechanics even though it is known to be based on incorrect assumptions about space, time and mass!

All models are representations of a far more complex reality and are useful precisely because they simplify the complexity. A common error amongst professionals who use detailed models on a daily basis is to confuse the model with reality, the map with the territory. Although this is an easy concept to understand it is much harder to remember in practice. Within the literature of energy barriers there are statements to the effect that 'since apparently cost-effective measures are not being adopted there must be hidden costs operating'. Whilst such tautologies do not further understanding, there are significant benefits to be gained by examining the barriers that have been proposed – namely they highlight ways in which policy may be able to influence the situation. A key concern of Government is to ensure that resources, both its own and those of the private sector, are used as efficiently as possible. There is therefore a strong culture within Government to justify policies in terms of neo-classical economics, the language of barriers and market failures is essential in this process.

The assumptions made by economists and technologists about personal motivation have been shown to be inadequate. Others have made the same observation[56] and pointed out that it is necessary to take account of the cultural, historical, social and organisational settings within which people decide and act. Indeed it is essential to appreciate the cognitive context within which other people operate and be willing to recognise that it has its own rationality.

There are many examples of apparently "irrational" or "perverse" behaviours which have dogged energy conservation for years which, when viewed from this perspective are actually nothing of the sort. You are invited to examine your own favourite examples of supposedly "irrational" behaviour. Here is a selection of examples from our own experience

- The ownership level of double-glazing (DG) is very much higher than that of cavity wall insulation (CWI). From an energy conservation perspective this appears perverse since the payback time for CWI is 2 to 5 years whereas the payback time for DG is generally in excess of 100 years. The assumption of perversity lies in the mistaken belief that people purchase DG to save energy. They don't. They purchase it mainly because many of their friends have already done so and claim it is a really good thing. They do so because it solves condensation problems, reduces draughts and makes sitting close to the windows more comfortable. They may justify their purchase by pointing to the increase in value of their property and reduced fuel bills – but these are post hoc justifications that are separate from the decision to purchase.
- Many plumbers and heating installers fail to recommend condensing boilers, even though when installed instead of a non-condensing boiler the additional cost is repaid within a year or two. The installers claim that the condensing boilers are less reliable, do not have a significantly higher efficiency and to work properly need larger radiators. But these (false arguments) are largely justifications for a culture among installers that simply does not accept these boilers. It is as much a question of fashion as anything else. If you are an installer who favours condensing boilers your peer group pokes fun at you. And because fewer of them are sold the wholesaler does not provide such good discounts, so there is less profit to you as installer for recommending them. So the majority of installers do not attend the free training courses available for installing condensing boilers, so when these boilers are installed it is not done correctly – which neatly reinforces the culture that these boilers are unreliable and more trouble than they are worth.

[56] See for example Shove, E "Gaps barriers and conceptual chasms: theories of technology transfer and energy in buildings" *Energy Policy* **26**(15) (1998) p.1105-1112.

- Milton Keynes Development Corporation organised an exhibition of "energy efficient" homes at a large site known as "Energy World". Builders employed architects (itself a major innovation) to come up with new energy efficient designs for the exhibition. Almost all the designs included conservatories or sun-spaces. Since many of them were heated the net effect was a significant increase in energy use per square metre of heated space (the insulation of conservatories is appalling compared to even badly built brick walls). From an architectural perspective sun-spaces introduced a fascinating new area into the dwelling, both in terms of external appearance and internal environment. Within the architectural culture this was an imaginative and creative solution to the energy efficiency brief – one to which most architects still subscribe.
- As the Managing Director of a small energy efficiency software and consultancy business I only once did anything to improve the energy efficiency of the premises we occupied – and that was to stop the offices becoming unbearably hot in mild weather. The rest of the time I was completely overwhelmed with demands to solve staff problems, prepare business plans, see clients, develop new products, resolve difficult complaints, prepare tenders and give presentations about the company and its products. In short as a businessman I did what all other businessmen do, I totally ignored insignificant cost items and paid attention to the factors that determined the future of the business.
- One of the products I devised for the business was an Energy Cost Guarantee (ECG). The ECG guaranteed that a household's fuel bills would not exceed a specified level, if that level were exceeded then a cash refund equal to the difference would be paid. The Guarantee was designed to help house-builders to market energy efficient homes – particularly after change in Building Regulations required a significant improvement in insulation and heating standards. The cost to the Builder was about £50 for a three-year guarantee. This scheme is operating – but at a very low level because builders refused to take on the Guarantee. There were two reasons for this. First the builders knew that energy efficiency is not a selling feature for new homes; the latest colour bathroom suite, a large patio and fitted kitchen were all more important. But this was not the main reason for their refusal. The main reason, as a number of builders privately confessed, was that they did not trust the quality of their own workmanship. They were terrified that the Guarantee would lead to claims that would point to inadequacies in insulation and heating systems that at present householders were unable to detect!
- Local authorities have frequently reduced budgets for repair and maintenance of property, even when these included highly cost-effective energy efficiency improvements. Council officers and members tend to give higher priority to spending onother things, notably visible improvements in key services that have a higher public profile.Capital spending is limited by central government, and therefore difficult choices have to be made. In this context, decision making procedures tend to produce popular, rather than economically optimal, decisions..
- An Energy Saving Trustpilot scheme to providing a cash-back for purchasers of low-emissivity glazing proved unsuccessful despite being modelled on successful similar schemes for cavity wall insulation and condensing boilers.. Subsequent analysis showed that a large part of the reason was that the scheme did not address the

> particular nature of the double glazing market. It failed to provide an incentive for the key actors - the largely self-employed double-glazing sales force. They earn money essentially by maximising sales. They are unwilling to risk losing a sale by promoting a new sort of window that is more expensive but looks exactly the same. It is the incentive to the salesperson that drives the market, rather than the potential savings to the householder or even the profits of the double glazing company.

Understanding the degree to which consumers, builders, plumbers, architects, business people, appliance manufacturers and so on are all acting rationally and consistently within their own worlds makes it clear how difficult it is to formulate policies that may be effective in any of these domains. In all cases, product purchase costs that are evident and understandable have a bigger effect than less apparently predictable possible future cost savings. This explains why the 'market barriers' tend to act in the direction of under investment in energy efficiency, not over-investment.

This, incidentally, also may help to explain the historic policy bias towards energy supply rather than demand management. One key difference is that the decision makers in the supply industries share many of the assumptions and culture with policy makers – indeed there was a period when such sharing was encouraged by secondments of staff between CEGB, AEA and DTI and Dept Energy. That sharing of culture ensured that most supply side policies would be successful.

Summary

It has been argued that both economists and technologists make incorrect assumptions regarding the motivations of households and businesses regarding energy efficiency. The fact that both models fail to account for the observed behaviour explains why they both groups subscribe to the idea of barriers to the take up of energy efficiency. In practice decisions are made in ways that are rational and consistent to the actors involved but to appreciate this it is necessary to comprehend their perspective, constraints and cognitive context. Although the models used by economists and technologists are flawed they are nonetheless useful and examination of the proposed barriers can be used to design policies to encourage the take up of energy efficiency measures.

The framework proposed here is thus one that adopts a multiple perspective approach that combines the insights from different models with an understanding of the actors involved in an issue.

3.2 Decision making in Business

Management literature contains a wealth of material on decision making in business. The following is a brief description of the main ideas drawn from this literature. Within the broad range of literature much emphasises the *necessity* of using imperfect information and less than rational procedures in reaching decisions.

- H.Simon[57] originated the theory of satisficing, or limited rationality. The main thrust of this theory is that there are limits to the number of options that can be considered and limits on the amount and accuracy of information that can be gathered. The key scarce resource is attention and theories of limited rationality are theories of the allocation of attention. It also follows that individuals pay attention to some things and thus do not attend to others. In practice decision-makers continue exploring options and gathering information until they reach a conclusion that is "good enough".
- J.G.March[58] significantly expanded the limits of rationality in decision making by pointing to other factors involved. These include the variability of preferences, the way in which goals are often developed by reflection on action (as opposed to being pre-given), the existence of conflict and political agendas within organisations, the way in which decision making arises from matching a changing set of contingent rules to a changing set of circumstances and the high level of confusion and complexity surrounding actual decision making.
- Numerous authors[59] have emphasised the plurality of organisations i.e. that they pursue a spectrum of goals, not all of which are self consistent. For example a large company may wish to maintain its market share, be seen to be technically the best, increase profits and be an exemplary employer. A smaller company may place higher value on keeping core staff, increasing market share and differentiating its products than on maximising profitability. In general it is impossible to optimise for more than one objective at a time, so the plurality of goals means some decisions will support and others undermine any particular goal. In addition to the official goals of an organisation individuals and departments within the organisation will have operative goals such as meeting their budget or increasing their staff numbers. Finally within organisations and departments there will be individuals with different goals. In the domain of energy efficiency it is well known that firms with an ambitious and accomplished energy manager achieve much better levels of energy efficiency.
- Lindblom's analysis of policy making decisions[60] (also applicable to business) lead him to identify "disjointed incrementalism" which has the following characteristics
  - Attempts at understanding are limited to policies that differ only incrementally from existing policies
  - Instead of adjusting means to ends, ends are chosen that are appropriate to available means
  - Ends and means are chosen together.
  - Problems are not solved but are repeatedly attacked
  - Analysis and policy making are remedial, they move away from ills rather than towards objectives.

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[57] see for example Simon, H.A. The new Science of Management Decision, Harper & Row 1960. In 1978 Simon received the Nobel Prize for economics for his work on limited or bounded rationality

[58] see for example March, J.G "Theories of Choice and Making Decisions", *Society*, **20**(1) (1982)

[59] see for example Perrow, C. "The analysis of goals in complex organisations", *American Sociological Review* **26** (1961) 854-856

[60] see for example Lindblom, C.E. "The policy making process", Prentice Hall 1968

- Analysis and decision making are fragmented and go on at several points simultaneously.

When dealing with businesses it is not surprising that the most common perspective on how decisions, particularly investment decisions, are taken is an economic one, this is also the most common assumption made by government policy makers. Whilst businesses of all sizes do conform to the general principles of maximising profits it is also clear that they *do not* conform exactly to the idealised model embedded in neo-classical economics. As indicated above there are profound reasons why in practice business decisions are not made entirely rationally and certainly never made with perfect knowledge in a perfect market. It is clear from the literature on energy efficiency opportunities available to business that a neo-classical economic perspective has both strengths and weaknesses.

- One strength of the economic perspective is that it does not automatically assume that energy efficiency is a universal "good" (as engineers are prone to assume). Commentators have raised the issue of whether resources other than energy are being used at optimal efficiency and the degree to which achieving high energy efficiency may impair other aspects of "optimal" resource allocation.
- A major weakness that has been pointed out is the tenacity with which some economists hold onto the ideal neo-classical model of how firms operate. This has taken two forms. The first argument is that good investment opportunities (in energy efficiency or anything else) do not exist because firms are, by definition, profit maximisers. The second is that if such opportunities do exist then there must be hidden costs or/and substantial market barriers preventing their uptake. These arguments are tautological in that the evidence for, say hidden costs, is that the investment opportunities are not being taken up. There is no way such arguments can be falsified and as such are unhelpful in understanding the situation.[61]
- A strength of the economic perspective is that, when well applied, it raises important questions of principle and evidence. For example in his critical review Sutherland[62] raises several embarrassing questions. In discussing the landlord-tenant barrier to energy efficiency he asks "Do renter occupied buildings typically contain fewer conservation features than owner occupied buildings?" When challenging the benefits of improved appliance standards in the US he points out that the "benefit is estimated as the present value of energy saved minus investment costs. The appropriate measure of benefits to consumers in the traditional economics model is consumer surplus, or net willingness to pay. … However, they provide no evidence that consumers prefer appliances with an initial higher cost but improved energy efficiency." Commenting on the advocacy of energy conservation programmes for power utilities he observes "The regulatory inefficiencies that are necessary to support utility conservation programmes are the same inefficiencies that encouraged the development and costly

[61] This argument is made at greater length in DeCanio, S. "The efficiency paradox: bureaucratic and organisational barriers to profitable energy-saving investments" *Energy Policy* **26** (1998) p441-454

[62] Sutherland, R.J "The economics of energy conservation policy", *Energy Policy* **24**(4) (1996) p.361-370

mistakes of nuclear power". These and many other similar arguments point to questions that require robust answers for any energy efficiency policy.

- However Sutherland also demonstrates another weakness in the neo-classical economic perspective, namely the assumption of, and belief in, the operation of perfect markets. Much like the tautologies associated with barriers to the take up of energy efficiency measures, many of the arguments about markets are self-sealing and do not permit any method of falsification. Fuel markets are by no means perfect and in most industrialised countries are either publicly owned or strongly regulated. (The regulation is deemed necessary to provide security of supply.) What is more the balance of power between fuel producers and consumers is firmly on the side of the producers. Thus the lack of evidence that "consumers prefer appliances with an initial higher cost but improved energy efficiency" is as likely to be a result of such appliances not being widely available and marketed as a true reflection of consumer preference in an ideally perfect market. However given the externality of climate change (not factored into energy prices) there are good reasons for presuming that policies to promote energy efficiency products and services are justifiable.
- There are schools of economic theory which have explored alternative models of how firms operate. For example the X-efficiency literature[63] regards a firm as a network of individuals linked together by flows of information and materials. In this setting bounded rationality, principal-agent problems and the lack of competitive pressure in oligopolistic markets reduces firm's effectiveness. A literature review by Button et al[64] found that the efficiency of a typical firm ranged from 65% to 97%, pointing to a substantial range of potential improvement. One study [65] found that compliance with regulations sometimes forced firms to become both more energy efficient and more financially efficient.

Appendix 2 summarises a review of the economic barriers and a classification scheme recently developed by Sorrell[66]. The review was part of a larger study that included seeking empirical evidence for the range of barriers proposed. The conclusions for the private and public sectors used in the study were that

- A major issue in all cases was constraints on staff time. This was interpreted as a hidden cost involving staff overheads. (It could also have been interpreted as reinforcing the importance of bounded rationality, particularly limited attention.)
- The second strong message was the limited access to capital. This reflects both a reluctance to borrow and the low priority given to energy efficiency within budgeting procedures.

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[63] See for example Leibenstein,H "Allocative efficiency vs. X-efficiency", *American Economic Review* **56** (1966) p.392-415 and also Frantz, R.S. "X-efficiency: Theory, Evidence and Applications", Kluwer Academic Publishers, Boston 1997. Note X-efficiency includes energy.

[64] Button, K.J and Weyman-Jones, T.G. "Ownership structure, institutional organisation and measured X-efficiency" *American Economic Review* **82**(2) (1992) p 439 - 445

[65] Porter, M.E. and van der Linde, C "Toward a new conception of the environment-competitiveness relationship" *Journal of Economic Perspectives* **9**(4) (1995) p 119-132

[66] "Barriers to energy efficiency in public and private organisations" S.Sorrell et al. SPRU (available on http://www.susx.ac.uk/spru/environmental/research/barriers.html)

- Third, there was more than one plausible explanation for the adoption of strict investment criteria, including recovery of staff costs, business risk, monitoring and control problems and financing increased gearing.
- Bounded rationality was found to be an important explanatory tool and provides an important limit on what can be achieved by correcting market and organisational failures.

One area not mentioned in the literature is that of motivation by individuals within businesses, presumably due to the presumption of profit maximisation by firms. In practice individuals and groups within a business will have a range of goals and motivations. For most senior managers motivation rests in resolving problems, meeting challenges, innovating and generally furthering the broad aims of the business (e.g. increasing market share, improving customer relations etc.) With the exception of energy managers, who exist only in large organisations with large fuel bills, there is no strong motive to even find out about energy costs, let alone reduce them by investment.

Hence a picture emerges of managers with a continuous stream of demands on their time and attention - crises, opportunities, problems, new products, budget cuts, staff issues – and with precious little time for anything other than keeping the business afloat. Cognitively she will be operating from rules of thumb, intuitions and occasional analyses. Most of their her information will come from colleagues, trade magazines and associates in the wider market. Her first priority will be to avoid disasters that threaten the business and the second will be to develop ways of growing the business. The third area of priority is to meet objectives, including budgets and profit targets. The fourth is to add enough to her own CV to be able to gain a promotion either within the company or elsewhere. The easiest way to increase profits is to increase sales (doing more of what is already being done) and the easiest way of reducing operating costs is to reduce staff (no investment required).

It should come as no surprise that most business managers do not consider energy efficiency. Within this picture what would work? The first priority must be to get the managers attention and to provide enough incentive to understand the issues and make decisions. Since the time available will be very limited success will be more likely if the options are presented in a very clear, relevant package – to which she can say “yes, do it”.

3.3 Household decisions

There has been less formal study of decision making in the household sector. However traditional sales and marketing knowledge is based upon experience in influencing decisions. Although not formulated in terms of satisficing or bounded rationality many core concepts are consistent with this view of decision making. For example developing a brand name that is well-known and trusted enables consumers to recognise products and trust their performance without lengthy research. Advertising is designed to grab one’s attention and usually deliver a very simple message (e.g. buy me!). At point of sale the public’s desire for bargains is exploited with sales, special offers, discounts and so on. In general commercial marketing to the public is based upon instant appeal, features that differentiate from the competition, generating trust and providing a bargain. In general there is very little provision of information on product performance (except where mandatory).

Fashion is an important feature of many retail markets, not just clothing. Foods go in and out of fashion, as do paint colours, magazines, music styles and holiday destinations. The power of fashion indicates the importance of group and peer opinion in reaching decisions. How one appears to ones friends and neighbours is an important part of an individual's sense of self-esteem.

When considering energy efficiency decisions it is important to distinguish between three different groups of households, namely the fuel poor, the well-off and those in between. For the fuel poor there is no realistic possibility of investing in energy efficiency due to lack of resources and access to capital. The Government recognises this and is directing grant programmes to this sector (HEES and much of EEC).

For the well off there is certainly an opportunity to invest in energy efficiency. Fuel costs are, for this group of householders between 2% and 3% of their total outgoings. This is paid by monthly direct debits and there is very little incentive to reduce such payments by, say 10%, by spending several hundred pounds. Fuel bills are already small and vary with the weather and occupancy factors, so reductions may not be visible. What is more fuel bills have reduced by 20% over the last decade and most consumers expect this trend to continue (perhaps incorrectly) .

Perhaps more importantly expenditure on energy efficiency does not give pleasure or rewards in the same way that buying holidays, new cars, new clothes, hi-fi systems, cameras and bathroom suites do. Energy efficiency is boring, invisible and usually not experienced directly. It is not fashionable and not something that people will admire you for having – indeed it is more likely to reduce one's standing.

Regarding expenditure on energy efficiency as an investment does not make it more attractive because the capital invested is lost when moving house. In a rational economic market the fuel efficiency of a property would be factored into its selling price, but this is not the case. One of the reasons why double-glazing is widely accepted is that people are willing to pay more for a property with it installed, the same is true of central heating – but not of cavity wall insulation, condensing boilers or loft insulation. So although the apparent return on the investment is high it is also certain that the capital will be lost.

If someone has overcome these difficulties and has a good reason for considering installing an energy efficiency improvement then a new set of barriers becomes apparent. Making decisions about energy efficiency expenditures have quite high risks associated with them due to

- Difficulties finding out reliable information on appliance performance and the effects of insulation measures

- Not knowing whether to go for the cheapest or most expensive quote for an appliance or work - and there are usually large differences in cost for apparently the same product
- Not trusting most of the obvious agencies including the fuel companies and sales staff (e.g. double glazing salesmen)
- Not trusting the tradespeople who will be involved in the installation. In general builders and plumbers are expected to make a mess of one's home and probably charge more for the privilege of so doing.

For the intermediate group of households, those between the fuel poor and the well off, fuel bills will currently account for between 3% and 6% of household income. For this group the household budget will usually be tight and although they would like to create more slack by saving outgoings, they do not have ready access to the necessary capital. What is more if the household does generate a surplus of a few hundred pounds there are usually a range of higher priority competing expenditures – a car repair, a new TV or a better holiday. Using a credit card to pay for the measure is not attractive since the interest charges on the loan will eat up a large proportion of the savings.

In short those who can, cant be bothered and those who are bothered can't afford to.

The situation is not much better when it comes to purchasing appliances. Generally people only replace major appliances such as fridges, washing machines and boilers when they have irrevocably broken down. In short people are forced into the purchase – and such purchases are well described as "distress purchases". In general people do not like making them. When they go to the retail showrooms they will be overwhelmed with a range of prices and features – number of wash programmes, the machine dimensions, drum capacity, temperature of the low wash cycle, spin speeds, drum capacity, pre-programme options - and a tag on the side that has a letter C among a large quantity of small print. The capital cost of the options is visible – the running costs are not. The energy-rating label cannot readily be translated into a cost in terms of £/year and so is largely ignored. [I think EST has market research data on this – I'm checking]

Clearly many of the market barriers identified in the previous section and Appendix 2 are operating here, limited access to capital, imperfect information, risk and adverse selection – all in a context dominated by harshly bounded rationality. Whilst within a neo-classical framework energy efficiency in the domestic sector appears to be in the self-interests of householders there is very little chance that it will be widely adopted for all the reasons set out above. Within this picture of household decision making what would work? As for the business sector the first and largest obstacle is to gain people's attention. Once it has been gained then a simple "buy me" message is likely to be more effective than any more complex information. If coupled with a discount, grant or cash-back then the chances of success are much higher – provided that the message and finance are provided through a trusted channel.

3.4 Barriers to the adoption of energy efficiency measures

The previous sections have argued that the most important barriers to the take up of energy efficiency measures are the ***lack of motivation*** of the actors involved coupled with the operation of ***bounded rationality***. With no motive to examine the issue and no spare attention it is not surprising that so many cost-effective opportunities are not adopted. A major component of the lack of motivation for energy efficiency is that energy costs are, for almost all actors, a small part of total costs and in many cases invisible. Most households and businesses do not know how much energy is used by the appliances they use on a daily basis. The fact that energy and energy efficiency are invisible also makes it difficult for people to understand and perceive the opportunities available to them.

It is hard to over-emphasise the importance of the operation of 'bounded rationality' or 'satisficing'. It is well documented, supported by empirical studies and is in direct opposition to the neo-classical assumptions regarding 'rational' decision-making. It manifests in people making decisions using rules of thumb and established procedures rather than researching each decision separately. It means that the people involved are already rejecting a lot of the information that is available to them, so providing additional information is unlikely to be helpful. The key to tackling this barrier is to gain the attention of the decision-makers.

Once a decision-maker's attention is on energy efficiency there are then a set of well-established economic barriers that obstruct the take-up or measures. The main barriers are;

1. **Split incentives.** This occurs whenever the costs and benefits of an investment accrue to different agents. The classic case is that of landlords and tenants, neither of who have an incentive to invest in improving the property rented. This is important in both domestic and service sectors. Another example in the domestic sector is house-builders and purchasers. Here the builder would bear the cost of the improvement and the purchaser the benefit. Within businesses split incentives occur between departments, for example where a purchasing department is not accountable for running costs.
2. **Adverse selection**. This refers to a case of asymmetric information between seller and purchaser that results in good products being driven out of the market by poorer products. Because builders/developers, surveyors and estate agents do not factor running costs into prices builders/developers are encouraged to build to the lowest possible standard, thereby undercutting homes and offices with better energy efficiency. A similar situation applies to most appliances, both domestic and commercial, because the purchaser is not provided with (and also not seeking) information on running costs.
3. **Access to capital**. The lack of access to capital is clearly a barrier in the case of fuel-poor households and public-sector managers subject to direct capital constraints. Within commercial companies capital is often rationed or less available for small investments. Organisations will impose much higher rates of return on small investments partly to offset the transaction costs (which are similar for all sized

investments) and partly due to distrust of the agents proposing the investments (this latter is also known as the ***principal-agent*** problem and can be regarded as a case of asymmetric information). Businesses are also reluctant to increase borrowing since this increases the risks associated with higher gearing. In the domestic sector it is quite hard to obtain loans of a few hundred pounds without paying very high rates of interest – which undermines any savings achieved.

4. **Imperfect information**. Within the neo-cl;assical framework lack of perfect information makes it impossible for agents to make 'rational' decisions. Where bounded rationality is operating, imperfect information is only significant if it forms part of the rule of thumb or procedure used to make a decision. In general information has 'public good' characteristics which means it is likely to be undersupplied.
5. **Credibility and Trust**. When a householder or business person receives new information its impact will largely be determined by the credibility and trust placed on the source of information. In general households and business people will distrust people who have an obvious a vested interest in the information (e.g. savings estimates from double-glazing sales people). They will also distrust a source giving advice that goes against the interests of the source e.g. fuel companies giving advice on how tom save fuel[67].
6. **Transaction Costs**. The costs of finding information, negotiating agreements and contracts and organising purchasing agreements are all examples of transaction costs usually excluded from cost-effectiveness calculations. However where these have been measured they have been found to be small, less than 10% of costs, and apply equally to purchases of high and low energy efficiency. One analysis concluded that at most transaction costs may impose a transient penalty on switching from an established supplier to a more efficient product[68].

It should be emphasised that these barriers are not exclusive, indeed it is common for several to be operating simultaneously. To succeed in increasing the adoption of energy efficiency measures policies need to address as many of these barriers as exist in any given situation,

[67] A study by Craig and McCann reported by Sorrell involved 1000 new York households being sent a pamphlet describing how to save energy. Half received the mail from the local utility and half from the state regulatory agency. The following month the households receiving the pamphlet from the agency used about 8% less electricity than those receiving the same pamphlet from the utility.

[68] Ostertag,K. "Transaction costs of raising energy efficiency", Working Paper at IEA International Workshop on Technologies to reduce greenhouse gas emissions. Washington May 1999. See http://www.iea.org/workshop/engecon/index.html.

4. Energy Productivity Policies

In section 1 we argued that the fact of climate change provided a new imperative for tackling energy productivity in both the medium and long term. In section 2 we reported the results of a wide range of studies and reports that showed that substantial improvements in energy productivity were available with current technology – and that more were in the pipeline. In section 3 we examined critically the theories used for understanding why the cost-effective potential improvements were not being adopted. The strong conclusion, reinforced by the empirical evidence of the last 20 years, is that without strong policy interventions the improvements in productivity will not be realised. This section is concerned with identifying the types of policies that are needed and how they can be most effectively implemented.

Broadly there are five types of policy intervention possible.

- Regulation. The Building Regulations, the EU Boiler Efficiency Directive, EU minimum standards for cold appliances are all examples of regulatory policies that have made substantial improvements to energy productivity.The way in which the energy sector is regulated can also be important. Whilst acknowledged to be very effective there is a political reluctance to increase the range or scope of regulations. In some cases, it may be administratively easier and politically more acceptable to use voluntary or negotiated agreements as an alternative. To be sure these will be effective, the option of regulation or other intervention is often retained.

- Taxation. Faced with such an obvious economic externality the textbook solution is to introduce a tax that effectively prices the environmental damage in the market. The Climate Change Levy and the range of similar taxes in other European countries are examples of this. However taxes can be a blunt instrument, are regressive in the domestic sector and are unpopular politically.

- Subsidy. Grants for loft insulation, cash-back schemes run by the EST and funding of demonstration schemes are all examples of the successful use of grants for promoting energy productivity.Subsidies may also be given through the tax system, for example by enhanced allowances or reduced VAT for specific investments. Such schemes are attractive to recipients but unpopular with HMTreasury – say no more!

- Information. Providing energy labels and disseminating best practice are examples of successful policies for improving energy use information. In the short and medium term the aims are to encourage better product development and to support the faster take-up of improved technology. Education has a role in improving understanding of energy and environmental issues.

- Market Transformation. Changing the structure of markets so that more efficient products and services are the norm is an important long term goal. Effective market transformation will often use a number of instruments in combination, for example regulation to eliminate the worst products on the market, information to increase consumer pressure and subsidies to promote high efficiency products. More direct Government intervention through procurement policies can also play a role. In the longer term, market transformation could also incorporate measures to support the ‘dematerialisation’[69] of many markets.

In what follows we start by examining how the framework developed in section can explain (or not) why certain energy productivity policies have been successful (or not). The spectrum of policies in the Climate Change Programme is then examined critically with a view to identifying ways in which the policies could be improved or strengthened. Finally we identify areas that are currently not covered by existing policies but which are likely to be important in achieving both the medium and long term reductions in carbon emissions.

4.1 Historical Examples

Building Regulations

The improvement in the energy efficiency of dwellings achieved with successive improvements to the Building Regulations has already been documented (see Table 2.2). Average heating costs for new homes were halved from 1965 to 1995 and are expected to halve again two years after the introduction of the proposed improvements to the Regulations. There are strong reasons for assuming that these improvements would not have occurred without regulation.

There are two important economic barriers operating, namely split incentives and adverse selection. Split incentives arise because the cost of improved standards is met by the builder and the benefits realised by the purchaser. In an ideal market the improved performance would be reflected in the price of the property. However the prevailing culture, amongst builders and estate agents, is that running costs are not important in house prices – and so they aren’t[70]. Adverse selection refers to situations in which low-quality products can drive high quality products out of the market. This occurs when information about the performance of the products in question is not available to purchasers. For the reasons stated above the fuel running costs of properties is not disclosed to potential purchasers. Since the energy efficiency measures are largely invisible purchasers will prefer the lowest cost property, all other (visible) things being equal. In this way properties embodying the lowest possible levels of energy efficiency will displace those with higher levels.

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[69] This refers to the shift from products to services as described , for example, by Tim Jackson in “Material Concerns”, Routledge, 1996. See also the discussion of energy services later in this section.

[70] Research carried out in association with the Energy Cost Guarantee – referred to in Section 3.2 – indicates that some house purchasers would be willing to pay more for a property with guaranteed lower fuel bills.

The introduction of energy ratings for houses[71] has not substantially changed the situation because

(a) the ratings themselves are designed for specialists not lay people and therefore are not easy to understand,
(b) most builders and estate agents still believe running costs are unimportant, and
(c) most importantly, running cost differences are not reflected in purchase prices.

As pointed out in section 3.3 householders operate under conditions of bounded rationality. House purchase is recognised as a stressful process, largely due to the wide range of incommensurate variables associated with alternatives. Adding more information about energy running costs (by labels) can be predicted to have negligible impact on the purchase decision – especially when the main sales staff involved regard it as irrelevant.

It should be noted that the same arguments apply in the case of the second-hand house market (i.e. sales of all properties other than new). Providing additional information into that market will not make any difference especially whilst all the professionals involved (estate agents, surveyors, mortgage lenders and insurers) consider running costs irrelevant to property values. The professionals will claim that they are simply reflecting the values of the purchasers, but this is a circular argument and one that cannot be broken simply by providing information. Unless, marketing can effectively incorporate rising environmental concerns, it is likely that the only way to significantly influence the second hand market is with regulations regarding the energy standards of properties that can be sold. The inclusion of an energy audit in the proposed new Sellers Pack is a first step to making this possible.

Green Lights Programme

Green Lights is a voluntary programme run by the Environmental Protection Agency (EPA) in the USA. Through the programme the EPA promotes energy efficient lighting systems to commercial firms. The programme has been running since 1991 and by 1995 more than 3500 participating firms had submitted information to the EPA on investment costs and returns; the average payback time reported was 3.3yrs with an internal rate of return averaging 45%[72]. In analysing why the programme had been successful Howarth et al[73] claim that it overcomes two important barriers, namely the principal-agent problem and split-incentives. The principal-agent problem manifests as restricting capital available for small projects by senior managers (either by direct rationing or by imposing a high rate of return requirement). The split-incentive issue arises because within firms the departments responsible for lighting is not the same as that which pays the utility bills.

The Green Lights programme overcame these barriers by the introduction of

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[71] Displaying an energy efficiency rating has been mandatory for new homes from January 2001.
[72] DeCanio, S. “The efficiency paradox: bureaucratic and organisational barriers to profitable energy-saving investments” *Energy Policy* **26** (1998) p441-454
[73] Howarth, R.B, Haddad, B.M, Paton, B “The economics of energy efficiency: insights from voluntary participation programs”, *Energy policy***28** (2000) p.477-486

> "credible data on relevant investment opportunities at a crucial point in a firm's organisational chart … The voluntary programme provides an alternative route for the flow of information that is free from the suspicion of misaligned incentives. In effect the EPA certifies the economic value of products and services with desirable environmental characteristics, short circuiting the principal-agent problem within firms by providing effective high quality information at the level of the firm that is most relevant to decision making….
> The same policy mechanism that addresses the agency problem also addresses the split incentive problem. The decision making level within the firm's hierarchy that maximises firm-wide profits for energy-efficiency investments is where facilities management and production budgets are combined in the same ledger. This may be as high as the chief financial officer. Without outside intervention, this level of the firm typically would not evaluate lighting retrofit or similar decisions."[74]

As well as overcoming these economic barriers the Green Light programme also succeeded in overcoming bounded rationality by attracting sufficient attention from senior management. If there were a facilities manager or energy manager within the firm advocating the lighting retrofit then the programme would have also been successful in strengthening his or her case, thereby overcoming the barrier associated with organisational power.

To succeed in all these different ways it was essential that the programme
(a) targeted senior managers within the firms
(b) presented clear, simple information and advice
(c) engaged the senior managers with a commitment[75]

Technology Procurement

The different actors involved in a product's lifetime may have a significant effect on its overall energy efficiency. A typical sequence involves the producer, a seller (either wholesaler or retailer or combination of both), a purchaser and, sometimes separately, a user. The final user may be the one to bear the energy costs and if these are small, in relation to purchase and other costs, they may not be effectively communicated back up the chain to the purchaser, seller and producer. Except where the users are also large volume purchasers there is little influence that users can have on product design – especially in mass markets where producers and sellers differentiate products by "features" of their choosing.

One way in which this feature of product markets has been tackled is through technology procurement. Olerup[76] describes the process used for 32 procurements in the white goods,

[74] Howarth et al (2000)
[75] The commitments were to submit annual reports on progress, upgrade at least 90% of eligible floor space within 5yrs subject to an IRR greater than 20%. In return the EPA provides information, software and technical assistance.

lighting, house building, industrial and commercial sectors in Sweden – with varying degrees of success. The key features of the process are

- Assembling a large enough group of buyers to convince the producers to make the necessary investments
- Using the buyers group and a technical expert to develop a specification for a new product that includes high energy efficiency
- Using government finance to organise a competition that reimburses all the firms who develop products that meet the specification
- Using further government finance to subsidise initial purchases of the new product, thereby accelerating market penetration.

The overall process takes 4 to 5 years. Olerup described the experience with washing machines in which the overall energy consumption was halved and other features, such as quietness, reduced water consumption, faster overall cycles, were also achieved in the new product. In this way, technology procurement works with key players in the market, directing greater attention to energy productivity in design, but also allowing businesses to incorporate energy productivity in their definition of a 'quality product'. This is important if the energy productivity is to be adopted into design culture.

This system of market transformation overcomes the barriers of split incentives (with potentially four different agencies involved) and adverse selection. It also provides mechanisms whereby users can influence product design – a feature that markets should provide but rarely accomplish so directly.

Energy Star

Energy Star is another voluntary programme run by the EPA, this time concerned with the energy performance of office equipment, particularly computers, monitors, faxes and photocopiers which all spend a significant length of time in 'stand-by' mode. The Energy Star system involves negotiating standards with manufacturers and then permitting the use of the Energy Star logo on equipment that meets the minimum standard. The result is a very simple pass or fail, logo or no logo. In all cases the standards are relatively easy for manufacturers to implement and involved very low or no additional costs. This allowed manufacturers to adapt products without redesign.

The programme aimed to influence the market by providing large customers with a simple criterion for specifying energy efficient equipment. The programme received a major boost in 1993 when an Executive Order was passed which ordered government procurement offices to purchase Energy Star compliant products whenever possible. Since all product manufacturers wanted to be available to the single largest purchaser within a comparatively short time all products in the market were Energy Star compliant. A major result of the programme has therefore been the removal of all the inefficient products from the market.

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[76] Olerup, B. "Technology development in market networks", *Energy Policy* **29** (2001) p.169-178

This programme illustrates another approach to market transformation, this time using the purchasing power of the largest buyer to influence the products available in the market.

As noted by Howarth et al when commenting on Energy Star and Green Lights, "The success of such programmes rests precisely on departures of real-world markets from the idealised assumptions of the neo-classical model." They also point out that the energy costs involved (for both lighting and office equipment) are "so small that they are typically ignored by profit-oriented firms".

HECAction

This is a programme run by the EST to support Local Authorities (LAs) in delivering activities as part of their role under the Home Energy Conservation Act (HECA). A typical scheme will involve a partnership between the LA and local installers in which the LA uses part of its EST funding to bulk-purchase insulation or heating equipment that is then sold on to householders at an appropriate discount. The bulk-purchase funds can be recycled, so the scheme can continue whilst there is sufficient demand for the products provided.

These schemes have only been successful in LAs where there was a champion for energy efficiency and where he or she was able to secure high-level support for the scheme. The case for senior support was considerably strengthened by the possibility of a grant from the EST.

The schemes succeeded in selling energy efficiency products to owner-occupiers because
(a) the support and promotion by the LA overcame sufficiently the distrust householders have towards installers and claimed savings from measures, thereby increasing take-up
(b) the discounts offered attracted attention and appealed to the widespread desire to secure a bargain
(c) the schemes were promoted imaginatively i.e. commercially and not like a government information campaign

The schemes are most effective where they seek to promote a high efficiency alternative of a product the householder already wants or needs to purchase (e.g. a boiler). This type of involvement of trusted non-profit making organisations in the market has also been used in the Energy Efficiency Commitment, with energy suppliers working in partnership with local authorities and the voluntary sector.

Thus the schemes overcame a significant number of the important obstacles identified in section 3.3, namely capturing the households attention, providing a discount or cash-back and overcoming the distrust of the installers. Such schemes could probably be used more widely and successfully if there were more funds available (HECAction grants have been restricted to about £1m/yr) and if the legal position of LAs working in collaboration with private sector companies were clarified.

Energy Labelling of Appliances

Labelling of white goods has formed an important part of EU energy efficiency policy. On the basis of the arguments in the previous section, energy labels on their own might be expected to be not very effective because

(a) purchasers cannot easily understand the labels and are already overwhelmed by options for different features,
(b) the labels are not easily translated into savings in running costs, and
(c)

the higher efficiency appliances may cost moreResearch does show that most people do not take note of the label. A large number of consumers do not understand it or its implications for cost savings. For some types of consumers, a simpler 'expert recommendation' approach to labelling is preferable.
Minimum standards, whether mandatory or through effective negotiated agreements offer a much more effective approach to eliminate inefficient goods from the market. However, more positive approaches to promoting products well in excess of the standard could be complementary. Similar research and testing infrastructure is needed to deliver both labelling and standards. And labelling can help set a framework both for future regulation and for incentives systems for marketing staff under other policy instruments.

However, there is a risk of 'label proliferation': the EU energy label, and the simpler EST 'Energy Efficiency' brand already exist. Any more complexity would be very unhelpful. Government has a role in establishing a clear way forward to ensure that any information provided has maximum impact – which probably implies simple content.

Domestic Energy Service Companies (ESCOs)

This is an area where there have been a wide range of initiatives and to date there has been no significant success. In the recent DTI report on "Energy Services in the Domestic Sector"[77], the provision of energy services was described in terms of a package that may consist of:

- Dual fuel energy supply
- Free home energy efficiency audit
- Provision and project managed installation of energy efficiency measures
- Finance for those measures
- Ongoing advice and promotion of energy efficient appliances and practices

The Report identified a wide range of barriers, business issues and dilemmas which would need to be addressed in order that energy services could develop within the current fuel supply market. The Report is succinct, direct and concludes with an action plan.

However in the light of the analysis in section 3 the new schemes proposed are still likely to face similar problems to those already tried. The major obstacles are:

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[77] Macklon, D.E. "Energy Services in the UK Domestic Sector: Barriers to Develkopment and Recommended Action Plan", DTI Sept 2000 (published Feb.2001)

(a) domestic consumers do not find the purchase of energy efficiency products obviously attractive
(b) households instinctively distrust fuel companies
selling products that reduce its potential for selling fuel.
(c) transaction costs are high compared to the low margins in fuel supply, and
(d) energy regulation encourages a ‘pile it high sell it cheap’ approach and has specific obstacles to longer term energy services contracts (e.g. the 28 day rule).

Some recent trends may encourage energy services. Liberalisation has certainly led to some limited ‘products’ broader than energy as a commodity. And the design of the Energy Efficiency Commitments will encourage an energy services approach. But the barriers to a fundamental change remain high. Unless ways to counteract all the barriers can be found it is likely that ESCOs in the domestic sector will remain an item on the wish list. An alternative approach that faces different problems is set out in Appendix 3.

Key Conclusions for Future Policy

The scope for energy efficiency improvement is large, so policy needs principally to address the reasons that decision makers (whether in business or households) do not invest. No single analytical approach or paradigm holds the key – a mix of policy instruments is very likely to be the most effective approach.

It is clear that successful policies have been able to address the barriers identified in section 3. Policies that have been less successful have failed because they have not addressed the core problem, which is one of limited attention for both householders and business managers. Adding information will not, on its own, help. The policies that have succeeded have done so by capturing attention at the right level, the right time and with a simple message.

The list of specific policy instruments that could be used is very long, but the principles that underlie there use are as follows:

(j) Energy prices do affect the culture in which decisions are made and the common expectation (based on recent experience) that energy prices will fall is unhelpful in encouraging the productive use of energy. Energy taxes therefore have an important role in setting a long term framework. However, energy taxes alone will be of limited effectiveness in many sectors and certainly will not produce the large improvements in energy productivity that are possible and necessary.
(k) Regulation remains a very effective policy instrument, as it can address information barriers with more information. Product regulation is likely to be particularly effective in markets involving small users of energy, e.g. for houses and consumer products. Process or emissions regulation is more appropriate for large business users. To maximise the potential for effective responses, regulation needs to be clear and set out well in advance of implementation. Negotiated agreements may be used as an alternative, but are

only likely to be effective where Government is clear that alternative policy instruments will be used in the event of failure.

(l) Regulation and market mechanisms are not in conflict. Energy labelling requires regulation, but is essentially a market mechanism. Similarly, emissions trading requires both regulatory controls and a market. Obligations on energy suppliers and others may be also more effective if they can be traded.

(m) The role of Government is essential as both regulator and fiscal authority. But Government can also play a key role as a promoter of innovation and market transformation, for example through its own procurement policies and by building partnerships with market players.

(n) Information can be effective, but only if it is carefully designed and targeted at the key decision makers. Industrial energy managers will require detailed information on technical performance. But for many consumers the simplest approach: 'buy this – it saves you money' may be the most effective.

(o) Information is more effective if it comes from trusted sources, and therefore there is a role for both local Government and the voluntary sector as partners in energy efficiency programmes.

(p) Subsidies can work, both by attracting consumer attention and altering prices. They will be most effective when cross-price elasticities are high, notably to differentiate efficient products from less inefficient goods providing the same energy service.

(q) Good marketing works and it is business that has big marketing budgets. Policies should therefore seek to involve businesses and to encourage them to sell energy efficient goods and services.

(r) Market transformation will tend to require a number of different instruments working together to address the different parts of the market.

(s)

Policies that seek to transform the market from energy units to energy services have a largelong term potential, and therefore should be given high priority, even though the short term problems are large. This will require changes to the philosophy and practice of energy regulation.

4.2 Implications for Climate Change Programme Policies

The aim of this section is to take a critical look at the policies set out in the CCP in the light of both the theoretical framework in section 3 and the lessons from examples in section 4.1. The aim is to explore strengths and weaknesses and point out areas where more needs to be done in order to achieve the declared objectives.

Domestic Sector

The main policies in the CCP are HEES, EEC, Building Regulations, market transformation for lights and appliances and replacement of community heating schemes.

HEES

The main points are.

(a) low carbon savings (at lest in the short term) due to targeting fuel poor, as comfort taking will be high.
(b) the scheme is currently scheduled to run for 5 years. It needs a longer term commitment to achieve the goals of policy.
(c) The scheme currently has some difficulties due to lack of heating installers. Without action this problem could recur every winter. There is a need to consider providing training schemes or apprenticeships to participating installers.
(d) Overall it will make a substantial contribution to reducing fuel poverty, but not to reducing carbon emissions in the short term.

EEC

The main points are

(a) The requirement is for 50% of benefits to be for disadvantaged households, many of which will be fuel poor. For the insulation schemes, the comfort take will be high (typically at least 50%) and so produce little carbon savings in the short term
(b) The other 50% of schemes will target private households and will achieve higher savings. Due to competitive pressures, the companies will target the cheapest savings where households have good payback periods. This might encourage the development of energy services.
(c) Schemes are only guaranteed to operate to 2005. With each successive EEC scheme the savings from existing technologies may be harder to generate unless the companies start working on longer term projects with builders, installers and appliance manufacturers. Hence there is a need to state that there will be schemes operating to 2010 to encourage development of longer term projects and partnerships.
(d) Government and consumer organisations could publicise the obligation on fuel companies. This would assist overcome the barrier of distrust.

Building Regulations

Main points

(a) The proposals should be enacted as soon as possible since every year of delay reduces savings and adds unnecessarily poor dwellings to the stock.
(b) The proposals for two, three and five years hence should be firmed as soon as possible to enable the building industry to start process of adaptation required
(c) In particular schemes should be developed for checking compliance with the higher standards. Building practices, detailing and air-tightness all become more important with the high standards.

Market transformation (lights and appliances)

Main points

(a) minimum standards are more effective than labels alone in improving average energy efficiency
(b) the approach should make use of government purchasing power wherever possible
(c) Government should provide impetus and support for ambitious EU programmes, and
(d) encourage energy companies to work with appliance manufacturers as part of EEC post 2002

Community Heating scheme improvements

Main points

(a) it seems doubtful that level of savings projected will be realised without substantial government incentives and financial support for LA, RSL and others running community heating schemes
(b) the opportunity should be used to reduce heat loads by improving dwellings (as well as improving heating plant)
(c) it should encourage more widespread use of small CHP plant as lead boiler in large scale boiler plant (for example on education campuses and large industrial sites)

Local Authority role

Main points

(a) Government needs to increase support and provide longer term funding (directly and/or through EST) for the development of partnerships between LAs and local installers, and
(b) provide clarification, and if necessary changes to legislation, to facilitate LAs becoming more involved with such partnerships

Other areas

Main points

(a) Fuel poverty will not be resolved until strategy for improving or demolishing solid walled properties is developed. These properties represent a quarter of the current housing stock, so to improve overall standard essential they are improved or removed.
(b) Policies will fail if founded on the assumption that householders will take action because it is in their own interests to improve the energy efficiency of their properties. Householders will only purchase energy efficiency measures if there are either regulations requiring improvement or incentives provided by a trusted supplier supported by commercial marketing campaigns. Providing information will not overcome the range of barriers involved.
(c) Too many important schemes are operated for short periods (1 to 3 years). This significantly increases the overhead costs per scheme and causes the supply and installation industry to have to gear up and accommodate funding gaps. Longer term commitments and smoother transitions between programmes will reduce unit costs and ensure better performance from the installers.
(d) Some policies require consumers to have a better understanding of the energy and environmental context of home energy efficiency. Neither marketing nor information campaigns will achieve this. Education is therefore likely to have a key long term

role. There is also evidence that children have ‘pester power’ that can influence shorter term actions.

Services Sector

Main Points
(a) Climate Change Levy (CCL) has captured attention of some managers but not so far provided any simple message of what to do.
(b) Low fuel bills and high staff costs for the sector means that most firms will be better off under the CCL. There will still not be a major incentive to reduce energy costs.
(c) Recycling CCL funds to provide free or very low cost energy audits could be very effective, provided there is support in implementation. One study shows companies adopt 80% of improvements suggested through audits.
(d) Support and encourage EU initiatives to introduce minimum standards for office equipment and other common commercial appliances.
(e) Consider schemes for tackling split incentives barrier in the sector. One option proposed is for an energy audit to be required at each new letting or rent review with an obligation on landlord to make some improvement. Major landlords may be willing to enter into a voluntary agreement on this.
(f) Implement the proposed new Building Regulations as soon as possible.
(g) Do more to promote the use of naturally ventilated buildings to reduce the growth of full air-conditioning, e.g. through fiscal measures and training. Impose stringent minimum standards on air-conditioning plant efficiency and control systems.
(h) In public sector ensure that targets set out in CCP are delivered through their inclusion in departmental Public Service Agreements
(i) Consider extending EEC to the commercial sector

Overall it is striking how few policies are targeted at this sector which whilst not as large as the domestic sector is one of the fastest growing.

Industrial Sector

Successive Governments have given primary attention to the role of information in programmes to improve industrial energy efficiency. Particularly when the objective was conceived in terms of cost saving, there was little reason for more direct intervention – the priority was to help industry to help itself. The major Government programme in the field has been the Energy Efficiency Best Practice Programme (EEBPp) and its predecessors. EEBPp supports a range of activities, but largely demonstration and benchmarking of energy use technology and management. It aims to provide unbiased information and, crucially, to undertake targeted information dissemination to relevant decision-makers in industry. Given the limited scope and resources (about £20M annually), it is generally acknowledged to be a successful programme, especially in the industrial sectors. Other countries have modelled their own information programmes upon it.

The new context of carbon constraints justifies a different level of involvement for Government in increasing energy efficiency. The implications of inefficiency are not confined to the finances of the individual company, but have important ramifications for UK international legal commitments and the global environment. Higher levels of market intervention are therefore justified. The implications are also very long term, and therefore there is a greater justification for support for innovation.

Until recently, Governments in the UK had not attempted to use either regulation or taxation as mechanisms for improving industrial energy efficiency. Neither, has there been active support for companies that promote energy efficient products and services, other than to the extent that EEBPp information may validate their marketing efforts. This contrasts with active involvement in the home energy efficiency market through the programmes of the Energy Saving Trust and active support for the Energy Efficiency Partnership for Homes.

The EU Integrated Pollution Prevention and Control (IPPC) regime will place energy efficiency on many large industrial sites in the framework of environmental regulation. About half of UK industrial energy use will be covered. In practice, however, regulation is likely to be less of a driver than the negotiated agreements the Government is seeking to put in place in these sectors (see below).

The key role of economic instruments to address business energy use was established early in the lifetime of the Labour Government[78]. Arising from this, the centrepiece of the Government's climate strategy in this sector is a package of policy instruments developed around the Climate Change Levy. The levy itself is a tax on business and public sector energy use, to be introduced in April 2001. For medium-sized industrial users it will raise prices of electricity by approximately 10% and gas by 20%.

To protect the international competitiveness of energy intensive industries, an 80% Levy rebate will be available to companies in sectors regulated under IPPC, subject to negotiated agreements on improving the energy efficiency or carbon emissions from the sector. Initial details of some of the agreements have been published recently[79].

The price effect of the Levy is expected to be limited – a reduction in emissions of less than 2 Mtoe (4%). Over industry as a whole, the costs of energy are low, averaging only 1.6% of total production costs[80] and energy use will therefore remain a minor concern even with substantial price rises. In the energy intensive industries, energy costs are already a major concern. Much has been done in energy efficiency and, in some cases, thermodynamic limits of existing processes are being approached. Government estimates long run price elasticities to be low[81]. However, the long-run effect of prices on future innovation is inevitably uncertain. In a business environment that is more open to

[78] HM Treasury. Economic Instruments and the Business Use of Energy. A Report by Lord Marshall, 1998.
[79] http://www.environment.detr.gov.uk/ccl/index.htm
[80] http://www.hm-treasury.gov.uk/pub/html/prebudgetNov98/marshall.pdf
[81] Department of Trade and Industry. Shaping Change. The Energy Report, 1997.

innovation and more aware of environmental concerns, the elasticity could well be higher than in the past.

It is estimated that the overall effect of the Levy package will be to reduce emissions by at least 5 MtC/year. However, it is important to note that most of this is not through the simple price effect. Renewables exemption, special treatment of CHP, the negotiated agreements and direct support for energy efficiency will deliver most of the reductions. Although not delivered by the Levy itself, they are critically dependent upon it. This has not always been recognised by critics of the Levy.

Perhaps the most important for the long term development of lower carbon energy supply options is that energy from renewable sources and energy used on site from good quality CHP will be exempt from the Levy. The effectiveness of these instruments will depend on the extent to which they can counteract the disadvantages for small generators of the New Electricity Trading Arrangements.

The Levy package will be fiscally neutral, as the £1 billion annual receipts from the Levy will be returned to Levy payers. Most monies will be returned via a reduction of 0.3% in employers' National Insurance Contributions. In addition, £100 million will be returned through one-year capital allowances for identified energy efficiency technologies. This support for energy efficiency will enhance the effect of the Levy. However, it is not clear that enhanced capital allowances are the most cost-effective means. Given the UK's low inflation and interest rates, one-year capital allowances have only a marginal effect on investment decisions. Much of the effect will be deadweight.

£50 million annually of Levy proceeds will be used to stimulate carbon reduction through support for renewables and for energy efficiency through the Carbon Trust. This will take responsibility for an enhanced EEBPp and have additional resources for energy audits and R&D. Good quality advice can be very effective, provided that it is specific to the company's needs. However, it is necessary also to address the other barriers that constrain cost-effective technologies. Outside the major energy users, concentration on information is unlikely to be sufficient. More direct support than in the past for energy efficiency products and services in the market will also be required.

The negotiated agreements will make a major contribution by 2010. The detail of all the agreements is not yet finalised, but the Government estimates they will reduce emissions by 2.5 MtC/year[82], implying an energy efficiency improvement of about 10% (or 1% per year) above business and usual. This is 60% of what has been estimated to be with short payback periods[83], implying that the agreements will not be challenging to deliver. Given the environmental, as well as economic, basis for policy, there is no reason not to require the full win-win potential to be exploited. Future revisions of the agreements (or other quantitative limits through emissions caps or regulation) should therefore seek to deliver at least all of the 'win-win' potential.

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82 http://www.environment.detr.gov.uk/ccl/index.htm

83 ETSU, 1999 Energy Technology Support Unit. Industrial Sector Carbon Dioxide Emissions: Projections and Indicators for the UK, 1990-2020.

Analysis of the negotiated agreements provides an important insight into policy effectiveness. Even though the agreements will only address part of the available win-win options, they will deliver emissions reductions of 2.5 MtC/year. This is ten times the projected price effect of the levy (even at the full undiscounted rate) in the same sectors. At first sight, this is in conflict with economic theory, which would tend to indicate that a tax should deliver emissions reductions in excess of those that are currently cost effective. The explanation, of course, lies in the relatively large scope for 'win-win' investment. With market failures of this size, economic instruments are **not** necessarily the most cost effective policy instrument. The negotiated agreements have provoked detailed analysis of the scope for energy efficiency improvements at the sectoral and company level. A tax instrument is more likely to be accepted as a financial penalty. Whilst this is not a rational response (in the neo-classical economic sense), it is explicable in the context of the operations or real companies, where engineers control energy use and accountants pay tax bills.

The Levy has also been an important driver for the development of an emissions trading scheme in the UK. The negotiated agreements will allow for targets to be achieved by trading through an Emissions Trading Scheme (ETS). The Government is also encouraging companies outside the framework of the agreements to join the scheme. It proposes to use £30 million to incentivise companies to take a carbon emission limit and thereby join the ETS. The Government estimates the ETS might reduce emissions by 2 MtC in 2010[84]. This will depend on ensuring that the incentive funds realise energy savings that are additional to business as usual measures identified in bottom-up assessments.

Where the negotiated agreements are based on absolute energy use or emissions (rather than per unit of output) there will be no limit on trading. However, only two sectors (steel and non-ferrous metals) have chosen this absolute approach, at least initially. It is Government policy that an absolute basis should be achieved by 2008. However, it is arguable that a significant problem for trading could have been avoided by requiring an absolute basis for the negotiated agreements from the outset.

Emissions from electricity generation do fit not easily into the framework of trading. The Levy is a downstream energy tax and power generators are therefore not taxed. The negotiated agreements treat primary energy use and emissions from electricity use as the responsibility of the final user. This is sensible, as generators are not in a position to affect electricity use, but it prevents full their inclusion in the ETS. The generators are major emitters and their scope to reduce emissions by changing the carbon content of electricity is large. Partial inclusion of the generators in the ETS may be key to its success and should be pursued as a priority. Negotiated agreements with the generating sector should be sought. Failing this regulation will be required to place a declining cap on the carbon content of electricity.

[84] Department of the Environment, Transport and the Regions, 2000. UK Climate Change Programme.

The long-term nature of climate change justifies increased support for innovation. Only this will deliver major improvements in energy productivity in the long term. Whilst major product and process change may deliver little to 2010 targets, they are critical to the longer-term strategy. There is some evidence that firms with high energy productivity also have high total factor productivity. Whilst this relationship needs to be examined in other parts of this project, it indicates that support for energy efficiency may have more fundamental benefits for industry than often believed. Whatever the economic case, the environmental constraints on carbon emissions point to the need for major increases in energy productivity in the long term.

4.3 Conclusions

Main points

(a) Examination of policies that have worked demonstrates that by accident or design they do address the main obstacles and barriers identified in section 3. It is striking that the most successful schemes have addressed *all* the major obstacles, not just one.

(b) Policies designed to address just imperfect information are generally not successful. This is to be expected since most actors are operating under conditions of bounded rationality and will therefore already be rejecting much information that is available.

(c) The most successful interventions in transforming markets involve the voluntary or regulatory introduction of improved minimum standards. There are several excellent examples that can be used as templates in other areas.

(d) The market transformations that have not worked have failed because they did not appreciate the culture and perspective of key agents in the process of delivering improved products to consumers. (e.g. heating installers and condensing boilers, salesmen for low-e double glazing).

(e) Although policies need to be *justified* within a neo-classical framework that framework should not be taken as an adequate description of the ways in which the agents operate. Policies need to be *designed* by taking multiple perspectives of the context into account and should aim to address *all* the known barriers and obstacles involved.

(f) The Climate Change Programme has a wide range of policies, many of which will be effective in the ways designed. However there remain serious areas where effective policies are still to be developed. The most important areas are
   1. the services sector, particularly commercial buildings and equipment
   2. small and medium sized businesses

   solid wall dwellings in the domestic stock

(g) In the industrial sector, the Climate Change Levy marks an important development away from a policy relying very largely on information. The effectiveness of the Levy looks likely to depend less on the simple price effect than the accompanying measures: exemptions for clean energy sources, greater Government support for energy efficiency, negotiated agreements and emissions trading.

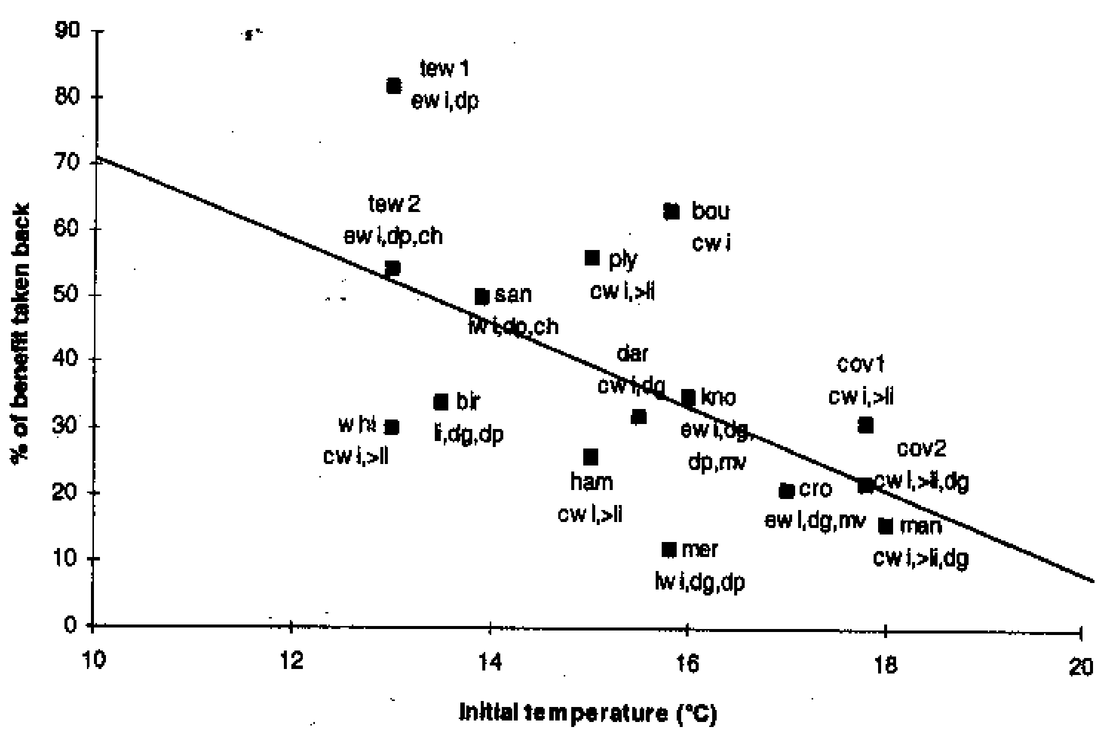
Appendix 1. Resource Productivity and the Rebound Effect

1. Since the 1970s, when improvements in energy efficiency were first proposed as counters to the significant oil price rises, there have been debates about the degree to which improvements in efficiency can lead to reductions in demand. The conservationists saw the issue in terms of needing less to provide the same service, so there had to be a reduction in use. They also pointed out that conservation generally cost a lot less than increases in supply. Their opponents argued that an improvement in efficiency was equivalent to a reduction in price and would therefore alter the equilibrium between supply and demand by shifting to a higher level of consumption. It is this (in various guises) that is known as the “rebound” effect. The strongest proponents of the rebound effect argue that efficiency improvements will, in the *long run*, be counter productive and lead to an increased use of the resource whose efficiency has been increased.
2. There are potentially two micro-economic shifts associated with energy efficiency improvements. The first is where energy is used to provide a service to final consumers, for example transportation or space heating. An improvement in transport energy efficiency reduces the cost of transport and results in a greater use of that transport mode. This is the inverse of the reduction in transport with increases in fuel prices.
3. The second micro-economic shift is based upon substitutability between inputs to production and the observation that if one factor becomes cheaper it will displace other factors and hence be used more. The historical association between increased efficiency of energy use and increased use of energy in industrialised countries is cited as evidence for this argument. This effect has to be a long run effect because in the short term investment in capital will preclude substitution between factors of production. The evidence is not compelling because there were many other factors involved in the growth of energy use and improvement sin the efficiency with which it was used.
4. There is also a macro-economic effect cited as contributing to the overall rebound. If consumers are able to save expenditure by improvements in energy efficiency then they will use those funds to purchase other goods and services which themselves require energy. Thus whilst consumption in the area subject to efficiency improvements may be reduced, over the whole economy there may not be any saving due to increased consumption elsewhere.
5. There is no doubt that these three components of rebound, increased consumption, factor substitution and displaced consumption all take place to some degree. The more interesting question is the degree to which these rebounds will undermine the potential savings from the improvements in efficiency. Put another way, is there any reduction in demand as a result of improvements in efficiency, and if so by how much?
6. Although this question has been most carefully studied for energy efficiency it will apply to all cases of improvements in resource productivity. There is now a substantial body of literature available for the energy efficiency case and this has

been brought together in a series of review articles in a dedicated issue of ***Energy Policy*** (Volume 28, June 2000). The following summary is largely a précis of the material contained in that issue.

7. Over half the fuel consumption in the domestic sector is used for space heating and this is where most historical effort and research has been directed for improving energy efficiency. It has been well established in the UK and elsewhere that not all the energy savings calculated from the improvement in efficiency are achieved in real projects. There are several reasons for this.
   7.1. For households on low incomes their use of fuel is constrained by what they can afford. Improvements in efficiency increase what they can afford and many choose to take a large proportion of the savings available as increased thermal comfort. This is often referred to in the literature as the "comfort factor" (but is actually identical to the rebound factor).
   7.2. When a house has its insulation improved it will cool down slower. This means that there will be an increase in the average internal temperature, even though the occupants have not adjusted their heaters or thermostats. Also previously under-heated areas of the property will benefit from reduced differences in internal temperatures. (Note these effects apply only to insulation, not to improvements in heating, appliance or lighting efficiencies.)
   7.3. In a comprehensive review of monitored insulation projects in the UK, Milne and Boardman[85] established that the main determinant of the proportion of theoretical

G. Milne, B. Boardman / Energy Policy 28 (2000) 411–424



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[85] Milne,G & Boardman, B. "Making cold homes warmer: the effect of energy efficiency improvements in low income homes." *Energy Policy*. **28** (2000) p 411-424

savings achieved was the average house temperature. In general the colder the property then the greater the rebound or comfort factor.

7.4. The authors estimate that the average rebound effect in the UK currently reduces the energy savings by 30%.It is only when house temperatures rise to about 21°C that all of the savings from efficiency improvements will be realised. This indicates that there is a "saturation" effect at about 21°C for space heating – which seems intuitively reasonable.

7.5. Measures that increase internal radiant temperatures (double glazing and wall insulation) tend to reduce the rebound effect (since occupants feel warmer without increasing the air temperature).

8. A survey of US experience by Greening, Green and Difiglio[86] shows a similar result. For programmes targeting space heating the rebound effect was between 10% and 30% i.e. the actual energy savings are between 10% and 30% less than the calculated savings (the same definition of rebound effect applies to all their results). For space cooling the evidence is less conclusive with a range of rebound between 0% and 50%. For water heating the rebound effect is in the range 10% to 40%, for lighting 5-12%, for white goods (appliances) 0% and for automotive transport 10-30%. The authors are critical of some of the work reported but feel that the overall conclusions are fairly robust. Their conclusions are consistent with the general high level of saturation for lighting and the fact that appliance use is not affected by its energy efficiency (which is largely unknown by the user).
9. The same authors examined the literature for firms adopting energy efficiency measures. They found that for lighting improvements the rebound effect was 2% or less and for processes between 0% and 20%. These are both short-term rebounds with no significant change in capital equipment. The literature review on long-term substitutability was inconclusive but indicated that the rebound effect was less than 100%, if it existed at all. Part of the issue here is that to some degree energy and capital are complementary rather than substitutable, so estimates of elasticities vary from 0.8 to negative values. [Another paper in the volume estimates ESUB, the elasticity of substitution (the percentage change in relative input cost shares over the percentage change in relative input prices). The conclusion is that capital and energy are relatively weak, long-run substitutes in the Canadian economy with a value of ESUB of 0.24.[87]]
10. Greening et al also examined the macro-economic effect of changes in patterns of consumption. They concluded that this would contribute at most a rebound effect of 0.48%. This is not a surprising result because the average energy intensity (kWh per £ value) of products in the economy is so much lower than that of fuels.
11. A study carried out at the IEA[88] showed that "key measures of activity (car use, manufacturing output, house area etc) have changed little in response to changes in energy prices or efficiencies since 1970…. Weighted by 1990 activity levels,

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[86] Greening,L.A., Green, D.L, Difiglio, C. "Energy efficiency and consumption – the rebound effect – a survey", *Energy Policy*, **28**, (2000) p.389-401

[87] Jaccard,M. & Bataille,C. "Estimating future elasticities of substitution for the rebound debate", *Energy Policy*, **28** (2000), p 451 - 455

[88] Schipper,L & Grubb,M. "On the rebound? Feedback between energy intensities and energy uses in IEA countries", *Energy Policy*,**28** (2000) p.367 - 388

intensities were 15-20% lower in 1994/5 than in 1973, which in turn meant real savings of energy…. Rebounds may have taken back some of the overall savings, but most remain, even after the fall of oil prices in 1986."

12. Overall the conclusion for the entire collection of articles is that "depending upon initial conditions, energy user incomes, and energy price changes, micro-rebound effects focussing on the end uses whose efficiencies improve might eat up 10% to 40% of the energy savings otherwise realised…Macro effects… seem to be small too."
13. Common sense suggests that rebound effects will be most severe in situations where the level of consumption is price sensitive and far from saturation. A good example of this is personal transport where fuel costs are well perceived and there is no evidence of any limit on the amount of travel demanded. In contrast where consumption is close to saturation and insensitive to energy costs then no rebound effect is to be expected. An example of this is domestic white goods where ownership is controlled by purchase price and the amount of use is not influenced by energy costs.

Appendix 2. Summary of economic barriers to energy efficiency

1. This summary is abstracted from Chapter 3 of “Barriers to energy efficiency in public and private organisations” S.Sorrell et al SPRU (available on http://www.susx.ac.uk/spru/environmental/research/barriers.html)
2. The authors review the literature on proposed barriers to energy efficiency (based on some 101 references). They divide the barriers into economic, behavioural and organisational and seek evidence for these in research carried out in the higher education, mechanical engineering and brewing sectors in the UK, Germany and Ireland. The authors are clearly most comfortable with economic theory and the perspective that provides.
3. The taxonomy of barriers considered by the SPRU team is presented as Table 2 (next page). They divide barriers into three perspectives, as summarised in Table 1 below (also taken from the report). It is not clear whether the authors regard the barriers as all distinct or whether some are the same barrier described from a different perspective.

Table 1. Summary of barriers by perspective.

Perspective	Examples	Actors	Theory
Economic	Imperfect information, asymmetric information, hidden costs, risk	Individuals and organisations conceived of as rational & utility maximising	Neo-classical economics
Behavioural	Inability to process information, form of information, trust, inertia	Individuals conceived of as bounded rational with non-financial motives and a variety of social influences	Transaction cost economics, psychology, decision theory
Organisational	Energy manager lacks power & influence, organisational culture lead to neglect of energy/environment issues	Organisations conceived of as social systems, influenced by goals, routines, culture, power structures etc	Organisational theory

4. There is a recognition that the imputation of barriers may be tautological, but this aspect of the problem is not pursued in depth. Our current view is that the imputation of barriers is necessary because the observed behaviours in the world do not match the predictions of neo-classical economics, which is assumed to describe the investment process. In short the barriers are used to support a failing theory, much as the ether was used to try to prop up Newtonian mechanics around the turn of the century. Like the properties of the ether, types and causes of barriers become more complex and implausible. Even so it is valuable to examine and analyse the imputed barriers precisely because they point to the areas in which the neo-classical

Table 2. A taxonomy of barriers to energy efficiency

Perspective	Sub-division	Barrier	Description	Comments
Economic	Rational behaviour	Heterogeneity	Technology may not be cost effective in a particular instance	An empirical question.
		Hidden costs	Technology investment entails extra costs or loss of benefits that are not reflected in engineering models.	Examples include overheads for staff, overheads for energy information systems, disruptions, hassle, and inconvenience.
		Risk	Stringent investment criteria may represent a rational response to risk	Energy efficiency investments may be a higher risk than others, or there may be business/market risk
		Access to capital	Some agents cannot obtain capital to invest.	A key issue is the level of gearing of a company and the expected consequences of further borrowing
	Market or organisational failure	Imperfect information	Agents lack sufficient information to make economically efficient decisions.	Information has public good characteristics and may be undersupplied by markets.
		Adverse selection	Agent cannot transmit or discover energy properties of a good.	A form of asymmetric information in which transaction costs prevent the energy efficiency benefits of a good from being signalled.
		Split incentives	Agent cannot appropriate benefit of investment - landlord-tenant type relationships.	Examples included departments not being accountable for energy consumption, and equipment purchasers not being accountable for running costs
		Principal-agent relationships	Principal may impose strict investment criteria to compensate for imperfect information	Asymmetric information creates incentives for the agent to maximise his utility to the detriment of the principal. Principal-agent relationships are pervasive within organisations.

Perspective	Sub-division	Barrier	Description	Comments
Behavioural	Bounded rationality	Bounded rationality	Cognitive limitations lead to agents satisficing rather than optimising and relying on routines & rules of thumb. Organisational routines may systematically neglect energy efficiency	Well established opposition to mainstream tradition in economics. Strongly supported by empirical studies of energy decision making. Routines are an organisational solution to bounded rationality
	The human dimension	Form of information	Form of information may be inadequate to stimulate action.	Results from social psychology. Form of information as important as cost.
		Credibility and trust	Agent may not trust source of information	Credibility enhanced by interpersonal contacts.
		Inertia	Agents resist change because they are committed to what they are doing and justify inertia by downgrading contrary information.	Derives from theory of cognitive dissonance.
		Values	*Lack of environmental awareness leads to neglect of efficiency opportunities*	*Not barrier but an important explanatory variable*
Organisational theory		Power	Agents lack sufficient power within an organisation to initiate action	Energy manager may lack status and authority
		Culture	*Environmental awareness and energy efficiency play no part in corporate culture.*	*Not a barrier but an important explanatory variable*

From: “Barriers to energy efficiency in public and private organisations” S.Sorrell, SPRU framework fails to describe what happens in the real world. Since policies have to be "rationalised and justified" within the neo-classical framework the language of barriers is a useful device for bringing policies into line with real world behaviour.

5. Sorrell's analysis of barriers is partly based on the work of Jaffe and Stavins who have distinguished between barriers that are also market imperfections and barriers which are "rational" i.e. not imperfections but part of the way markets operate. Four classes of market failure are identified; incomplete markets (including externalities and public goods), imperfect competition, imperfect information and asymmetric information. Of these four the authors of the SPRU report regard only the last two as important in explaining the "efficiency gap" i.e. the barriers to uptake of energy efficiency.

6 Imperfect information is particularly important in the markets for energy efficiency products because
   (a) the products are purchased infrequently
   (b) their performance is difficult to evaluate both before and after purchase (due to the aggregation of fuel bills)
   (c) there is likely to be rapid technological change between purchases
   (d) whilst capital costs are easy to assess, operating costs are not

   Note that there are two types of intervention possible to overcome this barrier, either by providing more information (e.g. energy labels) or by setting performance standards (i.e. regulation). The evidence shows that the latter is more effective (see also later points on bounded rationality). It is also possible to use both modes of intervention in the same area.

7 Asymmetric information occurs when one party to a transaction has information that is concealed from the other. Prior to a sale or contract this can result in *adverse selection* in which the bad drives out the good. The market for domestic and commercial properties falls into this category. Because running costs are not factored into the purchase or rental prices the builders/developers are encouraged to build to the lowest standard possible. After a sale or contract has been agreed asymmetric information manifests as *moral hazard* or *principal-agent* problems. Both terms refer to the fact the tendency to behave in ways that exploit the terms of the contract or sale, as for example people being careless once insured. The other main form of asymmetric information is *split incentives* or the *landlord-tenant* relationship. Split incentives can take place between economic agents (as in the case of landlord and tenant) or within an organisation, where the equipment purchasing manager may not have any responsibility for the running costs.

8 There are several types of economic barriers which are recognised as playing a role in the efficiency gap, but which are not market failures. This does not mean that there is no case for intervention, just that the case is not based upon the existence of a market failure[89]. The barriers identified under this heading are *heterogeneity, hidden costs, risk* and *access to capital.*
   8.1 Heterogeneity refers to the fact that although engineering calculations of costs and savings are based upon some set of average conditions, there will be significant

[89] For example the intervention by PESs in the market for CFLs was not based upon market imperfections. Nevertheless the intervention drmatically changed the market with a consequent reduction in CFL price.

departures from these that may account for the measure not being implemented. One obvious example is the hours of use of a CHP set or CFL. This is enormously variable and critical in assessing cost-effectiveness.

8.2 'Hidden costs' is a potential catch all category and has been invoked as a major contributor to the efficiency gap. Aside from the danger of tautology there is also very little hard evidence of the existence or magnitude of any hidden costs. Studies that have compared purchases of an efficient and inefficient alternative with the same hidden costs have found that the inefficient option is favoured. One estimate of the information costs associated with an efficient technology put them in the region of 3% to 8% of purchase costs.[90]

8.3 Risk refers to the possibility that there is something inherently more risky about energy efficiency investments than alternatives. Various models have been proposed to account for this and have been criticised as implausible. Since most of the efficiency gap is concerned with well established technologies there seems very little evidence that risk is a significant contributor[91]. (Sorrell points out that the apparent use of high discount rates is not the issue since that is simply a restatement of the existence of an efficiency gap).

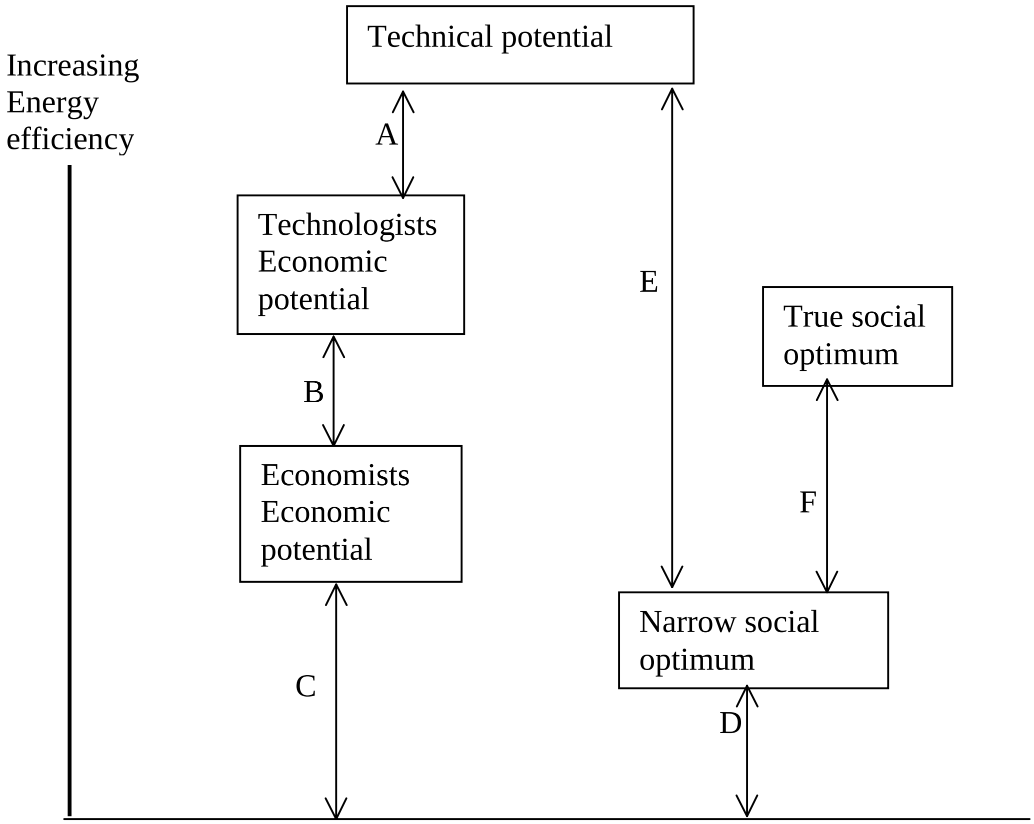
8.4 Access to capital[92] is known to be a constraint on low-income households and public sector organisations. In the case of private companies it is argued that to keep gearing ratios low companies ration their use of capital. Since energy efficiency projects are likely to be low on the list of priorities this may explain why they are not taken up. (However most studies into the area have found that energy efficiency projects are not even considered, let alone ruled out on a priority basis.)

9 The distinction between different types of barriers led Jaffe and Stavins to draw important distinctions between various estimates of the potential for energy efficiency. This is illustrated in the diagram below.

[90] The SPRU report does not comment on the fact that market barriers seem to always work against energy efficiency, never for it. For example there may also be "hidden benefits" associated with improved energy efficiency – an example is the increased lifetime and reduced maintenance costs associated with CFLs.

[91] One possible source of risk is that fuel prices might fall.

[92] Note that restricted access to capital may be regarded as a market failure. The SPRU authors describe limits that arise in an economically "rational" fashion – particularly within firms.



9.1 The gaps between the various boxes in the diagram correspond, in Jaffe and Stavins view, to the removal of different categories of barriers.

A. Corresponds to selecting only cost-effective measures from the available options.
B. Corresponds to eliminating the barriers considered by economists as rational, i.e. not market failures (heterogeneity, hidden costs etc).
C. Corresponds to eliminating the barriers that economists recognise as being part of a market failure (lack of information etc).
D. This is the sub-set of C for which the benefits are greater than the costs of intervention. Thus not all of the market failures in C can be cost-effectively removed.
E. The difference between the ultimate potential and the narrow social optimum represents all the barriers that are not removed, either because they are not market failures or because the costs of so doing exceed their benefits.
F. This difference represents the additional energy efficiency justified by environmental externalities.

9.2 It should be noted that the assumption that intervention should be confined to the elimination of market failures justified by a cost-benefit test is not universally accepted. Political objectives may require a greater level of intervention.

10 In addition to the various classes of economic barriers Sorrell's analysis also includes behavioural and organisational barriers. The main organisational barriers considered are split incentives and principal-agent problems – only now applied within a firm as

opposed to in the market for energy services. Other organisational barriers are discussed under 13 below.

11 Although in the general framework *transaction costs* are classified under the behavioural heading, in the final taxonomy used in the study transactional costs are not explicitly considered (as shown in Table 2). The explanation for this is, in Sorrell's terms, due to their implicit inclusion in the economic analysis summarised above. Sorrell refers to the work of Williamson and points out that there are two important behavioural assumptions included in transaction cost economics, namely bounded rationality (of which more later) and opportunism – otherwise known as lying, stealing and cheating. Opportunism may be an ingredient in understanding some markets, but does not seem to have a role to play in explaining the efficiency gap.

12 In a paper presented to an IEA Workshop, a member of the international team working on the SPRU project, Katrin Ostertag, describes experience in exploring the role of transaction costs in four energy efficiency case studies[93]. Her conclusions are

(a) Energy efficiency products do not necessarily have higher transaction costs than alternatives, and it is only a difference that is useful in explaining the preferential purchase of inefficient equipment and appliances.
(b) Even where energy efficiency products do have a higher transaction cost the difference, in so far as it can be measured, is marginal and
(c) The difference is usually only incurred the first time that an energy efficient product is purchased. Following the initial purchase the efficient product is on the same footing as the inefficient ones.
(d) Transaction cost analysis can provide leverage points that enable policies to reduce the overall costs of energy efficient options.

One conclusion that can be drawn from Ostertag's analysis is that transaction costs need to be analysed on a dynamic, rather than static, basis. Market transformation programmes aim to reduce transaction costs whilst mass markets develop.

13 The main behavioural barrier discussed by Sorrell is that of bounded rationality. He emphasises that limited attention will require participants to make use of cognitively efficient rules of thumb and fixed procedures for all sorts of large and small decisions. If energy efficiency is not included within these rules of thumb and procedures then it will not be considered at all. This is potentially an important explanation of the efficiency gap. Sorrell draws three main conclusions from his discussion.

A. Bounded rationality is a barrier that does not fit into conventional economic models. He notes that Eyre concludes that the failure to even attempt to maximise utility constitutes a market failure.
B. Although it is not possible to determine the exact proportion, this barrier certainly plays a significant role in the efficiency gap.
C. Bounded rationality may also undermine intervention programmes designed to improve energy efficiency. If agents currently do not use or lack the ability to use information there is little point in providing them with more.

[93] Available at http://www.iea.org/workshop/engecon/index.html

14 The other behavioural barriers identified by Sorrell are *form of information, credibility and trust, inertia* and *values.*

14.1 Studies have shown that unless information is specific and personal, vivid, clear, simple and relevant to the person's current experience, then it will not be effective in modifying the person's behaviour or purchasing pattern. These are all well known to sales and marketing folk and form the basis of the design of effective advertising and marketing materials.

14.2 It has also been demonstrated that households distrust many commercial vendors, particularly fuel suppliers.[94] Perception of credibility depends upon a wide range of factors including previous experience and whether the information being presented makes sense of that experience[95]. Leaflets and promotions on saving energy coming from a fuel supplier make no sense to the public at all.

14.3 There are many aspects and forms of inertia, but they all depend upon continuing to do something that is familiar and safe as opposed to making a change that might involve some unforeseen risk. It is also the case that households and firms regard themselves as endowed with their current buildings and energy bills. Foregone energy savings will be considered an opportunity cost, while the investment costs of energy efficiency measures will be an out-of-pocket cost. In general action requires greater justification than inaction. People also become committed to their current course of action and their own rationalisations for it.

14.4 In discussing the role of values Sorrell makes clear that in specifying the existence of a gap there is an assumed motivation to be economic, to save money. If such a motivation does not exist then the notion of an efficiency gap itself disappears – people and firms do not buy energy efficient products because they do not want them. Although dismissed by Sorrell, this perspective has, in this author's view, considerable merit. In his discussion of values Sorrell points out that for many people the purchase of energy efficient products arises from a commitment to the environment and that within organisations corporate values, the hobby horse of the CEO and effective product champions all play an important role in contextualising energy efficiency decisions.

15 The final barriers discussed by Sorrell are under the general heading of organisational. His discussion makes it clear that he finds the organisational literature difficult. Nevertheless some useful insights emerge. The first is that certain types of technology suit different organisational structures, particularly the degree of centralisation and control. Second the power structure and power relations within an organisation can have a significant impact on the decisions taken. In terms of energy efficiency the existence of, and power available to, an energy manager are often crucial. Finally the culture of the organisation can have a profound effect on the importance that energy efficiency and environmental values within the organisation.

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[94] A study by Craig and McCann reported by Sorrell involved 1000 new York households being sent a pamphlet describing how to save energy. Half received the mail from the local utility and half from the state regulatory agency. The following month the households receiving the pamphlet from the agency used about 8% less electricity than those receiving the same pamphlet from the utility.

[95] One reason for the distrust of energy efficiency products and advice from fuel suppliers is that the public knows fuel suppliers want to sell more of their main product (fuel) not less.

In this context it has often been recognised that promoting energy efficiency to the CEO of firms is often the most effective way to engage the organisation in energy efficiency.

16 The study used case studies in each of the three countries (UK, Ireland and Germany) to explore the existence of the various barriers identified by the theoretical analysis. Data was obtained from a total of 46 organisations in three sectors in three countries. The data was collected by use of questionnaires and interviews. The conclusions were that in the business sectors studied the economic barriers were the most prevalent and the most important in plausibly explaining the efficiency gap. This is not surprising given the strong economic perspective of the whole study[96]. The main conclusions drawn were:

16.1 A major issue in all cases in all countries was constraints on staff time. This was interpreted as a hidden cost involving staff overheads. (It could also have been interpreted as reinforcing the importance of bounded rationality, particularly limited attention.)

16.2 The second strong message was the limited access to capital. This reflects both a reluctance to borrow and the low priority given to energy efficiency within budgeting procedures.

16.3 Third there was more than one plausible explanation for the adoption of strict investment criteria, including recovery of staff costs, business risk, monitoring and control problems and financing increased gearing.

16.4 Bounded rationality was found to be an important explanatory tool and provides an important limit on what can be achieved by correcting market and organisational failures.

[96] To a hammer everything looks like a nail.

Appendix 3. An alternative approach to Energy Services

1. As explained in section 2 of the paper there is a long history of promoting energy efficiency measures to households that have failed to make any significant impact on the market. Some of the reasons for this were discussed in detail in section 3.3. For the non-fuel poor households who would be the target of ESCOs the obstacles include
   (a) the low proportion of expenditure on fuel costs
   (b) the loss of capital associated with energy efficiency investments
   (c) the lack of trust in both those providing information and the installers required to carry out works within the home.

   Coupled with the invisibility of energy efficiency and the constraints imposed by bounded rationality it is easy to understand why little progress has been made with the core energy efficiency measures in this sector. ESCOs would have to find ways to overcome these difficulties.
2. In the recent DTI report on "Energy Services in the Domestic Sector" by Dominic Macklon the provision of energy services was described in terms of a "package may consist of

   - Duel fuel energy supply
   - Free home energy efficiency audit
   - Provision and project managed installation of energy efficiency measures
   - Finance for those measures
   - Ongoing advice and promotion of energy efficient appliances and practices
3. The Report identified a wide range of barriers, business issues and dilemmas which would need to be addressed in order that energy services could develop within the current fuel supply market. The Report is succinct, direct and concludes with a challenging action plan. There is no need to summarise or reproduce that here.
4. Within the scope of the current PIU project the definition of energy services in the DTI Report is minimalist. A range of companies have attempted to make such schemes work, largely financed by EST start-up grants and all have failed. With the changes proposed by Macklon they would certainly be more viable and may well become significant if the fuel companies regarded such schemes as ways of marketing to and retaining customers.
   4.1. However fuel companies face an important additional obstacle, namely that to the public it makes no sense for a fuel supplier to be selling products that reduce the use of fuel. The reputation of fuel companies is still tarnished by the misleading campaigns and claims made when gas and electricity sought to increase their share of the domestic market. Together these pose a very serious problem of trust that would be difficult (and expensive) to overcome.
5. There is, however, an alternative and more comprehensive approach to the provision of energy services which may fit better with the longer term aims of the PIU project – and may also be more viable commercially. This is based on the ideas of 'dematerialisation' promoted by Tim Jackson and popularised in books such as Natural Capitalism.

6. A comprehensive energy service contract with a household would provide heating, cooling, washing and lighting services to the household for a fixed cost per year. The operating company (ESCO) would own the appliances and be responsible for their maintenance and replacement. The ESCO would also pay the bulk of the household fuel bill. The household would only pay for the part of the electricity bill that corresponds to electricity used by portable appliances plugged into 13A sockets in the dwelling (e.g. TV, hi-fi, iron, sewing machine, computer, toaster, kettle etc.)
7. There are two significant advantages for this comprehensive approach.
    7.1. The scheme "goes with the grain" of consumer attitudes toward energy efficiency and the purchase and maintenance of appliances. Everything is hassle free and guaranteed to work for a fixed sum of money per year – not quite as sexy as a holiday or new car, but clearly a positive return for the outlay.
    7.2. The ESCO has a major incentive to invest in all cost-effective energy efficiency measures and to also provide the householder with energy efficient and reliable appliances[97].
8. There are also two major disadvantages of such a scheme.
    8.1. The householder is now receiving a range of energy services for a fixed fee per year. Experience with households receiving heating on a flat rate (as in many communal heating schemes) indicates that consumption increases by, on average, 25%[98]. This would undermine the energy efficiency component.
    8.2. The main commercial risk for the ESCO is with the length of contract with the householder. Most energy efficiency measures have a payback period of 3-5 years and appliances have an expected lifetime of 5-7 years. It would therefore be essential for the ESCO to have contracts for 5 or more years to make the schemes commercially viable[99].
9. In order to make such a scheme work it would be essential to
    9.1. Monitor key variables in the household such that additional charges could be levied for leaving lights on, having the heating up high and excessive use of hot water. New remote sensing and monitoring schemes make this relatively easy to accomplish. The contract with the householder would then clearly state the additional charges for items such as heating to temperatures above 21°C. If the service contract included remote security monitoring and could also provide warnings for things such as high freezer temperature, then the remote monitoring would not be an additional cost but an additional service to the householder.
    9.2. The service would have to be tied to the property, not to the particular household, much the way that maintenance contracts are part of the purchase price or rent of

[97] It may be worth noting that the TV Rental business did a great deal to increase the reliability of TVs and video recorders through the centralisation of purchasing power and the need to reduce maintenance costs. A similar effect in the white goods market would be welcomed by many.
[98] It should be noted that this also applies in schemes where the user has no control over the level of heating provided i.e. there are no local controls. With a well controlled scheme there would still be a level of increased comfort, but less than the 25% recorded in poorly controlled schemes.
[99] A recent note from DETR "Energy Services In The Domestic Sector. Identifying The Myths, Promulgating The Message And Tackling The Problems" completely misses this point and suggests that the 28-day rule is not an obstacle to ESCO operation. The significance of the 28-day rule is obnvious to all business people, including Macklon.

"serviced" flats. Indeed the luxury flat market would be the obvious place to start such a business. Another obvious entry point is with builders of "executive" properties at the upper end of the market.

10. It seems that a comprehensive energy services scheme would have a better chance of commercial success than the more limited schemes tried to date and discussed further in the Macklon Report. It may be significant that the idea for the more comprehensive scheme arose from the literature on "dematerialisation" as a long-term solution to the environment/resource productivity issues. Commercially it seems to have a better chance of success because it fits better with consumer attitudes to energy efficiency and the purchase of the major energy using appliances.