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THE IMPORTANCE AND VIABILITY OF THE ENERGY EFFICIENT LIFESTYLE IN THE UK

By

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Executive Summary

This report is commissioned by DEFRA (the Department of Environment, Food and Rural Affairs) to consider possible methods for improving the energy efficiency of the UK. By illustrating why energy efficiency is of great importance to the UK, and why lifestyle is an important factor in combating the related problems. The main body of the report concentrates on four key areas which the government, through DEFRA, can act on, encouraging the public to make changes to their way of life. These four areas are *Heating and Changes in the Home*, *Energy-Saving Appliances and Equipment, Energy Efficient Private Vehicles* and *Food Transport*.

There are two main reasons why energy efficiency in the UK is of paramount importance. Firstly, the country relies primarily on fossil fuels for power generation, which will, at some stage, be consumed. Energy efficiency will prolong the duration that fossil fuels can be exploited, by reducing the rate of consumption. Secondly, power stations, industry and vehicles emit carbon dioxide into the atmosphere, which is believed to augment climate change. The consequences of this are difficult to predict but could include an increase in average global temperatures of 5ºC by 2100, increased flood risk, decrease in crop yields and extremes of weather [1].

Over 30% of the UK's energy is consumed domestically. This is an area of concern and improvements to domestic consumption will reduce the energy usage considerable [2]. Promoting solar water-heating and biomass fuels as a means of heating the home has clear advantages, such as independence from fossil fuels and carbon neutrality.

Businesses may be able to play a significant role in helping with the promotion of these alternative energy sources. Industries who require carbon-credits for emission, should be able to purchase credits, in advance, from the government at a 20% reduced rate. The government can then invest this money in domestic projects aimed at improving energy efficiency such as the installation of solar water-heating and bio-fuel heating systems. The government, who provides the industry with a corresponding number of carbon credits, will benefit in reduced national carbon emission.

Interest-free loans could also help encourage the spread of domestic alternative energy systems. These would be offered to people wishing to install energy-efficient systems and homebuyers wishing to purchase a house with these systems already installed.

On a smaller scale, energy consumption can be reduced through the greater proliferation of energy-efficient electrical appliances. The government should lobby the EU to extend the energy-rating scheme for appliances, then, using this scheme as a basis, tax lower grade goods to reduce the cost margin between efficient and

non-efficient items. Furthermore, goods below grade C on the EU Energy Rating scheme should be banned.

However, without the public realizing the significance of an energy-efficient lifestyle, the government cannot expect change. Education schemes should be introduced such that the public, of all ages, are informed of the changes they can implement without vastly altering their lifestyle.

Transport consumes a massive proportion of fossil fuels, whilst also emitting carbon dioxide. One way to improve efficiency is though the development and promotion of hybrid engines, which utilise an electric motor to assist a conventional petrol engine, reducing the fuel consumed. The government could promote hybrid vehicles through the reintroduction of the *alternative fuel grant* formally endorsed by the Energy Saving Trust (EST), to assist the purchase of such a vehicle. Increasing the cost of owning an inefficient vehicle through greater road tax and fuel duty would also ensure greater uptake of efficient vehicles and encourage manufacturers to include fuel-efficient technologies in their vehicle range.

This report also recommends increasing the current investment in alternative fuel sources such as hydrogen.

The food transport situation also should be improved. It is clearly preferable that more food is transported by rail and sea than air and road. Taxing air food-cargo, to fund improvements to the rail infrastructure, would promote the transport of food by highly efficient rail transport. This would result in an increase in the cost of food transported by air, thus encouraging the public to buy more locally sourced food.

In this report there are many recommendations on a wide range of subjects. Implementation of these proposals should improve the energy-efficient status of the UK, whilst ensuring the lifestyle of the public is altered very little.

Chapter 1.

Introduction

The two most pressing concerns related to energy consumption are the diminishing availability of fossil fuels and the effect that their burning has on the environment in the form of what is commonly termed “global warming” or "climate change".

Some of the possible effects of climate change are outlined in the review lead by Sir Nicholas Stern. He concluded that carbon emissions have already caused ½℃ increase in global temperatures and that if current trends continue there could be a further 5° rise over the coming decades [1]. This is in agreement with the Intergovernmental Panel on Climate Change (IPCC), who, in 2001, predicted that global temperatures are likely to rise from the 1990 average by between 1.4℃ and 5℃ by 2100 [3]. However, these figures are merely estimates.

The Earth's climate system is extremely complicated; the rate of carbon emission in the future is difficult to predict and there may be positive feedback mechanisms that act to accelerate climate change. One such example of the latter is the heating of the Earth leading to melting of glacial ice and a subsequent reduction in the albedo of the Earth's surface; thus the Earth reflects less solar radiation and global temperatures rise further leading to further glacial melting and so on [4]. Other effects outlined by Stern include increased flood risk, declining crop yields, damage to ecosystems and more extreme weather [1].

It is also important to note that the term "global warming" is somewhat of a misnomer. While the emission of “greenhouse gases” from power stations, industry and vehicles may lead to an overall increase in global temperature, temperatures may not increase everywhere. For example, some scientists [5, 6] predict climate change could lead to a “shutdown” of the North Atlantic Drift, which would lead to the British Isles having a cooler climate, more like Canada than somewhere warmer.

Clearly global warming cannot be tackled purely by a change in people's lifestyles. A complete solution would also have to include a global consensus on energy

generation methods, development of alternative technologies, cleaner industry, improved transport systems and energy-efficient businesses, all of which goes beyond the remit of this report. However, 31% of all energy produced in the UK is consumed domestically [2] and so energy efficiency on a domestic scale is by no means insignificant. In addition, being energy-efficient helps reduce the other problem outlined at the start of the section; our over-reliance on fossil fuels, and helps sustain what the Prime Minister termed the UK's "energy security".

While the majority of the public are likely to be aware of climate change, the fact scientists cannot decisively agree to what extent and over what timescale changes will occur may lead some people to conclude that is no real cause for alarm. Thus it is essential that the government, through DEFRA, acts to make the public aware that apathy is *not* a sustainable option, that they *can* make a meaningful difference and it *is* affordable, and not simply resort to headline grabbing for political gain. To do this, the government must offer incentives to people who choose to make changes to their lifestyle that are beneficial to the UK and penalise those who choose to be wasteful.

The report covers a range of areas and the recommendations given are diverse, feasible, economic and designed to help promote the concept that energy efficiency is possible without huge changes in the individual's way of life.

Chapter 2.

Heating and Changes in the Home

Water heating comprises around 8% of the UK's total energy demand [7]. Energy projects across the country have shown that tax breaks or financial rebates for implementation of energy saving measures can help lift people out of fuel poverty.

2.1 Advantages of Solar Water-Heating

There are currently 1,807 households in the UK who have applied for funding towards a solar water-heating system under the *Phase I: Low Carbon Buildings* scheme, which is managed by the government.

A solar water-heating system in the UK can supply up to 50% of a household's hot water requirement and can be used for tap-water heating as well as space heating. Installing a solar water-heating system can reduce the carbon emission created by a household by up to 0.6 tonnes per year as well as saving homeowners up to 50% on their hot water bill. This saving can be as much as £200 per year [8].

Installation of a solar water-heating system, supplying 1,000 to 1,500 kWh of heat per year, costs between £2,000 and £4,000 [9], however the investment could amortise in less than 15 years given appropriate government funding (see *Appendix A*). The government grants available depend on the size of the system installed and the fuel that is being replaced. A 'funding calculator' should be made available online such that the public, or more specifically, the building contractor can calculate the amortisation time for an individual household.

Incentives offered by the government for energy-saving devices could be improved by investing money that would otherwise go to purchasing emission credits through the carbon-trading scheme. This would mean that the money is reinvested in the UK, improving energy efficiency further, which will ensure less emission credits must be bought, thus allowing more money for the incentives. This is a self-sustaining situation, which would be good for the government to realise.

A household fitted with a solar panel in 2006 would result in an emissions reduction of 3 tonne of carbon dioxide by 2012 (see *Appendix B)*. Per household, this would equate to a £60 saving in carbon emission trading (assuming April 2006 prices). If this money were used to promote solar heating and bio fuels, both the British economy and the environment would benefit. Since carbon-trading prices under the European Union Emissions Trading Scheme (EU-ETS) are set to increase in 2007 from £27 to £68 per tonne, the UK would only profit from such an arrangement [10].

This report also proposes a new scheme through which additional funds could be raised by rewarding companies that participate in a campaign to reduce household emissions. Participating companies would be offered a 20% rebate on the projected 2007 cost of 1 tonne of carbon (i.e. £54.40 per tonne instead of £68 per tonne). The company would pay the required amount into a fund benefiting homeowners and businesses alike, funding solar panels and other renewable or sustainable energy technologies. The companies would, in return, be awarded a corresponding amount of carbon-emission credits. Thus participating businesses are benefiting through cheaper carbon credits whilst also helping improve the energy efficiency of homes and industry. However, companies who know they will exceed their emission caps in the future could buy carbon credits early when they are still cheaper than the government's proposed £54.40, which would undermine the scheme.

The current situation, as it presents itself to homeowners through the *Phase I: Low Carbon Buildings (LCB) Scheme*, does not allow landlords of rented property to apply for funding for energy saving technologies for the houses they own. This in turn means that tenants can never profit from the LCB program. The LCB program should be altered to include landlord's property, as the benefits of reduced emissions do not change if the house is owned by the occupant or is rented (see *Appendix C).*

If, by the year 2012, the number of households in the UK with solar panels was 3,600 (double current numbers) it would amount to a reduction of approximately 1,800 tonnes of carbon emission per year (see *Appendix D*), helping the government meet its Kyoto target and reducing the number of carbon credits the UK must purchase.

2.2 Advantages of Bio-Fuel Heating

As solar panels can only provide 50% of the heat required in the average UK household, a boiler or secondary heating system must also be present. Instead of a conventional gas boiler a biomass stove could be installed. Biomass is produced from organic materials, either directly from plants or indirectly via industrial, commercial, agricultural or domestic products [11].

The net accumulation of CO_2 in the atmosphere comes from releasing CO_2 absorbed millions of years ago, by the burning of fossil fuels. Biomass burning does not actually reduce emissions; nevertheless the CO_2 emitted into the atmosphere due to energy generation from biomass is balanced by that absorbed in its production. Furthermore, Biomass fuel (bio-fuel) is very cost-effective, especially when sourced locally, resulting in local investment and economic growth. It can also aid waste management by harnessing energy from products that are otherwise disposed of in landfills [11].

Many households will continue using their existing water heating systems (gas, oil or coal) as a secondary system to back-up their solar water heating. If pellet-fuel heating (a bio-fuel) was combined with a solar water-heating system, a net carbon emission reduction of ~1 tonne per year could be achieved for every household equipped (see *Appendix D)*. Energy generation from biomass would boost industries such as forestry and agriculture, as well as benefiting companies that process suitable bio-fuels. The bio-fuel companies could also increase their revenue by selling the waste products of the process, products such as sawdust, wood chips, bark, agricultural crop waste, waste paper, and other organic materials.

Although bio-fuels will not contribute to the emission reduction required to meet the Kyoto target, the government should consider an investment into these technologies as it would provide, with appropriate planning, a sustainable energy source in which the government can have a regulatory influence on prices due to the local production. This would ensure a stable supply and controlled price as well as helping the economy and businesses.

2.3 Proposed Measures

This report proposes that money should be allocated in the next budget for an information campaign, informing homeowners of the options available and the potential savings. This funding should flow into Non Profit Organisations (NPO) or Non Governmental Organisations (NGO) who use liaison officers to work closely with individuals in a community, ensuring that homeowners take measures tailored to their lifestyle. The current government funding would become more accessible, especially for the elderly who may not have access to the Internet and are least likely to change. Within this proposal would be a legislative change to make the home energy check, performed by the Energy Saving Trust (EST), compulsory for all new homes. Thus new homeowners would know which energy saving measures, specific to their house, would give them the greatest benefit. This will allow homeowners, in conjunction with a local liaison officer, to devise a tailored energy saving strategy for their home.

A scheme where homeowners are given a loan from the government for their initial expenditure on emission reducing measures would allow homeowner's to more easily afford energy saving measures. Considering the recent increase in fossil fuel prices, the scheme would see homeowners repaying their loan simply by continuing to pay their average water-heating bill minus what they spend on bio fuels, until the loan is repaid. This loan could be passed on from one homeowner to the next.

An extra incentive could be offered for the purchase of a house that is already outfitted with emission reducing measures. This may be in the form of an interest-free government loan of 10% of the property value, making these properties more desirable, compared against properties that do not have built in measures. This would also make it desirable for housing contractors to install energy saving systems when developing properties. This scheme however is extremely expensive as the projected initial outlay necessary from the government is estimated to be around £73million (see *Appendix E)* with the government losing approximately £4.5million (see *Appendix F)* from the interest-free repayments of the loans.

Many schemes are already underway, through the LCB program, to provide the public with incentives for solar or bio-fuel energy generation systems, but a lot more can, and should, be done. This is especially the case for the introduction of pellet fuels as a real alternative and by making the market for subsidies more easily accessible and understandable, allowing homeowners to make full use of the available government funding.

Chapter 3.

Energy-Saving Appliances and Equipment

Appliances and lighting account for 20% of the total household energy use [12]. Lighting alone accounts for up to 15% of the electricity bill [13]. By adopting energy-efficient measures and appliances, which are of the same quality as current appliances, the energy costs incurred may be significantly reduced.

The incandescent light bulb is an example of a particularly inefficient product used extensively in homes, converting only about 5% of the energy it receives into light. The most obvious action in this case is to replace incandescent bulbs with Compact Fluorescent Lighting (CFL), marketed in many countries as "energy-saving bulbs" [14]. Although more expensive, these bulbs use 25 to 80 percent less energy than incandescent bulbs [15, 16] and can last on average up to 12 times longer [13]. In a home, this conversion would bring about significant savings; earning the extra money it costs to buy them in less than a year (on average a saving of £9 per year per bulb) [13]. However, the conversion to energy-efficient light bulbs in the UK is dogged by setbacks; poor quality lights and fittings, compatibility with tungsten fittings and a lack of information. Furthermore the financial benefit of these products is often not considered to be of high enough importance in many households [12], where only the initial price is taken into consideration.

3.1 Labelling Systems

There is a wide range of energy-saving appliances available to the modern consumer including TV's, washing machines, dishwashers and energy-efficient light bulbs. To encourage people to choose energy-saving appliances, various labelling systems have been introduced to aid the identification of these products

The EU Energy Rating measures energy efficiency on a nine-point scale from grade A++ to grade G [16]. The system currently covers:

• Washing Machines (excluding twin-tub models);

- Tumble Dryers;
- Combined Washer-dryers;
- Lamps;
- Dishwashers;
- Ovens;
- Refrigerators and Freezers;
- Air Conditioners; and
- Boilers

The labelling is subject to various EU directives and operates on a pan-European basis. It uses a linear scale, whereby improving the rating by one grade will reduce the energy consumed by a fixed amount. The energy rating of an appliance is defined by the energy efficiency index as seen in *Appendix G*. A specific example of washing machine ratings and their energy consumption at a number of temperatures is shown in *Figure 3.1*.

Energy Rating	A	B	C	D	E	F
90℃ wash (kWh / cycle)	1.22	1.46	1.59	1.72	1.85	1.98
60℃ wash (kWh / cycle)	0.94	1.12	1.23	1.34	1.47	1.60
40℃ wash (kWh / cycle)	0.56	0.67	0.74	0.79	0.85	0.91

Figure 3.1: The energy consumption at a number of cycle temperatures of different ratings of washing machine [17].

Some information, such as the energy efficiency rating and the typical annual consumption, are universal requirements on the EU Energy Rating labels. Other information, specific to the product, may also be supplied [18].

However, the EU energy-rating label is becoming less effective; products with ratings C and below are all but obsolete, with very few stores stocking low efficiency products. For example, two of the main appliance retailers in the UK, Comet and Currys, stock only grade B or higher fridge-freezers [19, 20]. *Figure 3.2* illustrates the market share in washing machines, fridges and freezers, and shows that the proportions of products labelled as C or above have, in recent years, increased significantly.

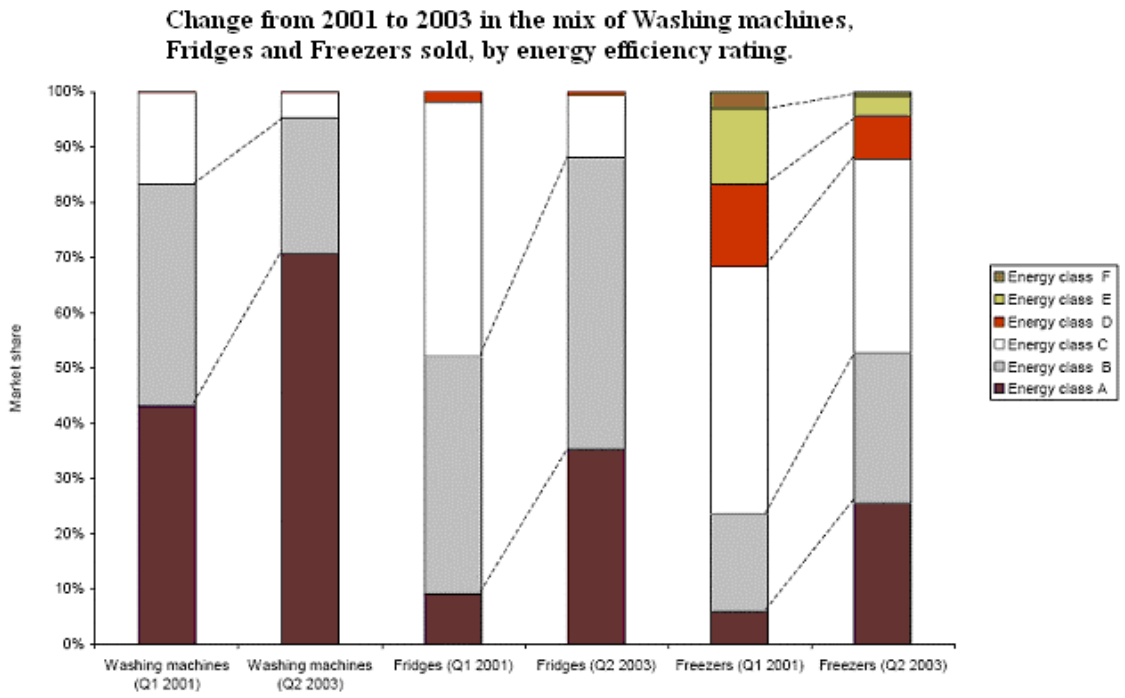

Figure 3.2: A comparison of the proportion of different energy ratings sold in washing machines, fridges and freezers across 2001 and 2003, illustrating the increase in more efficient products over time [21].

The "Energy Saving Recommended" logo can be found on the most efficient products to identify them. For a product to qualify for the logo, it must have an EU rating of A+ or A+ + for fridges and freezers, A or B for boilers and A for all other appliances [16].

For office equipment the "Energy Star" scheme helps in identifying energy saving products such as printers, computers and photocopiers. This aids consumers at a time when the energy consumption of office equipment varies considerably. For example, the consumption of a PC and printer can vary between 40 to 400 kWh/year, which amounts to a £25 difference in running costs [16].

However, whilst these labels give consumers a broad understanding of the energy efficiency of a product, the standards and requirements under EU legislation are open to interpretation by manufacturers. As a result, the performance of a product often cannot be compared to similar products within a rating band [12].

3.2 The Effects of Cost upon Energy-Efficient Appliances

Cost is the main issue dissuading consumers from purchasing energy-efficient items. The initial cost, however, may be offset by the long-term savings made on energy bills. This is shown in *Figure 3.3* [12].

Appliance and Rating	Typical annual saving* (£)	Extra cost in relation to a B rated product**	Amortisation time
Fridge Freezer (A+)	45	170	< 9
Chest/Upright Freezer (A+)	35	170	39
Refrigerator (A+)	20	77	11
Washing Machine (A)	10	-	Nil
Dishwasher (A)	20	-	Nil

Figure 3.3: A/A+ rated appliances with typical annual saving (see Appendices H & J).

Despite the problem of high prices inhibiting the sales of efficient appliances, the EU Energy Rating scheme has been deemed a success by the EST, who indicated that there is scope to introduce labels to a wider range of products such as toasters and microwaves [12].

To tackle the publics' ignorance about saving energy, inclusion of the average cost per year or per cycle for each appliance on the label could be considered. However, due to a recent study by Oxera, it has been discovered that providing this information does not influence customers to buy efficient goods and that the alphabetical system with its simplicity is a well functioning system [21].

The Energy Efficiency Commitment (EEC) was set up to encourage the reduction of energy consumption by placing obligations on energy suppliers to improve energy efficiency amongst their domestic customers. Initially electricity bills increased, providing around £23million per year, allowing energy companies to fund energy efficiency projects such as free light bulb schemes. Under the EEC, suppliers allocate subsidies to customers who take energy-efficient measures. These energy-efficient measures, however, must be specified by the suppliers and is usually based on insulation, not appliances. The scheme (from 2002 to 2005) was funded via a charge on customer's bills of up to £3.60 per customer, with an expected programme expenditure of around £150million per annum [22].

It was found by an Oxera questionnaire in 2005 that 43% of the public are in favour of a tax on highly inefficient products [21]. At present a 5% reduced rate of VAT is charged on a range of energy-efficient products such as central heating systems and heating appliances installed as part of a grant scheme. While EU VAT directives limit the scope for using VAT reductions on more energy-efficient products, subsidies could otherwise be provided in the form of a reduction of other forms of personal tax liability, although this would probably involve considerable administrative complexity. Alternatively, introducing additional charges on less efficient products could also provide the funds. Tax on the cost of domestic energy is not advised however, due to the number of people already below the poverty fuel line (defined as when more than 10% of the income of a house goes towards heating) [22].

3.3 Schemes

Since 1993, a network of 52 Energy Efficiency Advice Centres (EEAC's), funded by the EST, have been active across the country. These provide advice to householders and managing local and national energy efficiency schemes. EEAC's run a range of projects and pilot schemes, from grant schemes to fuel poverty

projects. Currently, 2 million customers have been advised, resulting in an average annual saving of £38 per household [23].

Whilst 2 million is an impressive number of people, when compared to the 21 million households in the UK, the number advised is only 9% of the population, indicating that many people are unaware of the EEAC's. Greater publicity of the EEAC's is needed to enable them to reach their full potential in helping more people to reduce their energy consumption. By extending the scope of these centres to work with school children (for example hands on activity centres), the importance of an energy-efficient lifestyle can be instilled in the next generation of homeowners.

Free light bulb schemes in the past have proved successful in increasing awareness of the benefits of energy-saving lighting. For example, the Energy Efficiency Commitment Annual Report of 2004/2005 from British Gas states;

'The target groups were all made aware of the benefits of low energy light bulbs'.

British Gas distributed free, low-energy consumption, light bulbs with a leaflet giving advice and instructions on how and where to install them. These were distributed via a number of channels including Help the Aged Handy Vans, "Warm-a-Life" and Social Housing. They also offered energy-efficient light bulbs to their customers at a reduced price and free light bulbs to customers who took part in other energy-saving initiative schemes [22].

It has been shown by the Oxera report (January 2006) that the involvement of energy suppliers within schemes is invaluable, providing the most cost-effective way of reaching the public [21]. If DEFRA were to support similar schemes, more people would learn of the benefits of energy-efficient light bulbs and become more confident in their quality.

3.4 Energy Saving Use of Appliances and Education

The first step to greater energy efficiency in the home may not be the introduction of new, more economical appliances (as this is usually a gradual process which occurs when the current appliance needs replacing) but in the way people use their existing appliances. For example, a turned off incandescent light bulb saves the electricity cost of turning it back on in 3 seconds while lowering the heating by 1ºC alone can save 10% of the heating bill [16,13]. Households in the UK now spend 10% of their electricity bill keeping appliances on standby, using 10 to 85 percent of the power they would have if left turned on. For the entire UK over the course of a year, this adds up to the annual output of two and a half 700MW power stations [13]. To encourage energy efficiency across the UK, informing people of the need to conserve energy and the effects of 'standby' consumption should be a priority.

The European Commission's report, *Education on Energy - Teaching tomorrow's energy consumers* states:

"A large part of our ideas and knowledge, and the basis of our adult behaviour, is absorbed during our education. Education systems have the capacity to modify an individual's attitudes by exposing them to new ideas and concepts." [24]

This is a familiar idea and is employed throughout the education system to raise children's awareness of topical issues such as water efficiency. The use of appropriate education is the most cost-effective method to save energy and promote energy efficiency [24].

In Brazil, educational activities for reducing energy have proved to be the most effective approach (see *Appendix K*). With an input of $744,860, 69.71GW per year were saved, leading to a cost-effectiveness of $0.01 spent for every kilowatt-hour saved. If the same system was applied in the UK, through leaflet schemes, fun energy-saving days for schools and introducing energy-saving issues to children in a more on-hands approach, the issue of saving energy could reach a much larger audience [24].

It is clear that education is an important tool in creating an energy-efficient lifestyle; by teaching about the conscientious use of appliances we can reduce the energy consumption of current and future generations.

3.5 Proposed Measures

Whilst current labelling systems are adequate to inform and encourage the customer to buy energy-efficient products, the range of products that the labels apply to could be extended. The current systems may be confusing for the customer and a single labelling system, covering all relevant appliances, would help to standardise the situation, as well as reduce costs incurred. Thus having one standard system would save money, which could be used to further promote the system. Furthermore, current goods below grade C should be banned; this would cut out a section of the worst efficiency products, forcing people to choose higher efficiency appliances.

The current EEC scheme is functioning well, helping to implement energy saving systems across the UK. The current programme could be improved for appliances by ensuring advisory companies recognise appliances as part of an energy-efficient system that could work towards a more energy-efficient home. Energy-efficient light bulb schemes should be included more prominently within the EEC and should also appear in other schemes, with educational packs funded by companies and endorsed by the government.

To encourage people to buy more efficient goods, a higher tax should be imposed on less efficient goods. This will bring the prices of high and low efficiency products to a more comparable level and therefore encourage people to buy more energy-efficient products. This is particularly relevant to the sales of energy-efficient light bulbs.

It is apparent the EEAC's are not widely known about and that more advertising and promotion is required. An advertisement on channel five TV in the daytime costs on average £2,000 and 30 days advertising, once a day, would therefore cost approximately £60,000, however even a short spate of advertising can significantly increase awareness. Another proposal is for the EEAC's to be included in schemes that reach out to children, such as hands on activity centres, which would instil energy-efficient values in the next generation [25].

Education is a highly important factor in encouraging people to use energy-efficient appliances. Through better education we can teach people, not only about the

existence of energy saving appliances, but also about the *use* of these appliances. Education is the most cost-effective method of reducing energy consumption, shown clearly by the scheme in Brazil. A leafleting campaign using the *Door to Door* service from the Royal Mail posted to half the households in the UK [26] and charged at £38 per thousand [27], could cost as little as £404,250.

Chapter 4.

Energy-Efficient Private Vehicles

4.1 Changes in Transport

Transport in the UK is a massive consumer of energy. There are an ever-increasing number of vehicles on the road, over 26 million as of 2005, almost all of which use petrol or diesel [28]. Certainly the use of these fuels cannot be maintained indefinitely as oil reserves are finite.

Vehicles produced today are much improved in terms of energy efficiency compared with previous models. Manufacturers have recognised that making energy-efficient devices standard ensures less fuel is used, thus creating savings for the customer making their product more popular [29]. As a consequence, whether intended or not, the greater efficiency leads to there being more fuel available for future years (see *Figure 4.1*).

Vehicles on sale after March 2001 are given efficiency ratings similar to that of white goods, with a scale between A (most efficient) and G (least efficient) based on emissions, allowing customers to compare the efficiency of different vehicles. The greater the fuel-efficiency of the vehicle the lower the cost of road tax [30].

Technology	Efficiency increase (%)
Variable Valve Timing and Lift Improve engine efficiency by optimising the flow of fuel & air into the engine for various engine speeds.	**5**
Cylinder Deactivation Saves fuel by deactivating cylinders when they are not needed.	**7.5**
Turbochargers and Superchargers Allows manufacturers to downsize engines without sacrificing performance or to increase performance without lowering fuel economy.	**7.5**
Integrated Starter/Generator (ISG) Systems Automatically turn the engine on/off when the vehicle is stopped to reduce fuel consumed during idling.	**8**
Direct Fuel Injection (w/ turbocharging or supercharging) Delivers higher performance with lower fuel consumption.	**11-13**
Continuously Variable Transmissions (CVT's) Have an infinite number of "gears", providing seamless acceleration and improved fuel economy.	**6**
Automated Manual Transmissions (AMT's) Combine the efficiency of manual transmissions with the convenience of automatics (gears shift automatically).	**7**

Figure 4.1: The percentage energy-saving that is possible using current vehicle technologies [30].

A number of vehicles, such as the Honda Civic Hybrid (or Honda IMA) utilise an electric motor to complement a normal petrol engine. The electric motor charges the battery during braking or idling and assists the petrol engine when moving, reducing the petrol required. This technology can achieve 61.4mpg (miles per gallon), much improved against a similar size petrol car of between 25-50mpg (see *Figure 4.2*) [30,31]. The Honda Civic Hybrid also has a CVT (*Figure 4.1*) to further improve fuel efficiency [30].

Vehicle	'06 Honda Civic IMA ES (1.4 litre)	'06 Honda Civic i-DSI SE (1.4 litre)	'06 Honda Civic i-CTDi SE (2.2 litre)
Fuel	Petrol/Electric	Petrol	Diesel
Transmission	CVT	6-manual	6-manual
CO^2 emission (g/km) / grade	109 / B	139 / C	140 / C
Miles/gallon (mpg)	61.4	47.9	55.4
Cost (on the road) [4]	16,300	14,100	16,000
Fuel cost / 12,000 miles (£)	800	1,025	962
Car tax / year (£)	30	100	110
Running cost / year (£) **(assuming 12,000 miles/year)**	830	1,125	1,072

Figure 4.2: The fuel efficiency of the Honda IMA against similar cars with different engines [30]. For the fuel cost calculation see Appendix L.

As can be seen in *Figure 4.2* the Honda IMA costs £2,200 more than the petrol equivalent, however the cost per year is only £830 against the petrol version of £1,125, a saving of £295 every year. This means that the higher initial outlay would amortise within 8 years. This is a reasonable amount of time, however tax breaks, grants and incentives (mentioned in detail in *section 4.3*) could reduce the discrepancy.

The Honda IMA costs only £300 more than the diesel equivalent. Thus with a saving of £242 on yearly running costs, a Honda IMA would only take only 18 months on the road, before the higher initial outlay is repaid.

The "Dust to Dust Report" conducted by CNW Marketing Research Inc, researched the total energy cost per mile over the whole lifetime of a vehicle including the manufacture. The report found that alternative fuelled vehicles and hybrids did not cost the least in energy (i.e. they use more energy in their lifetime than less efficient vehicles). Remaining with the Honda, the report states that the Honda Civic costs $2.420 per mile whilst the Honda Civic Hybrid costs $3.238 per mile (see *Appendix M*) this is a considerable amount considering the lifetime of the vehicles [32].

4.2 The Future of Transport

With a reduction in fuel production due to the depletion of reserves, the cost of a privately owned vehicle will increase immensely. The UK is heavily dependent on oil, evident during the fuel strike in 2000 [33]. For household use, an alternative fuel vehicle may be the answer.

One of the most attractive alternatives to conventional fuels may be the use of hydrogen, which can be burnt in a combustion engine or used to produce electricity in a 'fuel cell' to power an electric motor. Hydrogen engines are as efficient as current-market diesel engines though they do not directly rely on fossil fuels [34]. The first hydrogen filling stations are already operational in California and Iceland, both of which use a renewable power source to generate the electricity required to electrolyse the hydrogen from a supply of water [35].

In Iceland, government funded research into hydrogen as a fuel hopes to eliminate petrol/diesel cars in the near future. Hydrogen-fuelled busses have already been introduced to the nation's capital Reykjavik, through a joint-venture company, *Icelandic New Energy Ltd* (INE). The INE is proposing to considerably reduce Iceland's dependence on oil as a fuel through a 5-stage process. The first and second stages were establishing the fleet of hydrogen busses in the capitol; the third is converting all private transportation. The conversion is expected to be complete by 2030 [35, 36].

The problem with alternative fuels is that the market for the vehicle will not exist until the fuel is widely available across the country, however the fuel will not become widely available until there is a market. The Energy Saving Trust is offering grants to fuel suppliers towards installing alternative fuel pumps at their forecourts in the hope that this will help rectify the catch-22 situation [37].

Prior to fuel supply grants, the EST awarded grants to people who purchased alternative fuelled vehicles, hybrids or had a vehicle conversion to an alternative fuel,

reducing the higher cost of an alternative fuel vehicle. The scheme was abandoned in March 2005 [37]. As of 2005 the UK has 44,900 alternative fuelled vehicles on the road, only 0.17% of the total number of private cars [28].

As for the greater lifetime energy cost of the alternative fuel and hybrid vehicles mentioned in the previous section, the problem will only exists until the alternative fuels and hybrid vehicles are common on the market. When this occurs research by manufacturers will ensure that the energy cost of manufacture will be driven down to reduce consumer prices. The situation at present must exist to introduce these vehicles into the market, which will be the foundation for greater fuel efficiency in the future.

4.3 Proposed Measures

The oil forecast is bleak. Thus any schemes to introduce greater efficiency, or alternative fuel vehicles to the public, need to be considered. Incentives such as levying the London congestion charge for alternative, duel-fuel and hybrid cars [38], and reducing road tax for fuel-efficient engines [30] improve the popularity of these vehicles, but even more could be done.

One solution could be greater road tax for inefficient cars, increased parking cost in urban areas, increases to fuel duty or rationing of petrol/diesel. This would ensure the success of fuel-efficient vehicles and alternative fuels would become more popular [39]. Alternatively reducing the costs on efficient vehicles could work to a similar extent, though with low road tax for efficient vehicles already in place, there is little scope for many more financial incentives. Reintroducing grants, formally supplied by the EST, for people who purchase an alternative fuelled vehicle or hybrid would also help boost sales.

Increasing the gap between the cost of an efficient and inefficient car through tax incentives and parking charges could only bring the government more revenue. However, the amount would depend entirely on the balance between financially viable and economically crippling, i.e. too much tax on inefficient vehicles will stifle economic growth whilst too little would not show an impact. The costing of such a scheme, therefore, is beyond the scope of this report. As for increasing the duty on petrol and diesel, the public are already concerned by the price of fuel and the percentage of this cost that is tax. It is only too easy to cause public outcry by increasing fuel duty as evident after the 2p/litre increase in tax in the 2000 budget that sparked the national fuel protests [33].

The scheme set up by the Iceland government (supported by the EU) working towards a hydrogen economy could be mimicked in this country. Certainly if the Icelandic government can invest in new technology then the government in the UK could follow suit [35]. The *Technology Status Report: Hydrogen* by the Department of Trade and Industry (DTI) shows a clear study into the steps the UK should take to develop hydrogen as a fuel. It also states foreign governmental spending on such schemes; United States Department of Energy Hydrogen Program currently spends $30million a year, Japan has committed $28billion over the next 30 years (initiated in 1993) to hydrogen research though the World Energy Network [40].

The British government has earmarked £15million over 4 years for research into hydrogen as a fuel and supports the idea of a Hydrogen Coordination Unit (HCU) to focus research and development in the area. Additionally, the Energy Research Partnership (set up in January 2006 [41]) brings together public and private funders of energy research with additional funds from the government science budget of £40million per year rising to £70million per year by 2007/2008, a proportion of which would be concerned with hydrogen research [42]. This funding, although acceptable, could be further boosted if the extra money from increased tax on inefficient vehicles was used to research hydrogen as a fuel, then the level of funding depends entirely on the level of taxation to cars and fuel.

The advantages of fuel-efficient cars are not well publicised. For instance, the higher initial outlay on a hybrid car will be offset over time, by the savings made on fuel (see *figure 2*). A campaign to inform the public of the benefits of a fuel-efficient car, including points previously mentioned (low tax, zero congestion charge etc) could boost sales, which will provide manufacturers with the consumer demand required to increase production. The Vehicle Certification Agency (VCA) [30] provides a wealth of information on all current production cars including fuel efficiency data. This site should be widely advertised as the starting point for any potential buyers who intend to purchase a new car.

Chapter 5.

Food Transport

5.1 The Cost of Transporting Food

Food transport accounts for 30% of freight transport within the UK [43]. This is a major contributor to the amount of CO_2 and other pollutant emissions; 3.4% of CO_2 emissions arise from the transport of food. The environmental and social impact of food transport is estimated to cost the UK around £9 billion per year (see *Figure 5.1)* [43].

Problems caused by food transportation	Cost (£ billion / year)
Congestion	5.2
Accidents	2
Environmental pollution	1.081
Infrastructure wear	0.815
Total	**9.096**

Figure 5.1: The estimated social and environmental cost of food transportation [43]. Environmental pollution includes noise, air and CO_2 pollution.

The financial costs shown in *Figure 5.1* are estimated by, say, the repairs that roads must undergo due to degradation however the cost of environmental damage is hard to estimate financially as data does not exist for situations such as global warming,

5.2 How Food is Currently Transported

Food is currently transported to, from and within the UK by many different methods; all of which have their own advantages and disadvantages. To understand how much environmental impact is caused by food transportation, both the distance the vehicle travels and the amount of goods it carries, must be considered. For example, an HGV (Heavy Goods Vehicle) produces 5 times as much CO_2 per kilometre as a car, however a HGV can transport thousands of kilograms more food than a car.

To compare the relative use of the different transportation methods, the amount of food transported (in tonnes) is multiplied by the average distance travelled by a particular method (in kilometres), shown in *Figure 5.2*. This is known as the 'food-tonne km' and is a measure of the relative proportion of the UK's food transported by a certain method.

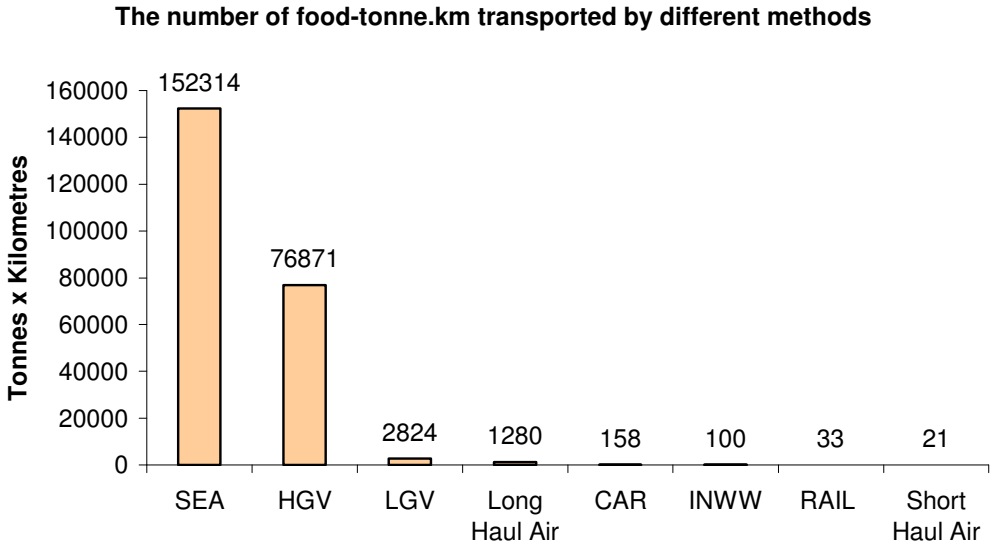

Figure 5.2: The food-tonne km of different transport methods [43].

Figure 5.2 clearly shows that that the greatest amount of food transport is by sea. This, however, is not a suitable indicator of the environmental impact of the various transport methods. For the environmental impact, the amount of CO_2 each method produces must also be taken into account. This is done by multiplying the food-tonne km for a particular vehicle by the proportion of emitted by the vehicle. The proportion of CO_2 emission is shown in *Figure 5.3.*

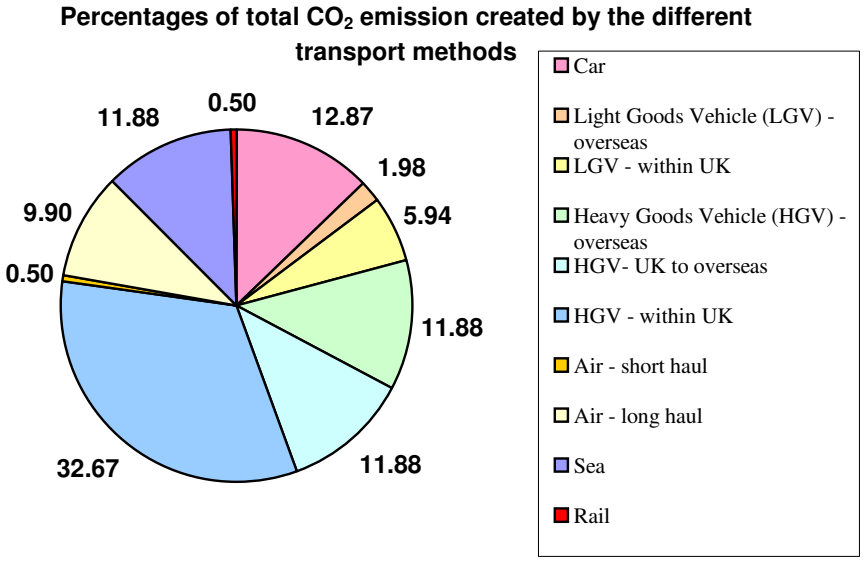

Figure 5.3: Breakdown of CO_2 emission from different methods of food transport [43].

It is apparent from *Figure 5.3* that air food transport accounts for over 10% of CO_2 emission of all food transport and therefore has a huge impact on the environment, considering the small amount of food transported by this method. Similarly HGV and LGV combined produce over half of the CO_2 emission of all food transport.

By taking food-tonne km values and multiplying by the amount of CO_2 produced by each vehicle type, it is possible to determine the efficiencies of the different methods of transport, regardless of mass transported and distance. *Figure 5.4* shows the efficiency of each mode of transport.

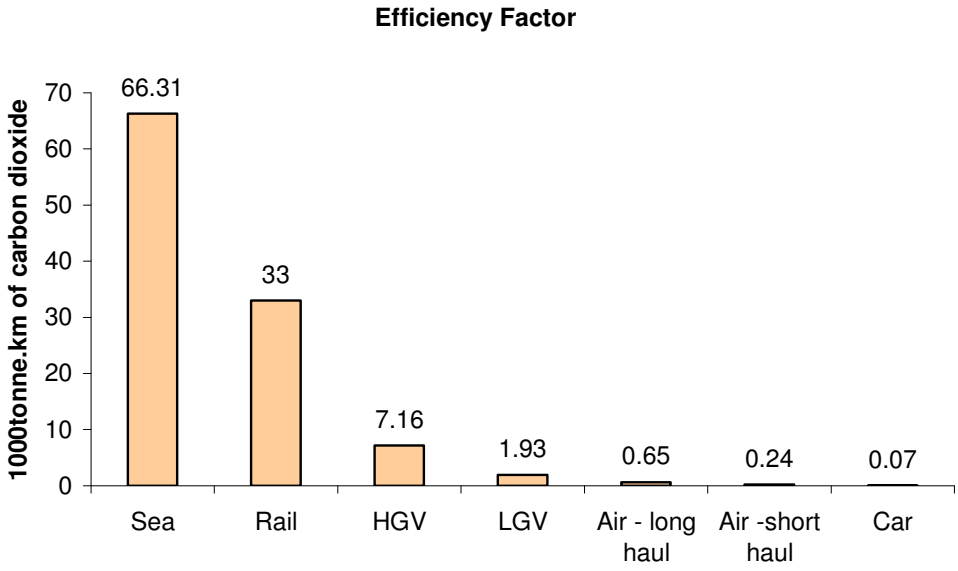

Figure 5.4: The Efficiency Factor for different transport types.

The most efficient form of transport is by sea (66,310 tonne.km CO_2) and the most inefficient form is by car (70 tonne.km CO_2). Air travel, at 0.65 tonne.km CO_2 for long haul and 0.24 tonne.km CO_2 for short haul has remarkably low efficiency factors. On land, rail transport is much more efficient than HGV or LGV.

Pollutants released at high altitudes (such as the altitudes at which planes fly) have a much greater environmental impact than ground based emissions. It has been calculated that the effect of any pollutants produced at high altitude will be 2.7 times greater than the same amount of pollutants released at ground level, this effect is known as radiative forcing [43]. Thus air travel accounts for the equivalent of 25% of total CO_2 emissions (compared to only 11% before considering the effects of radiative forcing), whilst only transporting only 0.5% of food-tonne km [43].

5.3 Local Sourcing

Many supermarkets are increasing the range of products that are locally sourced. There is no set definition for how far local produce can travel before it is no longer 'locally sourced', however it has been proposed (by a charity called Campaign to Protect Rural England (CPRE)) that food that has travelled less than 30 miles from the farm gate to where it is sold is acceptable [44].

The recent issue with 'green tax' on airways has made the public a lot more aware of how damaging aircraft is for the environment. This has brought the question of local sourcing into the public light. Local sourcing is starting to gain popularity, indeed *Figure 5.5* shows that the majority of people already buy local products to some extent.

Local products brought per week	Percent
None	13.8
One	21.6
Two to Three	33.0
Four to Five	8.4
Six plus	4.5
Don't know	18.7

Figure 5.5: The percentage of people who bought products sourced locally in the last week [45].

Many of the supermarkets in the UK are attempting to increase the number of food lines in their stores. ASDA now have at least one item of local produce per store, with some stores having a 'Locally Sourced' section. Tesco have over 3,000 lines in their stores to date [44]. Furthermore some stores have started accepting delivery of local produce directly, though this is only a small fraction of produce.

The usual situation is that produce is transported from the supplier to a national or regional distribution centre, from which the produce is then transported to all the stores across the country. In some cases the products can travel hundreds of miles only to end up in a store a few miles from where they were sourced. Distribution centres allow shoppers consistency of products across the country, however they are inefficient in terms of transport usage [44].

5.4 Proposed Measures

In writing this section we have come across several staggering realisations about how food is transported with in the UK. This includes how some of the most efficient forms of transport are rarely used.

It has been shown that the most efficient forms of transport are rarely used. Consider rail transport; despite being over 4.5 times as efficient as HGV it is still rarely used. If it were possible to carry a larger proportion of goods within the UK by rail this would lead to a significant reduction in CO_2 emissions as well as reducing the £9billion per year that food transport costs the UK economy.

It has also been shown that the most damaging form of food transport is by air. It is unacceptable that 25% of environmental damage is caused by only 0.5% of the food transport with the UK. Reducing the reliance on air food haulage could be achieved by introducing an air tax to counter the additional environmental damage caused.

Many supermarkets are responding to consumer pressure and starting to stock more local produce. This benefits local economies and helps to reduce the amount of environmental damage caused. Unfortunately there are no clear definitions as to what can be labelled as "local" produce. Thus a clearer definition, as suggested by

CPRE, and a financial incentive for retailers to provide a wider range of local produce, the total number of vehicle kilometres travelled by food could be reduced further.

Chapter 6.

Recommendations

Our recommendations are numerous, made evident by the extensive range of proposals within the separate sections. Thus to ensure our recommendations are clearly defined, the following points detail the specific areas that this report believes are either necessary requirements or which have scope for change;

1. ***Government loans available for energy-efficient home modifications.***

Homeowners looking to make their homes more energy-efficient should be offered an government loan for a proportion of the cost of the conversion. The homeowner would continue to pay the same amount in bills as before the conversion, yet the savings go to paying off the loan, after which the homeowner will benefit from the lower energy costs. This scheme could be passed from one homeowner to the next.

2. ***Interest-free loans available for purchase of energy-efficient homes.***

Consider a scheme offering an interest-free government loan to prospective buyers of an energy-efficient house. This scheme would ensure energy-efficient houses are more desirable than the non-energy-efficient, generating an incentive for contractors to build more energy-efficient features into houses. People moving house would also benefit from this scheme in both selling and purchasing property.

3. ***Advertising and extension of the Low Carbon Buildings Scheme.***

Making information more readily available through an advertising campaign, informing homeowners of potential savings and promoting the *Low Carbon Buildings Scheme*. Information should be available online and printed in a leaflet for distribution to places such as GP surgeries and post offices which are often a hub for communities, this will also allow the information to pass to the elderly who are less likely to access the information online. The funding for the LCB scheme should pass to NGO's who use liaison officers to promote energy efficiency in communities. Furthermore the LCB scheme should be extended to landlords as well as making the home energy test compulsory to homebuyers.

4. ***Extension of the Energy Rating scheme.***

The EU Energy Rating scheme is well established. Completely replacing the system would be counter-productive and confuse customers, however an extension of the scheme to include more appliances, such as microwaves and toasters, could be beneficial. Thus we recommend the government, through DEFRA, lobby the EU to make this change.

5. ***Public education on energy efficiency.***

Education is an essential aspect of any energy efficiency drive. It has the potential to be extremely cost-effective with the initial outlay in expenditure at least partially recouped by the money saved by reduced fuel consumption and environmental damage. It must target both the adult population and the younger generation. Educating adults will have an impact in the short-term and help to meet the Kyoto target of 2010. Educating children will have a long-term impact and help the UK reach its target for 2050.

6. ***Taxing / banning of less efficient appliances.***

Increasing the tax on less efficient/lower grade goods could be beneficial in two ways. Firstly, it will reduce the difference in cost between the grades thus promoting high efficiency varieties. Secondly, money made from the taxes could be reinvested in energy efficiency education schemes. A more extreme measure would be the outright banning of the sale of goods below grade C.

7. ***Changes to taxation on vehicles and revised urban parking charges.***

A widened car-tax window between efficient and non-efficient vehicles would promote the more efficient option. Similarly increasing the duty on fuel would also promote the efficient vehicle. However a detailed appraisal of the *amount* of tax that is necessary is required before implementation as these areas are sensitive given the current situation. High urban parking costs for inefficient vehicles could also help.

8. ***Further research into alternative fuel technology.***

Research into alternative fuels is already underway in the UK with money reserved for the research and promotion of hydrogen as a fuel. The increased taxes on inefficient vehicles could further support this research and accelerate the UK to the forefront of alternative fuel technology.

9. ***Reintroduction of the EST alternative fuel / hybrid vehicle grant.***

The EST formally provided public grants towards the cost of an alternative fuel or hybrid vehicle. The EST now provides money to filling stations such that they can extend their forecourt supply to include alternative fuels. The government should increase the funding to the EST such that both schemes can run simultaneously, increasing both demand and supply. Again the money for such a scheme could come directly from increased taxes as already mentioned.

10. ***Taxing of goods carried by air / promoting food transport by rail.***

Advise installing a tax of 5% of wholesale value of air food-cargo. Use the money raised by this new tax to improve upon the current rail network such that UK suppliers use it to transport more food within the UK. This would involve extension and repairing of the network itself, creation of more localised freight depots and an improvement of the current fleet. Greater rail usage would mean a decrease in food transported by road. This would mean less wear to road infrastructure, hence less

government money spent on repairs, and so more money for improvements to the rail system. Transport by rail is highly efficient in comparison to other forms.

Chapter 7.

Summary

There is clearly a need to improve energy efficiency in the UK in order to protect both our energy security and the environment. Whilst a comprehensive solution, including all aspects of UK commercial, domestic and industrial energy use goes beyond the remit of this report, the changes that can be made on a personal scale, when implemented nationally, would ensure a significant decrease in energy consumption.

The schemes we have outlined clearly delineate between an efficient and non-efficient lifestyle. The proposed taxes, charges and duties for a wasteful lifestyle are fully counteracted by the advantages of the efficient lifestyle. The public will have as much assistance as can be provided to make the transition from one to the other whilst those too stubborn to change will find themselves at an economic disadvantage.

Chapter 8.

Appendix

[**A**] Calculation based on a system that saves you £200 per year and costs £3,000 to install without taking government funding into account.

[**B**] Calculation based on an estimated emission reduction of 0.5 tonnes of carbon per year over 6 years (not including 2006) i.e. estimating that a house has a panel installed and running as of 1st January 2007 until 31st December 2012.

[**C**] Calculation based on the estimate that no maintenance work would have to be carried out on the solar panels as this maintenance would also have to be carried out on other heating systems and the price and frequency would depend strongly on the supplier.

[**D**] Calculation based on a CO_2 emission reduction of 0.5 tonnes per household per year achieved through the installation of solar panels and a further CO_2 accumulation reduction of 0.5 tonnes per household per year due to carbon-neutral energy production using bio-fuels.

[**E**] Calculation based on the assumptions, average house price in the UK ~£185,000 and 3,946 households which is the total number of households that have currently applied for funding under the governments LCB Phase I program.

[**F**] Calculation based on the assumption that the repayments are matched to inflation rates and using an average APR of 6.1% for the 3,946 households as before [46].

[**G**] Energy Index (EI) calculation:

$$EI = \left(\frac{\text{Measured Energy Consumption (MEC)}}{\text{Standard Energy Consumption (SEC)}} \right) x100$$

The SEC is a theoretical value, which depends on the type of appliance (fridge, freezer etc), the design temperatures of the compartment(s), whether they are frost-free, built-in, or climate class, and the volume of each compartment [47].

Rating	Energy Index (EI)
A++	< 30
A+	30 to 41
A	42 to 54
B	55 to 74
C	75 to 90

Figure 8.1: Showing the organisation of energy ratings for appliances [47].

Currently the EI calculation for A+ and A+ + is different to that for A to G and incorporates additional correction factors for climate class, built-in appliances and fridges with a chill compartment of less than 15 litres.

[**H**] Based on an appliance purchased new in 1995 being replaced with an energy saving recommended one and an average use of 274 cycles/year for a washing machine and 248 cycles/year for dishwashers with a cost of 7.5p/kWh [13]. Savings for A++ cold appliances are, on average, £5 a year greater.

[**J**] Prices from Comet [13]
During research it was found that in Comet, Dixons and Currys, comparatively A rated washing machines and dishwashers were cheaper than B rated appliances.

Appliance	Price [14]		Cost to run/ Year (7.5p/kWh)		Difference between grade A & grade B		Saving/ year (£)	Amortisation time (years)
	A+	B	A+	B	Price	Energy use/year (kWh/year)		
Fridge Freezer (6.5 cu ft model)	519.99	349.99	233.60	489.00	170.00	255.40	19.16	8.90
Chest/Upright (freezer 3.6 cu ft model)	289.99	119.99	190.00	248.20	170.00	58.20	4.37	38.90
Refrigerator (5.4 litre model)	257.04	179.99	113.15	210.00	77.05	96.85	7.26	10.60

Figure 8.2: Comparison of appliances of grade A+ and B.

- Washing machines and Dishwashers of grade A proved to be cheaper than similar appliances at B grade.
- Cold appliances were assumed to be running constantly.
- Based on cheapest prices on comparable products, i.e. same cubic capacity.
- Values taken from Comet [20].

[**K**]

Activity	Energy saved	Investments 1999	Cost effectiveness
	(GWh/year)	(thousand USD)	(USD/kWh)
Educational	**69.71**	**744.86**	**0.01**
Training	8.89	187.48	0.02
Industrial	64.02	3 805.02	0.06
Public illumination	172.87	15 965.66	0.09
Public buildings	21.68	2 706.27	0.13
Losses	368.01	50 336.51	0.14
Residential	21.99	3 212.90	0.15
Commercial	17.86	2 660.55	0.15

Figure 8.3: Analysis of cost effectiveness of various activities for reducing energy use in Brazil, 1999 [24].

[**L**] Fuel cost per 12,000 miles calculated using:

$$£/12{,}000 miles = \frac{12{,}000 \times A \times 4.546}{B} \qquad [30]$$

where : A = current cost of petrol/diesel
: B = Imperial combined fuel consumption
: 4.546= conversion from litres to gallons

[**M**] The cost per mile assumes an approximate number of miles before the vehicle is no longer roadworthy. This value is different depending on the vehicle. For the Honda the average is:

Honda Civic – 178,000 miles
Honda Civic Hybrid – 113,000 miles [32]

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