OVER A BARREL

Reducing the UK and Europe's oil dependency

A Report by the Institute for European Environmental Policy for Greenpeace UK

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CONTENTS

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EXECUTIVE SUMMARY

This report was commissioned against a background of growing world demand for oil, coupled with political instability and uncertainty in some of the key areas of oil supply. Coupled with this, Europe and the UK's demand for oil continues to rise, but increasingly developed countries find themselves in contention with major newly-developing countries such as China and India, where demand is growing even more rapidly.

Greenhouse gas emissions from fossil fuels are also a major concern worldwide, and the transport sector is generally regarded as particularly problematic in this respect. This reflects the almost-total dependence of the transport sector on oil, and the large and growing share of oil demand that is attributable to transport of virtually all types. There is a strong relationship between saving oil and reducing greenhouse gases, but this report focuses on oil rather than CO_2.

The purpose of this report is therefore to examine the potential within the transport sector to reduce its consumption, and by this means to reduce the UK and Europe's overall dependence on oil, over the next twenty to twenty-five years.

Chapter 2 describes a base case of current and future oil demand. European demand for oil is increasing, and must compete with demands not only from the US, Japan and other developed countries, but also from a growing number of major emerging economies. At the same time, although the question of available oil reserves is a vexed one, it appears that conventional oil reserves are dwindling, especially in a number of relatively small oil resources, notably including the North Sea. As a result, the main reserves in future appear likely to be increasingly concentrated in politically-volatile areas of the world, especially the Middle East.

As conventional oil reserves become scarcer and more expensive, alternatives are likely to become available in three main areas:

- unconventional sources of petroleum can be exploited, such as oil shales and tar sands;
- increasingly both coal and gas can be converted into synthetic liquid fuels to substitute directly for petrol, diesel etc; and
- agricultural feedstocks and other biomass material can increasingly be deployed in a variety of fuels.

However, none of these alternatives is without its own environmental issues, and they will be to a large extent generated outside Europe (especially the first and second groups). Therefore they are likely to increase the diversity of energy supply sources for transport in Europe, but may not greatly reduce our energy dependence. Hence it is important to consider options to improve the efficiency of use of oil, as well as diversifying the types and sources of fuel used.

Chapter 3 presents a breakdown of the use of petroleum products within the transport sector, both now and in the future. This illustrates that transport is the dominant source of demand for oil-based products, and this dominance is likely to grow as pressure to squeeze more transport fuels out of every barrel increases, and alternatives are found for the non-transport uses of oil. Within the sector, road vehicles are by far the largest source of demand, accounting for the majority of transport energy demand, and well over 40% of all the primary energy content of oil consumed in Europe. Aviation and shipping are also large and fast-growing sources of demand.

Chapter 4 then outlines the alternative mechanisms for reducing oil consumption for each transport mode. Options include improving vehicle efficiency; making greater use of lower-carbon fuels; changing the modal shares of different transport modes; and changing behaviour in various ways to shift the patterns of transport use. A very wide range of options is available, and these are capable of making significant shifts in the quantity of oil demanded, and hence also of the greenhouse gas emissions that are produced. The key question is how intensively society is prepared to pursue these options in order to attain a low-oil or low-carbon future.

Chapter 5 analyses a wide range of future scenarios in order to illustrate this point. Under 'business as usual' (BAU) scenarios, oil demand from all of the major modes continues to grow broadly in line with GDP. In contrast, some alternative scenarios suggest that radical reductions could significantly reduce future demand, as summarised below.

Summary of total oil demand scenarios

		UK	EU-15
Oil Demand (Mtoe)	Total 2005	92.0	619.7
	BAU 2030	109.3	729.3
	Alternative 2030	67.3	449.0
As % of 2005	BAU 2030	119%	118%
	Alternative 2030	73%	72%

As this table illustrates, the scenarios pose a clear choice in relation to future oil demand in 2030; either a further increase of around 20% in the total consumed, or a reduction of around one quarter relative to current usage. The latter case reflects significant reduction in land transport and non-transport use of oil, but still a significant increase in oil use for aviation which partly counteracts the cuts in other areas. As explained in the text, this reflects a 'mid range' selection of future scenarios; more dramatic increases in the BAU case, and more drastic reductions in the alternative case, are also conceivable.

Summary of total oil import projections

		UK	EU-15
Oil Imports (Mtoe)	Total 2005	7.0	499.0
	BAU 2030	56.3	660.8
	Alternative 2030	14.3	380.5
As % of 2005	**BAU 2030**	805%	132%
	Alternative 2030	205%	76%

As this table illustrates, the scenarios present an even starker choice in terms of likely future oil imports in 2030, especially for the UK. Here, the BAU case implies an eightfold increase in imports from their current (relatively low) levels; in the alternative case this could be restricted to a doubling of imports relative to current levels. For the EU-15, the BAU case appears to imply a further one third increase in oil imports by 2030 relative to current levels, whereas the alternative case could allow a cut in import levels of around one quarter.

Our analysis suggests that by 2030 the total cost of oil for the EU-15 will rise to around $300bn (£166bn; Ð239bn) annually in the BAU case, of which the UK will contribute $25bn (£14bn; Ð20bn). This amounts to several per cent of total GDP on the assumption of oil at $60 per barrel – several dollars lower than the actual price at the time of writing.

Although we spend a great deal of money on imported oil, this is not to say that it would be cheaper to buy something different. On the contrary, oil (particularly at its historically low prices of around $20-$30 per barrel) is a very cost-effective fuel. Nonetheless, as oil prices rise, the alternatives become correspondingly more attractive. For example, recent research involving the oil industry suggests that certain types of advanced biofuels might be directly cost competitive with petrol and diesel at current oil prices.

As this suggests, not all policy options to save oil are expensive - indeed, some appear to be very cheap or free, could be implemented rapidly, and might pay for themselves very quickly. This will be increasingly the case if oil prices persist at a high level or rise even further. The main requirement for alternative policies to be implemented would be serious political will to cut our dependence on oil and at the same time reduce greenhouse gas emissions from transport.

1. INTRODUCTION

1.1 Background and context

Over the last few years, rising prices have focused attention on our dependence on oil. Oil and petroleum products are currently the source of a substantial proportion of our energy use, both in the UK and the European Union (EU-15[1]). In 2004, petroleum-based fuels accounted for 47% of final energy consumption in the UK, with around three-quarters of this being used by the transport sector (DTI, 2005); this pattern is replicated across the EU-15.

Additionally, oil use, and therefore oil dependency, is increasing in the transport sector, whereas other sectors have diversified away from oil consumption (see Figure 1). That is, transport's share of oil use has risen steadily in both relative and absolute terms. While the rail subsector is powered in part by electricity derived from a variety of primary sources, the other and larger subsectors (road, aviation and shipping) remain almost wholly dependent on oil-based fuels.

In the past, much of the UK demand for oil has been met through the use of domestic stocks and imports from neighbouring countries such as Norway. However, rising demand, coupled with the depletion of proven reserves, is leading to an increased reliance on imported oil whose reserves are located primarily in politically unstable areas of the world. All the other states in the EU-15 are already dependent on imports to meet their oil needs.

> *Unless specific measures are taken to disengage the oil sector, especially in transport, [imported] oil dependence could reach 90% by 2020.*
>
> **European Commission, 2000**

The effects of this dependency, in terms both of our thirst for oil and of the increasing need to import it, are being brought into focus as our ability to cope with 'shocks' caused by disruption and high prices is increasingly examined in the media. For example, the UK oil crisis in 2000 was estimated to have cost the UK economy £250 million per day, while the recent Buncefield oil depot fire is estimated to have lost 5% of the UK petrol stock and brought about a significant amount of panic buying, as well as disrupting air traffic from Heathrow.

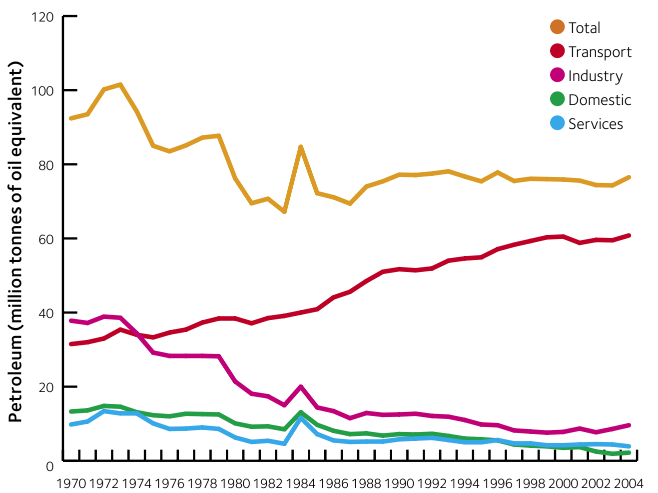
The price of oil has a well established relationship with both national and global economies. Recent work by both the International Energy Agency (IEA) (2004a) and the International Association for Energy Economics (IAEE) (Jones et al., 2004) has revealed the serious economic implications of sustained high oil prices or rapid price increases. The IEA study suggested that a sustained $10 per barrel increase to $35 would result in a 0.4% cut in GDP across the member states of the Organisation for Economic Co-operation and Development (OECD) over the first two years of the rise (IEA, 2004a). This relationship is also asymmetric, in that a corresponding cut in prices does not result in a reversal of the impact on GDP (Jones et al., 2004). And the actual rise in the price of oil has, of course, been much larger than was anticipated.[2]

> *The London Chamber of Commerce estimated that the relatively minor interruption to fuel supplies in autumn 2000 cost the UK economy around £250 million (€360 million) per day.*
>
> **Hills, 2004**

In addition to the economic effects, the control of natural resource commodities such as oil has been shown to be a significant contributory factor to the incidence and continuation of conflict and civil war (eg Collier and Hoeffler, 2000). Research on oil and conflict by the London School of Economics also suggests that geopolitical competition in our increasingly globalised world is likely to lead to greater insecurity. It found not only that oil revenues are used directly to finance conflict (eg in Angola) but also that the very presence of oil can have a significant impact on the character of a state, which in turn makes it more susceptible to conflict (LSE, 2003). Clearly this relationship has implications for global economic stability and the energy security of states which rely heavily on oil imports.

Of course, the consumption of oil is also key to what UK Prime Minister Tony Blair has referred to as 'the single most important long-term issue that we face as a global community' – climate change. With oil forming a significant share of the fossil fuel-derived energy mix in most countries, attention is increasingly being drawn to its contribution to climate change.

Figure 1
UK End use petroleum consumption by sector



Source: DTI 2005

1.2 Aims and objectives

The purpose of this report is to examine the potential within the UK and EU-15 to reduce the transport sector's consumption of and therefore overall dependence on oil over the period to 2030. The objectives of the report are:

- to review existing studies of oil use by the transport sector
- to establish a 'business-as-usual' baseline scenario for our current and future oil needs through:
  - the definition of existing and future (2030) oil demand, in general, and for the transport sector in particular, for the UK and EU-15
  - analysis of where our oil currently comes from and how this pattern is likely to change in the future
- to develop an alternative future scenario for the transport sector through:
  - examining the range of available mechanisms for reducing the oil consumption of the transport sector on a twenty- to thirty-year timescale
  - constructing a scenario to indicate by how much the UK and EU-15 could reduce their oil consumption and what some of the implications would be.

As already noted, the future consumption of oil has a direct bearing on carbon dioxide (CO_2) emissions and hence on climate change. While this is perhaps the greatest single issue facing the human race, it is not the main focus of this report. As a basic approximation, however, any reduction in oil consumption will have a corresponding benefit in terms of CO_2 emissions.

1.3 Structure of the report

The remainder of the report is structured as follows:

- Chapter 2 provides an overview of current and future oil demand and supply for the UK and EU-15.
- Chapter 3 presents a breakdown of the present and predicted consumption of oil-derived fuels within the transport sector, setting out the business-as-usual scenario.
- Chapter 4 then sets out the available mechanisms for reducing oil consumption.
- Chapter 5 details the potential for reductions in oil consumption by such mechanisms, on the basis of figures derived from existing studies.
- Chapter 6 draws together this work in order to formulate some conclusions.

2. CURRENT AND FUTURE OIL DEMAND AND SUPPLY

2.1 What is our current oil demand and supply pattern?

Imports already vastly exceed levels of primary production for the EU-15 as a whole, and import dependency[3] stood at 77% in 2003. In the UK, by comparison, primary production was still (as of 2003) in excess of demand and consequently the country was at that time a net oil exporter (see Table 1). What is also clear from Table 1 is that the UK alone was contributing around three-quarters of the EU-15's primary oil production.

Table 1
Key overall oil statistics for 2003[4]

	EU-15 Crude oil (Mtoe[5])	Expressed as a percentage of demand	UK Crude oil (Mtoe)	Expressed as a percentage of demand
Primary production	139.4	23.1%	106.1	128.5%
Net imports	465.3	77.0%	-23.9	-28.9%
Demand[6]	604.6		82.6	

Source: EUROSTAT, 2003

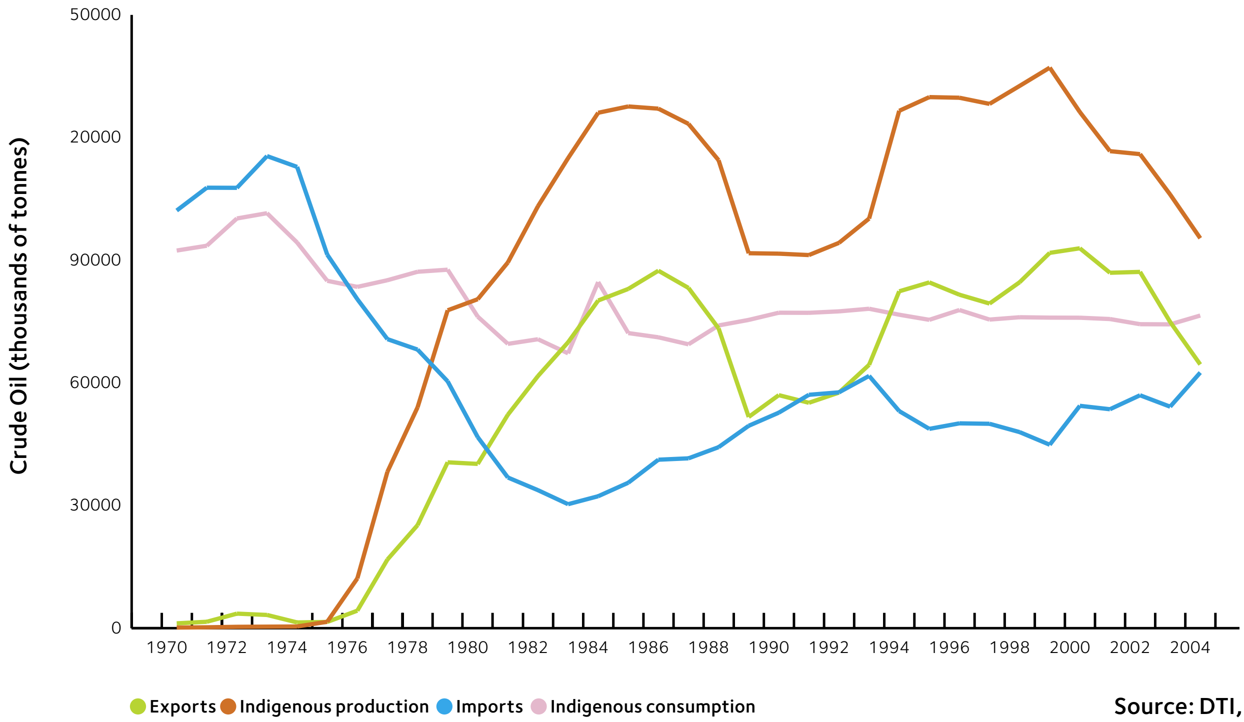
However, a more detailed examination of recent figures for the UK (see Figure 2) suggests that this is unlikely still to be the case. Imports and exports have rapidly converged, largely due to the rapid decline in domestic production in recent years. As a result, the UK is likely to become a net importer of oil in the very near future if indeed it has not already done so.

As the graph also illustrates, overall demand for oil fell in the 1970s owing to fuel switching away from oil, primarily in the industrial sector, in response to the oil price shock of 1973. The spike in demand in 1984 reflects a temporary reversal of this trend during the Miners' Strike. This trend combined with the onset of major exploitation of the offshore oil reserves in the North Sea to reduce imports dramatically and allow substantial export growth through the 1980s. The UK continued to be a net exporter through the 1990s as well, but production peaked at the end of that decade and reserves are now in rapid decline.

2.2 Where does our oil come from?

The origin of the EU-15's imported oil is clearly important from an energy security perspective. Table 2 illustrates that the majority of oil imported into the EU-15 comes from a very limited number of sources. Over three-quarters of these imports are from three countries or groups of countries, with around 20% each coming

Figure 2 UK oil trends



Source: DTI, 2005

from Norway and the Russian Federation, while the Organisation of Petroleum Exporting Countries (OPEC) accounts for 37% of imports. This lack of supply diversity clearly presents implications in terms of vulnerability to disruption and the scope for market price distortions. As already indicated in 1.1, the very presence of oil in a country has been found to increase and intensify the potential for conflict, which could create a feedback leading to further negative economic consequences such as price rises (IEA, 2004a).

Table 2
Origins of crude oil imported into the EU-15 in 2003

Source	Crude oil (Mtoe)	Percentage of the total
Norway	106.4	19.2%
Russian Federation	116.0	20.8%
OPEC	203.8	36.7%
Other	128.9	23.3%
All Countries	**555.1**	**100%**

Source: EUROSTAT, 2003

The vast majority of oil produced in the UK comes from fields in the North Sea, with the remainder from other offshore extraction and a limited amount of extraction onshore (see Table 3). The origins of the UK's imports are also largely dominated by production in the North Sea, as over two-thirds of the import total is made up by oil from Norway. OPEC and the Russian Federation then each account for around 10% of this total.

Table 3
Origins of crude oil in the UK in 2003

Source	Crude oil (Mtoe)	Percentage of the total
Domestic Production		
North Sea UK	84.3	85.1%
Other UK	14.8	14.9%
Total	**99.1**	**100%**
Import Origin		
Norway	32.6	67.0%
Russian Federation	4.4	9.0%
OPEC	5.0	10.3%
EU-15	0.9	1.8%
Other	5.8	11.9%
All Countries	**48.6**	**100%**

Source: DTI UKCS Production by Field Data: http://www.og.dti.gov.uk/information/bb_updates/appendices/Appendix9.htm and EUROSTAT, 2003.

2.3 What will our oil demand be like in the future?

Estimating future energy use is a notoriously difficult task, and whilst numerous projections are published each year from a variety of sources, caution must always be exercised when interpreting the results. Chapter 5 includes a more detailed discussion of future energy scenarios and analyses a range of available scenarios in greater detail. Prior to this analysis, however, Table 4 summarises official EU estimates of the future demand for oil, which suggests that by 2030 oil demand in the EU-15 and the UK will have grown marginally on 2000 figures.[7] What is perhaps more important however, is that the ratio of net imports to demand reported by DG TREN (2003) is projected to grow significantly for the EU-15, while the UK switches from being a net exporter to a significant importer.

Interestingly, this study only projects that the UK will become a net importer after 2020, while more recent evidence (eg Figure 2) strongly suggests it will actually happen much sooner than this as the trends have become more strongly adverse in the intervening years. Some commentators report that the UK is already a net importer, although the official annual data to support this claim were not available at the time of writing.

Table 4
Future oil projections for the EU-15 and UK for 2000 and 2030

EU-15	2000 Crude oil (Mtoe)	2030 Crude oil (Mtoe)
Primary production	160.4	84.2
Net imports[8]	472.4	582.2
Demand[9]	586.9	604.7
Change in imports from 2000		**109.8**
UK	**2000 Crude oil (Mtoe)**	**2030 Crude oil (Mtoe)**
Primary production	127.9	75.9
Net imports[10]	-40.1	16.7
Demand[11]	80.7	89.5
Change in imports from 2000		**56.8**

Source: Adapted from DG TREN, 2003

Table 5 shows that the oil sector is also predicted to remain the largest single share of primary energy demand from fossil sources in the EU-15 and to be responsible for approaching half of the associated carbon dioxide emissions by 2030. See Section 3.1 for further discussion of the relationship between primary fuel demand and end use demand.

Table 5
Predicted final energy demand and CO_2 emissions associated with selected primary energy sources for the EU-15 in 2030

	Energy demand		CO_2 emissions	
Primary energy source	Mtoe	Percentage of total final energy demand	Mt	Percentage of total energy-related emissions
Oil	604.7	35%	1591.6	43%
Gas	555.6	32%	1266.0	35%
Solid	222.5	13%	811.0	22%

Source: Adapted from DG TREN, 2003

2.4 Where is our oil likely to come from in 2030?

Whilst predictions about future demand are subject to great uncertainty, the availability of resources suggests that significant challenges lie ahead if energy supplies are to keep pace with demand. From the perception of the pessimistic 'peak oil' proponents (see Box 1), based on historical trends, the peak in oil production is imminent, which has significant implications for the future energy demands of society given the likely increases in demand caused by the growth of the economies of the developing world. The latter offers the prospect of rapidly increasing energy demands from a number of countries (most obviously India and China) with enormous populations. In January 2006, these two countries signed an agreement to cooperate in the acquisition of future oil reserves.

Box 1 The 'peak oil' argument

The extraction of crude oil, being a finite resource, necessarily has a beginning, middle and an end. The 'middle' is termed the peak of production and is the level at which production can no longer increase, but starts to decline until the resource is depleted. This theory and the bell-shaped curve associated with it were first proposed by Dr M King Hubbert in the 1950s, hence the term the 'Hubbert Peak' used in association with oil production. Related to the peak of production is the peak in the discovery of the resource, which is used to predict the production peak. The world peak in oil discoveries occurred in the 1960s and the proponents of this theory suggest that the world is now rapidly approaching its production peak (within the next two decades). Unfortunately the subsequent decline of production is likely to be in the face of rapidly increasing global oil consumption. This potential for divergence of production and consumption clearly poses potentially serious consequences for global energy supplies and the global economy. A recent announcement by the Kuwait National Oil Company that the production of the world's second-largest oil field is in decline may add more weight to the peak oil argument. The difficulty of predicting the production peak is compounded by the fact that a number of OPEC countries have not revised their reserve figures over time despite increasing production, and the Kuwaiti announcement is therefore viewed as significant.

A further strand within this debate is the fact that the oil being used to fuel our current consumption and development is relatively easy to extract and therefore relatively cheap. As resources are depleted, extraction becomes more difficult and more expensive, resulting in price rises. Rising prices will improve the economic case for finding and recovering oil reserves from more remote locations or of novel types (see Box 2 on non-conventional oil reserves), but at the same time the high costs of these methods will continue lead to higher energy prices over the longer term, with potential further for considerable economic and social repercussions.

Sources: http://www.peakoil.com/sample/index.html (privately funded website with no affiliation to any interest group or business). http://www.hubbertpeak.com/summary.htm (website synthesising information from geologists and petroleum engineers who subscribe to the peak oil theory). http://quasar.physik.unibas.ch/~fisker/401/oil/oil.html (online paper written by Jacob Lund Fisker, research associate at the University of Notre Dame, Indiana, USA)

Even the more optimistic view of groups such as the IEA is that, while the oil resources and non-conventional alternatives (see Box 2) exist for exploitation, massive focused investment will be needed in order to maintain production levels (see Box 3).

The prospect of increasing import dependency in both the UK and EU-15, in the light of these global concerns, means it is increasingly important to understand where imports are likely to originate. While it is not possible to state specifically which countries the UK and EU-15 will import from in 25 years time, by looking at local and worldwide reserves a picture develops of the likely main sources for oil.

Box 2 Non-conventional fuel supplies

Non-conventional oil sources, including deposits of extra heavy oil, tar sands, bitumen and oil shales, are increasingly becoming more economic to extract as high oil prices persist. Resources of heavy oil have been estimated at around seven trillion barrels, with the vast majority located in the United States, Canada and Venezuela (IEA, 2004). The IEA suggests, however, that the actual amount of oil that is recoverable from these resources is still very uncertain. Also, extraction is relatively energy-intensive, and this may further limit the amounts available and/or result in higher 'well to wheel' CO_2 emissions than those of conventional oil-based fuels.

In addition to these deposits, another potential source of oil products is the liquefaction and processing of coal, a process which is already in use in South Africa, for example. (Other hydrocarbon sources can also be used in this way, notably 'stranded' gas reserves that are a long way from the major demand centres.) This opens up a much greater pool of reserves, but it is again only likely to be economic as long as conventional oil prices remain high. Also, while this process offers some diversification in the sources of oil supply, it again presents a threat as large or greater than that of conventional oil in terms of greenhouse gas emissions unless carbon capture and storage techniques can be developed.

In the future a wide range of biomass sources may also be able to be converted in a similar way, although these techniques are still at the experimental stage. Already many EU states are blending a small proportion of biofuels (mainly bioethanol and biodiesel made from food crops such as oilseeds, grains and sugar beet) into conventional road transport fuels. See Box 4 in Chapter 4 for more detail.

Source: IEA (2004b) and http://www.eep.org/newsletters/newsletter150403.htm#reo1 (European Environmental Press Newsletter, Issue 44, 15 April 2003)

The most recent statistics (see Table 6) suggest that at current production rates, the life expectancy for the remaining oil reserves in the UK is probably less than a decade. This figure is based on the ratio of the expected reserves at the end of 2003 (the sum of proven and probable reserves plus the lower end of the range of undiscovered reserves) to the current extraction rate. The varying categories assigned to the reserves reflect the uncertainty involved in the estimation process, as not only do reserves need to be discovered, it must also be technically feasible and economically viable to extract them. This limited life expectancy contrasts significantly with the estimate by

DG TREN that the UK will only become a net importer in 2020 (see Section 2.3), suggesting that the latter might have taken an overly optimistic approach to the prospects of extracting known, and discovering unknown, resources.

Table 6
UK oil reserves

2003		Oil (million tonnes)
Reserves[12]	Proven	571
	Probable	286
	Possible	410
Undiscovered resources[13]	Lower	323
	Upper	1826

Source: National Statistics 2005

Box 3 Investment costs and supply chains

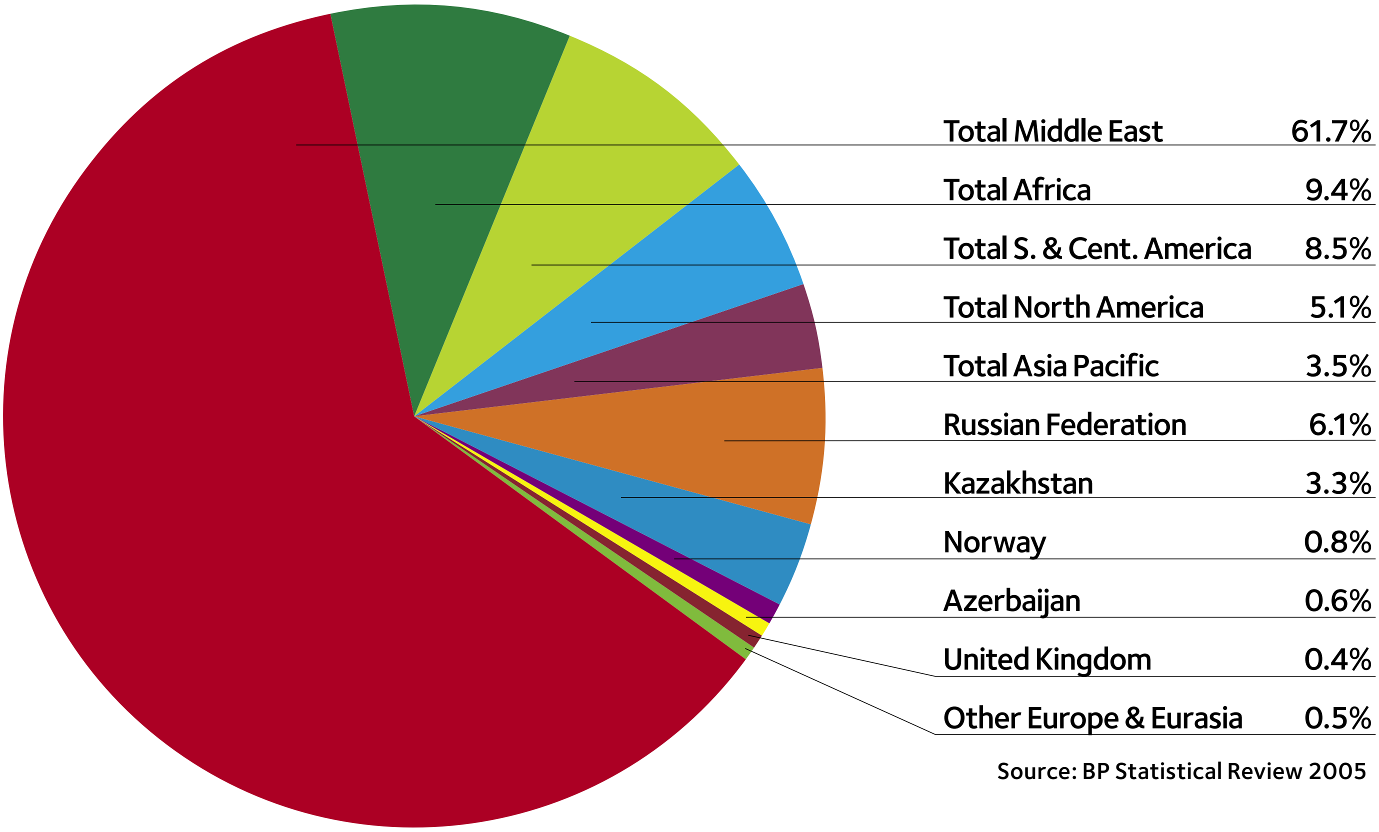
Significant conventional oil resources remain in various sources worldwide, and according to projections produced by the IEA, global oil production is unlikely to run out or even peak by 2030. However, massive investment will be needed in order to keep pace with demand projections. Globally, the IEA estimates that $3 trillion will be required in investment, and this investment must be focused in the areas where it is needed. The IEA points out that a number of the countries which have large oil reserves, such as Saudi Arabia and Kuwait, are currently closed to external investment, whilst others, such as the Russian Federation and Iran, place heavy restrictions on foreign investors. Under-investment in supply infrastructure for a variety of political or economic reasons could pose significant restrictions on the global supply of oil, according to the IEA.

Coupled with this problem is the increasing length of the supply chain necessary to transport oil from producer to consumer. The IEA estimates that $234 billion will be required for oil tankers and pipelines over the period 2003 to 2030 and predicts that the transport routes used will be increasingly vulnerable to disruption as the volume of traffic increases. Accidents, piracy or terrorist attacks on tankers or pipelines could cause significant disruption to oil flows, with a consequent effect on oil prices and supplies.

Source: IEA (2004b).

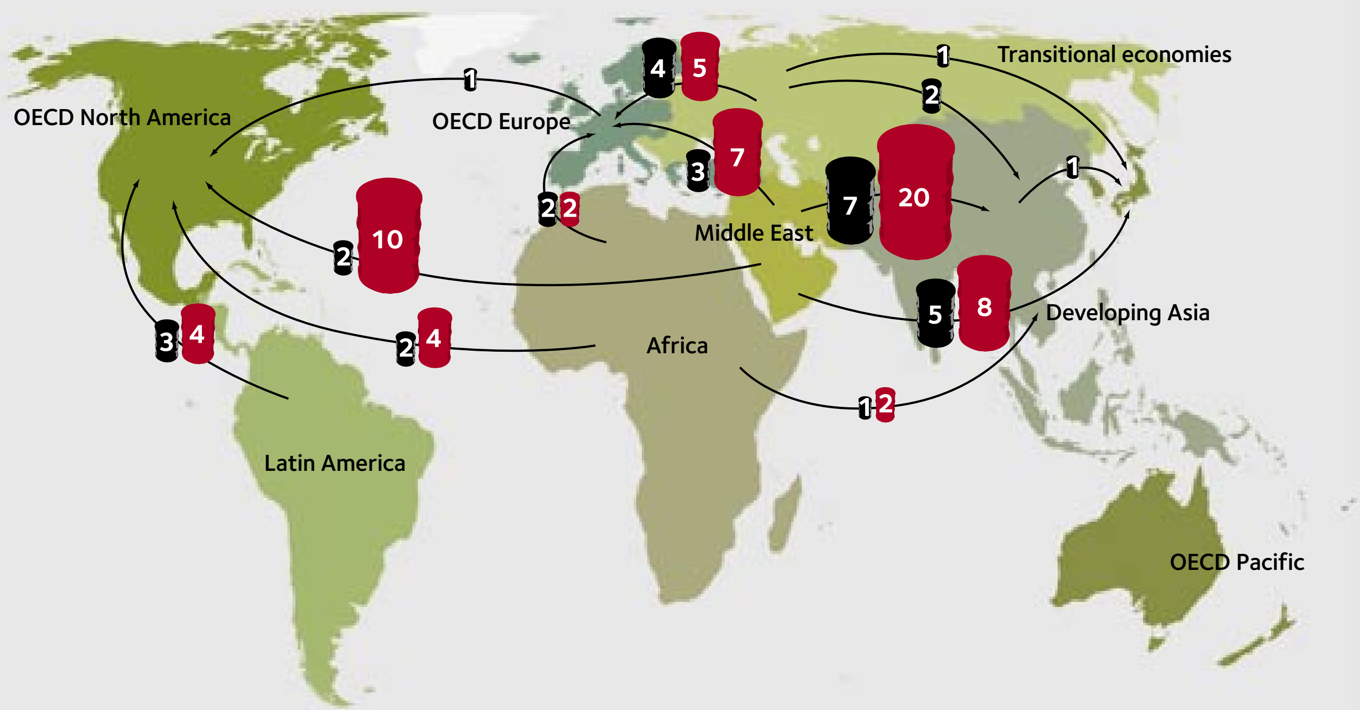
At the global level major proven reserves are strongly concentrated in a small number of countries. Figure 3 provides the geographical breakdown of reserves, revealing that almost two thirds of the global reserves lie in the Middle East, with most of the remainder spread across the continents of Africa, South and Central America and Eurasia. The dominance of OPEC as an oil producer grouping looks set to strengthen in the future, as the total proven reserves that the eleven OPEC countries control is equal to three-quarters of the total. In contrast, the level of UK reserves is equal to less than 0.5% of the total.

Figure 3
Percentage world regional shares in proven oil reserves at the end of 2004



Source: BP Statistical Review 2005

Figure 4
Major net inter-regional oil trade flows in 2002 and as predicted for 2030 (million barrels per day)



Source: IEA (2004b)

Examining this distribution more closely, the dominance of the Middle East and OPEC, in particular, is striking. Of the ten countries that have the greatest share of proven reserves, only the Russian Federation and Kazakhstan are not part of OPEC and the top five countries are all in the Middle East. Saudi Arabia, Iran and Iraq between them represent around 43% of the global total (see Table 7).

Table 7
Top ten countries with proven oil reserves at the end of 2004

	Thousand million barrels	**Percentage share of total world reserves**	**R/P ratio**[14]
Saudi Arabia	262.7	22.1%	67.8
Iran	132.5	11.1%	88.7
Iraq	115.0	9.7%	> 100.0
Kuwait	99.0	8.3%	> 100.0
United Arab Emirates	97.8	8.2%	> 100.0
Venezuela	77.2	6.5%	70.8
Russian Federation	72.3	6.1%	21.3
Kazakhstan	39.6	3.3%	83.6
Libya	39.1	3.3%	66.5
Nigeria	35.3	3.0%	38.4

Source: BP Statistical Review 2005

On the basis of the data in Table 7, the major global oil flows in 2030 are likely to be dominated by supplies from the Middle East. The IEA (2004b) suggests that net exports from that region will reach 46 million barrels per day (mb/d) in 2030 (see Figure 4). For Europe this will mean an increase from 3mb/d to 7mb/d from the Middle East, with another 2mb/d coming from Africa and 5mb/d from the Russian Federation and Central Asian countries. Figure 4 also shows that significant oil flows from the Middle East will be going to the United States, Canada, China and India. The recent State of the Union address by President Bush, in which he called on the USA to break its 'addiction to oil' and set a target of a 75% cut in US imports from the Middle East by 2025, perhaps highlights the extent to which this issue is becoming a political priority. The aspiration to reduce US oil import dependence could be interpreted as signalling a shift in global energy policy which may ultimately influence this business-as-usual scenario.

Examining the import dependency levels of several key countries and regions (see Table 8) suggests the extent to which they are likely to be in competition for oil resources in the future. It is important to highlight that the import dependency of all these countries is also predicted to rise, thus increasing their competition further. The implications of this increased competition alongside the lengthening of supply chains and overall control of resources are likely to be of growing global importance. In January 2006, India and China signed an agreement to cooperate in the acquisition of future oil reserves. The increasing influence of China in terms of global energy demand was the subject of a US Department of Energy study published in February 2006, which examined the potential impact on US political, strategic and economic interests and national security (Kirchgaessner, 2006). The literature suggests that the potential impact on the global economy of oil price shocks (IEA, 2004a) caused by disruptions to supply or conflict over resource control (LSE, 2003) is significant.

Table 8
Predicted percentage of oil derived from imports for selected countries and regions

Country/region	**2010**	**2020**	**2030**
EU-15	80%	85%	87%
China	55%	68%	74%
India	80%	87%	91%
OECD North America	35%	47%	55%

Source: Adapted from DG TREN (2003) and IEA (2004b)

SUMMARY
Current and future oil demand and supply

- Current demand in the UK is met largely by domestic production while the country remains until now a net exporter of oil.
- However, the long-term decline in UK reserves suggests that this will not be the case in the future, as the life expectancy of reserves is only 8.5 years at current rates of extraction, and the UK is expected soon to become a net importer, if it has not already done so.
- The EU-15 as a whole was already 77% import-dependent in 2003 and this looks set to increase to around 87% by 2030.
- Under the EU's official forecasts, the overall demand for oil in the EU-15 is predicted to remain fairly constant in the period to 2030, although it may continue to grow for the UK. A range of alternative scenarios is presented in Chapter 5.
- Proven global oil reserves lie predominantly in the Middle East and are concentrated in the hands of a small number of producers.
- Saudi Arabia, Iran and Iraq account for 43% of known world reserves.
- The Middle East is likely to become increasingly important as a source of supply for the UK and EU-15 as import dependency increases. Import flows from the Middle East to Europe are predicted to increase from 3mb/d in 2002 to 7mb/d by 2030.
- All the EU's major economic competitors over the next 25 years are also likely to become more dependent on imported oil, and some developing countries look set to increase their oil demand dramatically, thus increasing competition in the market place.
- Growing demand and a diminishing number of major suppliers both increase the risk of future disruption of conventional oil supplies, and there are significant risks and uncertainties attached to the known alternatives.

3. CURRENT AND FUTURE OIL DEMAND IN THE TRANSPORT SECTOR

3.1 What is our oil currently used for?

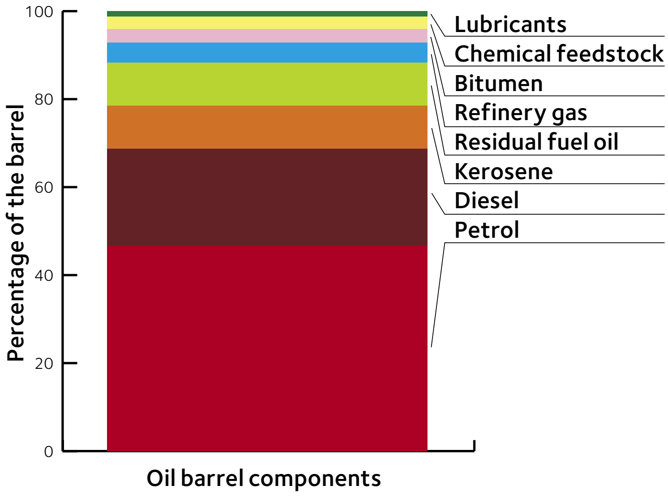
Although, as noted above, transport in Europe is almost wholly dependent on oil, it is not the case that oil is used solely for transport. The difference between total primary demand for oil and end use transport fuel demand (ie what is actually put into the fuel tanks of vehicles) is made up primarily of the following elements:

- Some oil components go to non-energy uses, eg as feedstocks for the chemical industry, lubricants, bitumen, etc.
- Some oil products are used for other energy supply purposes (eg space and process heat, electricity generation; powering non-transport machinery).
- Some oil products are consumed in the refining process itself.

However, transport is the dominant end use of oil, and, as Figure 1 illustrates in a UK context, this dominance is increasing over time. This is because some low-grade uses of oil (eg for heating) are in decline, while at the same time more transport-grade liquid fuels are being 'squeezed' out of every barrel.

When considering the transport sector, it is important to understand how the components of crude oil relate to the fuels used by each mode (Figure 5). As a point of reference, road vehicles use mainly petrol and diesel, while rail and aviation use diesel and kerosene, respectively, and waterborne transport burns both diesel (or gasoil) and residual fuel oil. For the remainder of this report these fuels will be collectively termed 'transport fuels'. In this section, the usage of fuels by each transport mode is explored more explicitly.

Figure 5
Component products of a barrel of oil



Source: Adapted from the Energy Institute

Examining the current use of petroleum products for transport in the EU-15 and the UK (Tables 9 and 10) reveals some very clear patterns. Most striking is the fact that road transport accounts for the vast majority of fuel used in the sector (72% for the EU-15 and 73% for the UK). The type of fuel predominantly used by road transport does differ between the EU-15 and the UK, however, with the EU-15 consuming relatively more diesel than petrol and the reverse being the case for the UK, where petrol use still slightly exceeds diesel. The reason behind this is the historically different approach to diesel. In most EU-15 countries, fuel duty differentials have favoured diesel over petrol, in order to increase the uptake of diesel cars and/or to protect domestic road haulage interests; in the UK, such an active promotion of diesel cars was not adopted. Liquefied petroleum gas (LPG) is a significant fuel source for road transport in some countries, but not overall.

Table 9
Current oil consumption by fuel type in transport for the EU-15, 2003[15]

Sector	Petroleum product (Mtoe)						
	LPG	Petrol	Kerosene	Diesel	Residual fuel oil	Total products	Percentage
Road	2.1	104.9	0.01	144.8	0	251.9	**72.4%**
Rail	0	0	0.012	2.1	0	2.1	**0.6%**
Aviation[16]	0	0.1	42.1	0	0	42.2	**12.1%**
Marine[17]	0	0.2	0.009	11.9	39.5	51.6	**14.8%**
Transport	**2.1**	**105.3**	**42.1**	**158.8**	**39.5**	**347.8**	**100.0%**

Source: EUROSTAT, 2003

Table 10
Current oil consumption by fuel type in transport for the UK 2003[15]

Sector	Petroleum product (Mtoe)						
	LPG	Petrol	Kerosene	Diesel	Residual fuel oil	Total products	Percentage
Road	0.1	19.9	0.0	17.7	0.0	37.7	73.0%
Rail	0	0	0.012	0.3	0	0.3	0.6%
Aviation[16]	0	0.045	10.7	0	0	10.8	20.8%
Marine[17]	0	0	0	2.0	0.9	2.9	5.6%
Transport	**0.1**	**20.0**	**10.7**	**20.0**	**0.9**	**51.7**	**100.0%**

Source: EUROSTAT, 2003

The marine and aviation subsectors are the next largest consumers of fuel, representing around one-seventh of the total for the EU-15 in each case. For the UK, however, the pattern is rather different with aviation having a much greater share, with more than a fifth of fuel consumed, while marine transport represents only 6%. The difference here results from the long-term establishment of the aviation subsector in the UK, reflecting the island geography of the UK and the presence of major international airport hubs such as Heathrow, which are destinations for many transatlantic flights from North America, for example. In terms of marine transport, for both the EU-15 and UK the majority of the fuel consumed is that for international shipping, known as marine bunkers. What is also clear from Tables 9 and 10 is that the quantity of fuel consumed in the rail sector is substantially less than that in the other main modes.

3.2 What will our future oil usage for transport be?

This section discusses what will happen to future demand under a 'business-as-usual' scenario – ie in a situation where there are no radical changes in vehicle technologies or fuels used, and where transport demand continues to grow as a function of GDP, much as it has in the past. As explained above this section is based on the EU's official forecasts, whereas some alternative projections of what the future may hold are addressed in Chapter 5, and the two sets of figures are not fully comparable.

Transport energy demand is typically projected to grow significantly to 2030, with a projected increase of just over a third for both the EU-15 and UK (see Table 11). As previously indicated, the vast majority of this demand is likely to be met by oil, with only the rail and a very small proportion of the road transport sector supplied by alternatives. In terms of how this demand is divided, it is clear that all sectors are expected to experience growth. The road transport and aviation sectors are predicted to undergo the largest growth, increasing their annual demand by almost one hundred million tonnes of oil equivalent (Mtoe) between them.

Examining the transport sector by fuel type reveals the dominance of oil under a business-as-usual scenario (Table 12). While there is predicted to be some market penetration of biofuels, natural gas, hydrogen and electricity, they are only expected to have gained a very marginal market share of around 5% of end use demand between them by 2030. Petrol and diesel are still likely to constitute the majority of fuel consumed, resulting in a large contribution by the transport sector to total CO_2 emissions.

Table 11
Projected end use energy demand by mode for the EU-15 and UK in 2030

Transport mode	EU-15 end use energy demand (Mtoe)	Percentage	UK end use energy demand (Mtoe)	Percentage
Road	325	**69.4%**	48.5	**69.5%**
Rail	5.3	**1.1%**	0.9	**1.3%**
Aviation	68.7	**14.7%**	15.7	**22.5%**
Marine	69.5	**14.8%**	4.7	**6.7%**
Total	**468.5**	**100.0%**	**69.8**	**100.0%**
Change from 2003	120.7	**34.7% increase**	18.1	**35.0% increase**

Source: Adapted from DG TREN (2003)

Table 12
End use demand for fuels in transport for the EU-15 and UK in 2030

Fuel	EU-15 (Mtoe)		UK (Mtoe)	
LPG	**3.2**		*	
Petrol	**121.8**		**22.9**	
of which mixed biofuels	6.7		1.5	
Kerosene	**68.7**		**15.7**	
Diesel	**217.8**		**28.7**	
of which mixed biofuels	11.4		1.8	
Residual fuel oil	**48.9**		**1.3**	
Total liquid fuels		**460.4**		**68.7**
Natural gas	**0.5**		*	
Methanol-ethanol	**0.6**		**0.1**	
Liquefied hydrogen	**0.7**		**0.1**	
Electricity	**5.6**		**0.9**	
Total other fuels		**7.4**		**1.1**
Total all fuels		**467.8**		**69.8**
Of which oil related products	442.3		65.4	

** represents less than 0.05Mtoe*

Source: Adapted from DG TREN (2003)

SUMMARY
Current and future oil demand in the transport sector from existing EU studies

- Road transport accounts for the largest proportion of oil-derived fuel used in both the EU-15 and the UK.
- Aviation also represents a significant share of fuel used and this is currently proportionally more important for the UK than the EU.
- Energy consumption in transport is projected to grow by a third from 2003 to 2030 for both the EU-15 and UK in a business-as-usual scenario.
- Most of the increase is likely to come from road transport and aviation where almost an extra one hundred million tonnes of oil equivalent will be consumed annually by 2030.
- In terms of the fuel type consumed, petrol and diesel are projected to represent the largest shares in 2030, as now.
- Under a business-as-usual scenario there is likely to only be a very limited penetration of alternative fuel sources (around 5%).

4. ALTERNATIVE MECHANISMS IN TRANSPORT TO REDUCE OIL USE

This chapter does not set out to provide an exhaustive list of policy measures to reduce oil use in transport (see, for example, JEGTE, 2006). What it does is to classify the principal means of reducing fuel use and provide examples of a number of measures that may be implemented over the short to medium term. Whichever the mode of transport – road, rail, water or air – the mechanisms to reduce the amount of oil used can be broadly classified into four types, namely those that encourage:

- **Vehicles that are more fuel-efficient.** Such mechanisms aim to encourage manufacturers to develop and bring onto the market more fuel-efficient vehicles, either by means of technological development or through the use of existing technologies.
- **The use of alternative transport fuels in vehicles,** for example biofuels, either mixed with or instead of conventional transport fuels.
- **The more efficient use of fuel in the transport system.** These mechanisms aim to make the transport system as a whole more efficient by ensuring that people and goods are transported in a way that minimises the use of transport fuels.
- **Less transport.** These mechanisms aim to eliminate journeys and therefore reduce the amount of fuel needed overall.

It is worth highlighting at this point that mechanisms to reduce oil use are in many cases similar to those that result in fewer emissions of CO_2 or even of other gaseous pollutants. This is because the combustion of fuel leads to the emission of these pollutants, although the exact nature of the link depends on the way a vehicle is used and the technology that it uses. It should also be noted that the categorisation used in this section is for the purposes of illustration and is in practice far from rigid, as many measures, particularly pricing mechanisms, have the potential to reduce oil use in many different ways, depending on how they are applied. Of course, many of the measures discussed below are already applied to some extent. The extent to which they will deliver reduced fuel use depends on the intensity with which they are applied and the existence and effectiveness of complementary policies and measures, both in the transport sector and in other sectors of the economy.

By launching a widespread eco-driving information programme, the EU could realise up to $6bn (£3.3bn; €4.8bn) in fuel savings every year [18]

Adapted from Eco-Driving Europe, 2002

4.1 Making vehicles more fuel-efficient

As noted above, mechanisms to encourage more fuel-efficient vehicles may be focused on stimulating manufacturers of vehicles, be they cars, trains, ships or aeroplanes, to develop and introduce new technologies that use fuel more efficiently. Having said that, it is important to emphasise that there are technologies already in existence, which, if applied more widely, could improve the fuel efficiency of vehicles significantly. Before discussing the mechanisms, it is worth quickly reviewing the technologies that might be encouraged. For cars, these include:

- improving the efficiency of existing internal combustion engine designs, eg by direct fuel injection for petrol cars
- improving transmission , eg by improvements to the clutch and gearboxes
- better car body design, eg improved aerodynamic efficiency and weight reduction
- low-friction tyres and more efficient lubricants
- advanced drive trains, eg in hybrid vehicles that use electric motors in addition to traditional internal combustion engine technologies (IEEP, TNO and CAIR, 2004).

If every car in the EU-15 today were an electric hybrid, the fuel savings would be equivalent to around $23bn (£12.8bn; €18.3bn) worth of oil per year, or a million barrels of oil every day [18].

Authors' own calculations

Of the different transport modes, most existing work on technologies for reducing CO_2 emissions and therefore on reducing fuel use relates to road transport. For other modes, the focus of recent policy work has been on reducing emissions of other pollutants, such as nitrogen oxides and volatile organic compounds, which does not necessarily lead to the use of less oil. For example, a recent report for the European Commission focused on reducing output of these other pollutants from ships through the application of a range of technologies, which could, if anything, marginally increase oil use (ENTEC, 2005). In the aviation sector, meanwhile, trade-offs often have to be made between the demands of fuel economy, reducing noise and nitrogen oxide emissions, and improving safety. Nonetheless, in the medium term it is anticipated that there could be a 10% to 20% improvement in fuel economy through improvements to aircraft engines (Fergusson, 2001). It is important to remember, however, that new, more fuel-efficient technologies will be introduced more slowly into the aviation sector, as it takes more time to design and build a new aircraft than, say, a car. Aircraft also have a useful life of up to 30 years (compared to an average of 12 for a car). Improvements in aircraft engine efficiency are in fact progressing relatively rapidly, but the fuel savings they offer are heavily outpaced by the growth in demand for air travel.

Mechanisms to encourage manufacturers to develop and introduce new technologies range from passive to prescriptive. On the more passive side are such mechanisms as **fuel-efficiency labelling** and the use of other publicity material. The aim of these is to stimulate consumer demand for more fuel-efficient vehicles, which in turn should have an impact on the market and therefore the types of vehicles that manufacturers produce. Such an approach is arguably more relevant for vehicles which have many potential purchasers, such as cars, than for those whose purchase is a commercial decision, eg lorries and railway engines. The existing fuel efficiency label is an example of such a mechanism, although, in order for such measures to be effective, they should arguably be introduced in parallel with economic incentives (see ADAC, 2005).

A 32% reduction in greenhouse gas emissions would be achievabl if we all switched to the best available car in class.

SMMT, 2005

For example, in the Netherlands, in 2002 a **tax rebate** was given for cars in the two most fuel-efficient categories, as indicated by their fuel efficiency label. The rebate was only in existence for one year, during which the number of more fuel-efficient cars purchased increased significantly, only to drop again in 2003 when there was no rebate (VROM, 2003, reported in ADAC, 2005). The Netherlands is now planning to integrate the rebate into its taxation system (through differentiating taxes) so as to encourage the purchase of more fuel-efficient cars (TNO/IEEP/LAT, 2006).

The **differentiation of taxes** according to a vehicle's characteristics is an increasingly common means of incentivising the purchase of more fuel-efficient vehicles. In the UK, both the taxation system for company cars and annual vehicle taxes have been differentiated according to a car's CO_2 emissions. An evaluation of the reform of the company car tax suggests that it has been instrumental in reducing the CO_2 emissions of new company cars (Inland Revenue, 2004). A number of European countries are considering similar changes to their taxation systems (TNO/IEEP/LAT, 2006)

Another means of encouraging the purchase of more fuel-efficient vehicles by public authorities is through so-called '**green procurement**'. Public authorities are allowed to take account of environmental considerations when purchasing new vehicles, eg vans, buses, dustcarts, etc. Clearly, private companies such as bus and rail companies, as well as telecommunications companies and other utilities, are able to do the same. These purchasers are important as they operate large fleets of vehicles, for example British Telecom is the largest purchaser of vans in the UK (TNO, LAT and IEEP, 2004), and therefore buy vehicles in bulk, which, in turn, has the potential to significantly influence the technology used by manufacturers in these vehicles. The adoption of green procurement policies by public and private organisations alike has the potential, therefore, to stimulate the introduction of more fuel-efficient vehicles onto the market.

A more prescriptive means of encouraging fuel efficiency would be to introduce **standards** that effectively force the introduction of more fuel-efficient technologies in vehicles. For the emissions of some pollutants, such as nitrogen oxides and carbon monoxide, such an approach has been particularly effective within the EU and elsewhere. In the EU, the last 20 years have seen tighter emission standards set for a range of road vehicles, including cars, lorries and motorcycles, and more recently for railway engines and boats used on inland waterways. These standards have resulted in significant reductions in the amount of these pollutants emitted (eg see IEEP, 2006). Such standards are also set in the USA (often broadly equivalent to those set in the EU), other developed countries and increasingly in the larger developing countries, such as China.

Similar standards to force the development and introduction of more fuel-efficient vehicles have not yet been seriously applied in most cases, as it is far more difficult to set a single standard for fuel efficiency. The best known example to date of a fuel standard (set for manufacturers rather than individual cars) is California's Corporate Average Fuel Efficiency (CAFE) standards. In the EU, manufacturers' organisations are currently party to a voluntary agreement to reduce CO_2 emissions up to 2008/09, and alternatives measures to go beyond that date are currently under consideration (IEEP, 2006).

The global nature of the maritime and aviation subsectors brings an additional complication to the application of mechanisms to stimulate the development and introduction of more fuel-efficient technologies in these subsectors. The standards that do exist for those craft are agreed at an international level within organisations such as the International Maritime Organisation (IMO) and the International Civil Aviation Organisation (ICAO). However, it is possible to introduce mechanisms at the local level to encourage the use of cleaner, and therefore potentially more fuel-efficient, technologies in visiting ships or aircraft. In Sweden, for example, ports are allowed to vary their port charges according to a ship's emissions of certain pollutants (NERA, 2005). At Zurich airport, an emissions surcharge is payable on landing fees for all aircraft, according to their respective emission standards (IPCC, 1999). However, to date such mechanisms have been targeted at reducing local air pollution, rather than encouraging more fuel-efficient vehicles.

4.2 Reducing the share of conventional transport fuels

In addition to mechanisms that focus on improving the fuel-efficiency of vehicles, there are mechanisms to influence the fuel that a vehicle uses. Many of the alternative fuels that could be employed are not derived from oil, and their increased use would, therefore, reduce the oil dependency of the transport sector. In some cases, the use of alternative fuels requires new vehicle technologies, whereas other fuels can be used in existing vehicles.

Our dependency on oil should be broken by 2020," said Mona Sahlin, Sweden's minister of sustainable development, "... which means no house should need oil for heating, and no driver should need to turn solely to gasoline.

The Guardian, **8 February 2006**

A recent report by the commission charged with delivering a strategy to break Sweden's oil dependence, provides targets to reduce petrol and diesel use by 40 to 50% by 2020.

Ends Europe Daily, **3 July 2006**

The types of alternative fuels that can be used in road vehicles include:

- electricity for battery-driven electric vehicles or some hybrids
- biofuels, which are fuels derived from plants rather than crude oil
- mineral gases, eg liquefied petroleum gas (LPG) and compressed natural gas (CNG)
- hydrogen (mainly for fuel cell vehicles).

Of these, mineral gases are already in use, although in relatively small quantities, but they require modifications to conventional internal combustion engine vehicle designs. Biofuels are currently the subject of much policy and academic attention, and can be blended with conventional fuels or used 'neat' in adapted vehicle designs.

Box 4 Biofuels for transport

Already many EU states are blending biofuels (mainly bioethanol and biodiesel) into conventional road transport fuels, although usually at low blend levels (ie only a few percent). These 'first generation' biofuels go some way to extend the oil-based fuels and to cut CO_2 emissions, but their scope is limited in most cases by cost, availability and/or conversion efficiency. Biofuels grown in Europe do not currently save a very high proportion of CO_2 emissions in most cases, and the quantities that can be produced are limited by availability of land. Imports are also available from a range of different sources outside Europe, but some of these come from sources that are not sustainable (eg soy plantations on land cleared from rainforest).

It is likely that, over the coming decades, these will be superseded by a 'second generation' of biofuels from more advanced processes (gasification, enzyme treatment, Fischer-Tropsch process, etc). Such processes could deliver new and more advanced synthetic fuels that are easier to substitute for oil-based fuels. Second generation processes offer the prospect of using a wider range of feedstocks including woody (lignocellulosic) materials. This could entail using most or all of the source plants (eg wood and straw as well as seeds, nuts or pulses) and a wider range of waste materials (eg forestry waste, biodegradeable municipal solid waste). As well as more efficient utilisation of resources, these processes tend to be more efficient in energy terms, and for these reasons it is expected that they will typically offer greater CO_2 savings at lower unit costs.

The rate at which such fuels become available over the coming decades is subject to significant uncertainty, and it is unclear how far the available feedstocks will be used for transport rather than, for example, heating. As with other unconventional fuel sources, they will become more attractive in cost terms if oil prices stay high.

In the longer term, fuel cells, probably using hydrogen, have the potential to replace traditional combustion engines.

For aviation, there are no real alternatives to kerosene in the short or medium term, although there is some potential for bio-kerosene. The options of biofuels and electrification are available for rail; and biofuels and the use of sail in shipping already exist. In the longer term, hydrogen fuel cells are also being developed for use in other larger vehicles, such as ships, trams and trains, although these are generally in the prototype or demonstration stage (Fergusson, 2001).

The principal mechanisms by which take-up of alternative fuels can be achieved are economic and regulatory. Tax differentiation, as discussed in Section 4.1 in relation to encouraging more fuel-efficient vehicles, can also be employed to encourage the use of alternative fuels. Many EU countries are introducing, or have introduced, tax incentives on biofuels with the aim of increasing their use in the transport sector. The environmental impact of biofuels is complicated, but it is possible on a limited scale that they can be grown, manufactured and used in ways that are environmentally beneficial, including in terms of total CO_2 reductions. In the UK, the existing tax incentive for biofuels compared to traditional transport fuels has not proved sufficient to encourage their wide use, so an accompanying regulatory measure requiring transport fuel suppliers to ensure that a percentage of their sales are biofuels is to be introduced (DfT, 2005). Several other countries are also now considering introducing obligations, and a range of subsidies are offered for both crop production and development of processing plant.

4.3 Encouraging the more efficient overall use of fuel

Mechanisms to encourage the more efficient overall use of fuel aim to reduce the amount of oil used by ensuring that total amount of travel which occurs is undertaken in more efficient ways. As well as being more efficient in terms of oil use, a maximally efficient transport system can also reduce other environmental impacts such as other emissions and noise.

One of the principal means of achieving a more efficient transport system is to increase the use of the modes that have the potential to reduce the average amount of conventional fuel used to transport a passenger or a tonne of freight a given distance, a process known as **modal shift**. In other words, to reduce the oil dependency of transport, the use of modes which use fuel more efficiently - public passenger road transport (ie buses, coaches and trains), and rail and shipping for freight - should be encouraged in preference to less efficient modes such as cars, lorries and aviation. In addition, higher load factors can be encouraged within individual modes of transport, for example by encouraging car sharing, increasing bus patronage, etc. Non-mechanised modes of transport (mainly walking and cycling) can also be encouraged for shorter journeys and offer the greatest savings of all, but are often neglected in transport policymaking.

The use of public transport can be encouraged in a number of ways, eg by:

- improving the quality of public transport vehicles and infrastructure
- giving priority to public transport as opposed to private transport, eg by means of bus lanes, giving road space over to trams, reducing the amount of parking spaces
- planning towns and cities around public transport and walking and cycling, instead of cars
- increasing the relative cost of private car use compared to public transport, eg by increasing the cost of parking and/or keeping the price of public transport low through subsidy or other means
- improving the provision of information about the alternatives to the private car through 'softer measures' such as behavioural change programmes or travel planning.

An alternative mechanism to achieve more efficient fuel use is to enable cars and lorries to take the most fuel-efficient route for their journey through the use of route-guidance systems, which are becoming widely available. Another quite different use of technology to deliver the more efficient use of vehicles is through journey matching techniques in workplaces to facilitate car sharing. In order to maximise the potential of car sharing, the reallocation of road space for high occupancy vehicle lanes can also be pursued.

Allied to these mechanisms are those to educate about and enforce more efficient use of fuel. The use of eco-driving techniques, for example, reduces fuel consumption by ensuring that the vehicle is driven optimally for the road conditions. Optimal speeds, gear changes and tyre inflation can all contribute to reducing the vehicle's overall fuel use.

If every driver in the EU-15 ensured that their tyres were correctly inflated, it could save around $2bn (£1.1bn; €1.5bn) in fuel costs each year, and the equivalent of 100,000 barrels of oil every day[18].

Adapted from IEA, 2005

Enforcement can also play a role here, as ensuring vehicles comply with speed limits can result in significant fuel savings, particularly on motorways. Both of these concepts can potentially apply to all modes in their particular context (eg DfT, 2003).

If a 90 kph speed limit was enforced on major roads in the EU-15, we could save around $10bn (£5.5bn; €8bn) in fuel costs each year, and half a million barrels of oil every day[18].

Adapted from IEA, 2005

4.4 Using less transport

The final set of mechanisms for reducing the use of transport fuels in the transport sector consist of measures to reduce directly the amount of fuel used by reducing the number or length of journeys taken. These can be broadly classified into measures that reduce the amount of travel by making it more difficult or more expensive, and measures that eliminate the need for journeys or freight transport. Note that such measures can also apply to public transport, as long as this is consistent with broader public policy objectives.

To some extent, some of the measures mentioned in Section 4.3 to improve the efficiency of overall fuel use, also potentially reduce travel by making it more difficult or costly to travel. However, those measures give preference to some modes over others. The measures discussed in this section are those that have the potential to decrease the amount of travel, and therefore the amount of fuel used, without generally encouraging the use of other modes.

One of the most obvious measures to reduce the amount of oil used in the transport sector is to increase the cost of travel. This could be done in a relatively untargeted manner by simply increasing the tax on the fuel used by the transport sector. During the 1990s, this was the principal mechanism that the UK government used to reduce CO_2 emissions from road transport. At the moment, public transport receives fuel duty rebates, which effectively limits the impact of this mechanism on these modes.
One of the key issues in relation to aviation is the absence of fuel duty on aviation kerosene in the EU, the imposition of which would have the potential to reduce the fuel used by the sector.

In the longer term, the technology should be available to enable road user charging whereby road users can be charged relative to how they use the roads. Such a charging system could simply be used, as with fuel duties, to increase the price of private road transport, or it could be used in a more sophisticated fashion, eg discouraging the use of certain roads at certain times of the day, or even to differentiate prices between public and private road transport.

Another means of reducing the amount of travel is to eliminate journeys altogether, eg through the use of the internet by home working or online shopping. If everyone who could were to work at home once a week, this would reduce the number of commuting journeys undertaken by these people by 20%. Similarly, internet shopping that removes the need for a visit to the shops can eliminate a journey, if the delivery comes in the conventional postal service, or reduce the number of necessary journeys, if a dedicated delivery van is used in an efficient way, as with internet grocery shopping. It should be noted, however, that, in the time saved by not making shopping journeys, other new journeys could be generated – so that estimating the potential net impact on oil use of internet shopping is not clear-cut (see for example Cairns et al., 2004).

SUMMARY

Alternative mechanisms in transport to reduce oil use

In order to reduce the conventional fuel used in the transport sector and thereby its dependence on oil, four key types of mechanism can be identified:

- **making vehicles more fuel-efficient** through the development, diffusion and procurement of more efficient technology
- **switching to alternative power sources** such as electricity, biofuels and mineral gases
- **encouraging more efficient use of fuel** through modal shift, higher occupancy levels, efficient vehicle operation, use of route guidance and education and enforcement
- **reducing travel** by tackling need and/or increasing costs.

However, no measure will be effective on its own, so it is important to have complementary measures in place to ensure that fuel use is actually reduced rather than shifted to another mode or non-transport use.

5. SCENARIOS FOR REDUCING TRANSPORT OIL DEPENDENCY

This chapter reviews and analyses a range of existing scenarios that estimate transport's future energy demand, and assesses what the potential impact might be on transport's use of oil in the UK and EU-15.

5.1 Methodology

In order to assess possible future oil demand levels for the transport sector, we have reviewed and analysed a range of future transport and energy scenarios that have been developed in recent years. In doing this we have not undertaken an exhaustive study, as the results are intended to be indicative rather than definitive, and there is in any case a broad range of uncertainties attached to projections of the situation twenty or thirty years hence. The predictions of selected scenarios in different transport modes were then used to model the implications for overall oil demand in order to give an indication of likely future oil demand under a range of transport scenarios, including both 'business-as-usual' (BAU) and 'with measures' futures.

Hence, the approach taken can be summarised as follows:

- review of selected existing scenarios that give projections of transport's demand for oil in both the UK and EU-15 to 2030
- identification of the most relevant business-as-usual and 'with measures' scenarios
- on the basis of the results of these scenarios, assessing the implications of business-as-usual and 'with measures' approaches for UK and EU oil demand to 2030.

It should be noted that the estimates in the scenarios selected in this chapter typically use 2000 as a base year. This gives us a fully consistent set of base assumptions to work from and is a cornerstone of the analysis. However, in order to reflect the current reality more accurately, we have rebased the calculations to 2005 by shifting the starting-point of the alternative scenarios forward by five years. As we do not yet have actual data on fuel use for the year 2005, this has entailed using a BAU projection which is expected to give the best reflection of progress (or the lack of it) in reducing oil dependence in the intervening years.

Although care has been taken to rebase and translate these scenarios in a mathematically realistic and transparent way, the purpose of this exercise was not to arrive at a firm forecast of future oil demand but rather to illustrate a range of possible future outcomes. In reality forecasting is not an exact science because it must make detailed assumptions about technologies that will be used, travel and transport behaviour, and a wide range of other social, economic and environmental factors a quarter of a century ahead or more; and these are, to one extent or another, unknowable and unpredictable. Future expectations of oil supply are equally uncertain, as explained in Chapter 2.

Some of the scenarios chosen (ie those that suggest the greatest potential to reduce oil demand) are quite radical insofar as they imply rapid technological and other changes, possibly at significant cost; yet in other respects they are still quite conservative, in that they are based on already-known technologies and some rather normative assumptions about future societies and economies. For example, they tend to assume that people's propensity to travel will continue to grow more or less in line with their income. Other, and even more different, futures might be possible.

5.2 Selection of studies

In Annex I we present a list of the studies considered for this work, although for the reasons noted we have not used all of these in our analysis. We have focused on a set of analyses with the following key attributes:

- from reputable and authoritative sources
- usable quantified scenarios of future energy consumption or CO_2 emissions
- covering the UK and/or the EU-15 (or a close approximation)
- covering the whole transport sector or its main subsectors (ie road, air, maritime)
- addressing both passenger and freight transport
- recently produced, and with a base date at or around the year 2000
- including medium-term forecasts for years 2020, 2025 and/or 2030.

On this basis, 11 studies were relied upon for various aspects of the analysis (as indicated in Annex I).

5.2.1 Using the data from the scenarios analysed

The set of scenarios used were generated for different purposes, and hence their results are expressed in a number of different units of output, for example:

- primary energy demand (typically in Mtoe of oil or oil products, or barrels of oil)
- end user energy demand – measured in mega-tonnes of oil equivalent (Mtoe), peta-joules (PJ, 10^{15} joules) or terawatt-hours (TWh, 10^{12} watt-hours) - sometimes disaggregated by fuel type, either for the whole transport sector or for some subsector(s) thereof.

- CO_2 or greenhouse gas emissions - typically in mega-tonnes of carbon (MtC), mega-tonnes of carbon dioxide ($MtCO_2$) or $MtCO_2$ equivalent (incorporating the effect of other greenhouse gases).

For the purpose of this exercise, it has only been necessary to convert between different units to the extent necessary to ensure a degree of equivalence between the baseline figures in each set of scenarios. For most purposes the percentage change between the baseline and the future scenario years is the most important result, although this implies the following simplifying assumptions and provisos:

- Using scenarios of carbon emissions, it can generally be assumed (where not specified) that the aggregate end user fuel demand will be broadly proportionate to the CO_2 emissions, particularly within a given subsector. This is because (at least in business-as-usual cases, where transport typically remains at least 97% fossil-based) the composition of fuels and the fuel mix are unlikely to change significantly over time. A continued switch from petrol to diesel can be envisaged in the road subsector, but the carbon:energy ratio of these two fuels is similar, so this has only a second order impact anyway. Changes in rail fuelling also have only a second-order impact as the total fuel use is very small anyway relative to road. This approach is not valid in scenarios that include a significant share of non-fossil fuel use, however; in these cases primary or end-use fuel estimates are needed, or at least an indication of the fossil:non-fossil fuel split, in order to apply a correction factor.

- Changes in end use demand in terms of fuels can be assumed to be approximately proportionate to the corresponding primary energy demand for oil over the period, as significant changes in the proportion of refinery losses are not likely. In this it is assumed that refinery losses are distributed in proportion to the energy content of the end-use fuels and other end products across the whole barrel. Again this is not the case where a significant share of non-fossil fuel is in use; in these cases end-use fossil-only fuel estimates are needed.

- However, it is likely that end use and primary fuel demand attributable to the transport sector will continue to converge over time, so a correction factor needs to be applied, as shown in Table 13 below.

- As Table 13 also illustrates, end use transport fuel demand constitutes a large and growing share of total end use demand, and is therefore the dominant determinant of the total. Further, as oil demand is driven primarily by the demand for the middle distillates from the barrel (ie petrol, diesel and kerosene – see Figure 5 above) that are almost totally determined by transport use, market prices are likely to adjust to secure a more balanced market for the other fractions, including both energy and non-energy uses. Nonetheless a further gradual decline in the proportions of the total barrel attributable to heating, power generation and non-energy uses is factored in as appropriate, reflecting the assumptions of the DG TREN baseline scenario (DG TREN, 2004b). In the latter case the ratio of transport end-use oil demand to total oil demand increases from below 50% to just over 70% between 1990 and 2030, to reflect the increasing dominance of transport fuels. In the analysis, this ratio is applied to transport oil demand to give total demand in all scenarios.

5.2.2 Characterising and grouping the scenarios used

The studies selected yielded a range of scenarios for different parts of the transport sector and/or relevant geographical areas. These varied very significantly in nature according to the approach taken and the objectives of the scenario exercise. They have been indicatively grouped into three main categories that can be characterised as follows:

- **Business as usual** scenarios are based broadly on existing trends and with no radical changes in technology, prices or behaviour anticipated. In such cases, transport activity tends to increase broadly in line with GDP. Note however that these scenarios tend to be based on historical fuel price trends from the past decade (typically equivalent to $25 to $30 per barrel in today's terms) that appear rather low by current standards. Others seek to reflect the possible impact of permanently elevated oil prices. These are 'top down' analyses that apply price elasticities with respect to demand, but do not imply policy measures explicitly. It should also be noted that some of the 'highs' chosen five years ago do not seem particularly high by the standards of the time of writing, so they do not radically affect the results obtained.

Table 13
Primary and final oil energy demand for EU-15 to 2030

	EU-15 oil demand (Mtoe)			Ratio final : gross primary	
Year	Gross primary oil consumption	Final demand (all oil as fuel)	Final demand (all oil for transport)	All oil	Transport oil
1990	580.0	425.7	288.0	73.4%	49.7%
1995	610.3	448.8	310.4	73.5%	50.9%
2000	629.1	472.8	351.3	75.2%	55.8%
2005	639.4	492.1	384.7	77.0%	60.2%
2010	646.1	511.8	406.8	79.2%	63.0%
2015	655.9	525.6	422.3	80.1%	64.4%
2020	662.4	544.3	444.7	82.2%	67.1%
2025	657.7	554.9	458.2	84.4%	69.7%
2030	666.4	563.6	468.4	84.6%	70.3%

Source: DG TREN (2004b)

- **With-measures scenarios** A further group explores the potential impacts of a range of policy measures such as those discussed in Chapter 4 through a more 'bottom up' analysis of individual elements of the transport system. These scenarios apply a wide range of different types of measures that are not further characterised here but include those outlined in Chapter 4, and do so with varying degrees of intensity. That is, some imply relatively mild application of alternative policies and technologies, while others are more radical. In some cases, ranges of results for groups of such scenarios are presented in a simplified way in this analysis.

- Target-driven scenarios Some scenarios are developed to meet specific targets – most obviously emission reduction targets. These scenarios may use elements of both 'top down' and 'bottom up' modelling and forecasting.

5.2.3 Identification of scenarios for further analysis

As noted above, a subset of the scenario studies presented in Annex I was found to be suitable for use in this analysis, although they varied considerably in terms of scope and approach. Nonetheless, it was possible to extract from these a set of scenarios giving a reasonable coverage of the study period, in terms of the main subsectors of the transport sector, and of the different scenario types set out above (ie covering both BAU and significant alternative 'with measures' or target-driven policy scenarios).

As described above, these studies had outputs in a range of forms, with some for example reporting on CO_2 emissions rather than fuel demand. In some of these cases, the underlying data sets were available to us, allowing us to extract the relevant data on fuel demand, even where this was not explicit in final reports. Elsewhere, it was possible to apply normalising factors or other simplifying assumptions in order to obtain a reasonable approximation of the fuel demand for each subsector, even where this was not directly available.

The net result of this exercise was to produce a set of future fuel demand profiles for the years covered in this study and to group these together for comparative purposes. The groups reflected the three main transport modes analysed, and (where available) the different typologies of scenarios. Note that data were not available for all study years in all of the scenarios used; where this was the case, linear interpolation was applied in order to fill the gaps.

Where several forecasts were available in the same group, a few were rejected on the basis of expert judgement as appearing to fall clearly outside the range indicated by others in the group. It is indicated in the text below where this was done. Aside from this, where more than one forecast was available in a group then the different results were either averaged to give a mid-point forecast for each group of scenarios, or a mid-range scenario was chosen as indicated. The 'with measures' and 'target driven' groups of scenarios were considered together in this process in order to give a BAU and a single alternative trajectory for each mode.

The results of this process are briefly presented in the next section.

5.3 Results of the review and analysis

5.3.1 Summary results of scenarios reviewed

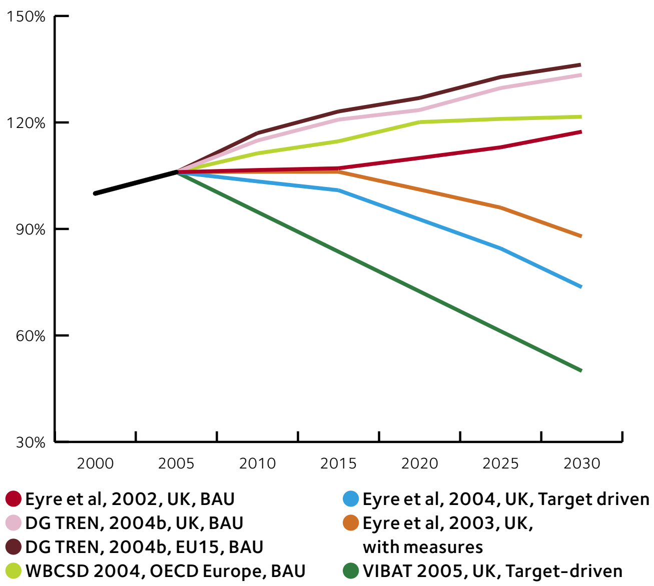
On the basis of the studies chosen, a range of fuel demand scenarios has been delineated for each of the main transport subsectors, as follows. For this purpose, scenarios at UK and EU-15 levels are presented alongside one another.

Note that the rail subsector is not addressed separately. This is because it is very small in terms of total oil demand relative to the other main subsectors, and hence it receives very little attention in scenario analysis. Few studies include even a BAU case for rail, and none offer significant alternative future scenarios. To simplify the analysis, therefore, and to focus on the more significant subsectors, oil demand for the rail subsector is included in the 'land' category of the results for oil demand alongside road, and is not discussed further in this analysis.

Road

As Figure 6 illustrates, scenarios for road transport (which are the most highly developed) show a very wide diversity of outcomes.

**Figure 6
Oil demand trajectories
from road transport scenarios**



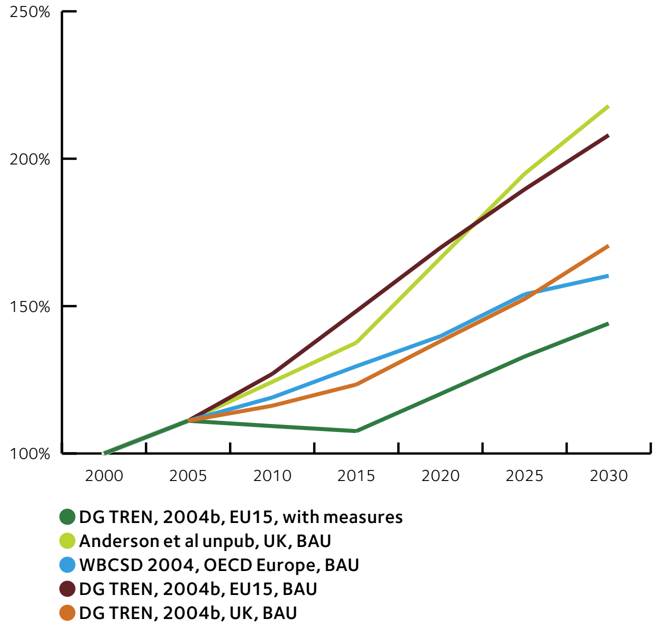
Business-as-usual scenarios for the road sector all show significant further growth in fossil fuel demand, typically from around 20% to 30% growth in demand by 2030 relative to 2000. The official forecasts discussed in Chapter 3 (DG TREN, 2004b) give the highest estimates, while BAU cases from WBCSD and Eyre *et al* envisage growth limited to around 20%. A mid-point trajectory of these four scenarios is taken as the BAU base case for this analysis.

In contrast, intensive 'with measures' scenarios project significant reductions relative to 2000 levels, typically around 20%, while the target-driven (VIBAT) scenario gives over 50% reduction. Eyre *et al* represents a mid-point for this group, and is therefore used in further calculations to represent the alternative scenarios.

Air

For aviation there is a less marked divergence in the demand projections, reflecting that there are no well-developed 'with measures' scenarios available – that is, none of our scenarios considered the impact of any significant changes in policy or technology on aviation.

Figure 7
Oil demand trajectories from aviation scenarios

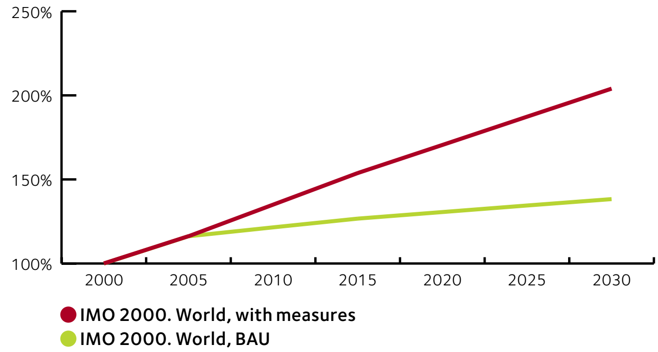


As Figure 7 shows, WBCSD and Anderson et al. are in close agreement on the business as usual (BAU) case, with both projecting an approximate doubling of demand by 2030. DG TREN's BAU scenarios by contrast appear over-optimistic, and were not used, so a mid-point of the first two was taken for the base case. DG TREN's with measures case was taken as representing a lower fuel demand outcome for the alternative case (although one still implying nearly 50% oil demand growth over the period 2000 to 2030).

Shipping

For shipping no full regional scenarios are available, in that European scenarios tend to focus on inland or inshore shipping, whereas international movements are generally more important. As a first approximation, therefore, the IMO's global projection shown in Figure 8 is taken as a reflection of the likely European share of world demand and to give a reasonable trajectory for demand growth. This appears reasonable given the global nature of the marine shipping industry.

Figure 8
Oil demand trajectories from shipping scenarios



As set out in Chapter 3, shipping is the third major oil demand sector. Furthermore, given in particular the rapid growth in containerised sea trade in recent years, growth rates for shipping are and are expected to remain very significant indeed. Although sea shipping is at present very fuel-efficient in terms of specific energy demand, this growth is in danger of being coupled with a projected deterioration in specific fuel consumption associated with higher ship speeds in particular. Hence the IMO projects a 70% increase in ship fuel demand by 2020 relative to 2000 in its base case, implying a doubling by 2030 if trends continue.

As against this, its 'with measures' scenario foresees a range of measures including improved propeller design and limitation of ship speeds that could significantly reduce the growth in fuel demand, and possibly largely counteract the growth in shipping activity. The latter is therefore adopted as the alternative scenario for the maritime subsector.

Note that the IMO's projections were only carried out up to the year 2020. However, it is necessary for the purposes of the present study to include figures for 2025 and 2030. Therefore figures for these years are extrapolated on the basis of the average rate of change implied by the respective scenarios.

5.3.2 Implications for oil demand

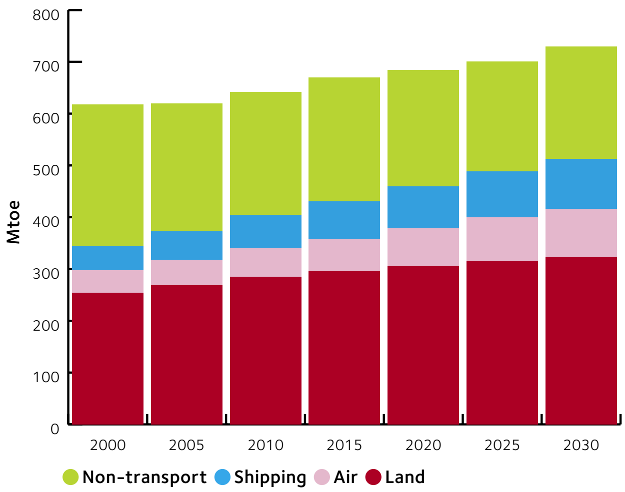
Given the chosen BAU and alternative scenarios, the oil equivalent final demand projection for each subsector was then calculated relative to the base demand figure for the year 2005. The subsector demand figures were then aggregated to give a total demand for the whole transport sector for each of the calculation years for both a BAU and an alternative case that were derived as described above. An uplift factor corresponding to the percentages set out in Table 13 was then applied to this total, in order to calculate the 'other' oil demand that would be expected to accompany the projected levels of demand for oil for transport purposes.

The results of this exercise are presented and discussed over.

Total oil demand – BAU case

Applying the above projections to the base case oil demand produces a BAU oil demand for the EU-15 as shown in Figure 9.

Figure 9
Projected primary oil demand for EU-15: BAU case



On this projection, the growth in total EU-15 oil demand for the land transport subsector is projected to level off somewhat towards the end of the study period, reflecting improved technical efficiency, some use of alternative fuels, and in some cases a saturation effect on total traffic demand. Total end-user demand for road traffic would nonetheless exceed 300Mtoe by 2020. In contrast, the aviation and shipping subsectors are projected to increase steadily in their future demands for oil, each exceeding 90 Mtoe by 2030. As a result, total transport end-user demand would be expected to exceed 500 Mtoe by 2030.

In contrast, other demands for oil are projected to decline gradually over the study period, reflecting the identified trend for transport demands increasingly to predominate in total oil demand. It is nonetheless projected that total primary oil demand for the EU-15 will continue to increase throughout the period until 2030. By that time, total oil demand is projected to exceed 700 Mtoe.

As Figure 10 illustrates, the situation would be broadly similar for the UK. That is, transport oil demand would continue to grow significantly, being only slightly offset by a decline in oil used for other purposes. In this BAU case, total UK oil demand would be expected to exceed 100 Mtoe per annum for most of the second half of the study period. The main differences in the UK case are that aviation is projected to play a larger role in total demand, and shipping a smaller one, than for the EU-15 as a whole.

Total oil demand – the alternative case

In the alternative scenario (shown in Figures 11 and 12), by contrast, oil demand for transport is significantly reduced, and a concomitant decline in use of oil for other purposes provides a multiplier effect. As a result there is a steady decline in oil demand across the study period.

Figure 10
Projected primary oil demand for the UK: BAU case

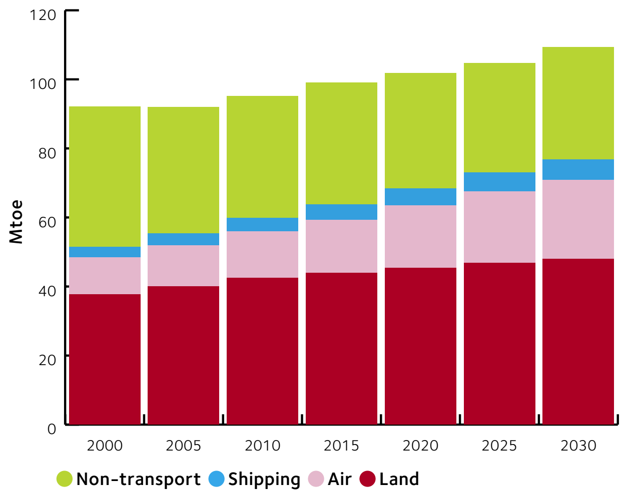
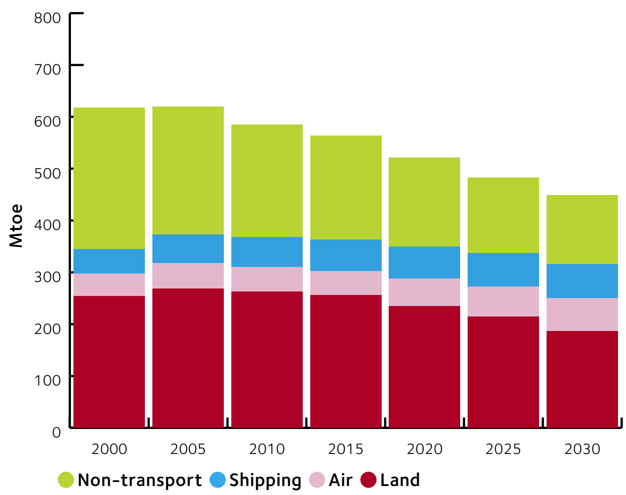
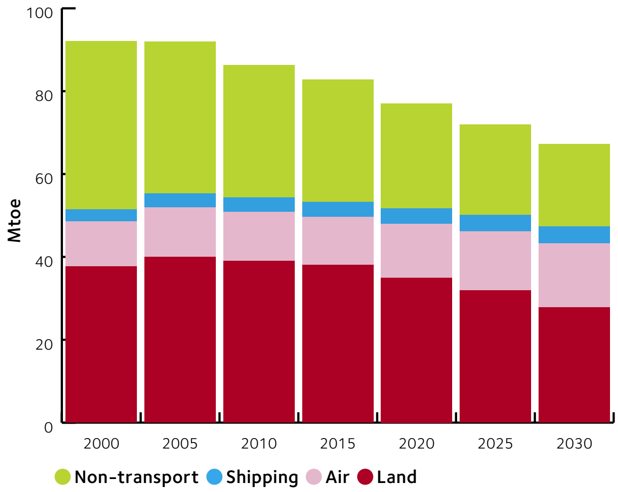


Figure 11
Projected primary oil demand for EU-15: alternative case



Relative to the BAU case, this results in increasingly large oil savings per year over the scenario period, amounting to nearly 300Mtoe per year for the EU-15 by 2030. Note that this still includes no absolute reduction in either the aviation or the marine subsector, but only a curbing of demand growth in each.

Figure 12
Projected primary oil demand for the UK: alternative case



Again, the position is projected to be similar for the UK, with substantial absolute reductions in oil demand projected over the period. In the case of the UK, however, the reductions in the road sector are somewhat offset by significant increases in aviation fuel demand.

Total oil demand – summary

Table 14 summarises projected total oil demand for the BAU and alternative scenarios for the UK and EU-15.

Table 14
Summary of total oil demand scenarios

		UK	EU-15
Oil demand (Mtoe)	Total 2005	92.0	619.7
	BAU 2030	109.3	729.3
	Alternative 2030	67.3	449.0
As % of 2005	BAU 2030	119%	118%
	Alternative 2030	73%	72%

As this table illustrates, the scenarios set out above demonstrate a marked difference in relation to future oil demand in 2030; either a further increase of around 20% in the total consumed, or a reduction of around one quarter relative to current usage. The latter case reflects significant reduction in land transport and non-transport use of oil, but still a significant increase in oil use for aviation which partly counteracts this. As explained above, this reflects a 'mid-range' selection of future scenarios; more dramatic increases in the BAU case, and more drastic reductions in the alternative case, are also conceivable.

5.3.4 Implications for oil imports

Having calculated future oil requirements at UK and EU-15 levels, it is now possible to consider the implications of these levels of demand for future oil security, by calculating the scale of imports needed and the degree to which we will become dependent on oil imports for transport and other purposes. To do this, however, it is essential first to make some assumptions as to the future level of domestic oil production, as net imports are calculated as the gap between projected demand and supply available from domestic reserves. These assumptions are discussed below.

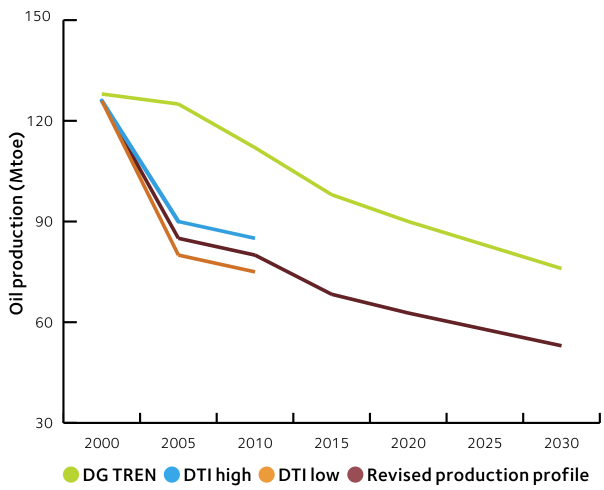
Note that the focus in this section is on *average net imports* per year, as these are the best indicator of expected levels of 'real' imports, and of the costs and import dependency that ensue

Future domestic production of oil

A region's oil production in a given year will reflect in part the known level of reserves, domestic production capacity, and a range of other factors. Rates of production are also influenced by the price of oil at any given time, and the level of reserves will also change over time. As a result of these and other factors, forecasting of future oil production is far from an exact science.

This point is amply illustrated by examining the variation between the projections of UK domestic production from DG TREN (2003) and more recent DTI (2005b) projections based directly on oil field data. As Figure 13 illustrates, significant differences exist between the two scenarios even in respect of the year 2010. However, this is largely because the DG TREN projections failed (perhaps understandably) to detect the rapidity of the fall-off in UK production over the period 2000-2005; beyond 2005 the projections run more or less in parallel. In light of these recent developments, though, the DG TREN projections now appear likely to significantly overstate UK production to 2030, while recent figures strongly suggest that this is not the case, and that the UK will become a net oil importer within quite a short period of time, if it has not already done so.

Figure 13
Projected future UK oil production



In order to reflect this and to take a better account of the lower and more recent DTI (2005b) figures for the years to 2010, the average ratio of the difference between DTI's mid-point value and DG TREN's has been taken and applied to the latter's projections of domestic production out to 2030, in order to give a more conservative projection out to 2030. This too is reflected in Figure 13. A corresponding reduction in total EU production has then been calculated on the same basis, and here the fall in UK output also has a significant impact because the UK is the main oil producer in the EU.

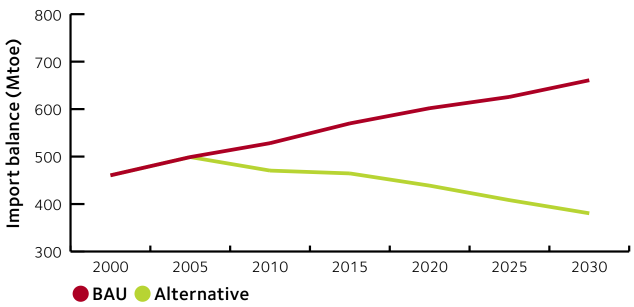
While these projections may arguably still be on the high side given recent estimates of UK reserves (Table 6), they are likely to prove more realistic than the DG TREN projections themselves.

Implications of transport demand for oil imports

Using these revised estimates of UK (and hence of EU) domestic oil production, it is now possible to produce estimates of future oil imports and exports for both the UK and the EU, and to illustrate the decisive influence of the level of transport oil demand upon these figures.

For the BAU case, as Figure 14 illustrates, imports for the EU-15 as a whole are expected to continue increasing inexorably, by more than 40% across the period 2000-2030. On the basis of these estimates, the EU-15 would be importing over 600Mtoe of oil every year by about 2025. In contrast, the alternative case would allow the EU-15 to reduce its dependence on imports by about a quarter in absolute terms from its present-day level, bringing the total below 400Mtoe by 2030.

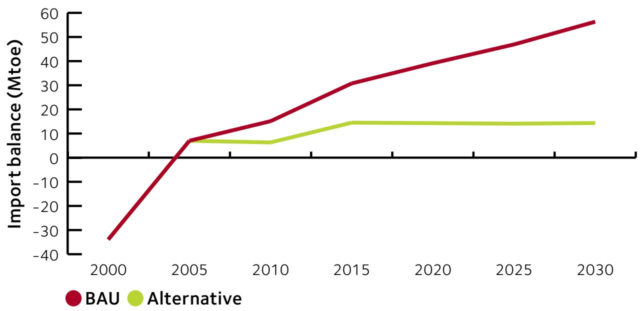
Figure 14
Projected EU-15 oil imports – BAU and alternative cases



For the UK, the contrast is even more dramatic. As Figure 15 illustrates, a continuation of BAU trends is projected to push the country very rapidly from being a net exporter in 2000 to an increasingly substantial net importer. Having exported approximately a net 35Mtoe of oil in the year 2000, this scenario would commit the UK to importing this amount every year by 2020 or earlier. By 2030, under these projections, net UK imports would exceed domestic production – the UK would be importing more than 50% of its oil.

In contrast, determined application of policy measures to reduce conventional oil consumption in the transport sector could help the UK to limit its net imports of oil for some years to come, from the BAU scenario's eightfold increase on current levels (as extrapolated from the DTI (2005b) production figures) to a mere doubling. On these projections, the UK would still become a net importer, but only for a few per cent of total oil demand, and imports are projected to level off significantly below 20Mtoe. In a situation like this, where two large numbers, both containing significant uncertainties, are being balanced against one another, the precise outcome is of course particularly difficult to predict. What seems certain, however, is that application of measures in the transport sector offers the possibility of dramatically limiting the UK's dependence on imported oil in the decades to come.

Figure 15
Projected UK oil exports and imports – BAU and alternative cases



Projected total oil imports – summary

Table 15 below summarises projected net oil imports for the BAU and alternative cases for the UK and EU-15.

Table 15
Summary of net oil import projections

		UK	EU-15
Oil imports (Mtoe)	**Total 2005**	7.0	499.0
	BAU 2030	56.3	660.8
	Alternative 2030	14.3	380.5
As % of 2005	**BAU 2030**	804%	132%
	Alternative 2030	204%	76%

SUMMARY
Alternative scenarios for reducing transport's oil dependency

- An examination of previous literature providing projections of future scenarios in transport was undertaken, and a number of scenarios were selected for further analysis. Based on their underlying assumptions, these scenarios may be grouped into:
  - Business as usual (BAU) scenarios
  - 'With-measures' scenarios
  - Target-driven scenarios.

- From these groups of projections, a single BAU and a single alternative scenario were developed to assess overall growth in oil demand and import requirements.

- Under the BAU scenarios, oil demand for road, aviation and shipping reveals high levels of growth; up 20% to 30% for road and over 100% for aviation between 2000 and 2030, and up 70% for shipping (2000 to 2020).

- Only road-based transport is projected to see a decrease in oil demand under the with measures or target-driven scenarios of between 10% to 50%. The air and shipping modes experience more restrained growth under these scenarios (50% to 2030 and 40% to 2020 respectively).

- For the EU-15, under the BAU scenario transport oil use would exceed 500Mtoe by 2030, of which around 300Mtoe would be for road transport, with aviation and shipping accounting for nearly 100Mtoe each.

- The UK situation in 2030 would be similar, although the proportional share from aviation would be higher (48Mtoe road, 23Mtoe aviation, and 6Mtoe shipping).

- Applying a range of measures to these sectors (the alternative scenario) could potentially save around 280Mtoe per year in total by 2030 across the EU-15, of which around 42Mtoe per year would be for the UK.

- The impact of these savings on the net import requirements for the EU-15 and UK is particularly striking, with the potential to reduce oil imports for the EU-15 from around 660 to 380Mtoe by 2030, resulting in significantly lower levels of imports than at present, rather than significantly greater.

- The alternative scenario could prolong the ability of the UK to remain only a modest net importer of oil more or less indefinitely; whereas the BAU scenario implies a huge increase in imports by 2030 from current levels of around 7Mtoe to over 50Mtoe per year.

6. SUMMARY AND COST IMPLICATIONS

This report has attempted to characterise the current and potential future situation for the EU-15 and UK in respect of the use of oil products as transport fuels. The key findings of this study are summarised below and are followed by a discussion of the implications including a consideration of costs involved.

- While overall oil demand in the EU-15 and the UK is likely to increase only relatively slowly over the period to 2030 under business as usual, an increasing proportion of this demand will have to be met through imports as domestic sources are already in decline. At current rates of production, the UK has less than a decade of production left and the EU-15's import dependence is likely to rise from 77% in 2003 to 87% by 2030.

- Oil has a large cost to the European economy, and this is growing; at current levels of consumption and prices this cost is around $280bn[19] (£156bn; €224bn[20]) per year, of which over $200bn (£116bn; €167bn) is made up of imports, accounting for approximately 2% of the EU-15's GDP. The road sector alone accounts directly for around $115bn (£64bn; €92bn) per year.

- Globally, the growing demand from the EU's major economic competitors is also coupled with an increasing dependence on imports, and as a result there is likely to be greater competition for resources. Competing demands for oil offer at the very least a strong possibility of higher or more volatile oil prices. This is likely to have growing negative impacts on European economies unless economy of oil use is significantly improved.

- The bulk of oil reserves are concentrated in relatively few countries and Saudi Arabia, Iran and Iraq control 43% of the world's known reserves. Import flows to the EU-15 from the Middle East are projected to increase to 7mb/d by 2030 (compared to 3mb/d today). Increasing levels of imports are likely to lengthen supply chains and increase dependence on geo-politically unstable areas of the world. There are also likely to be indirect or hidden costs associated with our dependence on imported oil. One indicator of the potential costs of disruption to supply was provided by the financial impact of the UK fuel protests in 2000.

- The use of oil is also a major contributor to our emissions of CO_2. Addressing this issue and these emissions is an important and urgent task, reflected in the mounting evidence of global warming and increasing intensity of political discourse on the subject. The costs associated with climate change resulting directly from the burning of oil and other fossil fuels are likely to be very large indeed.

- Transport will continue to drive future oil demand for both the EU-15 and the UK. If unchecked, transport's oil use in 2030 could exceed 500Mtoe across the EU-15 and 75Mtoe for the UK. Based on the figures used in our analysis, by 2030 the total cost of transport fuel for the EU-15 is projected to rise to around $300bn (£166bn; €239bn) annually in the BAU case, of which the UK will contribute $25bn (£14bn; €20bn). For the EU as a whole, most of this will be spent on imports, and a significant but smaller proportion for the UK. The exact proportion is particularly difficult to estimate owing to uncertainties about the exact size of remaining domestic reserves. This is on the assumption of oil at $60 per barrel – several dollars lower than the actual price at the time of writing.

- By implementing a range of measures to cut oil consumption, it may be possible to reduce this figure substantially. The projected savings on the import bill could be in the order of $125bn (£70bn; €100bn) per year for the EU-15, and nearly $20bn (£11bn; €16bn) for the UK.

- These potential reductions in consumption would have significant implications for import dependency levels, providing a reduction in the total imports of the EU-15 and providing the opportunity to greatly reduce the import dependency of the UK, thus leading to enhanced energy security.

Furthermore, not all policy options are equally expensive – indeed, some appear to be very cheap or to involve no outlay at all, and might actually pay for themselves very quickly. A recent study by the IEA (2005) indicates that measures such as car sharing and eco-driving can provide large impacts for less than $1 per barrel saved, whilst enforcing a 90kph (55mph) speed limit on motorways would cost less than $11 per barrel saved, as well as having significant safety and other environmental benefits.

Our transport systems (including vehicles, infrastructure and other supporting systems) are huge and complex and almost entirely oil-dependent at present. As a result, they could not be transformed overnight, and very strong concerted action would be needed to transform them even over a period of decades. Our choice is whether we continue increasing our dependence on imported oil and with it the risks of price shocks, vulnerability to supply disruption, and irreversible climate change, or decide instead to start reducing the degree to which we depend on oil. First and foremost, this means tackling the transport sector.

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Annex 1

SUMMARY OF SCENARIOS

Source	Scenarios	Modes/ options considered; Approach	Time lines	Scale	Pros	Cons	Use?
Eyre, Fergusson and Mills (2002) Fuelling road transport	1. BAU central demand 2. Worst case 3. Central case 4. High demand case (world markets) 5. Low demand case (global sustainability) 6. Vehicle innovation with BAU energy 7. Vehicle innovation with Renewables 8. Vehicle innovation with electrolytic H_2 9. Vehicle innovation with biomass H_2 10. High biomass case 11. Biomass combination	Road transport; fuels, vehicle technologies and demand. Bottom-up modelling of technology/demand scenarios.	2000, 2010, 2020, 2030, 2040, 2050	UK	Includes primary energy. Wide range of scenarios covering both demand and technology/fuels. All background data available.	Road sector only.	Yes
DG TREN (2004) Scenarios on key drivers 2030	1. World energy prices 2. Economic developments 3. Energy efficiency and Renewables 4. Transport – White Paper Option C 5. Extended Policy Options 6. Full policy Options	All modes and policies covered by White Paper; promotion of rail and higher load factors. 'With measures' policy scenarios modelled.	2000, 2010, 2020, 2030	EU	Authoritative All modes A range of scenarios	Commission policy-driven scenarios – possibly not fully representative.	Yes
AEA Technology (2002) Options for a low carbon economy – phase 2	1. Baseline 2. World markets 3. Global sustainability	Technologies incl. Hydrogen main focus road transport. Bottom-up modelling	2000, 2010, 2020, 2030, 2040, 2050	UK	Authoritative and detailed A range of demand scenarios	Work reflected in Eyre et al UK road sector only.	No

Source	Scenarios	Modes/ options considered; Approach	Time lines	Scale	Pros	Cons	Use?
Concawe/ EUCAR/ DG Research (2004) WTW analysis of future automotive fuels and powertrains in the European Context	All fuels were examined with the feasibility of a 5% substitution of passenger car transport distance, incremental costs and costs of CO2 avoided provided for: 1. Conventional hybrids 2. CNG 3. Syn diesel fuels 4. Ethanol 5. FAME 6. H2 from thermal processes 7. H2 from electrolysis 8. indirect H2 generation	Passenger car (5-seater) transport only; fuel types and powertrains	2002, 2010	N/a	Authoritative Good data on costs	Not scenario-based Addresses only limited fuel shift	No
DG Env (2003) Renewable Fuels for Cross Border Transportation	Analysis of life cycle assessments and costs for potential contributions from different fuel types: 1. ethanol from sugar beets 2. methanol from wood residues and fast growing trees 3. rape methyl esther 4. synthetic fuel from wood residues and fast growing trees 5. hydrogen from logging residues 6. hydrogen by electrolysis using renewable electricity	Covers all modes excluding electric trains; only considers fuel to 2030 in EU.	2008, 2020 2030	EU	Provides information on costs. Covers all modes.	Only considers fuel changes.	No
ECN (2004) Energy Trends for Europe Comparison of model scenarios	Baseline energy use scenarios (first phase of project report) evaluating 12 E3 models. PRIMES and MARKAL are the two sector specific models that subdivide the transport modes	Entire energy sector covered by individual models – only baseline work	2000. 2010, 2020, 2030, 2040, 2050	EU	Provides useful overview of baseline energy projections.	Only two models disaggregate to a sufficient level and are accounted for by other studies	No
Timms, Kelly and Hodgson (2005) World transport scenarios project (Tyndall)	Four IPCC SRES scenarios: 1. A1 2. A2 3. B1 4. B2 Two GSG scenarios: 1. Fortress World 2. Great Transitions	Excel spreadsheet database on transport activity (pax-kms, freight ton-kms by air, road, rail and water).	1995, 2025, 2050, 2100	Ger, UK, Fr, It and rest of EU-15	Authoritative. A number of scenarios tested. Covers all sectors and countries.		No

Source	Scenarios	Modes/ options considered; Approach	Time lines	Scale	Pros	Cons	Use?
Bishop and Watson (UKPIA) (2005) Delivering a low carbon economy	No scenario work, essentially and discussion of options in transport and other sectors with some simplistic example calculations				Recent work examining transport sector	Not scenario based and options covered by other studies	No
Page, M., Kelly C. E.; Bristow, A. L., 2004, Exploring scenarios to 2050 for hydrogen use in transport in the UK, paper presented at the European Transport Conference, Strasbourg.	Quantitative transport model of UK, four scenarios: 1. World Markets 2. Provincial Enterprise 3. Global Sustainability 4. Local Stewardship Assumptions made about how these relate to transport factors such as car ownership, congestion, bus use and technologies	Road, rail, air and water; different types of activity by different vehicle types and fuel consumption factors. More sophisticated approach for road. Bottom-up Target-driven	All years to 2050	UK	Authoritative. Follows similar scenarios to a number of other studies based on IPCC.	Relevant but data not received	Nes
Bristow et al. (2004) How can we reduce carbon emissions from transport? (Tyndall)	1. Examination of 5 previous studies to est. transport emission targets. Strategies examined: 1. Technology 2. Pricing for road use 3. Public transport 4. Telecommunications 5. Land use planning 6. Combination of measures	Only covers personal land- based transport. Target-driven scenarios.	2030, 2050	UK	Authoritative. Identifies real policy measures alongside technology.	Only covers land transport	No
IEA (2004) World Energy Outlook and IEA (2002) World Energy Outlook	Two scenarios 1. Reference (baseline) 2. Alternative policy scenario	Covers all modes (no disaggregation). Alternative policy scenario considers: 1. improved vehicle efficiency 2. increased sales of alternatively fuelled vehicles 3. demand measure (5% reduction road pax travel, 8% road freight)	2000 (from WEO 2002) 2002, 2020, 2030	EU	Authoritative. Includes aviation. 'With measures' scenarios	Lacks modal split	Yes

Source	Scenarios	Modes/ options considered; Approach	Time lines	Scale	Pros	Cons	Use?
DTI (2000) EP68 to 2020	Six scenarios: 1. Low growth high fuel prices 2. Low growth low fuel prices 3. Central growth high fuel prices 4. Central growth low fuel prices 5. High growth high fuel prices 6. high growth low fuel prices	Covers all modes in UK (disaggregation could be a factor) Main assumptions regarding transport are fuel duty changes (probably very out of date now)	2000, 2005, 2010, 2020	UK	Recognised source, varies fuel prices	Not beyond 2020 Updated for UK NAP 2004 Does not disaggregate to individual modes	No
WBCSD (2004) Mobility 2030 and SMP model	Builds on IEA 2002 work to examine defined indicators of sustainability incl. GHG emissions for reference scenario then discusses range of measures to reduce impact. Model provides reference case.	Covers all modes Provides some cost information on technologies and very in depth study of transport mitigation options	2000, 2005, 2010, 2015, 2020,	EU	In depth study covering all modes of transport	Does not disaggregate beyond the EU level	Yes
VIBAT (2005)	Two 'radical' back casting scenarios are developed: 1. New Market Economy 2. New Smart Social Policy	Covers all UK transport sectors, main focus is road transport	2000, 2030	UK	Up to date work covering all transport sectors	Scenarios are intentionally 'radical'	Yes
IPCC (2001)	Four main 'storylines': A1 rapid economic growth and adoption of technologies A2 Heterogeneous world, regional orientation slower economic growth and technology diffusion B1 Convergent world global solutions and reductions ion material intensity B2 Local solutions to sustainability, environmental protection and social equity at local and regional levels	Overall energy sector, no disaggregation to transport level – this work has been superseded by the Timms et al. study	1990, 2020, 2050, 2100	Global	Authoritative work	Not sector specific	No
Anderson, Bows and Upham (unpublished) Growth Scenarios for EU and UK aviation: contradictions with climate policy	Uses GCI model CCOptions to conduct contraction and convergence for 450ppm and 550ppm for aviation and examines implications for other sectors through 4 Tyndall scenarios reaching 60% cut in CO_2 emissions by 2050	Aviation emissions primarily	2030, 2050	UK, EU	Most up to date work on aviation, provides both BAU and alternative scenarios	As yet unpublished	Yes

Source	Scenarios	Modes/ options considered; Approach	Time lines	Scale	Pros	Cons	Use?
IEA (2005) Saving oil in a hurry	Quantifies the fuel consumption reduction potential for a range of measures from a 2001 baseline, no future scenarios	Primarily passenger car transport but could also apply to freight	2001	EU	Provides cost figures for measures reducing oil consumption	No projections	Yes
IMO (2000) Study of greenhouse gas emissions from ships	Quantifies fuel consumption for international shipping for with basic projections based on GDP and sea borne trade (low and high growth)	International shipping	1996, 2010, 2020	Global	Authoritative work on international shipping – main source for measures	Only projects fuel consumption to 2020	Yes
Endresen et al. (2003) Emission from international sea transport	Quantifies fuel consumption for international shipping for 1996, 2001, no scenarios	International shipping	1996, 2000	Global	More up to date information on current fuel consumption in shipping	No projections	No
Corbett and Koehler (2003) Updated emissions from global shipping	Quantifies 2001 fuel consumption for international shipping, no scenarios	International shipping	2001	Global	More up to date information on current fuel consumption in shipping	No projections	No

Annex 2
DEFINITIONS

EUROSTAT data definitions from CODED Eurostat Concepts and Definitions Database: http://forum.europa.eu.int/irc/dsis/coded/info/data/coded/en/Theme9.htm (accessed November 2005).

Primary Production: Any kind of extraction of energy products from natural sources to a usable form is called primary production. Primary production takes place when the natural sources are exploited, for example in coal mines, crude oil fields, hydro power plants or fabrication of biofuels.

Imports: Imports into a given Member State are:
a) goods which enter the statistical territory of the Member State from a non-member country and are:

- placed under the customs procedure for release into free circulation (goods intended to be consumed in the importing Member State or dispatched to another Member State), either immediately or after a period in a customs warehouse; or
- placed under the customs procedure for inward processing (including inward processing in a customs warehouse) or processing under customs control (usually goods destined to be processed, transformed or repaired for subsequent re-export) either immediately or after a period in a customs warehouse.

b) Some movements of goods are included in Eurostat statistics according to specific rules. In particular, ships and aircraft are included in arrivals of a given Member State when ownership is being transferred from a person resident in another Member State to a person resident in the Member State in question.

Exports: Exports from a given Member State are: a) goods which leave the statistical territory of the Member State bound for a non-member country, having gone through: the customs export procedure (final export, export following inward processing, etc.); or the customs outward-processing procedure (usually goods destined to be processed, transformed or repaired for subsequent re-import).

b) Some movements of goods are included in Eurostat statistics according to specific rules. In particular, ships and aircraft are included in dispatches of a given Member State when ownership is being transferred from a person established in this Member State to a person established in another Member State.

Gross Inland Consumption (Demand): Gross inland consumption represents the quantity of energy necessary to satisfy inland consumption of the geographical entity under consideration. Gross inland consumption is calculated as follows: primary production (Code 100100) + recovered products (Code 100200) + total imports (Code 100300) + variations of stocks (Code 100400) - total exports (Code 100500) - bunkers (Code 100800). It corresponds to the addition of consumption, distribution losses, transformation losses and statistical differences.

Final energy consumption – Road: covers quantities used in motor vehicles for the propulsion of such vehicles, whether utility vehicles or motor cars for own use or the use of others, including omnibuses belonging to railway companies. Consumption by civil engineering vehicles licensed to use the public road network is also included under road transport, in so far as they are subject to the normal taxation system, whereas motor fuel consumed by agricultural vehicles is included under agricultural consumption.

Final energy consumption - Rail: covers the consumption by railways and electrified urban transport systems (these data do not include inputs into electrical power stations managed by the railways).

Final energy consumption - Aviation: covers quantities consumed in aircraft in national and international air traffic.

Final energy consumption - Marine – Includes **National navigation:** covers the consumption in inland and coastal navigation and yachting and Bunkers: covers the quantities of fuel delivered to sea-going vessels of all flags. Vessels engaged in inland and coastal water transport are not included in the Bunker category.

Final energy consumption - Transport: covers the consumption in all types of transportation, i.e., rail, road, air transport and inland navigation.

LPG: Liquefied petroleum gases (LPG) are light paraffinic hydrocarbons derived from the refinery processes, crude oil stabilisation and natural gas processing plants. They consist mainly of propane and butane or a combination of the two. LPG are normally liquefied under pressure for transportation and storage.

Petrol (Motor spirit): covers leaded and unleaded motor spirit, aviation spirit and car spirit. It consists of a mixture of light hydrocarbons distilling between 30°C and 215°C. It is used as fuel for spark ignition engines. It may include additives, oxygenates and octane enhancers, including lead components such as TEL (Tetraethyl lead) and TML (Tetramethyl lead). Motor spirit (Code 3230) also covers unleaded motor spirit (Code 3234).

Kerosene: covers gasoline type jet fuels, kerosene type jet fuels and other kerosenes. These fuels are atmospheric distillates having a volatility intermediate between those of gasoline and gas oil and a distillation range generally between the limits of 100°C and 300°C. This fuel also includes kerosene-blending components.

Diesel (Gas/ diesel oil): Gas/diesel oil is primarily a medium distillate distilling between 180°C and 380°C. It comprises transport diesel (as road diesel for diesel compression ignition usually of low sulphur content) and heating and other gas oil (light heating oil for industrial and commercial purposes, marine diesel and diesel used in rail traffic and other gas oil including heavy gas oils distilling between 380°C and 540°C used as petrochemical feedstocks). Also blending components are included.

Residual fuel oil: Residual fuel oil covers heavy fuel oils including those obtained by blending. Kinematic viscosity is above 10 cSt at 80°C. The flash point is always above 50°C and density is always more than 0.90 kg/l.

ENDNOTES

[1] The EU-15 covers the 15 member states that were members of the EU prior to its enlargement in 2003. Data for the enlarged EU (ie EU-25) is not yet widely available. Also, future fuel demand is likely to follow a different trajectory in the new member states (oil demand is growing faster, but from a lower base per capita), so they are not comprehensively addressed in this report.

[2] At the time of writing Brent crude prices were above $60 per barrel (Source: www.bloomberg.com, 12 January 2006).

[3] Expressed as the ratio of net imports to total demand.

[4] For definitions of the terms see Annex 2.

[5] Mtoe = Million tonnes of oil equivalent

[6] The category used by EUROSTAT is gross inland consumption. It is calculated on the basis of a number of factors in addition to those in the table, which are outlined in Annex 2, therefore the sum of primary production and imports minus exports does not equal demand exactly.

[7] Note that these figures are not directly comparable with those in Chapter 5, as the coverage and base years are different and some alternative scenarios are preferred in the latter case.

[8] Net imports represent total imports minus exports

[9] The category used by EUROSTAT is gross inland consumption. It is calculated on the basis of a number of factors in addition to those in the table (primarily marine bunker fuels), which are outlined in Annex 2. For these reasons, the sum of primary production and net imports will not equal demand.

[10] See footnote 8

[11] See footnote 9

[12] Proven reserves are those with a greater than 90% chance of being technically and economically feasible to extract; for probable reserves this figure is greater than 50%; and for possible reserves this is less than 50%.

[13] Undiscovered resources are those that are as yet undiscovered but are assumed to be potentially recoverable.

[14] This is the ratio of proven reserves (R) to the current production level (P) and hence gives an indication of the number of years of reserves left if production continues at current rates.

[15] For definitions of the terms see Annex 2.

[16] For the aviation and marine subsectors we only have information in terms of fuel purchases from bunkers and not direct fuel burn. For aviation this can be considered a good approximation for fuel burn and emissions as aircraft do not carry large amounts of surplus fuel on board from one country to another, and the surplus fuel carried is likely to balance out to a large extent between inbound and outbound flights. In the case of the marine subsector however, seagoing ships have the capacity to store and transport their fuel long distances before it is burned, and therefore the international bunker fuel component may overstate or understate the actual fuel burn associated with the EU-15 or UK.

[17] This represents both inland shipping and fuel associated with marine bunkers used in international shipping. Marine bunker fuel is composed mainly of diesel and residual fuel oil, although a very small amount is derived from other fuels. For the purpose of these tables this fraction has been disregarded.

[18] Assuming an oil price of $60 per barrel

[19] Cost figures are based on an oil price of $60 per barrel.

[20] Assumes exchange rate of £0.555 and €0.798 to $1.

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