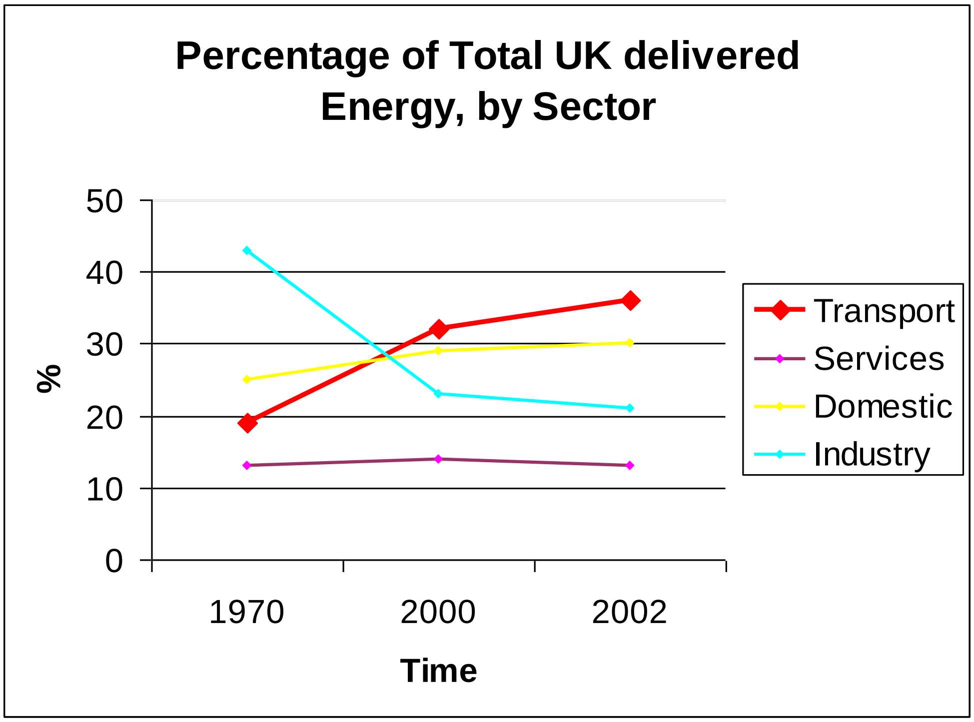
Transport Sector Energy Demand Projections

2010, 2015, 2020, 2025 and 2030

Introduction

1.1 The transport sector has seen an unprecedented growth in the percentage of delivered UK energy since 1970, ***Figure 1***.

Figure 1*: Percentage of UK delivered Energy by Mode of Transport (based on DTI data)*



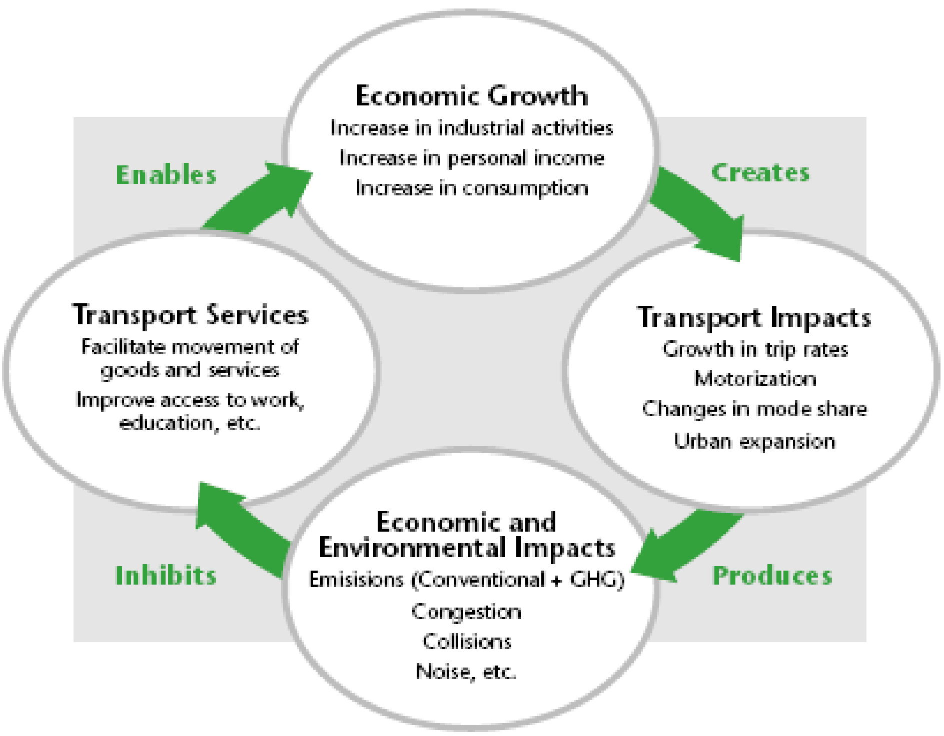
1.2 Between 1970 and 2000 total delivered energy rose by just under 10%. Transport energy use, however, rose by 96%. This increase was significantly greater than increases in domestic and services sectors. This increase could be attributed by many factors including society's desire of increased mobility, improvements in the road networks and decreases in the real costs of road transport (Maddison et. al 1996)

1.3 Our society is demanding and consuming energy at an unsustainable rate. In order to confront this issue, either we must reduce our energy consumption or find a sustainable way in which energy is generated (renewable resources) and consumed (non-polluting). This report will focus on the ways in which energy use in transport can be reduced to alter future demand projections.

1.4 The report will suggest a series of strategies that could be implemented, and how they could influence future demand projections.

1.5 The unsustainable nature of Transport in the UK is highlighted in ***Figure 2.***

Figure 2: *The Transport Predicament*



1.6 ***Figure 2*** illustrates the economic and social need for transport and the associated environmental and social consequences. The important factor in this diagram is the self-destructing or unsustainable nature of transport in the UK. If our society becomes too reliant on the current hydrocarbon based infrastructure and the economic and environmental impacts accumulate, there is potential to entirely inhibit all transport movement. This would effectively paralyse our nation, a situation that needs to be avoided at all costs. We must avert this destructive cycle by reducing energy use, whilst providing less energy intensive, yet feasible alternative modes of transport.

1.7 There are two distinct approaches to reducing energy demand in the transport sector (Boyle et. al 2003):

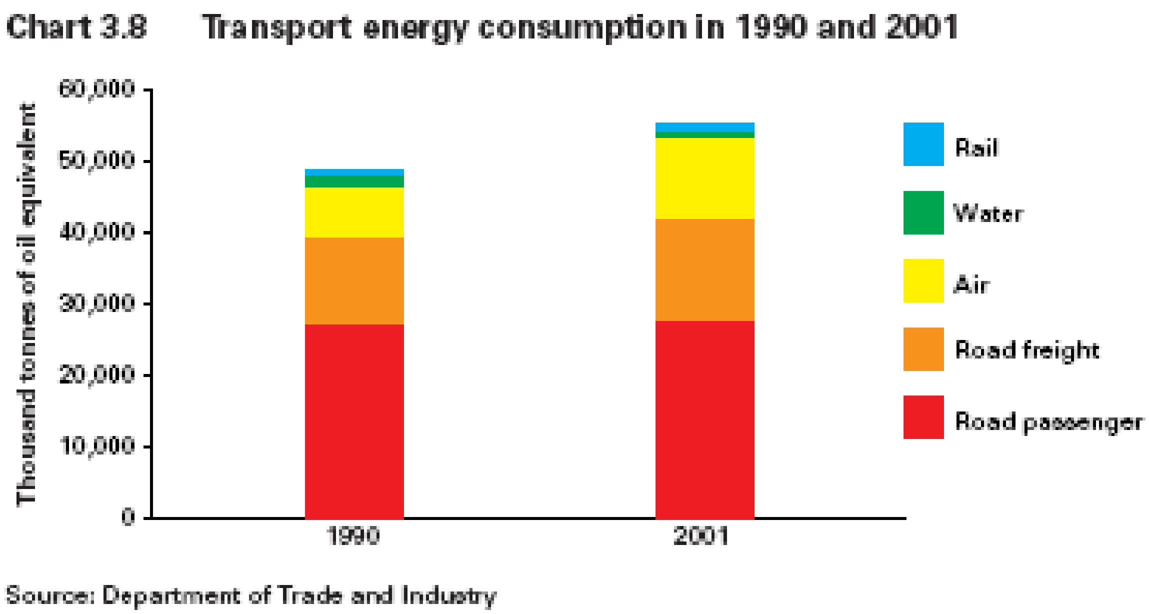
i. ***Technological approach***: Install improvements in energy conversion technologies so that vehicles require less input to achieve a given level of output i.e. improve fuel efficiency or switch to a less carbon intensive energy source.

ii. ***Social Approach***: This approach is more complex and will involve rearranging our lifestyles either individually or collectively, so that the energy to perform a given service is reduced in comparison with other methods of providing that service i.e. commuters using trains as opposed to the car. This may also involve reorganising communities from rural, spatially diffuse communities to more densely populated urban communities. Amenities tend to be concentrated in areas of high population density; therefore residents can shop, work and take children to school without using the car. Combined with this, services such as public transport tend to be more efficient. It is argued that our society should move towards these more energy sustainable communities, where we receive the same level of service but use a more efficient system.

Energy Demand in the UK

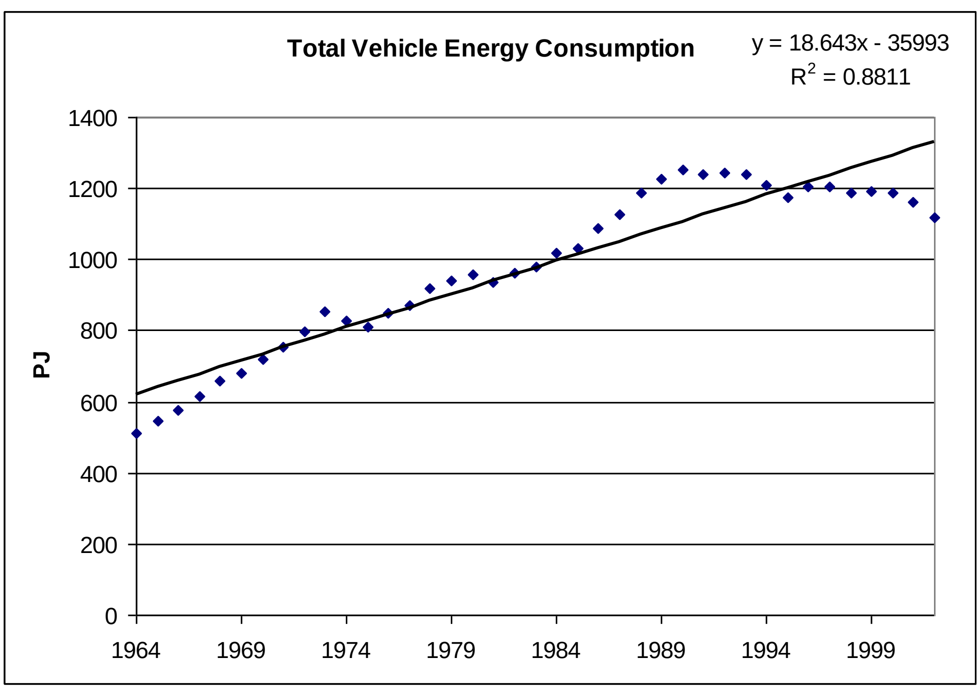
2.1 Motor vehicles dominate the transport sector in developed countries (Boyle et.al 2003), therefore this report will focus and make more accurate projections based on road passenger transport. The DTI estimate that road passenger transport accounts for over 50% of energy consumption in the UK (***Figure 3***), making it the most fundamental area reduce energy usage.

Figure 3: *Transport Energy Consumption by Mode of Transport*



2.2 It is important not to discount the other transport sectors; however, specific information regarding energy consumption is difficult to acquire. As a consequence of which, energy projections will be calculated for these sectors, albeit with less certainty.

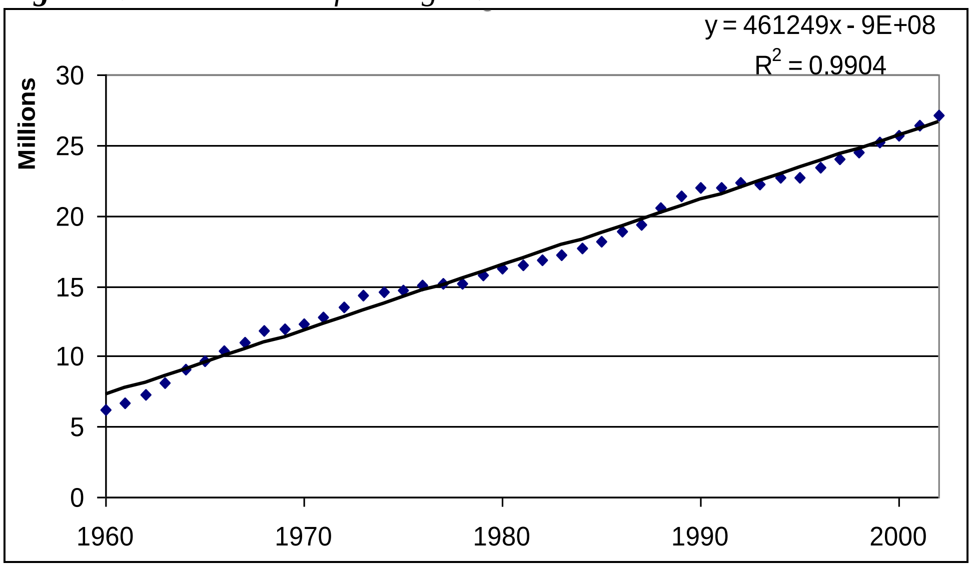
Figure 4: *Total Light Vehicle Energy Consumption*



2.3 ***Figure 4*** shows a steady increase in total vehicle energy consumption from 1964 to until the early 90's at approximately 18PJ per annum. However, in the mid to late 90's levels of energy consumption started to plateau and even began to decline. The graph must be broken down into the component factors which are responsible for the total energy consumption, in order to assess which factors are most dominant in dictating consumption and which can be targeted to reduce future transport energy consumption.

Total UK Light Vehicles

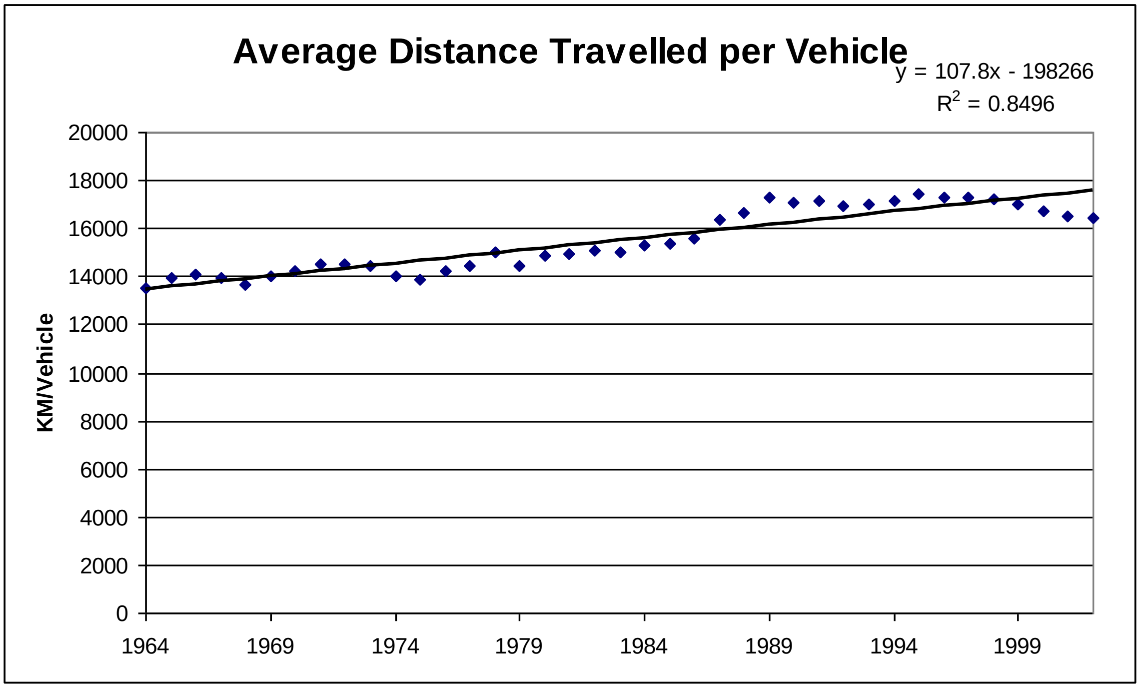
Figure 5*: Total number of UK light Vehicles*



2.4 ***Figure 5*** demonstrates that the number of light vehicles (Cars, Vans and taxis) on UK roads has consistently risen by approximately 45,000 new vehicles each year. This figure is continuing to rise at an unremitting rate and is showing no signs of reducing. However, the number of road vehicles is limited to a critical factor: there are limited numbers of people in the UK, who firstly can buy a car and secondly can drive one. Therefore the total number of vehicles is likely to begin to plateau as society saturates with vehicles.

Average distance travelled per vehicle

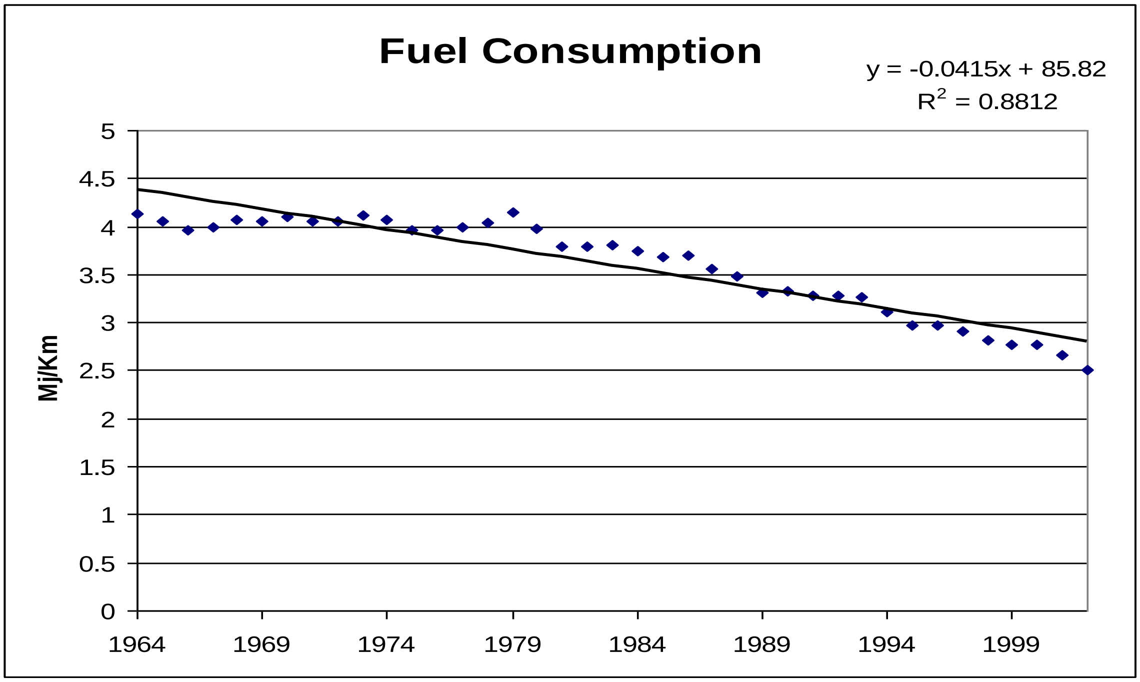
Figure 6: Km driven per vehicle



2.5 From 1964 to the early 90's the average distance travelled per vehicle was steadily increasing by approximately 110 km per year. This is likely due to a reduction in the real price of motoring and more dispersed societies. However by the late 90's this figure started to decline, suggesting either the public were more aware of minimising car usage or that fuel prices started to rapidly increase. Given our spatially diffuse and highly mobile society it is unlikely that is the near future this figure will significantly vary as the car is so heavily relied upon for commuting and leisure.

Fuel efficiency (fuel consumption per km)

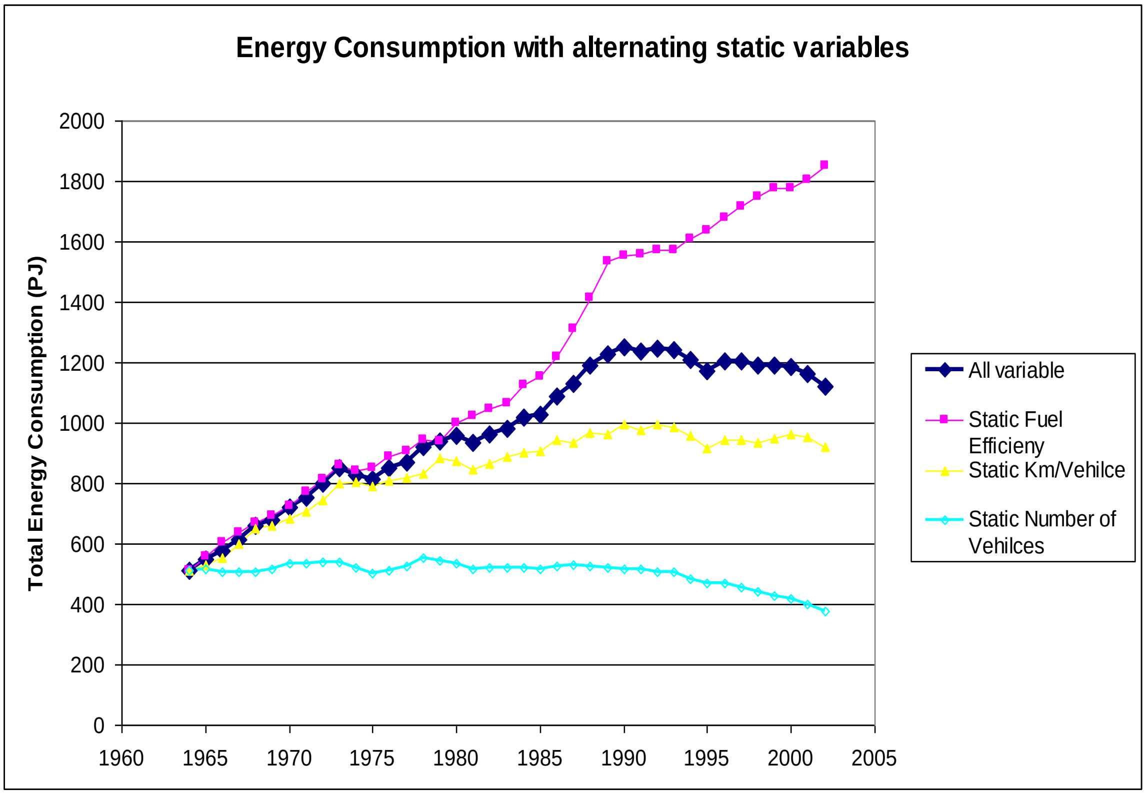
Figure 7: Fuel Consumption; MJ/km



2.6 Fuel consumption per/km has steadily decreased as engine efficiency has increased i.e. vehicle manufacturers are yielding more output per unit of input. This factor technically should be reducing overall energy consumption; however, this is assuming a static quantity of vehicles. Is the quantity of new vehicles flooding the market dwarfing any positive effect induced by improvements in fuel efficiency? In order to answer this question the report will assess each factor's relative contribution to total energy consumption.

Contributing Factors to Total Passenger Road Transport Energy Consumption

Figure 8: *Total Energy Consumption with alternating static variables*



2.7 ***Figure 8*** shows that fuel efficiency is the only factor which is actively reducing the total energy consumption, without improvements in efficiency the graph demonstrates how much greater energy consumption would be. The graph also indicates that the number of vehicles on the road is having the most profound influence in increasing the overall fuel consumption. Without an increase in the total number of vehicles the total energy demand would be significantly less. This highlights that in order to reduce energy consumption the total number of vehicles on the road must decrease or the number of km/vehicle and fuel consumption per km must significantly decrease. Is this a realistic solution?

Road Passenger Demand Projections

3.1 Given the previous data, projections have been calculated assuming three different scenarios: Optimistic, Pessimistic and Probable. In each of these scenarios, each factor increases/decreases at a different rate, reflecting alternative strategies and they're implementation.

3.2 In making these calculations it must be recognised that new strategies will take at least 2 years to pass though government procedures and several years for the manufacturers/ public to respond to them. Legislation will only effect new vehicles, given the long lifespan of the car (approximately 10 years), it will tale at least this amount of time before the market is saturated by new, more efficient vehicles (***Figure 9***)

Figure 9: *Road Passenger vehicle energy demand projections*

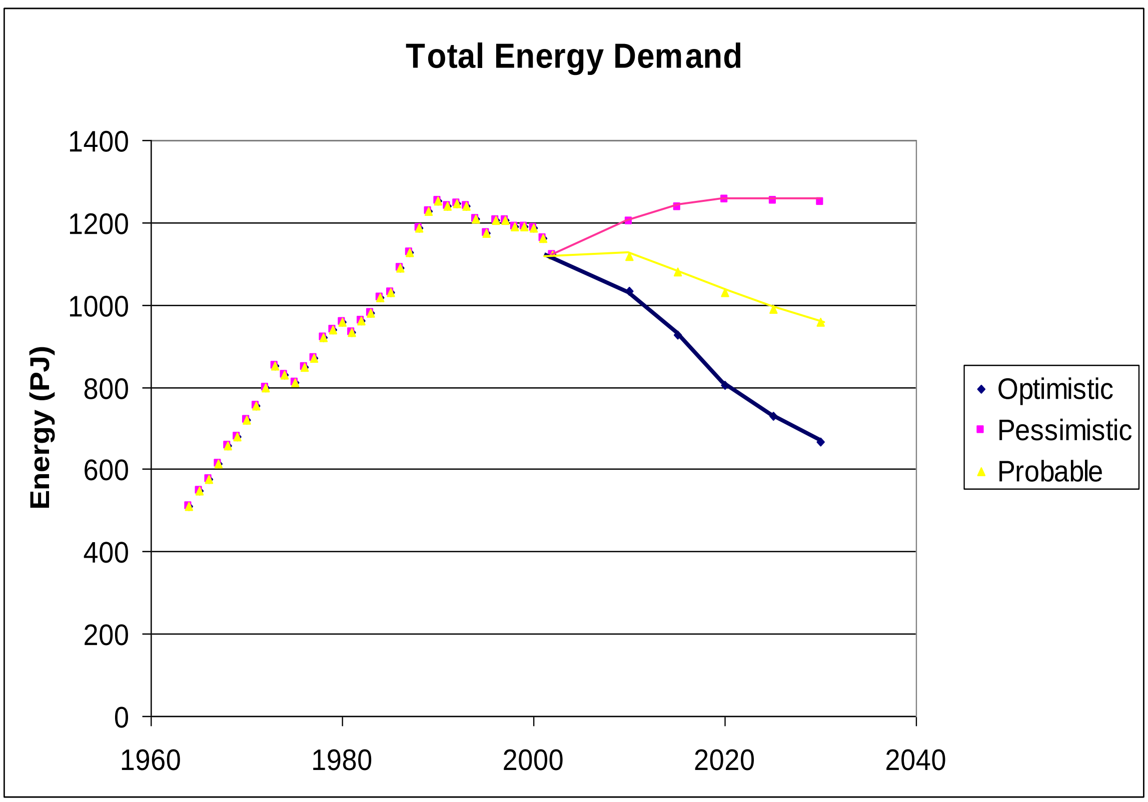


Figure 10 *Road Passenger vehicle energy demands (PJ)*

	Present	***2010***	***2015***	***2020***	***2025***	***2030***
Pessimistic	-	1201	1237	1255	1253	1248
Optimistic	-	1034	926	804	728	668
Probable	1120	1118	1082	1030	991	958

Figure 11: *Percentage change in factors given different scenarios, present -2030*

% change	**Optimistic**	**Pessimistic**	**Probable**
Total energy	-40%	+11%	-15%
No vehicles	+24%	+43%	+33%
Efficiency	-40%	-20%	-30%
Km/vehicle	-19%	-3%	-11%

3.3 ***Figure 9*** shows that there is likely not to be a significant increase in energy demand in either of the scenarios.

i. **Optimistic**: This scenario assumes that the number of new vehicles on our roads starts to increase at a lesser rate, technological advances and strict government regulation command a 40% improvement in fuel efficiency and that people use they're vehicles more stringently. This scenario assumes social, political and industrial cooperation.

ii. **Pessimistic:** This scenario assumes that the total number of cars continues to grow at a similar rate, and that fuel efficiency marginally improves through manufacturer competition as opposed to social or political cooperation. Government strategies are weak and the public are unwilling to employ energy saving measures, resulting in an increase in energy demand.

iii. **Probable:** This scenario takes middle-ground between the optimistic and probable scenarios, assuming that government will cooperate and that the public will respond, however, it accounts for failed legislations ad technological frontiers. This is the most likely, therefore realistic energy demand scenario, this will be the scenario used in the projections.

Total Transport Energy Demand Projections

4.1 Total Transport Energy demand was calculated using the following procedure: (***Figure 12)***

Figure 12: *Total Transport and Road Passenger Transport Calculations*

1970: Total energy demand: **6114 PJ** (Transport accounted for **19%**)

2000: Total energy demand: **6703 PJ** (Transport accounted for **34%**)

Assuming a continued total energy growth similar to that between 1970-2000

2030: Total energy demand: **7346 PJ** (Transport accounts for **39%**, based on *DTI projections)*

(7346/100)*39 = **2864 PJ Total Transport Demand 2030**

Of which **Passenger road transport will account for 958PJ** or **33%** *(probable scenario)*

4.2 ***Figure 12*** projects that road transport will demand 958PJ or 33% of transport energy demand. In order to calculate what modes consume the remaining 67% of energy in 2030, the following method was applied: (***Figure 13***)

Figure 13*: Freight and Air Energy Demand Calculations*

Currently Freight Transport consumes **29%** of Total Transport energy demand, with a previous growth rate of **17% (1990-2000)**

Freight transport will continue to increase but at a lesser rate: **17% (2000-2030)**, due to advances in efficiency and saturated markets.

Therefore by 2030 **Freight Transport will account for 33.9% or 970 PJ**

Air Transport energy demand will follow a similar pattern, at present the demand accounts for **18%** of Total Transport growth, with a pervious growth rate of **73% (1990-2000)**

Air transport will continue to increase but at a lesser rate: **73% (2000-2030)**.

Therefore by 2030 **Aviation will account for 31% or 889 PJ**

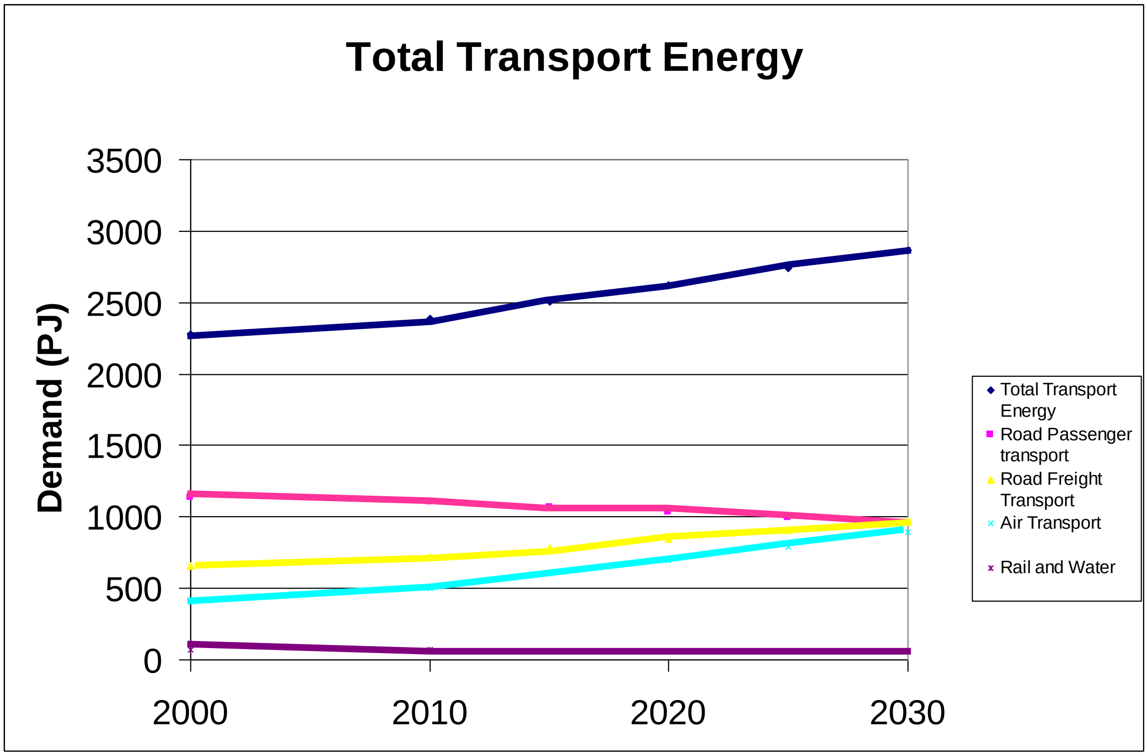
*The unaccounted **2.1% or 60PJ** will be consumed by **Rail and Water**, there contribution is marginal and is unlikely to fluctuate during, due to a lack of government funding.*

4.3 ***Figure 12*** and ***13*** do not include accurate projections for water or rail transport, as currently they're contribution to overall energy demand is marginal, and the lack of government funding will slightly decrease demand as services worsen. When Combined; ***Figures 12*** and ***13*** show the following change in energy demand over time (***Figure 14***)

Figure 14: *Total Transport Energy Demand by mode of transport*

Year	***Total Transport Energy***	***Road Passenger transport***	***Road Freight Transport***	***Air Transport***	***Rail and water***
2000	**2279**	1139	660	410	70
2010	**2390**	1103	722	505	68
2015	**2505**	1067	784	601	66
2020	**2622**	1031	846	696	64
2025	**2741**	995	908	791	62
2030	**2864**	958	970	889	60

Figure 15: *Total Transport Energy Demand by Mode of Transport*



4.4 ***Figure 15*** shows a gradual increase in the total transport energy demand, however predicts a more significant change in the composition of the different sectors. As vehicle efficiency gradually improves and the rate of growth of total cars reduces, the road passenger transport demand gradually declines by 15% by 2030. The lack of restrictions on air travel and the growing necessity for freight travel, both brought on my increased international business will cause a substantial increase in freight and air energy demand. These increases will effectively outstrip the benefits of a reduction in passenger road transport, therein resulting in the overall increase in Total Transport energy. The predicted changes will result in a more diverse transport industry, moving away from one dominated by road passenger vehicles.

Transport Fuel Type Projections

5.1 Predicting the principle fuel types within the transport sector is essential, as each fuel varies in energy density, abundance and polluting potential (***Figure 16***). The transport sector needs to be directed at maximising the use of highly abundant, high energy density non-polluting fuels. However, our dependence on oil will not change overnight, it is estimated that our current oil infrastructure is valued a £6 trillion. The transaction, if any, must be gradual and must build on the mistakes made from the oil infrastructure and the 'oil era' in general

Figure 16: *future fuel type projections*

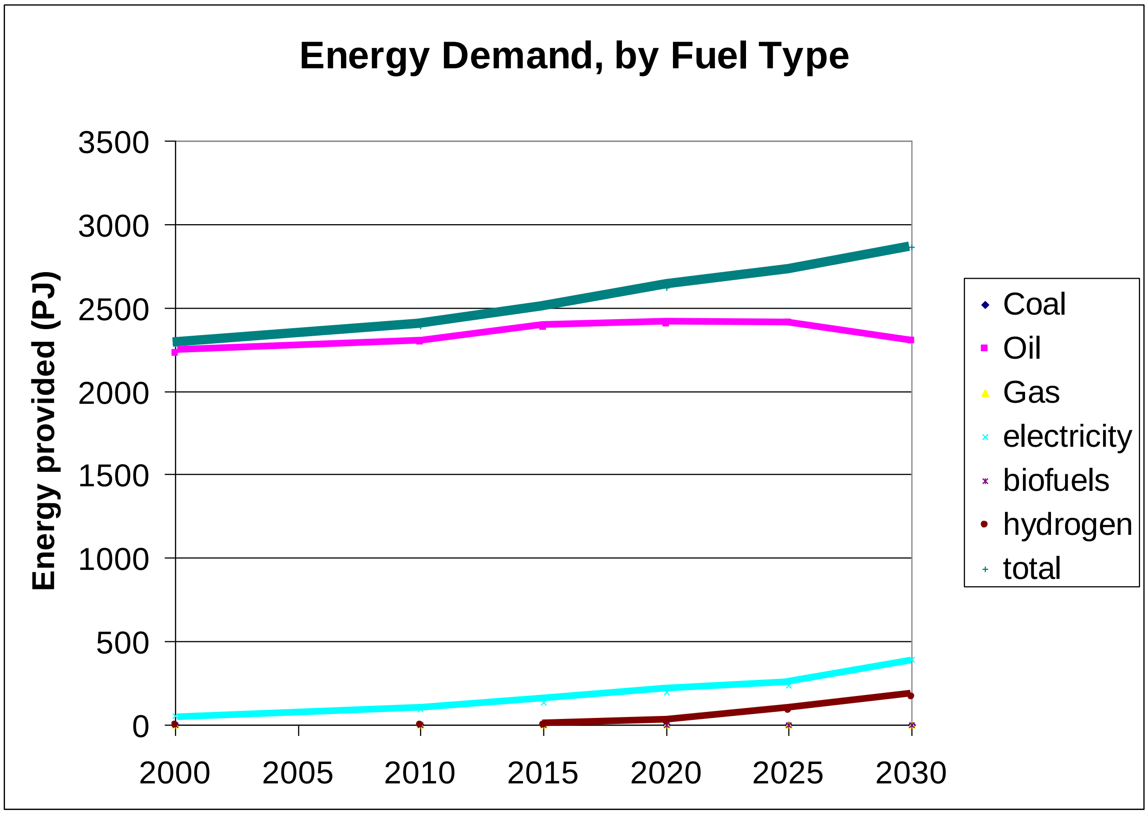


Figure 17: *future fuel type projections*

Fuel	2000	2010	2015	2020	2025	2030
Coal	0	0	0	0	0	0
Oil	2227	2292	2381	2402	2408	2299
Gas	0	0	1	2	2	3
Electricity	52	97	137	193	240	390
Biofuels	0	1	2	2	2	2
Hydrogen	0	0	1	23	89	170
Total	**2279**	**2390**	**2505**	**2622**	**2741**	**2864**

Figures based on 2003 DTI projections, however hydrogen has been considered as a fuel which has intern affected electricity and oil demands.

5.2 ***Figure 16*** and ***17*** show that oil will continue to be the dominant fuel type over the 30 year period. Legislation and changing public perception has little effect on oil in the first ten years due to delays in parliament and the lack of new vehicles entering the market. However, after 2010 new generations of electric vehicles will become economically feasible and practical to use, spurring the development of such vehicles, targeted at commuters. The low running costs and positive environmental statement created by the vehicles will rapidly boost sales, as a result of which oil starts to gradually reduce as electrical vehicles become more common place. The rail service also uses a significant majority of the present electricity demand in transport; this demand will stay low and consistent over the 30 year period due to a lack of investment and development in rail. Oil consumption does not start to reduce until the late 20’s; prior to this alternative sources are inadequate to cope with the increase in new vehicles. The government will set strict Ultra Low Emission and Zero Emission mandates, setting guidelines to manufacturers and setting targets for markets in such vehicles; between 10-20% ULEV’s and ZEV’s by 2030. This will encourage markets in such vehicles, with manufacturers competing to produce more efficient and low cost vehicles. The Government will provide significant investment in converting the out-dated oil infrastructure to accommodate liquid hydrogen and hydrogen gas. Hydrogen vehicles will start to become viable around 2015, and will begin to flood the market by 2020 growing at a near exponential rate as the benefits are realised. Hydrogen and electric vehicles will be developed side by side and even integrated to provide the best technical solutions. By 2030 these new, low carbon fuels will contribute 19.5% of total transport energy. The contribution of Gas and Biofuels will be marginal due to fundamental limitations such as a lack of land and disbelief in such technologies.

Conclusions

6.1 All of the previous projections assume that our government and society will begin to realise the real consequences of transport and begin to take precautionary action to reduce energy consumption, or to curb harmful vehicle emissions to lessen the environmental footprint.

6.2 The projections are slightly pessimistic, as they assume that our highly mobile, spatially diffuse society will not be able to change from our dependence on oil overnight. There will also be a slight reluctance to change from oil consuming vehicles, due to our attraction to the internal combustion engine, embedded in the car culture to which our society subscribes. However, given time and increased awareness there will be a movement away from our dependence of oil imports, to seek a fuel which provides us with energy independence. This is likely to be hydrogen or electricity (produced form renewable resources)

6.3 To conclude; the transport sector will become more diverse; seeing an increase in freight and air travel and a movement away from a dominance of road passenger transport. Oil will provide the vast majority of energy over the thirty year period; however oil demand will gradually start to decline as electricity and hydrogen become feasible. The process will largely rely on technological advances, mild changes to the structure of society and well directed government incentives (OECD 2004)

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