Critical Issues in Decarbonising Transport

Final Report of the Theme 2 project T2.22

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Executive summary

Objectives

The objectives of the project were as follows:

- To identify possible future trends in journey types and purposes that impact on the transport sector's carbon emissions;
- To identify the obstacles and drivers, including economic, technical, political, safety and behavioural considerations, which will help to determine future low carbon pathways;
- To characterise technologies that might contribute to decarbonising transport;
- To identify critical issues in relation to decarbonising transport; and
- To highlight key issues of relevance to the Tyndall programme for future analysis.

Work undertaken

The research consisted of the following elements:

- A literature review on trends and drivers in the transport sector that impact on the transport system's carbon emissions.
- A literature review on emerging technologies that might contribute to the decarbonising of transport.
- An analysis of the potential impact of particular technologies on trends and drivers.
- Consultation with experts on the potential impact of selected technologies on decarbonising transport.

The aim of each stage was effectively to identify critical issues for decarbonising transport and to identify issues that needed further investigation. The work was effectively a filtering process at which issues were identified, eliminated or explored further in the next stage.

Results

The project identified a number of critical issues for decarbonising transport:

1. Aviation – How to reduce aviation's contribution to climate change.
2. Ageing population – Uncertainty over how a future ageing population will travel.
3. Households – Whether households will use cars differently in the future.
4. More diverse car market – Whether this will encourage more car ownership.
5. New vehicle technologies – Ensuring that these will deliver CO_2 reductions.
6. Intelligent Transport Systems – Accompanying measures to ensure that they contribute to reducing transport CO_2 emissions.
7. ICT, generally – Identifying what use is made of travel time avoided.
8. Teleworking – Longer-term impacts on commuting trips, and optimising benefits.

9. Teleshopping – Net impact on trips, and optimising the benefits.

Relevance to Tyndall Centre research strategy and overall Centre objectives

The research was undertaken under the Tyndall Centre's Theme 2 'decarbonising society' and was a strategic assessment. In this respect it addressed Research Theme 2's medium-term foci as follows:

- Carbon substitution operations: In the transport sector this could be achieved in a number of ways, for example, substituting a carbon-producing fuel with a carbon-free one (eg hydrogen from renewable sources) or eliminating a journey (that would have produced carbon). These, and similar examples, would contribute to decarbonising the transport sector and so were covered by the research.
- Implementing the efficiency revolution: Increasing the efficiency of transport in relation to its carbon emissions can be achieved in a number of ways, for example by emitting less carbon per journey (eg journeys are made by public rather than private transport) or by ensuring that unnecessary carbon is not emitted, eg by improving traffic flow. Improving the efficiency of the transport sector in this way would contribute to its decarbonisation and was therefore covered by the research, where relevant.

Potential for further work

Further work is needed to explore the critical issues identified in the course of the research, as summarised above.

CONTENTS

Critical Issues in Decarbonising Transport

1 Introduction

This research was funded by the Tyndall Centre for Climate Change Research. The Tyndall Centre is a national centre for trans-disciplinary research on climate change and funds a range of research looking at various aspects of climate change. This project, which was undertaken by the Institute for European Environmental Policy (IEEP), together with the Institute for Transport Studies at the University of Leeds, is a strategic assessment of the critical issues in decarbonising transport in the UK. The need to decarbonise the transport sector is particularly important in terms of combating climate change, as to date reducing greenhouse gas emissions from this sector has proved relatively more difficult compared with other sectors (PIU, 2002).

Hence, when we talk about decarbonising transport, we refer principally to the need to reduce its carbon dioxide (CO_2) emissions. It should be noted that the focus of the research was critical issues relating to socio-economic and transport trends and emerging technologies. Consequently, we have not attempted to assess policy options either that might contribute to decarbonising transport (but which do not necessarily involve technology, eg modal shift and taxation, road pricing) or that might encourage the introduction of a particular technology.

This report describes the process by which this strategic review was completed and highlights the critical issues identified by the work. The first stage of this research was to consider which areas of the transport industry have in the past and are currently contributing heavily to carbon dioxide emissions in the UK. A literature review was completed that considered all modes of travel and reviewed the factors that are influencing their use. This identified certain critical trends that have the potential to increase carbon dioxide emissions in the future and identified the drivers for these trends. Chapter 2 provides a summary of this literature review and the critical issues identified within it.

From this literature review the investigators narrowed down the critical issues that had been identified and concentrated on passenger road transport. This enabled a more concise remit to be assigned to the next stage of the research, which was to identify the emerging transport technologies and assess whether they could potentially help in the process of decarbonising transport in the future. A summary of this review is provided in Chapter 3. From this review Intelligent Transport Systems (ITS) and Information Communication Technologies (ICT) were identified, as critical technologies where their potential impact on carbon dioxide emissions required further clarification. The method used to obtain a more concise picture of the potential future impact of these technologies on decarbonising transport involved consultation with experts through the use of a questionnaire (provided in Appendix 1). The critical issues identified by the experts with respect to ITS and ICT are discussed in Chapter 4. Finally this report concludes in Chapter 5 by considering the issues raised by this research and identifies a number of critical areas that have been identified that will require further research.

2 Review of trends in passenger and freight transport

This chapter examines passenger and freight transport trends for the UK both past and those predicted for the future. It is a summary of the review reported in Kelly and Bristow (forthcoming). Section 2.1 considers the passenger transport trends, while Section 2.2 examines freight trends. Section 2.3 identifies key some critical issues in decarbonising transport and the scope of the more detailed research.

2.1 Passenger travel trends

This review considered the main modes of passenger transport and looked at the changes that have occurred with respect to distances travelled, time spent travelling, the number of trips made and why people are making them. Overall, the different modes of transport have seen varying trends. People are now travelling further by car and air, but less by bus, on foot and by cycle. The key trends in transport demand to date (DfT, 2002a) are:

- Rapid growth in distance travelled alongside growth in car use in the 1970s and 1980s. This growth has slowed over the past ten years.
- A continued growth in distance travelled for the purposes of education, escort, shopping and business trips.
- A rapid growth in air travel over the last 25 years and the early impact of 'low cost' airlines.
- A fall in trips made by the non-motorised modes of travel (walking and cycling).
- A rapid recent growth in rail use.
- An increase in bus use in London offset by decline elsewhere.

Further, these trends are expected to continue. Short-run forecasts indicating the potential impact of the Government's 10-year plan are shown in Table 1.

Table 1: Short-term forecasts in the 10-year plan (2010)

		Index: 2000 = 100	
	Current (2000) billion vehicle kms	Without Ten Year Plan	With Ten Year Plan
Cars and taxis	378.7	121	117
Goods vehicles	29.3	118	109
Light goods vehicles	50.5	125	123
Buses and coaches	4.8	109	118
All motor traffic (except two wheelers)	463.3	122	117

Source: DfT (2002a) and DTLR (2000)

Longer-term forecasts suggest:

- 79% of UK households will own a car by 2031.
- Central growth forecasts suggest that total car kilometres will increase by 53% over the period 1996 to 2031.

- Air travel is expected to double by 2020.
- Low cost airline growth is expected to more than double based on 1998 figures by 2020.
- Bus and coach use will increase but slowly.
- Rail is still exhibiting growth but this is restricted by capacity constraints.

In examining why people travel the review covered both exogenous and endogenous influences on the demand for travel. However, in this context, it is sometimes difficult to clearly define what is external and what internal, especially with respect to aspects such as car ownership and license holding. Here we move from the clearly exogenous through to the clearly endogenous.

Population and age structure. National predictions (ONS, 2002) suggest that the total population will increase by 9% from 2000 to 2025. The main increase is expected to come from the older age groups and while in the past older people have been dependent on public transport this is changing and elderly people may be expected to maintain their car use.

Number of households. The number of households in the UK has been steadily increasing. One of the reasons for this has been the increase in single person households. In 1961 the average household size was 3.01, this is expected to decrease to 2.15 by 2021 (ODPM, 2002). There are many reasons for this, but the result is that this trend may result in more journeys, in particular to contact families that would have lived together and also for household maintenance trips.

Labour participation. One of the major changes to labour participation has been the increase in the number of women workers. Increasing participation rates would be expected to generate an increase in commuting trips.

The economy. Past trends have seen both passenger and vehicle kilometres rise inline with GDP. This trend appeared to weaken at the start of the 1990s, where the rate of growth in GDP exceeded that of traffic.

Incomes. A major determinant of travel is income. Evidence shows that as incomes rise more is spent on motoring, air and rail travel (DfT, 2002b).

Leisure time. People in the UK work longer hours and take fewer holidays than people in other European countries. If this should change, there is the potential for increased leisure travel. With a larger proportion of people at retirement age owning cars they will have more opportunities to use them.

Land use. The literature indicates that car use is influenced by population density and car ownership rates. International studies indicate that increased urban density significantly reduces per capita vehicle travel (Kenworthy and Laube, 1999).

Telecommunications. An increase in Information Communication Technologies offers opportunities to change travel behaviour, particularly for travel to work and for shopping. By 2005 it is envisaged that 5.7% of all grocery sales will be made online (DfT, 2002b) and NERA have estimated that video conferencing could reduce business travel by between 5% and 20% by 2007 and by between 10% and 40% by 2017 (DfT, 2002b). These technologies provide the potential to reduce trips made.

Household car ownership. One of the determinants of how people travel is whether or not they own a car. The number of households without cars in 1952 in the UK was 84%. In 2001 this figure was 26% and is expected to reduce further to only 20.9% in 2031 (DfT, 2002b). Evidence suggests that people who own cars tend to use the bus less and walk less (DoT, 1991). However, there will always be households without car access.

License holding. There have been two major trends regarding license holding. The first is the increase in women with driving licenses. 60% of women held a driving license in 2001 compared to 29% in 1975 (DfT, 2002b). The second is the increase in older people with driving licenses. 44% of people over 70 have a driving license in 2001 compared to 15% in 1975 (DfT, 2002b). These trends are likely to add to the increased use of the car in the future.

Costs of travel. One of the major factors that influence the demand for travel and the use of individual modes are the relative costs. One of the reasons why people have started to favour travelling by car is that as disposable incomes have risen the real costs of motoring have declined (DfT, 2002b) and at the same time rail fares and bus and coach fares have increased.

Speed of travel. An influence on the use of different modes of transport is the speed and convenience with which the mode can be used. While people are on average travelling further, the average travel time per trip has not significantly increased (DfT, 2002b). This is due to people switching to the faster modes of transport such as air and the car. While the speed of travel keeps increasing people are likely to travel further and continue using the faster modes of travel.

Changes in supply. A major influence on the passenger transport industry arises from structure and regulation. Recent changes in the passenger transport industry have included the abolition of fuel duty escalator in 2000, the deregulation of the bus industry in 1986 and the privatisation of the rail industry in 1996. No further major changes in organisational structure are anticipated.

The key influences that are likely to be important in the future with respect to CO_2 emissions are presented in Table 2.

Table 2: Current trends and their expected impact on CO_2 emissions

Trend	Transport impact	CO_2 impact
Increase in population	Increased demand for travel	↑
Increase in elderly	Increase demand for car in the older age groups due to an increase in the license holding	↑
Increase in female licence	Increase demand for the car	↑
Increased GDP	Increased demand for car, rail and air travel	↑
Increased labour market participation	Increased demand for commute trips	↑
Land use increased dispersion	Increase trip length	↑
Increased leisure and disposable income	Increased demand for leisure travel	↑
Increased telecommunications	Decrease need for commute, business and shopping trips possibly offset by demand for other trips.	↓
Current cost trends	Reinforce increased demand for the car, decrease in air and decreased demand for bus and rail.	↑
Increased speeds	Increased trip lengths	↑
Supply as is	Increased demand for car and air.	↑
Congestion	Decreased demand for car	↓
	Cars operate inefficiently	↑

2.2 Freight trends

The review on freight transport in the UK considered the main statistics used to describe the freight industry, which are Goods lifted, average total distances travelled and goods moved. These three statistics were used to examine the freight modes of road, rail, water and air. The key findings from the review of trends were:

- Road freight is and will continue to be the dominant mode in freight transport.
- The trend is for larger road freight vehicles, which can transport larger quantities of goods. This may be more efficient if the vehicles are fully loaded.
- Changes in transportation by pipe and water have been dominated by the discovery of North Sea Oil.
- Airfreight stabilised in the late 1990s both in terms of goods lifted and goods moved.
- Rail freight started to increase both in goods lifted and goods moved at the end of the 1990s.

Central growth forecasts suggest that there will be 36% more rigid HGV kilometres travelled and 131% more articulated HGV kilometres travelled in 2031 compared to 1996 (DETR, 1998). As with the passenger transport review the endogenous and exogenous influences on demand were considered for freight.

Population growth. Population growth is likely to have an effect on freight transportation through increased demand for goods in the future.

Individual incomes. As individual incomes have increased, so demand for goods have increased and this has caused an increase in freight both transported and quantity. As incomes have increased, people have started to demand goods with a high value composition, but low weight and perishable goods. These goods favour road transport, which can deliver 'just in time'.

Economic growth. The general trend has been for freight demand to grow at the same rate as economic growth. SPRITE (1999) suggests that economic growth will affect freight demand through diversification and increased international trade, rather than increases in tonnes lifted.

Home shopping. While an increase in home shopping has the potential to reduce passenger transport trips, if it is not organised efficiently it could increase the amount of kilometres that freight vans and lorries make to deliver to peoples' homes.

Changes in commodity structure. The characteristics of the transport requirements of 'emerging commodities' have tended to favour road over other modes of freight transport. This has increased the demand for road transport.

Changes in the operational behaviour of companies. Modern production techniques have led firms to seek to reduce their stock levels, shorten turn around times and generally improve their flexibility to react quickly to the needs of the market. One example is Just-in-Time production where quick, reliable and highly flexible transport service is needed and presently, only road freight can provide it. A trend has been to increase the centralisation of stock. This has lead to cost savings, as fewer depots are required.

Increased speeds. The cost effectiveness of freight travel has increased more rapidly than that of other surface modes. Mckinnon and Woodburn (1993) argue that the increase in the distance travelled by road freight was increased by the development of the motorway network in the 1970s. This allowed freight to be transported by road at a lower cost and also for an increase in the distance travelled by road.

Applications of advanced information and communication technologies. SPRITE (1999) reported that the application of ICT has improved the efficiency and reliability of freight transport. Since ICT has, to date, predominantly been introduced in the roads sector, road freight has gained a further competitive advantage against other modes.

Travel costs. The literature suggests that road transport tonnage demand is inelastic with respect to price, whilst it is elastic when computed in tonne kilometres, which suggests that changes in the cost of road freight would have a greater impact on distances than on the amount of freight lifted.

Changes in supply. A wide range of public and private organisations governs freight modes. At present, no significant changes are anticipated.

The sector is dominated by road freight, which has found favour in the past for its ability to provide for 'just in time' production, lower travel costs and increased speed on the motorway network. The potential impact of the range of factors on carbon dioxide emissions is provided in Table 3.

Table 3: Current trends and their expected impact on freight and CO_2 emissions

Trend	Impact on Freight	CO_2 Impact
Population growth	Increased trips	↑
Individual incomes	Increased trips	↑
Economic growth	Increased trips	↑
Home shopping	Increased trips for delivery vehicles	↑
Changes in commodity structure favouring road travel	Increased distance and trips on road freight	↑
Increase speeds	Increased trip length	↑
	More efficient use	↓
Changes in the operational behaviour of companies	Increased demand for road freight	↑
Reduction in road travel costs	Increased road freight travel	↑
Further application of ICT to road freight	Increased transportation by road freight	↑
	More efficient use	↓

2.3 Issues for Decarbonising Transport

Current trends, both exogenous and endogenous to the transport system, are overwhelmingly towards further increases in personal motorised travel and road freight transport. Thus without changes to trends and/or technology CO_2 emissions are likely to increase over time.

However, it is important to distinguish at this point the issues that are important for this research, as its aim is to undertake a strategic assessment of the critical issues in decarbonising transport. Of the trends discussed in the chapter, clearly the most fundamental in terms of CO_2 emissions are the increasing use of the modes that are currently more carbon-intensive (ie that produce more CO_2 per unit distance travelled per passenger or unit of freight), principally road and air. The decline in the use of the less CO_2-intensive modes, eg public transport, walking and cycling for travel is clearly a concern, as modal shift towards these modes would be beneficial to decarbonising transport.

As against this, however, the whole field of transport trends as outlined in Sections 2.1 and 2.2 is vast, and it would have been impractical for us to attempt to undertake research across the whole subject. We have therefore attempted to focus the field of research onto certain critical areas by excluding others as argued in the paragraphs that follow. Where issues have been excluded from our further research, we note these as important areas for future research, but have concluded that we cannot usefully add much further value within this study.

Air Travel

It is clear from the discussions above that air travel is a growing and carbon-intensive transport mode. The Royal Commission on Environmental Pollution (2002) has recently well documented the possible technologies and wider options for reducing aviation's CO_2 emissions. It concluded that, while there are opportunities to improve the environmental performance of individual aircraft, these were limited in scope, and their impact would be negated by the projected growth in aviation. Consequently, it recommended a number of policy measures that would affect both the supply and demand side of aviation.

To date, there has been a lack of political will to address aviation's contribution to climate change, partly as a result of its international nature and partly as a result of its perceived economic benefits, although neither of these issues are as a significant an obstacle as is often portrayed (eg CE, 2002). In the UK, the government is currently consulting on the future of aviation, including possible action to reduce its environmental impact (eg DfT, 2002d; HMT and DfT, 2003).

It can be seen from the above that this is an ongoing policy debate, which is largely independent of future technological developments, reflecting the fact that the latter are a second order issue. As a result, there was felt to be little added value in investigating aviation further in the course of this research, and that we should focus instead on surface transport modes.

Road Transport

Of the surface transport modes, the trend analysis above clearly demonstrates that private road transport for both passenger travel and freight haulage is the fastest-growing and most carbon-intensive of the main modes. It therefore seemed reasonable to focus our further research in this area.

Furthermore, private road transport systems are particularly complex, as there are a large number of actors each of whom makes their decisions more or less independently. There are potential developments in vehicle refuelling technology that have the potential to reduce road transport's CO_2 emissions, but it is not yet clear which technologies will eventually reach the market (eg Fergusson, 2001). In the meantime, there are a number of other relevant technologies, such as intelligent transport systems and information and communication technologies that are put forward as having a potentially beneficial impact on road transport's CO_2 emissions (eg Proper, 1999; RAC, 2002).

However, our previous experience suggested that there is a lack of an overview, or even a concerted framework for analysis, of these various possibilities. As a result, it was decided that potential technologies for reducing emissions from private road transport should be the focus of the next stage of the research – the literature review of technologies. This is summarised in Chapter 3.

Passenger or Freight?

We initially anticipated that we would analyse both passenger and freight transport, not least to identify any areas of overlap in drivers, relevant technological developments, etc. Reflecting this approach, Sections 2.1 and 2.2 treat each of these areas in turn.

However, this analysis itself suggests that the drivers of trends in the two areas are in fact quite distinct in many respects, and those for freight are rather less well studied and largely outside the study team's areas of expertise. To do justice to both freight and the passenger sector, would, therefore, not have been possible within the resource constraints of the project. We therefore concluded that road freight does indeed present some critical issues for future consideration, but that our efforts would be best focused on road passenger transport and the range of technological issue areas that we have identified.

3 A Literature Review of Emerging Transport Technologies for Private Road Transport

The aim of the literature review relating to technologies was to give an overview of the major technologies that are emerging that might have a potential contribution to decarbonising the transport sector. As explained in Section 2.3, it was decided that this review should focus on the technologies that are being, or could potentially be applied, to private road transport. These technologies include those that affect the vehicle and its use of infrastructure, as well as those technologies that are not solely related to transport but do have a potential impact on travel behaviour, eg communication and information technologies. This section gives an overview of the technologies reviewed and is a summary of the full literature review (Kröger *et al*, 2003). We categorised the technologies that should be the focus of this review as:

- New vehicle engine and fuelling technologies;
- New in-vehicle and other related technologies, including the development of Intelligent Transport Systems (ITS); and
- Information and communication technologies (ICTs), including teleworking and teleshopping.

A summary of the results of the literature review with respect to these three types of technology is given in the following three sections (ie Sections 3.1 to 3.3), followed by our conclusions on 'critical issues' (Section 3.4).

3.1 New Vehicle Engine and Fuelling Technologies

Scope and Definitions

The review of developments in fuelling technologies focused on four of the main possibilities (a summary of the attributes of which can be found in Table 4):

- In relation to engines:
    - Hybrid vehicles; and
    - Fuel cell vehicles, which have a dedicated electric motor;
- In relation to fuels:
    - Hydrogen for fuel cells from one of a wide range of possible sources; and
    - Biofuels, including esters and alcohols made from biomass sources.

Hybrid vehicles have the potential to deliver some of the benefits of both battery electric and conventional internal combustion engine (ICE) technology, while mitigating some of the more serious limitations of both. In a hybrid, a small ICE engine generates power on-board the vehicle much more efficiently than in a conventional ICE vehicle, not only because it is smaller, but also because it can be operated at near maximum efficiency during most of its operating time. Hence there will be relative savings in terms of CO_2 emissions resulting from efficiency gains of at least 20 or 30%, and possibly as much as 50%. However, the cost of hybrid vehicles remains high, but this can be expected to fall both as sales increase and as the technology matures (Fergusson, 2001; DTI, 2003).

Table 4: The attributes of alternative engine and fuel technology

Attribute	Engines		Fuels	
	Hybrid	Fuel cell electric	Biofuels	Hydrogen
Vehicle regulated pollution emissions	Probably reduces regulated pollutants	Virtually no tailpipe emissions, but may be significant upstream emissions depending on fuel source	Tailpipe emissions may be increased or reduced	Tailpipe emissions reduced or eliminated; fuel cycle emissions vary greatly according to production method
Vehicle CO_2 (and other greenhouse gas) emissions	Reduces CO_2	Virtually no tailpipe emissions, but may be significant upstream emissions depending on fuel source	Fuel cycle CO_2 probably reduced, but also may be some N_2O from agricultural soils	Tailpipe emissions eliminated; fuel cycle emissions vary greatly according to production method
Vehicle noise	Engine noise reduced	Engine noise virtually eliminated	Engine-dependent	Engine-dependent
Speed and drivability	Probably improved	Probably improved	Some types may adversely affect performance of conventional engines	Engine-dependent
Refuelling infrastructure	May use existing infrastructure	Probably requires major new infrastructure	Significant new infrastructure	Major new infrastructure
Cost of motoring	May reduce running costs	Uncertain	Probably increased costs	Probably increased costs
Ancillary features	Yes	Yes	Engine-dependent	Engine-dependent

Vehicles powered by fuel cells offer advantages in terms their minimal contribution to air quality problems in addition to being far more energy-efficient than ICEs in road vehicles. They therefore have the potential to reduce transport's CO_2 emissions. There are a number of configurations of fuel cell technology under development or investigation for road transport, but the most promising appears to be the proton exchange membrane (PEM) cell type. This is currently being investigated in relation to light commercial vehicles, but manufacturers seeking to produce working models for passenger cars are also looking at this option. There are strong possibilities for simple mass production of this particular technology, which in turn suggests that costs could fall rapidly once the technology began to be deployed on a significant scale (Nevin, 1999; Fergusson, 2001; DTLR *et al*, 2001).

Fuel cells for vehicles are powered by hydrogen, but there are important issues to be resolved with respect to how hydrogen is best generated and stored. There are three main routes whereby hydrogen can be delivered to the fuel cell, as follows:

- Hydrogen generated in a stationary plant and pumped into a tank in the vehicle in either compressed or liquefied form;
- Methanol fuel, reformed to hydrogen on board the vehicle; and
- Petrol (with very low sulphur content) reformed on board the vehicle.

It is not clear which of these will be the most commercially advantageous option and the fuel and automotive industries currently have different preferences. The impact on CO_2 emissions crucially depends on which eventually emerges as the preferred option. Further, if the first of the three options above is implemented, hydrogen can be derived from a number of sources, the costs and environmental impacts of which differ significantly (Fergusson, 2001; Padro and Putsche, 1999; Foley, 2001; Pembina Institute, 2000).

Biofuels are one of the few options for producing liquid (or indeed gaseous) fuel for conventional motor vehicles from non-fossil sources. In principle, they can offer diversification away from oil-dependence and a substantial reduction in CO_2 emissions, and other environmental benefits. However, the benefits in terms of CO_2 emissions can vary significantly depending on the source of the fuel, its means of production and the use of any by-products. For the UK, the most immediately promising primary crop source of domestically-produced biofuel is biodiesel or rape methyl ester (RME), which is already widely produced commercially and can be used as a direct substitute for mineral diesel fuel. However, given the likely limitations on supply, blending up to 5% of RME into conventional diesel is a preferable approach. In the short term, production of bioethanol from wheat or sugar beet suffers from many of the same limitations as biodiesel. In the longer term, however, new technologies may make it possible to produce ethanol commercially from ligno-cellulosic crops, or vegetable waste materials, in more energy-efficient way (Fergusson, 2001; Mortimer *et al*, 2003; Eyre *et al*, 2002).

Discussion

From the discussion above, it can be seen that there are a number of new vehicle fuelling technologies that could have an effect on the overall emissions of CO_2 from the transport sector. However, the most significant impact of these technologies is determined by the application of the technologies themselves, and is largely independent of how they are used. For the purposes of the current research, however, it is important to identify whether any of these might also contribute to decarbonising transport by affecting behaviour.

As mentioned in Chapter 2, improvements to the relative performance of a mode of transport, eg speed and quality, could potentially contribute to its increased use. Consequently, future technical improvements to alternatively-fuelled cars might affect travel behaviour by encouraging additional trips. As a result, this could reinforce existing trends of increasing car use and the decline of other modes, as well as in turn, contributing to the increasing trends in the number of cars in the car fleet and the number of drivers. However, if any impacts such as these were to occur, they would only be at the margin particularly when compared to the likely CO_2 reductions per kilometre that might result from the wider use of some of these technologies. Hence, any additional CO_2 resulting from the increased use of these vehicles is unlikely to negate the reduction in CO_2 emissions resulting from the application of the technology. It appears fair to say, that a new vehicle fuelling technology has the potential to significantly reduce CO_2 emissions, but through technological innovation rather than changing behaviour.

3.2 New In-Vehicle Technologies and Intelligent Transport Systems

Scope and Definitions

With respect to new vehicle technologies, the literature review addressed the development and implementation of new body and in-car technologies and Intelligent Transportation Systems (ITS).

While the exterior of the future 'mainstream' passenger vehicle will look quite similar to the one we know today, there are already trends towards less conventional cars, eg two-seat cars such as the Smart Car and multi-purpose vehicles (MPVs) such as Mercedes V-Class or Renault Espace. It is these market segments that are on the increase. However, whether such development leads or is a response to consumer opinion is far from clear (RAC, 2002; Smart, 2003; DTLR, 2001; Kröger *at el*, 2003). Body technologies that might have positive environmental benefits include 'smart' active suspension systems and light-weight vehicles (Maeder, 2000).

In the future, the interior of vehicles will be more technologically advanced and there is a 'strong design trend towards making the car a "mobile living room"' to make cars increasingly more comfortable (RAC, 2002, p.61). Mobile air conditioning will become a standard feature in future vehicles, even in northern Europe, however, they result in direct emissions of the fluorinated gas, HFCs-134a (used in most systems after 1994) and indirect emissions of carbon dioxide, both greenhouse gases (European Commission, 2003; Schwarz, 2002).

Another crucial technology that can be as much related to infrastructure as to the vehicle are Intelligent Transportation Systems [ITS]. These are 'a broad range of diverse technologies applied to transportation to make systems safer, more efficient, more reliable, and more environmentally friendly, without necessarily having to physically alter existing infrastructure' (Transport Canada, 2002). ITS make use of a variety of advanced technologies, including computers, communications, sensors, collision warning systems and vehicle-sensing technologies, in order to secure, manage and control transportation systems. ITS services can be divided into two categories: 'intelligent infrastructure' (including electronic toll collection and ticketing, smart card technology, route guidance and incident management systems) and 'intelligent vehicles' (including collision avoidance and speed limitation technologies) (Proper, 1999).

Discussion

There is no doubt that in-vehicle and related technologies have the potential to change the way in which vehicles are used and the attractiveness or flexibility of doing so. Much of the literature identified in the review (see Kröger *et al*, 2003) relates specifically to cars. This focus may be due to the fact that private industries and interests drive technological developments in this field, particularly in the car manufacturing area. In principle, however, there is no reason why many of the technologies outlined here could not equally be applied to public transport – and indeed some already are. The way in which these technologies develop, and whether they are preferentially applied to cars or to public transport, has the potential to have a significant influence on travel behaviour, and on the balance between the different modes.

Furthermore, it is also worth noting that the literature emphasises the potentially positive effects, including on the environment, of ITS applications in the transport sector, the most important ones being enhanced security and improved flow of the road network. For example, some authors argue that ITS offer environmental benefits resulting from a decrease in mileage and fuel consumption and thus fewer emissions of greenhouse gases and conventional pollutants (eg ISEB, 2000; ERTICO, 2003; Proper, 1999; Graham and Marvin, 1999). However, this emphasis on benefits is sometimes uncritical or simplistic, perhaps reflecting the vested interests of the advocates of the new vehicle technologies. This is reflected in the number of reports from interest groups, but a shortage of objective, academic analysis.

An alternative argument could be the application of the logic of the induced traffic debate, as characterised by SACTRA (1994), to the use of ITS to improve the efficiency of the road network. As a result of the work of SACTRA, it is now widely accepted that the provision of more road space has actually induced traffic with the result that the new road space soon fills up. Extending the conclusion, it could be argued that improving traffic flows and the efficiency of the network through the application of ITS effectively only increases the capacity of the road network and thus could induce traffic and subsequently CO_2 emissions. This contrasts to many of the authors quoted above, who predict a reduction in traffic levels as a result of wider application of ITS. However, as Hojer (1996) underlines, the impact of ITS depends on how it is implemented. If, for example, ITS is combined with some form of road pricing to both improve flow and manage demand, then there could still be positive environmental benefits. However, to date, the actual impact of road pricing in terms of its impact on CO_2 emissions has not been widely assessed, as a result of the relative lack of long-running, significant schemes.

In relation to in-car technological developments, those that make a car more comfortable could encourage car use, but there are no indications from the literature whether this effect might be significant. There is also the possibility that more varied vehicle designs might stimulate the market for second or third cars, as these offer a significantly different product in terms of where it might be used, eg in urban areas for two-seat cars such as Smart. Again, it is far from clear whether this is a real phenomenon that might be significant.

However, a range of 'smart' technologies is now enabling changes to patterns of vehicle ownership and use – such as facilitating secure access to shared cars in car clubs or car share schemes (eg Walder, 2000), and improving booking services for community taxis and flexible bus services (Wigglybus, 2003). With the same logic as above, innovations that improve the attraction of alternative modes, ie public transport or car sharing, can make these more appealing. The literature suggests that car sharing, in particular, can contribute to reducing car use and increasing the use of public transport (eg Meijkamp, 2000). Clearly this is a complex area, and countervailing arguments can also be raised. However, the impact overall is likely to be determined by broader aspects of the transport and social systems, such as levels of car ownership; the quality, service level and degree of integration of public transport systems; etc than by the enabling technologies themselves.

Equally, the literature makes reference to the possibilities of using related technologies to enhance the application of infrastructure charging regimes. However, the majority of the technical discussion on such charging schemes focuses on the design of the charges themselves, rightly reflecting the fact that it is the application of the charge, rather than the technology used to apply it, which has the major impact on travellers' behaviour.

3.3 Information and Communication Technologies (ICTs)

Scope and Definitions

Information and communications technologies (ICTs) can broadly be defined as 'a wide range of services, applications, and technologies, using various types of equipment and software' (Commission of the European Communities, 2001, p. 3). ICT services include telephony, fax, e-mail, transfer of files and the internet. The rapid development and spread of ICTs is often referred to as a new industrial revolution. Vast flows of data, voice, video, and images are being sent across conventional telephone networks, wireless and radio systems, satellite networks, internet and video networks. Access to, and ownership of, personal computers and the internet in the UK has increased significantly over the last decades and the prices for these technologies are falling considerably (European Telework Online, 2003).

Our literature revealed that two areas of ICT applications were agreed to be potentially most important in the medium term: telecommuting and teleshopping.

Discussion

The assessment of the impacts of ICTs has received some academic attention, mainly in the US (eg Mokhtarian, 1996 and 2000; Niles, 1994, 2001a, b and 2002) and the UK (eg Graham and Marvin, 1999) but also in Germany (eg Kordey and Gareis, 2000). Nevertheless, it becomes clear that the literature focuses on one main debate: substitution versus complementarity, ie whether applications of ICTs have a substitution or complementary effect on the patterns of vehicle use.

On the one side, NERA (2000) and RAC (2002) suggest that telecommunication developments have great potential to reduce the need for physical travel by substituting for it. NERA (2000) mentions a reduction of increases in traffic congestion by approximately 45%. In this case, the reduction of the number of vehicle trips would be environmentally beneficial, as pollution levels, noise and congestion would all be reduced. On the other side, Graham and Marvin (1999), Handy and Yantis (1997), Niles (1994), Topp (2002) and Zumkeller (2000) suggest that ICTs will have a complementary, rather than a substitution effect on travel, resulting in the increase of physical travel. As Graham and Marvin (1999) state, 'Overall, transport and telecommunications actually feed off and fuel, more than simply substitute, each other' (p. 6). Topp (2002) and Zumkeller (2000) compare the impact of ICTs on physical travel with the impact of the telephone, which resulted in an overall increase in physical travel. Zumkeller (2000) claims a connection of the complementary effect of new telecommunications to the fact that transport and media developments have historically been correlated. Mokhtarian (1996) comments that telecommunications technology is inherently neutral on travel behaviour; its impacts depend on how we use it.

Overall, the reviewed literature does not offer a clear-cut picture of the impacts of ICT on patterns of vehicle use. Further research in this field is clearly needed.

3.4 Conclusions on Impact of Technologies on Decarbonising Travel Behaviour

As the research is seeking to identify the potential contribution of these technologies in decarbonising the transport sector, it is important to consider the above discussion in the context of each technology's direct impact on CO_2 emissions, and its indirect impact through changes in behaviour.

For some technologies, such as some new vehicle fuelling technologies, it can be concluded that the principal impact in the context of decarbonising transport will be to reduce emissions per unit distance travelled, rather than through changing travel behaviour. In the longer term, however, there is some possibility that radical changes in technology could significantly reduce the real cost of travel, and if this were to occur, then increases in distance travelled might result. However, these effects are still likely to be only marginal when compared to the total reductions delivered. Accordingly, we have concluded that this area of technology is not strongly relevant to the context of this analysis, although it is potentially very important in terms of overall road transport CO_2.

The same cannot necessarily be said for ITS applications. The extent of any impact of ITS on transport's CO_2 emissions will clearly depend on how it is applied. For example, the application of route guidance systems could lead to a relative decrease in CO_2 emissions for any particular journey, as such systems can determine the most direct route to a certain location, thus avoiding driving unnecessary kilometres. However, the discussion of Section 3.2 revealed a lack of clear understanding of the potential impacts of some new vehicle technologies and intelligent transport, eg route-guidance systems. Others, such as those that would make driving more comfortable, eg air conditioning, might also have adverse impacts at the margins. Owing to the complexity of the issues at stake, this was concluded to be an important area for further investigation.

Some smart technologies, eg smart cards, could be beneficial for public transport or car sharing arrangements, and might therefore encourage their use. However, as was argued in Section 2.3, in terms of decarbonising the transport sector, public transport and car sharing are not a major focus. Also, the key determinants of any change in behaviour towards these options was seen to be mainly a response to the underlying structure of the transport provision, with 'smart' technology playing only a marginal enabling role. For this reason, it was considered that these applications fall largely outside our remit for further consideration.

Finally, road pricing technologies were highlighted as potentially playing an important role in improving the environmental performance of transport. Again, however, it was judged that it was the application of pricing itself that would be the key determinant of any changing behaviour; the role of new technology in applying the pricing policy would be at most a second order issue. This therefore was not seen as a ‘critical issue’ area for our analysis.

As discussed in Section 3.3, ICTs enable different travel patterns for potentially a broad range of activities with teleworking and teleshopping having possibly the greatest potential. The fact that both of these have the potential to replace actual journeys with a telecommunication clearly suggests that ICT has the potential to impact on transport’s CO_2 emissions. However, there appeared to be no consensus on the likely scale or even direction of such impacts, so this was agreed to be a critical area requiring further consideration.

4 Expert Views on the Critical Issues

Having identified the key areas where our literature sources showed serious uncertainties and/or complexities, selected experts were sent a questionnaire asking for their opinions on the potential impacts of Intelligent Transport Systems (ITS) and Information Communication Technologies (ICT). The aim of this consultation was to highlight the range of views on the potential impacts of these technologies, and to consider the extent to which these reinforced, qualified or questioned the results of our literature search. Thus, the questionnaire was designed primarily to test our key findings in each area. In addition, we sought responses to help identify potential enablers, drivers and barriers to helping technology in these areas to contribute to decarbonising transport in the future.

Thirteen responses were received, and although this is not enough to constitute a statistically significant sample, the respondents were all experts in relevant fields and therefore their views do have a bearing on the research. We have included graphical representations where appropriate to illustrate the range of views as to the different responses in relation to both the direction and magnitude of anticipated effects of applying each measure.

4.1 Intelligent Transport Systems

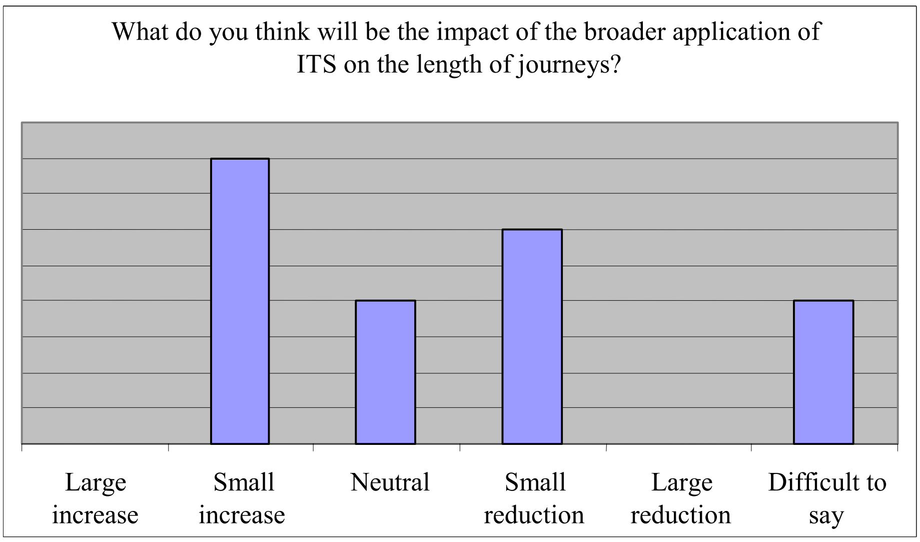
As was discussed in Section 3.2, some authors argue that ITS offer environmental benefits resulting from a decrease in mileage and fuel consumption and thus fewer emissions of greenhouse gases and conventional pollutants (eg ISEB, 2000; ERTICO, 2003; Proper, 1999). These however are largely *ceteris paribus* findings; our review identified a range of issues that suggest that the full benefits may not be realised. Thus the experts were asked for their views on the potential impact of ITS.

The Experts' Responses

Impact of ITS on journey lengths and frequencies

As Figure 1, below, illustrates, there was a largely bimodal distribution of views on journey lengths, with most arguing for either a small increase or a small decrease in mileage travelled as a result of broader applications of ITS.

Figure 1: Impact of ITS on journey lengths

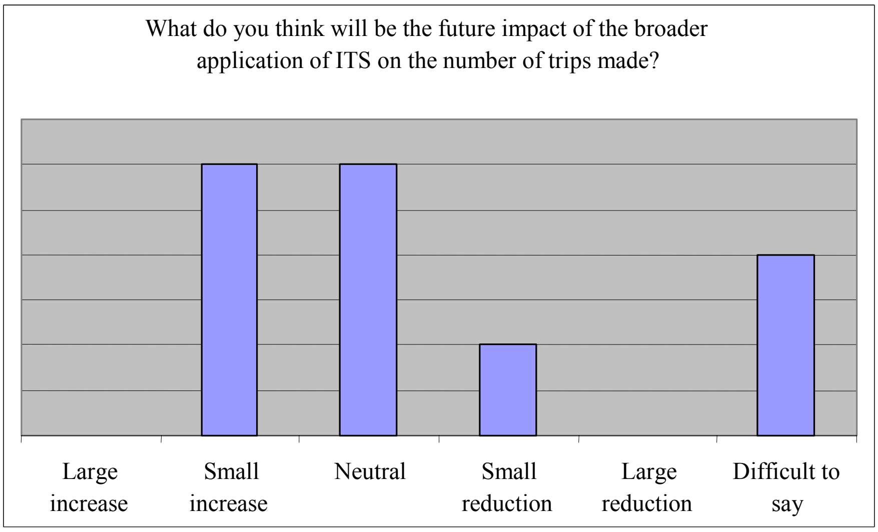


Mileage reductions were argued to arise primarily from improved navigation in private cars. As against this several reasons for possible increases were cited, including:

- ITS will reduce queuing time in congested traffic, but could increase journey length in avoiding bottlenecks;
- Better integration of public transport modes might encourage more multi-leg public transport journeys, which are often longer than equivalent car journeys; and
- Improving the ease, cost, reliability and quality of car journeys might encourage extra mileage.

The views in relation to the potential impact of ITS on the number of trips were similar (see Figure 2), although on balance it could be set that the view was slightly more in favour of a positive impact on the number of journeys made. The reasoning for this was similar to the reasons cited above for a possible increase in the length of journeys.

Figure 2: Impact of ITS on the number of trips



Broader impact of ITS on the transport system

Whatever their misgivings about the potential impact on the number and length of trips, a majority of experts felt that ITS could bring about an improvement in the quality of operation of the transport system. Also, it was pointed out that the development of information systems to date has done little more than scratch the surface of the potential, for example in relation to driver assistance and collision avoidance.

Barriers to, and drivers and enablers of, the wider uptake of ITS

There are still perceived to be substantial barriers in terms of technological feasibility, cost, and penetration in many areas of ITS, much more so than with teleshopping and teleworking (see below). Currently there still appear to be substantial questions about whether the benefits justify the costs. In relation to improvements in informatics, the issue of privacy and civil liberties were also raised as being a barrier to wider uptake.

A major driver behind the introduction of ITS applications was considered to be the increasing levels of congestion and the need to tackle these. This was coupled with the appreciation that it is both cheaper and more acceptable to squeeze more capacity from existing capacity than to build new infrastructure. It was also put forward that ITS is perceived as improving the saleability of new cars. More generally the large number of commercial actors seeking major new markets in this area, coupled with the perceived public need for more widely-accessible, reliable real-time information, was also considered to be an important driver. Presumably, this will impact on expectations in relation to both public and private transport.

Notwithstanding reservations noted above, improvements in ITS technologies are seen as the main enablers of more use of ITS.

Complementary policies

Particularly if combined with road pricing or other motoring tax increases, ITS was seen as a good approach to encourage modal shift. More integrated pricing structures and better information were also argued to assist with this. Greater availability of GPS systems and the appropriate satellite navigation were regarded as important supporting developments.

Overall impact

Taken together, experts doubted that ITS would have a substantial effect on traffic levels, or on decarbonising transport. The most important area in terms of its potential was seen to be the indirect impact of ITS in enabling more and better road charging.

Commentary on Experts' Views of ITS

Experts seemed generally convinced that ITS could contribute significantly to the provision and quality of transport services. In contrast, they were much more sceptical of some of the claims in the literature for substantial environmental benefits as well, and overall they felt that the impacts would not be dramatic. There were also reservations as to whether many of the technologies were yet market-ready.

The experts also showed an awareness of the potential for ITS to be applied to all transport modes and to intermodal or novel transport services, which corrected a bias in the literature primarily in favour of in-car ITS.

4.2 Teleworking

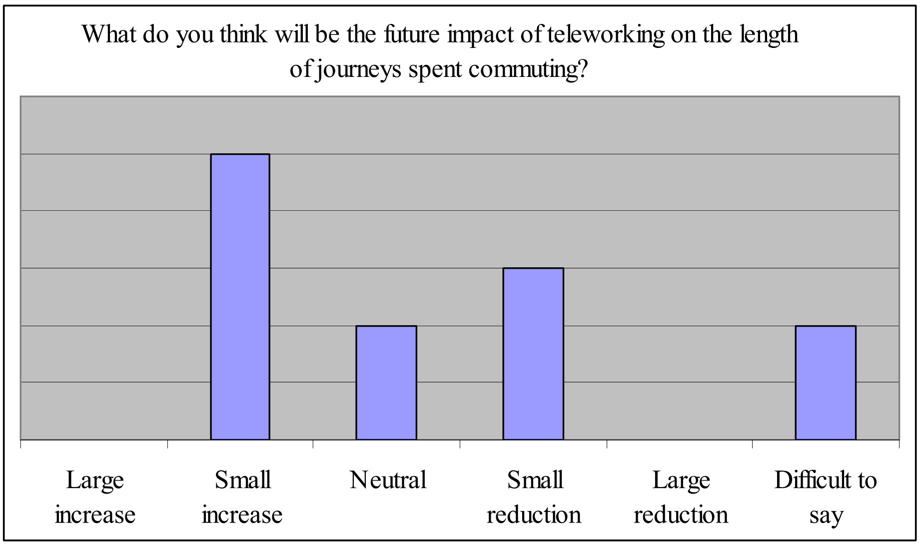
As mentioned in Section 3.3, the DfT (2002c) suggests that there might be an annual 9% increase in the number of teleworkers over the next 10-15 years, while the RAC (2002) estimates that by 2010 teleworking could lead to a reduction in commuter traffic of 15%. However, more complex substitution and second order effects, such as additional trips, have been suggested by other analyses, raising the question of whether teleworking has a large part to play in decarbonising transport in the future.

The Experts' Responses

Impact of teleworking on the length and number of commuting journeys

There was a mixed set of answers as to whether the length of commuting journeys would increase or decrease as a result of teleworking. Some people felt that an increase in the amount of teleworking could increase the length of commuting journeys, while others felt that the length of these journeys would decrease. Figure 3 shows the apparent lack of consensus, however, there was in fact more consensus than at first appears.

Figure 3: Impact of teleworking on the length of commuting trips



It was clear from the responses that elaborated the views, that those who concluded that teleworking would *reduce* trip lengths were referring to the total weekly trip length, not the length of single journeys. Typically, respondents felt that total commuting distance was likely to be reduced along with the number of trips, but that a reduction in work trips would be offset to one degree or other by other trips (eg to local shops).

Most respondents also placed some emphasis on the potential 'second round' or even 'third round' responses to the possibility of teleworking. One respondent insisted that teleworking would not encourage people to live further from their workplaces, but most others felt that it could. Two possible mechanisms highlighted the potential complexity of cause and effect here. First, that commuting less often might tempt people to live further from work to enable them to access cheaper housing and/or better quality of life. Conversely, it was felt that people might also consider jobs further a field when changing jobs, given the increased availability of ITS.

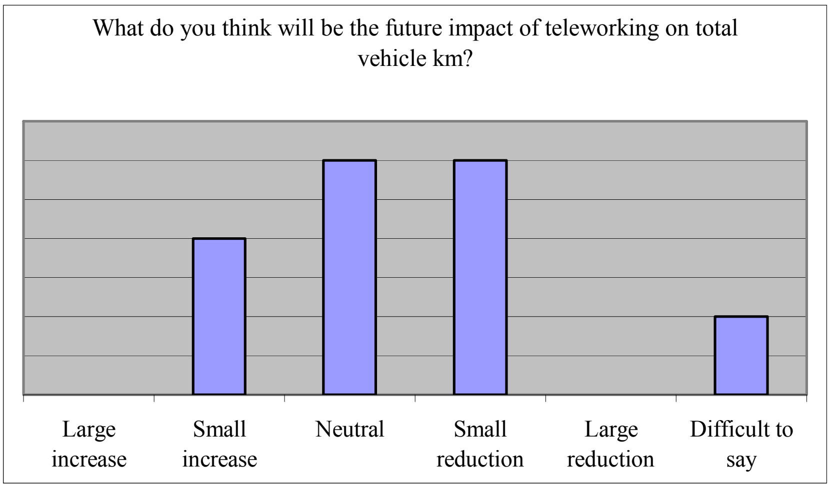
There was a strong consensus among the experts that teleworking in the future could enable a small reduction in the number of commuting trips undertaken. Most stressed the limitations to the extent of teleworking, anticipating that many people might commute less frequently, but that few would work exclusively from home. Again there was some emphasis on the additional number of alternative trips engendered when working at home (including other work-related trips), but it was anticipated that these would not outweigh the commuting trips avoided.

Impact on other trips and total distance travelled

As discussed, the main concern was that there might be a 'rebound effect' as some teleworkers make trips during the day, but that these would be relatively few, short, and typically off-peak. Also the possibility of another family member making use of the car if it remained at home was noted. Some studies were cited in support of these effects, and one respondent noted that the average number of trips made tends to vary rather little anyway.

There was no consensus on whether teleworking will be beneficial for the transport sector as a whole, ie whether it will lead to an increase or a decrease in total distance travelled for all types of journey (see Figure 4). This typifies the very mixed views of the many factors associated with teleworking; in essence, whether work trips saved would be more than compensated by additional non-commuting trips or longer commuting trips in the longer term, or not.

Figure 4: Impact of teleworking on the total amount of travel



Some thought that teleworking might have more complex interactions, for example, in reducing the cost-effectiveness of public transport season tickets, which might, in turn, mean that the car is used instead of public transport for those commuting journeys that are undertaken. Equally, however, it was suggested that some teleworkers might sell their second car and use the train for their less frequent journeys. Also other positive benefits might emerge, eg greater use of local facilities (including shops), revival of rural communities, etc.

Barriers to, and drivers and enablers of, the wider uptake of teleworking

It was suggested that one of the main barriers to the wider uptake of teleworking was that many jobs are not suited to it, so its natural scope was sometimes exaggerated. It was also noted that there was a need for face-to-face meetings, and for social interaction with colleagues. It was also felt there were sometimes significant practical limitations on having the necessary work facilities at home (eg insufficient space, young children) and that attitudes of employers were not always judged to be positive.

When asked what the principal drivers and enablers of teleworking were, there was virtual unanimity that the main enabler of increased teleworking was the availability of better and cheaper ICT equipment, and in particular broadband. Changing working methods and increased employer flexibility were also cited. The list of drivers suggested was lengthy and quite diverse, as follows:

- Worse traffic conditions/dislike of commuting/excessive travel to work time;
- Desire for a better work/life balance/flexible hours;
- House prices in urban areas driving people further out to achieve decent quality of life and/or accommodation;
- Pressure from employees for office desk space savings; and
- Greater productivity of teleworkers.

Complementary policies

There was a strong consensus that road pricing would be an important complementary policy to teleworking. It was suggested that employer or government subsidies to reduce the set-up costs could also help.

Commentary on Experts' Views of Teleworking

The expert views broadly complemented our literature review, in particular in emphasising a wide divergence of views as to the extent to which the first round benefits of fewer commuting trips would be offset by a range of second or third round impacts. Protagonists remain particularly optimistic about teleworking, but independent experts are much more sceptical. The second round effects cited would include other trips during the day, or an acceptance of longer commuting journeys on fewer days. Complexities and uncertainties of other impacts, eg on car ownership levels, overall trip patterns and modal split of household journeys, were also raised.

Implicitly or explicitly, the emphasis of the experts was on one or two days per week teleworking, not the total work-from-home model. A number of barriers were perceived, in particular for the latter; but there are also important enablers now in place (notably better and cheaper ICT equipment), and a range of positive drivers such as a desire or need to move out of the cities.

4.3 Teleshopping

Apparently boosted by improving ICT, teleshopping is clearly growing and has already extended significantly beyond the long-standing mail order sector. The DfT (2002c) predicts that by 2005 5.7% of all grocery sales will be made online. The RAC (2002) predicts that by 2010 15% of all grocery sales will be made online and that this could reduce car trips to the shops by 10%.

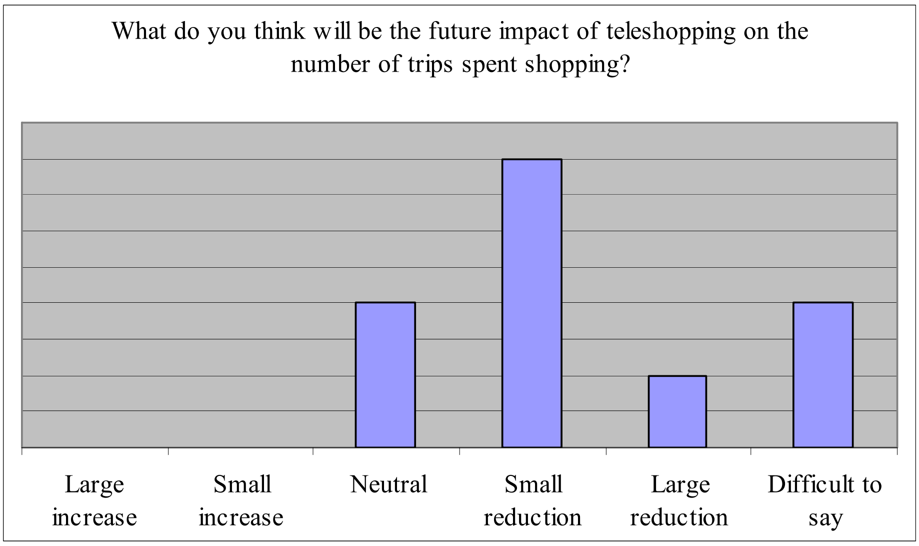
However, there appears to be a range of uncertainties with respect to the impact of teleshopping, even more so than with teleworking. First is the question of whether delivering goods by dedicated vans, eg groceries, really improves the situation in traffic or environmental terms. Also, there are legions of potential second round impacts – principally the question of what people do with the time that they save by shopping on line.

The Experts' Responses

Impact of teleshopping on length and number of shopping trips

No expert felt that teleshopping would actually *increase* journey lengths or the number of trips for shopping (see Figure 5 in relation to the number of trips, but the results in relation to journey lengths was identical), and the majority suggested these would be reduced. It seems to be accepted that teleshopping will increase, as people are becoming increasingly more comfortable with shopping online, and are 'time poor'. However, detailed responses suggested that one important effect would be that some remaining shopping trips would come to be regarded more as leisure than life-maintenance; this in turn would imply more specialist and distant locations rather than local ones. On the other hand, more local 'top up' shopping was suggested, eg for perishable goods, with staples being delivered less frequently to the house. The potentially countervailing impact of van deliveries was widely stressed.

Figure 5: Impact of teleshopping on the number of shopping trips

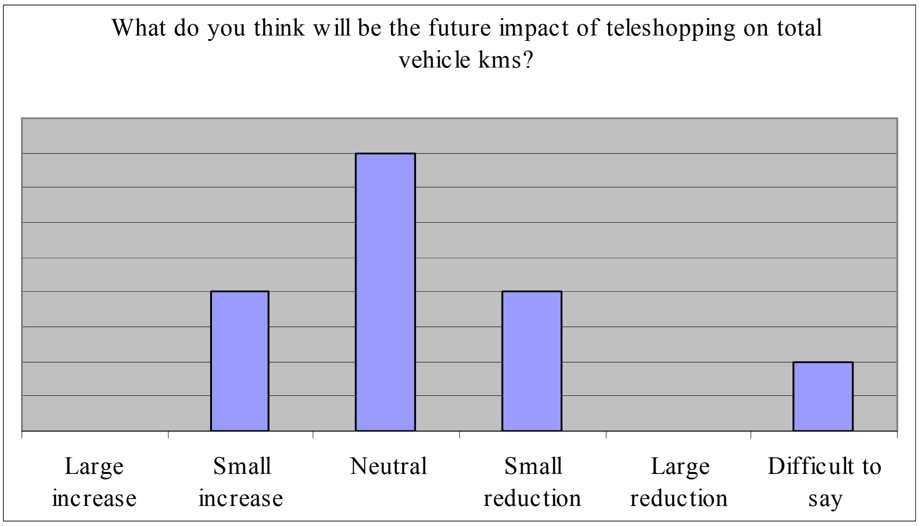


Further complexities were noted, however. For example, for some goods it was argued that people might visit stores but then buy goods on line because it is cheaper; alternatively, people browsing on the internet may inspire people to go out and purchase more goods.

Impact on total distance travelled

Views on whether the total distance travelled would increase or decrease as a result of teleshopping were symmetrically spread (see Figure 6) with half of those expressing an opinion concluding that there would be a 'neutral' impact. Changes were attributed partly to the changing nature of shopping trips and the interaction of teleshopping with actual shopping trips. Van deliveries were seen as an important countervailing influence, although some noted that the scale of this effect might depend significantly on the efficiency of van trip-chaining.

Figure 6: Impact of teleshopping on the total amount of travel



Some respondents raised broader issues in relation to teleshopping, eg (a) that there might be equity benefits in improving some people's access to a range of shops and products; and (b) that teleshopping might in the long run lead to substantial restructuring of the retail sector.

Barriers to, and drivers and enablers of, the wider uptake of teleshopping

The major barriers put forward to the wider uptake of teleshopping were very diverse range of possible barriers, some of which are surmountable, but others potentially quite fundamental. It was pointed out that some people enjoy physical shopping, at least for certain purposes, and that people often prefer to touch and smell their goods prior to purchase. More generally, there is still a prevalent mistrust of buying things that have yet to be seen, and a resistance to trying new things. Security concerns (eg use of credit cards, legal protection) were also cited as barriers, along with the need to be at home to take delivery. Access to the internet was cited as a driver, but it was also stressed that home ICT penetration is still patchy.

As might be expected the experts identified similar enablers and drivers for teleshopping as for teleworking. These included the widening availability of cheap, high quality internet access, which was almost universally seen as the key enabler. Better credit card security and generally greater ease of payment were also noted.

Broader socio-economic drivers cited included busy lifestyles, and the desire for time savings/convenience; companies competing for business and the desire to drive down costs (eg Amazon); and individuals' desire for access to a wider range of products.

Commentary on Experts' Views of Teleshopping

The expert views strongly reinforced the conclusions of our literature review. They do see that there is substantial potential for teleshopping, but most felt that it would have rather little effect on overall traffic levels. By analogy to conclusions on teleworking, first round benefits of fewer shopping trips would be offset partly by the need for van deliveries, as well as by a complex range of second round impacts. Here the second round effects cited would include other trips substituted for shopping trips, or various changes in the nature of 'shopping as leisure'.

Two potentially important societal changes that might result were equity benefits in improving some people's access to a range of shops and products; and substantial restructuring of the retail sector.

5 Identification of Critical Issues in Decarbonising Transport and Research Needs

This report has presented the critical issues for decarbonising transport in relation to trends and technologies. It did not attempt to assess policy options that might either contribute to decarbonising transport, but which do not necessarily involve technology, eg modal shift and taxation, road pricing, or those that might encourage the introduction of a particular technology.

Current trends, both exogenous and endogenous to the transport system present a future that is overwhelmingly towards further increases in personal motorised travel and road freight transport. Without changes to trends and or technology CO_2 emissions are likely to increase over time. The second part of this work has considered the potential impact of emerging technologies on the CO_2 emissions of passenger road transport both identifying technologies with the potential to cut future CO_2 emissions such as using alternative fuels (eg hydrogen) and also emerging technologies where the net impact on CO_2 emissions requires further investigation (eg ICT). In completing this work a number of critical issues for decarbonising transport have been raised. The rest of this section now addresses each of these in turn.

1. Addressing aviation – Its emissions are on the increase and the potential CO_2 reductions from technical changes are more than negated by its projected growth. Additional measures are urgently needed.
2. Ageing population – It is not well understood how the behaviour of the future elderly (largely driving license holders) will compare with that of the current elderly. If car use is maintained into old age, there are unresolved issues over the impact of the change when drivers are no longer capable of driving. It is unclear to what extent elderly car drivers' lifestyles will remain car dependent.
3. Households – It is not known whether future households will have the same need for a car as the current ones. If household car ownership rates continue to increase, this may have very adverse implications for those who do not have a car. Multi-vehicle households may also alter the way that they use their cars, but it is not known what effect this might have.
4. More diverse vehicle market – It is also possible that the emergence of cleaner/smaller/easier to drive vehicles may induce people who otherwise would not have driven to drive a car, and this could have important consequences.
5. New vehicle refuelling technologies – These have the potential to contribute to substantial CO_2 emissions reductions in the longer-term, but it is essential to ensure that they do so by addressing the whole fuel cycle.
6. Intelligent Transport Systems – It is important to identify these can actually contribute to decarbonising transport, and what accompanying measures should be implemented to ensure that this happens, eg road pricing.
7. ICT generally – There is a need to clarify and understand what use people will make of the time avoided for travelling as a result of ICT applications.
8. Teleworking:
    - There is a need to clarify whether this has an impact on travel in terms of where people choose to live and how and when they choose to travel to work, or even on car ownership.

- It is also important to identify how teleworking can be optimised (for the overall benefit of the environment and transport sector), eg by changing employer and employee attitudes and disseminating good practice.

9. Teleshopping:
   - There is a need to identify the real net impact of shopping journeys being replaced by delivery journeys, and identify ways in which these might be encouraged to evolve to ensure an environmental benefit.
   - There is also a lack of understanding of the broader effects on shopping behaviour, the structure of the retail sector, and the potential interactions between the two.
   - There is a need to identify how teleworking can be optimised (for the overall benefit of the environment and transport sector), eg by more flexible means of delivery.

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Appendix 1: The Expert Questionnaire

Critical Issues in Decarbonising Transport: The Role of Technologies

Survey to obtain the views of experts

The objective of this survey is to obtain your views about the potential impact of selected technologies on the transport system. This survey is being undertaken by the Institute for European Environmental Policy and the Institute for Transport Studies at the University of Leeds, as part of a project funded by the Tyndall Centre for Climate Change Research.

The project

The ***context*** of the project is the need to decarbonise the transport sector, ie reduce its carbon dioxide (CO_2) emissions and thus its contribution to climate change. The ***aim*** of the project is to review the potential impacts of technological developments on travel behaviour in this context and consequently identify which technologies should be promoted to this end. A review of technological developments has been undertaken, which has identified potential technologies that can influence travel behaviour and have the potential to reduce CO_2 emissions. The literature review did not reveal whether, or under which conditions, these technologies can contribute to decarbonising the transport sector.

The survey

The objective of this survey is to ascertain your view, as an expert in a relevant aspect of transport, of the potential contribution of these technologies to decarbonising the transport sector. The survey covers the following technologies: Intelligent Transport Systems (ITS); and Information and Communication Technologies (ICT). Only answer the questions or sections that you feel comfortable answering. Please indicate below, which you have answered and what you feel your level of expertise is.

Name		
Position		
	Answered: Y/N	Expertise*: 1 to 5 (see note)
Intelligent Transport Systems		
ICT – teleworking		
ICT – teleshopping		

* Where 1 indicates a general knowledge of transport policy and 5 indicates that you are an expert in this field

Please could you e-mail your answers to Iskinner@ieeplondon.org.uk by Friday the 18th of July.

If you fill in the questionnaire by hand please could you either post or fax your answers to:

C Kelly
Institute for Transport Studies
University of Leeds
Leeds
LS2 9JT
Fax: 0113 2335334

INTELLIGENT TRANSPORT SYSTEMS (ITS)

Definition

Intelligent Transport Systems include making use of a variety of advanced technologies, including computers, communications, sensors, collision warning systems and vehicle-sensing technologies, in order to secure, manage and control transportation systems.

ITS can be divided into two categories: 'intelligent infrastructure' (including electronic toll collection and incident management systems) and 'intelligent vehicles' (including collision avoidance and warning) (Proper, 1999).

Summary of the Main Impacts of ITS from the literature

- Environmental benefits in terms of a decrease in mileage and fuel consumption and thus fewer emissions of greenhouse gases and conventional pollutants (eg ISEB, 2000; ERTICO, 2003; Proper, 1999).
- The provision of information about road conditions may improve the efficiency of the network, which could result in a 6% reduction in mileage (Graham and Marvin, 1999).
- The Urban Traffic Control System (SURF 2000) in Paris has resulted in a decrease in congestion, which enabled a better flow in the traffic system (20% savings in travel times and 30% reduction in the number of stops) and a reduction of fuel consumption by 10% (ERTICO, 2003).
- Environmental benefit from the integration of transport modes, mainly resulting from the shift from the private car to public transport (Bundesministerium für Verkehr, Bau- und Wohnungswesen, 2003).

Impact of the introduction of ITS

What do you think will be the impact of the broader application of ITS on the length of journeys? (Please highlight and explain your answer)

Large Reduction	Small Reduction	Neutral	Small Increase	Large Increase	Difficult to say

What do you think will be the future impact of the broader application of ITS on the number of trips made? (Please highlight and explain your answer)

Large Reduction	Small Reduction	Neutral	Small Increase	Large Increase	Difficult to say

What do you think will be the net impact of the broader application of ITS on the operation of the transport system? (Please highlight and explain your answer)

Large Improvement	Small Improvement	Neutral	Small Deterioration	Large Deterioration	Difficult to say

If there are any significant impacts of ITS that you feel have not been covered above, please elaborate:

Barriers, drivers and enablers of the increased application of ITS

What, if any, do you think are the principal barriers to the wider use of ITS?

What, if any, do you think are the principal drivers of the wider use of ITS (ie what factors are behind its increasing use)?

What, if any, do you think are the principal enablers of the wider use of ITS (ie what developments are allowing its use to increase)?

ITS and decarbonising transport

In your opinion, which technologies/policies would combine well with ITS to reduce trips and distances travelled? (Please explain)

How large an impact do you think ITS will have on decarbonising transport in the future? (Please state and explain)

Which ITS technology do you think has the largest potential to reduce total vehicle kms? Could you explain your answer?

INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT)

ICT technologies include conventional and mobile telephones, fax, e-mail, transfer of files and the Internet. Examples of applications include: Teleworking, Teleconferencing and Teleshopping.

Teleworking

Definition: People who work at home at least one day a week and use both a phone and a computer to do their job (National Statistics, 2002). 2.2 million teleworkers existed in the UK in 2001 (National Statistics, 2002)

Predictions

Department for Transport (2002) suggests a 9% annual increase in the number of teleworkers over the next 10 –15 years.
RAC (2002) Suggest that by 2010 teleworking could lead to a reduction in commuter traffic of 15%.

Trips affected by Teleworking

The main impact will be on commuting trips. Past data suggests:

- Total distance travelled per person for commuting has increased by 20% since 1985
- Total trips per person for commuting have declined by 12% since 1985.
- 70% of trips to work were usually made by the car in 2000.

Impacts of Teleworking

What do you think will be the future impact of teleworking on the length of journeys spent commuting? (Please highlight and explain your answer)

Large Reduction	Small Reduction	Neutral	Small Increase	Large Increase	Difficult to say

What do you think will be the future impact of teleworking on the number of trips spent commuting? (Please highlight and explain your answer)

Large Reduction	Small Reduction	Neutral	Small Increase	Large Increase	Difficult to say

What do you think will be the future impact of teleworking on trips other than for commuting? Could you explain your answer?

What do you think will be the future impact of teleworking on total vehicle kms? (please highlight and explain your answer)

Large Reduction	Small Reduction	Neutral	Small Increase	Large Increase	Difficult to say

Are there any significant impacts of teleworking that you feel have not been covered above, please elaborate:

Barriers, drivers and enablers of teleworking

What do you think are the principle barriers to the wider take up of teleworking?

What do you think are the principle drivers of the wider use of teleworking (ie what factors are behind its increasing use)?

What do you think are the principle enablers of the use of teleworking (ie what developments are allowing its use to increase)?

Teleshopping

Definition: Teleshopping represents the relocation of retail sales from conventional shopping in stores/shops to shopping online, i.e. via the Internet, over the phone or digital TV.

Predictions

Department for Transport (2002) predicts that by 2005 5.7% of all grocery sales will be made online.
RAC (2002) predicts that by 2010 15% of all grocery sales will be made online and that this could reduce car trips to the shops by 10%.

Trips affected by an increase in teleshopping
The main impacts will be on trips to the shops. Past data suggests that:

- Since 1985 the number of miles travelled per person for shopping have increased by 46%.
- The car has a 61% modal share for shopping trips compared to 42% in 1985/86.
- The number of shopping trips per person for shopping have remained fairly stable and have only increased by 2% from 1985/1986 to 1999/2001.

Impacts of Teleshopping

What do you think will be the future impact of teleshopping on the length of journeys for the purpose of shopping? (Please highlight and explain your answer)

Large Reduction	Small Reduction	Neutral	Small Increase	Large Increase	Difficult to say

What do you think will be the future impact of teleshopping on the number of shopping trips made? (Please highlight and explain your answer)

Large Reduction	Small Reduction	Neutral	Small Increase	Large Increase	Difficult to say

What do you think will be the future impact of teleshopping for trips other than for shopping? Could you explain your answer?

What do you think will be the future impact of teleshopping on total vehicle kms? (Please highlight and explain your answer)

Large Reduction	Small Reduction	Neutral	Small Increase	Large Increase	Difficult to say

Are there any significant impacts of teleshopping that you feel have not been covered above, please elaborate:

Barriers, drivers and enablers of teleshopping

What do you think are the principle barriers to the wider take up of teleshopping?

What do you think are the principle drivers of the wider use of teleshopping (ie what factors are behind its increasing use)?

What do you think are the principle enablers of the use of teleshopping (ie what developments are allowing its use to increase)?

ICT and decarbonising transport

In your opinion, which technologies/policies would combine well with ICT to reduce trips and distances travelled? (Please state and explain)

How large an impact do you think ICT will have on decarbonising transport in the future? (Please state and explain)

Which ICT do you think has the largest potential to reduce total vehicle kms travelled? Could you explain your answer?

Thank you for answering this questionnaire