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LOW CARBON PRIVATE VEHICLES

Private vehicle use is increasing. It now accounts for 86% of miles travelled in the UK, compared with just 27% in 1952. Cleaner fuels and exhaust technologies such as catalytic converters have reduced emissions of some pollutants from vehicles. However, carbon dioxide (CO_2) emissions continue to rise, with a projected increase of 10% between 2000 and 2010. This POSTnote examines technologies as well as current government initiatives aimed at reducing CO_2 emissions from private vehicles.

Background

According to the House of Commons Select Committee on Transport a "sustainable" future for private vehicles must include reduced emissions of CO_2 and other pollutants and improved vehicle safety[1]. This POSTnote focuses on CO_2 emissions in particular because these emissions are rising, not falling, as vehicle use increases. Currently, there are no mandatory requirements to reduce CO_2 emissions from private vehicles. Although technologies that reduce these emissions exist, they are not being widely deployed. Research funded by the Department for Transport (DfT) suggests that technology alone will not deliver necessary reductions in CO_2 emissions, and controls on how much a vehicle is used are needed[2]. Behavioural change could be a key way to cut emissions of CO_2 and other pollutants, especially from older vehicles.

Policy

A raft of UK and European measures to reduce CO_2 emissions exists (see Box 1). In addition, the Government's 2002 *Powering Future Vehicles Strategy* set the aspirational target that by 2012, 10% of new cars sold in the UK will be low carbon (defined as emitting <100 grammes per kilometre (g/km) of CO_2). However, in 2004, only 481 of these vehicles (0.02% of the new car market) were sold. In 2004, the UK Government published its transport strategy, the *Future of Transport*. It included the following objectives:

- that vehicles will "contribute almost no CO_2 to the atmosphere" in the long term;
- the encouragement of new vehicle technologies and fuels;
- better planning and management of the transport network.

In pursuit of these objectives the DfT has adopted a technology-neutral and target-led approach to provide a "level playing field" for innovation. This is supported by industry, academics and environmental groups.

Technology

Vehicle technology is constantly being improved. However, the latest technologies are normally fitted to new vehicles only (~10% of the fleet annually): they do not address the impacts of older vehicles.

Engine technology

Internal combustion engines

In an internal combustion engine (ICE), fuels such as petrol, diesel, compressed natural gas (CNG) or hydrogen are burnt in an enclosed cylinder. This produces force that is transmitted mechanically to the wheels. The technology is reliable, well-accepted, flexible and has almost total market penetration. However, ICE-driven cars are only ~20% efficient and produce pollutants, although emissions of pollutants other than CO_2 have been reduced markedly already. Major car manufacturers expect the ICE to remain their core business over the next 20–30 years but believe that future developments – such as improved fuel management systems, advanced transmission and hybrids (see later) – could deliver additional efficiency gains. The International Energy Agency (IEA) acknowledges that the ICE combined with biofuels could have a role in a "near-zero-emissions transport system"[3].

Box 1. Key transport emissions initiatives

- 'Euro' standards – these control vehicle emissions and were introduced in 1992. Standards are tightened periodically and in 2006 the Euro IV standard comes into force. They have been the primary driver for improving engine management and fitting catalytic converters to exhaust pipes. Ford believes "the toxicity of vehicle exhaust gases, excluding CO_2, is now ~1% of pre-Euro levels".
- Company Car Tax (CCT) – is calculated by taking a percentage of the value of the car. This is calculated using the vehicle's CO_2 emissions: it ranges from 15% for ≤140 g/km CO_2, up to 35% for ≥240 g/km CO_2. So, tax on a fuel-efficient Toyota Prius is around £1,000 per annum, whereas on a Land Rover Discovery it is around £6,000. HM Revenue and Customs estimates the CCT scheme saved 200,000 tonnes of CO_2 in 2003.
- Graduated Vehicle Excise Duty (gVED) – is also calculated using CO_2 emissions and ranges from £65 per year for vehicles that emit ≤100 g/km CO_2 to £165 per year for ≥185 g/km CO_2 for a petrol car.
- New car labelling scheme – in August 2005, a new voluntary labelling scheme for all new vehicles was launched by the Low Carbon Vehicle Partnership. By October the labels were in 75% of showrooms. The system is simple and easy to understand: A is the most efficient and F is the least.
- The Association of European Automobile Manufacturers (ACEA) voluntary agreement – ACEA has agreed to reduce average new car emissions to <140 g/km CO_2 by 2008. The average new car sold in the UK in 2004 emitted 171.4 g/km CO_2, 0.4% less than in 2003.
- London Congestion Charge (LCC) – has reduced CO_2 emissions within the zone by 20%, although figures are not available for outside the zone. The LCC's advent has seen sales of exempt vehicles double in the first year.

Electric vehicles
An electric vehicle (EV) is one in which energy stored in a battery is used to power an electric motor driving the wheels. EVs have dominated some significant niche markets (for example, forklift trucks) for many years, but have never made a substantial impact on the private vehicle market. This is because of their initial high cost and limited mileage before recharging is needed. EVs are ~80% efficient, have no exhaust emissions and, if recharged from renewable or nuclear energy sources, are considered to be zero-emissions vehicles. The IEA endorses the EV as a "near-zero-emissions transport option"[3].

Hybrids
A hybrid vehicle combines an ICE with a battery and electric motor. The ICE is used for 'cruising' (at higher speeds); the battery provides additional power (when going uphill, for example) or during stop-start city driving. The vehicle automatically switches between the two or uses both, according to driving conditions. There is a range of different types of hybrid with different battery sizes, some of which use 'regenerative braking systems'. Hybrids increase the overall efficiency of a vehicle and reduce exhaust emissions. Future hybrid systems are in development. These vehicles operate almost entirely as EVs for short journeys, with the battery being recharged from access points located at home or work, and the ICE being used on longer journeys, when the short battery range is a problem. Many vehicle manufacturers as well as Friends of the Earth (FOE) consider hybrids to be part of the short- to medium-term future of private transport.

Fuel cells
A fuel cell reacts hydrogen with oxygen (from the air) to produce water and electricity. Although still at the development stage, fuel cells offer two main advantages. First, they are 40−60% efficient. Second, the vehicle produces no emissions other than water vapour. However, total emissions depend on how the hydrogen is produced (see page 3). Most major vehicle manufacturers believe that fuel cells based on hydrogen may be the long-term solution (over the next 20−50 years), although significant technological barriers exist. They suggest that widespread use of hybrids could make an eventual transition to fuel cells more realistic, as replacing the ICE with a fuel cell would remove the need for a mechanical transmission system, reducing cost significantly. The IEA endorses fuel cells as a "near-zero-emissions transport option"[3], although Transport 2000, Sustrans and others suggest that they are not likely to deliver substantial benefits in the short term. Three fuel cell buses are currently running in central London as part of a wider European initiative of 30 such buses: they already offer significant benefits for air quality in urban centres.

Vehicle design
Improved vehicle design can significantly reduce energy consumption and therefore CO_2 emissions. For example:

- *Use of lightweight components.* Aluminium radiators are lighter than their steel counterparts and have become the norm within the past 5 years.
- *Tyre pressure.* Maintaining tyre pressure at the recommended levels has a significant impact on vehicle efficiency and therefore emissions. Automatic warning systems that alert drivers of low tyre pressure are being considered by car manufacturers.
- *Aerodynamics.* In recent decades, computer modelling has led to significant advances in aerodynamics that improve vehicle efficiency.
- *Active sensor systems.* Systems such as advanced automatic gearboxes can improve efficiency. A computer makes decisions to maximise performance or efficiency.

Fuels
At present oil-based fuels, primarily petrol and diesel, provide for nearly all the UK's transport needs. They are a significant source of emissions of pollutants including CO_2. Tighter fuel quality requirements have removed lead and reduced sulphur levels significantly. However, CO_2 emissions are intrinsic to these fossil fuels. FOE, Transport 2000 and others state that all fossil fuels are "unsustainable". In 2000, a European Commission Green Paper set the objective of replacing 20% of conventional fuels with alternatives such as biofuels, natural gas and hydrogen by 2020. Some academics believe we need to promote a gradual transition to alternatives in parallel with reductions in dependence on fossil fuels.

Biofuels
Biofuels such as bioethanol and biodiesel are derived from vegetation. In 2005, the DfT introduced the Renewable Transport Fuels Obligation, which "commits the UK to using 5% biofuels by 2010". Biofuels are attractive because initially relatively little or no modification is required to introduce them within the existing infrastructure. They are often described as carbon neutral because although they emit CO_2 when burned, CO_2 has been absorbed from the air during plant growth. However, this carbon neutrality is dependent upon the crop and its cultivation and processing ('lifecycle emissions'), which all have energy costs. CO_2 'savings' can thus vary from +100% to –30% (where 30% more energy is used to produce the fuel than is saved by using it instead of a conventional fuel). Biofuel production can also result in destructive practices such as deforestation and intensive agriculture. To avoid such negative impacts, any regulatory framework promoting biofuels would need to encourage best practice, ensuring the environment is protected during biofuel production. FOE believes that biofuels have to be part of the solution, but bigger savings can probably be achieved by improving vehicle efficiency and reducing vehicle use.

Hydrogen
Hydrogen (H_2) can be used in both fuel cells and ICEs to power vehicles. It can be made from fossil fuels such as coal and gas, but this produces CO_2. It can also be made from water using electricity; if this electricity comes from a renewable or nuclear source this does not produce CO_2. H_2 is currently used only in demonstration vehicles. Barriers to the wider use of H_2 centre on a lack of market demand, combined with the need for carbon-free production. In addition, the 2004 Department of Trade and Industry's (DTI's) *Strategic Framework for Hydrogen* states that for a 20% switch from conventional to fuel cell/H_2-powered vehicles to happen, six large nuclear power stations or 2,200 wind turbines would need to be built by 2030 to provide enough carbon-free H_2. Despite these issues, there is consensus that H_2 is likely to be a long-term zero-emissions option but that there will not be significant numbers of H_2-powered vehicles on the road before 2030. The Institute for European and Environmental Policy (IEEP) states that "anyone seriously considering that hydrogen is going to solve all our problems now is trying to find an excuse to do nothing". However, the IEA considers that H_2 combined with fuel cells and carbon-neutral electricity generation has the potential to deliver a "near-zero-emissions transport option"[3].

Behaviour
The way vehicles are used affects all private vehicles, both old and new. Behaviour can be modified to reduce emissions using external devices (such as speed cameras or road user charging) or internal devices (such as automatic speed limiters).

External methods: for example road-user charging
Road user charging (RUC) could encourage drivers to use their vehicles less and thereby reduce CO_2 emissions, although much would depend on the design of the scheme. Global positioning systems (GPS) or mobile phone technology is used to track the distance a car travels, with charges made accordingly. Components of the required technology are already used in many new cars in the form of navigation systems or stolen vehicle tracking. The DfT is currently investigating how RUC could be implemented. A form of RUC already exists that could help to deliver the Government's road user charging agenda (see Box 2).

Box 2. Pay-as-you-drive insurance schemes
These schemes offer insurance by the mile. The system uses a 'black box' that collects real-time vehicle data from customers' vehicles and charges according to use. Norwich Union uses this system. In addition, their young driver pilot product aims to directly modify driver behaviour by discouraging vehicle use during the early hours, when young drivers are more likely to be involved in a serious accident. Young drivers who reduce this risk by choosing to drive only outside the early hours could save up to 30% on their insurance premium.

The Institute for Public Policy Research (IPPR) believes that RUC combined with a carbon tax could reduce CO_2 emissions from private vehicles to 92% of year 2000 levels by 2010[4]. Variable RUC charges, with higher rates for the most CO_2-emitting vehicles, would provide incentives both to reduce vehicle use and to promote the purchase of less polluting vehicles. The Campaign to Protect Rural England supports RUC in principle but is concerned that implementing it only on major roads would simply divert traffic to minor roads.

Internal methods: for example automatic speed limiters
Reducing speed can reduce emissions. The IEA reports that fuel consumption is 30% higher at speeds above 75 mph compared with 56 mph[5], and highlights the importance of enforcing speed limits. Speed can be controlled using external methods such as speed cameras and road humps. However, such devices can actually increase CO_2 emissions if drivers respond by rapidly slowing and accelerating rather than driving at a steady slower speed. Internal devices can be more effective at controlling speed and reducing emissions. They include cruise control, speed limiters fitted to heavy goods vehicles and automatic speed limiters (ASLs). ASLs are considered to be the future of speed limiting. They locate a vehicle using GPS, look up the appropriate speed limit on a database, and prevent the vehicle accelerating above that limit. ASL trials have been run in Leeds by the DfT. As well as reducing speeds, improving efficiency, and reducing pollutant and CO_2 emissions, slower speeds reduce the number of fatalities. Research conducted by the DfT showed that a pedestrian hit by a vehicle travelling at 40 mph has a 15% chance of survival. A pedestrian hit at 20 mph, however, has a 95% chance of survival[6].

Impacts of high levels of private vehicle usage
It is significant that over the past 50 years there has been a shift towards more private vehicle use[7]. Vehicle occupancy rates are down and total distances travelled by private vehicle are up. This is partly due to private vehicles having become much cheaper and public transport having become more expensive in real terms[8]. This shift has caused increased CO_2 emissions but has also increased social exclusion and poorer health within society. For example, a report from the Office of the Deputy Prime Minister (ODPM) found that poorer children are five times more likely than affluent children to be killed on the roads[9]. Sustrans and others believe current levels of private vehicle use are "not sustainable" and efforts should be made to encourage alternatives such as walking, cycling and public transport.

Barriers to low carbon private vehicles

Market demand versus reduced emissions
The ACEA voluntary agreement aims to reduce average CO_2 emissions across the new vehicle fleet to <140 g/km by 2008 (Box 1). However, in 2004 the average new vehicle in the UK emitted 171 g/km and there is a consensus that this target is unlikely to be met[1]. Although the car industry is marketing vehicles with relatively low CO_2 emissions (<140 g/km), such vehicles represented just 15.5% of the market in 2004. Many car manufacturers believe consumers currently value vehicle performance and status over lower CO_2 emissions and market their products accordingly. In addition, current trends in safety and performance tend to increase weight and reduce vehicle efficiency.

Policy issues
Effectiveness of economic instruments
The Government has attempted to change consumer behaviour and push the vehicle market to reduce emissions by promoting less polluting vehicles through the gVED and CCT (Box 1). However, the DfT's 2003 report *Assessing the Impact of Graduated Vehicle Excise Duty* concluded that the current gVED scheme does not offer a large enough financial incentive to encourage behavioural change. It suggested that band differences of more than £100 would be needed before most car buyers would consider switching vehicles. In addition, since the inception of gVED and CCT in 2002, almost 250,000 drivers have opted out of CCT and taken a cash equivalent to purchase a vehicle privately. This enables drivers to buy vehicles with higher CO_2 emissions and to avoid the financial penalties of CCT. Transport 2000 and others therefore question the overall impact these policies have had on reducing CO_2 emissions.

Industry targets
The European automotive industry has a good track record of meeting compulsory new vehicle standards (see Box 1). The IEEP believes that a new vehicle average of less than 120 g/km CO_2 would be relatively easy for the car industry to comply with and that this could be achieved by introducing compulsory standards on CO_2 emissions. Transport 2000 and others have also called for such mandatory targets to be introduced for CO_2 emissions. In 2002, the state of California introduced new regulations on CO_2 emissions from vehicles. In response automotive manufacturers launched a legal challenge, as they feel it will damage competitiveness.

Changing behaviour
Measures that modify driver behaviour have the greatest potential to reduce total CO_2 emissions because they affect the entire fleet. The UK's Transport Research Laboratory believes that many of the policies that reduce CO_2 emissions also reduce other environmental and social impacts of vehicles. Research funded by the DfT[2] suggests a target of a 60% reduction in CO_2 from transport by 2030 will only be possible using an integrated approach that includes both technology (to improve efficiency and reduce emissions) and behavioural change (to reduce distance driven). In recent years, however, Government focus has shifted towards reducing the environmental impacts of vehicles only, not reducing the distance driven.

Overview

- Private vehicle use is increasing.
- Despite improvements in vehicle efficiency, CO_2 emissions are rising as vehicle use increases.
- Biofuels, hybrids and electric vehicles could provide emissions reductions in the short to medium term.
- Hydrogen fuel cells, biofuels and electric vehicles could provide zero-emission options in the long term.
- Without additional legal instruments in place, technology cannot be relied upon to deliver emissions reductions.
- Reductions in vehicle use are required to deliver significant reductions in CO_2 emissions.

Endnotes

1 House of Commons Transport Select Committee (2004) Seventeenth report of session 2003–2004, *Cars of the Future.* HC 319-I.
2 Halcrow Group and Bartlett School of Planning (2005) *Visioning and Backcasting for UK Transport Policy*.
3 IEA (2004) *Energy Technologies for a Sustainable Future: Transport*.
4 IPPR (2003) *Putting the Brakes on Climate Change*.
5 IEA (2001) *Saving Oil and Reducing CO_2 Emissions in Transport*.
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7 Office of National Statistics (2000) *Social Trends* **30**, Matheson, J. and Summerfield, C.
8 DfT (2000) *Transport 2010: The 10 Year Plan*.
9 ODPM (2003) *Making the Connections: Final Report on Transport and Social Exclusion*. Report by the Social Exclusion Unit.

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