Take the save

In 2000, the UK government delivered its 10-year transport plan. This highlighted the massive rise in private car use over the past 40 years coupled with a slow decline in bus and coach use and a very slow rise in the number of rail passengers (fig 1, overleaf).

The plan set out to reverse these trends, restraining the growth of road travel and transferring much future growth to rail. This was intended to stabilise land transport carbon dioxide emissions in 2010 at a level of 6% below the 2000 figures.

In retrospect, the plan was too ambitious to be politically acceptable in the current climate and, amid much criticism, many of the forecasts were scaled back. However, the need to reduce emissions has not gone away and many climate scientists consider that a 60% reduction will be needed over the next 40 years.

Adopting a sensible transport policy is not easy, but one fact is clear: to cut greenhouse gases, transport cannot adopt a "growth as usual" approach. The efficiency of road and rail vehicles needs to be increased, cutting fuel consumption per passenger-km or tonne-km, while a reduction in personal travel and movement of goods is critical.

The industry could obtain energy from non-carbon sources while passengers and freight could also be

car and the planet

THOUGHT TRAINS WERE ALWAYS 'GREENER' THAN CARS? THINK AGAIN

By Roger Kemp

transferred from high- to low-consumption modes of transport. But here we hit an interesting issue. Which modes of transport are high-consumption and which are low-consumption? Indeed, for years the train has epitomised the green option but is this still the case?

EFFICIENT MOVES

The average fuel efficiency of petrol-fuelled cars in Great Britain improved significantly in the decade from 1978 but has been largely static thereafter (fig 2, overleaf). Although the efficiency of petrol engines continues to improve, these gains have been offset by increased sales of larger luxury cars and sports utility vehicles (SUVs).

Sadly, the US tells a different story. Here the fuel efficiency trend has been negative with values falling to 20.4 MPG(US) in 2001, the lowest level since 1980 and a drop of nearly two miles per gallon from the 1987-88 peak. SUVs are the main reason for this negative trend.

Looking forward from a European perspective, the European Community's wider strategy is to reduce average carbon dioxide emissions from new passenger cars to 120g/km by 2010, compared to the 1998 estimated average level of 186g/km. The strategy includes voluntary agreements with the European, Japanese and Korean →

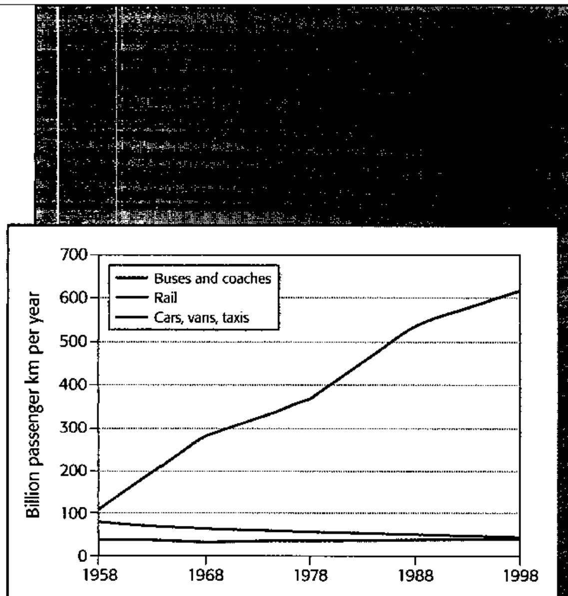
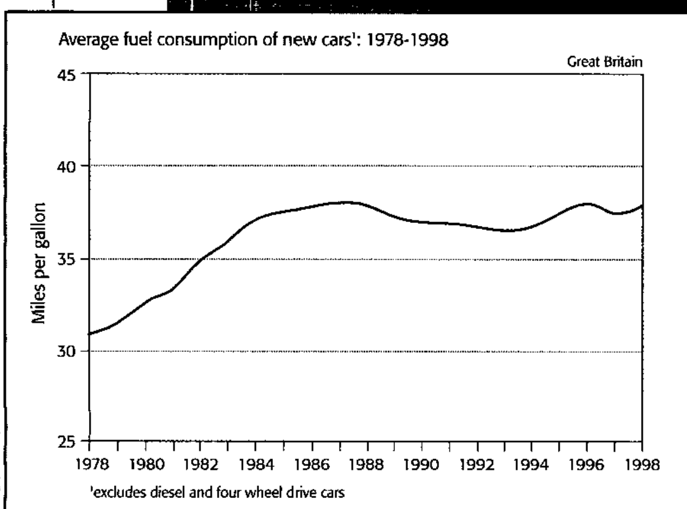


Fig 1: Government statistics reveal a massive rise in private car use since the late 1950s



Credit: DETR

Fig 2: Car fuel efficiency has remained static since the late 1980s

automobile manufacturers to reduce average carbon dioxide emissions from new passenger cars to 140g/km by 2008.

While achieving such targets for fuel efficiency requires technical development, legislative and fiscal incentives are crucial. Persuading motorists to 'downsize' will be difficult in an environment where real motoring costs are not rising, particularly as larger and less fuel-efficient vehicles are driven by the better-off or those for whom motoring is an allowable business expense. At present there does not appear to be the political will to tackle these issues.

But what about rail fuel consumption? Internationally, rail vehicles are becoming more efficient. A comparison of a 30-year old passenger train and double-deck TGV of the same capacity, shows the newer train having half the aerodynamic drag per seat at 150 km/h.

However, this is not the full tale for rail. Since rail privatisation, rolling stock development in the UK has emphasised performance and attracting passengers. It is not surprising that far more development effort has been invested in reducing journey time than in improving fuel consumption.

As an example, the 10-car high speed trains (HSTs) operated on the West of England routes once typically had two power cars, each fitted with a 2250 HP Paxman Valenta engine. On some services these are being replaced by a greater number of five-car multiple units, each car equipped with a 750 HP Cummings QSK19 diesel engine.

The maths is simple. To carry roughly the same number of passengers, the installed power has increased from 4500 HP to 7500 HP, and it would be surprising were there not a concomitant increase in fuel consumption. To add to this, legislation for disabled access or crashworthiness tends to reduce the number of seats on a train, upping the emissions per passenger-kilometre further.

Energy consumption rises dramatically at speeds over 200km/h although running on newly constructed lines, where trains rarely have to accelerate or brake, improves the figures. However, for a high speed train running over a new line from London to Edinburgh, increasing the speed from 200km/h to 350km/h saves almost two hours in journey time but trebles energy consumption (fig 3).

PLANES, TRAINS AND AUTOMOBILES

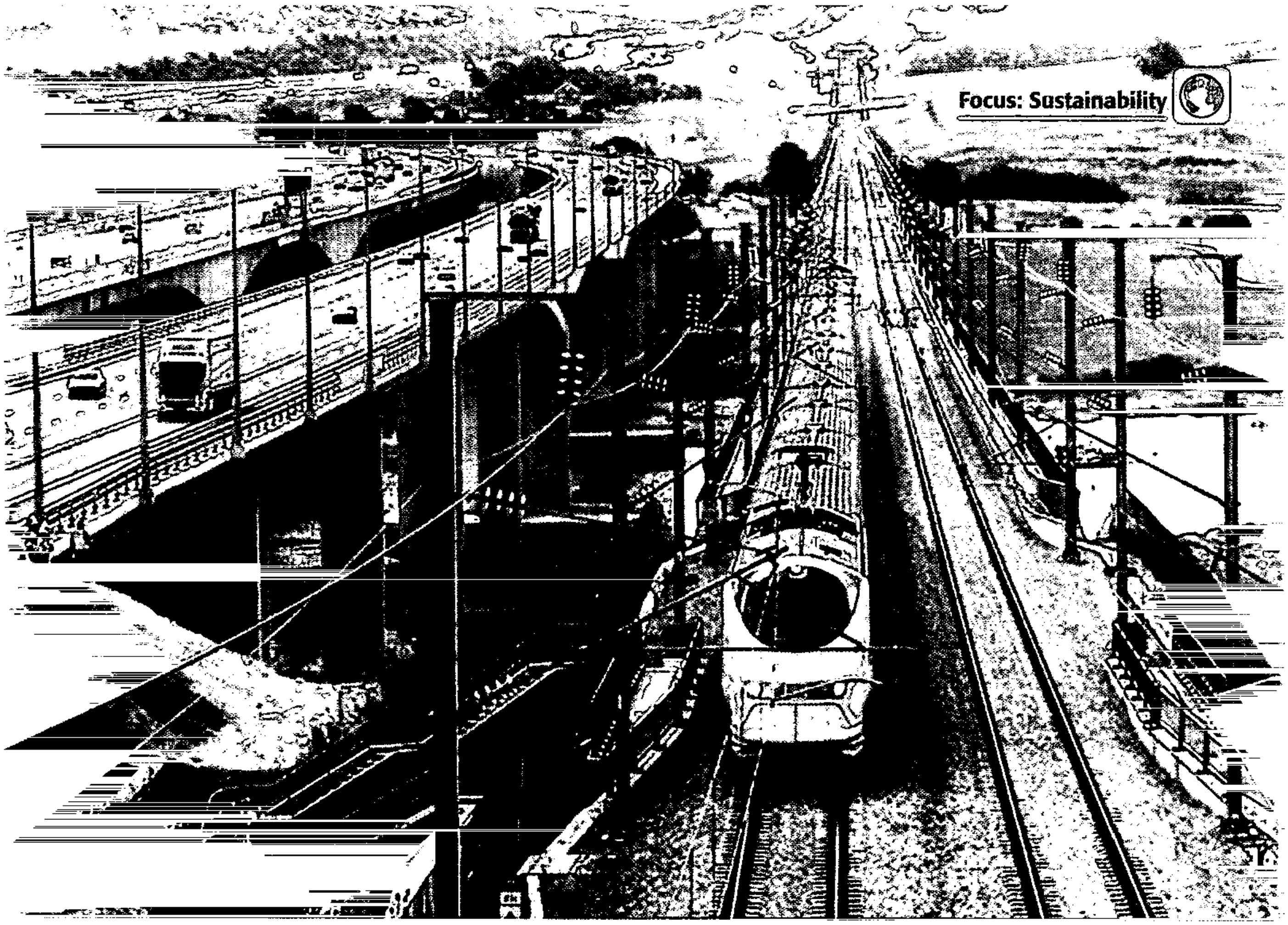
So, given these factors, are trains still the 'green' option? Whether or not the carbon dioxide emissions created by such a train service are greater or less than those caused by a similar number of people travelling in cars or aeroplanes depends on two factors. First, the passenger loadings of the two alternatives and, second, the energy source.

In the past, some studies have compared a fully-loaded train with everyone driving their own car. Not surprisingly trains are shown in a good light. At the other extreme, why not compare cars with every seat occupied and a half-full train?

A recent study of the environmental impact of a new high-speed rail line calculated the relative energy consumption of different transport modes, specifically the consumption of primary fuel – assumed to be oil – per seat over the London to Edinburgh route. The transport compared was an Airbus A321, a VW Passat TDI and two hypothetical trains running at 225km/h and 350km/h.

Made public in April this year, these results have taken the transport industry by surprise as they suggest the primary fuel consumed per seat by a 225km/h train is much the same as that used by an efficient modern car. What's more, at speeds of 350km/h there is little to choose between a high speed train and a modern aircraft (fig 4).

Days after the results hit the national press, the



[image: Eurostar]

Above: Will taking the car and leaving the train at home help beat carbon dioxide emissions?

Parliamentary Under Secretary of State for Transport was quizzed over carbon dioxide emissions of various modes of transport from London to Edinburgh. His reply showed that trains produce far less carbon dioxide than road transport (see table, below right). So, what is the reason for this discrepancy of more than 5:1 between these two sets of figures?

Part of the reason is because the Minister's figures were based on cars with an average of 1.56 occupants (31% full for a five-seater car) while trains were, on average, a surprising 70% full. He also appears to have taken an average figure for the fuel efficiency of cars rather than using figures for an efficient modern diesel car as used in the study. Finally, he gave figures for present day trains running at a maximum speed of 200km/h rather than the high speed trains running at 225km/h.

This difference between these sets of figures shows how easy it is to change a number of assumptions and radically alter the conclusions. The situation is further confused when you compare electrically hauled trains with diesel or petrol-fuelled cars. For the results presented in April, all energy was converted to kg of oil – on the basis of 1kWh = 8.3×10^{-5} tonnes oil equivalent – to ease comparisons, but is this an over-simplification?

The energy supply mix for electricity generation is dominated by coal 33%, combined-cycle gas turbines 28% and nuclear 17%, (*Power Engineer,* Dec/Jan 2004, p8-9). ➔

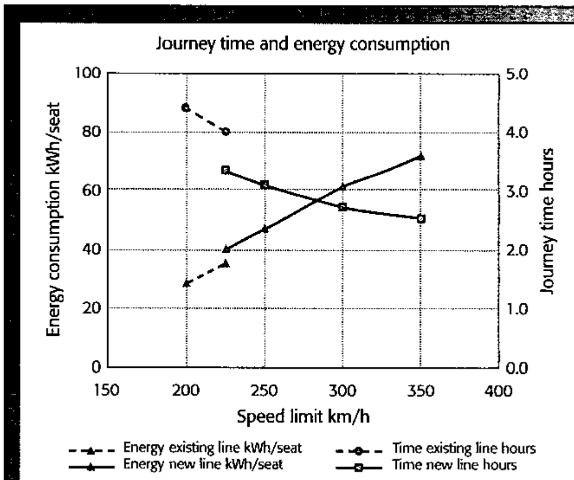


Fig 3: Energy consumption in trains rises dramatically at speeds of more than 200km/h. Solid lines represent journey time and energy consumption on a new track, broken lines show extrapolations for lower speed operation on the existing line

London to Edinburgh	CO_2 emissions per passenger – journey (kg)
Aviation	96.4
Rail (Class 91-modern high speed electric train)	11.9
Car	71.0
Coach	9.2

Table: Government data on carbon dioxide emissions from different transport modes

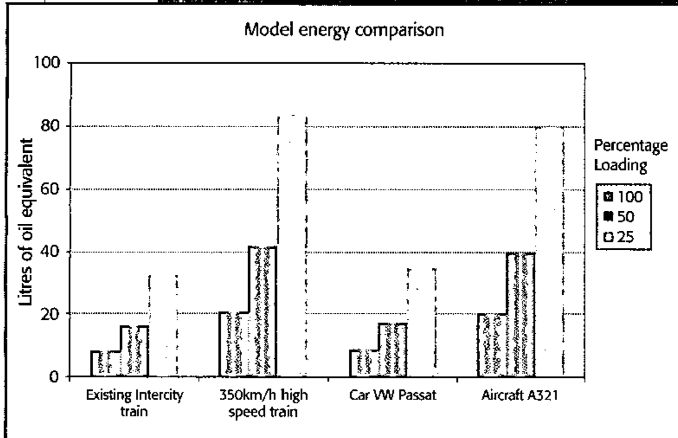


Fig 4: Energy consumption comparison for different modes of transport

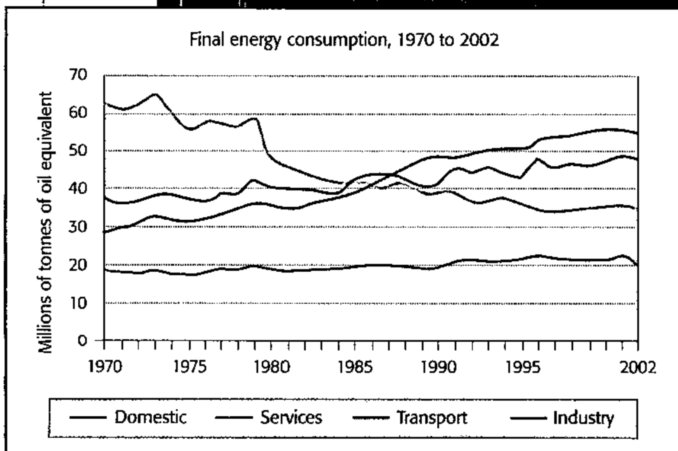


Fig 5: Energy consumption in the transport sector continues to rise

Working out the carbon emissions from this supply mix is one way to make a comparison.

However, you can ask what additional generation would be brought online to feed the additional load imposed by a new railway and calculate the emissions for that. Alternatively Network Rail could negotiate a supply contract with a nuclear generator or wind turbine operator and claim that all electric trains run on 'carbon free' energy. Three different methods of calculation, and three very different answers.

GOING GREEN?

Press coverage of the April results prompted a flurry of activity, calculations, emails and meetings, which combined to produce three key points. Firstly, no-one had authoritative train energy consumption data at their fingertips, suggesting few people considered it important.

Second, unlike the situation for cars, there is no standardised method of calculating the amount of carbon dioxide produced by trains, which leads to wide variations in the assumptions made and the eventual figures. And, finally, the plethora of different measures – including MJ and tonnes oil equivalent, tonnes carbon and grams of carbon dioxide per seat-km – makes comparison of environmental impact almost impossible for the non-specialist.

But, measurements aside, UK railways rely on public subsidy. Support for this subsidy is based, at least partially, on the presumption that railways are "a good thing" environmentally. For some operations, such as commuter services into large cities or long distance container transport, there is no question that this is true.

However, the environmental case for building new high speed lines and transferring resources from road to rail depends on a proper understanding of energy efficiency and carbon emissions. This, in turn, is heavily dependent on the future mix of electricity generation.

Making sense of this complicated situation and explaining it to policy makers is crucial and will be an important challenge to power engineers. However, studies so far do beg the question, is transport actually sustainable?

ANSWERING QUESTIONS

Most people would expect sustainable transport to give the 'right' answers to three key questions. First, does our transport system rely on fuel or other natural resources that are likely to become exhausted in the foreseeable future?

While the imminent exhaustion of natural resources – in particular hydrocarbons – has been predicted for more than half a century, optimists point out that the rate at which reserves are discovered continues to match the rate at which they are depleted. Although the auditors of some international oil companies may beg to differ, no-one seriously expects oil reserves to become exhausted in the next 50 years.

And while the price of liquid fuel is likely to increase, this is unlikely to change the economic viability of using crude oil in transport. A large portion of the pump price is made up of taxation so the "price" is effectively set politically.

Second; are levels of local pollution caused by transport likely to impose significant limits to its use? The last 10 years have seen key pollutants from transport plummet.

Oxides of nitrogen are down 34%, volatile organics compounds (VOCs), 40%, carbon monoxide and particulates have dropped 42%, smoke by 50% and lead by

> **“Studies so far beg the question, is transport sustainable?”**

more than 90%. And this is despite a 10% increase in personal travel and a 15% increase in goods movements.

Progressively stringent emission standards for new road vehicles will ensure that improvements continue, and while we cannot be complacent, local pollution is unlikely to be a limiting factor in transport policy, other than in specific areas, for any predicted growth rates.

The third question asks, are transport policies compatible with national targets to reduce global pollution, in particular ‘greenhouse gases’? Transport is one of the major sources of greenhouse gases – principally CO_2 – in the UK and has continued to increase over past decades (fig 5).

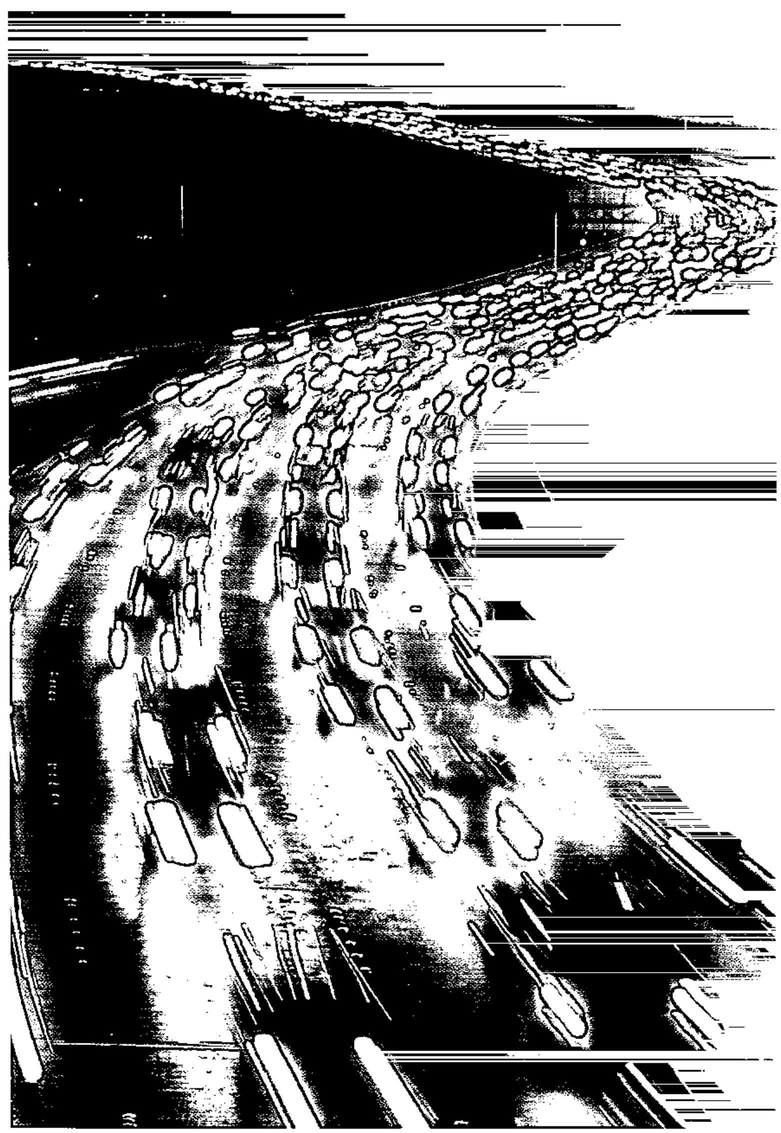
Current UK transport policy envisages a reduction of emissions of greenhouse gases from transport by 2010 that would leave emissions from the sector slightly above 2000 levels. In the longer run demand for transport is expected to increase and without further efficiency gains or developments in low carbon technologies for transport, emissions are expected to rise.

But what about carbon dioxide concentration targets? The European Commission and the Royal Commission on Environmental Pollution both suggest 550ppm is a sustainable limit. However, the Intergovernmental Panel of Climate Change (IPCC) calculate this would result in a temperature rise of more than 2.0°C, which the Stockholm Environment Institute says would “elicit rapid, unpredictable, and non-linear responses that could lead to extensive ecosystem damage”. The Global Commons Institute (GCI) suggests a lower target of 450ppm.

Ministers have talked about a massive 60% reduction in carbon dioxide emissions by 2050 but how would these cuts be spread? One way would be the principle of ‘equal pain’ with all sectors suffering the same level of cuts. An alternative favoured by transport engineers is that, as it is much easier to feed static plant than mobile vehicles from renewable resources, the cuts should be borne by the electricity supply industry and domestic consumers. Meanwhile the proportion of carbon-based fuel taken by transport should be allowed to increase.

The 1987 Bruntland Commission defined sustainability as “development which meets the needs of the present without compromising the ability of future generations to meet their own needs”. With this in mind, is sustainable transport an oxymoron or can engineers actually provide a solution? ■

however stringent emission standards on road



Further reading: RJ Kemp, Environmental impact of high-speed rail, IMechE, Seminar on High Rail Speed Developments, April 2004. Professor Roger Kemp is based in the Lancaster University Engineering Department.