Energy Policy 36 (2008) 4444–4448

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Enabling technologies for demand management: Transport ☆

Roderick A. Smith *

Department of Mechanical Engineering, Imperial College London, Exhibition Road, London SW7 2BX, UK

ARTICLE INFO

Available online 4 November 2008

Keywords:
Demand management
Transport modes
Technology

ABSTRACT

Rising transport demand is likely to be the biggest hurdle to reducing our greenhouse gas emissions. Globally and nationally, transport is consuming an ever increasing share of our total energy use. Furthermore, the bulk of energy used in transport comes from the burning of petroleum products. This brief paper summarises options arising from the two routes to reduce energy demand in transport: improved and more efficient use of existing and possible new transport modes, and the reduction of transport demand. In both areas, the prospects in the immediate and longer-term future are hedged with difficulties. Automobiles and aircraft have improved considerably in recent decades, but future improvements are likely to be incremental. The introduction of hydrogen as a fuel is appealing, but there are technical problems to be solved. Active reduction of demand for transport will require a decoupling of the link between demand and growth in gross domestic product. Globally, this will be very difficult to achieve. Various modes of public transport exist that are efficient in terms of their energy use per passenger kilometre. But they need large investments to make them more attractive than the automobile. However, population concentration in mega-cities, allied with congestion, will make such innovation essential. Policy measures can be assisted in their implementation by new technology, but will remain politically problematic.

'The only function of economic forecasting is to make astrology look respectable,' J.K. Galbraith, 1908–2006

1. Key challenges

Rising transport demand is likely to be the biggest hurdle to reducing our greenhouse gas emissions.[1] Transport is consuming an ever increasing proportion of our total energy use. Furthermore, the bulk of energy used in transport comes from burning petroleum products.

For example, in the UK, greenhouse gas emissions from industry have fallen from 20.5 MtC in 1990 to 11.8 MtC in 2000 and are projected to decrease further to 11.1 MtC by 2020. By contrast, the figures for transport were 40.3 MtC in 1990, 43 MtC in 2000 and projected to increase to 47.8 MtC in 2020. Therefore, industry's share of total greenhouse gas emissions will have fallen from 10% in 1990 to 7% by 2020, while transport will have risen from 19% in 1990 to 29% in 2020. The situation is similar in all developed economies, and transport demand in developing counties is frequently growing by 10% or more per annum. Transport took a 42.3% share of world energy consumption in 1973. By 2003, its share had risen to 57%.

Transport's final energy use has risen by 62% since 1980 (Fig. 1), while its share of petroleum product consumption has risen from 32% in 1980 to 70% in 2004 (Department of Business Enterprise & Regulatory Reform, 2008). In 2006 transport consumed 74% of our oil (Department of Trade and Industry, 2006). Worldwide, there is a very strong link between propensity to travel and gross national product (GNP), although in the UK there has been a small decoupling of this link in recent years. Furthermore, people's daily travel-time budget is remarkably insensitive to GNP, meaning people travel by faster modes of transport as they become richer, and faster modes of transport consume more energy per passenger unit distance transported.

Here then is the nub of the problem. We, that is, the world economies, desire to grow GNP. It is likely that this will cause an equivalent growth in transport demand. There is a growing realisation that this is an unsustainable goal, which has prompted a debate about improving our quality of life. Such arguments are unlikely to persuade the developing economies that progress means anything other than producing more and selling more. Developed economies are also increasingly reliant on goods produced elsewhere. Many would argue that we need to increase transport provision in order to grow the economy. Certainly, the inefficiencies caused by congestion and inconveniently long door-to-door journey

☆ While the Government Office for Science commissioned this review, the views are those of the author(s), are independent of Government, and do not constitute Government policy.

* Tel.: +44 20 7594 7007.
E-mail address: roderick.smith@imperial.ac.uk

[1] The level of CO_2 emissions worldwide is now about 20% higher than when the Kyoto protocol was signed in 1997. The two largest factors are increased coal burn in China and rising transport demand worldwide.

0301-4215/$ - see front matter © 2008 Queen's Printer and Controller of HMSO. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2008.09.072

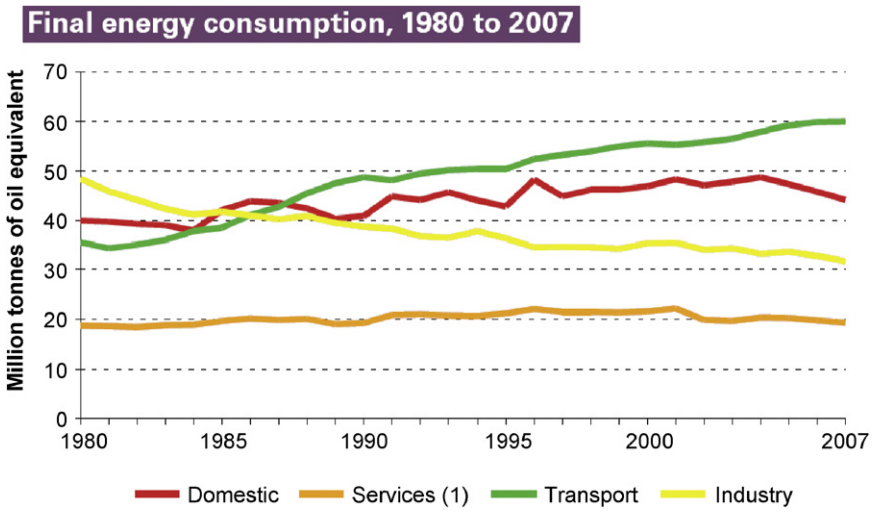

Fig. 1. Changes in final energy use, by sector, 1980–2007 (Department of Business Enterprise & Regulatory Reform, 2008).

times cannot be assisting economic growth. Can we reduce transport demand or, failing this, can we use technology to reduce or contain the growth of emissions arising from transport?

The past 50 years have seen relatively small changes in our domestic transport scene. The rise of the automobile has seen a significant switch from public transport modes. Use of the train has remained constant and, because of rising overall demand, its mode share has fallen. Motorways have made long-distance journeys much quicker, so overall journey times match or beat rail journeys. Although motorways are only 1% of road length, they carry 19% of the total traffic.[2] Transport into and within large cities, particularly London, depends strongly on rail. The most significant rise has been the use of aircraft for both domestic and international travel. The jet engine has served to 'democratise' air travel; fares have significantly reduced in real terms. New technologies have not been commercially successful—e.g. Concorde, the hovercraft—and have had little significance. The development of high-speed trains for journeys up to about 4 h has been significant in many other countries. The role of technology has largely been to reduce costs and therefore to stimulate demand. Congestion is becoming a major obstacle to economic growth, with current losses estimated to be in the order of £20 billion a year. Because cars are stationary for approximately 96% of their life, they are singularly inefficient as transport machines. Parking is a major problem, which suggests that schemes for vehicle sharing should be pursued with vigour.

These issues are shared by most developed countries. The sharp rise in automobile traffic in developing economies gives cause for concern if global emissions are to be contained.

Transport's central role in the economy and its pervasive influence on daily life make rapid changes in this sector difficult to achieve. Its relatively weak sensitivity to energy price movements and the long time constants associated with infrastructure change make it difficult for governments to implement measures to improve sustainability. Some possible measures include:

- improving vehicle and systems energy efficiency,
- increasing the use of renewable and other low-carbon energy sources and expanding world access to cleaner and more efficient transport technologies, coupled with a more rapid development and deployment of advanced technologies,
- developing politically acceptable, but aggressive, policies to shift the direction of transport to a more sustainable path.

2. Improving vehicle and system energy efficiency

Because cars so dominate the transport market, it is appropriate to consider this sector first. Harmful emissions have been significantly reduced by catalyst exhaust systems. The situation with CO_2 is not as good because, while potential fuel economy has been improved, this has largely been offset by increased car mass, with safety and comfort systems such as air conditioning. There is little scope for further significant improvement of conventional engines, but hybrids show promise and have been successfully introduced. The weakness remains the life of batteries and their poor energy-density characteristics. Some, but not major, advances are possible.

Many claims are made for hydrogen-powered cars. The major obstacles to implementation remain the need for energy-efficient and greenhouse-gas-free methods for the production of hydrogen, suitable storage devices and the development of a new infrastructure for distribution. It is unlikely that a significant switch can be made in the next decade or so, but the prospects for 25–50 years look promising.

Similar prospects arise for buses and coaches, which, given high load factors, are currently considerably more efficient per passenger kilometre than cars, but have the advantage of being refuelled from a localised and limited infrastructure.

Because rail has a low mode share, despite its energy efficiency, it is unable to significantly contribute to future energy savings unless there is a large mode switch for which additional capacity would be needed. There are currently some indications that, in the UK, a capacity deficit has been reached that is being managed by raising fares, which in turn may only serve to increase road use. In terms of intercity transport, the development of new infrastructure (either rail or maglev) could, as has been demonstrated elsewhere, provide this capacity, with good energy efficiency even at speeds of 300–350 kph. Such an infrastructure could ease overheating in the south east. It would be arranged to allow easy access to car users and would enable airports to be developed in the regions. Additionally, the capacity freed on conventional lines could be used for freight.

[2] There are approximately 8 million cars per 1000 km of motorway in the UK, compared with an EU average of 3.5 million (European Road Federation, European Road Statistics, 2007).