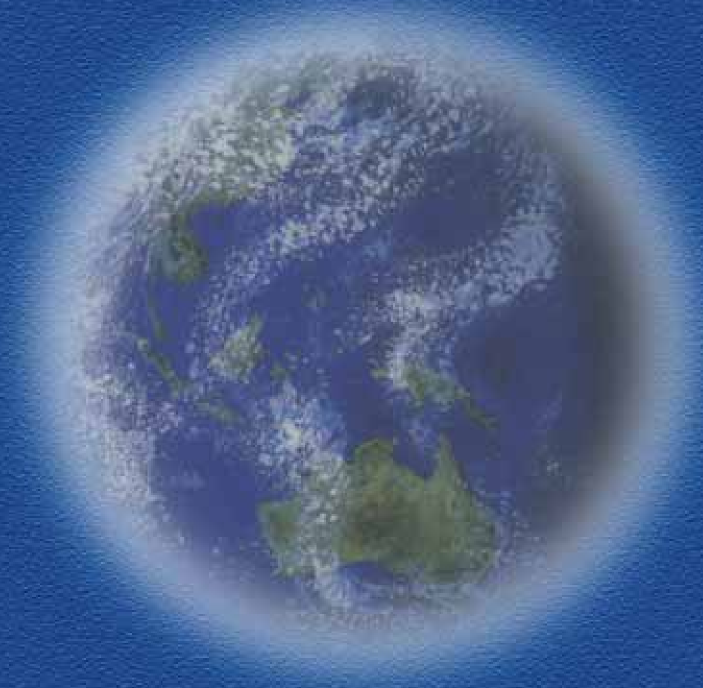
GREENHOUSE POLICY OPTIONS *for* TRANSPORT

greenhouse

policyoptions for transport



REPORT 105

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DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

GREENHOUSE POLICY OPTIONS *for* TRANSPORT

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foreword

Under the National Greenhouse Strategy, released in November 1998 following agreement by the Commonwealth, State and Territory governments, the Australian Transport Council (ATC) is responsible, among other measures, for one relating to economic instruments and transport. On instruction from the Council of Australian Governments, ATC commissioned this study from the Bureau of Transport and Regional Economics.

This final report takes account of the diverse comments received on the draft report, *Transport and Greenhouse: A Study of Policy Options*, which the Bureau released in November 2000. This report also reflects the many recent international developments in the transport sector that have a potential impact on greenhouse gas emissions, as on other transport externalities.

The authors are grateful to those that assisted the development on this report by commenting at the draft stage. David Bray provided valuable guidance in his role as an independent reviewer of the draft report. The project benefited significantly from the depth and breadth of experience of colleagues in the BTRE—all of whom were generous in providing valuable assistance when needed. Josh Gordon made an important contribution in the early stages of the report.

The study was researched and written by Lyn Martin under the direction of Dr Mark Harvey. Phil Potterton assisted in the latter stages of the project.

Tony Slatyer
Executive Director
May 2002

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...AT A GLANCE

- This report examines measures involving the transport sector with potential to reduce greenhouse gas emissions, in terms of their economic, environmental and fiscal impacts and informed by international and Australian evidence. The Australian Transport Council referred this issue, a measure under the National Greenhouse Strategy, to the BTRE.

- Australia produces less than two per cent of the world's greenhouse gas emissions. Transport accounts for around 14 per cent of Australia's total greenhouse emissions. Road transport dominates transport sector greenhouse gas emissions and is the main focus of this report.

- A limited set of measures can improve economic efficiency, while also reducing greenhouse gas emissions: road congestion pricing; conversion of some of the fixed costs of car use to variable costs, so ensuring that motorists face more accurate prices; removal of parking-related distortions (e.g. regulations on the minimum number of spaces for new buildings and underpricing of employer-provided spaces); and reducing passenger motor vehicle tariffs to encourage uptake of newer, more fuel efficient cars.

- Road congestion pricing would see significant reductions in transport greenhouse emissions. For further reductions, as may be required to meet international commitments, economy-wide approaches would minimise the impact on living standards, by allowing abatement activity to flow to those areas that can achieve the abatement at least cost. Of the two available alternatives, tradable emissions permits have greater international momentum in the Kyoto environment than carbon taxes, which have often assumed a role of industry assistance or a general revenue source.

- Many other transport initiatives (e.g. enhanced public transport and high occupancy vehicle lanes) have been promoted for their greenhouse benefits, while being primarily aimed at transport and other environmental objectives. Greenhouse benefits are often smaller than might be expected, in part because measures that succeed in shifting vehicles off unpriced congested roads create capacity that is filled by new journeys.

executive summary

Australia's target under the Kyoto Protocol is to restrict growth in greenhouse gas emissions to 108 per cent of 1990 emissions, in the period 2008-2012. The National Greenhouse Strategy (NGS) is a major component of the Government's response. Under module 5 of the NGS, the Australian Transport Council (ATC) is responsible for the delivery of nine transport measures. The measures are national in scope and require coordinated delivery across jurisdictions. One of these, 'Economic Instruments and Transport', has been assigned to the BTRE and provides the basis for this report.

The report discusses policy options for the transport sector in terms of their environmental, economic and fiscal impacts, on the basis of experience from overseas countries and Australian jurisdictions. It focuses primarily on the road transport sector.

AUSTRALIA'S GREENHOUSE EMISSIONS

On a per capita basis, Australia is one of the highest emitters of greenhouse gas emissions in the world. Although rising both in absolute terms and on a per capita basis, Australia's greenhouse gas emissions are declining in relation to Gross Domestic Product (GDP). Greenhouse emissions increased by 17.4 per cent between 1990 and 1999. However, emissions per person increased by only 5.8 per cent over the period and emissions per dollar of GDP fell by 13 per cent.

GREENHOUSE EMISSIONS FROM TRANSPORT

In 1999, Australia produced 1.5 per cent of the world's total energy-related carbon emissions. Transport accounted for around 14 per cent of Australia's greenhouse gas emissions. Over the past decade, greenhouse gas emissions from transport have increased at a slightly faster rate than total greenhouse gas emissions (20 per cent compared to 17 per cent).

Road transport is responsible for about 85 per cent of total transport sector emissions. Over half of these emissions are due to passenger vehicles, while road freight accounts for around 30 per cent of road transport emissions.

MEASURES TO REDUCE VEHICLE KILOMETRES TRAVELLED

There is a wide range of measures aimed at discouraging low occupancy vehicle use, in order to reduce VKT without significantly impacting on personal mobility.

These measures do not seek to address specifically the cost of fossil fuel use and therefore, from an economic perspective, represent an indirect rather than a direct approach to reducing greenhouse gas emissions. Of particular importance, in terms of the impact on greenhouse, is the 'induced traffic' effect, which many of these measures give rise to. With strong underlying demand for unpriced urban road space, which is suppressed by congestion, measures which succeed in enticing solo drivers off the road create spare capacity that is then at least partly filled by new journeys. This acts to constrain greenhouse benefits.

Enhancing public transport

Traditionally, public transport's strength has been in moving large numbers of people efficiently between major collection points and central business districts (CBDs) and within CBDs. In general, public transport's share of total travel is small and declining in the face of a number of universal trends including: rising incomes; the declining share of commuting trips relative to trips for leisure and other purposes; the falling cost of car travel; more dispersed employment and settlement patterns; more flexible working hours; and increased workforce participation by women with a resulting increase in multi-trip requirements. As a result, it has often proved difficult and costly to induce a mode shift towards public transport.

Recent technical developments (e.g. traveller information systems, more user friendly ticketing and payments systems and better fleet management) may have potential to bring about some mode shift to public transport, while frequency of service appears to have the greatest impact on patronage.

In addition, reforms in the regulatory environment governing public transport could encourage a more efficient modal mix by bridging the gap between the services offered by public and private transport—in particular, more flexible public transport (such as dial-up minibus arrangements) and lower taxi fares, through 'lighter' taxi regulation.

While a mode shift to rail public transport, in particular, may generate benefits in terms of greenhouse gas emissions, overseas experience indicates this is commonly achieved at a high economic and fiscal cost per additional commuter.

Parking policies

The cost of parking, in principle, should reflect the value of the land in the best alternative use. Parking policies in the form of increased charges for publicly available spaces are often used to increase the cost of travel, with the aim of reducing congestion. While often succeeding in encouraging some mode shift, increased parking charges in CBDs in effect only target some of the vehicles contributing to congestion—those that park in the CBD—while ignoring the growing through-traffic (including taxi traffic).

Access to the option to 'cash out' employer-provided parking spaces should encourage the more efficient use of parking spaces and would lead to varying degrees of mode shift, depending on the local circumstances. Again, the impact of induced traffic would reduce any gains.

While the impact on congestion may be limited, an economic case can be made for removing institutional distortions that often serve to reduce the cost of parking: regulations on minimum parking requirements for new buildings and concessional tax treatment of employer provided parking spaces.

Personalised journey planning techniques

Personalised travel planning schemes (such as Travel Blending®) involve advice to households on ways to change their travel patterns to reduce car usage and encourage a mode shift to public transport. The advice covers measures such as combining and chaining car trips, information about transit alternatives and suggestions for walking and cycling.

While there have been many trials around the world, use of such programs is still limited. Evaluations of those trials conclude that where public transport services and quality are much higher than perceived, personalised approaches can have very large effects, but where such a gap does not exist, the travel behaviour effects could be negligible.

High occupancy vehicle lanes

High occupancy vehicle (HOV) lanes may reduce congestion if they entice a significant number of solo drivers off the road and previously discouraged solo drivers do not take their places (induced traffic effect). Failing this, they will tend to increase congestion on the remaining lanes. In the US, underutilisation of HOV lanes and increased congestion on general lanes have seen many HOV lanes converted to High Occupancy Toll lanes. These allow access for fee paying solo drivers.

Park and ride

Park and ride facilities have had mixed success in terms of reducing VKT and greenhouse gas emissions. Park and ride can encourage mode shift (for part of the trip) from passenger motor vehicles to public transport, through making parking easier on the city outskirts. However, such a change can also lead to an increase in VKT and overall traffic congestion, as traffic shifts from the CBD to the central city fringe, as previously dedicated public transport users now drive to the park and ride facility and as new traffic is attracted into the CBD by the reduced congestion.

Non-motorised transport

An estimated one-third of day-to-day car trips are three kilometres or less in length. This suggests there is considerable scope for a greater reliance on bicycling and walking. The gains, particularly in terms of local emissions, would be significant, given that cold starts account for a large proportion of noxious emissions. However, distance is often a minor factor in mode choice, compared with other considerations such as time, comfort, safety and passenger and parcel carrying capability.

In addition, even if large gains were achieved, because they would originate from such a small base (walking and cycling account for two to three per cent of kilometres travelled), they appear unlikely to make a noticeable impact on VKT.

Shifting freight from road to rail

On average, rail freight uses significantly less fuel per tonne-kilometre than road freight and, accordingly, produces lower greenhouse gas emissions per tonne kilometre. Measures to encourage a shift to rail can include increased investment in rail infrastructure and regulatory reform to improve rail operating efficiency and measures to encourage providers to allow efficient transfers between modes.

Opportunities to capture significant greenhouse gas emission reductions from shifting freight from road to rail are generally quite limited. Internationally, only a small proportion of total freight carried by road tends to be contestable (i.e. long-distance non-bulk and residual bulk traffic). In addition, long distance road freight movements are relatively fuel-efficient compared to the average. For Australia, it has been estimated that, if a third of the contestable freight were shifted from road to rail, the greenhouse gas emissions produced by road freight would fall by less than one per cent.

Some countries have specified targets for rail freight task share, regardless of the costs and benefits of shifting freight from road to rail. However, economic benefits are best assured through measures that result in prices in both modes that accurately reflect resource costs, including infrastructure use, capital and environmental and safety externalities.

Road use charges

Road use charging in various forms (tolls, heavy vehicle charges and congestion charges) is being more widely adopted internationally in response to the availability of low-cost monitoring and charging technology and pressure on authorities to achieve a more efficient use of the road network in the face of growing congestion.

Of the road use charges available, congestion charging offers the greatest potential gains, in terms of both greenhouse abatement and resource use efficiency. Importantly also, congestion pricing, by targeting the source of the problem, avoids the induced traffic effect.

The extent of both efficiency and greenhouse gains depend critically on the design of the road use charges. In particular, excessive charges on key routes could lead to such roads being underutilised and an overall increase in congestion, as drivers crowd onto the unpriced roads. International experience suggests local trials are important. In addition, the use to which the revenue is put has significant efficiency implications and would be a key consideration in terms of gaining community acceptance. Significant community benefits could be available from gradually replacing existing transport taxes and charges with more accurate charges to reflect infrastructure costs and external costs.

Carsharing and ridesharing

Carsharing refers to the formal shared use of cooperatively owned vehicles and, in effect, is a cooperatively-run car rental service. In contrast, ridesharing/ carpooling (in Australia) refers to regular arrangements involving owner-drivers and multiple occupants. Both can lead to a reduction in VKT, notwithstanding the induced traffic effect.

Carsharing caters to niche markets in Europe and North America and is yet to become established in Australia. Car sharers bear the fixed costs of car use as a variable charge and, in consequence, face a higher marginal cost of car usage compared to car ownership. However, despite strong growth from a small base, carsharing appears unlikely to play a significant role in reduction of total VKT, with correspondingly small greenhouse gas reduction gains.

In the US, tax incentives for ridesharing, often using vanpools, have been established to match those employer provided benefits for (commonly) solo drivers. These schemes appear to work best where employees of a firm share common residential locations. In general, the net reduction in VKT may be small, after allowing for a range of factors, including the extra VKT required for pick up and drop off of passengers and the fact that not all ridesharers are former solo drivers.

Flexible working arrangements

More flexible daily working arrangements are increasingly being adopted and can reduce congestion through helping to spread the peak hour traffic. If they also lead to a more concentrated working week, they can also reduce VKT.

However, given the widespread nature of flexible working arrangements, there may be limited scope for further gains in this area in Australia.

Telecommuting has a very small, if growing, role in Australian work travel patterns. While it may reduce the demand for commuter travel, overseas research indicates this can be offset by individuals' increased social travel, albeit not necessarily during peak period congestion.

Intelligent Transport Systems

There is a wide range of Intelligent Transport System (ITS) developments with equally varied impacts. ITS should result in more efficient use of the transport network through better informed decision making and low cost communication for the transport community. From a greenhouse perspective, most gains from ITS will be through reductions in congestion and in VKT. At a national level, inter-operability (e.g. in relation to vehicle charging and tracking technology) is an important threshold issue.

MEASURES TO REDUCE GREENHOUSE EMISSIONS PER KILOMETRE

A vehicle's greenhouse emissions per kilometre are a product of its fuel efficiency (litres per kilometre) and its carbon emissions per litre. There is a range of measures which focus on advances in technology which are directed at one or both of these two aspects. However, actual emissions are also a function of distance travelled. To the extent that these measures are successful in improving vehicle fuel efficiency, they may lead to an increase in VKT, due to the reduction in the cost of driving. Estimates of this 'rebound effect' vary widely from a 10 to 50 per cent offset in fuel savings, with the mid-range being around 20 per cent.

Mandated fuel efficiency standards

Mandated fuel efficiency standards influence motor vehicle manufacturers to produce vehicles with higher average fuel efficiency than new vehicle buyers would otherwise demand.

In the US, improvement in fuel efficiency of new vehicles followed the introduction of Corporate Average Fuel Economy (CAFE) standards in 1975. However, there remains debate over how much of this improvement is due to CAFE and how much to the sharp rise in fuel prices that encouraged consumer demand for more fuel-efficient vehicles in the 1970s.

Over the past two decades, fuel efficiency of new light vehicles has continued to improve in the US, when account is taken of the changing nature of the average vehicle (more comfort features, greater power and improved safety).

Mandated fuel efficiency standards have not changed significantly over this period.

Australia has experienced trends similar to those of the US in terms of fuel efficiency and the changing nature of the average new light vehicle. Further improvements could be achieved by reducing the tariffs on imported vehicles, accelerating, through lower prices, the penetration of newer, more fuel-efficient vehicles in the national car fleet.

Feebates

Feebates, like mandated fuel efficiency standards, are aimed at encouraging the purchase of 'greener' vehicles and involve a system of taxes (fees) for more polluting vehicles and rebates for the more environmentally friendly vehicles. There have been few empirical studies on the impact of feebates on fuel efficiency. However, the available OECD research suggests that the impact to date has not been significant.

Voluntary agreements with manufacturers

Voluntary agreements are aimed at encouraging manufacturers to pursue priorities that they may not pursue in their own commercial interests. It is difficult to determine the impact of such agreements and empirical evidence is scant. However, the OECD has observed that voluntary targets do not always result in improvements relative to business as usual.

Scrapping older vehicles

Government funded programs in parts of North America and Europe provide incentives to scrap older vehicles. There is some debate about whether reducing the average age of the fleet has the beneficial net impact on greenhouse gas emissions that might otherwise be expected. Older vehicles are often driven less than newer vehicles and the emissions associated with the additional vehicle production may offset any gains from improving the average fuel efficiency of the fleet.

Alternative fuels

Alternative fuels are not necessarily more 'greenhouse friendly' than conventional fuels. While, on a per litre basis, alternative fuels may have a lower carbon content, they may also be less energy-intensive.

Currently, the Alternative Fuels Conversion Programme encourages the use of CNG and LPG by commercial road vehicles and public transport buses. However, the evidence of a net reduction in greenhouse emissions in commercial CNG vehicles relative to diesel vehicles appears mixed. Advances in diesel technology have meant that diesel passenger vehicles can be as greenhouse friendly as LPG vehicles (although local emissions may still be an issue), while having the advantage that a distribution network is already in place. For light vehicles, the greenhouse gas emission gains from LPG are relatively small and appear insufficient to justify the excise-free status afforded this fuel.

Particularly in view of rapid changes in technology, there is a case for policies that avoid designating preferred fuel types but instead ensure that fuel prices reflect the greenhouse emission externalities associated with each fuel type.

ECONOMY-WIDE MEASURES

Economy-wide measures to reduce the use of carbon-based fuel have the potential to ensure either that greenhouse abatement is maximised for a given cost or that a given level of greenhouse abatement is achieved at least cost.

In contrast to other measures considered in this report, these measures seek to address the source of greenhouse gas emissions directly, in the transport as in other sectors. However, an associated threshold difficulty with either approach (and especially with carbon taxes) is the uncertainty surrounding the value in economic terms of greenhouse damage. This uncertainty reflects other, at least partial, unknowns, including the effects of emissions on climate and the timing of those effects. However any policy adopted to reduce greenhouse gas emissions implies a value, although it will not be as transparent as in the case of carbon taxes and emission permits.

Carbon taxes have an advantage of relative familiarity and simplicity. However, overseas experience is that they are liable to become converted either into forms of industry assistance (i.e. the rationale is lost amid exemptions and differing industry rates, regardless of emission characteristics) or into sources of general revenue.

While there are issues to be resolved in terms of the detail and enforcement of emission permits, emissions trading appears to have greater momentum internationally than do carbon taxes. A number of European countries have implemented or are in the process of implementing schemes and some companies are trialing internal emission trading schemes.

CHOOSING THE BEST POLICIES

Measures to address greenhouse gas emissions can usefully be considered under three headings: measures that improve economic efficiency, while also working to reduce greenhouse emissions; economy-wide initiatives that, while involving an economic cost, will ensure that the cost of achieving a given level of greenhouse abatement is minimised; and measures that require careful case by case consideration in terms of their economic and environmental outcomes.

Measures in the first group have net benefits for the community, even aside from their contribution to greenhouse abatement. Those discussed in this report include:

- pricing road use to better reflect resource costs, in particular, congestion pricing;
- reviewing the efficiency and equity case for some fixed costs of car use to be applied on a variable basis (e.g. insurance and registration costs);
- removing distortions in the demand and supply of parking spaces, such as regulations on minimum parking requirements for new buildings and the lack of a choice between cash and employer-provided parking spaces; and
- reductions in passenger motor vehicle tariffs, to encourage uptake of more fuel-efficient vehicles.

While road congestion pricing would see significant reductions in greenhouse gas emissions, these measures together would not achieve the abatement target assigned under the Kyoto Protocol.

Of those measures with positive abatement costs, the preferred ones to achieve significant reductions in greenhouse gases, with least impact on living standards, are the economy-wide approaches of either carbon taxes or tradeable emission permits. These would ensure that abatement activity would flow to the areas of least-cost within the economy. For the transport sector, since fuel use is a relatively small part of the total cost of travel, the response to such measures are likely to be similarly small. Hence, under a least-cost approach, the larger share of abatement activity would be borne elsewhere.

Other initiatives to reduce the amount of travel undertaken by vehicles and individuals (e.g. enhanced public transport, high occupancy vehicle lanes, shifting freight from road to rail and personalised travel planning schemes) need to be assessed on a case by case basis, first and foremost in terms of their costs and their transport (i.e. non-greenhouse) benefits. Both because they address the problem of greenhouse gas emissions indirectly rather than directly and because of the 'induced traffic effect', greenhouse emission savings from these initiatives can be smaller than might otherwise be expected.

introduction

The National Greenhouse Strategy (NGS) is a major component of the Government's response to the Kyoto Protocol. Under module 5 of the NGS, the Australian Transport Council (ATC) is responsible for the delivery of nine transport measures. The measures are national in scope and require coordinated delivery across jurisdictions. Measure 5.1, relating to economic instruments and transport, was referred by the ATC to the BTRE on instruction from the Council of Australian Governments.

Under the terms of reference (see Appendix 1) the BTRE was asked to examine economic policy instruments relating to transport for consistency with efficiency, fiscal, and environmental objectives. In undertaking this task, the BTRE was required to draw on information currently available rather than to initiate new research.

'Efficiency' was interpreted as economic efficiency, concerned with resources (such as labour, capital, land and energy) being allocated in a way that ensures their highest return from the point of view of the nation as a whole. The broad justification for pursuing efficiency objectives is that they produce a 'larger cake', which can then be sliced to pursue better other objectives (such as equity).

From an efficiency point of view, motor vehicle use is not inherently 'bad', nor are alternatives, such as public transport, inherently 'good'. The theoretically optimum mode split would occur when individuals base their travel decisions on prices that reflect the full marginal costs to society of each available option.

'Environmental' impact in this context refers specifically to the impact on greenhouse gas emissions. The report focuses mainly on carbon dioxide emissions since these account for most transport-related greenhouse gas emissions. Also, carbon dioxide emissions are easier to monitor than other greenhouse gases, because they are produced approximately in proportion to the amount of energy used.

Environmental and efficiency objectives can coincide when environmental factors are fully costed and explicitly incorporated into economic evaluations. The efficient level of pollution is unlikely to be zero, just as the efficient level of congestion is unlikely to involve free-flowing traffic. The aim in terms of sustainable transport would be to ensure that motorists faced price signals that reflected the social as well as the private cost of their activity. In that way, they could choose between, say, reducing greenhouse gas emissions from their transport activity or from reduced domestic power use.

'Fiscal' has been interpreted as the budgetary impact of a particular policy for all levels of government. For many of the measures reviewed, the fiscal impact would depend on the detail of the measure. In these cases, observations have been confined to whether the impact is likely to be positive or negative.

Overall environmental impact is of concern when policy instruments that are beneficial in terms of greenhouse gas emissions damage the environment in other ways. For instance, the increased use of diesel in passenger cars may result in lower greenhouse gas emissions but higher levels of local emissions, such as particulates. Conversely, catalytic converters reduce local emissions but increase fuel use and, in doing so, lead to an increase in greenhouse gas emissions.

The report draws general conclusions about the instruments under review, but the ultimate impact of any measure would depend on the design details of each particular measure and the location and circumstances in which the measure was applied.

There are many ways to categorise the various policy options. Commonly, a distinction is made between economic instruments and regulatory instruments, on the basis of whether or not the instrument impacts directly on prices in the market (such as emission taxes). Regulatory instruments, such as emission quotas or standards, usually impact only indirectly on prices.

Three factors govern greenhouse gas emissions from transport vehicles:

- total vehicle kilometres travelled (VKT);
- litres of fuel used per vehicle kilometre (fuel efficiency); and
- greenhouse gas emissions per litre of fuel used ('emissions intensity').

A reduction of say 20 per cent in any one of these factors (with the others remaining constant) would result in a 20 per cent reduction in greenhouse gas emissions. Hence, in terms of cost effectiveness, any reduction in greenhouse gas emissions should focus on that factor where the desired percentage change can be achieved at least cost. It also underlines the fact that, if increases in greenhouse gas emissions are to be avoided when, say, economic growth leads to a growth in vehicle kilometres travelled (VKT), then offsets are required either in terms of increased fuel efficiency and/or reduced emissions intensity.

Few if any policy instruments in operation today are specifically targeted at a reduction in greenhouse gas emissions. Reductions in greenhouse gas emissions tend to be a secondary benefit arising from policy instruments, such as those to alleviate congestion by discouraging the use of single occupancy vehicles (SOVs).

The focus of this report is on road transport, reflecting the fact that 90 per cent of transport emissions originate from road transport. The report draws on previous research and contrasts with an earlier report by the Bureau of Transport and Communications Economics that adopted modelling techniques to provide a comparison of the impact of alternative policy measures to pursue reductions in greenhouse gas emissions (BTCE 1996a).

chapter 1

GREENHOUSE GAS EMISSIONS AND THE AUSTRALIAN TRANSPORT SECTOR

KYOTO ORIGINS AND OUTCOMES

There is widespread support within the scientific community for the view that human activities have contributed to global warming, increasing the quantity of the most important greenhouse gases—carbon dioxide (CO_2), methane (CH_4), nitrous oxide, and a variety of manufactured chemicals such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).[1] There is less agreement on the actual extent to which human activities have contributed to greenhouse gas atmospheric concentrations and the consequences of human-induced (anthropogenic) global climate change.

A decade of international meetings and negotiations have focussed on developing a system for containing future growth of greenhouse gas emissions.[2] In December 1997, more than 160 nations initialled the Kyoto Protocol and signalled their commitment to address the problem of climate change, through the adoption of binding targets for industrialised countries. The Protocol required industrialised countries to reduce their total emissions of carbon dioxide and other greenhouse gases by an average of roughly five per cent compared to 1990 levels, by 2008–2012. Developing countries were not required to meet quantitative emission goals.

For the Protocol to enter into force, at least 55 countries who are parties to the Convention must ratify it, including enough industrialised countries to represent at least 55 per cent of their total 1990 carbon dioxide emissions. At the end of 2001, 40 countries had ratified the Protocol. However, Romania was the only industrialised country to have done so. Prime Minister John Howard reiterated it was not in Australia's national interest to ratify the Kyoto Protocol

1 For a comprehensive review of the issues and links to related sites see the US Environment Protection Agency site at http://www.epa.gov/globalwarming/. For a dissenting view see http://www.vision.net.au/~daly/.

2 A brief history of the negotiating process is available on the UNFCCC site at http://unfccc.int/issues/briefhistory.html.

if the US, which emits a quarter of the world's man-made greenhouse gases, and developing nations such as China were not on board.

Following the Seventh Conference of the Parties (COP-7) to the United Nations Framework Convention on Climate Change (the Framework Convention) in Marrakesh, Morrocco, November 2001,[3] Russia and the 15 countries of the European Union (EU) signalled their intention to ratify the Kyoto Protocol. In addition, Japan and Canada have embarked on a process that is anticipated to end in ratification.

On 14 February 2002, President Bush outlined a voluntary climate plan aimed at reducing 'greenhouse intensity' in the US by 18 per cent over the next 10 years, reasoning that:

> … the policy challenge is to act in a serious and sensible way, given the limits of our knowledge. While scientific uncertainties remain, we can begin now to address the factors that contribute to climate change.[4]

On 27 February 2002, Australia and the US announced that they would set up the US-Australia Climate Action Partnership to work on practical ways of dealing with climate change.[5] A major issue for Australia is to pursue cost-effective measures to reduce greenhouse gas emissions and to avoid negative impacts on Australia's trade competitiveness.[6] As the Department of Foreign Affairs and Trade stated in March 2002, 'the Government believes that effective action to address climate change needs to include all major emitters, including the US and developing countries'.[7]

Australia's perspective

Australia does not make a large contribution to global emissions. In 1999, Australia's greenhouse gas emissions from anthropogenic sources were equivalent to about 125 million tonnes of carbon, representing about 1.5 per cent of the global total.[8] However, on a per capita basis, Australia's greenhouse

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3 See AGO brief report on COP7 at http://www.greenhouse.gov.au/international/marrakesh.html.

4 Greenhouse gas intensity is the ratio of greenhouse gas emissions to economic output. For details see http://www.whitehouse.gov/news/releases/2002/02/climatechange.html.

5 For details see http://usinfo.state.gov/topical/global/climate/02022702.htm.

6 The Hon. Alexander Downer, Minister for Foreign Affairs, joint media release, 15 February 2002. See http://www.foreignminister.gov.au/releases/2002/fa021j_02.html.

7 See Secretary's Speech: Australia's Current Priorities for International Treaty Negotiations http://www.dfat.gov.au/media/speeches/department/020313_sec_treaties.html.

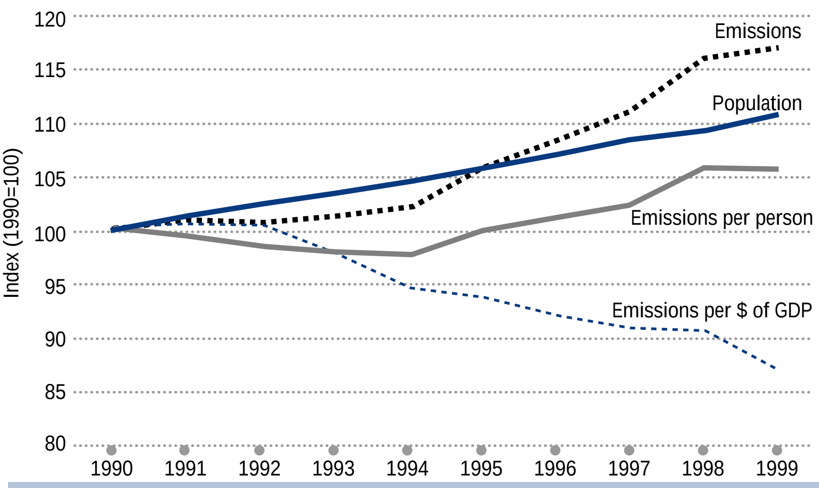
8 One tonne, or 1000 kilograms, of carbon is equivalent to 3.67 tonnes of CO_2.

gas emissions are among the highest in the world (see Turton & Hamilton 2001 and EIA 2000). Australia's high per capita emissions rate has been attributed to a number of factors including:

- with no nuclear power and little hydro-electric power, Australia is faced with greenhouse intensive power generation;
- more than 80 per cent of Australia's exports, including aluminium, steel and agricultural products, are greenhouse intensive;
- Australia is a geographically large country with a relatively small population so people and goods travel long distances and there is less opportunity to take advantage of economies of scale in transport; and
- Australia is still undertaking land clearing (National Greenhouse Strategy 1998, p. 1).[9]

Australia's greenhouse gas emissions, although rising both in absolute terms and on a per capita basis, are declining in relation to Gross Domestic Product (GDP). Emissions increased by 17.4 per cent between 1990 and 1999. However, emissions per person increased by only 5.8 per cent over the period and emissions per dollar of GDP declined by 13 per cent (see Figure 1.1). The latter decline reflects the high growth of the (low emitting) service sector,

FIGURE 1.1 AUSTRALIA: GREENHOUSE GAS EMISSION PER $GDP AND PER PERSON 1990–1999



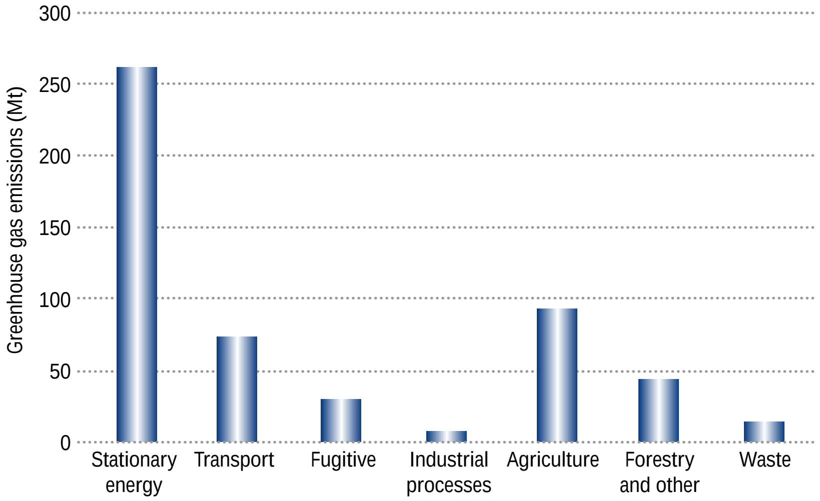
Source Data from AGO 2001.

9 Note that emissions from land clearing have not been included in the estimated emissions presented in the NGGI 1999 due, in part, to the great deal of uncertainty surrounding land-clearing emissions. BTRE estimates that if land clearing were included then the current 'sink' of 26 Mt of greenhouse gas emissions attributed to Forestry and Other would become a positive contribution of 46 Mt.

improvements in the average efficiency of energy use and the relatively small increase in emissions from agriculture.

In general, greenhouse gas emissions reflect energy consumption. In 1999 around 80 per cent of Australia's greenhouse gas emissions (net emissions, excluding land clearing) resulted from the use of energy fuels—coal, petroleum, and natural gas (i.e. from the burning of fossil fuels to produce electricity and to power transport vehicles).[10] Stationary energy, through its heavy reliance on coal, accounted for around half of Australia's greenhouse gas emissions in 1999. In the same period, agriculture contributed 18 per cent of total greenhouse gas emissions and transport around 14 per cent (see Figure 1.2).[11]

FIGURE 1.2 TOTAL EMISSIONS BY SECTOR 1999



Source BTRE estimates including impact of land clearing.

Most emissions from the stationary energy and transport sectors and land-use change take the form of carbon dioxide, while methane accounts for the bulk of emissions from the other sectors. Overall, carbon dioxide constitutes 68 per cent of Australia's greenhouse gas emissions and methane 25 per cent. Most of the growth in greenhouse gas emissions over the last decade has been accounted for by the growth in carbon dioxide emissions.

10 The reduction of 4 per cent in Europe's greenhouse gas emissions between 1990 and 1999 can be attributed in part to the shift from coal to gas during the 1990s, particularly in Germany and UK.

11 BTRE estimates differ from those of AGO, because the former include the contribution of land clearing to total greenhouse gas emissions. Note that the chart includes land clearing.

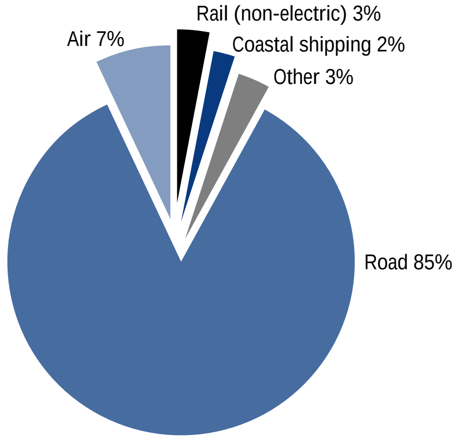
As well as being a significant source of emissions, the energy sector has been characterised by faster than average growth in emissions over the past decade.

THE TRANSPORT SECTOR AND GREENHOUSE EMISSIONS

Greenhouse gas emissions from transport are due principally to the use of fossil fuels—the main transport energy source. Carbon dioxide is the major greenhouse gas produced by transport emissions, with 2.26 kilogram (kg) of carbon dioxide being produced for every litre of petroleum consumed by motor vehicles.[12]

Greenhouse gas emissions from the transport sector increased by 20 per cent from 59.7 Mt carbon dioxide equivalents (CO_2-e) to almost 71.7 Mt CO_2-e from 1990 to 2000.[13] Around 85 per cent of greenhouse gas emissions from the transport sector are due to road transport (see Figure 1.3). Between 1990 and 2000, emissions from road transport grew from 51.5 Mt CO_2-e to 61.5 Mt

FIGURE 1.3 TOTAL EMISSIONS BY MODE 2000



Source BTRE estimates.

12 Product of carbon dioxide emission factor and energy density (BTCE 1995, p. 181, Table V.4).

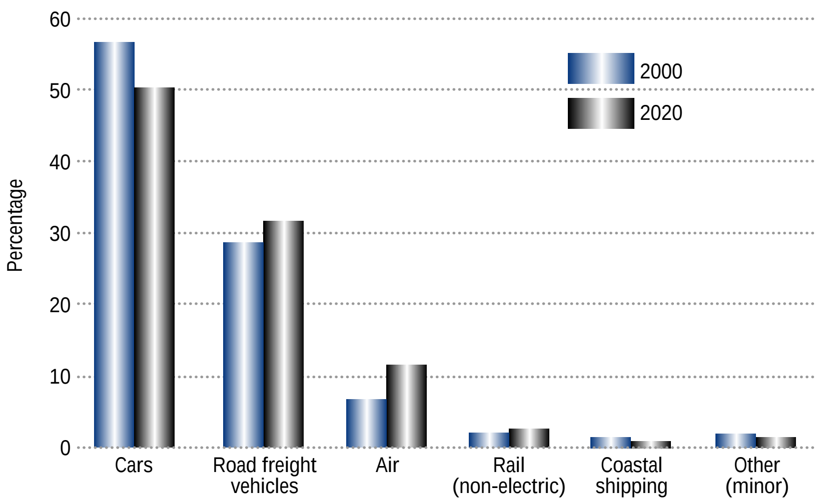
13 BTRE estimate of direct CO_2 equivalent from energy end-use. CO_2-e is a measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP) using carbon dioxide as the base. For instance, the GWP for methane is 24.5. This means that an emission of one million tonnes of methane is equivalent to an emission of 24.5 million tonnes of carbon dioxide (EEA Glossary: http://glossary.eea.eu.int/EEAGlossary/C/carbon_dioxide_equivalent).

CO_2-e—an increase of 19 per cent. Emissions from freight transport grew slightly faster than those from passenger vehicles, reflecting the relative growth in VKT of each vehicle group.

Road

Growth in road emissions is expected to continue as both the population and the economy continues to grow. However, the share of emissions due to cars is expected to decline, as car ownership approaches saturation levels and as emissions from both road freight vehicles and civil aviation grow at a faster rate than those from cars (see Figure 1.4).

FIGURE 1.4 DISTRIBUTION OF TRANSPORT EMISSIONS BY VEHICLE TYPE 2000 AND 2020

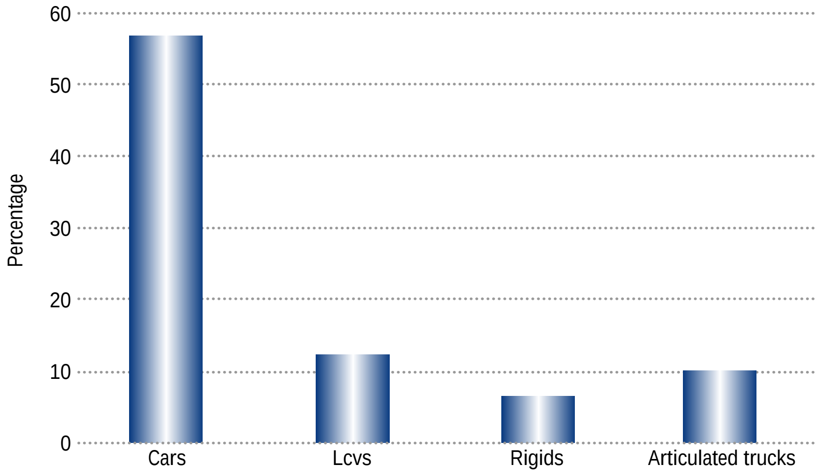


Source BTRE estimates.

In 2000 over half the emissions from road transport were due to passenger vehicles, (see Figure 1.5), reflecting the fact that passenger vehicles accounted for around 60 per cent of on-road fuel use and almost 80 per cent of vehicle kilometres travelled (VKT).

While there have been ongoing technical gains in engine performance, these gains have tended to be offset by increasing demand for larger vehicles and the standardisation of previously optional features such as air conditioning, power steering and automatic transmissions. Some factors that inhibit the improvement in fuel intensity are due to government regulations:

FIGURE 1.5 DISTRIBUTION OF ROAD TRANSPORT EMISSIONS BY VEHICLE TYPE 2000



Source BTRE estimates.

> Competing design considerations also inhibit improvements to fuel economy. In certain cases, fuel economy benefits have been realised, but have been offset by safety features such as air bags and increased emission controls which add weight to the vehicle and reduce its efficiency (Transport Canada 1998).[14]

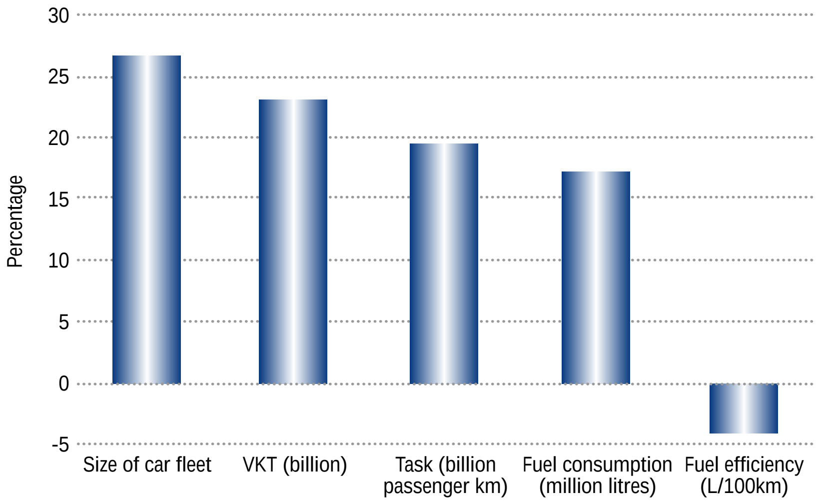
The result is that there has been little improvement over the past decade in the average fuel intensity of cars.[15] Average VKT per car has probably not altered markedly over the last 10 years. The task (measured in terms of passenger-km) has been estimated to have not grown as much as car VKT, since the average occupancy rate has probably declined. This would be in line with trends in other industrialised countries. The improvement in fuel intensity (nearly five per cent—from 12.02 litres per 100 kilometres to 11.47 litres per 100 kilometres[16]) is also reflected in the relatively smaller increase in fuel consumption than in VKT.

14 Between 1985 and 1995 the average weight of all new cars in Europe increased by 20 per cent. On average 10 per cent higher vehicle mass leads to approximately 5 per cent higher fuel consumption values (EVA 1999, p. 69).

15 Fuel intensity refers to the intensity of fuel use and is typically measured in litres per 100 kilometres for road vehicles.

16 In terms of petrol equivalent (BTRE estimates).

FIGURE 1.6 CHANGE IN CAR FLEET CHARACTERISTICS 1990–2000



Source BTRE estimates.

Aviation

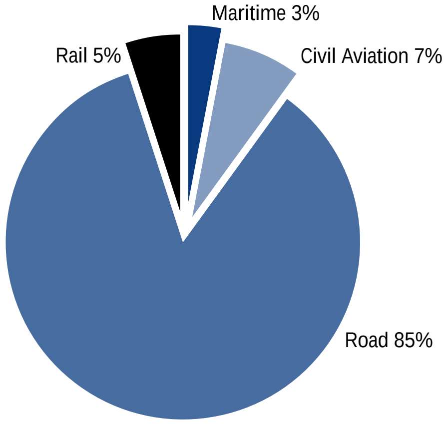
Emissions attributed to air transport, while not a major contributor to total transport emissions, have grown significantly since 1990, almost doubling by 2000.

An issue that complicates estimates of emissions trends from domestic air transport is the treatment of fuel used by international services. If total fuel uplifted in Australia is included in the calculations, the share of emissions attributable to road vehicles declines as the share attributable to air services increases (see Figures 1.7 and 1.8).

Rail

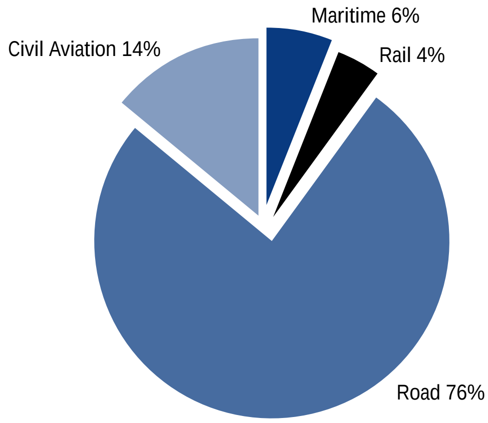
Data for rail emissions in the National Greenhouse Gas Inventory (NGGI) are incomplete as the NGGI covers only diesel powered services. In the NGGI, electricity generation emissions for rail are attributed to the stationary energy sector rather than to the transport sector. The decline in the non-electric rail emissions shown in the NGGI reflects mainly the increasing electrification of the rail network. The BTRE estimates that emissions from rail (including electrified rail) have increased from 3.6 Mt in 1990 to 3.9 Mt in 2000, in line with the growth in the freight task.

FIGURE 1.7 TRANSPORT EMISSIONS BY MODE 2000: DOMESTIC FUEL USE



Source BTRE estimates.

FIGURE 1.8 TRANSPORT EMISSIONS BY MODE 2000: FUEL UPLIFTED IN AUSTRALIA



Source BTRE estimates.

Domestic shipping

Greenhouse gas emissions from the domestic shipping sector are strongly influenced by the level of activity and the energy source—the greater reliance on coal relative to fuel oil, the greater the emissions. The mid-nineties saw a decline in the use of coal and a subsequent decline in emissions. Emissions in 1999 were almost five per cent below their 1990 levels, due in part to an improvement in the overall utilisation of the fleet.

CONCLUSIONS

Given the dominance of the road transport sector as a source of greenhouse emissions, now and into the foreseeable future, the ensuing Chapters 2, 3 and 4 discuss options for reducing greenhouse emissions from this sector. Economy-wide measures discussed in Chapter 5 would affect emission in all transport sectors, as discussed in that chapter and in Chapter 6.

chapter 2

REDUCING VKT

Many policy measures focus on reducing VKT, for a range of reasons including an improved urban environment, reduced congestion and reduced pressure for the expansion of the road network. This chapter reviews those measures. The bulk of the measures are aimed at reducing VKT without impinging significantly on mobility, generally through encouraging more intense use of vehicles. Some measures aim at reducing the demand for travel.

The average vehicle occupancy rate in Australia is around 1.1 persons. In common with many other countries, Australia has experienced a declining vehicle occupancy rate as incomes have grown and the real cost of motoring has declined. A low rate of vehicle occupancy concerns policymakers, not only because it means higher emissions for a given level of passenger kilometres travelled, but also for the pressure it puts on the transport network. Don Pickrell, Chief Economist of the US Department of Transportation's Volpe Transportation Research Center, estimated that increasing vehicle occupancy rate in the US to 1.6 persons per car at rush hour would defer thousands of miles of highway construction and consequently save billions of dollars (Hirten & Beroldo 1997, p. 11).

There are a large number of strategies employed by policymakers to increase vehicle occupancy: encouraging a shift to public transport, assistance for personalised travel planning, facilitating ridesharing programs, and favourable network access and parking charges for high occupancy vehicles (HOVs). A factor that must be considered when considering these measures is the induced travel effect that tends to offset partially any gains in reducing VKT.

INDUCED TRAVEL

Induced travel is defined as the increase in VKT due to the reduced time cost of travel (DeCorla–Souze 2000, p. 17 and Noland & Lem 2000, p. 4).[1] Since

1 By defining induced traffic in terms of an increase in total VKT, traffic diverted from other roads would not be included, unless the diversion involved a change in distance for the trip (see Noland & Lem 2000 for further discussion).

travel time is the major component of variable costs experienced by those using private vehicles (Noland & Lem 2000, p. 2), demand for urban car travel is likely to be more sensitive to changes in travel times than to changes in money costs (Industry Commission 1994, p. 25).

Programs that are successful in generating a mode shift from, say, cars to public transport would reduce the time cost of travel for those remaining. At a lower (time) price, more travel would be demanded.[2] This response is generally referred to as 'induced travel'.[3] While generally referred to in the context of road network expansion, induced travel could be expected to occur whenever the time costs of travel decline, regardless of the cause of the decline.[4]

The sources of induced travel are:

- increased usage by current patrons;
- shift from other modes; and
- new traffic, say, through suburban expansion.

The significance of induced travel depends on a range of local factors and the time period considered. Estimates vary widely from a 10 to 50 per cent offset in fuel savings, with 20 per cent representing the middle of the range (TRB 1997, p. 117).

Induced travel would not be considered a negative in economic terms, because it satisfies a pent–up demand, benefiting those that engage in the extra travel. However, the emissions from the induced travel reduce the greenhouse benefits of many measures that are aimed at reducing VKT.

PUBLIC TRANSPORT

In Australia, motor vehicles account for around 93 per cent of passenger kilometres, with public transport and non–motorised transport accounting for the remainder (BTCE 1996b). In line with many other developed countries, Australia has experienced a long–term decline in per capita public transport ridership in most urban areas. Public transport's share of the urban commute

2 This increase in the quantity demanded as the price declines goes some way towards explaining the 'fixed travel time budget' that many analysts observe. Newman and Kenworthy 2000, (p. 21) noted the tendency for commuting times to adjust to around 30 minutes on average in all cities independent of how well they are provided with transport infrastructure.

3 The term 'generated traffic' or 'generated travel' is often used in the UK.

4 There is also a history of debate over the existence of induced travel and its policy significance. For many years, the UK Department of Transport used a procedure for road planning firmly based on the assumption that new road capacity did not lead to any increase in the total volume of traffic (Goodwin 1996, p. 148).

in Australia currently accounts for less than 10 per cent of urban trips in Australia, from around 30 per cent of all trips in Melbourne in 1950 (Cox 2000). Although, relative to other Australian cities, the decline in ridership in Melbourne was not so large over the decade to 1994 (see Table 2.1). In western Europe, per capita public transport ridership is declining in most areas. In the US, public transport's work trip market share declined from 7.1 per cent to 4.3 per cent between 1980 and 1995 (Urban Transport Fact Book 1996).

TABLE 2.1 PER CAPITA PUBLIC TRANSPORT RIDERSHIP IN FIVE AUSTRALIAN CITIES: ANNUAL PASSENGER JOURNEYS (LINKED TRIPS) PER CAPITA

	1984	*1994*	*Change*
Adelaide	74.8	56.2	-24.8%
Brisbane	72.8	64.0	-12.1%
Melbourne	99.4	93.1	-6.4%
Perth	65.4	54.4	-16.8%
Sydney	178.3	155.4	-12.8%
Total	119.0	103.3	-13.2%

Source Urban Transport Fact Book 1996.

The two main options on the supply side to encourage a shift to public transport are lower fares and better services.

In many countries, including Australia, concessional fares are available to students. Under a notable program in the US, Unlimited Access, students from more than 50 colleges and universities have fare–free access to public transport service in return for an annual lump sum payment from the university to the public transport agency of around US$30. Unlimited Access has been credited with increasing student public transport ridership between 71 per cent and 200 per cent during the first year and between two per cent and 10 per cent per year in subsequent years (Brown et al. 2001). This has reduced operating cost per rider for public transport operators, facilitating improvements in operating frequency. Similarly, in many Australian States, the value of student concession fares are reimbursed to public transport providers by the State Government.

Authorities in many countries, including Australia, have pursued cost reductions through replacing government monopoly provision of public transport with competitive tendering of services according to public specifications. Melbourne, Adelaide and Perth have completed conversions to competitive tendering. Increased patronage can be a condition of the contract, such as in the case of the Melbourne tramway where the target is set at a 60 per cent passenger growth in five years.[5]

5 For more details of the international trends in competitive tendering in public transport see Cox and Duthion 2001.

More commonly, public transport authorities seek improvements that go some way to matching the service characteristics that drivers want: frequency of service, speed, convenience (proximity plus easy access to fare and timetable information), safety, security and comfort.[6] The European Commission's 2001 White Paper on transport identified the need to:

> … make the alternatives to the car more attractive in terms of both infrastructure (metro lines – trams – cycle tracks 97 – priority lanes for public transport) and service (quality of service, information given to users). Public transport needs to achieve levels of comfort, quality and speed that come up to people's expectations (EC 2001, p. 88).

Operational improvements such as dedicated bus/taxi lanes and priority at traffic signals are ongoing in all Australian cities. Most cities have instituted performance measures to monitor the quality of service provision.

Smart Bus trials are under way in Melbourne, involving more frequent service, improved reliability, provision of real time information at bus shelters and better connections with other transport services.[7] Trams have exclusive rights of way and Citylink reserves one lane for buses and trucks during peak hours. The Brisbane bus prioritisation program includes the provision of an inner–city bypass and a 200–kilometre system of busways (Soon & Hu 1999, p. 102).[8] In New Zealand, public transport authorities in Auckland are installing Global Positioning System (GPS) guided system that will ensure traffic lights turn green on the approach of a bus.[9]

Increasing public transport use is one of the aims of the integrated transport plan for Sydney, Action for Transport 2010. One of the measures to pursue this aim is the construction of seven rapid bus–only transitways, with the Parramatta to Strathfield link due for completion in 2002.

At the international level, recent improvements in Zurich have been aimed at providing a range of high quality services through:

> … a very wide network, lines serving residential areas–particularly with zone buses, high frequency (even at night and out of rush hours), tram tracks separated from general road traffic, priority to transit vehicles when arriving at traffic lights, special fares praised by very efficient advertising campaigns,

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6 Advances in communication technology will be adopted increasingly to improve bus operations. For instance, incorporating global positioning systems into bus operations at http://icbirmingham.icnetwork.co.uk/0100news/0100localnews/page.cfm?objectid=11349635&method=full

7 For background and detail see Victoria Department of Infrastructure at http://www.linkingvictoria.vic.gov.au/doi/internet/transport.nsf/headingpages-display/linking+victoriasmart+bus?opendocument#what.

8 Australia is reported to be among the most advanced countries in the world in the field of computerised signal timing (Soon & Hu 1999, p. 106)

9 See http://onenews.nzoom.com/news_detail/0,1227,80965-1-7,00.html.

environment friendly tickets, rainbow passes, reduced fares for youths, combined passes for special events (EPE n.d.).

In London, Transport for London (T*f*L) has been established to develop an integrated transport strategy and to 'modernise' public transport. T*f*L currently includes London Buses, London River Services, Tramlink, Docklands Light Railway, Public Carriage Office (responsible for taxi and private hire vehicle licensing), Street Management and Victoria Coach Station. It is planned that London Underground will come within the ambit of T*f*L.

Light rail systems have been developed in many metropolitan areas in the US over the past decade. Other technologies, such as the guided French–made Civis hybrid buses, are to be trialed in the Las Vegas area in 2002 in the hope of achieving the speed and convenience of light rail at a fraction of the cost of development.[10]

Improved services can be anticipated from the range of technical improvements that are in the pipeline. Advanced Public Transportation Systems (APTS) have the potential to transform public transportation through improving safety, punctuality, information provision and quality of service. The three main components of APTS are traveller information systems, electronic payment systems, and fleet management systems.[11]

Increasingly, public transport operators in Australia and overseas are providing patrons with access to real–time service schedules through telephones, personal computers, mobile phones, pagers, hand–held computers, cable television variable message signs, and information kiosks.[12] Prototypes of public transport information kiosks in London will offer journey planning, timetabling facilities, real–time bus timekeeping, parking space information, local news and free email.[13]

As of June 2000, there were 170 public transport information systems in use in Europe as well as more than 600 Internet web sites providing information for public transport users.[14] Systems such as NextBus system, introduced by the Washington Metropolitan Area Transit Authority in September 2001, uses

10 For more details see http://www.lvrj.com/lvrj_home/2000/Oct-23-Mon-2000/news/14594926.html.

11 Intelligent transport systems (ITS) are reviewed separately as they also have a significant impact on other modes of transport.

12 Casey, R, Volpe National Transportation Systems Center, http://www.transact.org/Progress/may01/transit.htm.

13 Local Transport Today, 28 June 2001, Issue 318, p. 7.

14 For an overall view of telematic-based public transport information systems in operation or in the process of being implemented as of June 2000 see http://www.ul.ie/~infopolis/existing/index.html.

satellite and global positioning system (GPS) technology to track buses' progress with 95 per cent accuracy.[15]

The introduction of electronic payment systems, through magnetic stripe cards, smart cards or hybrids containing both a smart card and a magnetic strip, can reduce collection costs and make fare payment more convenient for travellers.[16] Interoperability between public transport systems allows travellers to access all public transport services within a region with a single payment card.[17] Furthermore, these systems can help public transport managers gather real–time data on travel demand to improve planning and scheduling.

Fleet management systems have benefited significantly from advances in communications and computer technology. Improvements that will enhance service provision and make public transport more attractive to travellers include:

- wireless public transport communication systems—generally wireless communication between public transport vehicle and public transport agency;
- geographic information systems (GIS);
- automatic passenger counters providing more reliable and lower–cost data on which to design service provision;
- traffic signal priority systems technologies to enable faster, more reliable public transport service and reduced operational cost; and
- automatic vehicle location systems.

Environmental impact of enhancing public transport

Enhancements to public transport could result in a mode shift and, in turn, in a reduction in VKT and lower greenhouse emissions. Equally, increased assistance to public transport may produce no beneficial impact on greenhouse gas emissions.[18] Much depends on the mode shift achieved, the source of any increased patronage, the environmental superiority of public transport and the significance of the induced traffic effect.

Shifting solo drivers out of cars into public transport is no easy task. Research suggests that the propensity to shift is low. The cross–elasticity of car demand

15 For more details of the NextBus system see http://content.snv.omnisky.com/content/nextbus.pqa/mini_about.html.

16 *Very* smart cards search for the lowest fare for which the traveller is eligible.

17 As of the end of July 2001, no US cities had fully implemented a regional smart card program for public transport.

18 Increased assistance may not involve expenditure. Prioritisation systems for public transport are, in effect, a tax on other traffic and an increase in the effective subsidy for public transport.

with respect to bus and train fares appears to be less than 0.10 (IPART 1996, p. 35, Luk & Hepburn 1993, p. 15). In other words, a 10 per cent decrease in public transport fares would be expected to lead to slightly less than a one per cent reduction in car travel.[19]

Wootton asserted that it is wrong to assume that 'improved public transport services will satisfy people's travel demand, persuade them out of their cars and solve the problems of congestion and pollution' (Wootton 1999, p. 161). The reluctance to shift reflects the same factors that have contributed to the decline in public transport's role: growing affluence and changing demographics. Rising incomes and falling car prices have made possible a much greater geographical separation of home, work and shopping. This suburbanisation of both living and working locations has led to decentralised travel markets that are not well served by the conventional forms of public transport.

As the Industry Commission concluded:

> … the drop in public transport patronage throughout Australia is partly a reflection of the declining relevance of existing radial [without the cross connections of the spider–web pattern] transport services in meeting many people's needs (IC 1994b, p. 421).

Corridor systems characteristic of public transport services are effective for journeys in and out of the city centre, but provide limited access to the suburbs unless both starting and ending destinations happen to lie on a corridor (Lowson 1999, p. 14).

Suburbanisation, a long–term trend in many countries, is characterised by lower population densities that reduce the viability of public transport. As noted by Cox (2001) 'virtually all urban growth in major European cities has been in the suburbs over the past 40 years'. In the US in 1990 more than 60 per cent of US employment and two thirds of US office space were located outside urban centres (Cox and Love 1993). While, public transport's CBD (central business district) work trip market share in Sydney (including North Sydney and Haymarket) is 65 per cent, this area now represents less than nine per cent of the Sydney area's employment (Cox 2001 quoting Troy and Smith). The other two largest employment centres, Chatswood and Parramatta, account for approximately one per cent each.

Work hours, patterns and locations are also becoming increasingly flexible, to the detriment of public transport usage. The daily commute to work, the trip generally most suited to public transport, represents a declining share of total travel. The Transport Data Centre (2000, p. 3) estimated that for Sydney, commuting trips represent only 15 per cent of all travel and only 27 per cent of trips undertaken in the peak period. Also, the growth of two income families and increasingly complex daily travel patterns have contributed to the

19 For details of other relevant studies see BTRE Elasticities Database at http://dynamic.dotars.gov.au/btre/tedb/index.cfm.

long–term drift away from public transport towards the use of private motor vehicles (O'Toole 1998).

Many US cities have constructed or are planning light rail systems with the hope of attracting commuters from cars to reduce air pollution and traffic congestion. While light rail attracts strong federal funding support in the US, it has also come in for heavy criticism. Observers have questioned whether the building of new urban rail systems has reduced traffic congestion. Cox observed that:

> … it is typical for promoters to claim that light rail will carry the same passenger volume as six or even 12 lanes of freeway/motorway traffic. This is specious and misleading, in view of the fact that the average new light rail line in the United States carries barely 20 percent of the volume of a single freeway/motorway lane.[20]

Cox and Love (1993, p. 2) argue that in the US no metropolitan area that built or expanded urban rail systems in the 1980s experienced an increase in public transport's market share).[21] Research by the US Department of Transportation (DOT) indicates that new urban rail systems have generally cost more than anticipated to build, cost more than anticipated to operate, and carried far fewer riders than planned (Cox and Love, 1993). The same DOT study estimated the cost of each new rider attracted to a rail system ranged from US$4,800 to US$17,700 annually.

In brief, it is the 'increased travel complexity' typical in our community that discourages the use of public transport (see also Cervero 1999, p. 69). As the value of time rises, time savings become increasingly important. Dudson (1998, p. 109) reported that in Europe, those who commute by car save one hour per day. In 1993, a conference of European ministers of transport observed that 'the return to the era when public transport played a significant role is unlikely since conditions have changed so dramatically' (ERCa 1995).

An increase in patronage of public transport does not necessarily mean a reduction in fuel use. More fuel may be used carrying additional passengers who previously walked, or who were car passengers, than is saved by the number of car drivers attracted to use the bus. Philipson and Willis (1990, p. 627) found that, while free public transport for Adelaide (a 100 per cent reduction in fares) would probably result in a 30 per cent increase in patronage, only around half of riders are likely to come from cars and even less would have been drivers. Hence, it was estimated that car trips would decline by considerably less than two per cent.

Modelling by the Bureau of Transport and Communications Economics (BTCE) indicated that, if peak period public transport fares were reduced by 80 per cent

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20 Cox, March 2000, http://www.publicpurpose.com/pp-railpol.htm.

21 Despite an opening of a new light rail line in Portland, Cox and Love (1993, p. 2) report that 'passenger transport's work trip market share decreased 33 per cent'.

(i.e. to 20 per cent of normal levels), commuting travel by private cars would fall by 12 per cent, reducing emissions from passenger transport in urban areas by 4 per cent (1996, p. 261). However, key assumptions in this model may no longer hold—in particular, that there is excess capacity in the public transport network during peak periods.

The load factor for public transport is critical in determining whether fuel usage per passenger–kilometre is higher with private transport than public transport. Fuel use and greenhouse gas emissions per passenger–kilometre for public transport would vary considerably depending on factors such as location, time of day, whether average or marginal emissions are being considered and whether they consider full fuel cycle energy use.

If full fuel cycle energy use were taken into account, emissions from electric trains or trams would depend on the source of the electricity.[22] If patronage were increased through expansion of transport services, this would lead to increased fuel use. The Vice President of the International Association of Public Transport (Union Internationale des Transports Publics—UITP) has observed that:

> … public transport can be improved in a variety of ways but, all other things being equal, providing more service will lead to more fuel consumption, which in turn will result in greater CO_2 emissions (Bayliss 2002, p. 10).

While Bayliss focussed on bus services, caution should also be observed when assuming greenhouse gains from passenger rail. While an average commuter train may generate less greenhouse gas emissions than urban cars per passenger kilometre, it is often only during peak hour that these trains are at capacity. As with buses, there will be times when their operations produce higher emissions per passenger kilometre than cars.[23]

The sustainability of any reduction in greenhouse emissions as a result of a mode shift to public transport would also depend on the induced traffic effect, as previously discouraged traffic takes the place of those diverted to public transport.

Even if there were a sustained reduction in VKT due to the shift from SOVs to public transport, the impact on greenhouse gas emissions may be minor. At the low end of the estimates, Dudson (1998, p. 108) observed that:

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22 Electrically powered rail may contribute to greenhouse gases at the source of power generation. Even ‘green’ sources of power such as hydroelectricity can contribute to global warming through the release of carbon monoxide and methane generated by decaying vegetation (New Scientist 3 June 2000, vol. 166 no. 2241 p. 4).

23 Research by the US Congressional Research Service indicates that inter-city rail is becoming the least efficient fuel mode. See http://www.publicpurpose.com/ic-amtrakfuel.htm.

> … even if efforts to increase ridership were successful and patronage doubled, and, even in the more improbable event that the increase was from diverted motorists, greenhouse gas emissions would be reduced by only 0.6 per cent.

Dudson's conclusion follows from the fact that public transport accounts for a very small proportion of all urban trips (three per cent in the US), so that a mode shift that doubled total public transport patronage would have minimal impact on total urban car emissions. Also, some of the 'mode shifters' would come from multiple–occupancy vehicles.

If the findings of researchers such as Howitt and Altshuler (reported in Gómez–Ibáñez et al. 1999), that investments in public transport have generally had minimal impacts on air quality hold for Australia, then they are unlikely to have an impact on fuel use and greenhouse gas emissions.

Efficiency impact of enhancing public transport

From an efficiency point of view, motor vehicle use is not inherently 'bad' or public transport use inherently 'good'. There will be an optimal mode share that would fluctuate over time and would be generated when the marginal costs and benefits faced by individuals reflect those faced by society.

Public funding of public transport is generally based on access and service provision rather than on efficiency considerations such as correcting for market failure.[24] However, there are two efficiency arguments commonly advanced to support a role for subsidising public transport. There is an argument that the existence of economies of scale in some user costs provides a case for subsidising public transport (Tisato 1997, p. 329). User economies of scale arise from the increased frequency that follows from a growth in patronage. In other words the growth in patronage creates external benefits for other users in the form of greater frequency of service. Tisato concludes that 'as in all cases of economies of scale, efficient pricing at marginal social cost will result in a financial deficit and a need for a subsidy' (1997, p. 330).[25]

24 Doubt has been cast on the case for subsidising public transport to help the disadvantaged. The Industry Commission noted that there are many disadvantaged people who are not beneficiaries of the public transport subsidies and that subsidies for public transport generally 'boost the income of the more affluent by virtually the same proportion as those who are less well off' (IC 1994a, p. 197).

25 However, economies of scale are a feature of many operations, few of which are championed as cases for government assistance. Also, establishing market failure is only half of the equation—there is also a need to establish that government intervention with its inevitable complications, would produce a more efficient outcome.

The second and generally more prominent argument relates to the absence of appropriate road pricing and the tax treatment of private motor vehicles. To the extent that these two considerations mean that the marginal cost of travel faced by private vehicles is less than the social marginal cost of travel, then there would be an 'overuse' of private cars from society's point of view. If it were not possible to correct these distortions by charging directly for road use and by removing distorting tax concessions then, theoretically, there would be scope to achieve a second–best improvement by providing a similar subsidy for any close substitute, such as public transport.

However, more accurate road user charges are possible. Furthermore, there is considerable debate over whether motorists experience a net subsidy or a net tax, after account is taken of all taxes on motor vehicle purchase and use. Even if a net subsidy were assumed, this would need to be compared to the subsidies inherent in the public transport system.[26] In Australia, fares in the urban rail passenger system only cover a small proportion of the cost of service provided (PC 2000, p. 265). For instance, the average fare paid by passengers per journey in the urban rail network in Brisbane was approximately $1.45 in 1997–98, while the average subsidy per passenger journey was approximately $7.90 (ibid.).

The issues involved in determining the optimal level of funding for public transport are complex and it is difficult to unravel the funding that may be provided to offset market failure from that provided for access and equity purposes.[27] Funding to public transport is rarely subjected to close scrutiny. As observed by Samuel (1999), 'cities heavily subsidise public transport trips and make large investments in public transport infrastructure without –any expectation of financial return on the investment'.

The efficiency gains or losses associated with an increase in assistance for public transport would need to be determined on a case by case basis. However, efficiency gains may be available through the continued restructuring of public transport and through removing barriers to the more efficient operation of public transport.

The President of the National Competition Council (NCC) observed;

> There is some recognition of the need for greater competition in the delivery of urban passenger transport services. The issue is not so much about ownership, whether public or private, but more about the level of competition and accountability within the system (Samuel 2000, p. 1).

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26 BTCE (1995) discusses the difficulties of separating the subsidy component of rail from the community service obligations such as concessionary fares for pensioners.

27 Amos and Starrs (1984) proposed that about half of the subsidy for public transport in Adelaide in 1981–82 could be justified on the basis of externalities (excluding environmental externalities that were not quantified).

Also, institutional barriers in the form of the UK Competition Act could prevent the implementation of through–ticketing because the level of cooperation that is required between operators could be regarded as collusion.[28]

Other ways to promote public transport

Public transport can be promoted indirectly by removing or reducing barriers to its use. Two factors that are regarded as inhibitors to the use of public transport are the relatively favourable tax treatment given to cars (mentioned above) and the institutional constraints that significantly increase the cost of personalised public transport.

Relative tax treatment of commuting options

There is a widely–held view that the tax treatment of private vehicles relative to more environmentally–friendly public transport is unfair and damaging to the environment:

> The Commonwealth's fringe benefits tax sends a very decided signal. An executive living in Turramurra for example, who drives to the CBD every day and notches up another 15,000 kilometre [per annum] on weekends … can get an annual tax break from the Federal Government of around $5000 a year for his or her upmarket company car. An office worker from western Sydney who takes the train into the city receives no tax benefit at all (Carr 1999).

Since around half of new car sales are fleet purchases and salary packaging covers other cars, through arrangements such as novated leases, the concessionary tax treatment impacts on a significant share of the light vehicle fleet.[29] Similar salary packaging incentives apply in other countries. Some countries, such as Germany and the Netherlands, have traditionally provided tax benefits for commuters using both private vehicles and public transport. New rules were introduced in the Netherlands, removing the commute benefits for solo drivers from January 2001, while maintaining it for public transport, bicycles and carpools (DTLR 2001, Ch. 4).

Shoup and Willson (1992a) examined options for extending employer–provided benefits to public transport and concluded that the preferred strategy would be to offer employees a choice of cash or a public transport 'voucher' equivalent to the benefits associated with cars.

In the US, under the federal Transportation Equity Act for the 21 Century (TEA–21), an employer can provide a farecard voucher (Metrochek) to their employees as a commuter benefit for public transport or vanpools. The monthly commuter benefit can be any amount the employer chooses to provide,

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28 Source: *Rail Business Intelligence*, No 168 14 Feb 2002.

29 For more information on novated leases see http://www.gefleet.com.au/faqs.html.

although a maximum of US$100 per month ($1,200 per year) is allowable tax–free or pre–tax to employees.[30] In Washington, the Metrochek vouchers are not confined to public transport and are accepted by more than 100 different transportation organisations (including trains, buses and vanpools) throughout the region.

Taking the program a step further, some employers in the US are offering *fully* subsidised public transport benefits to employees. The Des Moines Metropolitan Transit Authority (MTA) operates an Employer Support Program (ESP), enabling participating employers to offer a tax–free subsidy for their employees who use public transport for their commute. Currently, around 50 organisations in the Des Moines area participate in this program and pay up to 100 per cent of their employees' monthly public transport fares.[31]

More mode–neutral tax treatment of private and public transport could see some mode shift since a significant proportion of vehicles would be impacted—fleet sales account for almost half of new passenger car sales.[32] In those areas where private and public transport are close substitutes, a more mode–neutral tax treatment would avoid distorting choices and the efficiency losses associated with them.

Encouraging more flexible public transport alternatives

Public transport goes beyond buses, trains, trams and ferries, to include any transport available for public hire. Institutional factors that limit competition in the public transport market may increase its cost and/or service level, and hence, discourage its use. Restrictions in the taxi market and the associated curtailment of the hire car industry are being increasingly subject to scrutiny both in Australia and overseas. If, for instance, more liberal taxi licensing led to taxi fare reductions and a greater availability of taxis, then there could well be a reduction in private car ownership in urban areas, as taxis and taxis plus mass public transport options became competitive options. In general, reduced car ownership results in reduced driving—the result of shifting some of the fixed costs of car use to variable costs (Shaheen et al. 1998, p. 47).

Most of Australia's states and territories have a range of laws that regulate taxis, beyond those that are necessary to ensure that taxis are safe and provide a minimum standard of service. Taxi numbers are generally constrained by requiring each taxi to have a licence and limiting the number of licences issued,

30 For details on Metrochek see http://www.wmata.com/riding/metrochek/metrochek.cfm#What%20is%20Metrochek?

31 For further details see http://www.dmmta.com/ESP.html.

32 DISR, Key Automotive Statistics 2001, Figure 1.2.2, available at http://www.disr.gov.au/industry/auto/KAS/2001/kas2001html.doc?ois=y.

with the result that most people requiring a taxi licence must purchase it from an existing licence holder.

The main impact of these restrictions is higher fares than otherwise and the reduced availability of taxis—most noticeable during periods of peak demand. The National Competition Council (2000, p. 2) reported that restrictions on taxi licences add around a third to the average taxi fare. The Productivity Commission (1999b, p. ix) estimated that, for Sydney alone, the cost of entry restrictions on users of Sydney taxis is in the order of $75 million per year—a cost that studies show is borne most heavily by low–income households.

These costs would be manageable if they were justified by the benefits. However, this does not appear to be the case. The Productivity Commission observed that, despite the cost being so significant, there was no evidence of offsetting benefits. Accordingly, it considered that there was a strong case for the removal of such restrictions (PC 1999b, p. ix).[33] The National Competition Council observed that 'in contrast to the laws that regulate minimum safety and quality levels, restrictions on the number of licences, and therefore the number of taxis, have no benefit for the community' (NCC 2000b, p. 1). The NCC concluded that no compelling argument could be made to justify the licensing restrictions on taxis and that the need for comprehensive taxi reform was urgent (NCC 2000b, p. 6).

A number of countries such as Japan, Sweden, Ireland, New Zealand, South Korea, UK and many cities in the US have moved towards deregulation of the industry.[34] However, deregulating taxis is not without controversy with some cities in the US reporting a deterioration of services.

The Dutch Government has scheduled a series of reforms for the taxi industry whereby the number of restrictive rules will be reduced and the system of local quotas for the number of taxi licences is to be abolished. Competition is to be encouraged among taxi firms through the setting of a national maximum charge.[35]

In Sweden, deregulation has involved removing controls over:

- fares (although drivers are required to inform customers about the fare prior to trips, and taxicabs must be equipped with receipt writing meters);
- the number of taxi licences;

33 These recommendations were accompanied by a discussion of compensation and adjustment assistance for licence holders.

34 Deregulation has not always been satisfactory. For a recent review of taxi deregulation around the world see Kang (1998). For wider reading on the subject see *The Revolving Door of Regulation,* http://www.taxi-l.org//papers.htm#deregulation.

35 For further details see http://www.minvenw.nl/cend/dvo/international/english/summaries/eng1297.html#Fewer%20rules%20for%20taxi%20transport.

- the requirement for all taxicabs to belong to a radio booking centre;
- geographical areas; and
- operating hours.

In conjunction with these moves, regulations governing the qualifications of drivers have been broadened.

In Quebec, taxibuses have been established as complements to traditional bus services (Trudel 1999). The 'taxibus, available on a one–hour notice, becomes a public transport service that can stand up to any possible comparison with conventional bus transportation service' (Trudel 1999, p. 125). Overseas, a number of cities have 'taxibus' services that can multiple–hire and have greater route flexibility than a bus, but at a lower cost than a taxi.

Restrictions on taxis have been reviewed in most Australian states. The Northern Territory has removed restrictions on the number of taxi licences, although fares are yet to fall as the taxi plate buy–out was funded by a tax on fares. A 'Maxi–taxi' service operating on the Queensland Gold Coast is covered by flexible rules that allow 'door–to–door' service, shared rides and complete delivery of accessible services (Soon & Hu 1999, p. 100).

Impact of encouraging more flexible public transport alternatives

There would appear to be prospects of efficiency gains from replacing the current prescriptive regulations on taxis and hire cars with 'light regulations' covering, say, safety of passengers and the provision of information regarding fares and conditions.[36] Deregulation is likely to encourage the growth of the more flexible forms of transport that many, including Lowson (1999), argue are required to meet the fundamental need for 'anywhere–to–anywhere transport'. Mees (2000, p. 45) observed similarly that 'if public transport is to play a part … it will need to offer service to a wide range of destinations at a range of times, while achieving high occupancies'.

Commenting on the Canadian experience, Litman observed:

> … regulatory reform involves changing motor carrier and taxi regulations to encourage competition, innovation, diversity and efficiency in the provision of transportation services. Many jurisdictions have rigid restrictions on transportation services. Firms attempting to introduce a new transportation service, such as commuter express buses, shuttles and jitneys or shared taxies, are often prohibited altogether or face excessive regulation. Taxi service is often highly regulated in ways that limit consumer choice and affordability (VTPI TDM Encyclopedia, n.d.[37]).

36 Gregg (*Canberra Times*, 31 May 2000) outlined a possible approach for deregulating the ACT taxi industry.

37 http://www.vtpi.org/tdm/tdm53.htm.

A significant barrier to the growth of demand–responsive vehicles could be the absence of the subsidies that characterise the traditional forms of public transport. The taxibus system in Quebec receives a government subsidy up to 40 per cent of its revenues. This appears to be a proverbial 'win–win' situation as the service provided is superior to that provided by a standard bus service and the subsidy is less. Another option for assisting the 'transport disadvantaged' would be to fund vouchers for low income earners that could be used with a wide range of transport options, including taxis, minibuses and possibly car rentals.

The fiscal implications of encouraging greater competition within public transport depend on the compensation arrangements put in place. There are arguments for and against full compensation for the removal of taxi licensing restrictions. One pragmatic approach is that adopted in the Northern Territory where full compensation was paid, financed by taxi users through fares.[38]

PERSONALISED JOURNEY PLANNING TECHNIQUES

Personalised journey planning involves the provision of individualised analysis and advice to people, with the principal aim of achieving a mode shift. The two programs utilised in Australia have been Travel Blending® and TravelSmart®.

Travel Blending was developed by Steer Davies Gleave and Monash University for the NRMA as a tool for reducing air pollution prior to the 2000 Sydney Olympic Games (Tisato & Robinson 1999, p. 688). It is based on the premise that through better informed decisions people can rely less on motor vehicles and more on blending modes of travel. The process involves an initial contact with people to determine whether they have potential to modify their travel behaviour to use more public transport and are interested in doing so. The next step involves providing:

- a simple way of recording their travel behaviour (travel diaries);
- a set of ideas for changing their behaviour, customised for each individual person in the household, and including measures such as combining and chaining car trips and making use of transit walking and cycling where appropriate; and
- a simple system of monitoring any changes they make (Steer Davies Gleave 1999).

TravelSmart is a community–based program developed by the Western Australia Department of Transport using IndiMark® to encourage people to use alternatives to travelling in their private car.[39] IndiMark is a direct

38 Kenny and McNutt (1998) cite a significant legal precedence for limiting the extent of such compensation payments. Rimmer and Fleming (2000) provide an analysis of the issues involved in government compensation payments.

39 TravelSmart homepage is located at http://www.travelsmart.transport.wa.gov.au/.

marketing method aimed at travel behaviour change—usually in favour of public transport.[40] The Perth Metropolitan Transport Strategy has set a target of reducing by one-third car–as–driver trips by 2029 (from 4.7 million to 3.1 million). Following a pilot program in 1997, a large–scale project was implemented in south Perth involving over 15,000 households. The current commitment is to expand the program across half of the Perth Metropolitan Region, involving 600,000 residents at an estimated cost of $26 million.[41]

Impact of personalised travel planning

To the extent that people are making poor transport decisions due to lack of information or because they fail to adequately consider the alternatives, personalised travel planning could induce a shift away from solo driving. The Travel Blending trials conducted in Adelaide and Sydney recorded significant reductions in car use among those that persevered in the program. A study of 329 households in Adelaide saw a reduction of 17 per cent in VKT (Tisato & Robinson 1999). While there were pollution reduction benefits from this trial, they were of ‘relatively small magnitude’ compared to the other benefits (Tisato & Robinson, p. 697). Tisato and Robinson estimated a range of benefit–cost ratios for the Adelaide trials, all of which were significantly greater than one (1999, p. 701), indicating that travel blending has the potential to score well on efficiency grounds.

TravelSmart trials in Perth recorded a 17 per cent reduction in VKT, an increase in walking by 16 per cent, cycling by 91 per cent and transit by 21 per cent (Brög et al., 1999, p. 562).

Other trials have not produced such encouraging results. A trip–reduction pilot program in Denver used a pilot group and a control group to isolate the impact of the training in trip reduction strategies from external factors (Higgins 1995, p. 37). The results indicated a reduction in trip numbers for the pilot group compared to the control group. However, there was no change in solo driving, VKT or cycling that could be attributed to the program. An increase in cycling occurred in both pilot and control groups, suggesting that it was due to some outside influence such as a regional promotion. ‘The increase in walking was the only increase in alternatives to solo driving apparent due to the pilot program’ (Higgins 1995, p. 38).

In a review of the effectiveness of personalised travel planning, the Department of Transport and Local Government and the Regions (DTLR) concluded:

40 IndiMark was developed in Europe in response to the limited success of general marketing of public transport.

41 See TravelSmart successes at http://www.travelsmart.transport.wa.gov.au/pdfs/highlights.pdf.

> … it is apparent that while there is evidence to suggest that this type of approach can be very effective in changing travel behaviour, there is, as yet, no conclusive pattern emerging as to when and where it is most useful. This highlights the complexity of processes leading to travel behaviour change, and our only partial understanding of those processes (DTLR 2002).

The encouraging results produced by some initiatives, such as TravelSmart in Perth, relate principally to the increased use of public transport. As discussed in the previous section, the link between higher public transport use and reduced greenhouse gas emissions has not been empirically verified. Also, the results appear to relate only to those participants who passed the initial screening stage and who then maintained their participation in the program until the final stage. Hence, assuming that the results are replicable across the wider community could produce overly optimistic expectations.

Following an extensive review of personalised travel planning techniques the UK Department for Transport, Local Government and the Regions (DTLR) concluded that programs worked best where there was a gap between the perception of public transport services and the reality:

> For public transport , where services and travel quality is much higher than is perceived, personalised approaches can have very large effects, but where such a gap does not exist the travel behaviour effects could be negligible (DTLR 2002, Summary p. 8).

Overall, the DTLR concluded that, in terms of the principal aim of encouraging a mode shift, the number of personalised journey planning techniques that have been implemented is 'not great enough to allow a full evaluation of effectiveness' (DTLR 2002 ch. 8). Further, it was argued that until more trials were conducted the DTLR argued that it was inappropriate to generalise about the potential impacts of these initiatives in new contexts.

As far as efficiency is concerned, an element of co–payment by the principal beneficiaries—the public transport operators and the program participants—would provide a market test of whether the benefits exceeded the costs. Without this, the assumptions adopted in any evaluation (such as no cost attributed to the extra value of time involved in 'blended travel') will determine the outcome. Without some financial contribution from the individuals that benefit from the program, it would be difficult to determine reliably how the information provided by the personalised travel program is valued.

The fiscal impact of personalised travel planning initiatives would depend on the structure of the programs and how the programs were funded. To date the travel blending projects carried out in Australia have been taxpayer funded although scope appears to exist for co–payment.

RIDESHARING

Ridesharing generally refers to an established arrangement where two or more people travel on a pre–arranged regular basis, often in a private motor vehicle for commute purposes.[42] The most common form of ridesharing in Australia is carpooling, where the vehicle is usually owned by the driver. One UK Internet–based company, Liftshare, lists the following advantages of ridesharing:

- reduces parking problems;
- reduces congestion and pollution;
- reduces the need for a private car;
- widens recruitment catchment areas;
- reduces the number of single occupancy cars;
- facilitates the integration of public and private transport;
- provides a real solution to the lack of public transport in rural areas;
- undercuts the cost of nearly all other transport methods; and
- enables the creation of sustainable integrated communities throughout the UK.[43]

While ridesharing exists within families and between work colleagues, there is no comprehensive ridesharing operation in Australia. However, smaller scale ridesharing programs currently operate at the three universities in Perth, WA and plans are under way to extend the programs. 'Easy Share', a ridesharing initiative introduced in Sydney in 1997, involved a computerised carpooling service based on a 24–hour computer matching system.[44] Easy Share was established with support from three organisations including the NSW Roads and Traffic Authority. For a small annual fee, the system provided motorists with access to other drivers travelling the same route at the same time, offering 50 locations in NSW. However, the service no longer operates.

Ridesharing operations are well established in other countries. The schemes vary in their service coverage, ranging from a simple database matching of potential 'sharers', to a more comprehensive multi–faceted approach such as that provided by Share–A–Ride in Pennsylvania:

> The Share–A–Ride program is a free computerised service that could potentially match you with convenient transit services, carpools, vanpool groups, even walking and bicycling opportunities if you work in the 5–county southeastern Pennsylvania region. Even employers can get on board by locating matches for their employees.[45]

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42 For examples of creative public transport options see *Community Transportation: Reinventing Urban Transit,* November–December 1998, available at http://www.ctaa.org/ct/novdec98/.

43 For more details see http://www.liftshare.com/.

44 An Internet site advertised the scheme, but all bookings were via an interactive computer phone system.

45 http://www.share-a-ride.org.

Possibly the longest established and largest ridesharing system is Citynetz in Germany—reported to have 1.5 million users each year and growing strongly. Others, such as Cyberlift, also use the Internet to match potential carpoolers. A Canadian carpooling Internet site (Commuter Connections) provides an online savings calculator as well as advice on carpooling etiquette.[46]

In the US, ridesharing is more common than public transport use, with two and a half times as many Americans travelling to work by sharing rides than by public transport (Cervero 1999, p. 68). State and local governments often play an active role in promoting ridesharing. The earliest government–initiated ridesharing programs were introduced in the US in 1977 as one element of the response to the 'energy crisis' (Hirten & Beroldo 1995, p. 9). A decade later, concern over worsening air quality in Los Angeles, saw the introduction of regulations in southern California requiring employers with 100 or more workers to develop trip–reduction programs (Giuliano & Wachs 1992). In 1995, these regulations were repealed in 1995 at which stage the Californian Department of Transportation (Caltrans) discontinued funding for the ridesharing program (Hirten & Beroldo 1997).

With the trend away from mandated ridesharing programs, many states in the US now provide financial incentives for firms to assist in the operation of ridesharing programs for their staff. Federal taxation incentives also encourage ridesharing and the use of public transport. Under the Transportation Equity Act for the 21st Century (or TEA21), introduced in 1998, employees can now claim up to US$100 per month in non–taxable public transport and vanpool benefits.[47] The added advantage for the employer is that the public transport or vanpool payment is exempt from federal and state payroll taxes.

Vanpools are a distinctive feature of ridesharing operations in the US. Washington DC, with the highest average vehicle occupancy rates in the US, is home to almost a thousand vanpools operating in the Washington DC area.[48] Vanpools are generally formed from a group of people living and working in the same geographic area, and may be employer–operated, leased, individually or even publicly owned. Vanpools are promoted as being lower cost and offering greater flexibility than some of the more standard forms of commuting:

> Trains are usually tied to train tracks, and most often, those tracks are controlled by someone else. Buses pick up and drop off at centralised locations. Commuting by train or commuter bus usually requires additional forms of transportation to complete the journey. In most instances, vanpools are far cheaper to use than any other form of transportation (ABS Vans).[49]

46 http://www.carpool.ca/.

47 Prior to 1 January 2002 the maximum claim was US$65/month.

48 Pisarski (1997, p. 8) and http://www.absvans.com/.

49 ABS Vans: http://www.absvans.com/Van_Pooling/Information/information.html.

One major US vanpool contractor, ABS Vans, compiled the following cost comparison:

TABLE 2.2 ANNUAL US COMMUTING COST COMPARISON[50]

Mode	*Cost*	*Other transport required*	*Other transport cost*	*Total cost*	*Commute time (in hours)*
Single Occupant Vehicle	$8,684	NO	$0	$8,684	756
Carpool	$2,171	NO	$0	$2,171	378
Vanpool	$1,560	NO	$0	$1,560	378
Train	$2,227	Metro	$554	$2,781	882
Bus	$1,920	NO	$0	$1,920	630

Source ABS Vans.

The significant savings in commute time for car or vanpools relative to SOVs appear to be due, in part, to the access to high occupancy vehicle (HOV) lanes.

There are many ridesharing organisations in the US, such as the Share–A–Ride program—a free computerised service operating in the south eastern Pennsylvania region that matches travellers with convenient public transport services, carpools, vanpool groups, even walking and bicycling opportunities.[51] Despite these, ridesharing in the US has slipped from 20 per cent in 1980 to nine per cent in 1995 nationwide and is still declining according to recent surveys (Orski n.d.).

Impact of ridesharing/carpooling

Ridesharing or carpooling usually involves more time, extra planning to make advance arrangements and the loss of personal flexibility in terms of small tasks like shopping or collecting children on the way home. As incomes rise people put a higher value on time and ridesharing seems to decline. However, policymakers see ridesharing as a prospective way of reducing VKT. In California, it has been reported that ridesharing services led to estimated reductions of:

- 419 million vehicle miles travelled;
- 20 million gallons of fuel consumed; and
- 7,000 tons of pollutants (Herten and Beroldo 1997, p. 11).

50 October 1998 US$ prices using a popular route from Fredericksburg, Virginia to Rosslyn, Virginia. All time and costs are computed on a yearly basis. Based on 252-day work-year.

51 http://www.share-a-ride.org.

ABS Vans estimated that through servicing over 11 million commuter miles in the states of Virginia and Maryland they reduced the number of single occupancy vehicle roundtrips by 110,000 and the quantity of pollutants by 2.9 million pounds (approximately 1,300 tonnes) in 1997.[52]

The university ridesharing programs in WA, while generating other benefits, are not anticipated to noticeably reduce greenhouse gas emissions (DEP 1999).

However, even where the measures appear to be having environmental success, such as with the ridesharing in California and Washington DC, credit may not be due to the policy measure. A publicly funded program to encourage ridesharing can only take credit for the increase that is attributable to the program, not for the total level of ridesharing. Pisarski (1997, p. 7) argues that family carpooling is the main source of ridesharing in the US and hence not noticeably influenced by measures aimed at encouraging ridesharing.

The estimates of the environmental benefits of ridesharing programs in California undertaken by Herten and Beroldo (1997) appear to reflect the *total* benefits of ridesharing in California, including those that would eventuate in the absence of policies aimed at encouraging ridesharing. The estimate of benefits would also be inflated if it were assumed that all those using, say, ridesharing would otherwise be solo drivers. When calculating the environmental gains from vanpools, ABS Vans did not take account of the possibility that some vanpool participants may previously have used public transport, have had an informal sharing arrangement with other drivers or simply commuted less.

Again, as with other demand management measures, there is no guarantee that any reduction in the number of SOVs due to ridesharing programs would be sustained. If congestion declined as a result of the ridesharing programs, other, previously discouraged commuters, could be encouraged to join the commute.

In brief, from both an environmental and efficiency perspective, the benefits of ridesharing should be distinguished from the benefits attributable to programs that encourage ridesharing.

The fiscal impact of ridesharing programs depends on the detail of the programs. Ridesharing programs can be based on regulations, such as those used in the past in California. Such programs would have no fiscal impact on government budgets. The more standard approach involves some financial commitment from the public purse, although this is not likely to be major. In the US it is common for this involvement to take the form of coordination of the ridesharing program via the Internet. As with personalised travel planning, there is scope for beneficiaries to bear a share of the cost. As well as serving as a market test of the value of the service, an element of co–payment would also reduce the fiscal impact.

52 http://www.wmata.com/riding/metrochek/metrochek.cfm.

HIGH OCCUPANCY VEHICLE (HOV) LANES

HOV lanes—those set aside for the exclusive use of cars with two or more occupants—are widely regarded as a cornerstone of travel demand management efforts. These lanes are normally less congested than the remaining lanes and hence offer time savings. HOV lanes may be purpose–built or may involve the reassignment of an existing lane. They are more commonly found on urban freeways but are also implemented on arterial roads. The immediate aim of these lanes is to encourage drivers to abandon their single occupancy vehicles (SOVs) in favour of ridesharing. Kitamura et al. (1999, p. 144) quote Gard in reporting that:

> On March 15, 1976, the median lane in each direction of a twelve mile, eight lane segment of the Santa Monica Freeway was reserved during peak traffic hours for the exclusive use of buses and carpools carrying three or more persons. After the implementation, carpool ridership increased by 65 per cent and bus ridership more than tripled.

In the US, a number of underutilised HOV lanes have been converted to High Occupancy Toll (HOT) lanes where single drivers pay tolls in order to get access to the faster flowing HOV lanes.[53] As of 1999 there were 23 HOT lane projects (at varying degrees of development) in 11 states of the US (Poole & Orski 2000).

Environmental impact of high occupancy vehicle lanes

HOV lanes are implemented with the aim of encouraging higher vehicle occupancy, thereby reducing the number of cars on a road and perhaps making a contribution to environmental objectives. However, converting an existing lane into a HOV lane is unlikely to produce environmental benefits unless a significant number of solo drivers become carpoolers and 'new' solo drivers do not take their place.

In general, it appears that the environmental gains from HOV lanes are often negative. HOV lanes tend to result in increased congestion in the regular lanes which, in turn, increases emissions. In many areas of the US, this has led to pressure to convert HOV lanes into general purpose lanes. One often cited case is the Santa Monica Freeway where the conversion of a regular lane to a HOV lane in 1976 caused 'near–instant traffic paralysis' (Cervero 1999, p. 67). Also:

> … energy savings and air quality improvements were insignificant. Accidents increased significantly and non–carpoolers lost more time than carpoolers gained. Prompted by heated public outcry, poor press notices and derisive news commentary, the project was terminated after only 21 weeks (Kitamura et al. 1999).

53 The term 'value pricing' is adopted to reflect the higher value service that is being offered in return for the toll.

In 1995, two HOV lanes were returned to general usage within days of opening because of the traffic snarls created by dedicating a lane to HOVs (Cervero 1999, p. 67). More recently, underutilisation of two HOV lanes in New Jersey led to them being decommissioned in 1998 and many more states in the US have followed suit (Cervero 1999, p. 67).

The great majority of HOV lanes in the US now require only two HOV occupants. Only a proportion of the passengers would be former solo drivers. In Singapore, the introduction of the Area Licensing Scheme (ALS) in 1975 saw a significant shift from buses to HOVs because HOVs were exempted from paying the ALS fee (Roth 1996, p. 130). Also, any gains from enticing SOV drivers to shift to HOVs would be muted by the induced traffic effect.

Efficiency and fiscal impacts of high occupancy vehicle lanes

HOV lanes are inherently economically inefficient, because they exclude SOVs even when the marginal social cost of SOVs using the HOV lanes is lower than the cost of their using the alternative (more congested) lanes.

The efficiency gains available from allowing SOVs access to HOV lanes have led to the conversion in the US of underutilised HOV lanes to High Occupancy Toll (HOT) lanes. The efficiency gains generated from such a move are two–fold: greater utilisation of the previous HOV lanes and less congestion in the lanes abandoned by those shifting to the HOT lanes. However, abolition of the HOT lanes and introduction of optimal congestion charges remains the most economically efficient solution.

Much of the impact of HOV lanes depends on whether HOV lanes are created from a reassignment of the current infrastructure or whether they are purpose built. For the reassignment option, the fiscal implications are negligible. The expansion of the infrastructure for purpose–built HOV lanes clearly have a major fiscal impact.

PARKING

Parking policies are used both as a carrot or stick to manipulate traffic flows. For instance, parking in the CBD can be made more difficult and costly while parking on the outskirts can be made easier and cheaper.

Increasing parking costs through reducing supply or increasing charges

Parking constraints are regarded by some as ‘one of the most powerful tools open to land–use planners in seeking to reduce car–based travel in the short term’ (Main Roads WA 1998). Parking restrictions have been used in recent years as a key element of transport policy in many countries (Axhausen & Polak 1991, p. 59). A range of measures is available:

- restraints on the supply of parking including restricting access to parking at certain times of day, for certain durations, or to certain classes of user (Feeney 1988, p. 229);
- changes in the composition of parking stock;
- adjustments in tariff structures; and
- stricter enforcement measures.

In many areas, particularly in some European cities, reduction in supply has meant outright bans on parking (and driving) in the CBD. More commonly, policies are aimed at reducing numbers of parking spaces available, either directly or through zoning regulations. The European Economic Research Centre (ERC) went further to suggest that regulations should be defined in terms of *maximum* numbers of parking spaces per area of new construction, rather than minimum numbers.

> At a time when European cities are implementing zero parking spaces building standards in urban development plans, French cities are waiting for a reform of the French urban development code for at least being able to integrate maximum standards in their rules considering town planning (ERCb 1996).

In 1995, the Government Office for London proposed, unsuccessfully, that the maximum number of parking spaces in new private non–residential developments across London should be significantly reduced—to less than half the previous number in some areas (EPE).

A car–free residential development has operated near Bremen in Germany since 1996 and more are planned. Comprised of 210 apartments and homes, this development is restricted to families who do not own cars. Visitors are allowed to drive in and are subject to time–sensitive parking charges (EPE).

While parking controls can be developed as stand–alone instruments, they tend to be part of a coordinated package and are often associated with improvements in public transport.

> The concern to offer attractive public transport is part of an integrated approach to mobility taken by the Zurich authorities that aims at reducing the use of cars and improving the quality of urban life standards. As parallel measures, parking and waiting restrictions were introduced for general traffic (EPE).

In Helsinki, the removal of parking spaces was accompanied by regulations that encouraged businesses to be located 'in such a way that people would use public transport for their journeys to work' (ERC 1995, p. 243). Similarly, the *New Traffic Management and Parking Guidance for London*, released in February 1998, accorded high priority to parking control initiatives that encourage a shift to public transport, walking or cycling (DETR 1999a). Parking restraints were also included in the package of reforms developed for Dublin following a review of the transport situation in Dublin.[54]

54 It was anticipated that this package of reforms would lead to a reduction of almost 30 per cent in the level of hydrocarbons, carbon dioxide and carbon monoxide in the peak hours in 2011 (ECEc).

A less direct approach to parking policy is the removal of factors that reduce the cost of parking, in particular, the tax breaks associated with the use of private vehicles. In most cities, a significant share of parking spaces (other than on–street parking) is in private hands. A great deal of this is employer–provided parking. Shoup and Willson (1992a, p. 169) estimated that, as a result of employer–provided parking, 'nine out of every ten American commuters who drive to work do not pay for parking'. In Bern, 70 per cent of parking places are provided by the employer (EPE). Estimates for London indicate that around 80 per cent of drivers have access to employer–provided parking:

> … despite the stabilisation of parking supply in Central London, there is still a large quantity of private off–street parking which is uncontrolled, and which is made available for employees free of charge. This in effect is a major subsidy to car commuting, contrary to the general policy of restraint (EPE).

Removing tax deductions for employer–provided parking to increase the cost of parking is regarded as a serious policy option (TTNCCP 1998, p. 134). Many interest groups, including the Light Rail Transit Association (LRTA) in the US, have long advocated the removal of such tax breaks along with those for company cars and private motoring fuel (LRTA 1997).

An alternative is a tax to discourage employer–provided parking. John Prescott, the UK Minister for Transport, recently observed that 'workplace car parking charges can counter the effective subsidy of free parking space given to rush hour commuter car traffic' (DETR 1999c). Legislation in Britain has been changed recently to permit local authorities to increase parking charges to target traffic congestion and pollution.[55]

Authorities in Sydney have levied off–street, non–residential parking spaces in the CBD at the rate of $400 per annum since 1992 (NSW Treasury 1999, p. 26). Recently, the NSW Government announced plans to double the levy in existing areas and extend the current levy to parking stations and car parks in four previously levy–free urban areas around Sydney (Scully 2000).

Environmental impact of parking policies

The parking measures outlined are targeted at increasing the cost of parking and, through this, the cost of driving, either in absolute terms or relative to alternative forms of transport.[56] The evidence of drivers' responses to

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55 For discussion on attacking traffic congestion and pollution in Scotland through road user and workplace parking charges see http://www.scotland.gov.uk/library2/doc01/taco-03.htm.

56 It is possible that a simple reduction in the number of parking spaces available could have a perverse impact on the environment if motorists spend more time driving around searching for parking spaces. One surprisingly high estimate is that 30 per cent of urban traffic is caused by motorists looking for somewhere to park (TTI 2000, p. 96). However, this may become of less concern as in-vehicle information systems become standard and, with them, ready access to real-time parking information—including the facility to 'prebook' parking spaces.

increased parking charges is mixed. A wide variation in the responsiveness of commuters to increases in parking costs is to be expected, given that local conditions would have a significant impact on commuters' choices.

The BTCE observed that 'commuters' responses will be relatively slight in the long run, in reduction of numbers of commuter trips, commuter VKT and total VKT' (1996, 115). The BTCE (1996b) estimated that a trebling of the (then) current all day parking charges in all Australian capital cities would reduce transport related greenhouse gas emissions by four per cent. In Canada, the TTNCCP (1998) reported that if employees faced the full cost of parking (rather than having it provided 'free' by the employer) a reduction of 40 per cent in single occupant vehicle (SOV) use could be expected (TTNCCP p. 135). However, there was no attempt to estimate the greenhouse impact of such an outcome.

> The response to an overnight increase in the cost of parking for federal government employees in the US in 1979 indicated that 'elasticities vary considerably but are relatively low' (Feeney 1988, p. 240). The variation in response is ascribed to 'differences in alternative parking supply, attractiveness of other modes, trip lengths and socioeconomic and worksite characteristics' (Feeney 1988, p. 240).

The Californian parking cash–out program appears to have had a favourable environmental impact. Shoup (1997, p. 206) estimated that vehicle emissions (local and global emissions) attributable to the firms studied declined by 12 per cent as a result of the program.

As with any policy that is successful in reducing traffic flows, the environmental benefit may be a temporary phenomenon, as the reduction in commuting traffic could be diluted in due course by a compensatory increase in through traffic (including taxis):

> … there is evidence in places such as central London, that success in reducing terminating traffic in an area by means of parking controls can be offset by additional through traffic attracted by the improved road conditions. In central London around 40 per cent is through traffic, without an origin or destination in the area (EEC 1996, p. 167).

The IC (1994, p. 224) also observed that:

> … the major limitation of tackling congestion through parking policies, using quantitative restrictions or the imposition of penalties, is that they have no effect on through traffic, which in many areas makes a large contribution to congestion.

Efficiency impact of parking policies

To ensure economic efficiency, the prices facing consumers should reflect the marginal social cost of the good or service concerned. Analysts commonly observe that, when parking is unpriced, it is 'overconsumed' by motorists.[57]

57 See, for instance, Litman & Greenberg 2000.

Todd Litman, Director of the Victoria Transport Policy Institute in Canada and a vigorous advocate of paid parking, argues that 'free parking is a form of underpricing that is economically inefficient and inequitable' (Litman & Greenberg 2000). Litman's argument relies partly on the fact that parking is often provided as part of a 'bundle' of services and that such bundling, by its very nature, is inefficient because it results in either underpricing or overpricing of components of the bundle.

Under some circumstances 'bundling' of goods or services may be the most efficient pricing structure available. Goods and services are commonly 'bundled'—warranties with products, food on planes, toilet facilities to name just a few. In the context of information goods it has been observed that 'the arguments in favour of bundling are strong, and suggest that *à la carte* or unit pricing will not be the dominant mode of commerce in information goods'.[58]

There are a number of circumstances apart from bundling that can 'distort' the price of parking:

- government–controlled parking may not be priced at appropriate commercial rates;
- conditions of employment may mean that parking is either provided free or free of income tax (i.e. paid for out of pre–tax income rather than post–tax income); and
- zoning regulations may impose a maximum or minimum number of parking spaces to be provided with a development.

Local governments may alternatively pursue policies that increase and decrease the price of parking, depending on their immediate policy objectives. At times, the same objective may be associated with conflicting strategies. For instance, some planners recommend zoning regulations:

> … to force the supply of parking above the quantity that would be provided by the private market, whereas others recommend an upper limit on the number of parking spaces in order to force the supply below what would be provided by the private market, both with the goal of reducing traffic congestion (Pickrell & Shoup 1980, p. 13).

The first step towards a more efficient supply of parking spaces would be to remove those regulations common to many countries that mandate minimum or maximum numbers of parking spaces per area of new constructions. Minimum parking standards are often aimed at ensuring that building owners meet the cost of parking rather than shifting the burden onto the publicly available parking. In France, such regulations have been labelled as 'pernicious' by environmental groups because they increase the number of parking spaces available and thus they limit the efforts made by local authorities to encourage the use of transit (EPE). In response to community concerns, the draft Planning

58 http://www.firstmonday.dk/issues/issue2_7/odlyzko/.

Policy Guidance note 13 (Transport) for England specified maximum, rather than minimum, parking standards.[59]

It is possible that regulations dictating a minimum or maximum number of parking spaces would be unnecessary if all elements of car use were efficiently priced. In such circumstances, managers of local government-owned car parks would not be concerned about parking from a new development spilling over into the established car parks. In such an undistorted market, the efficient number, composition and price of parking spaces would be determined by supply and demand. Parking charges would vary to reflect many factors including location and time of day.

The reality is that policymakers do not operate in a 'first–best' world. However, for the following reasons, higher than market–based parking charges represent a very indirect way of pursuing goals such as congestion reduction.

- they target stationary rather than moving traffic. Since parking charges target only those that park, the road space released by discouraged parkers may be taken up by through–traffic (including taxis).
- they do not vary significantly with different levels of congestion.
- they can create increased VKT, as drivers search for parking places.
- they do not apply to commercial vehicles or company cars with private parking spaces.

The target for the higher parking charges is often the daily commuter and, in particular, the solo driver. However, travel to and from work accounted for only 24 per cent of total distance travelled by passenger vehicles in 1999 (ABS 2000). Again, any congestion relief achieved through discouraging the commuter share of the traffic is likely to be only temporary as other traffic takes advantage of the (temporarily) improved conditions.

It is difficult to deny Neutze's conclusion that, ‘parking charges are very poor substitutes for congestion charges’ (IC 1994a, p. 225). The reason is simply that they do not target those causing the congestion, nor do they adjust adequately during the day to reflect congestion levels.

If there were artificial constraints on the supply of parking spaces (such as highly constrained zoning regulations), then the price of parking could be above the marginal social cost, even taking into account externalities associated with driving. If this were the case, policies that further raised parking charges would be highly inefficient.

One source of efficiency gains would be to remove those factors that currently distort the demand and supply of parking spaces away from an ‘economic optimum’. For instance, regulations requiring a minimum number of parking

59 *Local Transport Today,* Issue 312, 5 April 2001, p. 9.

spaces per building and favourable tax treatment of parking could cause the price of parking to be less than the marginal social cost of provision.

The most certain efficiency gains are likely to be those available from cashing–out programs. In the US, an increasing number of employers are allowing employees to 'cash out' their parking space. The efficiency gains from cashing-out programs are relatively clear cut. In the short run, the provision of a cashing–out option ensures that parking spaces are used by those that value them most highly. In the long run, such an option would encourage the optimal number of parking spaces.

An interesting case study in Sydney involved a group of shop assistants opposing a suggestion that they pay a daily parking fee at their place of employment (AFR 17 August 2000, p. 35). However, while parking is paid for by the employers and provided free to the employees, there is scope to improve the situation to make all better off. Under current arrangements, some employees receive no value from parking and others place a lower value on parking than the market. If employees were given the option of cashing out their right to park, both groups would be better off, parking spaces would be used more efficiently and there would be clearer signals to determine the optimal number of parking spaces. This story is repeated for every company that provides subsidised parking.[60]

Employer–paid parking encourages SOVs and, in one study, was found responsible for a 36 per cent increase in the number of cars driven to work Shoup (1997, p. 202). 'This tends to work at cross purposes with costly public policies designed to reduce traffic congestion, energy consumption, and air pollution' (Shoup & Willson 1992a, p. 169).

Shoup and Willson estimated that the average employer–paid parking subsidy in downtown Los Angeles is equivalent to US$0.11 per mile travelled to and from work. Thus, imposing a congestion toll of US$0.11 per vehicle mile travelled would raise the cost of driving to the Los Angeles CBD by only as much as employer–paid parking already lowers it (Shoup & Willson 1992b).[61]

Apart from working at cross purposes with other public policies, parking subsidies shield employees from the accurate price signals about the cost of parking, encouraging the inefficient use of parking spaces. Shoup and Willson (1992b) observed that the employer spends US$4.10 on parking subsidies for every US$1 the employee saves on the cost of parking and driving. Hence

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60 It could even be feasible to establish a web site where parking spaces were sold and traded daily. Hence, those that retained a parking space as a form of insurance could still be encouraged to use alternative means of transport if they sell their space for a particular day on the spot market.

61 However, if the equivalent of the parking fee were charged according to congestion levels, it would encourage some beneficial time shifting to avoid congestion.

there is considerable scope to achieve efficiency gains for a cashing-out program, while benefiting employer and employee.

A study of eight Californian firms (covering almost 1,700 employees) that implemented a parking cashing–out program showed that it:

- reduced the number of solo drivers to work by 17 per cent;
- increased the number of carpoolers by 64 per cent;
- increased the number of transit riders by 50 per cent; and
- increased the number who walk or bicycle to work by 39 per cent (Shoup 1997, p. 201).[62]

A parking cashing–out program appears to offer more certain efficiency gains than other parking measures due to the simple fact that the former involves the removal of a distortion—the remuneration packaging that favours driving over other forms of commuting. As Shoup (1997, p. 201) noted, 'the benefits derive from subsidising the people, not the parking'—i.e. by providing individuals with a choice undistorted by selective subsidies. The benefit–cost ratios of the eight cashing–out programs studied were all greater than four. While the scope for gains of this magnitude from cashing–out programs would depend on a number of factors including the alternatives available to solo driving, the important consideration is that the gains are invariably significant.

Legislation was implemented in California in 1992, whereby employers of more than 50 employees who subsidise employee parking must offer a parking cashing-out program. Under a cashing–out program, employees may opt for the cash equivalent of the parking space.[63] The Californian law also allows the options of replacing the parking subsidy with a general commuting allowance and the provision of a parking subsidy only for carpools. Cashing out allows an employer to offer free parking, yet offer all commuters the same subsidy, regardless of how they commute (Shoup 1997, p. 210).

The state of Maryland has recently introduced legislation to encourage employers to offer cash in lieu of parking by entitling a business entity to claim a tax credit in an amount equal to 50 per cent of the cost of providing a cashing-out program, up to a specified maximum value (Tencer et al. 2000).

62 Dadson et al. (1999) noted that the study indicated that a cashing-out program is likely to have the most positive impact if implemented in a downtown or central business district where public transport and carpooling are more viable options.

63 A parking cashing-out program is defined by the legislation as 'an employer-funded program under which an employer offers to provide a cash allowance to an employee equivalent to the parking subsidy that the employer would otherwise pay to provide the employee with a parking space…' (Dadson et al. 1999).

Fiscal impact of parking policies

Introducing a tax on parking in the form of a parking space levy would have a positive fiscal impact. The fiscal impact of increasing parking costs through a reduction in the number of parking spaces would depend on the alternate use of the land.

The fiscal impact of a parking cashing–out program would depend on location and details of the program. In the Californian study, because many commuters chose the cash option, taxable income increased resulting in an increase in income tax revenues of US$17 per employee per year after cashing out (Shoup (1997, p. 210). The existence of a Fringe Benefits Tax in Australia would lessen the impact on taxable income and tax revenues.

PARK AND RIDE

Park and ride initiatives provide another avenue for encouraging the increased use of public transport. Park and ride involves the establishment of free or concessional parking sites outside the CBD where commuters can leave their cars and catch public transport services into the central part of the city. Park and ride facilities are common overseas, particularly in the US and the UK, both as permanent fixtures and temporary features for special events (such as county fairs).

Increasingly park and ride schemes are increasingly being adopted to encourage a greater use of public transport. The provision of park and ride facilities during the Sydney Olympics was an essential component of the transport arrangements. When road pricing was introduced in Singapore in 1975, S$6.5m was spent to establish 14 park and ride stations offering 'fast, regular, comfortable and relatively cheap mini–bus transport services between the fringe parks and the CBD' (Button & Pearman 1985, p. 40).

Environmental impact of park and ride

The impact of park and ride facilities on the environment depends on the extent to which park–and–rides discourage the use of private vehicles. Available evidence suggests that park and ride facilities have mixed success with the outcome depending on critical factors such as site location, car park pricing, characteristics of transit (fares, frequency, reliability, speed) and the cost of the alternative—driving into the CBD.

The Nottingham park and ride was reported to be successful in reducing traffic in the city centre. The experience in Singapore was markedly different:

> The attempt to attract car users on to transit proved to be an almost complete failure. The park and ride facilities were hardly used at all and many of the sites were soon transformed into housing estates, tennis courts, self–drive car hire centres, second hand car lots, overnight bus parks, etc. (Button & Pearson 1985, p. 44).[64]

64 The failure of park and ride in Singapore has been attributed to the fact that HOVs and taxis were exempted from paying the ALS fee—they expanded at the expense of buses (Roth 1996, p. 130).

Pankhurst (2000) argues that 'it was not possible to demonstrate that park and ride resulted in a net reduction in urban congestion 'downstream' of the sites'. There were a number of reasons for this:

- suppressed demand had re–filled the road space made available by park and ride sites;
- some patrons of the park and ride sites had switched from transit services using their cars more to reach the park and ride sites; and
- the introduction of park and ride had lowered the generalised cost of travel and hence encouraged more trips.

Pankhurst (2000) also observed that these unintended consequences of park and ride facilities could lead to increased car dependency. In a review of eight park and ride facilities on the fringes of UK urban areas, in every case the total additional traffic generated outside the urban area was greater than that avoided within the urban area. From this Pankhurst concluded that 'the main effect of the schemes is traffic redistribution, and that their role within traffic restraint policies is unlikely to be directly one of traffic reduction'.

Efficiency and fiscal impacts of park and ride

Due to the wide variability surrounding park and ride facilities, it is difficult to make general statements about the economic efficiency of such measures. In an environment where no other prices were distorted efficiency would be maximised if users were charged the marginal social cost of using the facility. The distortions created by the lack of congestion pricing in CBDs may justify a price for parking on the outskirts below the marginal social cost but, since the public transport component is generally heavily subsidised, this is probably already occurring.

The impact on fiscal management would depend on the characteristics of the scheme. Clearly, a scheme that fully cost recovered would have no fiscal impact. Increased transit patronage may increase fare box recovery rates, unless more was spent on service provision.

NON–MOTORISED TRANSPORT

The promotion of non–motorised transport is argued on the following grounds:

- the high proportion of car trips that are 'bicycle trip length'. One third of all car journeys are estimated to be three kilometres or less—an easy cycling distance. The average length of each bicycle trip is 2.5 kilometres (DOTRS 2000)[65];

65 More recent figures put the average bicycle trip length at 1.4 miles [2.25 km] and the average walking trip length at 0.5 miles [800 metres] (Schaper 1998, p. 11).

- a cold car motor pollutes more than a hot one, especially when equipped with a catalytic converter. It can take three miles or more before pollution control devices such as catalytic converters start to become effective (PSRC 1995)[66]; and
- in most industrialised countries, the use of non–motorised transport (bicycling and walking) has declined significantly over the past 40 years.

In other words, short trips in cars are the most environmentally damaging and short trips are the most attractive for walking and bicycling. Bicycling and walking are promoted as efficient, low–cost and low–impact modes of travel that can be particularly effective in maximising the effective use of local roads and public transport services (PSRC 1995).

A number of Australian cities are adopting programs to encourage increased use of non–motorised transport. Most cities have ongoing programs to improve walking and cycle paths. Adelaide and Perth have specific programs aimed at increasing the attractiveness of cycling.

The Netherlands also has a tradition of encouraging the use of bicycles through a range of policies including:

- spending 10 per cent of their road budgets on bicycleways over the last 22 years;
- aiming for two bicycle routes for every destination, one of which is safe for the more vulnerable members of society;
- ensuring that cyclists, along with pedestrians, have priority in most Dutch cities;
- in the six years to 1996, spending US$1.2billion on the Dutch Master Bicycle Plan which involved upgrading existing bicycleways, building new ones and providing secure bicycle parking at railways stations; and
- in the event of collision with a bicycle, the presumption of fault has been shifted to the car driver.[67]

In California, in an effort to encourage greater use of bicycles for commuting, the Mobile Source Air Pollution Reduction Review Committee (MSRC) has earmarked US$400,000 to fund an interactive, Internet–based bicycle route

66 Note that promising developments in catalytic converters indicate that total hydrocarbon emissions from cold starts could be reduced by 84 per cent and total carbon monoxide emissions by 91 per cent.

67 To avoid liability, a motorist is now required to prove in court that the cyclist ignored traffic regulations and acted recklessly. It is anticipated that, as a result of the new rule, drivers will have to pay an extra 100 Dutch guilders (about A$80) each year for car insurance. The new law will not apply to motorways or main country roads (T.A. Magazine, March/April 1998, p. 10, available at http://www.transalt.org/press/magazine/982MarApr/10auto-free.html).

and map system.[68] The system will provide personalised route guidance and related information such as location of bicycle facilities, bubblers and restrooms en route.[69]

Münster, a city of 280,000 people in the North–Rhine–Westfalia province of Germany, has reported 'outstanding success' in encouraging the use of non–motorised transport, combining the following strategies:

- expanded system of bicycle ways, increasing from 145 kilometre to 252 kilometre in 20 years to 1995;
- upgraded path system so most paths are separated from both 'auto' and pedestrian traffic;
- a tree–lined, seven-metre-wide expressway that circles the city centre providing direct connections with 16 major bicycle routes radiating from the city as well as with 26 paths leading to the CBD;
- widespread use of traffic calming measures in residential streets and speeds restricted to 30 kilometres per hour;
- right–of–way priority for bicycles and pedestrians, innovations in parking including special bicycle rack designs, sheltered racks, theft–proof bicycle cages and spacious bicycle lockers for rent at key transport nodes, which also provide room for changing and storing clothes; and
- bicycle access to lightly travelled roads restricted to local traffic (Pucher 1997).

Impact of non–motorised transport

Some European cities have been aggressively pursuing programs to encourage the use of non–motorised transport. Cities in Germany have been implementing policies to promote bicycling and walking, reversing the international trend to such an extent that the bicycling share of urban trips in western Germany increased by 50 per cent from 1972 to 1995—from eight per cent to 12 per cent of all urban trips (Pucher 1997, p. 31).

While the impact of each of these programs would clearly vary according to the details of the program and the conditions under which they were introduced, the environmental impact of even a successful program is likely to be small. A National Cycling Strategy, launched in the UK in July 1996, set a target of doubling the amount of cycling by 2002 and again by 2012. Wootton (1995, p. 164) estimated that 'at this level, cycling would return to 1955 levels by 2012 and will then be barely one per cent of the amount of travel by car'. Similar conclusions have been drawn for the US. Schaper (1998, p. 11)

68 Details of the activities of the Mobile Source Air Pollution Reduction Review Committee available at http://www.msrc-cleanair.org/.

69 http://www.msrc-cleanair.org/index.cfm?fuseaction=full&nid=26.

estimated that bicycling and walking combined accounted for 0.4 per cent of total passenger miles travelled. Hence, in the US, even if programs to encourage the use of non–motorised transport were extremely successful and led to a doubling of activity, it would probably still represent less than one per cent of passenger miles travelled. In Australia, a similar doubling of the share of work trips made by bicycle would lead to three per cent of trips to work being made by bicycle.[70]

To estimate the potential for shifting from cars to bicycles from the fact that a third of car trips are the same distance as the average bicycle trip is simplistic. There are many factors, such as the age and fitness of the traveller, weather, suitability of dress, number of passengers, and load carried, that could render bicycling a poor substitute for some of this car travel.

In addition, the extent of environmental gains would depend on the source of the increased non–motorised travel. Clearly, the greatest gains would occur if the solo drivers deserted their cars and took up cycling to work. However, if the 'new cyclists' were formerly transit patrons, the environmental gains would be much less.

The impact on efficiency depends on the project design process. A sound procedure has been set out in the Metropolitan Transportation Plan (MTP) for the Central Puget Sound Region in Washington State. The MTP explicitly recognised the need for a more accurate method to evaluate the impact of investments in pedestrian and bicycle facilities and programs, and the need to demonstrate their cost effectiveness. In pursuit of performance–based strategies for pedestrian and cycle paths, the MTP identified three areas that were regarded as crucial:

- the need to develop and implement an ongoing, region–wide data collection program on pedestrian and bicycle use;
- the need to quantify and predict reductions in potential trip or vehicle miles travelled or changes in mode split; and
- the need to quantify potential air quality benefits based on the trip or VMT reductions.

The efficient use of resources would be encouraged if these procedures were adopted when considering the development of pedestrian and bicycle facilities.

CARSHARING

Carsharing generally refers to the formal shared use of cooperatively owned vehicles.[71] More accurately, carsharing is the common use of vehicles by

70 Compared to the current two per cent (DOTARS).

71 For an up-to-date overview of carsharing/car clubs, see Smart Moves at http://www.smartmoves.co.uk/carclubs/carclubs.html.

various users *in succession and independent of each other* (Harms & Truffer 1998).[72] The momentum for carsharing arrangements arises from concerns over the 'waste' from automobiles spending an average of 95 per cent of their time in a parking place. It is argued that, ideally, 'a more economically rational approach [would] use vehicles more intensively' (Shaheen et al. 1998, p. 35). Like carpooling (involving more than one person using the same car *at the same time*), carsharing is aimed at a greater utilisation of current transportation resources.

Carsharing organisations (termed car clubs in the UK) are generally community–based operations run on a small scale. Some carsharing operations exist with only one vehicle.

> Carsharing may be thought of as an organised short–term car rental. Individuals gain access to vehicles by joining organisations that maintain a fleet of cars and light trucks in a network of vehicle locations. Generally, participants pay a usage fee each time they use a vehicle (JWTPP 1999, p. 19).

While structures vary, commonly 'co–owners' pay an entry fee for joining a (usually non–profit) company or cooperative of carsharers. Members share a common fleet of vehicles parked at strategically located sites in the city. Bookings can be made by phone or, increasingly, through the Internet. The cooperative is responsible for maintenance. The amount invoiced depends on the standard of the vehicle, distance driven and the time of absence from the parking lot. Hence, charges take account of both fixed costs (purchase price, registration and insurance) as well as variable costs (fuel, wear and tear).

Carsharing in Europe dates back to 1948 and have typically attracted government subsidies in their initial period of operation. Two of the most active carsharing countries in Europe are Switzerland and Germany which collectively claim over 100,000 participants (Shaheen et al. 1999, p. 38). Mobility Carsharing in Switzerland service over 20,000 members with 1,000 cars in 800 locations.[73] Carsharing programs have been launched in France, Japan, Scotland, Britain, Italy, Singapore, and in North America: Seattle, Portland, Washington DC areas, and Massachusetts, Quebec, Montreal, Vancouver, and Toronto.[74] Flexcar is estimated to be the largest program in the United States with a 200-vehicle fleet serving more than 3,000 members.[75]

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72 For current detail regarding leading international carsharing programs, see http://www.ecoplan.org/carshare/general/overview.htm and http://www.smartmoves.co.uk/carclubs/carclubs.html.

73 For more details see http://195.65.210.68/e/index.htm.

74 See http://www.metropolismag.com/html/content_1000/electric.htm.

75 http://transit.metrokc.gov/travel_options/carshare.html.

Some operations, such as CarShare of Portland, operate as private, for–profit ventures. Flexcar in the Seattle region is a joint effort of the county, the city and a company called Mobility, Inc. In the UK, Carvenience is a car club run by Avis Car Rental in suburban north Oxford. Budget Rent–a–Car ran the Edinburgh City Car club for two years, but pulled out when membership failed to reach half the originally anticipated level. The City of Edinburgh has since approved an injection of almost UK£40,000 to allow the club to continue operating.[76]

Some of the more established carsharing organisations are moving beyond providing a low cost alternative to car ownership into 'mobility management' packages. These are generally based on partnerships with public transport organisations and other businesses.

Impact of carsharing

The main environmental benefit of carsharing derives from the fact that participants in carsharing schemes tend to significantly reduce their use of cars. 'Vehicle travel will be reduced because drivers are more directly confronted with the per–usage cost of driving, and presumably will respond rationally by reducing vehicle usage' (Shaheen et al. 1999, p. 47).

The US CarSharing Network reports a study by the Swiss Office for Energy Affairs that indicates that car owners who switch to carsharing reduce their driving by over 70 per cent, although the Network itself reports a reduction in individual members' driving of a more modest 'over 50 per cent'.

However, not all carsharers would be previous car owners: some carsharers may have been diverted from transit where their contribution to emissions was less. Others who drive relatively small numbers of kilometres per annum (less than 12,000 kilometres has been the suggested cut–off point for the US) and tend to own older vehicles with low capital costs, may be induced to give up their relatively fuel–inefficient cars, yielding some environmental benefits.

Given the fact that car hiring, an arrangement similar to carsharing is currently available in Australia, the likelihood that the development of carsharing organisations in this country would have a significant impact on motoring habits is low.

Efficiency gains may be available from carsharing (and car rental) because some of the fixed costs of car ownership are converted to variable costs.

76 For details of the Council's decision see http://www.edinburgh.gov.uk/CEC/Corporate_Services/Strategic_Support_Services/Council_Decisions_31_05_01/Lvcap0105.html#Car.

Depreciation, insurance and vehicle taxes are paid either immediately before or immediately after use of the vehicle.[77]

Shaheen et al. argue that:

> … the variable cost of using the owned vehicle is relatively low, and thus the driver has an incentive to drive more than is economically rational. In contrast, payments by carsharing participants are closely tied to actual vehicle usage. A carsharing system in effect transforms fixed costs of vehicle ownership into variable costs (Shaheen et al. 1999, p. 36).

While it is clear that higher variable costs would have an impact on dampening the demand for car use, it is not clear that the choice that most drivers make in favour of higher fixed costs and lower marginal costs is economically irrational. The majority of Australians choose the large fixed costs with low variable costs combination of home ownership over the high variable costs of renting. In the context of car ownership, buyers are often confronted with the trade off between higher capital outlay and lower running costs since, for a given size of vehicle, the more fuel efficient are often the more highly priced.

Perhaps more importantly, the aims underlying carsharing—converting fixed to variable costs—can be pursued through policy changes that can be justified in their own right. A strong case can be made for both vehicle registration charges and insurance to be paid not only on a kilometre basis but also ‘at–the–pump’.[78] This can be done in such a way that, on average, motorists do not pay any more than before.

The Bay Area Transport and Land Use Coalition have also argued that shifting some fixed costs to variable costs would produce more accurate price signals and would enhance efficiency by revealing the true costs of transportation to consumers. Furthermore, the benefits from such pricing reforms would be almost immediate (BATLUC 2000).

The momentum for such pricing reforms may increase as devices such as global positioning satellites (GPS) and in vehicle transponders (IVT) become more readily available. Currently under way in the US is a significant trial by a major insurance company of vehicle insurance that is paid on a per kilometre basis. Progressive's new auto insurance product, Autograph, determines a consumer's auto insurance rate based on actual vehicle usage, including when and how much the vehicle is driven.[79] The cost of insurance depends on how much

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77 High vehicle ownership taxes in Singapore produce the extreme in terms of high fixed costs relative to variable costs. The outcome is that on an island that measures barely 35 kilometre east to west and 20 kilometre north to south, the average car, using some of the world’s most expensive petrol, clocks up 20,000 kilometre a year—much the same as in the US (Economist, 1998a)

78 For a useful paper on pros and cons and practical modifications see Khazzoom 1999.

79 For more details see http://www.progressive.com.

the car is used, speeds and the routes taken. For some it has meant reductions between 25–50 per cent in costs for those signing up. Special tracking equipment is installed in the vehicle and global positioning satellites are used to constantly record the car's location, direction and speed. The system does not detail which road the car is on or in which neighbourhood it travels but whether it is urban, suburban or rural, and the time of day.

The loss of privacy may be an issue for some but there is an advantage to having the insurance company keep track of the vehicles. The equipment can be used for enhanced driver services, such as navigation help, unlocking doors remotely if the car has power locks and the keys have been left inside and, if the car is stolen, Progressive can locate the car and disable the ignition by remote control.

Environmentalists are generally supportive of pay–as–you–go insurance because it increases the variable cost of driving, thereby discouraging driving and encouraging alternative modes, such as public transport use. When the possibility of pay–as–you–go insurance was floated in California, one community group, SaveGas, concluded that pay–as–you–go insurance would save more fuel [and, if so, greenhouse gas emissions] than any other possible policy change.[80]

The US Environmental Protection Agency (EPA) is interested in the scope for pay–as–you–go insurance to reduce VKT and has signed an agreement with Progressive to undertake such a study (Wald 2001).

The pertinent question for policymakers is whether there are currently any administrative or regulatory barriers that prevent insurance companies adopting pay–as–you–go insurance. Clearly, the scope for more accurately targeted charges will be greater when GPS becomes standard equipment. While the ‘high–tech’ successfully trialed in Texas may not suit Australian conditions at present, there may be other options worth exploring such as the charging for insurance and registration ‘through the bowser’ as advocated by Litman (1997). Registration and insurance costs could be converted to a variable charge, using either odometer readings or a fuel levy.[81] In both cases, the fixed cost of motoring would decline and the variable cost would increase—the outcome sought by advocates of carsharing.

The effect on government budgets would depend on whether any public funding was involved in establishing carsharing schemes. The Edinburgh City Council funding contribution to the city car club represents almost A$1,000 per member over two years for which the assistance is provided. In Europe, the pattern has been for governments to provide ‘seed money’, which often declines as the carsharing organisations become more established. There is a

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80 http://www.geocities.com/bbkkorg/savegas/insurance.html.

81 Although a fuel levy is a poor approximation for kilometres travelled because of the wide variation in fuel intensity of vehicles.

risk that any public funding in this area could squeeze out normal commercial activities and, in the long term, be detrimental to the development of such schemes.

CAR–FREE DAYS

Car–free days are a relatively new phenomenon in modern cities and are generally aimed at local pollution but would also impact on VKT and congestion. Bogota, Colombia, where morning and evening rush hours normally bring paralysis to the city streets, recently enjoyed its first ever 'car–free day'. All motorised traffic was banned from the city streets except buses, taxis and the armoured jeeps used by government officials and diplomats. Mayor Penalosa declared the day a success, observing that pollution had declined and that 'the city should do this sort of thing every year' (BBC News 2000a).

After successful experiments in the big industrial cities of Milan and Turin, Italian drivers were required to leave their cars at home for four consecutive Sundays in February 2000 in an attempt to reduce air pollution. In Rome, the whole city centre was closed off with both free public transport and free admission to museums and archaeological sites (BBC News 2000b).

The number of countries scheduling car-free days increased dramatically in 2001. World Car-Free Day was celebrated on 20 September 2001. The United Nations now has a Car-Free Day Program.[82] In Australia, Centennial Park in Sydney has a car-free day on the first Sunday of every season.[83]

Impact of car-free days

The impact of car-free days depends very much on the details of the program. In Mexico, the implementation of the No Driving Day Program (NDD) in November 1989 resulted in reduced fuel use and an increase in public transport usage. However, once the program was made permanent, it led to substantially different consumer behaviour than anticipated. Residents of Mexico City purchased more vehicles in order to always have at least one vehicle available on any given day.

The efficiency cost of the NDD Program relates to the fact that the program made no distinction between the relative values of various days. Work, leisure, and commercial/industrial delivery travels were treated as if they are of equal value. But of course they are not. However, the fact that 41 per cent of vehicles cited for violating the NDD restriction in the program's first year were commercial delivery vehicles show that some users value access more highly than others.

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82 See http://www.uncfd.org/index2.php.

83 For more details see http://www.cp.nsw.gov.au/aboutus/free.htm.

Car-free days may reduce local pollution for a day but at a considerable cost in terms of inconvenience. Some trips are cancelled, others delayed and others taken using alternative forms of transport. It is difficult to be conclusive as to whether the benefits of car free days outweigh the costs. Generally, such days are implemented without prior evaluation of the benefits and costs. In addition, the impact of car-free days may be difficult to discern, since they are aimed principally at promoting long–term changes of commuting habits, through raising awareness about alternative forms of transport.[84]

FLEXIBLE WORK ARRANGEMENTS

The main form of flexible working arrangements that impacts on VKT is telecommuting. The term telecommuting is often used to include any method for working productively outside the traditional office:

> Telecommuters include everyone from computer programmers in Denver reporting to an employer in Australia, to an executive who stays at home one morning to study a complex contract, to a data–entry clerk who works on a desktop in her spare bedroom, to a sales person who rarely leaves the territory in which he lives and works.[85]

Continuing improvements in technology, including more robust networks, increased bandwidth, a new generation of remote configuration tools, new software utilities and wireless connectivity all contribute to the ease of remote connections and hence encourage telecommuting. Access to high speed Internet will significantly boost the popularity of telecommuting:

> Advances in broadband communications technologies and high–speed Internet access are making new types of working arrangements and enterprises possible for the first time. With broadband infrastructure, no longer will it be the case that urban areas will have the monopoly on the highest–paying jobs. Many knowledge–based industries are becoming less dependent on the services associated with urban zones.[86]

Other findings include:

- in 2000, somewhere between 8 and 32 million people telecommuted full time in the US, depending on survey under consideration;
- relative to Europe, only Finland, Netherlands, and Sweden have a higher per capita telework participation than the US;
- workers in telecommuting and flex–time programs experienced a 35 per cent reduction in insomnia and other sleep disorders;

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84 Ex-post evaluation reports of the International Car-Free Day campaign 2001 are available at http://www.22september.org/part/en/day02.html.

85 http://www.knowledgetree.com/ata-adv.html

86 See *Taking the I-train to work,* http://archives.seattletimes.nwsource.com/cgi-bin/texis.cgi/web/vortex/display?slug=techtranop12&date=20020212

- 87 per cent of companies on the year 2000 Fortune '100 Best Companies to Work For' have telecommuting programs; and
- most telecommuters report better relationships with spouses and children, improved personal morale, and fewer sick days.[87]

The role of government appears to be limited to the tax treatment of home offices and perhaps demonstration projects.[88] In many countries, including Australia, home offices can be depreciated for tax purposes. In the Netherlands, an employer can make a significant tax–free contribution to the employee to cover costs of setting up a home office, on the condition that the office is used at least once per week in lieu of a normal commute.

For the Australian work force, however, the significance of telecommuting is not clear. No large–scale academic research on teleworking has been undertaken in the Asia Pacific region and there is a similar lack of large–scale research in other regions (Lindorff 2000, p. 2).[89] Lindorff surveyed 157 Australian companies, including 98 of the 1998 Business Review Weekly's 'Top 100' companies and found few employees teleworking from home.

The impact of telecommuting on VKT (and fuel use) would depend, in the first instance, on whether, as some research suggests, telecommuters, freed from the burden of travelling to work, increased travel time for other purposes and if so, by how much. Even if they maintained or increased their VKT, telecommuters are likely to reduce their travel during congested periods.

While generally not impacting on VKT, flexible hours, whether they are for work, shopping or schools, would make it possible for people to shift their travel away from the congested periods of the day, with potential greenhouse benefits. Moreover, if flexible arrangements resulted in a more concentrated working week, VKT would be reduced.

The Productivity Commission (1994) cited evidence of a reduction in peak hour travel by more than 50 per cent in Ottawa following the introduction of 'flexitime' to government offices—mainly through an increase in early arrivals. If this reduction in congestion could be sustained, then there would be greenhouse gains in proportion to the fuel saved (for more on the impact of congestion on greenhouse gas emissions see Chapter 4 of this report). However, given the widespread nature of flexible hours arrangements in Australia, there may be limited scope for further gains in this area.

87 Sourced from the detailed list of current telecommuting surveys at http://www.langhoff.com/surveys.html#top.

88 The NSW Roads and Traffic Authority initiated the first major teleworking program in Australia in the early 1990s.

89 Lindorff, M., 2000, Home-based Telework and Telecommuting in Australia: More Myth than Modern Work Form, *Asia Pacific Journal Of Human Resources,* 2000, vol.38 no. 3, http://www.shrmglobal.org/publications/ahri/0101article4.pdf.

INCREASED URBAN DENSITY

The origins of the case for increased urban density (generally discussed under the label 'smart growth') can be traced to a 1974 economic study in the US, *The Costs of Sprawl,* which concluded that high–density, planned communities are less costly to build and live in than low–density 'sprawl' and produce less pollution (Campbell 1998). More recently, another US study, *Driven to Spend* reached similar conclusions.[90]

O'Toole (1999) identified some basic characteristics of smart growth:

- increase in urban densities, through the use of urban–growth boundaries which restrict development on rural lands bordering cities, and minimum density zoning which limits development to either multifamily dwellings or multibusiness complexes;
- emphasis on public transport especially rail rather than highway construction;
- reducing the attractiveness of driving through 'traffic calming', reducing the number and width of driving lanes and speeds with barriers or other obstacles;
- planning land use to ensure that neighbourhoods and businesses are oriented around public transport and are pedestrian–friendly; and
- imposing architectural design codes that discourage driving and promote walking and public transport.

In essence, smart growth aims to be more town–centred, public transport and pedestrian orientated, with a greater mix of housing, commercial and retail uses, while preserving open space and many other environmental amenities.[91] Advocates of smart growth identify many transport benefits (less congestion, reduced traffic, decreased travel times, and reduced emissions) as well as more general benefits such as the conservation of open space, lower infrastructure costs, more affordable housing and protection of open space.

While a number of municipalities and states in the US have embraced the concept, Portland, Oregon, is widely regarded as the pioneer of smart growth. In October 2000, the Governor of California signed smart growth legislation into law.[92] Recently, voters in Colorado, Arizona, Oregon and Washington had the opportunity to endorse or reject smart growth.[93] In Colorado,

90 A joint product of the US Surface Transportation Project and the Center for Neighborhood Technology. For a copy of the report see http://www.transact.org/Reports/driven/default.htm.

91 The Smart Growth Network home page provides useful background reading. See http://www.smartgrowth.org/default.asp.

92 For details see http://www.transact.org/Ca/smart_growth1.htm.

93 For details see http://www.alliance.napawash.org/ALLIANCE/Picases.nsf/e24ffc586e80044a852564ed006eb5be/e34f64cdda41cdbb852569cc000fb026?OpenDocument

Amendment 24, requiring voters to approve any development in outlying areas, was defeated at the polls in November 2000.[94]

Transit–oriented development (TOD), a variation of smart growth, has been identified as the dominant urban growth planning paradigm in the US (Nelson & Niles 1999b). Over the past two decades numerous metropolitan areas in the US have embraced the concept of TOD with the aim of reducing the number and length of automobile trips and improving air quality. This has been accompanied by a major resurgence of investment in light rail.

Impact of increased urban density

Smart growth is a widely debated topic in the US. The main criticisms focus on light rail investments that are a core feature of many smart growth projects in the US.[95] It is argued that these projects have consistently involved major overruns of capital costs and lower than expected patronage figures (Pickrell 1989).[96]

Nelson and Niles (1999a) argued that there is little evidence that TODs produce environmental and social benefits commensurate with the costs of the major transportation system improvements that they require.[97] In some cases, analysts argue that investment in light rail has worsened overall transit–system financial performance while providing little or no gains in public transport ridership (Richmond 2001).

Many urban areas in the US have been polarised on the issue of the introduction of light rail to help revive the urban core and discourage further 'sprawl'. Kansas City went to the polls on 7 August 2001 to determine whether a sales tax increase of a half cent should be implemented for 25 years to help build a 24–mile light–rail starter system. The move was rejected, as it has been annually for the past four years [98]

Criticisms of Portland's experience focus on the rapidly increasing congestion from higher density living. Evidence from both the US and other countries indicates that higher density urban areas are characterised by much higher

94 For an insight into the debate see http://www.google.com/search?q=Colorado+Amendment+24.

95 For a list of light rail and urban planning experts with alternative views to Portland's Metropolitan Government see http://www.cascadepolicy.org/transit/experts.htm.

96 Bundy (2001) has estimated the cost overrun for Seattle light rail at almost US$2 billion.

97 For a recent brief review of the debate over whether TODs will reduce auto travel and increase use of alternative modes of transport see, Dueker and Bianco 1999.

98 For an introduction to the debate see www.kansascitylightrail.com.

levels of traffic congestion and air pollution than the more expansive US urban areas (Cox 2000a).[99] Charles concluded that:

> Unfortunately, there is only minimal consumer demand for dense, mixed–use communities, and absolutely no evidence that building TODs will reduce traffic. In fact, densifying a region through transit–oriented development makes traffic worse, because even though the transit ridership in a dense area is marginally higher than in a more dispersed community, the ridership gains are swamped by the sheer number of people living in the TOD, most of whom own and use cars (Charles 2000).

Also, public transport is generally starting from such a small base that even if patronage doubled (putting severe pressure on peak hour services), the impact on traffic flows would be negligible. In Atlanta, the recently adopted 25–year *Regional Transportation Plan* proposes strict smart growth initiatives, yet the number of jobs within a 40–minute transit ride of people with automobiles will rise only from 10 per cent in 2000 to 11 per cent in 2025 (Cox 2000a).

The impact of smart growth in reducing other costs is also being questioned. Campbell (1998 p. 11) cites research that used US Census Bureau data from 247 US counties, representing 59 per cent of the American population, to determine how increases in population densities affect quality of life and costs. The results were almost exactly the opposite of those reported in *The Costs of Sprawl.* Most costs (including home ownership, shelter, and food) were significantly higher in the dense urban areas. Also, the higher crime rate in inner–city areas in the US is often cited as a significant factor in the relocation from crowded urban areas to more spacious suburbs.

While there are many lessons to be learnt from past development practices, these alone do not justify a radical change of direction. The uncritical pursuit of policies to increase the density of cities to achieve better utilisation of public transport may not be in the public interest. A prerequisite for sound land use would be to ensure that development costs are not distorted by subsidies (such as the partial recovery of infrastructure costs): in other words, that the price signals that determine settlement patterns accurately reflect the benefits and costs facing society. As the Industries Assistance Commission (IAC) observed, a major contribution to achieving efficient patterns of urban settlement would be to ensure that all costs are accurately accounted for and not distorted by taxes, subsidies or other measures (IAC 1993).[100]

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99 *In Pulling Up the Ladder*, Cox argues that, as a direct result of the development restrictions inherent in ‘smart growth’, Portland’s housing affordability declined by over 50 per cent between 1991 and 2000, with serious implications for lower income groups.

100 Zoning regulations commonly dictate minimum size blocks and hence encourage sparser settlement—possibly sparser than that desired by the market.

The major distortions often have their origins in government policies and regulations. For instance, minimum block sizes common in Australia would contribute to 'urban sprawl', as would restrictions on multiple occupancy in urban areas.[101] Also, the tax structure distorts investment in home ownership relative to other investments, encouraging larger homes on larger blocks.[102] In Australia, linking the reduction in fringe benefits tax to the annual mileage covered by the vehicle also encourages a longer daily commute.

In brief, while there are clearly desirable elements of smart growth, such as the integration of land use patterns and transport, little definitive research has been done to support the case for higher urban densities, particularly in association with major new public transport projects. The first best strategy would be to remove those distortions that influence home sizes and location.

SHIFTING FREIGHT FROM ROAD TO RAIL

Trains have the potential to consume less energy and cause fewer greenhouse gas emissions than trucks for a given freight task. In practice, the relative fuel–efficiency of rail depends on a number of variables, including train length, load factor and fuel source and consequently estimates vary. The Australasian Railways Association (ARA) suggests that, on average, rail freight uses one third of the fuel required by road transport per tonne of freight hauled and hence produces one–third of the greenhouse gas emissions (ARA 2000b, p. 7). This is supported by the Association of American Railroads who have stated that, 'on average, railroads are three or more times more fuel efficient than trucks'.[103] In contrast, the Railway Association of Canada claims that, 'on average, in 1999 trucks generated 12 times as much greenhouse gas emissions as rail per tonne–kilometre.'[104]

A number of countries are examining options for shifting freight from road to rail, as a way of reducing pressure on the road network while achieving environmental gains. The European Commission (EC) has a stated aim of returning transport mode shares to 1998 levels by 2010.[105] In the UK, the transfer of freight from road to rail has long been a government objective,

101 In Canberra there was a brief period when dual occupancy was permitted in the inner city areas. Community opposition succeeded in reversing the policy.

102 In the US, mortgage payments are tax deductible. In Australia, capital gains from the family home are not taxable. It is likely that more generous tax treatment of the family home encourages a relatively higher level of investment in houses than otherwise, with possibly bigger houses on large blocks on the edge of town. Gittins (2001) has argued that the current structure of the First Home Owners Grant, despite having positive attributes, encourages urban sprawl.

103 See http://www.aar.org/GetFile.asp?File_ID=149.

104 See http://www.railcan.ca/documents/energy90-99.pdf.

105 *Local Transport Today*, Issue 320, 26 July 2001, p. 9.

supported through freight facility grants and, more recently, Track Access Grants. The Strategic Rail Authority's (SRA) 2001–2010 freight strategy provides for £4 billion of investment in rail freight over the plan period. The expansion in public funding is aimed at additional route capacity to provide Britain's freight trains with higher priority, with the objective of achieving an 80 per cent growth in rail freight traffic over 10 years. If achieved, this would represent an increase in rail's market share of the freight task from its current seven per cent to 10 per cent (SRA 2001, p. 3).[106]

In Europe, the main barrier to rail's increased competitiveness has been the absence of the seamless operation that is available to road freight. The European White Paper on transport, released in September 2001, provided a strategic overview for shifting the balance between modes of (EC 2001). While progress has been slow, reforms are gaining momentum. Building on the White Paper and the earlier 2001 package of rail directives, the European Commission adopted a second package of measures 'to speed up the process of creating an integrated railway area' (EC 2002).

The single most important issue identified by the European Commission relates to the coordination of freight traffic across railway administrations. To facilitate this, the EC is focussing on:

- consistency in regulations;
- technical interoperability; and
- consistency in access charging.

A similar situation exists in Australia where, despite considerable progress, there remain different regulation and enforcement regimes from State to State. These increase the cost of rail freight and limit the quality of service that can be provided. The recent development of liberalised access to rail tracks assists rail's competitiveness. Nonetheless, there are seven different access regimes that freight operators face. This can militate against consistent access charges. It also increases transaction costs and lengthens the logistics chain.

Environmental impact of shifting freight from road to rail

Rail already dominates land–based bulk freight movements. Opportunities to capture significant greenhouse gas emission reductions from shifting freight from road to rail are often quite limited because, generally, only a small

106 There are a number of policy initiatives that could be used to encourage a shift of freight from road to rail. For instance, in Canada, the President of Canadian National Railway has urged the Federal Government to consider tax breaks for shippers who make greater use of rail and intermodal facilities. See http://www.thestar.com/cgi-bin/gx.cgi/AppLogic+FTContentServer?pagename=thestar/Layout/Article_Type1&c=Article&cid=989120101566&call_page=TS_News_Columnists&call_pageid=970599109774&call_pagepath=News/Columnists.

proportion of total freight carried by road is contestable. This contestable area is long–distance non–bulk and residual bulk traffic. In addition, the degree of potential emission reductions that would result from any such switch are modest, because long-distance road freight movements are relatively fuel efficient compared to average road freight movements.

In terms of specifics, the BTCE estimated that the shifting of freight from road to rail would lead to a maximum fuel and emissions savings of around 0.5 per cent of total emissions from the road freight sector (BTCE 1996b, p. 213).[107] The report noted:

- roughly one third of truck tonne–kilometres in Australia occurs within cities;
- much of the non–urban rail task is either not in sufficiently large volumes or transported over large enough distance to be considered for transport by rail;
- it is mainly the intercapital road freight task that lends itself to switching to rail and this represents around 12 per cent of the trucking task; and
- the trucks that compete directly with rail are often the most fuel–efficient of the fleet, hence this 12 per cent of trucking task accounts for only 3.5 per cent of truck fuel use.

Efficiency and fiscal impacts of shifting freight from road to rail

The efficiency and fiscal impacts of shifting freight from road to rail would depend on the policies adopted to pursue a shift of freight from road to rail. However, to the extent that there were distortions that disadvantage rail relative to road, their removal would produce efficiency gains for the community.

The case is often made that the rail sector suffers from unfavourable treatment vis–à–vis road in a number of areas including access charges and infrastructure investment. While progress is ongoing in the pricing in both modes, there remain acknowledged deficiencies, the net impact of which is difficult to determine.

A distortion identified for road freight is that, on average, the current charging mechanism under–recovers road costs (including capital costs) from some heavy vehicles and over–recovers costs from other heavy vehicles (BTE 1999c).[108] With regard to rail, while bulk freight covers cost and is generally profitable, this is not the case with non–bulk freight—the sector that competes

107 Assuming that all four main rail corridors (Sydney–Melbourne, Sydney–Brisbane, Melbourne–Adelaide, and Adelaide–Perth) were upgraded.

108 The NRTC is obliged to structure the heavy vehicle charges to fully recover road costs, including capital costs.

directly with road freight. In the past, there has been little expectation that the revenue raised would cover a return to capital. As observed by the ACCC:

> Existing charges set by ARTC in the marketplaces result in revenues that fall significantly below a level that would allow for the business to earn an adequate long–term economic rate of return (ACCC 2001, p. x).

Furthermore, the Australian Rail and Track Corporation (ARTC) has stated that it is not in a position to increase charges to recover the full economic cost of its assets (ARTC 2002, p. 5).

Capitalising on the significant advances in understanding of the costs of infrastructure use and in the technology available for more accurate pricing of both road and rail would generate efficiency gains both between and within the modes. In addition, the development of a single rail access regime and the harmonisation of regulations across jurisdictions would facilitate the development of a seamless operation, significantly improving rail's competitiveness with road.

There are a number of policy measures that could be adopted in pursuit of a shift of freight from road to rail. The fiscal impact would depend on the details of the measure and the source and conditions of the funding (i.e. debt, equity or budget provision).

CONCLUSIONS

Few, if any, transport policy measures are aimed directly at abatement of greenhouse gas emissions. Hence, it may not be surprising that measures seldom provide significant gains in terms of greenhouse emissions. However, the reasons are complex and the dynamics are not always fully appreciated.

Individuals choose their mode of travel on the basis of a wide range of factors, chief of which are often the cost in terms of travel time and the frequency and reliability of service. Also important, if usually less so, is the financial cost, which may include the public transport fare or the cost of vehicle operation—including fuel use—and ownership.

This helps to explain why measures which entail a significant change in travel time (e.g. new road connections) or more frequent public transport services can lead to significantly changed travel behaviour, while many other measures elicit much smaller impacts. For the same reason, to the extent that measures succeed in reducing VKT and securing a mode shift, the opportunity for faster (i.e. lower cost) travel, on roads that are less congested than previously, itself induces additional travel, at least partially offsetting the gains.

As a consequence, the reduction in VKT which individual measures achieve is often considerably less than planned, with a correspondingly lower outcome for greenhouse gas emission savings.

In addition, the success or failure of a measure in one location may give little guide to its impact in another location. Local conditions (such as density of population, alternative transport modes available, and surplus capacity in the public transport system) will vary, as will the configuration of the measure. While often lacking, rigorous evaluation in advance of implementation and post–implementation studies would provide policymakers with valuable information.

chapter 3

REDUCING EMISSIONS PER VKT

Emissions in general may be reduced through improving fuel economy of cars (reducing litres of fuel used per VKT) or through reducing emissions per litre.[1] However, there is limited scope for reducing greenhouse gas emissions per litre since carbon emissions are a function of the carbon content of fuel.[2] Hence this chapter focuses mainly on strategies for improving fuel economy.

Improvements in fuel economy can be achieved through technological advances, improvements in the road network and through better driving and vehicle maintenance practices. To date, most policy focus has been on improving the fuel efficiency of vehicles.

Internationally, both regulatory and pricing mechanisms have been used to encourage improvements in vehicle fuel economy. While the cost of regulations tends to be less transparent, regulations invariably have a tax/subsidy element to them. For instance, in order to comply with fleet average fuel efficiency standards in the US, a manufacturer such as GM finds it necessary to 'lower the price of its small cars by increasing the price of its large cars and using the profits to subsidize the lowered price of its small cars' (Lave & Lave 1999, p. 264).

The main strategies pursued are mandated fuel efficiency standards, inspection and maintenance programs, preferential tax treatment of more fuel efficient vehicles, voluntary agreements with manufacturers and the provision of information to encourage purchase of more fuel-efficient vehicles.

1 Alternatively, improvement in fuel economy may be indirectly due to the reformulation of fuel. The use of low sulphur fuels has enabled the application of fuel-saving technologies. Fuel with a higher octane rating can reduce fuel consumption per kilometre, but only if used in cars designed for it.

2 Methane emissions can vary significantly with the technology employed but they only account for one per cent of transport's greenhouse gas emissions.

MANDATED FUEL EFFICIENCY STANDARDS

The average fuel efficiency of new motor vehicles can significantly influence transport fuel use and, consequently, greenhouse gas emissions. Advances in engine technology over the past 20 years have meant that in Australia, the average fuel consumption per unit of maximum power output by the engine has decreased by around 45 per cent (BTRE 2002). Almost offsetting these gains have been increases in both the average weight and power of new vehicles due, in part, to the growing popularity of both 4WD passenger vehicles and heavier vehicles in the light commercial category.[3] The net result, in line with overseas experiences, is an improvement in the average fuel efficiency of the new light vehicles over the past 20 years of around 10 per cent.

Mandated fuel efficiency standards are widely regarded as a device to force the accelerated uptake of fuel saving technology. Mandated fuel efficiency standards apply in a number of countries. The longest standing regulations of this kind are the Corporate Average Fuel Economy (CAFE) standards introduced in the US in 1975.[4] CAFE standards require companies to maintain the average fuel efficiency of new vehicles at around 28 miles per gallon (MPG) for cars and 21 MPG for light trucks (which includes passenger vans, utilities and sport-utility vehicles).[5]

Initially, CAFE was aimed at reducing US oil consumption and US reliance on imported oil but, over time, emphasis has shifted and objectives have widened to include a reduction in greenhouse gas emissions. The US Senate is currently debating tightening of the standards to 33 miles per gallon (7 L/100 km) for passenger cars and 26 miles per gallon (9 L/100 km) for light-duty trucks (LDTs) by 2010.[6]

Car manufacturers have not always met the standards and, in the calendar year 1998, paid over US$55 million in fines for failing to comply for passenger cars in model years 1996 and 1997.[7] The penalty is calculated as follows:

> $5.50 for each tenth of a MPG by which a manufacturer's CAFE level falls short of the standard, multiplied by the total number of passenger automobiles or light trucks produced by the manufacturer in that model year. Credits earned

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3 The category All Terrain Wagons (ATW) now encompasses 4WD vehicles.

4 The same standards have been adopted in Canada on a voluntary basis. For further details see http://oee.nrcan.gc.ca/english/programs/motorvehicles.cfm and OECD 1997c, p. 98.

5 Equivalent to a fuel intensity of around 8.5 and 11.5 L/100 km. For an excellent article covering both background and developments associated with CAFE standards see Bamberger 2001.

6 For a list of key issues in the proposed legislation see http://www.planetark.org/dailynewsstory.cfm/newsid/14570/story.htm.

7 This is a significant increase from the previous calendar year (1997), in which manufacturers paid civil penalties totalling $806,465 for failing to comply with the fuel economy standards for passenger cars in model-years 1994 and 1995 (US DOT 1999).

> for exceeding the standard in any of the three model years immediately prior to or subsequent to the model years in question can be used to offset the penalty. (US DOT 1999).

There is scope for the standards to be relaxed by the US Department of Transportation (DOT) on the grounds of economic practicability, an option that was exercised when oil prices halved in 1986 (Greene 1997, p. 32).

The relevant questions with regard to the potential contribution of mandated fuel efficiency standards to greenhouse gas emissions are whether they are effective and, if so, at what cost. Also, whether past success serves as a guide to future success from further tightening of the standards. Ultimately, the question for Australia, as a relatively small player in the international car market, is whether it is sensible to adopt fuel efficiency standards that are different from those that prevail in the countries from which we source most of our vehicle imports.[8]

Environmental impact of mandated fuel efficiency standards

The environmental impact of mandated fuel efficiency standards is complex and the source of much debate. The debate stems from whether the standards lead to an improvement in fuel efficiency, whether this, in turn, leads to lower emissions and, finally, whether the measures taken to improve fuel efficiency (use of lighter materials) produce higher greenhouse gas emissions that offset any gains from lower fuel use.

The program most studied and debated are the CAFE standards. In the 20 years after CAFE standards were introduced in the US, the average efficiency of the new car fleet almost doubled and average emissions improved even more (Dudson 1998, p. 107). Many observers attribute these gains to mandated fuel efficiency regulations.[9]

> The CAFE standards played the leading role in bringing about the 50 per cent increase in on-road fuel economy for light-duty vehicles from 1975 to 1995. This increase in fuel economy held down gasoline consumption with an effectiveness of 80–90 per cent, taking into account the rebound effect. Today, consumers spend over $50 billion per year less on motor fuel than they would have at 1975 miles per gallon levels (Greene 1997, p. 32).

Supporters of CAFE have also pointed to the significantly lower gains in fuel economy of light-duty passenger vehicles in Europe and Japan between 1973 and 1991 as testimony to the contribution of the CAFE standards to improved fuel efficiency.[10] However, critics contend the more dramatic improvements

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8 Exports from Australia, being such a small share of the destination market, are probably not an issue.

9 Among others, Howitt and Altshuler concluded that CAFE standards in the US have produced significant results (Gómez-Ibáñez et al. 1999).

10 US (53 per cent) compared to that of Europe and Japan (7 and 2 per cent respectively).

in fuel economy in the US compared to Europe and Japan were due not to CAFE standards, but to the fact that the US price increase was much greater in a relative sense. Fuel taxes before then had been very low and US manufacturers had greater scope for fuel efficiency gains (Wooldridge 1994).[11]

Against this, it is argued that fuel price rises, rather than CAFE, were the main source of the improvements in average vehicle efficiency (Porter 1999, p. 47). The bulk of the fuel efficiency gains occurred between 1978 and 1982—the period in which US petrol prices almost doubled (Hogarty 1999, p. 8).

In the US, average new light vehicle fuel economy peaked in 1987 and has been essentially flat over the past 16 years.[12] The trend for total light vehicles in Australia has been similar. However, this trend should be viewed in light of the changing nature of the vehicle fleet. The average vehicle today is quite different to that of 20 years ago. In the US, the average vehicle is now 22 per cent heavier, 84 per cent more powerful and has 27 per cent more acceleration. Taking the changing nature of vehicles into account, fuel efficiency has improved by around 25 per cent. How much of this is due to mandated fuel efficiency standards is the source of speculation (EPA 2001).

Porter argues that:

> … it is difficult not to conclude that CAFE for fuel efficiency rose when the market would have produced greater fuel efficiency in any case and that CAFE standards stopped rising when they began to require manufacturers to produce more fuel-efficient cars than consumers wanted to buy (Porter 1999, p. 47).

There is also the claim that the structure of CAFE encourages consumers to purchase larger, less fuel-efficient vehicles. The view is expressed that the 'more generous' fuel efficiency standards for light trucks (minivans, pick-ups and sports utility vehicles) further encouraged the market shift that saw the demand for SUVs grow from two per cent to 22 per cent of the market in 25 years. However, this shift in consumer preference has not been confined to the US.

If mandated fuel efficiency standards resulted in a more fuel-efficient fleet, resulting greenhouse gains would be reduced by the 'rebound effect'—the tendency for people to drive more when the fuel cost per kilometre decreases. Hence, a 10 per cent improvement in fuel efficiency, regardless of the source, will not translate into a 10 per cent reduction in emissions. Estimates of the rebound effect vary but range between 20 and 40 per cent, depending on the price of fuel (IPCC 2001).

Another factor that must be taken into account when considering mandated fuel efficiency standards for environmental objectives is the greenhouse gas

11 When average fuel efficiency is quite low (13.3-MPG) significant gains can be more readily achieved than when average fuel efficiency is already quite high, as in Europe and Japan.

12 EPA (2001) Light-Duty Automotive and Fuel Economy Trends at http://www.epa.gov/otaq/cert/mpg/fetrends/r01008.pdf.

emissions produced to achieve the standards. For example, the production of lighter weight materials such as aluminium and plastics will generally produce higher greenhouse gas emissions than more traditional materials and, when taken into account, make it possible for mandated standards to have a negative effect on the environment.

Also, there can be conflict between improving fuel efficiency and other environmental objectives. In the US, CAFE standards have lead to a situation where automakers are trying to install more diesel engines in light trucks, since these engines improve fuel economy by up to 30 per cent, even though they burn with more ambient emissions than regular engines (McEachern 1998).

Overall, while CAFE standards may have contributed to higher fuel efficiency of cars, when the total light fleet is taken into account, the final impact remains uncertain. The National Research Council (2002, p. 3) stated that CAFE standards reinforced the incentive that automakers had to reduce costs by reducing the weight of vehicles. In a similar vein, Schipper observed that:

> In our exhaustive survey of worldwide changes in energy use over the past twenty years, we found no significant changes in fuel choices or energy efficiency that were not somehow underscored by energy prices favouring the change (quoted in BTCE 1996, p. 145).

The trends in US fuel economy appear to be very similar to those experienced in Australia, despite significant differences in fuel prices and the absence of mandatory fuel efficiency standards in Australia. However, it is also important to acknowledge the significance of imported vehicles in the Australian market.

Efficiency impact of mandated fuel efficiency standards

Mandated fuel efficiency standards involve government regulations overruling consumer preferences—a move that would generally involve efficiency losses. The National Research Council (NRC) observed:

> Consumers have a wide variety of opportunities to exercise their preference for a fuel-efficient vehicle if that is an important attribute to them. Thus, according to this logic, there is no good reason for the government to intervene in the market and require new light-duty vehicles to achieve higher miles per gallon or to take other policy measures designed to improve the fuel economy of the fleet (NRC 2002, p. 2)[13]

Mandated fuel efficiency standards generate efficiency losses through distorting the fleet mix and raising vehicle costs. Compliance costs in the US vary, often considerably, between firms (OECD 1997c, p. 39). Efficiency losses are minimised when the marginal cost of compliance is equated across all firms. Porter (1999, p. 60) estimated that the cost of achieving a given level of mandated fuel efficiency could be reduced by 20 per cent if the system allowed

13 The NRC went on to observe that there may be other reasons apart from efficiency, such as greenhouse gas emissions and security of energy supplies.

abatement costs to be equalised between firms. This could be achieved by establishing a market for tradable fuel-efficiency permits (or credits), allowing the fuel efficiency targets to be achieved by those firms that could do so at the lowest cost. The low cost firms would sell credits to high cost firms, up to the point where marginal compliance costs were equalised.

> CAFE regulations permit marginal abatement costs to be equalised *within* firms but not *across* firms. Manufacturers are permitted to achieve the standard on average, rather than for every vehicle model, thereby minimising the cost of achieving the dictated standard. However, this has resulted in price distortions whereby 'companies sold smaller, more efficient cars at a loss in order to balance the sales of larger, less efficient cars and maintain adequate levels of fleet fuel economy (Plotkin 1999, p. 15).

To the extent that CAFE standards have been successful in encouraging smaller, more fuel-efficient vehicles, there may have been a cost to safety and to lives. The review by the National Research Council (2002) concluded that the 'downweighting' and downsizing that occurred in the late 1970s and early 1980s, some of which was due to CAFE standards, probably resulted in an additional 1,300 to 2,600 traffic fatalities in 1993 (NRC 2002, p. 3).

For Australia, an alternative way to encourage the purchase of more fuel-efficient vehicles would be to accelerate the planned tariff reductions for passenger motor vehicles. Tariffs on passenger motor vehicles were reduced to 15 per cent in 2000 and are scheduled to fall to 10 per cent in 2010. At this point 'effective assistance to the passenger motor vehicle industry is expected to remain equivalent to more than double the manufacturing average' (Productivity Commission 2000, p. 18).

The current tariff of 15 per cent is equivalent to a tax on new motor vehicles of A$2,100 (Emmery 1999). It is likely that the higher prices resulting from this tax burden encourage motorists to hold on to their cars longer, thereby slowing the penetration of emission-reduction technology and newer, more fuel-efficient vehicles in the national car fleet.[14] In addition, given that 4WDs attract a lower five per cent tariff, it is possible that the current differential encourages the purchase of larger and, on average, less fuel-efficient vehicles.[15]

Fiscal impact of mandated fuel efficiency standards

The main fiscal impact of a CAFE standards-type scheme would revolve around the cost of administering the scheme and the fines paid by those companies that

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14 While the fuel efficiency of new light vehicles has been relatively flat over the past 14 years, fuel efficiency for passenger cars has continued to improve (BTRE 2002, p. 2).

15 The evidence is not entirely clear on this point. The diesel segment of the 4WD market may be as fuel efficient as the large family cars that they often replace. Further, the recent growth in the 4WD market appears to have been in the smaller vehicles (e.g. Toyota RAV-4 and Honda CRVs), which are likely to be more fuel efficient than the average new car.

fell short of their targets. There could be a small loss in fuel excise revenue if average vehicle efficiency exceeded that which market forces alone would have produced.

FEEBATES

Feebates refer generally to fees on fuel-inefficient vehicles and rebates on fuel-efficient ones. The fees and rebates may impact at point of sale or on annual registration fees and usually offset each other ensuring fiscal neutrality. Operationally, feebates are quite simple:

> … when you bought a new car, you would pay an extra fee if it were an inefficient user of fuel, or alternatively get a rebate if it were energy-efficient. The neutral point would be set so that fees and rebates balanced, so it became neither an inflationary measure nor a disguised tax (Quinion 1999).

Apart from the operational simplicity, feebates are politically attractive because they reward those who purchase environmentally-friendly vehicles by taxing those who fail to, without penalising existing car owners. Feebate variations already exist in Ontario (Canada), Germany, Denmark, Austria, the UK and parts of the US, and are soon to be introduced in NSW.

The system in Ontario involves a tax of US$75 to US$4400, which is levied on new cars using six or more litres per 100 kilometres. Purchasers of vehicles using less than six litres per 100 kilometres are paid a rebate of up to US$100. A variation on the scheme is used in Austria where new vehicles with greater fuel economy (less than eight litres per 100 kilometres) attract a lower rate of sales tax than other new vehicles.

Feebates represent differential tax rates at the point of vehicle purchase. They could equally be applied as differential registration charges or differential taxes on other vehicle costs such as insurance. In the UK, the Government has reduced the motor vehicle tax (vehicle excise duty or VED) on the purchase of more fuel-efficient vehicles and on those that use more ‘environmentally friendly’ fuel. Under the new system, 95 per cent of individuals and companies purchasing vehicles will pay less VED than under the existing rates, with reductions ranging from £5 to £70.[16]

Environmental impact of feebates

Feebates, like mandated fuel efficiency standards, would result in lower greenhouse gas emissions if they led to an improvement in the average fuel efficiency of the fleet and a VKT no higher than would have occurred in the absence of feebates. While feebates serve as a more direct way of taxing less

16 For more detail see http://www.dvla.gov.uk/newved.htm.

fuel-efficient vehicles and subsidising the more fuel-efficient vehicles than mandated fuel efficiency standards, their impact and shortcomings are similar.

The impact of a feebate scheme on greenhouse gas emissions would depend on the levels of the taxes/subsidies adopted, the cut-off points used to define fuel-efficient and fuel-inefficient vehicles, the responsiveness of car buyers' to the price changes and the significance of the rebound effect, as the lower cost of driving more fuel efficient vehicles encouraged more driving.

There have been few assessments of feebate programs. In Ontario, following the introduction of the feebate system, sales of fuel efficient cars as a percentage of total car sales increased from 2.6 per cent in 1990, to 5.3 per cent in 1991, and to 7.4 per cent in 1992 (Morris 1994). However, Morris questioned whether this market shift could be attributed to feebates since the tax-equivalent of the feebate constituted less than one per cent of the sales price of the car and hence was unlikely to have influenced customers' choices. Rather, the recession and the 13 cents per gallon increase in the provincial gasoline tax in July 1991 were more likely to have influenced consumer preferences (Morris 1994).

Modelling conducted for the US Department of Energy concluded that feebates would reduce greenhouse gas emissions through improving the average fuel economy of new vehicles and reducing fuel consumption in cars and light trucks by seven to eight per cent (Kahn 1994). However, under the assumptions adopted for this modelling, the savings in fuel costs to consumers would be sufficient to offset the higher purchase cost associated with more fuel-efficient vehicles. Hence, it would be rational for car buyers to purchase the more fuel-efficient vehicles, even in the absence of feebates.

The OECD concludes from experience in Ontario and Austria that feebate schemes in operation have 'not achieved a measurable improvement in fuel economy.' (OECD 1997c, p. 47). However, this lack of effectiveness may reflect the design of the program. The Ontario program excludes light trucks and minivans and has few steps between cars of different fuel efficiency. A flat rate of Can$75 applied to 90 per cent of new vehicles sold and the rebate of Can$100 was regarded as symbolic rather than influential (ARI 1995). A more comprehensive program with more significant differentials could have a larger impact.

The environmental impact of the feebate scheme is limited by the fact that it targets the vehicle rather than the primary source of greenhouse gas emissions—fossil fuel use. By targeting the vehicle, the rebound effect becomes an issue. The increase in driving of around 20 per cent due to the lower cost of driving could create other environmental problems that offset any greenhouse gains.

Efficiency impact of feebates

Feebates are seen as a way of taxing inefficient vehicles to internalise environmental and other external costs associated with automobile ownership and use (ARI 1995). However, in general no attempt is made to calibrate the feebates to reflect external costs, such as the greenhouse gas emissions. In fact, it would be difficult to set the feebates to internalise externalities because the externalities are a function of vehicle use, not of vehicle ownership. A 'gas guzzler' that is rarely used would produce significantly less in the way of greenhouse gas emissions than a more fuel-efficient vehicle that was used extensively.

Consumer choices are distorted by feebates in the same way that CAFE regulations distort the relative prices of motor vehicles. The basic difference is that with mandated fuel efficiency standards manufacturers adjust vehicle prices in order to achieve the mix of sales necessary to achieve the standards. With feebates, the Government performs this function through setting the vehicle categories for fees and rebates. These distortions produce efficiency losses similar to those that arise from CAFE regulations.

Fiscal impact of feebates

The fiscal impact would depend on the design of the scheme. The scheme could be designed to be revenue neutral after administrative costs and the feebates were taken into account. However, such revenue neutrality would require considerable administrative costs through continuous monitoring of the market and periodic adjustments to take account of unexpected market shifts.

PROMOTING TECHNOLOGICAL IMPROVEMENTS

The Majority Report to the President (1995) stated that 'technological improvements are integral to achieving greenhouse gas reduction goals'. One policy option is to provide government assistance to advance these improvements.

Technological improvements over the past 25 years have doubled fuel economy in new cars in the US (Porter 1999, p. 48). A shift to lightweight material has been one of the main sources of gains. As Plotkin (1999, p. 18) observed:

> Weight reduction has been a key factor in improving the US automobile fleet's fuel economy since the early 1970s and will likely play an important role in future improvements.

Apart from material substitution, Plotkin (1999, p. 19) identified the most important of the new technologies, in terms of fleet fuel efficiency, as:

- aerodynamic drag reduction;
- engine friction reduction;
- variable valve timing;

- direct injection stratified charge gasoline engines;
- turbocharged direct injection (TDI) diesel engines; and
- advanced tyres.

Vehicle manufacturers are also investing significant resources in engine redesign, the development of less polluting vehicles, in particular, hybrid cars and fuel cell vehicles.[17] Honda *Insight*, a hybrid vehicle powered by both a small internal combustion engine and a battery-driven electric motor and Toyota's hybrid, the *Prius*, are both now available in Australia. In 2000, General Motors introduced the *HydroGen 1*, the first road-going test car combining fuel-cell technology with pure hydrogen.

Technological improvements in heavy vehicles are ongoing. When Scania launched its concept truck for the 2010s, it outlined a 50 per cent capacity increase in payload and volume accompanied by a 20-25 per cent reduction in fuel consumption and emissions per tonne transported.[18] The increased payload would allow a reduction of up to 30 per cent in the number of trucks on the roads, thereby greatly reducing congestion and, in turn, reducing fuel use and greenhouse emissions.[19]

Table 3.1 illustrates some expectations of the timing, costs and benefits of improvements in 'known technologies'.

From this, the *Foundation Paper on Climate Change* (1998) concluded that 'manufacturers can achieve a large reduction in fuel consumption without necessarily shifting to new power sources'. Furthermore, based on the estimates in the table, the US Office of Technology Assessment (OTA) estimated that a medium-size vehicle could achieve around 6.0 L/100 km by 2005 and 4.5 L/100 km by 2015 using these technologies, at a net price increase to the buyer of up to US$1,600 in 2005, and up to US$5,200, in 2015' (FPCC 1998, p. 68).

Dudson (1998, p. 107) supports the suggestion that advanced materials could lead to major cost reduction, pointing out that the recent 75 per cent decrease in the cost of producing the new ultra-light, carbon-fibre material significantly enhances its commercial prospects. *The Economist* (2000c) reports that 'every 100lb (about 45kg) removed from a Ford Focus … improves its fuel-economy

17 A great deal of information on these technologies is readily available on the Internet. See, for instance http://www.energy.ca.gov/education/AFVs/fuelcells.html for fuel cell vehicles and http://www.times.org/archives/2000/hybridcars.htm for hybrid vehicles.

18 *The truck of the 2010s:New concept truck unveiled by Scania*, 29 September 1999, http://www.scania.com/news/archive/wwwtxt/N99070EN.htm.

19 The use of road-friendly (air) suspension and eight axles that each put no more than 8 tonnes on the road substantialy reduces road wear compared to a conventional semitrailer rig.

TABLE 3.1 LIGHT-DUTY VEHICLE TECHNOLOGIES (SHORT AND MEDIUM TERM)

Technology	*Timing of introduction (years)*	*Cost (retail price per vehicle US$)*	*Potential % reduction in fuel consumption*
Aerodynamic improvements	3–20	40–120	2.5–6.5
Advanced tyres	5–15	20–40	2–7.5
Advanced materials	5–15	1000–8000 (could even be a reduction)	9–23
Advanced electronic controls	<5	50–100	5–15
Improvements to spark ignition engines	<5	100–200	5–15
Gasoline direct injection	3–5	300–600	17–25
Advanced diesel engines (TDI)	3–5	800–1200	20–29
Advanced automatic transmissions	0–5	100–200	1–10

Note Direct injection technologies require very low sulphur fuels and further development of NOx reduction technologies.

Source Adapted from a similar table in *Foundation Paper on Climate Change—Transportation Sector*, Dec 1998, p. 68.

by a full mile a gallon'. Honda's new *Insight* passenger car is made largely of aluminium and composites while the luxury Audi A8 and the mass market Audi A2 are aluminium intensive vehicles. Dudson (1998, p. 108) anticipates the possibility of 'triple efficiency cars, with comfort and convenience that matches conventional cars', on sale in the year 2005.

However, Dudson (1998) makes no mention of the costs involved in reaching this point. If the total cost of the short to medium-term technologies in the above table tended towards the higher side of the range, costs of the new technology could be around US$10,000 per vehicle—a cost that could hinder the uptake of the technology.[20] Hybrids cost more to manufacture than conventional vehicles and Toyota is reported to lose US$20,000 for every one it sells (*The Economist* 2000c).

20 Although there is likely to be only a low probability that the costs of all the developments would tend towards the higher end of the scales.

Porter (1999) argues that further gains in fuel economy would be significantly more costly than past gains, citing as evidence the fact that 'new US cars now get almost as much MPG [miles per gallon] as European cars even though fuel prices are much higher in Europe than in the US'. From this Porter concludes:

> Both engineering estimates and evidence from abroad suggest that further increases in the fuel efficiency of the American automobile will be very expensive unless cars are reduced in size a great deal, many safety and comfort features are removed, or cars are basically redesigned (1999, p. 49).

A development promising greater fuel efficiency for light trucks (including pickups and SUVs) is the Displacement-on-Demand, small-block-V8 engine scheduled to be released by General Motors in 2004. This technology offers major improvements in fuel economy via the ability to switch back and forth from eight to four-cylinder operation as driving situations demand. Steady-state highway driving could produce savings as high as 20 per cent.

Savings in greenhouse gas emissions in the order of 25 per cent are being claimed for the technology-enabling feature of low sulphur fuels. In many countries, including Australia, low and ultra low sulphur fuels are being introduced on the strength of their local environmental benefits—fewer particles (linked to asthma and cancer) and few sulphur oxides (which cause acid rain). Greenergy, the supplier of Citypetrol in the UK, argues that the lower sulphur fuels such as Gasoline Direct Injection (GDI) allows the use of new technologies that produce significant reductions in carbon dioxide emissions.[21]

In Australia, increases in allowable mass associated with road-friendly suspension will lead to a reduction in fuel consumption and emissions per tonne of payload. Other technical developments, such as liftable axles, also have the potential to substantially lower fuel consumption and emissions.

Impact of promoting technological improvements

There is considerable scope for advances in technology to have positive impacts on the environment—although these will be diminished by the 'rebound effect' discussed above. Hybrid cars use both fossil fuel and electric motors, so the level of emissions depends not only on the reduction in fossil fuel use but also on the source of the electricity used to charge the batteries. Fuel-cell vehicles produce zero emissions only when they are fuelled with hydrogen. However, hydrogen production, storage and distribution will also cause greenhouse gas emissions. Fuel-cell vehicles may also run on hydrocarbon fuels, like methanol or petrol, producing emissions, although less than conventional motors.

However, since the new technology applies only to new vehicles, the full environmental impact would only be felt with the turnover of the fleet.

21 See http://www.greenergy.com/our_company/media_centre/arc_march_2000_budget.html.

The case for dedicating public funds to encourage the development of these technologies hinges on the extent to which the manufacturers are unable to extract sufficient benefits from these technologies to make investment worthwhile. The prospect of commercial rewards provides significant stimulus for many of these developments. There are numerous small-scale examples of firms adopting technology for purely commercial reasons, but incidentally generating environmental benefits at no cost to the public purse. For instance, the Findlay trucking group introduced an on-board monitoring device to ensure that engines were running correctly, thereby lowering maintenance costs. The incidental benefit is a resultant fuel saving and hence a reduction in emissions of up to 10 per cent (ATN 2000, p. 34).

There are different views about what governments should do in terms of encouraging appropriate technology in the pursuit of efficiency gains. One view, expressed in the Majority Report to the President (1995) is that 'the path of technological progress, while promising, is unpredictable but can be pushed by government intervention as has so often been demonstrated in the past'. On the other hand, the Government is not always best placed to 'pick winners' in vehicle technology, as history testifies. In the early 1990s, California introduced an electric-vehicle mandate whereby an increasing fraction of vehicles sold had to be electric in future years. This has since been rescinded, reflecting their current disadvantages:

- high initial cost (two to five times the price of similar conventional cars);
- short range between recharges (one third to one-sixth that of conventional cars); and
- need for expensive battery replacements (Porter 1999, p. 62).

The fiscal impact of government funding to accelerate technological improvements would depend on the extent of the funding and the arrangements put in place for sharing the benefits of the research.

INSPECTION AND MAINTENANCE PROGRAMS

In the US, inspection and maintenance (I/M) programs have long held a central position in the regulatory efforts to reduce local emissions from cars and light trucks.[22] The Environment Protection Authority (EPA) encourages states to run I/M programs that require all vehicles to be tested at government-supervised centres at intervals ranging from six months to two years. Inspection protocols can range from relatively simple and inexpensive tailpipe testing to more complex and expensive dynamometer testing.

22 In the US, I/M programs were first introduced in the Clean Air Act of 1963.

Tough vehicle inspections operate in western Europe and Japan. In Australia, a system of annual inspections is in operation for trucks and various States have also run inspection programs for passenger motor vehicles.

Impact of inspection and maintenance programs

The aim of I/M programs in the US and in Canada is, through blanket testing, to reduce local pollution by ensuring that emission-control systems are performing acceptably. While I/M programs have widespread support, their effectiveness has been questioned by many including Roth (1996, p. 92) who has argued that I/M programs fail to detect the 10–15 per cent of gross polluters who are responsible for most of the pollution by cars in the US.

Green (1997) goes further to argue that the current I/M programs are conceptually flawed and produce misguided incentives:

> Traditional I/M programs require that all vehicles be tested and embody the assumption that universal pursuit of marginally high-emitting vehicles will be more effective than a targeted attempt to clean up only very high-emitting vehicles.

Green points out that there is growing evidence that not only can high-emitting vehicles be reliably identified with a broad range of techniques, but also that drivers of these vehicles can be given incentives to either repair or retire their vehicles.[23]

One system that has been successfully tested since 1987 is the Stedman remote sensing device. This infrared remote sensing system allows on-the-road testing that picks up the gross polluters (including carbon dioxide emissions) while avoiding the large costs associated with routine and universal checks. It has been shown to be a highly effective tool for identifying high emitting vehicles on the road, as well as being effective at targeting tampered and defective vehicles.[24] The economics of the remote sensor is also appealing. As Dr Donald H. Stedman, leader of the team that developed the infrared remote sensing system observed:

> It seems to us that there must be some cost/benefit implications when a single remote sensor can measure tailpipe emission from 58,063 vehicles, without inconveniencing the drivers, during the same time period that two teams can do 307 traditional inspections and EPA can carry out 80 of their new tests (Stedman 1995).

Other technology, such as OEM2100, the portable on-board mobile emissions monitor, can measure exhaust emissions from recently produced light and

23 Incentives such as fines if repairs are not undertaken or possibly payments for the retirement of gross polluters (see next section).

24 For further details see http://www.feat.biochen.du.edu/reports.html.

heavy-duty vehicles.[25] The system is claimed to provide a more accurate measure than the stationary dynamometer emissions tests.

In brief, there is a great deal of doubt surrounding the effectiveness of I/M programs in reducing vehicular emissions. The costs of compulsory I/M programs are imposed on all vehicles, regardless of their fuel efficiency. They do not encourage regular maintenance but rather a delay in maintenance to just prior to the set test appointment.

No figures are available for Australia. However, using US data, inspection costs could range from US$8 to US$43 per inspection.[26] Those figures do not include the cost of time and inconvenience to the driver, or the costs of repairs that might be ordered. Assume, for the sake of illustration, $20 for the inspection cost and $10 for the driver's cost—a total of $30. If the 12 million vehicles in Australia were required to undertake an inspection even as infrequently as once every two years, the cost would be $180 million per year, for a doubtful benefit.

> Traditional I/M programs have been neither efficient nor fair. They do not produce incentives for motorists to drive cleaner vehicles, and they have not produced substantially cleaner air in the areas they serve even after attempts at reform. Adding insult to injury, traditional I/M programs have also inconvenienced the majority of motorists who drive clean vehicles (Green 1997).

Fiscal impact of inspection and maintenance programs

The fiscal impact of I/M depends on how the services are charged. If the charges were based on full cost recovery, there would be no fiscal impact. As far as alternative monitoring techniques are concerned, such as on-board monitoring equipment, the fiscal impact would depend on the detail of the program.

VOLUNTARY AGREEMENTS WITH MANUFACTURERS

Voluntary agreements between government and vehicle manufacturers are attractive because they avoid the coercion associated with the regulatory alternatives and provide scope for greater flexibility. Under such systems, the Government and vehicle manufacturers negotiate over changes to vehicles and sales mixes, rather than the Government imposing them (OECD 1997c, p. 42). A major advantage of voluntary agreements is that, by their cooperative nature, they minimise dissent between government and industry groups. (ECMT 1997, p. 61).

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25 For more detail see http://www4.ncsu.edu/~frey/emissions/sld004.htm.

26 The lower cost being for New Jersey and the higher cost for California (Roth 1996).

Typically, voluntary agreements involve manufacturers committing as a body to achieve specified efficiency improvements by a specified date. There is no obligation on the part of any one manufacturer. For example, the European Commission (EU) has negotiated with European vehicle manufacturers and importers to achieve average vehicle fuel consumption of 5 litres per 100 kilometres for new petrol cars and 4.5 litres per 100 kilometres for new diesel cars. Achieving this target by 2005 would represent a reduction of two to three per cent per year (OECD 1997c, p. 31). A later commitment from the European car manufacturers association (ACEA) involves a 33 per cent reduction in fuel consumption (compared to 1995) by 2008 (TTNCCP 1998, p. 60). A 1998 agreement between industry and EU officials involves a voluntary reduction in carbon dioxide emissions from vehicles by 25 per cent in 10 years through an average fleet-wide fuel consumption of 41.3 miles per gallon—equivalent to 5.7 litres per 100 kilometres (Pew Centre 2000, p. 8).

Australia has in place an Environmental Strategy for the Motor Vehicle Industry (ESMVI), the aim of which is, through negotiation with industry, to reduce the average fuel consumption of new cars by 15 per cent. It is estimated that, by 2020, this could result in around 10 per cent less greenhouse gas emissions than would otherwise occur, assuming that there was no 'rebound effect'.[27] Light commercial vehicles and 4WDs will be brought into the agreement when the Commonwealth negotiates new targets with industry for the years 2005 and 2010.

Impact of voluntary agreements

The aim of voluntary agreements is to move companies to pursue priorities that may not be consistent with their own commercial interests. The impact of such agreements depends on how effective they are in changing consumer preferences.

Apart from the possibility of forestalling mandatory regulations, it is difficult to see why companies would pursue targets determined by voluntary agreements, if such targets ran counter to their commercial interest. The more likely scenario is that they would reach agreement on a course of action that they had already intended to take. This view is partially supported by modelling work undertaken by the OECD where voluntary targets do not always result in improvements 'relative to business as usual' (1997c, p. 43). Thus, the environmental benefits of voluntary targets are probably very small.

It seems unlikely, therefore, that voluntary agreements have any impact on the efficient allocation of resources—unless of course they forestall other policies that have a net economic cost.

27 BTE 2001, p. 22.

Voluntary agreements, in themselves, are unlikely to have a fiscal impact unless there is some form of quid pro quo involved, where vehicle manufacturers receive more generous treatment from government in some other aspect of their operation. As a minor consideration, if voluntary agreements reduce company profits, tax revenues could decline.

EDUCATION AND PROVISION OF INFORMATION

Governments often assume the role of providing information to encourage individual behaviour that is in the community interest. In terms of transport choices, information could be targeted at the demand side, such as the Smogbusters Way to Work program, or the supply side, such as information on the costs of motoring and tips to reduce fuel use.[28] Regular tuning can reduce fuel usage by up to 10 per cent and simple steps like increased tyre pressure can result in a 3 per cent improvement in fuel economy.[29]

If motorists were made aware of these savings they might maintain their cars better, leading to greater fuel economy and less emissions (even after adjusting for the possibility of increased car usage). If motorists fail to take account of the marginal financial costs of motoring when making travel decisions, then it could be in the community interest to encourage greater awareness in this area.

Colorado successfully trialed the 'Smart Sign'—a simple and humourous sign to convey individual information to passing drivers regarding the scope for improved fuel economy by better maintenance of their engine. Emblazoned across the top of the 3.4 m x 2.4 m sign was 'Your Car's Health', below which was a cartoon car whose facial expression changed with changing emission levels. This was supplemented with a painted emissions plume into which the 'GOOD/FAIR/POOR' was displayed. At the bottom of the sign appeared a motivational message of '$aving You Money' for 'GOOD' readings and 'Co$ting You Money' for 'FAIR/ POOR' readings.[30] A follow-up survey showed that 16 per cent of those with a 'poor' reading had already taken corrective action as a result of the sign.

The researchers concluded:

> The Smart Sign system proved to be a reliable and robust system capable of delivering accurate emissions information in a high volume setting. It achieved a high approval rate from the driving public and provided information which

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28 Smogbusters is a national community education program aimed at reducing workplace travel in SOVs, involving the Commonwealth Government and Conservation Councils in Queensland, NSW, Victoria, SA and WA funded through the Natural Heritage Trust.

29 The EPA (US) maintains a web site with tips on how to drive efficiently and save fuel. See http://www.epa.gov/epahome/cnews2_052501.htm.

30 For more details select 'Smart Sign' at http://www.feat.biochem.du.edu.

could be understood. It demonstrates one approach for intelligent highways of the future to detect gross polluting vehicles (Bishop et al. 2000, p. 115).

The provision of information may serve as a form of moral suasion, changing individual attitudes and perceptions to transport on a large scale and leading to significant reductions in emissions from transport. There is evidence to show that many individuals would engage in activities that are not necessarily in their personal interest but in the wider interests of society—such as separating rubbish for recycling. Hence educational programs may lead many to purchase more fuel efficient cars, to keep them better maintained, and to drive them in a manner that they feel produces greater returns to society than to them personally.

Provision of information to consumers that enables them to make better decisions can generate economic benefits. However, information programs are not costless. Efficiency gains depend on determining the efficient level and type of information—possibly in the absence of any market price signals. It is an empirical question whether, in any particular instance, the benefits exceed the costs.

There is a range of information-providing roles that can be adopted by government, with fuel efficiency labelling being one of the most common.

Fuel efficiency labelling of new cars

Fuel efficiency labelling involves the application of a label on new cars usually providing details of either the relative or absolute fuel efficiency (e.g. litres per 100 kilometres) associated with particular models under test conditions. The aim of such labelling is two-fold: to encourage consumers to purchase more fuel-efficient vehicles and to encourage producers to pursue technologies for more fuel-efficient vehicles. Vehicle labelling programs are mandatory in Japan, the US, Sweden and the UK and voluntary in Canada and New Zealand. In Canada, new cars, vans and light-duty trucks for sale display 'EnerGuide' labels showing a vehicle's city and highway fuel consumption ratings and estimated annual fuel cost.

An attraction of mandating model-specific labelling is that it ensures accuracy and standardisation, thereby facilitating comparability of the fuel consumption characteristics of different vehicles. It is unlikely that this could be achieved without some degree of compulsion.

Australian Design Rule 81/00, covering fuel consumption labelling, came into effect on 1 January 2001. Model-specific fuel efficiency labels are required on all new motor vehicles up to 2.7 tonnes. The labels display details of fuel consumption per 100 kilometres.[31] The labelling scheme is aimed at

31 The fuel consumption value applied to the fuel consumption label is derived from the city cycle test procedure undertaken in accordance with the requirements of AS2877 – 1986.

encouraging the purchase of fuel-efficient vehicles by making information about fuel consumption performance of specific passenger cars readily available (AGO 1999c).

Impact of fuel efficiency labelling

A positive environmental impact of fuel efficiency labelling relies on purchaser behaviour changing in response to the information provided by the label. The extent to which this will happen is an empirical question for which little data is available. Historically, fuel efficiency has been a relatively unimportant factor in determining choice of vehicle in Australia, with Australian consumers generally more concerned about resale value, suitability for tasks performed and whole of life costs (BTCE 1996, p. 127).

Research from Europe is equivocal. One frequently quoted study suggests that a four per cent reduction in fuel use is possible from fuel efficiency labels (EVA 1999). However, this finding should be treated cautiously, as this estimate was based on consumer speculation about consumers' likely responses to fuel efficiency labels, rather than on observable behaviour. Other European studies indicate that the gains from fuel efficiency labelling are more likely to be around one per cent of fuel consumption (Fickl & Raimund 2000). The credibility of these conclusions would be greater if, as with the EVA study, the four per cent figure was based on actual observed behaviour. Also, there is the question of transferability of such findings to Australia, where consumers may not be as ‘sensitised’ to fuel prices as in Europe.

Determining the response of Australian consumers to fuel efficiency labelling of vehicles is difficult. While energy efficiency labelling of ‘white goods’ has been seen as a success, the overall similarity of many white goods would mean that energy use is likely to be a more significant factor in that area than it is in vehicle purchases. Surveys would be of limited use in accurately gauging the impact of fuel efficiency labelling. When surveyed, many potential consumers would like to believe that they would be influenced by such a label, but when decision time came, the significance of saving, say, 100 litres of fuel a year could be overwhelmed by features such as comfort, power and reliability.

The 1996 BTCE study concluded that: a labelling scheme would result in only a very small reduction in emissions by 2010, but that the reduction could be achieved at close to negligible cost (BTCE 1996). Factors such as the rebound effect (the increase in VKT due to the decline in the cost of driving as a result of greater fuel efficiency) were accounted for in the BTE’s estimates.

Another issue is whether labelling is the most effective way of providing fuel consumption information. The costs for Australia could be around $3 million per year (assuming 600,000 new car sales at a cost of $5 per label). In the US, a citizen group produced a book which provides environmental ratings of motor vehicles: *The Green Buyers Car Book: Environmental Ratings of 1994 Cars* *and Light Trucks*.[32] The book ranked over 900 cars and light trucks on their contributions to smog, global warming, oil spills, ozone depletion, and solid waste. The American Council for an Energy-Efficient Economy, an independent, non-profit research group dedicated to advancing energy efficiency, has released a *1999 Guide to Green Cars and Trucks*, setting out details such as vehicle's emissions standard, fuel economy, fuel costs, health effects, CO_2 emissions, and overall environmental impact.[33]

In Australia, the *Fuel Consumption Guide*, is available both in hard copy and on the Internet (AGO 1999e).[34] Information in this form may have some advantages over compulsory fuel efficiency labelling in that a wider range of information can be provided and comparisons can be made without prospective purchasers physically inspecting vehicles. However, the information may have less impact than that presented on the windscreen of the new vehicle.

The fiscal impact is likely to be negligible, but would depend on how the scheme was funded. The cost of the Australian scheme will be met by manufacturers, with the administration costs covered by the broader Compliance Plate Fee.

Vehicle maintenance and driving habits

Sensible driving habits can reduce fuel consumption by 15 per cent. Various organisations in many countries provide tips on driving to reduce fuel consumption.[35] In the Netherlands, the New Way to Drive is being promoted as the ‘driving style of the 21st century’, promising more comfort and pleasure through:

- modifying the driving style to take account of modern engine technology;
- maintaining the tyres at the correct pressure; and
- making use of the advantages offered by fuel-saving accessories, such as cruise control and board computer facilities.[36]

Driving at 120 kilometres per hour, rather than 90 kilometres per hour, increases fuel use considerably. Therefore significant savings in greenhouse emissions could be achieved through lower speed limits and tighter enforcement.[37]

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32 Out of print.

33 For details see http://greenercars.com/pr7.html.

34 The *Fuel Consumption Guide* is produced by the Australian Greenhouse Office with the assistance of car manufacturers, assemblers and importers. It provides model-specific fuel consumption information for new passenger cars.

35 For instance http://www.canadiandriver.com/news/010831-7.htm.

36 http://www.hetnieuwerijden.nl/english/content.html.

37 However, the increased time costs could offset the gains in terms of reduced fuel/greenhouse emissions. See Alberta Transportation’s Speed Limit Briefs at http://www.cis.state.mi.us/opla/eo/trans/tips_drive.htm.

The impact of measures to change driving behaviour would depend on many factors including the medium used and the extent to which drivers believed that it was within their own self interest to change. The fuel savings from driving slower might not offset the increased time costs involved. The optimal speed limit from the community's point of view takes into account a number of factors, of which safety and time costs figure prominently.

ENCOURAGING THE USE OF ALTERNATIVE FUELS

The term 'alternative fuels' generally refers to those fuels that are regarded as environmentally superior to the mainstream fuels, because they have the potential to reduce one or more components of vehicular emissions. The US Department of Energy (DOE) defines alternative fuels as those that are 'substantially non-petroleum and yield energy security and environmental benefits'.[38] Table 3.2 sets out the characteristics of alternative fuels.

TABLE 3.2 CHARACTERISTICS OF ALTERNATIVE FUELS

	Compressed natural gas (CNG)	*Ethanol*	*Liquefied natural gas (LNG)*	*Liquefied petroleum gas (LPG)*	*Methanol*
Chemical structure	CH_4	CH_3CH_2OH	CH_4	C_3H_8	CH_3OH
Primary components	Methane	Denatured ethanol and gasoline	Methane that is cooled cryogenically	Propane	Methanol and gasoline
Main fuel source	Underground reserves	Corn, grains or agricultural waste	Underground reserves	A by-product of petroleum refining or natural gas processing	Natural gas, coal.or woody biomass
Energy content per gallon	29,000 Btu	80,460 Btu	73,500 Btu	84,000 Btu	65,350 Btu
Energy ratio compared to gasoline	3.94 to 1 or 25% at 3000 psi	1.42 to 1 or 70%	1.55 to 1 or 66%	1.36 to 1 or 74%	1.75 to 1 or 57%
Liquid or gas	Gas	Liquid	Liquid	Liquid	Liquid

Source Department of Energy (US).

38 The DOE recognises the following as alternative fuels: methanol and denatured ethanol as alcohol fuels (alcohol mixtures that contain no less than 70 per cent of the alcohol fuel), natural gas (compressed or liquefied), liquefied petroleum gas, hydrogen, coal-derived liquid fuels, fuels derived from biological materials, and electricity (including solar energy). See http://www.afdc.doe.gov/questions.html#definition.

The alternative fuels listed in the table all have a significantly lower energy content than gasoline.

A number of countries have adopted concessionary taxes for different fuels. In Australia, as part of Measures for a Better Environment and in conjunction with the new tax system, the Commonwealth Government is providing incentives for using alternative cleaner fuels and has foreshadowed new arrangements from 2002 to further support the uptake of cleaner fuels. Petrol and diesel are subject to high excises while alternative fuels, such as LPG, are excise free and subsidies are provided for the conversion of vehicles to these fuels from diesel. From 1 July 2000, subsidies for alternative fuels that compete (or potentially compete) with diesel were increased to offset the impact of reductions in diesel excise on the commercial attractiveness of alternative fuel vehicles.[39]

In the USA, Federal taxes on petrol are about US5 cents per gallon higher than levied on 'gasohol' (which contains 10 per cent ethanol) or on LPG. In 1999, the UK introduced reductions in fuel tax for ultra low sulphur diesel (ULSD) and road fuel gases (LPG and CNG). Taxis in New York City attract subsidies of US$4,000–6,000 from the State and US$5,000 more from Ford to convert to compressed natural gas (CNG).[40] New York City also mandated a percentage of electric vehicle sales (One electric vehicle for every 49 non-electric vehicles sold in the State) to apply from August 1997. However, this law was struck down as being out of step with the national standard. Also in the US, government assistance is provided for the production of ethanol.[41] As well, flex-fuel vehicles, capable of running on both ethanol and standard fuel, are, in effect, subsidised under the CAFE standards.[42]

Impact of promotion of alternative fuels

Clearly the impact of any measure to encourage the use of alternative fuels would vary with the detail of the measure.

Alternative fuels play only a limited role in most countries, due to a number of factors, the relative importance of which varies over time. Alternative fuels:

39 This covers LPG, CNG, ethanol and fuels derived from canola oil and recycled waste oil.

40 The limited number of refuelling stations constrains uptake of the technology.

41 Roth (1996) suggests that subsidies for ethanol serve more as a hidden subsidy for corn producers rather than more noble environmental objectives. However, there is a good prospect that ethanol may be produced from cellulosic using a shorter fermentation process, setting the stage for cellulosic ethanol to replace cornethanol as a low-greenhouse-gas fuel.

42 When calculating overall MPG for CAFE purposes, the US Government assumes that 'flex-fuel' vehicles operate half the time on ethanol, thereby lifting the MPG rating of a 20 MPG gasoline-operating vehicle to 33 MPG (Porter 1998, p. 63).

- are generally less convenient to users, particularly in terms of refuelling options;
- are costly to produce;
- entail adaption costs for the vehicle; and,
- for some fuels, have the potential to pollute groundwater (Porter 1998, p. 63).

In the US, by 1998 only 3.6 per cent of all highway gasoline use had been replaced by alternative fuels (GAO 1999).

The environmental benefits from encouraging the use of 'less polluting' fuels are yet to be fully assessed either in Australia or overseas. The US General Accounting Office (1999), when assessing the impact of the alternative fuels program for buses noted that 'data are limited on the extent to which alternative fuel transit buses provide air quality benefits in urban areas'.[43]

A significant difficulty in assessing the environmental impact of alternative fuels is that they each impact differently on the four major environmental components of emissions: greenhouse gas emissions, particulates, air toxic emissions and smog. This could mean, for instance, that lower greenhouse gas emissions could be achieved at the cost of a higher level of air toxic emissions.

A draft study by US government agencies for Congress has found that the program designed to encourage automakers to make vehicles that increase the use of alternative fuels such as ethanol may have increased demand for gasoline and worsened environmental damage.[44] The program gives automakers special fuel economy credits for manufacturing vehicles which can operate with a mixture of gasoline and alternative fuels such as ethanol made from corn and other renewable crops. However, few of the dual fuel vehicles actually use ethanol because of a lack of service stations supplying it. The report went on to observe that infrastructure remains a significant hurdle. In the US, there were only 101 stations nationwide that provided fuel mixtures of gasoline and ethanol and, of the 176,000 gas stations nationwide, only 2.9 per cent of them were alternative fuel stations, the report said.

The UK proposal to differentiate vehicle excise duty on the basis of carbon dioxide emissions appears to penalise diesel vehicles and evoked a strong protest from the Institute of Electrical Engineers (IEE). In a discussion on the reform of vehicle excise duty to ensure a cleaner environment the IEE (1999) argued for focusing on emissions rather than technology and that taxing use should be the primary mechanism, since usage rather than ownership generates emissions and pollutants.[45] The IEE also pointed out that:

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43 The environmental target for these programs has been urban air quality.

44 Planet Ark, *US fuel rules may cause more pollution*, 22 June 2001 http://www.planetark.org/dailynewsstory.cfm?newsid=11296.

45 The discussion covered all vehicle emissions.

- the diesel (compression ignition) engine is inherently more fuel efficient than the petrol (spark ignition) one;
- ultra low sulphur diesel (ULSD) offers substantial benefits to the quality of urban air by reducing the amount of nitrogen oxide, black smoke and particulate produced during combustion;
- petrol engines produce higher levels of carbon monoxide and hydrocarbons than diesels, particularly with older vehicles, with the latter including highly carcinogenic benzene;
- while gasoline direct injection engines offer the prospect of improved fuel efficiency, they are currently producing higher oxides of nitrogen levels than conventional petrol engines;
- comparisons of diesel and petrol engines often ignore the fact that petrol engines produce high emission levels when running with a fuel-rich mixture and before catalytic converters have reached working temperature—conditions under which many short urban journeys occur;
- recent research suggests that it would be premature to judge particulate hazards on the basis of larger particulate (PM10) alone since petrol engines may produce higher levels of the smaller (PM2.5) particulates than modern diesel engines.

The IEE (1999) concluded that it was inappropriate to discriminate against diesel engines, as there have been major advances in the car diesel engine in the last few years, the benefits of which are only beginning to be felt in terms of environmental impact.

There could be significant efficiency and environmental gains from differential taxes on fuel reflecting the external costs associated with their use. However, there are many parameters apart from fuel type that influence fuel emissions, ranging from type and weight of vehicle and emission control technology employed to operational circumstances, such as speed profile, road type, traffic density, motor condition (cold start versus hot mileage) and vehicle and maintenance.

As the IEE pointed out, modern diesel engines are considerably less polluting than older engines, making it difficult to design an efficient emissions tax based on fuel type alone. A combination of taxes may be necessary, with the fuel being taxed at a base rate reflecting the emissions produced by a modern diesel engine and the vehicles with older diesel engines attracting an extra tax, reflecting their annual usage of fuel.

The International Association of Public Transport noted that while natural gas is very environmentally friendly, the 'carbon dioxide emissions from natural gas-powered vehicles are higher than for diesel' (UITP 2000). The reasons identified by the UITP relate to the performance of modern diesel engines:

> … high-yield energy transformer that is tried and trusted reliable, compact and economical. Its ecological performance is constantly being improved thanks to new engine types, sophisticated refining techniques … as well as techniques for emission after-treatment.

The UITP goes on to observe that natural gas offers ‘indisputable geopolitical advantages’ but that:

> … the consumption and CO_2 emissions from natural gas-powered vehicles are higher than for diesel. Despite improvements, operational results from a number of European cities suggest reliability levels and capacities below diesel. What is more, CNG vehicles cost an extra 25% to purchase, before taking into account the high fixed-infrastructure costs (e.g. filling stations, safety etc.), and they are more expensive to maintain (UITP 2000, p. 2).

It follows that the geopolitical advantages would need to be significant to offset these disadvantages.

Ideally, in order to avoid distorting relative prices of different types of fuel from different sources, any program to tax fuels according to emissions would need to cover all fuels. The fuel duty concessions in place today have not been calibrated to reflect the external costs associated with fuel use. In the absence of such calibration, it is likely that some fuels are over- or under-subsidised and that environmental objectives could be achieved at lower cost, by calibrating the concessions/taxes to better reflect the different levels of environmental damage associated with different fuels.

The subsidy inherent in the excise exemption of alternative fuels probably exceeds the environmental benefits it is meant to target. As the BTCE observed:

> On the basis of the limited emissions costing available, it appears unlikely that the environmental benefits from most alternative fuels are as large as the existing ‘subsidy’ they now receive (BTCE 1994, p. 213).

The fiscal impact would depend on how much ‘encouragement’ is given to alternative fuels and whether it is given in the form of a subsidy on alternative fuels, or a tax on traditional fuels. For Australia, where LPG is excise-free, unpublished BTE estimates of the excise forgone in 1998–99 on the sales of LPG range from \$1.55 billion to \$1.86 billion, relative to the situation where LPG bore a petrol-equivalent excise.[46]

46 Depending on whether the excise were set at 35 or 43 cpl.

MODERNISING THE VEHICLE FLEET: ACCELERATED SCRAPPING OF OLDER CARS

Since older vehicles generally use more litres of fuel per kilometre and produce more emissions per litre than newer vehicles, one way to reduce greenhouse gas emissions would be to reduce the number of older vehicles on the road.[47]

Measures that encourage the modernising of the vehicle fleet are often regulatory. However, they can also take the form of taxes or subsidies.

In California, there are regulations that force 'Gross Polluters' to be repaired or removed from the roads. These generally older vehicles represent only 10–15 per cent of all California vehicles, but are responsible for over half of vehicle smog.

Any program that reduces the cost of new vehicles relative to old vehicles would encourage the modernisation of the car fleet. For instance, the higher the fuels costs, the more attractive are new vehicles, with their greater fuel efficiency, relative to the older vehicles. A more direct approach is pursued in some countries with programs encouraging the accelerated scrapping of older cars.

Government-funded car scrapping programs are currently in place in France, the US, Spain and Hungary. Many countries of western Europe encourage the accelerated scrapping of older cars through exempting from car-purchase taxes buyers who trade an old vehicle for scrapping.

When the first scrapping program in the US was signed into law in 1995, it was presented as a groundbreaking, market-based and highly cost-effective pollution control measure[48]. Scrapping programs in the US, particularly in California, typically allow firms to gain pollution credits by purchasing and scrapping older vehicles. These credits can be offset against pollution from, say, a refinery or a power plant.[49]

Environmental impact of car scrapping programs

The environmental benefits of car scrapping programs are not clear. Modelling work undertaken by the BTCE (1994) suggested that the greenhouse benefits of a car scrapping scheme are limited to a 1–5 per cent reduction in cumulative emissions between 1996 and 2015, due mainly to the gradual nature of the process. Analysis undertaken by the US Department of Energy suggests that the scheme may be effective when applied to the US car market under certain

47 While the added features of new vehicles (such as power steering and air conditioning which are now almost standard in new cars) have reduced fuel efficiency gains, the older cars are still less fuel efficient than the fleet average.

48 http://www.baaction.org/ev_project/Scrap_old_cars.html.

49 First initiated in Los Angeles by Unocal in 1990.

conditions. However, critics of the US scheme argue that it is poorly designed and that the companies avoid installing the equipment mandated by Clean Air Act by purchasing and retiring old cars to gain pollution credits.

Two other general criticisms of accelerated car scrapping schemes are:

- the 'gross polluters' purchased by government under the scheme may have been little used; and
- the scheme could end up drawing out vehicles that were about to be scrapped anyway (referred to in the literature as 'zombie vehicles').

Scrappage programs in Canada aim to overcome these last considerations by specifying that a scrapped vehicle has to have been in regular use (confirmed by proving that the vehicle has been insured for the last two years) and that it must be drivable (Taylor 1999).

More fundamental criticisms of accelerated scrapping programs exist. The main objection to such programs is that they fail to take into account the full lifetime pollution of an automobile. Kay (1998) argues that almost half of the pollution associated with cars occurs in production. Hence removing an aged car from the roads, only to replace it with a new one is of doubtful environmental benefit. This is reinforced by research by a group of Dutch scientists who calculated that, when the energy used in scrapping old cars and the emissions released in new car manufacture is factored into the equation, reducing the average age of cars in the Netherlands by three years would increase carbon dioxide emissions by four per cent overall.[50]

Efficiency impact of car scrapping programs

The private decision about whether to scrap a car would be made by comparing the running costs (including allowances for increased probability of breakdown and shabby appearance) plus scrap value, with the alternative forms of transport, such as newer secondhand cars, new cars, transit and so on. In the absence of distortions, the market will engender economically optimal scrapping rates. Hence, schemes to accelerate scrapping of older cars would have net efficiency costs.

However, the current set of distortions impacting on the demand for motor vehicles has an ambiguous impact on the average age of the vehicle fleet. Fuel excise, at rates considerably higher than average tax rates in the economy, already encourage a shift to newer, more fuel efficient vehicles while simultaneously discouraging the use of older, less fuel-efficient cars. In effect, relatively high fuel taxes serve to shorten the lives of cars.

50 http://www.scoop.co.nz/stories/HL0002/S00068.htm

In contrast, import tariffs, through increasing the cost of new vehicles, encourage the retention of older vehicles. Hence, a measure available to encourage a younger vehicle fleet would be to reduce import barriers, or perhaps to replace the barriers with direct assistance for domestic manufacturers in the form of subsidies.

Fiscal impact of car scrapping programs

The scheme envisaged by the BTCE was estimated to cost up to $1.8 billion over a 20 year period (BTCE 1996b, p. 84).

INTELLIGENT TRANSPORT SYSTEMS

The term Intelligent Transport Systems (ITS) is used as a catchphrase to cover a 'wide range of technology-based tools for managing transport networks and providing services to travellers' (Carter & Carter 2000). ITS is the application to transport operations of advanced computer, communications and information technology. While these applications are adopted as a result of competitive pressures in the transport-related industries, they often lead to benefits to the wider community in terms of reduced operating costs, improvements in safety, enhanced services and improvements in the capacity of existing infrastructure.

Impact of ITS

Successful ITS applications can have a significant effect on fuel use through improved traffic flow and more efficient network usage. It is possible that a reduction in congestion through a more technically efficient operation of the transport network would reduce greenhouse gas emissions. However, there is no guarantee that reduced congestion would reduce greenhouse gas emissions, as such an improvement could lead to an increase in VKT and a consequent increase in fuel use and greenhouse gas emissions.

Current ITS applications include traveller information, traffic management, security and emergency management, and payment systems. Advanced traveller information systems (ATIS) provide information to road users to assist them in planning their trips, avoiding congestion bottlenecks and selecting the best routes to their destinations. ATIS use different mediums ranging from the traditional radio and TV broadcasts to telephone information providing real-time traffic information using pre-recorded messages and covering the latest traffic conditions for a selected area, and to dynamic message signs—electronic message signs strategically placed along the road to inform motorists of traffic conditions.

ITS Australia, the industry peak body, identified three broad areas in which ITS solutions offer significant capacity to assist Australia's efforts to reduce transport related greenhouse gas emissions:

- the alleviation of road congestion and travel demand;
- the improvement of transport modal integration; and
- the optimisation of engine operations to avoid unnecessary fuel use and emissions.[51]

Along with the computerisation of traffic control, roadside signalling systems, where the traffic control infrastructure communicates with motor vehicles, are increasingly being used. The most common of these are systems such as the automatic toll-booths used on the Sydney toll roads, the City Link in Melbourne, the Gateway Bridge in Brisbane, and three other tollways in Southeast Queensland.

Such technology can also be used to ensure buses/trams run on time through ensuring that they get priority at traffic lights when running late. Another application is the bus/tram locator system that can keep passengers informed of 'real' arrival times.

ITS is used to improve traffic flows through the variable roadside signs in use around Australia. Variable Message Signs (VMSs) can provide up-to-date information relating to road conditions, accidents and relevant detour information. In a similar vein Variable Speed Limit Signs (VSLSs) have also been installed at various locations along the M4 Motorway in NSW to indicate the speed limits that are appropriate to the prevailing traffic and road conditions.

In Melbourne, an Automatic Congestion and Incident Detection System is used to estimate the time it will take to travel to the next exit. This information is conveyed to motorists at the entrance ramps. VicRoads also uses the data collected to provide information regarding traffic conditions over the television and telephone network. Brisbane has a similar system for the SE Freeway.

Clearly, the impact of ITS would depend critically on the detail of the system. The US Transportation Research Board concluded that:

> At this stage, projections of how these systems will evolve and influence motor vehicle travel are largely conjectural; hence, confident predictions of effects—positive or negative—on future motor vehicle petroleum use and CO_2 emissions are not yet possible (TRB 1997, p. 114).

CONCLUSIONS

The sharp rise in fuel prices over the 1970s stimulated the demand for and production of more fuel-efficient vehicles. Most of these gains came from the use of lighter materials, aerodynamic improvements and better engine design. The technological improvements have been sufficient to maintain the average fuel-efficiency of passenger vehicles over the past two decades, despite a

51 See ITS *Australia Annual Report 1999–2000* p. 9 in 'Library' at http://www.its-australia.com.au.

consumer shift to heavier, more powerful vehicles. The technical improvements alone, without consumers' demands for increased comfort, power and acceleration capabilities, would have seen fuel efficiency improve by around 25 per cent.

Controversy continues over the effectiveness of technology-inducing regulations, such as mandated fuel efficiency standards. Further fuel economies are available, at a price. However, the role of alternative fuels, such as LPG, CNG and ethanol, in slowing global warming appears to be limited. As the US Transportation Research Board observed, 'alternative energy sources, depending on their composition, energy output and production process, may or may not produce significantly less carbon dioxide than traditional petroleum motor fuels' (TRB 1997, p. 134). Apart from the low energy density of alternative fuels, reducing vehicle operating range and interior space, manufacturing and operating costs are higher.

Research into new vehicle propulsion technology involves substantial investment and technical risks. If assistance were to be provided for such research, the federal research and development programs would be the logical source of funds.

The multi-faceted nature of ITS makes it difficult to be unequivocal about the net impact of ITS on greenhouse gas emissions from transport. However, it is unlikely that the greenhouse benefits of a particular ITS project would be instrumental in determining whether or not the project went ahead.

The lowest cost alternatives in terms of technical improvements could be to provide information on the most effective use of the technology and to reduce the trade barriers that increase the price of more fuel-efficient vehicles.

chapter 4

ROAD-USE CHARGES

Any measure that discourages vehicle use has the potential to reduce greenhouse gas emissions. Increasing the cost of vehicle use would generally lead to a reduction in VKT, although many ways of increasing the cost of vehicle use would reduce economic efficiency. However, appropriately designed road-use charges can be an exception, promoting economic efficiency while at the same time reducing greenhouse gas emissions.

The economic case for road-use charges has been well established for over 75 years, although it is only more recently that advances in technology have made it more practical, and environmentalists have embraced such charges. The growing international interest in road-use charges has also been spurred on by increased pressure on the network, as the growth in VKT in many countries outpaces the funds available for the expansion of the network.

This chapter examines the economic case for road-use charges and the potential impact of such charges on road transport's contribution to greenhouse gas emissions. Despite the fact that the primary aim of road use charges has been unrelated to emissions, road use charges may prove to be more effective at reducing greenhouse gas emissions than other abatement measures.

THE CASE FOR ROAD-USE CHARGES

Motor vehicles in Australia attract an assortment of taxes and charges, few of which could be said to resemble road-use charges. Road tolls are clearly road-use charges as there is a strong relationship between the service provided and the charges. Registration charges, drivers' licence fees, stamp duty on the purchase of vehicles and import duty on vehicles are more like taxes, since they do not relate to road usage per se.

The classification of fuel excise is more complex since there is some relationship between road use and excise paid. Also, in Australia some excise paid by heavy vehicles is treated as a road-use charge, accounting for around two-thirds of the road costs attributable to heavy vehicles. The remainder is accounted for by vehicle registration charges (NRTC 1999). On the other hand, excise paid by light vehicles is regarded as a tax. The design of road-use charges depends on the specific aim being pursued, which could be raising general revenue, recouping the cost of road provision, or internalising the externalities associated with road use.

General revenue

With the post-war growth in private motoring, fuel excise has offered an attractive way for governments to raise general revenue. The Fuel Taxation Inquiry (FTI) identified the following advantages of excise as a source of consolidated revenue:

- compared with many other goods, fuel is widely used by the community;
- the demand for fuel is relatively stable and is not very sensitive to changes in price. It consequently provides a reliable source of revenue for government; and
- the administrative framework required to collect specific fuel taxes is relatively less onerous than for other taxes (FTI 2001).

In Australia, fuel excise is a significant single source of revenue, raising almost $12 billion in 2000–2001—around eight per cent of Commonwealth revenue (FTI 2001, p. 20). Since excise is a flat rate per litre, the *ad valorem* value of the excise fluctuates with movements in fuel prices. The lower the retail price of fuel, the higher the *ad valorem* equivalent. When bowser fuel prices are around 83 cents per litre (cpl), the excise is equivalent to an *ad valorem* tax of 100 per cent.

Recovery of infrastructure costs

From a pricing viewpoint, there are two dimensions of road infrastructure costs to consider: road wear and road capacity. While heavy vehicles account for virtually all of the road wear attributable to vehicles (not weather), passenger motor vehicles account for the bulk of capacity requirements.

Heavy vehicle charges

Many countries apply road-use charges to heavy vehicles, although for most systems the charging system is similar to that adopted in Australia—a combination of fuel tax and registration charges graduated by weight. Uniform national charges for heavy vehicles (gross vehicle mass of greater than 4.5 tonnes) have applied in Australia since 1995. Around 70 per cent of road costs attributed to heavy vehicles by the National Roads Transport Commission (NRTC) are recovered through the diesel excise and the remainder through annual registration charges based on vehicle class (NRTC 2001, p. 3). The NRTC recognises that the current charging system has significant shortcomings, one of which is a failure to take account of external costs of heavy vehicle use.

Another significant failing is that charges per truck are not closely related to road wear caused by the truck. It is the axle weight that causes the road wear and not the weight of the truck. This means that a truck with two axles can cause more damage than a much larger truck with more axles. Fuel excise is a poor proxy for a road-wear charge. Although more fuel is used with heavier trucks, fuel consumption *per tonne* declines and hence excise paid per tonne declines as the weight increases. In contrast, the cost of road wear per tonne rises very steeply with weight per axle.[1]

While there are few jurisdictions that charge heavy vehicles on the basis of a key determinant of road wear—axle weight—some have implemented weight–distance charges, based on the tare weight of the vehicle and distance travelled. For instance, New Zealand's pioneering heavy vehicle charges, introduced in 1977, involve a weight–distance tax using vehicle distance measuring devices (odometers and hubodometers).[2] Recently, the Ministry of Transport announced the adoption of an electronic system of road-user charges that 'will enhance the efficiency and fairness of these charges'. The electronic system will overcome the shortcomings of the current system, where charges are based on the average road damage cost attributed to heavy vehicles and also on vehicles' average rather than actual weights.[3]

In Tasmania, a 'special mass access scheme' for heavy vehicles has been trialed, with the aim of developing an efficient charging system that could benefit both infrastructure providers and users:

> Australia's taxation system does not currently provide us with incentives to use the most appropriate transport infrastructure. Variable road damage and congestion costs need to be reflected in the price we pay for road use. Without this information, we can not be expected to make rational and sustainable decisions regarding our use of roads (DIER 1999a).

The Tasmanian Intelligent Access Project (IAP) involves on-board GPS/GSM[4] units allowing authorities to monitor compliance with access agreements tailored to individual operators on specified roads of known tolerances (DIER

1 Small et al. (1989) p. 11 points out that 'a rear axle of a typical thirteen-ton van [truck] causes over 1,000 times as much structural damage as that of a car; if illegally loaded to nineteen tons, it would cause at least three times more damage'.

2 Details of the current charging system are available at http://www.ltsa.govt.nz/factsheets/38.html.

3 See NZ Ministry of Transport http://www.transport.govt.nz/html/15news/land-transport-package/facts5.shtml.

4 Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardisation group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz (International Engineering Consortium at http://www.iec.org/online/tutorials/gsm/).

1999a).[5] In simple terms, the IAP provides a mechanism for trucks to pay to exceed the mass limits on specific roads that can accommodate such loads. Trials are currently being extended to other States. An integral part of the IAP is the development of the range of technical standards that will ensure inter-operability between the major public transport systems.

On 22 March 2002, the German Federal Diet and the Senate of the Federal Parliament agreed on the introduction of a kilometre-based highway fee for heavy trucks. The expected A$6 billion raised by the levy per annum will be earmarked for transport infrastructure with around a half going to road projects, almost two-fifths going to rail projects and the rest to inland waterway projects.[6] Trucks over 12 tonnes will be charged an average of 26 cents per kilometre—between A$0.17 and A$0.29 depending on weight and engine type (*Today's Railways* no. 74, February 2002, p. 11).

Tolls

Tolls to finance road construction and operation represent the most explicit form of road-use charges currently in operation, both in Australia and overseas. In Europe, toll financing for roads developed in response to rapid growth in VKT and budget constraints following World War II. Private sector involvement in toll roads is growing increasingly common, particularly in countries such as Spain (from 1953), Mexico and France. In the late 1960s, the Spanish Government embarked on a national highway plan that involved intercity 'autopistas' to be built by private concessionaires and financed with tolls (Gómez-Ibáñez & Meyer 1993, p. 125). In Mexico, over 5,300 kilometres of new toll road concessions were granted between 1989 and 1994—most of which have not met projections and have had to be restructured with significant public funding (Estache et al. 2000). Authorities in France have opted for a private toll tunnel to close the missing link in the A-86 Paris ring road (Poole 2000). Many of the countries in eastern Europe are favouring the use of toll roads and private concessions for these roads.

Toll-financing of road infrastructure became increasingly popular during the 1980s, possibly as a way of shifting expenditure 'off-budget'. In Norway, while toll financing has been used to supplement government funding for over 50 years, its use has increased considerably in the last two decades. Today, around 25 per cent of the total annual budget for road construction comes from more than 30 tolled-road projects throughout the country (Odeck & Bråthen, 1995). The best known are the cordon toll ring systems around the cities of Bergen, Oslo and Trondheim. Canada has 19 toll roads, bridges and tunnels and is currently exploring the concept of dedicated road funds where there is a

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5 For more details see IAP at http://www.transport.tas.gov.au.

6 X-Rail News (Wk 14) at http://www.x-rail.net/news.htm.

strong link between the funds raised and funds invested in identifiable road segments (CTARP 2001).

In line with international trends, the use of toll-financing in Australia in recent years has been associated with private sector involvement. This echoes early days of settlement in Australia when Governor Macquarie resorted to tolls to fund improvements in the road system:

> Finance for the road construction and maintenance program was provided from Government funds, public subscription or tolls. The right to collect tolls was let to private operators who were called upon to construct roads and maintain them for ten years. To ensure that the condition of the major roads in the colony did improve, the administration specified a standard of construction and maintenance which the operators of the toll roads had to meet (ABS 1974).

As in the days of Governor Macquarie, private sector involvement is generally based on specified standards of service provision and usually involves a 'sunset' clause. Typical is the Dartford-Thurrock Crossing (Queen Elizabeth II Bridge), the first major privately financed road project in the UK, begun in 1988 and due to remain in private hands and to be tolled until September 2002. The final 12 months of tolls provide a maintenance fund and the crossing then reverts to the Government free of debt (DETR 1999a).[7]

The Build, Own, Operate and Transfer (BOOT) model has been adopted for the private financing of the Sydney tollways and the City Link in Melbourne.[8] While successful in many aspects, there have been significant criticisms of the use of BOOT schemes and other types of Public-Private Partnerships (PP) and Public Finance Initiatives (PFI) for infrastructure provision.[9]

In general, few roads rely entirely on tolls, with government support often provided through provision of the right-of-way and, at times, a cash contribution.[10] While the community acceptance of tolling appears to be greater with new roads, tolls may also be introduced to fund significant

7 For details of other private finance initiatives in the UK see http://www.dtlr.gov.uk.

8 A BOOT scheme generally involves a concession being granted to the private sector to construct and operate a piece of infrastructure for a specified period of time under agreed conditions, such as a right to charge a toll. At the end of the specified period, ownership is transferred back to the public sector.

9 See in particular separate articles by Quiggin, Tanner, Goldberg and Harris at 1998 conference on the topic http://www.signposts.uts.edu.au/articles/Australia/index.html.

10 The extreme situation is possibly that of the Skye bridge in Scotland where at least 60 per cent of the cost of the bridge was met by the taxpayer before the first concrete was poured. Of the £25 m invested, just £500,000 was provided by the PFI consortium. Source: http://www.guardian.co.uk/comment/story/0,3604,543165,00.html.

improvements of established roads.[11] In one particular case in India, the State Government has authorised road improvements, a highway help-line and electronic signs to be funded by the introduction of road tolls.[12]

Internalising transport externalities

There is growing concern over the external costs associated with transport activity, in particular emissions, noise, visual disamenity and obstruction of access. While the term 'externalities' is often used loosely, in general it refers to the significant, non-monetary, and unintended consequences of transportation—the difference between the private and the social costs of motoring. If there is a disparity between social and private costs, individuals will not receive price signals that indicate the full costs of their actions on society as a whole:

> ... if markets fail to take into account significant costs or benefits of transportation, an economically inefficient use of resources will generally result. Intervention to correct or at least counteract the market failure could lead to an increase in social welfare (Greene 1995, p. 4).

The standard economic solution to unpriced externalities is the introduction of a tax to internalise the externalities and, by doing so, to align the marginal private and marginal social cost of motoring. In the case of car travel, a journey would then be undertaken only if the benefit to the user was greater than or equal to the cost to society of providing the journey. Pricing above or below the cost to society of providing an additional journey would be economically inefficient and hence would reduce community welfare.

The significance of externalities varies between transport modes and location. Recent research from the Institute of Transport Studies, UK, concluded that neither road nor rail travel in Britain is priced efficiently from an economic point of view (Sansom et al. 2001). The greater the variation in external costs the less useful aggregate figures are to policymakers. Mumford (2000) estimated that the social cost of petrol cars by road-user type in the UK ranges from 0.79 pence per kilometre on a motorway to 43.4 pence per kilometre for urban central peak hour traffic.

Emissions

Until recently, most, if not all, heavy vehicle charging systems neglected environmental costs. In June 1999, the European Parliament approved changes to the charging system for heavy vehicles to take account of the (local) emission characteristics of the vehicles and road wear costs. In essence, the changes

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11 For instance, drivers using the Drogheda bypass in Ireland may soon face tolls. For current details of tolled roads see http://www.ettm.com/.

12 See Business Line (India) http://in.biz.yahoo.com/010812/17/12w9h.html.

involved scaling vehicle taxes and the uniform heavy goods vehicles' charges (the Eurovignette) to reflect more closely the damage caused to the environment and road infrastructure.[13]

However, the charging system is still quite blunt, taking account of the vehicle characteristics, rather than distance travelled or axle weight. Lighter vehicles pay less and vehicles meeting the EURO-II standard are charged less than EURO-I vehicles. There are maximums set for daily, monthly and annual charges and some countries enjoy 'concessionary' treatment.

Switzerland's Heavy Vehicles Fee (HVF), introduced on 1 January 2001, charges on the basis of the kilometres driven as well as on the maximum weight and the emission class of the vehicle.[14] For a 34-tonne truck, the fee is between Euro 0.30 and 0.43 per tonne-kilometre, depending on emission class (Oehry, B. 2000, p. 42).[15] All vehicles need to be fitted with a tachograph and an On-Board-Unit (OBU). The OBU records the required trip data automatically and includes a movement sensor to ensure that the tachograph signal is not intentionally interrupted or falsified.[16] The fees involve a uniform emissions charge regardless of the density of the population and are not location specific.

The Standing Advisory Committee on Truck Road Assessment (SACTRA) Report identified some advantages of the direct pricing of emissions over the more standard regulatory approach. Emission charges:

- minimise the costs of achieving a given reduction in emissions;
- provide incentives to find ways of reducing emissions further;
- make transparent to drivers the marginal social cost of air pollution; and
- raise revenue (SACTRA 1999).[17]

13 The third component of the heavy vehicle charge, diesel excise, is not affected. For more details see http://europa.eu.int/comm/transport/themes/land/english/lt_11_en.html#eurovignette.

14 For more background see U. S. Department of Commerce, National Trade Data: Bank http://www.tradeport.org/ts/countries/switzerland/mrr/mark0017.html. For more operational detail see http://www.t-e.nu/Fact-sheets,%20responses,%20etc/9-00%20Comparative%20information%20 %20transport%20prices%20and%20taxation.htm.

15 Equivalent to Aus50 to 70 cents per tonne kilometre, at the exchange rate in early April 2002.

16 The tachograph is a sealed and calibrated instrument for checking the legal work/rest hours requirements, and for assisting with accident investigations. It is a compulsory piece of equipment for heavy goods vehicles in commercial use (Oehry 2000, p. 41).

17 Only the first three points have efficiency implications, unless emission charges provide a less costly way of raising revenue than the alternative sources.

In theory, the simplest emission costs to internalise are those arising from carbon emissions since they are produced in a fixed proportion to fuel quantity, varying in a predictable way with type of fuel.[18] To the extent that a cost can be assigned to greenhouse gas emissions, a per litre tax based on the carbon content of energy, or tradable permits that approximated the tax, both provide a direct method of achieving reductions in greenhouse gas emissions.[19]

However, local emissions are a different matter, since they vary with the technology, time, location and weather conditions. Gómez-Ibáñez (1997, p. 170), in a review of five studies addressing the question of whether road users pay their way, identified two common failings:

- the use of average externality costs as a proxy for marginal costs; and
- the excessive reliance on control costs where damage costs are available.

Control costs, often used for convenience, can be significantly higher than the damage costs and hence over-estimate the cost of emissions. Austroads (2000), in a review of methods of evaluating transport externalities, concluded that 'control costs rarely capture true damage costs'.

Congestion

Many studies report that congestion costs are the most significant of the externalities associated with transport. Martin (1996, p. 5) observed that congestion costs appear to be 'by far the single largest external cost in Australian cities'. While time represents a significant proportion of congestion costs, fuel consumption and therefore emissions are greater under congested conditions. Vehicle emissions can be twice as high under congested conditions due to longer idling times, stop-start driving and less than optimal running speeds (BTE 2000a).[20] The Bureau of Transport Economics (BTE) estimated indicate that traffic delays and interruptions to traffic flows in 1995 generated an extra 13 million tonnes of greenhouse gas emissions per year.[21] This represented 17 per cent of annual greenhouse gas emissions due to the transport sector and approximately three per cent of Australia's total greenhouse gas emissions (BTE 2000a, p. 2).

18 For simplicity, carbon is often regarded as a useful proxy for greenhouse gas emissions, even though it may represent as little as 60 per cent of greenhouse gas emissions once indirect emissions are taken into account.

19 A similar outcome could be achieved with tradable emissions quotas, the main difference being whether it is considered more important to set the emission damage cost or to set the quantity of emissions allowed.

20 One US research body reports that volatile organic compounds (VOCs) and carbon monoxide are 250 per cent higher under congested conditions compared with free-flowing traffic (Schiller 1998).

21 Of which CO_2 totals 10.5 million tonnes.

De Nocker et al. (1998, p. 14) also observe that the impact of congestion on pollution is very marked:

> For petrol cars peak values are a factor 2 to 3 higher than 'free flow' externalities for a small city and a factor 3 to 4 for a big city, with the higher ranges for the most recent vehicle types. For diesel cars these factors go from 3.5 for a EURO 0 [pre-1998] to 2.5 for the other types (both for small and big city). These results indicate that the impact of congestion on air pollution externalities is higher than estimated in earlier studies for Belgium (Mayeres, 1997) or the US (Litman, 1995).

Future congestion levels are also a source of concern. In the US, congestion costs increased nine per cent in the 12 months to 1997 (Schrank & Lomax 1999, p. 4). In Australia, projections suggest that congestion costs could be as high as $30 billion per year by 2015 (BTE 1999b, p. 3).[22] Even if congestion does not grow as it has in the past (due to, say, car ownership reaching saturation point and a lower rate of population growth), the costs associated with the current levels of congestion may already be sufficient to justify a policy response.

Congestion pricing

In the past, regulatory solutions aimed at reducing VKT have been favoured for reducing congestion externalities. As Small et al. (1989) noted and as discussed in an earlier chapter of this report, the numerous regulatory measures to reduce congestion (including ride sharing, higher parking fees, measures to encourage public transport use and land-use planning) have failed to have substantial impacts. Apart from the often small initial impact, there is the latent demand for peak-period travel, manifested as 'induced traffic'. If travel demand measures have some initial success in reducing the demand for peak-hour travel, the reduction in congestion will itself attract new peak-period users, diminishing the initial gains (Small et al. 1989, p. 85).

Appropriately designed congestion charges, by dealing with the source of the 'problem', have a greater probability of success. As observed by the US Bureau of Transportation Statistics:

> … if the goal is to reduce congestion, then a congestion fee is the most effective approach (in the narrow sense of delay reduction per dollar charged). Because of their indirect treatment of congestion, other pricing strategies are simply not as effective (BTS 1995).

The underlying principle is relatively simple:

> … each motorist is unaware (or at least unresponsive) to certain costs he imposes on others and hence does not take those costs into account when deciding whether or not to make a car journey (Button & Pearman 1985, p. 30).

22 Assuming that total traffic in Australia grows at the projected rate of 30 to 45 per cent between 1995 and 2015, while road capacity grows at a slower rate (BTE 1999, p. 3).

As Goodwin (1997) noted, since ‘the benefits to each driver are less than the costs they cause to everybody else, and the overall use of resources—*waste of resources*—is greater than it should be’.

In theory, the optimal charge is that which makes up the shortfall between the marginal private cost and the marginal social cost of travel.[23] Charges would need to vary with time of day and location. Small et al. (1989 p. 86) noted that this is a form of peak-load pricing, identical to that used in other industries that face marked fluctuations in demand. In theory, the congestion charge can be set to ensure that the motorist faces the marginal social cost of joining the traffic stream.

Determining the optimal prices is not straightforward. Button and Pearman (1985, p. 35) suggested that ‘a rough approximation to the optimal price would be made initially with subsequent iterations and changes occurring in the light of experience’. The congestion-pricing package adopted for State Road 91 (SR 91) in California involved extensive consumer surveys before the initial implementation and a number of iterations following implementation.[24]

While the economic case for congestion charging is strong, politically it has been very difficult to implement. Despite being actively promoted since the mid-1970s by the Federal Government and transportation planners in the US, congestion pricing (in contrast to road tolling) has made little progress (Colgan & Quinlan 1997, p. 117). The widespread community resistance to congestion pricing can be tracked to its image as ‘yet another tax on motorists’. While there is considerable scope to generate welfare gains, the winners and losers from congestion pricing will be determined by the use made of the revenue generated. There can be significant offsets if the revenue is recycled, say, through the reduction of other taxes faced by the motorists in question.

There are a number of economically defensible uses for the funds, including the reduction of other motoring taxes, offsetting a portion of the land rates in those suburbs whose residents pay most of the congestion charges and investing in the expansion of road infrastructure where economically warranted. While it is often argued that the introduction of congestion charges should be accompanied by an increase in investment in public transport, this may not be in the wider community interest. First, investment in either public transport or road projects should be evaluated on its merits. Funding should not be guaranteed regardless of the competing claims on the public resources. Second, the case for subsidising public transport to reduce congestion no longer holds when congestion is charged for directly. A separate but related consideration

23 For a full explanation of the mechanics underlying this see Harvey (1999).

24 In the first two years of operation, tolls were adjusted five times to include an increased number of toll levels, off-peak adjustments and implementation of holiday toll schedules (Brahm 1999).

is that, in most cases, the introduction of congestion pricing would encourage public transport use and, accordingly, improve the economics of public transport investments.

The proposed congestion charging for London is a simple cordon toll system with a charge of £5 payable on entry to the centre of London between 7a.m. and 7p.m.[25] While some estimates suggest that the measure will have little impact on congestion, it is likely to raise £200 million per annum, which will be diverted to fund a backlog of improvements in the public transport system.[26] The long list of vehicle classes attracting concessionary treatment, including alternative fuel vehicles and taxis, suggests that there are other objectives besides reducing congestion, since congestion is not a function of fuel type or of vehicle purpose. While a zero emission car or bus would not have to pay a direct emission tax, they would be expected to pay a congestion fee accounting for both the cost of time loss and the additional emissions caused to other cars through increased congestion (Hoelzer & Requate, 2001, p. 15).

Congestion pricing, of various levels of sophistication, has been used in a number of overseas countries, including Singapore, France, Canada and the US. One of the earliest and simplest systems was Singapore's Area Licensing Scheme (ALS). Introduced in 1975, it used cordon pricing to discourage access to the CBD during peak hours. The ALS succeeded in shifting many vehicle trips from peak to non-peak hours, increased the average speed of vehicles and decreased the proportion of solo drivers. In 1998, the monthly licences were replaced by electronic road pricing (ERP) facilitating a greater variation in charges and, in particular, the pricing of peak hour use at a premium.[27] The tolls were set to produce average speeds in the CBD of around 50 kilometres per hour.

The Sunday afternoon congestion on the A1 in France—from Lille towards Paris—declined by 15 per cent following the introduction of congestion charges (Schille 1998). In Norway, the flat tolls set previously as simple revenue raisers have been modified to resemble congestion pricing, with increased tolls during the morning peak periods. The change is reported to have eased traffic congestion and to have produced a better environmental outcome (Odek et al. 2000). The introduction of higher peak morning charges in Trondheim has been credited with achieving a 10 per cent reduction in CBD traffic during toll hours, an overall decrease in traffic of four per cent, and an increase in weekday bus travel of seven per cent (Loukakos 2000).

25 *London Charge Zone Interactive Guide* is available at http://www.guardian.co.uk/flash/0,5860,526746,00.html.

26 http://society.guardian.co.uk/governinglondon/story/0,8150,519599,00.html.

27 For charging details see Singapore's Land Transport Authority site http://traffic.smart.lta.gov.sg/erprates.htm.

In Florida, congestion-pricing trials involved the reduction in the tolls on two bridges by as much as 50 per cent during off-peak time periods.[28] The traffic during those periods increased by an average of six per cent while traffic during the typical rush hours declined by an average of five per cent. While this impact on congestion appears relatively minor, it was estimated to have saved 15,000 hours of total travel time over a year (Marsteller 2001).

Advanced congestion pricing experiments have been implemented in the US, where congestion pricing has officially been renamed 'value pricing'.[29] In December 1995, the world's first fully automated toll road using electronic tolls was opened on a portion of California's State Route 91 (SR 91).[30] The private project, consisting of four 'Express Lanes' along the median of the Riverside Freeway (SR 91) has been heralded as the best US example of congestion pricing implementation.[31] The tolls vary with traffic volumes, and direction.[32]

> Using automatic vehicle identification (AVI) and advanced traffic management systems (ATMS), State Route 91's express lanes have dramatically decreased congestion along one of the state's busiest highways. The 10-mile stretch of no-cash toll road is the first of its kind in the world, and the first in the United States with a congestion-based pricing system.[33]

Another application of interest is the dynamic pricing system operating on two special tolled lanes of San Diego's Interstate Highway 15 (I-15). Tolls are adjusted every six minutes up or down to ensure a smooth flow of traffic. The actual charges are posted on roadside electronic message boards, three-quarters of a kilometre before the lane starts, allowing vehicles time to leave the congested road and find an alternative route in order to avoid the toll. On a normal day, tolls can range from US$0.75 to US$4, but can go as high as US$8 if traffic becomes unusually heavy (Charles, H. 2001).

Public resistance to congestion charges appears not to have been a major issue with either Interstate 15 or SR 91 presumably because free, albeit often more

28 For more detail including a definition and principles of efficient value pricing go to 'Learn about pricing' from http://www.hhh.umn.edu/centers/slp/conpric.

29 Congestion pricing is officially known as value pricing in the US—Orski identifies a practical distinction between value pricing and congestion pricing and discusses the implications of the change for policy makers http://www.nawgits.com/ko_valpric.html.

30 91 Express Lanes homepage: http://www.91expresslanes.com/default.asp.

31 Travel Choice Modeling at http://www.rsginc.com/services/trav_choic_mod/proj_sr91.html.

32 By regulation, concessionary tolls apply to high occupancy vehicles. Also, the US$130 m, 10-mile, four-lane toll project, located within the median of an existing eight-lane freeway, is restricted to light vehicles http://www.dot.ca.gov/hq/paffairs/about/toll/status.htm.

33 HNTB http://highways.hntb.com/3b1_sr91.htm.

congested, lanes of the one road are available. Nevertheless, to the extent that congestion increases on the surrounding network in response to the tolls, to capture greenhouse benefits pricing would need to apply to these routes also.

In many countries, including Australia, the use of tolls has been restricted to expanded network capacity. However, the New Jersey Turnpike Authority appears to have successfully introduced congestion charges to an established (previously tolled) roadway. Tolls that vary with congestion levels were introduced on the New Jersey turnpike in 2000 and, at the time, constituted the most extensive use of variable tolling on any major American toll road. The changes represented an increase in tolls of around 40 per cent to fund improvements to the Turnpike. Variable tolling and discounts were offered to those users opting for electronic toll collection (ETC). As a result, motorists using the turnpike outside of peak periods and paying electronically experienced only a small increase in tolls.[34]

Many countries, including UK, Germany and South Korea have completed or are conducting congestion pricing feasibility studies, with the Bristol and Edinburgh trials using roadside beacons and gantries and dashboard-mounted black boxes. The Netherlands is considering a revenue-neutral kilometre-based charge involving the installation of On-board-Units (OBUs) for all vehicles—a system that could be adapted to include congestion charging.[35] .

A report released in February 2002 by the UK Commission for Integrated Transport (CfIT) argued for replacing a portion of current road-use related taxes with revenue generated by congestion pricing.[36] Titled *Paying for Road Use*, the report identified significant gains from congestion pricing:

- 44 per cent reduction in congestion;
- reduced and more reliable journey times; and
- a reduction in the amount of traffic by almost five per cent.

The report also argued that more investment in roads, railway lines, bus lanes or motorways would not solve the congestion problem, because road building itself creates more demand and, even if the number of people travelling by public transport in Britain were doubled, it would only be equivalent to five years' growth in car traffic (Walters 2002).

A key recommendation of the report, supported by such diverse bodies as the Freight Transport Association, RAC (formerly the Royal Automobile Club) and the Confederation of British Industry, is the restructuring of motoring taxes to maintain revenue neutrality. In the words of the vice-chair of the

34 See http://www.nycroads.com/roads/nj-turnpike/.

35 For more background see http://www.acidrain.org/AN3-01.htm#Road_pricing_NL.

36 Available at http://www.cfit.gov.uk/reports/pfru/index.htm.

CfIT, 'we simply need a radical rethink in the way we structure motoring taxes, to take some lessons from other public utilities and to make use of developments in technology'.[37]

ENVIRONMENTAL IMPACT OF ROAD-USE CHARGES

Road-use charges, in particular those calibrated to internalise emission and congestion costs, have the potential, where appropriately applied to all relevant roads in the network, to be of significant benefit to the environment. Fixed road-specific tolls are a different matter. The impact of road tolls on greenhouse gas emissions could be positive or negative and would depend on a number of factors, such as the level of congestion tolerated on the system and operational details of the toll collection mechanism: free-flow electronic tolling or manual toll booths. Fixed tolls may reduce congestion in the short run, by discouraging some drivers, and in the longer term, by raising funds (if the funds raised are used) for expansion of the network. If introduced on established roads, tolls, on one hand, may slow the growth in VKT through increasing the cost of travel. On the other hand, if the tolls resulted in traffic being diverted to secondary roads, often termed 'rat-running', congestion on the non-tolled roads could increase. Some council members in Bristol, England, voiced this fear when they opposed the road pricing proposals, arguing that they 'will fail to tackle congestion in the city by moving more traffic onto other commuter routes and residential streets'.[38]

The responsiveness of road users to a change in motoring costs, say, through the introduction of congestion charges, can be measured by the elasticity of the demand for VKT with respect to the 'price' of travelling.[39] In aggregate, responsiveness to increases in the cost of driving is low—most studies estimate own-price elasticities of private vehicle travel demand of between –0.015 to –0.04.[40] When restricted to urban travel, elasticities are higher. Oum et al. (1992) report own-price elasticities of urban private vehicle travel demand of between –0.01 and –1.26. The elasticity of the demand for vehicle travel would vary between locations depending on factors such as the reason for the travel, the scope for time shifting of travel and the availability and substitutability of alternative modes of transport.

In general, the gains from optimal congestion pricing will be maximised when non-uniform charges apply across the whole network. The BTCE (1999b, p. 317) estimated that even with the lower levels of congestion prevailing in

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37 Vice-chairman's forword at ibid.

38 *Local Transport Today*, 31 May 2001, Issue 316, p. 1.

39 For a simple explanation of the elasticity of demand see http://www.xrefer.com/entry.jsp?xrefid=445152&secid=.-&hh=1.

40 BTE Transport Elasticities Database http://dynamic.dotrs.gov.au/bte/tedb/index.cfm.

1995, optimal congestion pricing in Australian cities would result in, on average, the following (related) outcomes during morning peak hour:

- an increase in average speed from 34 to 46 kilometres per hour;
- a reduction in travel time by 39 per cent;
- a reduction of 84 per cent in delay times; and
- a reduction of 29 per cent in fuel consumption (BTCE 1996, p. 53).

Greenhouse gas emissions would decline in proportion to the decline in fuel consumption in Australian cities—around 30 per cent. Hence, optimal congestion pricing could result in a five million tonne reduction per annum in greenhouse gas emissions, or around one per cent of Australian greenhouse emissions from all sectors in 1995 (BTE, 2000, p. 3).

More accurate road pricing for freight vehicles could lead to reductions in greenhouse gas emissions. Since the fuel used per tonne kilometre is generally lower for heavier vehicles, increases in mass limits could reduce fuel use and hence the level of greenhouse gas emissions for a given freight task. A number of countries are pursuing the link between enhanced mass limits and more accurate road use charges for heavy vehicles. A study on the impact of permitting 44-tonne trucks for general use in the UK found that such a move would result in:

- traffic levels falling by around 100 million vehicle-kilometres per year;
- 1,000 less trucks on the road than would otherwise be the case; and
- a decline in carbon dioxide emissions of between 80,000 and 100,000 tonnes (CfIT 2000b).

While such a move raises the question of competition between road and rail the CfIT study noted that 'while we have been unable to examine possible longer term changes in logistics patterns, our study shows that the savings in mileage and environmental benefits are likely to outweigh effects from increased lorry mileage and the loss of some rail freight' (CfIT 2000b, p. 2).

EFFICIENCY IMPACT OF ROAD-USE CHARGES

The potential for efficiency gains from road-use charges depends on the type and detail of the charge. Tolls are generally aimed at revenue raising rather than at improving the efficiency of resource use. As Gómez-Ibáñez and Meyer (1993) observed:

> In general, the advantages and disadvantages of tolls must be weighted against those of alternative financing schemes or of building fewer roads. Toll financing may not encourage optimal road use and investment, for example, but financing through fuel or broad-based taxes may do worse or no better.

Setting the tolls too high could lead to under-utilisation of the tolled road and increased usage of alternative roads. A recognised drawback of the current

EU directive on the charging of heavy goods vehicles is that it only allows road tolls and user charges to be applied to motorways. To ensure efficient utilisation of the network, motorways should not have higher charges than trunk roads, otherwise road freight operators would be encouraged to shift to trunk routes where environmental costs and accident risks are normally higher.[41] Setting the tolls too low would produce an inefficient level of congestion and, in the case of heavy vehicles, excessive road wear.

The efficiency gains from accurately calibrated congestion pricing could be significant. The BTE estimated the efficiency gains from congestion pricing at $1.1 billion per year (BTCE 1996a, p. 52). The BTCE (1999b, p. 317) concluded that:

> … the results therefore indicate that implementation of road-use charges in each of the six capital cities would be worthwhile even without taking into account the desirability of reducing greenhouse gas emissions'.

The realisation of these potential gains from congestion pricing would depend critically on their manner of implementation, with optimal charges varying within and between cities, and with time. The estimated average level of optimal congestion pricing for Australian cities as at 1995 ranges from three cents to 17 cents per kilometre, with the maximum level of optimum charges peaking at $1.26 per kilometre for Melbourne (BTCE 1996, p. 52).

Establishing the appropriate congestion pricing would involve a trade-off between theoretical niceties and practical expediencies. As Harvey (1999) observed:

> Any practical system of marginal cost pricing will therefore involve averaging across consumers, times and places … There would exist an optimum trade-off between the efficiency gains from a more complex pricing system that better reflects costs, and the administrative costs of such complexity.

Bray and Tisato (1997) observed that the pursuit of optimal congestion pricing may be difficult to justify and identified a broader range of pricing options that could improve welfare outcomes but at a lower implementation cost than finely-tuned congestion pricing. Clearly, as telematics technology spreads downmarket and On-Board-Units (OBUs) become standard equipment, implementation costs of sophisticated emissions charges and congestion pricing will continue to fall. Accurate charging schemes to internalise the cost for both congestion and emission externalities:

> … require continuous monitoring of vehicles in order to calculate distance travelled or even more complex indicators of external costs imposed. These

41 Per Kågeson Nature Associates 2000, *Bringing the Eurovignette into the electronic age*: position paper on the need to change Directive 1999/62/EC to accommodate the introduction of kilometre charging for heavy goods vehicles http://www.t-e.nu/Fact-sheets,%20responses,%20etc/6-00%20-%20T&E%20position%20on%20Kilometre%20charging.htm#ReplEurovignette.

systems may be GPS driven or utilise similar technologies. Whilst more complex and costly, many of these technologies already exist on a trial basis (CUPID, p. 8).

A major consideration in achieving efficiency gains from road-use charges (with the serendipitous outcome of reducing greenhouse gas emissions) is the difficulty in accurately estimating the marginal cost of transport externalities, including global costs such as greenhouse gas emissions. However, the current default approach of bestowing a zero value on both global and local emissions is difficult to defend in terms of community interest. Furthermore, the question is not whether a perfect system of emission charges can be achieved, but, rather, how some of the benefits to the community can be captured from utilising the available technology to improve the price signals facing road users.

FISCAL IMPACT OF ROAD-USE CHARGES

The fiscal impact of road-use charges is potentially very large. Gross revenue from the 407 Express Toll Route in Toronto, Canada, is anticipated to be around Can$2 million per week from a pricing structure that involves a maximum peak hour toll rate of Can$0.10 cents per kilometre.[42] It has been estimated that the application of theoretically optimal congestion pricing systems in six Australian mainland capital cities would generate around $2 million per morning peak hour (BTCE 1996a, p. 52).

The fiscal impact of any system of road-use charges depends on both the details of the charging system and the use made of the funds generated—mainly whether taxes are reduced or public transport subsidies increased. Compensating losers could play a significant role in determining the political acceptability of congestion pricing. The main winners from congestion pricing would be those road users who place a high value on their time, such as business users and private commuters with multiple jobs or inflexible care-giving responsibilities. Public transport users may also benefit, as buses become quicker and more reliable with reduced congestion.[43] The losers would be:

- those who value the time saving less than the charges and hence either stop commuting or are diverted to less preferred routes or to less preferred times;
- those who continue to use the road but for whom the *net* benefit from the road use has fallen; and
- those who previously used (or live along) alternative routes that become more congested due to the diverted traffic.

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42 For details see *Tool Roads Newsletter* http://www.itsonline.com/407_ps.html.

43 Unless there were offsetting increases in fares to cover congestion charges levied on buses.

Adroit use of the funds generated by congestion pricing can ensure that these people can be compensated for these levels of losses. Small (1992) suggested using the revenue from congestion pricing to:

- replace regressive sales and fuel taxes;
- provide a travel allowance of US$10 a month for every employee in the region regardless of mode of travel to work;
- rebate local rates; and
- improve transportation throughout the area.

How the funds generated by congestion pricing are used would seem critical to both public acceptance of congestion charges, distributional impact and net welfare gain to the community:

> ... it weighs heavily on the side of viewing the revenues from congestion pricing as a substitute for other revenue sources rather than a gigantic windfall for expanded government programs; yet it still provides for substantial new services, which can help attract support from diverse interests provided the services are chosen to serve real needs (Small 1992, p. 12).

Small (1992), in a case study based on southern California, developed a package of congestion pricing and revenue use aimed at attracting wide support, leaving even low-income ‘captive’ drivers better off.

Button and Pearman (1985, p. 37) observed that the main, politically acceptable uses for the revenue from congestion charges would be for it to be:

- returned to motorists in the form of an income transfer, in such a way that it does not negate the crucial price signals conveyed by road-use charges;
- deployed for road infrastructure;
- diverted to public transport; or
- used to offset reductions in taxation elsewhere in the economy, such as fuel excise.

In evaluating each option, Button and Pearman (1985) concluded that the first was of more theoretical than practical interest since it is difficult to directly compensate motorists for congestion charges without blunting the impact of the charge on travel behaviour. Button and Pearman saw the second option as having doubtful merit, as roads require evaluation on their own. However, the deployment of the funds for road infrastructure tends to make the charges more palatable for road users. One of the few road operations currently using a form of congestion pricing is California’s privately owned SR 91. Income generated is used to:

> ... pay capital and operating costs, such as setting up an extensive safety program, ensuring a rapid-response capability for clearing disabled vehicles, paying for a state highway patrol presence along the road, and reimbursing the California Department of Transportation for maintaining the road (Finch 1996).

Also, from a theoretical perspective, it can be shown that network expansion is justified where the marginal cost of congestion exceeds the marginal cost of expanding the network.

Button and Pearman argued that, given the current high level of subsidies for public transport, further diversion of funds could be difficult to justify as being in the public interest. In Canada, the California Tax Reform Association (CTRA) Panel concluded urban public transport projects should be permitted to compete for road funds rather than being guaranteed a fixed portion of revenue raised from road-use charges (CTRA 2001, ch. 12). This approach would require each project, whether road or public transport, to be evaluated on its merits. The Panel pointed out that the principal justification for subsidising public transport—reducing road congestion—would disappear once congestion charges were implemented. Small (1992, p. 5) also cast doubt on the use of such funds to finance improved public transport, suggesting that it could be more appealing to the planners than to users.

The final option, offsetting other forms of revenue raising, was regarded by Button and Pearman (1985) as the 'least objectionable'. This implies revenue neutrality, that is, total tax receipts remain unchanged. A congestion-pricing package that guaranteed revenue neutrality, so that the overall level of taxes was not increased, could be attractive on many levels.[44]

In some situations, revenue neutrality seems to be regarded as a precondition for the political acceptability of congestion pricing to help allay community fears that congestion pricing represents a new and creative form of taxation. In the UK, the CfIT Report (2002) has emphasised that funds raised through congestion pricing should be offset by reductions in both vehicle tax and fuel excise. If revenue neutrality were maintained, with congestion pricing involving a restructuring of road-related charges/taxes, rather than an increase in taxes, then the fiscal implications would be minimal.[45] On the other hand, there is a widespread view that congestion charging should not be revenue neutral and that a substantial portion of funds raised from congestion charges should be used to enhance public transport and/or reinvested in transport infrastructure. A key principle of the New Transport Initiative adopted by Edinburgh City Council is that 'all revenues raised from charges should be reinvested in additional transportation improvements and a significant proportion of those transportation improvements should be in place prior to the introduction of charges'.[46]

44 If the taxes reduced were distorting resource allocation, as is likely to be the case, further efficiency gains would ensue.

45 The restructuring of taxes may not be limited to road-related taxes but could extend to property rates and other ways to compensate those losers from congestion pricing.

46 Edinburgh City Council 2000, *New Transport—Phase 1: Final Report*, 10 April 2000, http://www.edinburgh.gov.uk/downloads/transportinitiative.doc (9 July 2001).

The preconditions for road user charging in Edinburgh are that:

- the revenue must be spent only on transport;
- the money raised must be additional to, not in place of, existing funding;
- transparent accounting for income and expenditure; and
- there must be significant investment in public transport from the outset.[47]

If the policy approach as outlined in the Canadian report, Vision and Balance, were adopted, then only that expenditure that could be justified on the basis of consistent project evaluation could be diverted to either public transport or to road infrastructure. In this case, the net fiscal impact would be uncertain.

The use of congestion pricing funds could be influenced by the commonly held view that the burden of congestion pricing falls more heavily on low-income earners. Button and Pearman (1985, p. 37) cast doubt on this contention, observing that 'the tendency for the wealthy to make more and longer journeys in urban areas could counterbalance their supposed gain'. Dadson et al. (1999) noted that, in Toronto 'most roads suitable for pricing are primarily used by middle or upper income drivers', so road tolling has also been considered as a way to tax the rich. Evidence from California produced similar results:

Moreover, congestion pricing would almost exclusively affect middle and high income individuals due to the fact that a very small percentage of rush hour drivers are poor. In 1990, the Bay Area Congestion Pricing Task Force used Census figures from that year to show that the average income for commuters on the Bay Bridge was $68,000, a number 50 percent higher than the average household income for the area from which they were commuting (Schiller 1998).

The fiscal impact of road-use charges in general, and of congestion pricing in particular, is thus inextricably linked to the design of the charges and to how the funds generated are deployed.

CONCLUSIONS

When choosing between measures to pursue reductions in greenhouse gas emissions it makes sense, in the first instance, to adopt those measures that generate greenhouse benefits as a side-product and produce sufficient community benefits to justify implementation. Appropriately calibrated road-use charges—mainly congestion charges—may be one such measure. With dramatic advances in computer and communication technology over the past decade, such charges are increasingly feasible. If the availability of more accurate road-use charges for heavy vehicles resulted in the wider application of enhanced mass limits, a favourable greenhouse impact is likely.

47 http://www.edinburgh.gov.uk/CEC/City_Development/Transport_and_Communications/Local_Transport_Strategy/Results/consultleaflet2.html#now

With other road-use charges, such as toll charges, the impact on greenhouse gas emissions is less certain. The impact of tolls on VKT and congestion (and hence on greenhouse gas emissions) could be positive or negative.

It is important to recognise that the cost of most externalities depends critically on local conditions, including the technology employed, and hence the use of an average figure would generally defeat the purpose of the measure. Hence, the frequent question 'do road users pay their way?' is misleading. The better question, from the community's point of view is 'are taxes and charges for road use structured in such a way as to encourage an efficient use of resources?'. The crucial point is that the efficiency gain and hence the value to the community of road-use charges comes, not from equating total charges to total costs incurred, but from aligning the price signals faced by individuals with the activity's costs to society. In terms of this alignment, congestion charges offer the greatest potential for reductions in transport greenhouse gas emissions.

While there are potentially large efficiency gains from implementing more accurate road user charges, ultimately the realisation of gains will depend on the design of the charging system. Determining, say, the appropriate congestion charges would involve a trade-off between administrative simplicity, environmental objectives and economic efficiency. The important point to note is that:

> … if pricing is to have beneficial impact effects, it must be closely tied to the actions that create the costs, and robust functional relationships are essential. Large-scale aggregates are of limited value for pricing (Lee 1997, p. 123).

More accurate pricing is possible, and indeed desirable, without an increase in overall costs of road use. As noted in the EC White Paper, 'it is not so much the overall level of taxes that needs to change significantly, but rather their structure, which needs to be altered radically to integrate external and infrastructure costs into the price of transport' (EC 2002, p. 72/73).

The disbursement of funds could also impact on resource efficiency. The main choice here is between revenue neutrality or generating a surplus that could be used for, say, enhancing the transport infrastructure. Ideally, in the latter case, all modes would be able to compete for the transport funds available, avoiding the temptation to earmark fixed sums to, say, public transport.

Since many other countries are further advanced than Australia in terms of road-use charges, the opportunity exists to observe and learn from experiences elsewhere.

chapter 5

ECONOMY-WIDE MEASURES

Market incentives for greenhouse gas abatement, such as taxes and tradable permits, provide a significant advantage over the more specific transport measures discussed earlier. Market incentives provide a mechanism for capitalising on the low cost abatement opportunities, wherever they occur in the economy, thereby minimising the cost of abatement to the community. The outcome would be that the marginal costs of abatement would be equalised across all sectors—the condition necessary for least-cost abatement.

CARBON TAXES

While there are a number of greenhouse gases, interest centres on carbon mainly because it is by far the most significant greenhouse gas and is administratively simpler to deal with, compared with the other greenhouse gases.[1]

The logic underlying carbon taxation is simple: if carbon emissions cause damage, then carbon emission should be taxed to reflect this damage. While this has a sense of natural justice about it, a more important reason is to ensure that producers face accurate signals regarding the benefits and costs of their activities. Hence, the aim is to create an environment in which the marginal private costs and benefits equal the marginal social costs and benefits. There are a number of ways of pursuing this, but the most direct is to impose a tax on the production process equivalent to the difference between the marginal private and marginal social cost of emissions.

Unfortunately, putting a value on the damage caused by greenhouse gas emissions is most difficult, due to the lack of precision in understanding what will occur, where and when. However, this is more critical if the aim is to achieve an optimal level of greenhouse gas emissions—optimal from an

1 The terms 'carbon tax' and CO_2 tax are often used interchangeably, but since 3.67 tonnes of CO_2 contains one tonne of carbon, a $100/tonne tax on carbon emissions would be approximated by a $30/tonne tax on CO_2 emissions.

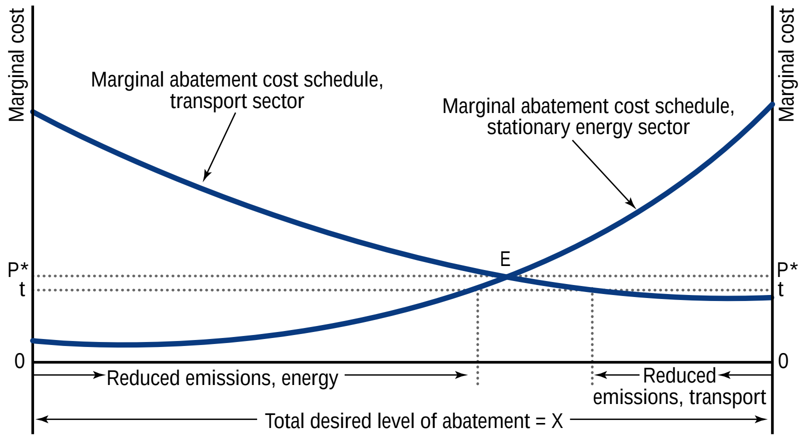
economic point of view. If the goal is to pursue a particular level of greenhouse gas emissions, such as the Kyoto target, then the tax rate necessary to achieve this can be estimated and then finalised by trial and error.

How carbon taxes work

Carbon taxes make direct use of price signals to pursue environmental goals. Figure 5.1 illustrates how a carbon tax can bring about an abatement of emissions at least cost to the community. The example concerns two sectors, transport and stationary energy, but applies equally for two firms, industries or countries.[2]

The hypothetical marginal abatement cost curves for the two sectors are drawn in opposite directions. Hence, the stationary energy sector's marginal abatement cost curve is read from left to right (with the level of abatement increasing in this direction) and the transport sector's curve from right to left (with the level of abatement increasing in this direction). The curves are upward sloping reflecting the fact that low-cost options for abatement are pursued first, with additional levels of abatement requiring increasingly costly options.

FIGURE 5.1 A BASIC CARBON TAX



2 As is usual in this simplified analysis, prices everywhere are assumed to equal marginal social costs.

When a carbon tax, *t*, is levied per tonne of carbon, both sectors would invest in emission abatement as long as it was no more costly than paying the tax. From Figure 5.1 it can be seen that, if these marginal abatement cost schedules applied in reality, the energy sector would undertake a larger burden of emission reduction activity because it can do so at a lower cost than the transport sector. To impose levels of emission reduction on the sectors at variance with these levels would be inefficient and would increase the total cost to society of achieving an emissions target.

It can be seen that the tax *t* does not produce the level of abatement required (*X*). To achieve abatement of *X* at least-cost, the tax of *P** would be needed. In practice *P** would change over time as abatement costs changed due to factors such as shifts in demand and the introduction of new technology.

These changes could see changes in the share of abatement activity between sectors as least cost abatement activities were pursued.

Different models estimating the marginal abatement cost (MAC) curve for 'light duty vehicles' have been summarised by the OECD (1997, pp. 101–5). For example, a MAC schedule estimated by the UK Department of Transport suggests that fuel savings of over 45 per cent can be achieved relatively cheaply, increasing the cost of a US$16,000 vehicle by only eight per cent.

A number of carbon tax proposals were canvassed in Australia during the mid-1990s. The then Department of Environment, Sport and Territories proposed a levy at the modest rate of $4.59 per tonne of carbon ($1.25 per tonne of CO_2) (Chisholm 1996, p. 2).[3] The proposal encountered considerable opposition from industry, with claims that any reduction in the profitability of energy intensive industries might cause some industries, such as the aluminium industry, to review investment plans in Australia. A carbon tax could take a variety of forms, but for administratively simplicity it is likely to impact on the transport sector through either a tax on fossil fuels at the point of refining/importing or a tax at the bowser. A carbon tax on transport, regardless of where it were collected, would appear as a tax on fuel.

Taxes have the advantage of being administratively simple and already a familiar part of most financial systems. Carbon taxes have the added attraction that, in the course of ensuring a more efficient level of greenhouse gas emissions, revenue is generated as a side product. If the revenue raised from carbon taxes were used to replace less efficient taxes, there is scope to make the community better off.

3 At this time, the Australian Conservation Foundation also proposed a tax of about $20 per tonne of carbon (Chisholm 1996, p. 2). At this rate, if the tax applying to fuel were fully absorbed in fuel prices, prices would increase around 1.3 cents per litre.

Environmental impact of carbon taxes

Carbon taxes would discourage the production of carbon and could be expected to have a favourable environmental impact, provided that other emissions, causing other kinds of environmental damage, were not substituted.[4] The effectiveness of a carbon tax would depend on the elasticity of energy use with respect to energy price and the size of the tax. There is evidence to suggest that the transport demand for fuel is relatively inelastic in the short run, although possibly twice as elastic in the long run. If it were assumed that the long run price-elasticity of petrol use was about –0.2, then a tax that doubled the price of petrol would, after about 20 years, result in a 20 per cent reduction in annual petrol use. However, carbon taxes of this magnitude are not currently being considered in the international arena. A tax of around $100 per tonne of carbon would represent roughly an eight per cent increase in petrol prices and lead, in turn, to an estimated long run reduction in fuel use of 1.6 per cent. If the long run price elasticity of the demand for petrol proved to be double the above estimate, then the reduction in petrol use would also double.[5]

The impact of a carbon tax on the demand for fuel would also depend in part on whether there were offsetting tax reductions, in particular, reductions in fuel excise. The incidences of the two taxes would differ, as the carbon tax would be calibrated to reflect different levels of carbon in different fuels, unlike the current fuel excise.

Environmental gains could be greater (or efficiency costs less for the same net reduction in carbon dioxide emissions) the more comprehensive the system. For instance, if equivalent subsidies were provided for carbon sinks such as forest growth.[6] Also, if administratively feasible, the environmental gains could be greater (or costs less) if taxes were applied to all six of the major greenhouse gases weighted by the global warming potential of the individual gases (carbon dioxide equivalents). The incidence of the tax would differ considerably if it were based on carbon dioxide-equivalents rather than on carbon dioxide. If the tax were based on carbon dioxide equivalents, the stationary energy sector and the transport sector would both bear a smaller share of abatement costs than if a tax were based only on carbon dioxide alone.[7]

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4 The downside in terms of the environment is the possibility that penalising carbon producing activities encouraged activities that produced more damaging emissions.

5 Luk, J. & Hepburn, S. (1993) report estimates of the elasticity of demand for petrol with respect to petrol price ranging from –0.05 to –0.21 in the short run and from –0.20 to –1.03 in the long run.

6 Some firms are already paying State Forests of New South Wales to plant and manage forests as a hedging device against potential future trading schemes (*The Economist* 2000a, p. 67).

7 In 1999, stationary energy accounted for 82 per cent of gross carbon dioxide emissions but only 57 per cent of gross carbon dioxide equivalent emissions. Similarly, transport accounted for 22 per cent and 16 per cent respectively (AGO 2001, table 2, p. A-5).

Another possible disadvantage of carbon taxes from an environmental perspective is that in any time period, the level of emissions would be difficult to predict with a great deal of certainty. Predictability of the level of emissions at any point in time may not be a serious drawback since environmental targets such as the Kyoto Protocol are, in many ways, arbitrary. The fluid nature of the outcome may even be an advantage—as more information on the potential benefits of greenhouse gas abatement comes to light, carbon tax rates can be adjusted accordingly, taking account of the cost of uncertainty arising from frequent adjustments.

Efficiency and fiscal impacts of carbon taxes

A tax that applied equally to all greenhouse gas emissions and included a subsidy for sinks would, under certain assumptions, offer the most efficient way of pursuing greenhouse objectives. The assumptions are those needed to make all prices in the economy equal to marginal social costs. In reality, the existence of taxes, subsidies, trade barriers, imperfect competition and unpriced externalities means that a uniform emissions tax and sink subsidy will not achieve the theoretically available efficiency gains. However, the practical difficulties of attempting to tailor the taxes and subsidies to adjust for these distortions (the 'second-best' approach), along with the resultant increased susceptibility of the system to lobbying by vested interests, supports the pursuit of the first-best policy, the preferred policy approach.

It has been argued that focussing only on carbon dioxide (carbon) emissions, rather than carbon dioxide-equivalent emissions, would increase the cost for the US of meeting its Kyoto commitments by 60 per cent (Reilly et al. 1999). Taxing only carbon emissions could encourage substitution towards other more potent greenhouse gases such as methane, nitrous oxide and chlorofluorocarbons (Poterba 1993, p. 52). The environmental and efficiency losses resulting from this substitution would need to be assessed against the administrative simplicity of a carbon tax.

The principal advantage of a carbon tax is that it would allow the marginal cost of abatement to be equalised across all areas—a condition necessary to minimise the efficiency loss associated with achieving a given abatement target. While carbon taxes may be resisted because of their impact on fuel prices, achieving the same abatement target through regulatory measures would have a greater, but hidden cost. Furthermore, if other taxes were reduced to make the carbon tax revenue-neutral, fuel prices may not increase.

The fiscal impact would depend on the level of the tax and the use of the funds. According to BTCE estimates, a carbon tax of $100 per tonne would raise around $1 billion a year. (BTCE 1996, p. 158). Offsetting this would be reduced revenues from taxes elsewhere reflecting the negative effects on the economy of the new tax. This fiscal windfall could be reduced somewhat over time, as consumers adjusted to higher fuel prices by purchasing more fuel-efficient vehicles.

Other considerations

A common objection to any policy that raises the price of fuel is that the tax burden falls proportionally more heavily on low-income households as they spend a greater proportion of their income on consumption. However, there is evidence that such taxes can be less regressive than current taxes on travel. Cousins and Potter analysed the distributional effects of a higher fuel tax to replace the current vehicle taxes, and concluded that 'EEC member countries could shift all or part of their annual vehicle charges to taxes on fuel without regressive changes in the distribution of wealth'. This is because the poor drive less distance than the wealthy.

The difficulty of implementing and maintaining comprehensive and rigorous carbon tax is evidenced by the experiences in Europe where exemptions are routinely used as a form of industry assistance. Exemptions can be significant, such as in Norway where the industries exempt from the carbon tax are responsible for about 40 per cent of Norwegian carbon emissions (Alfsen 1999, p. 7). Rate variations (often unrelated to the carbon content of different fossil fuels) add to administrative complexity and to the cost of the schemes. A few case studies are included below.

European experience with carbon taxes

Norway

Despite strong resistance from the petroleum industry, the Norwegian Government introduced a 'carbon tax' in 1991. In technical terms, the carbon tax is not a true carbon tax, but rather a series of differential tax rates for different fuels, with tax rates being only loosely based on carbon content. Power intensive and export orientated industries are completely exempt from the tax.

Furthermore, the tax is treated mainly as a revenue-raiser and the rate is frequently (usually bi-annually) subject to re-assessment in connection with general debates on national budgets, generating considerable uncertainty for the manufacturing sector. As Alfsen (1999, p. 7) observed, 'the tax has … not been treated as primarily an environmental tax, but rather has been an integral part of the fiscal tax regime.'

In 1998, moves to introduce more consistent carbon tax rates were defeated in the Norwegian Parliament. With the support of industry, the Government is currently investigating the feasibility of introducing a system of tradable permits (Kasa 1999).

Sweden

The Swedish Parliament passed a bill in 1990 introducing a carbon tax and a value-added tax on energy. Existing taxes on various fossil fuels were lowered by between 25 and 50 per cent as part of overall fiscal reform. The carbon tax was originally levied at the rate of Sk250 per tonne of carbon dioxide (A$42) and was applied to oil, coal, natural gas, LPG, gasoline and fuel for domestic air transport. The tax was subsequently raised to Sk370 per tonne of carbon dioxide (A$61), but fuel used for electricity production was exempted from the tax, and the tax levied on industry was reduced to about 25 per cent of the tax paid by other energy users.

In July 1997, the Swedish Government raised the carbon tax on industry to Sk185 per tonne of carbon dioxide (A$31), bringing it up to about half of the tax faced by other energy users. The availability of exemptions induced ‘artificial’ restructuring of companies and also made the scheme expensive to administer (Baron 1996, pp. 27–35).

Denmark

A tax on energy use in the household sector has been in place since 1977. The tax was increased considerably in 1986 to offset a fall in oil prices. A specific carbon tax on energy consumption was introduced in 1993. In the case of the household sector, the energy tax was converted into a tax on carbon dioxide of DKr100 per tonne (A$19). Companies receive a concessional rate through a rebate of 50 per cent.

In 1996, a new tax regime was introduced with markedly different rates for ‘heavy’ (energy intensive industries or those operating in a competitive environment) and ‘light’ industry (all other industries).[8] One complication is that the criteria of ‘energy intensive’ and ‘operating in a competitive market’ are open to negotiation (Baron 1996, pp. 27–35). Energy use for space heating is taxed at yet a different rate. Leaded and unleaded petrol are both exempt from the carbon tax on the grounds that petrol is already very heavily taxed. The carbon tax applies to diesel, which is still taxed relatively lightly compared to petrol.

Finland

Finland was the first country to explicitly tax the carbon content of fossil fuels. The tax was initially imposed in 1990 at the low rate of Mk7 per tonne of carbon dioxide (A$1.70), but this rate was doubled in 1993 to Mk14 per tonne of carbon dioxide (A$3.40). The result was a 1–2 per cent rise in the price of

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8 ‘Heavy industry’ (or industry facing competition) is taxed at the rate of DKr 25 per tonne of CO_2 (A$5). ‘Light processes’ are taxed at the rate of DKr 90 per tonne of CO_2 (A$17).

electricity, a 5–8 per cent rise in the prices of coal, heavy fuel oil and petrol, and a 10 per cent rise in the price of diesel.

Prior to 1997, the tax was split into a fiscal component, a carbon component and an energy component. In 1997, the Finish Government made two major changes. First, taxes on fuels for heat generation were restructured to shift the emphasis from a carbon/energy basis to a carbon only basis (Mk70/t carbon dioxide). Second, the tax on fuel input to power generation was removed, and replaced with a tax on all electricity consumed with differential rates for households and industrial users (Baron 1996, pp. 27–35).

TRADABLE PERMITS

Tradable permits offer a similar economy-wide approach to pursuing Kyoto objectives. While the implementation of tradable permits differs significantly from that of carbon taxation, under some circumstances the impact of both instruments can be the same. A carbon tax involves setting the tax and allowing the level of emissions to adjust, while tradable permits sets the level of emissions, allowing the permit price (tax impact) to adjust. A carbon tax impacts on the level of emissions produced, just as permits impact on the cost of producing those emissions, regardless of how the permits are allocated initially. These measures are not mutually exclusive. It would be quite possible to have a combination of permits and carbon taxes.

How tradable permits work

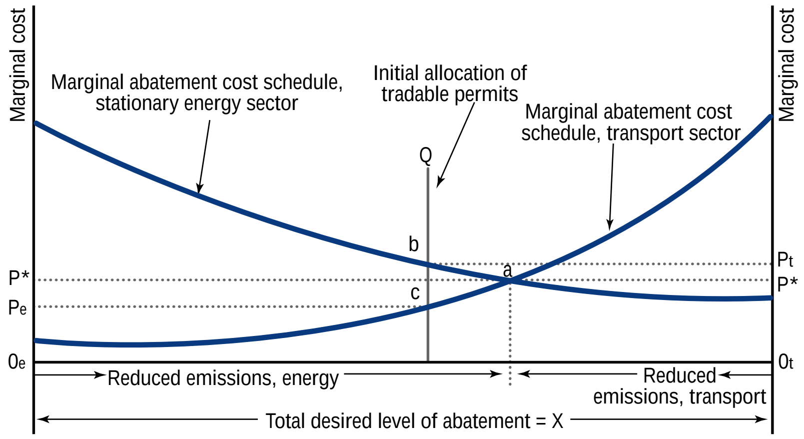
A tradable emissions permit is the legal right to emit a specified quantity of greenhouse gas (e.g., one tonne of carbon dioxide emissions). This right can be bought or sold on the permit market, with the price determined by the demand and supply of permits.

Tradable permits would impact on the transport sector through higher prices for fuel. Just as carbon taxes set the price of emissions allowing the quantity to adjust, tradable permits set quantities, leaving prices to adjust. Hence, as long as the quantity response to price changes is known (or can be discerned), a similar outcome can be achieved with both instruments.

The most likely mechanism for implementing tradable permits would be a requirement for permits at the refining/importing level. Figure 5.2 illustrates how a market in tradable permits, assuming all prices equal marginal social costs and zero transactions costs, achieves a target level of abatement at least-cost. As with Figure 5.1, this example draws on two sectors, transport and stationary energy, but applies equally for two firms, industries or countries.

The two sectors' marginal abatement cost curves are drawn in opposite directions. The stationary energy sector's marginal abatement cost curve is read from left to right, with the level of abatement increasing in this direction. The transport sector's curve is read from right to left, with the level of

FIGURE 5.2 TRADABLE EMISSIONS PERMITS



abatement increasing in this direction. The curves are upward slopping to reflect the expectation that, as abatement increases, the low cost options for abatement are exhausted so that abatement becomes increasingly more expensive on a per unit basis.

Suppose that the stationary energy sector is initially allocated 0_eQ emissions permits and the transport sector 0_tQ emissions permits.[9] The total number of permits allocated is X. At this allocation, it costs the transport sector P_t to abate the marginal unit of emissions, while it costs the stationary energy P_e. Since it is less costly for the stationary energy sector to reduce emissions than it is for the transport sector, both sectors can gain if the transport sector buys one unit of the stationary energy sector's emissions allocation.

The transport sector would continue to purchase permits from the stationary energy sector so long as it is cheaper to buy the right to emit rather than undertaking the abatement within the transport sector. The stationary energy sector will be happy to undertake more abatement (and to sell some of its permits to the transport sector) so long as the revenue it receives from abatement is greater than the cost. For any unit of emissions traded, price will always fall between the two sectors' marginal abatement cost curves. Trade will continue until point *a* is reached. The final 'market clearing' price is *P**. The gains from trade in this case are equal to area *abc*. No trade will take place beyond a, because the cost of abating in the transport sector is less than the cost of

9 For sake of exposition, this simplified analysis abstracts from international trading of permits. International trading would reduce the price of permits.

abating in the stationary energy sector. Point *a* is thus an equilibrium, at least until either of the two sectors' abatement costs change. Whether the transport sector sells permits to the stationary sector, or vice versa, depends on their relative marginal abatement cost schedules. These are not known at present, and need not be known for the scheme to be introduced.

Figure 5.2 illustrates two important results. First, following trade, marginal abatement costs are equalised. Permit trading schemes are therefore, under the assumptions of the model, least-cost. Second, the desired level of abatement, *X*, is realised. Unlike carbon taxation, tradable permits result in a completely predictable environmental outcome.

If the target level of abatement changed, the number of permits could be reduced either through a government buy-back scheme (if the permits were long-lived) or by issuing fewer permits (if the permits were short-lived). Increasing the quantity of permits could be achieved either through establishing appropriate ground rules when the permits were initially allocated or, alternatively, possibly through some compensation to quota owners.

Each permit would represent the right to emit a specified quantity of emissions, for example, one tonne of carbon dioxide equivalent emissions. Permits could apply to either the short or long term.[10] The AGO's preference is to have the permits last for the five-year Kyoto commitment period (1999a, p. 22). If firms expect the demand for tradable permits to grow faster than the supply (thereby pushing up prices) firms could purchase more permits as insurance against future price rises. Alternatively, if the cost of abatement were expected to fall through the introduction of new technology, permit prices would decline.

The time period of the permits involves a trade-off between a number of factors, including flexibility for policymakers and certainty for both industry and policymakers. A combination of long-term and short-term permits as suggested by McKibbon and Wilcoxen (2000) could possibly meet the desire for both flexibility and certainty.

Impact of tradable permits

Environmental

A widely perceived advantage of tradable permits, particularly in the context of Kyoto, is that they result in a fixed quantity of emissions. Hence, in terms of achieving a benchmark (such as *X* tonnes of abatement of carbon dioxide emissions per year), permits may engender a greater degree of environmental certainty than other policy instruments. The directness with which permits target environmental goals may also be regarded as superior to the indirect approach of carbon taxes to environmental benchmarks.

10 Once property rights were established, permit owners could feasibly lease permits for periods as short as a day.

Efficiency

Along with carbon taxes, tradable permits are more efficient than other measures such as mandated standards, because firms can make their own decisions about the best emissions control technology to use, rather than having the technology dictated by the Government.

Permits provide firms with options to:

- increase emissions (by purchasing more permits);
- decrease emissions by selecting the most appropriate abatement technology or scaling back output;
- do nothing (so long as they do not exceed their quota); or
- provide greenhouse gas sinks as a means of obtaining additional permits.

Hence, faced with a limit on emissions, firms and individuals are able to continually adjust their activities and use of technologies in response to short and long-term needs and circumstances, and to do so at least cost to the economy. Companies are in a position to decide whether it would be cheaper to invest in new, cleaner technology, wind back production or to buy extra emission rights on the market. The incentive for improvements to abatement control technology is on-going because firms can profit by undertaking more units of abatement where the cost of abatement is less than the cost of the permit. In contrast, under a regulatory approach, there may be a disincentive for firms to reveal new abatement technology since this can, and typically has, led to a tightening of regulations (Tietenberg 1992, p. 374). Also, the regulatory approach does not generally allow flexibility to respond to short-term fluctuations such as generated by changes in demand and the prices of other inputs.

The other feature of emissions that allow compliance costs to be minimised is, like carbon taxes, allows abatement activity to be undertaken by those firms, sectors (and, if internationally traded, countries) that can undertake the abatement at the lowest cost. Any restrictions in the use of permits would reduce the efficiency gains associated with the permit system. Exempting any sector of the economy from the permit system would increase the cost of abatement to the economy. Also, for a given amount of greenhouse gas emissions, there would be efficiency gains if emissions trading covered all greenhouse gas emissions. Although a carbon tax could, in principle, be broadened to become an ‘emissions tax’, an emissions trading package is likely to be better suited to deal with all six greenhouse gases included in Kyoto.

Much attention focuses on the allocation methods that could be adopted for permits. While it is of critical importance to the main stakeholders, as long as trading is permitted and transaction costs are low, the initial allocation method should not inhibit an efficient outcome. If, in Figure 5.1 for example, the initial allocation, *Q*, fell to the right rather than the left of point *a*, then the transport sector would sell permits to the stationary energy sector and receive revenue, rather than the reverse. This issue is explored more in the following section.

Another feature of permits is that they automatically adjust for inflation and price shock. A sudden (and extended) rise in the price of oil (as was experienced following the OPEC oil price hikes of 1973 and 1980) would probably lead to a reduction in oil demand and, consequently, a period of lower greenhouse gas emissions. This, in turn, would put downward pressure on the price of permits, helping to reduce the shocks imposed on the world economy. Carbon taxes have no such automatic adjustment mechanisms, since the price is fixed by a central agency. However, the regulator could adjust the carbon tax rate in response to significant changes in the market.

The efficiency cost of emission permits could be greater if there were high transaction costs associated with the operation of a permit system. For instance, if it were difficult (costly) to delineate the legal rights embodied in a permit, to monitor and verify the use of these rights, to locate potential trading partners and to arrange legal transfer, then the cost-effectiveness of a permit system could be at risk.

However, the monitoring and enforcement required for the operation of emission permits would be the same as that required for the operation of carbon taxes. Sophisticated technologies are available for the location of trading partners (although a simple web site could possibly do the job), and as long as there was sufficient depth to the market, there should be few serious impediments to its smooth operation.

There are other concerns over the impact of internationally traded permits. In particular, the fact that some countries including the Russian Federation and the Ukraine would potentially have a great deal of excess permits, or 'hot air', to sell on the international market because economic activity in those countries has declined markedly since 1990.[11] While important, this need not be further discussed here.

Fiscal

The fiscal impact depends critically on how the permits are initially allocated. There are two main methods of allocating tradable permits: 'grandfathering' and auctioning. In the case of grandfathering, permits are given to firms currently responsible for greenhouse gas emissions. The number of permits allocated to each firm is typically based on historical emissions outputs (AGO 1999, p. 26). This, it is argued, minimises the impost on industry.

11 McKibbin & Wilcoxen (1999a, p. 3) pointed out the possible detrimental impact that the across border sale of these permits could have on the economies of emerging nations. 'The economic pressures caused by the large transfers of wealth internationally that underlie the claims over permits, could cause severe fluctuations in real exchange rates and international capital and trade flows.'

Free or concessional access to permits could also be argued on the grounds that 'past investment and production decisions, taken in good faith, are not excessively penalised by emerging greenhouse commitments' (AGO 1999, p. 26).

The fact that the permits are given out free of charge does not mean there is no incentive to abate emissions. For each additional tonne of carbon dioxide emitted, the firm forgoes the revenue from selling a permit. A firm could choose to sell some of its permits if the cost of reducing its emissions was less than the market value of the permit. A firm would purchase permits if it were cheaper than undertaking abatement measures. Abatement would therefore still occur up to the point where the marginal cost of abatement equals the permit price established in the market.

The other option for allocating permits is to auction them (or to employ some other similar method such as tender).[12] Auctioning the permits reduces the number of trades that need to take place and hence transactions costs (unless the cost of holding the auction itself is significant) because the permits would most likely be purchased, in the first instance, by those who value them most highly. In contrast, in the case of grandfathering, another round of trading would be necessary. Thus, the efficiency loss associated with grandfathering depends on the level of transaction costs, and on how closely the initial distribution of permits, under grandfathering, mirrors the final distribution after trading. With electronic trading, transactions costs might prove to be minor.

Auctioning rather than grandfathering tradable permits, means that the taxpayer would benefit from the revenue at the expense of industry (unless the auction revenue was returned to firms as a form of compensation for the loss of 'de facto' emission rights that history had bestowed on them). Permit revenue could be considerable. The AGO (1999, p. 14) has estimated that the Australian permit market could be worth up to $12 billion per year, representing approximately 7.5 per cent of total Australian taxation revenue. The auction revenue could be used to reduce taxes thereby generating efficiency gains.

A possible disadvantage of grandfathering the permits is that, compared to an auction system, it would favour incumbent firms over new entrants thereby possibly reducing competition within industries. Even though the impact of grandfathering on existing firm's marginal costs would be the same for an incumbent firm as for a new entrant, the grandfathering could have the effect of a grant to an incumbent firm that is not available to a new entrant.

12 The choice between auctioning and grandfathering implies a judgment about who owns the rights to emit: established firms that have been emitting in the past or the community as a whole—a contentious issue.

A major concern with grandfathering is the rule for allocating permits. The allocation rule receiving most consideration is historical emission levels. If firms knew with a fair degree of certainty that the more carbon dioxide they emit in one period, the more permits they will receive in a subsequent period, a perverse incentive would be created to increase emissions in the first period. Since permits have economic value, such a system would, in effect, amount to an emissions subsidy.

Grandfathering and auctioning are the two polar approaches. A range of compromise solutions in between would be possible, involving various combinations of part auctioning and part grandfathering. The acid rain (sulphur dioxide) permit market in the US combines both methods of allocation (Schmalensee 1998, p. 55).[13] The Environmental Protection Agency (EPA) grandfathers the permits to producers on the basis of past fuel usage and 'good practice' technology. The Chicago Board of Trade also offers direct sales of permits annually at a fixed price ($1,500). Compliance is monitored using certified equipment that measures (on an hourly basis) volumetric flow, opacity and emissions of SO_2, NO_x and CO_2 from each firm. Firms face a fine of $2,000 for every ton of emissions over the permitted amount.

The jury is still out on the success (or otherwise) of the US acid rain permit program. While it has its critics (such as Georgia 1999 or Hartley 1997, p. 6), there are many who argue that it is testimony to the applicability of tradable permits:

Economists have argued for decades that, where the tradable permit approach can be used, it is superior to command-and-control environmental regulation. The US acid rain program appears to prove this argument correct in practice. Not only did Title IV more than achieve the SO2 emissions goal established for Phase I, it did so on time, without extensive litigation, and at costs lower than had been projected (Schmalensee et al. 1998, p. 66).

CONCLUSIONS

Internationally, it is likely that use will be made of both carbon taxes and emission trading schemes for dealing with greenhouse gas emissions. In April 2001, a climate-change levy (CCL) was introduced in Britain aimed at reducing carbon emissions by around five million tonnes a year by 2010 through encouraging the non-domestic sector to become more energy efficient.[14] Only industrial energy use is targeted and the package is fiscally neutral across the whole of British industry. Raising an estimated £1 billion per year, all of which

13 Sulphur dioxide causes acid rain. The original aim of the sulphur dioxide trading scheme was to reduce SO2 emissions by 10 million tons below 1980 levels by 2000.

14 Details of the program can be found at http://www.climate-change-levy.com/ccl.html.

will be recycled through a reduction of 0.3 per cent in the employers national insurance contributions; and by making £150 million available for additional support for energy efficiency measures.

Internationally, the momentum behind emissions trading appears to be greater than that behind carbon taxes. The independent research body, the US Pew Centre on Climate Change, has declared that emissions trading has become the 'policy of choice' for addressing climate change. In a report entitled *The Emerging International Greenhouse Market* (Pew Centre 2002), the authors observed:

> … with the recent agreements in Bonn and Marrakech, with new carbon trading systems in Europe, and with private sector interest and activity across many economic sectors both here and abroad—we are beginning to see the outlines of a genuine greenhouse gas market[15]

A growing number of companies and governments have begun to purchase reductions generated in most part by the programs that offer 'credits' for emission reductions. In Australia, the Commonwealth Bank has advertised its interest in purchasing the rights to all Greenhouse Gas Emission Reductions produced under the Greenhouse Gas Abatement Project.

Internationally, most greenhouse gas trades have taken place 'under a voluntary ad hoc framework involving a commodity defined by the trade's participants and known commonly as verified emissions reductions (VERs)' (Pew Centre 2002). The report points out that these carry only the possibility, but not a guarantee, that governments will allow them to be applied against future emissions reduction requirements. The report estimated that 65 trades of greenhouse gas emissions totalling 50 million to 70 million tonnes have occurred over the past five years and that the emissions reductions traded for between US$0.60 and US$3.50 per tonne of carbon dioxide equivalent.[16]

While some countries have implemented emission trading schemes, there are a number of others with schemes in the pipeline.[17] Denmark launched an emission trading scheme in 2001, and have sold carbon dioxide emission permits to companies in the US and Germany. Britain is also due to introduce an emission trading scheme in April 2002—the world's first national greenhouse gas emissions trading scheme. Under the terms of the voluntary scheme, companies that sign up and reduce emissions will be able to sell their surplus emission allowances to others for whom reducing emission would be more expensive.

15 Report is available at http://www.pewclimate.org/projects/trading.cfm.

16 http://www.planetark.org/dailynewsstory.cfm?newsid=15107&newsdate=21-Mar-2002.

17 For access to papers on the Dutch, Danish, Norwegian and UK schemes see http://www.iea.org/envissu/files/agenda.htm.

> Trading will allow participants to meet their targets at the lowest cost, either by reducing their own emissions or, if it is cheaper, by buying emissions allowances from other participants who have found it worthwhile to beat their targets. Consequently, the scheme will enable environmental targets to be met as cost-effectively as possible.[18]

The European Union (EU) is planning to introduce an EU state-wide, company-based emissions trading system by 2005. The EU scheme will cover only carbon dioxide emission while the British scheme covers all six greenhouse gases. As with the British scheme, under the EU proposal, companies are allocated an allowance to emit carbon dioxide. Those that fall below their ceiling will be able to sell the extra emission rights to those companies which will exceed their limits.[19]

18 Source UK Pre_Budget Report http://www.hm-treasury.gov.uk/Pre_Budget_Report/prebud_pbr01/report/prebud_pbr01_repchap07.cfm

19 For a brief but detailed description see http://www.planetark.org/dailynewsstory.cfm/newsid/12613/story.htm.

chapter 6

CHOOSING THE BEST POLICIES

This chapter discusses the measures to address greenhouse emissions that have been the subject of this report under three headings. These are: measures that improve economic efficiency, while also working to reduce greenhouse emissions (win-win); economy-wide initiatives that, while involving an economic cost, would ensure that the cost of achieving a given level of greenhouse abatement is minimised; and measures that require case by case consideration in terms of their economic and environmental outcomes.

WIN-WIN MEASURES

There is, firstly, a limited set of transport sector measures that have the potential both to reduce greenhouse emissions and improve economic efficiency. In this sense they are 'win-win' measures. Importantly, this does not necessarily mean that there are no losers. But it does mean that the overall gains are such that, in theory, losers could be fully compensated and society would still be better off for the change.

These win-win policies have negative abatement costs. Even if climate change were not an issue, there would still be a strong case for implementing them on the grounds of their efficiency benefits alone. Those discussed in this report include:

- pricing road use to better reflect resource costs, in particular, congestion pricing;
- removing distortions in the demand and supply of parking spaces, such as regulations on minimum parking requirements for new buildings and the undercharging of employer-provided parking spaces;
- reviewing the efficiency and equity case for some fixed costs of car use to be applied on a variable basis (e.g. insurance and registration costs); and
- reductions in passenger motor vehicle tariffs.

For some of these policies, the assertion that they can improve economic efficiency needs to be qualified. They can be implemented in ways that reduce or even reverse the potential efficiency gains, for example, road pricing where the prices imposed are well above marginal social costs with the result that the priced road space is underutilised.

Policies that improve economic efficiency and reduce emissions levels are the top ranking policies and should be considered first for implementation. However, they are unlikely to provide a sufficient level of greenhouse gas abatement in respect of the Kyoto target. That being the case, measures that have positive abatement costs need also to be considered.

ECONOMY-WIDE MEASURES

Two economy-wide measures were reviewed, tradable emissions quotas and carbon taxes. These are the most cost-effective instruments to achieve large cuts in greenhouse emissions levels. They can be applied as tightly as required to produce any desired amount of abatement. The marginal abatement cost is highly transparent, being equal to the permit price or amount of the carbon tax. Individuals and firms everywhere would maximise their economic welfare by not producing any emissions that can be avoided at a cost less than the permit price or carbon tax. So the same marginal abatement cost would apply across and within all sectors of the economy. The situation would not arise where it was costing individuals $60 to save a tonne of carbon dioxide emissions in transport, while the same amount could be saved for $20 by economising on individuals' use of electricity.

In theory — that is, in a world of no taxes or subsidies and prices equated with marginal social costs throughout the economy — these measures would achieve the desired level of abatement at the lowest possible cost. If marginal abatement costs differed between two emitters, the same level of abatement can be achieved at a lower cost by shifting abatement from the high cost abater to the low cost abater. In practice, however, if a carbon tax or permit system were implemented in Australia with, in particular, the existing fuel excise still in place, the marginal abatement costs for the transport sector would be much higher than that for other sectors.

Carbon taxes and tradable permits also have the advantage that they create direct financial incentives to develop and implement new technologies that will reduce emissions.

By way of comparison between the two types of measure, the international experience appears to favour tradable permits over carbon taxes. Carbon taxes have often lapsed into forms of industry assistance, through exemptions and differing industry rates and into sources of general revenue. While the permit experience at this stage is much more limited, the existence of a separate institution in the form of a market for permits appears a more promising basis to avoid industry assistance objectives displacing environmental objectives. The cost of abatement would be set by the market, but would be a function of the quantity of carbon permits that were released. Hence, the abatement cost could be stabilised by the authorities through the purchase and sale of the permits. Defining and enforcing the property rights, particularly if they were to be traded internationally, could still involve significant administrative costs.

TARGETED MEASURES

Other initiatives, which target specific parts of the transport sector, should in all cases be evaluated carefully in terms of their economic and environmental outcomes before being implemented.

This report has raised doubts about the effectiveness of many of the targeted measures in meeting environmental objectives. Where some evaluation has been undertaken with promising results, the question remains as to how transferable these results are beyond the target group and the particular conditions surrounding the trial.

Often ignored when evaluating the benefits of such specific measures is the 'induced traffic effect' caused by pent-up demand for private mobility. Measures that have shifted cars off roads create spare capacity that is filled by new travellers. Some measures can even have negative environmental effects, for example, converting existing lanes into high occupancy vehicle lanes, increasing congestion in the other lanes or roads. It is doubtful that targeted measures alone, even a large number implemented in unison, can engender a level of abatement of the size that may be sought.

INTEGRATED STRATEGIES

It has been argued that by combining a number of targeted measures into an 'integrated strategy', a greater level of carbon dioxide reductions can be achieved than the sum of the reductions for each measure in the package were each to be implemented in isolation: in other words, that the whole is greater than the sum of its parts.

While there are clear advantages in integrated, coordinated policies that reinforce each other, such symbiosis cannot be automatically assumed. In some cases the whole may be less than the sum of its parts. For example, this report has discussed targeted policy measures in terms of those that reduce VKT and those that reduce emissions per VKT. To the extent that the policies to reduce VKT are successful, there are fewer VKT on which to make savings from policies that lower emissions per VKT.

In other cases, measures will be complementary. For example, if public transport, cycling and walking in an urban area are made more attractive so that they become better substitutes for car travel in the eyes of commuters, policies to discourage car travel may become more effective. They also increase the options available to commuters, raising the effectiveness of personalised journey planning techniques. Even the effectiveness of the economy-wide measures can be increased (or, for the same level of abatement, the costs reduced) with a higher cross-elasticity between car travel and less energy-intensive means of transport.

The staggered introduction of various measures would enable a more accurate assessment of both the impact of each measure and the viability of extra measures. For instance, the introduction of congestion charging would lead to some mode shift and, over the longer term, a change in location patterns.

This report has cast doubt on the effectiveness in reducing emissions of many specifically targeted policies. Combining a number of ineffective measures into an integrated strategy will not create an effective policy. For example, the gains from synergies between measures are also subject to erosion by the induced traffic effect. Just as the environmental benefits from measures implemented in isolation can be evaluated, so also can the effects of integrated strategies.

CONCLUSIONS

Actions taken to bring about major reductions in greenhouse gas emissions will inevitably impose economic costs, at least in the short run, as people are forced to make less desirable consumption choices and to suffer cuts in living standards. However, society as a whole will benefit from greenhouse measures that have negative marginal abatement costs. The most significant of these measures that improve economic efficiency while, at the same time, yielding environmental benefits would be road traffic congestion pricing.

For further emission reductions, economy-wide measures such as carbon taxes or tradable permits would provide the least cost alternative. Properly implemented, these measures act to minimise the total cost to society, by ensuring that the least-cost abatement activity is undertaken before the higher cost. For a given cost, the maximum level of abatement is achieved by ensuring that the marginal abatement cost is equalised across the economy.

Finally, there is a wide range of policy alternatives that target parts of the transport sector. In many cases, these measures attempt to replicate the outcome that would be expected if more accurate price signals applied to private urban transport. These initiatives need to be considered on a case-by-case basis, looking at all their environmental effects and, crucially also, at their economic costs and benefits. In view of the induced traffic effect and other factors, the impact of many of these measures on emissions is, in many cases, much smaller than might be first thought.

appendix 1

TERMS OF REFERENCE

The ATC, on instruction from COAG, hereby refers the study of economic instruments and transport to the Bureau of Transport Economics (BTE). The BTE will have a draft report ready for circulation by 31 January 2000 and the final report by 30 June 2000.

There will be an independent review of the BTE's report. The reviewer will prepare a separate report for the ATC.

Background

The National Greenhouse Strategy (NGS) was released in November 1998 following agreement by the Commonwealth, State and Territory Governments. Under module 5 of the NGS, the Australian Transport Council (ATC) is responsible for the delivery of nine transport measures. The measures are national in scope and require coordinated delivery across jurisdictions. One of the measures relates to economic instruments and transport. This study will examine economic policy instruments relating to transport (incentives and disincentives) to ensure that they are consistent with fiscal, economic and environmental objectives, including greenhouse objectives.

Scope of the reference

In undertaking this study, the BTE is to:

a) Review economic policy instruments relating to transport used in selected overseas countries and evaluate their performance from available literature.

b) Review economic policy instruments relating to transport adopted by Australian jurisdictions and evaluate their performance from information available.

c) Consider modifications to existing policy instruments and identify untried instruments that are potentially applicable.

d) Assess whether currently adopted and potentially applicable economic policy instruments for reducing greenhouse gas emissions by transport are consistent with the fiscal, economic, and environmental objectives of governments. In specifying the fiscal, economic, and environmental objectives to use as benchmarks for the assessment, the BTE will be guided by advice from relevant Commonwealth and State agencies.

e) Identify priority economic policy instruments for reducing greenhouse gas emissions by transport that meet fiscal, economic, and environmental objectives.

appendix 2

INSTRUMENTS USED IN OTHER COUNTRIES

Environmental policy at both the international and domestic levels has traditionally been dominated by regulation and moral suasion. In recent times, however, there has been an increased recognition of the contribution of economic instruments.

This appendix provides an overview of the instruments by country of use in alphabetical order. It is difficult to ensure that it is current as policies are constantly changing. Hence the list should be regarded as illustrative rather than comprehensive. Useful sources included ECMT (1997); Baron (1996); IEA (1997a); OECD (1997) and an extensive World Wide Web search. In October 2001, the OECD released a report detailing more than 200 new policies and measures that were taken in the year 2000 to address energy-related emissions in IEA member countries. In the report, *Dealing with Climate Change: Policies and Measures in IEA Member Countries* (2001 Edition), actions are listed under five major headings: fiscal policy, tradable permits, regulatory instruments and voluntary approaches, R&D policy, and policy processes. In addition, policies are classified according to energy source and end-use.[1]

CANADA

- A voluntary tradable permit scheme for NO_x and VOCs is operating in Ontario aimed at reducing smog in the Windsor–Quebec corridor;
- Tradable permits exist for ozone depleting substances (ODS);
- Various financial incentives are provided to encourage the development of the natural gas vehicle market. For example, $500 is provided for vehicle conversion, $1,000 towards the purchase of a new natural gas vehicle and $50,000 for each new vehicle refuelling station.
- Alternative-fuelled vehicles are exempt from 10 cent federal excise; and
- Elimination of federal excise tax of 8.5 cent per litre on the alcohol proportion of petrol-ethanol and petrol-ethanol to encourage use of alternative fuels. Market share for alternative fuels is currently 2 per cent in Canada.

1 For more detail see http://electrade.gfi.fr/cgi-bin/OECDBookShop.storefront/EN/product/612001321P1?affiliate=oecddirect.

- As of 2000 there were 19 toll facilities in Canada and four more under consideration.

Regulation

- A 'Corporate Average Fuel Consumption' (CAFC) standard of 8.6 litres per 100 kilometres for cars and 11.5 litres per 100 kilometres for light trucks;
- Mandated volatility limits and oxygenation standards;
- Voluntary agreements undertaken between the Canadian Government and individual vehicle manufacturers concerning fuel efficiency of new vehicles;
- Publication of *Fuel Consumption Guide*;
- Labelling system to provide consumers with information on individual vehicles;
- Training initiatives to promote environmentally friendly driving techniques; and
- Fleet energy programs designed to promote use of alternative fuels and energy saving measures in public and commercial vehicle fleets, mainly through education and training.

CZECH REPUBLIC

- Taxes on particulates, SO_2, NO_x, CO, VOC, toxic substances, and freons from large and medium sources.

DENMARK

Background

- Under the Kyoto Protocol, Denmark agreed to adopt the target of reducing greenhouse gas emissions to eight per cent below 1990 levels by the first commitment period, 2008–2012. As part of the European Union's internal burden sharing arrangements, Denmark negotiated to further reduce emissions to 79 per cent of its 1990 levels by the first commitment period;
- Currently, the Danish transport sector contributes approximately 20 per cent of the total Danish CO_2 emissions from the energy consuming sectors;
- The major goal of Danish policy is to reach an average fuel efficiency of 5 litres per 100 kilometres for gasoline-fuelled cars and 4.5 litres per 100 kilometres for diesel-fuelled cars by the early part of next century;

- Tradable permits in CO_2 emissions from power plants scheduled to be introduced in 2000;
- Carbon tax on energy from non-renewable sources except for petrol and natural gas. The exemption of petrol from the carbon tax markedly limits its impact on the transport sector;
- Fiscal reforms implemented in 1993 allow for real increases in fuel taxes, modifications in tax structure for goods vehicles and small lorries;
- A 'green user fee' is applied annually to every car, set to encourage the use of more fuel efficient cars;
- Subsidies to cover additional costs associated with the purchase of environmentally friendly buses; and
- Infrastructure investment designed to strengthen railway system and synergies between road and rail.

FINLAND

Background

In the 26 years to 1996 CO_2 emissions in Finland from motor vehicles have decreased. CO_2 emissions from all sources have remained stable. Finland's target under the Kyoto Protocol is to reduce emissions to eight per cent below 1990 levels by 2008–2012. As part of the EU's internal burden sharing arrangements, Finland has negotiated to not increase emissions by more than 1990 levels by 2008–2012;

- Carbon tax applied to all forms of energy. The carbon tax is levied per ton of CO_2. This translates to about FIM 0.13 (AU$0.03) per litre (as of 1996);
- A fuel tax of approximately FIM 3.00 (AU$0.75) per litre for petrol and FIM 1.50 (AU$0.38) per litre for diesel. A lower level of fuel tax is applied to unleaded reformulated petrol and non-sulphur diesel. This has resulted in the market share of these fuels increasing to 90 per cent of total consumption;
- Reduced VAT for public transport tickets (valued added tax applied at six per cent. Normal rate is 22 per cent);
- Taxation designed to favour more fuel-efficient cars;
- Reduced tax deductions for business travel expenses;
- Mandatory vehicle inspections with minimum emissions requirements;
- Zero lead standards;
- Investment in electric railways;
- Privatisation of railways to improve efficiency;
- Development of high-speed passenger train connections to make public transport more attractive; and

- Sectoral planning re-organisation to account for transport in land-use planning.

JAPAN

Background

CO_2 emissions resulting from the Japanese transport sector have risen steadily and currently account for roughly 19 per cent of Japan's total CO_2 emissions output. Under the Kyoto Protocol Japan has agreed to reduce emissions to six per cent below 1990 levels by 2008–2012;

- Low emissions vehicles (CNG-fuelled vehicles, hybrid engine and methanol-fuelled vehicles) attract a lower automotive sales tax as well as lower annual automobile ownership taxes and acquisition tax;
- The systems that supply alternative fuels also receive favourable tax treatment;
- Subsidies are provided to local public organisations or private companies that introduce electric, natural gas or other low-emission vehicles and systems that supply fuel for these vehicles;
- Subsidies are provided to petrol stations that fuel supply equipment for electric, CNG and methanol-fuelled vehicles along with conventional fuel pumps;
- Fiscal incentives facilitate the introduction of energy efficient technology in ships;
- Fiscal incentives are provided to encourage use of shipping and rail over road for freight transport, with special tax rates and concessionary loans to assist in improving facilities for cargo handling, storage and stevedoring;
- Standards are set for vehicle efficiency improvements and regulations mandate that manufacturers indicate energy efficiency. Under current standards for passenger cars, vehicle manufacturers must realise an average improvement of 8.5 per cent over 1992 efficiency levels by 2000. For gasoline fuelled trucks an average improvement of 4.8 to 5.8 per cent over 1993 results must be realised by 2003;
- Inspection/maintenance programs operate for motor vehicles;
- Zero lead standards mandated;
- Different fuel efficiency targets for different classes of vehicles have been adopted (mini cars: 19 km/L by 2000; small cars: 13 km/L by 2000; standard size: 9.1 km/L by 2000; Light trucks: 9.5-16.5 km/L by 2000. It is estimated that this measure will lead to an 8.5 per cent improvement in fuel economy 1992–2000;
- Technological progress is being made in the development and introduction of direct-injection gasoline engines, lean burn engines and other energy efficient engines. Efforts are also being made to introduce energy-efficient equipment in trains, ships and planes;

- Improved traffic management through new bus lanes, automatic signalling and control systems for illegal parking;
- Interest free loans for the construction of freight terminal facilities designed to facilitate longer container trains and yield economies of scale;
- Domestic Inter-modal Transport Terminals are being built to increase the efficiency of the transport network. Efficiency is also enhanced through the provisions of roll-on/roll-off facilities and international container ship terminals in strategic locations to minimise overland transport distances and
- No car zones, dedicated bus lanes (Tokyo).

SINGAPORE

- The Area Licensing Scheme: road pricing aimed at reducing congestion in the CBD. Drivers were required to purchase windscreen stickers on entering the zone. The program was so successful that it was extended and replaced with an electronic road pricing system;
- The weekend Car Scheme: owners of cars under the scheme can normally only drive on weekends. Participants receive a rebate on vehicle registration fees and import duty. Day licences can be purchased to operate cars during the week;
- A vehicle quota system requires that new vehicle buyers have to bid for quota allocations in a monthly public auction. On average, taxes on new cars increase the price of a S$29,103 duty free vehicle to S$266,28 (Clarke & San 1998, p. 57);
- Road taxes that increase with vehicle engine size to encourage smaller, more efficient vehicles.
- Financial incentives are provided to encourage scrapping of older, less efficient vehicles;
- Staggered work hours; and
- Car pooling incentives.

SWEDEN

Background

- Under the Kyoto Protocol, Sweden agreed to adopt the target of reducing greenhouse gas emissions to 8 per cent below 1990 levels by the first commitment period, 2008–2012. As part of the European Union's internal burden sharing arrangements, Sweden has negotiated to increase emissions by 4 per cent above 1990 levels by the first commitment period, provided that the EU meets its 8 per cent reduction target as a whole;

- Over the period 1990–1995, CO_2 emissions resulting from the Swedish transport sector (not including construction equipment) increased by 8 per cent. Over this same period CO_2 emissions resulting from road transport increased by 1.7 per cent;
- In terms of CO_2 emissions per capita, Sweden is 37 per cent below the OECD average, emitting approximately 6.2 Kt CO_2 per person per year;
- Carbon tax of SKr 0.86 per litre (A$ 0.15) for petrol and SKr 1.05 per litre (A$ 0.18) for diesel (implemented 1991);
- General environmental and energy tax of approximately SKr 3.3 per litre (A$ 0.57) for petrol and SKr 2.0 per litre (A$ 0.35) for diesel. Tax rates have increased from 1990 levels. Tax rates are differentiated between different fuel grades to encourage the use of cleaner vehicles and less polluting fuels;
- A value added tax of 25 per cent levied on petrol (implemented 1990);
- Tax rebates offered on vehicles with low emissions;
- Taxes on company cars structured such that individuals pay more of the variable cost component of car ownership – to discourage car usage;
- A kilometre-based tax on diesel powered trucks, cars and buses was abandoned in late 1993 (due to administrative reasons compounded by the fact that EU does not allow border controls);

- A system of environmental classification of cars was introduced in 1992 aimed at encouraging better emissions control technology and increasing demand for cars with low emissions. The environmental classes include requirements on emissions of carbon dioxide, hydrocarbons, nitrogen oxides and particulates for three groups of passenger cars, light goods vehicles and heavy goods vehicles. The proportion of environmentally classified passenger cars increased from 11 per cent in 1992 to 60 per cent in 1996;
- Mandated volatility limits and oxygenation standards for fuel;
- Volvo committed to reducing its fleet average fuel consumption of cars sold in the EU by 25 per cent below 1990 levels by 2005;
- Agreement reached (1996) between the National Maritime Administration, the Swedish Shipowners Association and the Swedish Port and Stevedoring Association on the installation of catalytic converters on ships for the limitation of nitrogen oxides and on the use of low-sulphur oil;
- SKr 500 million (AUD 87) spent from 1993–1996 on programs to improve the organisation and operation of the transport system, aimed at promoting a more ‘energy-efficient, climate-friendly transport structure’; and
- Retrofitting catalytic converters.

SWITZERLAND

- A system of tradable permits for VOCs and NO_x operates on a small scale;
- Taxes on landing aircraft for NO_x and VOC emissions (used to finance anti-pollution measures around airports);
- A one-off increase in fuel prices in 1993 to bring Switzerland in line with other EU countries;
- Mandatory speed limitation devices for heavy vehicles;
- Certain vehicles are subject to mandatory inspection and maintenance;
- Regulations requiring a reduction in average fuel consumption of new cars of 3.2 per cent per year between 1996 and 2001; and
- Information campaigns to encourage urban traffic management, car-pooling and environmentally-friendly driving.

THE NETHERLANDS

A Dutch aid scheme for reducing greenhouse gas emissions in the field of transport was approved by the European Commission in July 2001. The draft regulation from the Dutch Minister for Transport and Public Works provides for non-refundable grants for investment, information, consultancy, training and demonstration projects to reduce CO_2 emissions in the field of transport.

The following are examples of the types of activities which may be supported:

- fitting devices to check that vehicle engine speed is the optimum for energy saving;
- publicity campaigns directed at employers, promoting carpooling among employees;
- training heavy goods vehicle drivers in fuel-saving driving techniques.

The aid scheme has been allocated a budget of EUR 36 million (approximately A$58 million) and should remain in force until the end of 2007.[2]

UNITED KINGDOM

Background

As part of the European Union's internal burden sharing arrangements, the United Kingdom agreed to a target of a 12.5 per cent cut in greenhouse gas emissions (from its 1990 levels) by 2010. The Government then set a separate

2 Source: http://europa.eu.int/rapid/start/cgi/guesten.ksh?p_action.gettxt=gt&doc=IP/01/935|0|RAPID&lg=EN#file.tmp_Ref_1.

goal of a reduction in CO_2 emissions by 20 per cent below 1990 levels by 2010. The UK's greenhouse gas emissions are on a downward trend at the moment due mainly to the deregulation and liberalisation of the energy markets in the 1990s which resulted in a shift from carbon intensive fuels such as coal towards gas and nuclear energy.

As of October 1998, the transport sector accounted for 23 per cent of total carbon dioxide emissions, of which 85 per cent came from road traffic.[3] Emissions from the transport sector are estimated to increase around 5 per cent above 1990 levels by 2000.

Fuel duty strategy: introduced in 1993, the fuel duty strategy has been the main tool for reducing emissions from road transport. This initially involved a commitment by the Government to raise fuel duty by using a price escalator of at least 5 per cent a year on average in real terms. In the 1998 Budget this was increased to 6 per cent per year in real terms. This is designed to encourage car manufacturers to produce more fuel-efficient vehicles and drivers to invest in maintenance and adopt more efficient driving habits. Since its introduction, fuel duty has experienced real annual increases, on average, of 6.75 per cent for unleaded petrol, 7.75 per cent for leaded petrol and 8.25 per cent for diesel. The fuel duty 'escalator' was withdrawn (probably due to intense public opposition) in November 1999 and replaced with a policy of annual reviews of fuel prices.

Budget 99 announced the Government's intention to introduce a tax (Climate Change Levy) on the industrial and commercial use of energy with effect from April 2001[4]. The levy was aimed at cutting CO_2 emissions by 2.2 million tonnes per year, with no overall increase in the burden of taxation on business. The revenues raised would be recycled to business through a cut of 0.5 percentage points in the main rate of employer National Insurance contributions and additional support for energy efficiency schemes and renewable sources of energy.[5] Despite this, the levy has met intense opposition from industry, claiming that it would cost a total of 155,000 jobs and result in an output loss of £11.4b. While the Government explored the option of structuring the levy so that it reflected the *carbon content* of different fuels, it was decided to use the *energy content* of fuels as the basis of the levy. It was anticipated that the levy would be introduced at the differential rate of 0.6 pence per kilowatt hour on electricity and equivalent to 0.21 pence per kilowatt hour on gas and coal to industry. The Government foreshadowed that it intended to set significantly lower rates for energy intensive firms that agree to targets for improving their

3 UK Department of the Environment, Transport and the Regions, UK Climate Change Programme – a consultation paper.

4 For more details see http://www.hmce.gov.uk/bus/excise/climchg.htm.

5 Draft Regulatory Impact Statement available at http://www.hmce.gov.uk/notices/ccl-ria.htm.

energy efficiency in accordance with the Government's criteria. The Government did not propose to extend the levy to energy used for powering public transport. The levy would not be imposed on road fuels (petrol, diesel, CNG, LPG) or aviation kerosene (AVTUR) and AVGAS or on the domestic use energy.

- A vehicle excise duty (VED) which was previously applied at the same rate for all cars is now applied at two separate rates. For existing cars, there will be a lower rate for those with smaller engines. For new cars the VED will be varied according to CO_2 emissions. Company car taxation will be based on CO_2 emissions from 2002, to encourage drivers to choose more fuel efficient vehicles. More than half the new cars in the UK are bought for business drivers;
- The Government is in the process of developing, in collaboration with business, a domestic emission-trading scheme;
- Support for rail over other modes is provided through 'targeted support for rail freight' through the freight facilities grant and the 1993 track access grant;
- Fuel duty rebate for bus operators to encourage greater use of public transport;
- Stricter vehicle emission standards introduced, including the fitting of catalytic converters to passenger cars;
- A voluntary target of 140 grams of emissions per kilometre by 2010;
- A Greener Monitoring Forum aims 'to coordinate voluntary initiatives between the public, private and voluntary sectors'. Activities include the 'Tune Your Car' campaign and the publication of environmental information on new cars;
- The Government is involved in a two-year trial to assess the viability of alternative fuels (CNG, LPG, electricity and biodiesel). Includes information on costs and emissions in real operating conditions;
- A congestion-charging scheme for Greater London, scheduled for introduction in 2002. For the first 10 years, funds raised will be invested in public transport;
- Government is continuing to develop innovative transport measures, such as road-user charging and workplace parking levies;
- A general policy of liberalisation and privatisation designed to improve the efficiency and scope of public transport network and, by improving efficiency, lead to a reduction in greenhouse emissions;
- A new integrated transport policy that, it is argued, will deliver a better quality transport system with lower CO_2 emissions;
- Commission of Integrated Transport;
- Road Traffic Reductions (National Targets) Act 1998;

- Department of Environment and Freight Transport Association published a guide to fuel consumption in freight haulage fleets with the aim of offering practical guidance on how companies can improve fuel efficiency;
- Initiatives such as 'TravelWise, Don't Choke Britain' and the Association of Commuter Transport (ACT) aimed at challenging people to change their values and lifestyles. The ACT originated in the United States and it encourages businesses to make travel plans for their employees' journey to work;
- 'Are you doing your bit?' is a £25 million government funded publicity campaign aimed at encouraging the public to cut down on their energy use;
- Government is working with leading UK businesses to encourage them to report publicly on the action that they are taking to improve their efficiency;
- Planning guidance is provided to local authorities concerning issues such as speed limits designed to optimise safety and vehicle efficiency. Consideration is currently being given to reducing speed limits on rural roads from 60 miles per hour to 50 miles per hour;
- Additional funding for local authorities (£700 million over three years) to develop integrated transport systems along with new powers for road user charging and the workplace parking levy. As an added incentive authorities which introduce pilot schemes using the new powers will be able to keep all the revenue to use on transport improvements for at least the first 10 years; and
- The United Kingdom actively supports proposals to end the current tax exemptions for international aviation fuel. It is working within the International Civil Aviation Organisation to try to achieve this end;

The following measures were announced in a pre-budget report in November 2000:

- A freeze in duties on fuel until April 2002;
- 2p-a-litre cut in excise duties on ultra-low sulphur petrol from (spring) Budget day 2001, to add to a 1p cut in tax on the fuel introduced on 1 October 2000;
- Fund for scrapping or converting older lorries;
- 'BritDisc' system to charge overseas trucks for using British roads;
- Abolish vehicle excise duty on tractors;
- The lower rate of vehicle excise duty on smaller cars has been extended from those under 1200cc to those up to 1500cc, an additional five million drivers a £55 discount;
- Vehicle excise duty rate for lorries will be cut, giving the average lorry driver a saving of £715 a year;

- The 100 separate rates of vehicle excise duty for lorries to be replaced by seven bands;
- The DTLR sponsored TransportAction *PowerShift* program providing grants to motorists to cover the cost of converting their vehicles to use clean, low-duty Liquefied Petroleum Gas (LPG).[6]
- Greenhouse gas emissions trading scheme introduced in April 2002.

UNITED STATES

Background

The US accounts for most applications of tradable permits, with two major schemes currently running for air quality management: the Acid Rain Trading Scheme and the Californian RECLAIM scheme (facilitating trades in NO_X and SO_2)

- Federal income tax deductions for alternative-fuelled vehicles. For example, up to US$2,000 for 'clean fuel' cars, US$5,000 for light commercial vehicles, US$50,000 for heavy trucks and buses, US$100,000 for refuelling stations/equipment and up to US$4,000 for electric vehicles;
- A number of states also offer further vehicle tax deductions, rebates or credits for environmentally friendly vehicles.
- A 'Gas Guzzler' tax of US$1,000 – US$7,700 levied at an increasing rate for cars with a fuel efficiency of less than 22.5 miles per gallon (12.85 L/100 km).
- Reform of federal tax subsidy for employer parking (US$65 per month per space) such that employees can choose between US$65 per month extra in taxable income or the parking space. Designed to encourage use of public transport and car-pooling and so on for commuting.
- Mandated standards for catalytic converters, crankcase emissions, oxygenation and volatility limits. The setting of emissions standards eliminated 2-stroke motorcycles;
- Random inspection of cars and LCVs in areas that do not meet federal minimum air quality standards. Vehicles must meet certain minimum performance standards (determined at a state level depending on air quality);
- Corporate Average Fuel Efficiency (CAFE) standards: The standard for passenger cars is currently 27.5 miles per gallon and for light trucks is 20.7 miles per gallon;
- Transport conformity rule designed to ensure that state clean air implementation plans are consistent with state transport infrastructure plans.

6 For more details see http://www.press.dtlr.gov.uk/0110/0421.htm.

- Fuel economy labels for new cars. The current label provides fuel economy and fuel cost estimates for a given vehicle as well as the range of fuel economy ratings for other new vehicle models in the same class size;
- Fuel economy guide published annually by the US Department of Energy. Provides information to consumers on fuel economy and fuel cost estimates of new vehicles. All US vehicle dealers are required to 'prominently display' a copy of the guide.
- Combined research between the US Government and US Council for Automotive Research aimed at improving vehicle fuel efficiency. For example, efforts are currently being made to design a vehicle of up to triple the fuel efficiency of today's vehicles;
- Government pilot of a 'telecommuting' program.
- Some states have experimented with congestion pricing programs;
- Car-pooling incentives.

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abbreviations

ARI	Apogee Research International Ltd
AAA	Australian Automobile Association
ABC	Australasian Bus Company
ADO	Automotive diesel oil
AGO	Australian Greenhouse Office
AIP	Australian Institute of Petroleum
APTA	American Public Transportation Association
ARA	Australasian Railway Association
ATN	Australasian Transport News
BATLUC	Bay Area Transportation and Land Use Coalition
BTCE	Bureau of Transport and Communications Economics
BTE	Bureau of Transport Economics
BTRE	Bureau of Transport and Regional Economics
BTS	Bureau of Transportation Statistics (US)
CER	Community of European Railways
CCWA	Conservation Council of Western Australia
CfIT	Commission for Integrated Transport (UK)
CUPID	Coordinating Urban Pricing Integrated Demonstrations
DOT	Department of Transportation (US)
DEP	Department of Environmental Protection (WA)
DIER	Department of Infrastructure, Energy and Resources (Tas)
DETR	Department of the Environment, Transport and the Regions (UK)
DTLR	Department for Transport, Local Government and the Regions (UK)
DOTRS	Department of Transport and Regional Services
EC	European Commission
EEA	European Environment Agency
ERC	Economic Research Centre
ERP	Electronic road pricing
EU	European Union
EVA	Austrian Energy Agency (Energieverwertungsagentur)
FHWA	Federal Highway Administration (US)
FTI	Fuel Tax Inquiry
GAO	General Accounting Office (US)

IAC	Industries Assistance Commission
IC	Industry Commission
ICLEI	International Council for Local Environmental Initiatives
IEA	International Energy Agency
IEE	Institute of Electrical Engineers (UK)
IPART	Independent Pricing and Regulation Tribunal of NSW
LRTA	Light Rail Transit Association (US)
NBER	National Bureau of Economic Research (US)
NCC	National Competition Council
NREL	National Renewable Energy Laboratory
NRTC	National Road Transport Commission
OECD	Organisation for Economic Cooperation and Development
ORR	Office of the Rail Regulator (UK)
PC	Productivity Commission
PMT	Passenger miles travelled
PSRC	Puget Sound Regional Council (US)
RAC	Railway Association of Canada
RPPI	Reason Public Policy Institute
RTPI	Real-time passenger information systems
SACTRA	Standing Advisory Committee on Trunk Road Assessment (UK)
SEDD	Scottish Executive Development Department
STPP	Surface Transportation Policy Project
TRB	Transportation Research Board (US)
TTI	Traffic Technology International
TTNCCP	Transportation Table National Climate Change Process (Canada)
TTP	Transport Technology Publishing
UIC	International Union of Railways
UITP	International Association of Public Transport (Union Internationale des Transports Publics)
VMT	Vehicle miles travelled
VTPI	Victoria Transport Policy Institute
WAPC	Western Australia Planning Commission
WRI	World Resources Institute