Transport & Greenhouse - Do the Users Know What They Want?

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Abstract:

In Australia roughly one-third of man-made greenhouse gas emissions are a result of transport activity (the remaining two-thirds is split approximately equally between electricity generation and commercial/industry uses). Various groups and individuals have proposed, often with quantification of their impact and effect, measures that will reduce the level of transport emissions

This paper examines a broad range of strategies, including the provision of better public transport services, the encouragement of alternative modes of travel making better use of the existing transport resources, more fuel efficient vehicles, alternative vehicle taxing schemes, changes to urban structure and the role of technology, that could be introduced to reduce the greenhouse emissions from transport activity. It attempts to quantify their impact and assess the costs and benefits to Government and the public. The research demonstrates the most popular "solutions" are amongst the most costly and least effective.

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Introduction

There is still considerable debate about the impact of the 'Greenhouse effect' on Australia, its timing and its consequences.

However in October 1990 the Australian Government announced its adoption of an interim planning target to stablise emissions of greenhouse gases at 1988 level by the year 2000 and to reduce emissions by 20% by 2005 (the Toronto goal). This decision was conditional on the avoidance of measures which have net adverse economic impacts nationally or which affect Australia's trade competitiveness in the absence of similar actions by major greenhouse gas producing nations.

In November 1990 the South Australian Government announced its endorsement of the Commonwealth target, subject to the same conditions. However, achieving a 20% reduction in emissions in South Australia by 2005 will not be an easy task, particularly in the transport sector.

One third of man-made carbon dioxide emissions in South Australia comes from transport. 80% of this is produced from road transport of which 60% comes from private cars and 30% from freight vehicles. 70% of car emissions and 50% of freight vehicle emissions are produced in Adelaide. In addition, a continuation of present trends of urban expansion, declining use of public transport and reduced level of vehicle occupancy sees total annual vehicle-km in South Australia increasing by over 40% by the year 2005.

This paper examines a broad range of strategies that could be introduced in South Australia to reduce greenhouse emissions from transport activity. The strategies are placed in three groups - the popular solution, the low cost options, and those strategies that require major changes, technological developments or major investment. It shows that the most popular 'solutions' are amongst the most costly and least effective.

Popular Solutions

Public Transport

As presently operated, public transport is geared to cater for peak demands. During the peak period load factors on vehicles exceed 100%. Considerable investment in new vehicles, vehicles that would only be used for a small proportion of the day, is therefore needed if public transport is to increase its market share during peak periods. In addition, the continuing low density expansion and dispersal of residential, commercial and industrial activities in Adelaide makes the provision of public transport at an affordable price to the user and governments increasingly difficult.

Given an adequate number of vehicles, for public transport to compete with and increase its market share it must offer equivalent convenience and better journey times than cars.

During the off-peak it is difficult for buses to equal car travel times, because buses must stop frequently to load and unload passengers while cars proceed relatively unhindered. In congested peak period conditions the travel time on buses can be competitive provided the buses are assisted by priority schemes that minimise traffic induced delays.

Bus priority improvements range from low cost easily implemented arrangements through to high cost treatments which require several years for planning, design and construction.

Low cost bus priority improvements include the repositioning of bus stops, on-street parking controls, changes to pavement markings and traffic signs, special turn lanes, adjustments to traffic signal phasing to better respond to the operational characteristics of buses, the use of short bus only lanes to assist in queue-jumping at traffic signals, and transit or exclusive bus lanes along existing roads. The most beneficial as far as bus operations is concerned are exclusive bus ways but, because exclusive lanes take road space from other users, they are usually only considered in corridors with significant bus movement and high levels of traffic congestion. High occupancy vehicle lanes may confer wider travel behavioural effects than bus lanes in certain instances because they also encourage the use of high occupancy private cars and taxis.

Exclusive busways are particularly applicable to trunk and express services and may allow very high speed operation of the buses operating on them. Given their high cost, high travel demands and frequent services are needed to justify their introduction.

Operating constraints which inhibit the maximum potential benefits from transit lanes, bus lanes and busways can occur if they have not been adequately planned for in preliminary road planning and transport reservations. There is therefore the need to recognise at an early stage the requirement for integrated road and traffic management which takes into account the needs of public transport.

Substituting public transport trips for trips made by private car is often propounded as the panacea for the Greenhouse effect problem. There is no doubt that a transfer of trips from private to public transport will have some impact on both greenhouse gas emissions and urban congestion, but the proportion of trips that transfer from private to public transport, or their environmental effect, should not be exaggerated.

The modal split for trips in Adelaide is presently about 90% private car and 10% public transport. A transfer of only 10% of car trips to public transport therefore almost doubles the number of public transport trips.

The difficulties and cost of even a 10% transfer is considerable. The vehicle fleet would need to be doubled (700 buses at $0.3 million each, 150 diesel railcars at $2 million each and 20 trams at $1 million each - a $1/2 billion investment) and operating deficits would double to about $300 million per year. The size of even the present public transport deficit is of serious concern.

In addition, public transport, by its very nature, caters predominantly for high capacity radial trips - trips from the suburbs to City centre. In Adelaide 9% of all weekday trips are made to the City centre and 36% of these are by public transport; 11% of all work trips are made to the City with 54% of these by public transport. Public transport therefore already makes a very important contribution to meeting radial trip needs. It is difficult to see how these levels could be increased substantially without major, and perhaps unpopular, private vehicle restriction measures (parking controls, control by congestion, cordon areas) or major changes in urban structure and job location.

Despite its high cost, a transfer of 10% of car trips to public transport would reduce road transport carbon dioxide emissions by less than 4%.

Electrified Public Transport

Several studies have indicated that the electrification of neither the bus nor the rail system in Adelaide can be economically justified. In addition, public transport fuel use and levels of greenhouse gas emissions are almost insignificant when compared to that produced by other road users, and the electricity that would be used in any electrification scheme would still be generated by burning fossil fuels. The greenhouse gas emissions would only be removed elsewhere. Electrification of Adelaide's urban rail network would only reduce the carbon dioxide emissions from transport by 2%.

Freight Movement

Interstate freight represents only about 4% of the total South Australian freight transport task. On the interstate routes, rail carries 31% of the Adelaide to Melbourne freight, 25% of the freight to Sydney, and 35 and 65% of interstate freight to Brisbane and Perth respectively.

Within South Australia, 96% of all road freight moving within South Australia has an average road haul length of less than 60km.

These figures have three main implications. Firstly, the freight task is predominantly produce to market and urban distribution. Secondly, the majority of intrastate trips are unsuited to rail movement. Thirdly, a substantial proportion of interstate freight is moved by rail but, because it represents such a small proportion of the total freight task, transferring additional freight from road to rail would have very little effect on total fuel consumption and greenhouse gas emissions.

If 10% of all rural road freight was transferred to rail, carbon dioxide emissions from transport would be reduced by less than 1%. Despite this, where it is cost effective there are environmental benefits in transferring long distance freight from road to rail. For road freight, improving overall efficiency by encouraging fuel efficient vehicles and driving techniques, loading to maximum capacity and utilising back loading capacity would have a positive impact, though this is hard to quantify. Some form of electronic brokerage might help maximise the use of vehicle capacity.

Low Cost Options

Fuel Efficient Driving Techniques

Basic driver training and examination concentrates on the acquisition of physical skills to control a motor vehicle and acquiring a knowledge of road rules and regulations. More advanced driver training concentrates on accident avoidance.

In most instruction programs, driving a vehicle in a fuel efficient way is ignored, despite evidence that the fuel efficiency of two drivers driving at the same speed can vary by up to 20%. Studies of commercial vehicle fleets also show that if the worst drivers were brought up to the level of the average, fuel efficiency within fleets would improve by at least 7%.

An education campaign aimed at promoting fuel efficient driving techniques and practical training sessions would be beneficial. A knowledge of fuel efficient driving techniques could also be made an essential pre-requisite for obtaining a learner's permit or a driver's licence.

As well as the general public, the education and training campaigns should be targeted at fleet operators where financial savings would provide an incentive for them to participate in a conservation program.

It is difficult to quantify the exact savings in fuel consumption and consequent reduction in greenhouse gas emissions that would result, though if fuel consumption was reduced by 15% because of driver education, carbon dioxide emissions from road transport would be reduced by about 15%.

Fuel Consumption Rating

The Department of Primary Industries and Energy publishes a booklet giving details of the fuel consumption for cars sold in Australia.

This could be extended to compulsory labelling of vehicles. The label could show, for example, the fuel consumption of the vehicle for the standard urban and rural driving cycle, how it compares with the most efficient vehicle in its class with the same engine size, and how it compares with the average vehicle of the same engine size. Greenhouse 'impact rating' could also be shown.

This option is relatively cheap and easy to implement and provides the consumer with information about what the market provides. With this information buyers might choose more efficient vehicles, which could result in an overall increase in the efficiency of the total vehicle fleet, and would provide an incentive for vehicle manufacturers to improve fuel efficiency.

If this measure caused the fuel consumption of the vehicle fleet to improve at the rate of 1% per year, by 2005 the total carbon dioxide emissions from road transport would be 10% less than if this measure was not introduced.

Vehicle Emission Standards

When purchased, new motor vehicles comply with the emissions levels specified in the Australian Design Rules (ADRs). However, if the engine is not tuned regularly, over the life of the vehicle emissions of greenhouse gases (carbon dioxide, hydrocarbons and carbon monoxide) and fuel consumption increase substantially.

Except when issued with a vehicle defect notice, motor vehicles in South Australia are not subject to any inspection of mechanical fitness or compliance with emission standards. Annual or biannual inspections, where all vehicles would have to comply with specified emission levels, would encourage regular tune-ups. This would reduce total fuel consumption by about 4% (a conservative estimate), equating to an overall 1% reduction in carbon dioxide emissions.

Annual or biannual testing would be a minimum requirement. This would involve the establishment of a network of test stations, investment in testing equipment, a procedure to ensure that all vehicles were tested and additional charges to vehicle owners to cover the cost of testing.

Although vehicle owners would benefit financially from fuel savings, there might be inequitable social impacts because the less wealthy might own old vehicles that were unable to pass an emissions test.

Vehicle Registration Fees

The present vehicle registration fees are based on power and mass. Fees increase as both power and mass increase. Registration fees, however, could be restructured to encourage the use of more fuel efficient vehicles. In this case the fee payable would depend either on fuel consumption or on greenhouse gas emissions. The registration fee then becomes a vehicle efficiency tax rather than a vehicle owner tax.

Such a change would necessitate the development of a vehicle efficiency rating system. This could be based on the Department of Primary Industries and Energy fuel consumption figures or, if implemented, the result of the vehicle emission test, providing a direct feedback to registration fees

Because the third party insurance premium is the major component of fixed charges, unless the new registration fee system strongly favours efficient vehicles (for instances a five fold increase in registration fees for fuel inefficient vehicles), this option might provide little or no incentive for change.

An alternative approach would be to abandon registration and compulsory third party fees altogether, and replace them with an additional tax on petrol. The additional tax, to be revenue neutral would raise the price of petrol by about 17c/L. This option would be relatively easy to implement and administer and would provide a constant reminder when fuel is purchased that fuel inefficiency is expensive. It would, however, discriminate against those who cannot afford a newer, lower fuel consumption vehicle but who still need a motor vehicle for day-to-day activities.

If such a measure improved vehicle efficiency by 1% per year, by 2005 carbon dioxide emissions from road transport would be reduced by 10%.

Fuel Efficient Speed Limit

Although rural travel times would increase, a reduction in the non-urban road speed limit from 110 to 80 km/h would decrease the fuel used on long distance trips by between 20 and 30%. A 25% reduction corresponds to reducing carbon dioxide emissions from transport by about 8%. There would also be significant safety benefits.

Although this option would be relatively easy to implement, requiring only regulatory and sign changes, it might be extremely unpopular with rural travellers and constant enforcement would be difficult.

Alternative Modes

The efficiency of urban transport can be improved by encouraging the use of more fuel efficient modes. Walking has obvious health and energy benefits for short trips. The topography, climate and trip lengths in Adelaide make bicycles, mopeds and small motorcycles a rational choice for many trips, but concerns for status and safety often mitigate against such modes.

Non-motorised forms of transport could be encouraged by publicity; encouragement and the provision of facilities like local and regional bike plans which identify and grade alternative bike routes within urban areas; improved road infrastructure which provides greater safety for bicyclists and moped users; greater awareness of the need for bicycle and moped planning; recognition of the need to provide access and storage facilities for two wheeled users when interchanging with public transport systems; and publicity and promotion of the benefits of bicycles, mopeds and small motorcycles. If these measures reduce the number of car trips in Adelaide by 10%, carbon dioxide emissions from road transport would be reduced by about 4%.

Strategies that require Major Change, Technological Developments or Major Investments

The Private Car

The most grossly under-utilized resource in the urban transport system is the private car. Not only do private vehicles spend most of the time idle but, even when in use, load factors are very low. In fact, if governments operated their public transport services the way individuals do their private vehicles, public transport would be unaffordable.

The main challenge is to make more effective use of the private car. There are a wide range of measures that could be adopted to increase the efficiency of private vehicles including area entry and parking strategies that favour high occupancy vehicles; toll strategies that impose additional tolls on low occupancy vehicles; dedicated road space for high occupancy vehicles; fuel pricing schemes that give a rebate to, for example, car pool vehicles; car pooling schemes, both formal (fixed origin and destination with regular participants) and informal (no fixed structure); incentive schemes by government, commerce and industry to encourage group riding; group ride taxis where taxis provide a scheduled pre-booked transport service for a group of commuters; every car a taxi scheme in which private cars are allowed to carry fare paying passengers; jitney services where vehicles ply for hire along a specified route; organised hitch-hiking schemes; and company and government car schemes where multiple occupancy of company and government cars is compulsory.

The difficulties of introducing any of these measures should not be underestimated. The institutional impediments are considerable. The potential benefits, however, are significant. An increase in average vehicle occupancy in Adelaide to 2 people per car instead of the present 1.4 would reduce the total vehicle-km travelled by 30%, reducing carbon dioxide emissions from road transport by about 13%.

Fuel Efficient Vehicles

The fuel efficiency of vehicles, both private and public, passenger and freight, has improved as a result of technological developments made by the vehicle manufacturers. The most significant recent developments have been the widespread introduction of electronic fuel injection and electronic engine management systems.

Foreseeable road vehicle developments include ceramic engine components that will allow engines to operate at higher temperatures thus improving efficiency, drive-by-wire systems where the direct mechanical link between accelerator and engine is replaced by computer control that maximises efficiency while minimising emissions, and continuously variable transmission systems that optimise transmission ratios to maximise efficiency.

Technical innovation will continue to occur without government intervention. However, as an incentive the Government could introduce legislation along the lines of the Corporate Average Fuel Economy regulations that apply in the United States. These regulations specify the fuel economy targets for the average of the total fleet of vehicles sold by any one manufacturer.

With the present rate of turnover of the vehicle fleet in South Australia, to meet a target of a 20% reduction in carbon dioxide levels from vehicles by 2005 a target of an annual vehicle efficiency improvement in new vehicles of 2% would be needed. A 2% annual improvement means that new vehicles would be 35% more fuel efficient by 2005. This is likely to involve a significant downsizing of both vehicles and engines, and a considerable reduction in vehicle mass which may have safety implications.

This measure would probably have to be introduced Australia-wide, rather than just a South Australian initiative, would have to be developed through industry/Government discussions, and may require general support from the general public.

Use of Compressed Natural Gas (CNG) and Liquified Petroleum Gas (LPG)

A petrol engine properly tuned to use compressed natural gas (CNG) produces 33% less carbon dioxide emissions that the same engine using petrol. Although the conversion of vehicles is expensive, CNG is considerably cheaper than petrol and diesel because of lower government excises. With the existing cost structures, there are strong financial incentives for high usage vehicles to convert to CNG.

Current technology also allows diesel engines to operate, with minor modifications, on CNG. Trails with CNG powered diesel vehicles have indicated that emission levels of carbon dioxide are reduced by approximately 25%.

The reduced volumetric efficiency of CNG compared to diesel (very large fuel tanks are required to give an equivalent range) pose major problems for long haul operations, but CNG as a replacement for diesel is a feasible alternative in urban areas.

As an example of the reduction in emissions level that may be achieved, if all road vehicles were converted to run on CNG rather than petrol or diesel fuels, carbon dioxide emissions from transport would be reduced by about 27%.

Although South Australia's reserves of natural gas are limited, world reserves are enormous and increasing the proportion of CNG vehicles would provide a long term strategy for substantially reducing greenhouse gas emissions. In could also provide a bridge to compressed biogas (CBG), the production of which could be sustained in the long term by the growth of suitable crops.

The most mature alternative fuel is liquefied petroleum gas (LPG). LPG has a well established market, only minor modifications are needed for a petrol engine to use it, it provides a significant saving for high milage vehicle operators, the refuelling network is extensive in the metropolitan area and expanding in rural areas, and it is considerably cleaner burning than petrol or diesel.

While providing a short term alternative, in the medium to long term supply constraints will limit its market penetration.

Compressed Biogas (CBG)

When scrubbed and compressed, CBG can be used in CNG vehicles and dispensed in CNG equipment Greenhouse gas emissions from CBG vehicles are the same as CNG.

Assuming the adequate supplies of biomass crops can be grown in Australia, energy from biomass offers a long term solution to energy supply in terms of security of supply, reduced greenhouse gas emissions, and the potential to balance carbon dioxide emissions as emissions would be balanced by crop uptake of carbon dioxide. If 10% of all vehicles used CBG, emissions of carbon dioxide from road transport would be reduced by 3%.

Methanol and Ethanol Produced from Biomass

When burned, methanol and ethanol produce less carbon dioxide, carbon monoxide and nitrous oxide, and fewer unburnt hydrocarbons than petrol. Furthermore, if methanol and ethanol are produced from biomass, there is a potential to balance carbon dioxide emissions with carbon dioxide uptake through biomass renewal. If emissions and uptake are balanced and if all vehicles use methanol or ethanol, total carbon dioxide emissions would be reduced by approximately 27%.

Wood is the most usual biomass feedstock for methanol and a wide range of crops beside wood can be used to produce ethanol. One impediment would be competition with agriculture for usable land, especially if agricultural zones decrease in size because of climatic changes.

As energy from biomass offers a long-term solution to energy supply (in terms of energy security, reduced greenhouse gas emissions, and the potential to balance carbon dioxide emissions), it would be prudent to continue research and demonstration in this area.

Electric Vehicles

Despite extensive research and development, battery packs for electric vehicles are still expensive, heavy and unreliable. The limited range, poor performance and long recharging time are additional impediments to the acceptance of electric vehicles.

If these problems could be overcome and if electric cars were to run on electricity derived from photovoltaic, nuclear or hydro sources, greenhouse gas emissions would drop considerably. If all vehicles were to be recharged from, for example, photovoltaic electricity, total carbon dioxide emissions would decrease by almost 30%. If, however, battery recharging was from fossil fuel generated electricity, emission reductions would be negligible.

While attractive, to be feasible this option will depend on a break-through in battery technology and the introduction of electricity generating systems that do not rely on fossil fuels.

In the longer term, it might become feasible for electric vehicles to be powered by the inductive transfer of power from wires buried in the road surface. This would overcome the battery storage and recharge problem.

Hydrogen Vehicles

Hydrogen is cleaner burning than other fuels - it releases only water; no carbon dioxide or carbon monoxide is produced. Although producing hydrogen from water by electrolysis is a well established technology, storage and distribution technologies have not been sufficiently developed to make hydrogen powered vehicles commercially feasible.

This option is, however, attractive in the long term. If all vehicles were run on hydrogen produced from non-fossil fuel electricity, total carbon dioxide emissions would be decreased by almost 30%.

Personal Rapid Transit System

A long term solution to greenhouse gas emissions while still satisfying urban travel needs might be the construction in Adelaide of a Personal Rapid Transit (PRT) system powered by non-fossil fuel electricity from, for example, solar generators. PRT refers to a type of transport system consisting of small electrically propelled vehicles operating on an exclusive guideway under completely automatic control. All stations have by-pass loops for through traffic so that all trips are non-stop from origin to destination. Service is provided at passenger request, either immediately or after a short wait. Personal service is assured by making each vehicle available to a single person or a small party travelling together.

A comprehensive network of guideways and stations, either elevated or below ground, would be provided in the urban area such that all origins and destinations would be no more than a few hundred metres walk from a station. Special vehicles would also be used for freight distribution and other tasks such as waste collection.

The major operating economies and improved service levels promised by computer controlled driverless urban transport systems set off a multi-billion dollar surge of research and development activity in the late 1960s and early 1970s in both the public and private sectors of the industrialised nations. A major reversal and collapse of interest followed in the second half of the 1970s, with only a handful of companies remaining active in the sector. Despite this, close to 50 new automated transit systems have now been constructed and put into service in the world.

Although none of the presently operating systems are as extensive as a PRT system (they cater mainly for a limited corridor), most of the required PRT technologies (computer control, wheeled propulsion and magnetic levitation, switching systems, ticketing, guideway design and construction, information systems) are either in use or proven in prototype development.

The major impediments to an extensive PRT system, however, is non-technical - the cost. As an order of magnitude estimate, a PRT system for Adelaide would cost as much as the total investment in the existing road infrastructure and the vehicles that use it. PRT is affordable only if the government and private expenditure on the existing transport system is totally directed into it. The result, though, would be a clean, quiet, safe, efficient, comprehensive transport system for all users that would enhance the quality of life in Adelaide.

If 80% of all trips in Adelaide were made by PRT, carbon dioxide emissions from road transport would be reduced by 34%.

Communication Technologies

Communication technologies offer the ability to move the message, not the person. The surprise free future sees the introduction of communications equipment (cellular telephones, communications consoles, universal access to data and information bases, three dimensional television and low-cost readily-accessible teleconferencing) that will offer an order of magnitude improvement over today's basic telephone. Possible outcomes are that individuals in a broad range of activities will be encouraged or will choose to work either from home or from community work locations, that teleshopping with goods pick-up from centralised locations will replace many shopping trips, and that students, rather than travelling to compound-like institutions, will be taught at home or at local centres.

Although the transport and social research literature is divided about the transport implications of advanced communication systems, the potential impact on the way in which individuals organise they daily lives could be considerable. There is a need to monitor and plan for such changes.

If communications technologies could offer a suitable replacement for 25% of all car trips, carbon dioxide emissions from road transport would be reduced by 11%.

The Road Infrastructure

Governments have almost exclusive control over the road infrastructure and this can be improved to increase energy efficiency. In urban areas the travel time benefits of minor road improvements and coordinated traffic signal schemes are obvious, well documented and recognised. The Sydney Co-ordinated Adaptive Traffic System (SCATS) for example, which controls and coordinates traffic signals in Sydney, Newcastle and Wollongong, reduces the number of stops on a typical journey by up to 45% and delays by 23%. As a consequence fuel consumption is reduced by about 12%. Reductions in greenhouse gas emissions flow from such coordinated traffic signal schemes. The Adelaide co-ordinated traffic light scheme will produce similar benefits.

The next major step, and one that will involve both private and public sectors, will be the introduction of intelligent vehicle and highway systems (IVHS) that allow interaction between vehicles and the road infrastructure. Ambitious research programs are underway overseas - PROMETHEUS in Europe, PATH in USA and RACS in Japan. Stage one of these schemes will provide vehicle drivers with route selection advice to assist navigation. Subsequent steps will allow real time interaction between vehicles and the road. The road network will know the origins and destinations of vehicles using it and will provide individual vehicles with route advice to minimise delays, travel time and fuel consumption. Such interactive systems are expected to improve the overall efficiency of the road network by at least an order of magnitude.

Unfortunately the European, American and Japanese systems as presently conceived use incompatible technologies. There is a role for monitoring overseas developments, to lay the framework for the regulatory and technical environment, and to encourage and adopt these technologies as they become available.

Spatial and Temporal Structures

The existing city structure and temporal management see major tidal flows from the suburbs to the central business district that effectively utilised only half of the road infrastructure. In addition, the major part of public transport fleet is idle for the major part of the day, except during the peak periods when occupancy levels exceed 100% in one direction but are almost zero in the reverse.

For both the road and public transport systems, providing reverse loadings or spreading the duration while reducing the intensity of peak demands has obvious efficiency benefits.

Superimposed on this are cross suburban trips, some of considerable distance, that are very difficult to cater for with conventional public transport.

There is a need to develop urban structures that reduce travel demands, that provide reverse flow loadings on the transport system and that encourage individuals to live close to work

This demands better integration and coordination of land use planning, traffic management and transport planning; the need to promote urban consolidation, particularly in areas close to existing and proposed transport corridors; planning for effective penetration by feeder buses in new urban areas; developing public transport services in new growth areas at an early stage to encourage early use and behavioural patterns; concentrating employment and other activities at major regional centres that are well served by public transport; encouraging the location of major employment centres on the arterial road and rail network; providing efficient and attractive transport interchanges at regional and sub-regional centres; and implementing traffic management measures which foster better accessibility to established centres by public transport, commercial, freight and private vehicles.

If a combination of measures could reduce the number of car trips by 20%, carbon dioxide emissions from vehicles would be reduced by 11%.

In addition better use can be made of time as a congestion reducing strategy by, for example, encouraging flexible and staggered working hours, permitting a seven day working week (allowing individual choice of working five of the seven days) and allowing extended hours for commercial, industrial, government and educational facilities. Spreading peak demands on the public transport system and the road infrastructure has both efficiency and service benefits.

Road Pricing

It is now technically feasible to charge motor vehicle owners for the lengths of road that they use. In the systems that have been developed, each motor vehicle is fitted with a unique passive identification device, usually about the size of a video cassette, on the underside of the vehicle. The identification device is interrogated by sensing loops buried beneath the road surface (similar to traffic light sensing loops). A comprehensive network of sensing loops throughout urban (and possibly rural) areas allows centralised monitoring of the road links used and hence the distance travelled by each vehicle.

In an effect to produce a strategy for reducing road congestion, a scheme using this technology was trialled in Hong Kong. It proved that it was feasible to bill motorists for use of the road network - the charge in Hong Kong was to be dependent on distance travelled with a surcharge for using congested links.

The use of such technologies might have an application in reducing vehicle use, and hence greenhouse gas emissions, in Adelaide. If a charge is placed on the use of the road network it is possible that users might consider the worth of individual trips and whether alternatives (for example, public transport, trip linking, shared rides) might be more appropriate.

The scheme could work in several ways, perhaps, for example, a simple distance based tariff or, like water rates, payment only after a certain threshold distance limit.

There are obvious privacy issues that would need to be resolved before a scheme of this nature could be implemented (one of the reasons why the Hong Kong trial floundered was because of centralised monitoring of individual trips) and the social implications need some consideration (for example, the less wealthy living in outer urban areas making long commuting trips for which public transport is not a feasible alternative would be penalised).

It is difficult to estimate the actual reduction in vehicle use and consequent reduction in greenhouse gas emissions that this sort of scheme would produce. It would obviously be price sensitive. The effects of user-pays water pricing indicates that it is possible to change behaviour patterns, and if road pricing reduced car trips in Adelaide by 20%, carbon dioxide produced by road transport would be reduced by about 8%.

Conclusion

Apart from the widespread use of alternative fuels (the technical and logistical feasibility of which is questionable by the year 2005) and technical innovation (fuel efficient vehicles and personal rapid transit systems), the only options that have the potential to significantly reduce the emissions of greenhouse gases from transport are those that require considerable changes to individual behaviour.

Whereas the 'popular solutions' imply major government funding of resources and infrastructure, and do not produce a significant reduction is gas emissions, the options that do produce significant reductions require a major commitment from individuals - either in sharing transport resources by ridesharing, by adopting fuel efficient driving techniques, or by altering the physical and temporal structures of cities.

But perhaps the major lesson is that to achieve the Toronto target of a 20% reduction in carbon dioxide emissions by the year 2005 a commitment to change far in excess of any witnessed to date is required from both Government and the community.