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TRANSPORT ENERGY ISSUES: EVALUATION OF CONSERVATION MEASURES

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ABSTRACT: *The case for conserving petroleum energy in transportation is presented and the need for government policies to achieve desired conservation goals is established. Energy conservation is only one of many objectives in transport planning and policy, and conservation measures must therefore be evaluated in the context of other objectives. The most promising areas for transport energy conservation are identified, and selected policy measures are evaluated. In order to achieve the most significant impacts, petroleum conservation measures should be directed primarily at the private car. The car has considerable potential to adapt to the needs for energy conservation, and offers the most important option for conserving transport energy without impinging on people's travel patterns and preferences.*

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THE ISSUES IN CONTEXT

Energy efficiency in transportation has been identified as one of the ten most critical issues in transportation by the Executive Committee of the Transportation Research Board (1976) in Washington. The extent to which specific energy conservation policies are necessary or desirable in Australia depends on the answers to four questions:

1. Should we conserve transport energy?
2. If so, how much should we conserve and by when?
3. To what extent can we rely on the private market system to accomplish conservation goals?
4. If government policies for energy conservation in transportation are needed, what are the policy options available?

The emphasis of this paper will be on the issue of identifying and evaluating alternative policies for energy conservation in transportation. However, it is thought desirable to briefly address the first three questions stated in order to place the policy issues in a proper context.

Should we conserve transport energy?

Energy conservation in transportation is essentially synonymous with conservation of petroleum, given the fact that transport is almost wholly (98%) dependent on petroleum fuel. In view of the prospects of rapidly increasing oil prices, increasing dependence on oil imports and insecurity of supply (Australian Transport Advisory Council 1978) there appears to be a strong case for conserving petroleum energy. However, energy conservation has to be considered relative to other objectives pursued in transport planning and operation such as enhancing road safety, increasing economic efficiency and level of user services, keeping down costs and maintaining or improving accessibility to opportunities.

How much should we conserve and by when?

Without venturing into the difficult and uncertain area of specific forecasting, we here proceed on the premise that the consumption of petroleum by transport should be reduced to virtually zero by the year 2000 and should be reduced substantially by 1985. While a considerable margin of error may be involved, this aim is suggested by Australian and World crude oil depletion rates. Beyond conservation, the inexorable long term depletion of world oil reserves necessitates substitution of alternative energy sources.

Will the market work it out?

There are a number of important reasons why we cannot wholly rely on the market mechanism to bring about the desired conservation of transportation energy. The major reasons include the insensitivity of the demand for petrol to increases in the price of petrol as well as the existence of imperfections on the supply side of the markets for petroleum, motor vehicles and transport services.[1] The insensitivity of the demand for petrol to its price is evidenced by numerous overseas studies (for example Charles River Associates 1976, Hartgen 1975, McGillivray 1976, Skinner 1975), and the few existing Australian studies (Schou and Johnson 1978, Hensher 1977a) have confirmed this finding. The implication of the inelasticity of demand for petrol with respect to price is that even substantial price rises are not likely to result in satisfactory fuel savings. For instance, a short-run elasticity in the range of -.02 to -.07, as estimated by Australian studies (Schou and Johnson 1978 and Hensher 1977a), indicate that a 10 per cent increase in the price of petroleum would only decrease demand by about .2 to .7 per cent.

The private market system is not wholly capable of ensuring that scarce energy resources are allocated in the most efficient way over time within the transport sector. As a consequence, deliberate government policy is called for to achieve the necessary conservation of transport energy and ensure a smooth adjustment and transition to alternative energy sources.

Energy conservation in the context of other policy objectives

In order to determine the optimal mix of policies for energy conservation in transportation, researchers, planners and policy makers need to explore all possible alternative measures and their effects, and attempt to evaluate and compare different measures. It is not sufficient to examine the technical potential for energy savings by various measures, as individual preferences and social acceptance are crucial determinants of the actual success of a particular conservation policy. On the premise that the overall concern is with maximising the net social benefit of scarce resources, rather than just minimising energy consumption, it is clearly desirable that a broad range of impacts be taken into account in the evaluation.

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1 The large capital investments required, long lead times and uncertainty associated with the development of new technology, and the existence of economies of scale have given rise to oligopolistic market structures and, in the case of many transport services, government monopolies.

Conservation measures must be evaluated in the context of both the multiple objectives of transport policies and the total community resource costs they imply. Transport serves a variety of social and economic needs, and trade-offs may be necessary between energy conservation and other policy objectives concerned with, for example, traffic congestion, accessibility, mobility, safety and pollution. There is no universal prescription for energy conservation in transport; it is important that a many-pronged approach should be maintained as there is no unique optimal course of action.

The problem of criteria for evaluation

Alternative policies designed to conserve energy in transportation are likely to have disparate social, economic and environmental impacts, and it is therefore desirable to establish a set of criteria on the basis of which various policies can be evaluated and compared. The criteria for evaluation should include not only the energy effects but also all the other significant impacts of a policy measure. Relevant considerations may include capital investments required, total user costs, timing of conservation benefits, travel times, vehicle miles travelled, level of services, accessibility to opportunities, individual preferences, emission levels, safety, employment, distribution of income, ease of implementation and the likelihood of achievement.

It would clearly be desirable to have a set of well defined criteria on the basis of which consistent evaluation could be undertaken of policy measures and all their relevant effects. However, as suggested by the vast array of considerations involved, it is no easy task to define such criteria. The difficulty in defining suitable criteria (i.e., principles to be taken as standards in judging) arises partially from the fact that value judgements are necessarily involved in establishing priorities and trade-offs, and it is inevitable that different persons will adopt different, albeit quite valid, criteria. To the knowledge of this author no attempt has been made in the Australian context to compare and evaluate policies on the basis of clearly defined criteria. The establishment of such criteria remains an unresolved issue, and one which deserves more attention by planners and policy makers. It is, however, considered beyond the scope of this paper to make a serious attempt at resolving this issue.

In the remaining parts of the paper the most promising areas for energy conservation in transport will be identified, and selected policy measures will be discussed.

IDENTIFICATION AND EVALUATION OF CONSERVATION MEASURES

Identification of promising policies

In the short term we are confined to looking for opportunities to conserve petroleum within the transport system as it exists today, and that means a system dominated by the private automobile. In Australia over half of all car/station wagon milage occurs in capital city urban areas (Nicholas Clark 1975b, p.8). City driving typically involves low occupancy rates, 'stop-start' driving, short trips and high fuel consumption. It has been estimated that the energy intensity of urban driving is nearly three times as great as that of non-urban driving (Nicholas Clark 1975b, p.78). On this basis it may be argued, that in order to achieve the most significant impacts, fuel conservation measures should be directed primarily at urban passenger transport and at the private car.(1) The private motorist, consuming about 60 per cent of transport petroleum energy, has a relatively low perception of real motoring and fuel costs, and is not expected to be very responsive to petrol price increases.(2) If the potential fuel savings offered by a range of conservation options concerned with the private car are to be realised, government policy initiatives will be required.

Selected policy measures

The policy measures to be discussed here fall into five categories:

1. Improving the fuel efficiency of automobile use through operational changes or increasing occupancy rates.

2. Inducing shifts to more efficient modes.

3. Improving the inherent efficiency of the car mode by promoting shifts to smaller or more fuel efficient vehicles and improving the technical efficiency of vehicles through design and other changes.

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1 Although energy conservation measures could be suggested for other sectors as well, there is little doubt that measures affecting the level and efficiency of fuel consumption of the private car in urban passenger transport will be of prime importance.

2 In the rail, sea, air and road freight sectors where most of the task is performed by government and commercial operators, the perception of fuel cost is relatively high and market forces might be expected to bring about the appropriate increases in energy efficiency. (Australian Transport Advisory Council 1978).

4. Encouraging the introduction of new technology involving substitute fuels and unconventional propulsion systems.

5. Reducing travel demand by modifying land use patterns and employing advanced communications.

These measures will now be discussed in turn and an attempt will be made to evaluate their impacts and likely success.

Improving the Fuel Efficiency of Automobile Use

Operational changes

For any level of automobile use important fuel savings can be obtained by reducing speeds, improving traffic flows, modifying driving habits and keeping vehicles properly maintained. The fuel consumption of a particular vehicle is highly dependent on the average speed and idle time during a journey. Tests have demonstrated that the lowest fuel consumption occurs at a steady speed of between 50 and 65 kph. (Orski 1974). Fuel consumption rises very steeply as speed increases above this level or, as is probably more likely in Australia city driving, falls below that level. At peak hour when average speeds are low, the average fuel consumption can exceed the optimum by a factor of two. In Sydney about 30 per cent of petrol is consumed at speeds below 24 kph and 65 per cent below 32 kph. (Hamilton 1978, p.29). This implies that important fuel savings could be achieved if it was possible to significantly improve traffic flows in urban areas. While much has been done already, some scope remains for making better use of the existing road infrastructure by, for instance, extending the clearway principle to all major arterial roads and for all hours of the day. However, major improvements in traffic flow may require expansion of the existing road network and massive investments which are unlikely to be justified on economic or social grounds.

Improved car maintenance to ensure that engines are properly tuned can theoretically improve the fuel efficiency of vehicle operation, however the fuel cost savings for the motorist would most likely be less than the cost of additional tune-ups. Some fuel economies might be achieved by encouraging drivers to improve their driving habits (reduce high speed driving, rapid acceleration and deceleration, and improve usage of gears). During fuel economy tests it has been demonstrated that differences in average fuel economy of up to 20 per cent result from differences in driving behaviour (Australian Transport Advisory Council 1978, p.134). However, there is no evidence of how willing or able motorists are to modify their driving behaviour, and it is unlikely that the potential fuel savings from this source would be very significant. The most important social benefit of improved driving habits, and reduced speeds in particular, would be a reduction in the number of fatal road accidents and serious injuries.

Increasing occupany rates

Increasing the efficiency of automobile use by promoting higher occupancies (car-pooling) is a policy measure which received considerable attention in the U.S. during the 1973-74 oil embargo and price increases. The merit of car-pooling for work commuting trips is that it can be introduced with very short lead time and without significant capital expenditure. This makes it a prime option to include in a contingency plan for an emergency situation. However, the practical difficulties involved in implementing car-pooling on a large scale makes it unlikely that any major energy savings could be achieved in a non-emergency situation. The difficulties arise mainly from the fact that car-pooling requires changes in people's travel patterns and life styles, which may be inconsistent with individual preferences. The major disadvantages of car-pooling from the point of view of the individual concern restriction of freedom, dependence on other people and inconvenience of having to pick up and wait for others (N.S.W. Traffic Authority 1977).

Incentives which have been suggested to promote higher occupancies for the work trip include exclusive lanes, reduced tolls, preferential parking, lower parking fees and automobile insurance subsidies. It has been argued that the benefits of car-pooling include reduced congestion and air pollution as well as energy savings. However, it must be noted that these benefits are unlikely to be extendable to non-work trips,(1) and may indeed be offset by increases in the number of non-work trips undertaken as a result of the greater availability of automobiles for such trips. Thus the absolute fuel savings likely to result from policy measures to increase automobile occupancy rates are probably small.

The general problem with measures designed to increase the energy efficiency of automobile use through operational changes or increasing occupancy rates is that such measures, by their nature, require adjustments in people's travel patterns and habits. Such adjustments are unlikely to occur to any great extent as a result of voluntary measures, and non-voluntary measures are unlikely to be socially acceptable except for in emergency situations.

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1 The origins and destinations of non-work trips are too dispersed in time and space to be candidates for car-pooling.

Inducing Shifts to More Efficient Modes

There appears to be widespread adherence to the view that attracting automobile travellers to public transport ranks highly among policies to conserve scarce energy resources in transportation. As discussed elsewhere (Schou 1978; Peterson 1979[1]) this argument tends to be based on a narrow interpretation of the issues involved. It tends to ignore the difficulties of meaningfully comparing energy efficiencies of different modes and, in particular, the issue of indirect energy requirements of various modes is often ignored. In addition, important issues of travel choice behaviour and individual preferences are generally disregarded. It must be pointed out that it is meaningless to discuss the technical possibilities for energy conservation without considering the characteristics of travel behaviour.

Empirical evidence on travel behaviour has indicated beyond doubt that people are unlikely to be attracted from their cars to public transport by increased petrol prices, decreased public transport fares or improved public transport services. (Hartgen 1975, Skinner 1975, Peskin, Schofer and Stopher 1975, Stuntz and Hirst 1976, Ford Foundation 1975, Hensher and Bullock 1977). The value of time is an important element in a traveller's choice of mode. The value of time varies with trip purpose but is usually high enough that changes in fuel costs or public transport fares have negligible effect on mode choice. People value the use of the private car highly, and are prepared to pay a premium for it. The car provides convenient, flexible and demand responsive transport services. For most trip purposes, other than Downtown commuter trips, public transport is inferior and total public transport patronage is unlikely to ever be significantly greater than it is now (Hensher 1977b).

When due consideration is given to available evidence on travel behaviour and preferences, the energy conservation potential of public transport appears to be very limited. Furthermore, it is becoming clear from a number of recent studies that the energy savings which could be achieved through more efficient automobiles by far exceed the potential savings from the increased use of public transport. However, public transport will always be necessary to provide reasonable access to opportunities for people who do not own cars or cannot drive. Since 21 per cent of Australian households do not own a car (Hamilton 1978) there is clearly a case on equity grounds

1 Paper to be presented at this Forum.

to provide some form of public transport, though decisions on the form to be provided should take into account energy considerations. For instance buses are more energy efficient and capital efficient than rail, and are also more flexible in adapting to changing needs of the community.

Improving the Inherent Efficiency of the Automobile

Improving the inherent efficiency of the automobile by promoting shifts to smaller, more fuel efficient vehicles and improving the technical efficiency of vehicles through design and other changes will be the most important option for conserving transport energy in the 1980's. The most important reasons for this are as follows:

. The savings potential of improving vehicle efficiency is much larger than that of any other policy measure, because motor vehicles now consume the major share of transportation energy and operate at efficiencies considerably below what existing technology could achieve.

. Gains in vehicle efficiency can be achieved without major impacts on the quality of transport services and may not require changes in the behaviour of either consumers or institutions - except for vehicle manufacturers, of course.

. Implementing improvements in vehicle efficiency can reduce total cost of automobile ownership and operation; to the extent that it does, it will be favoured by market forces (Transportation Research Board 1977).

. While lead times of up to 20 years may be required to achieve maximum fuel savings from particular design improvements, substantial economies are achievable within a few years. This is due to the fact that newer vehicles account for a disproportionately large share of vehicle kilometers travelled. In Australia some 50 per cent of vehicle kilometers travelled are by vehicles four years of age or less (Hamilton 1978, p.33).

The move towards smaller and/or more efficient automobiles is well under way in Australia, as evidenced by the increasing market share of four cyclinder cars at the expense of V-8's. This is consistent with the findings of overseas studies (Mogridge 1978, Sacco and Hajj 1976) which have suggested that the major impact of petrol price rises is a change in the structure of the car market with smaller vehicles gaining an increased share of the market. However, on present evidence it is not possible to determine the extent to which this trend in Australia has been influenced by petrol prices.

Recently the Australian motor industry announced a voluntary uniform code of practice for passenger car fuel consumption reduction (Federal Chamber of Automotive Industries 1978). The code is based on a reduction in average fuel consumption of new passenger cars of 15 per cent by 1983 and approximately 20 per cent by 1987 when an average of 8.96 litres per 100 kilometers should be achieved. This is comparable to the average fuel efficiency of 8.6 litres per 100 kilometers which is required of new cars in the U.S. by 1985.

Policy measures to promote more efficient automobiles should include a combination of measures which encourage the design and manufacture of fuel efficient vehicles and measures which encourage the purchase of these vehicles. Graduated registration fees and sales taxes could be designed to discriminate against the larger and less fuel efficient vehicles, and import tariffs could be lowered selectively for fuel efficient vehicles. A system of fuel economy labelling could be introduced to increase consumer awareness of comparative fuel consumption characteristics and their implications for fuel and motoring costs.

It should be pointed out that decisions announced in the last Federal Budget (1978/79) to cut sales taxes on locally made cars and to raise tariffs on imported cars would tend to work in a direction opposite to that which would be desirable from a fuel conservation point of view. This is so because many fuel efficient imported vehicles would be penalised while, for instance, the locally produced V-8's would be favoured. The move to world parity pricing of domestic crude oil and the increase in petrol taxes are unlikely to be effective in encouraging the purchase of fuel efficient vehicles as the demand for new motor vehicles is very insensitive to vehicle operating costs (Australian Transport Advisory Council 1978).

It may be concluded from this section that considerable potential exists for improving the fuel efficiency of the automobile by means of existing technology, without impinging on travel patterns and life styles. To realise this potential, government policies need to provide strong encouragement for the motor vehicle manufactures to produce fuel efficient cars and provide incentives for people to own fuel efficient cars.

Introducing New Technology

Substitute fuels

Beyond conservation of petroleum fuels the inevitable long term depletion of world oil reserves necessitates substitution of alternative energy sources. The substitute fuels which have been investigated in the engineering literature include LPG, LNG, methane, methanol, ethanol, hydrogen and liquified coal (Institution of Engineers 1977). Most of these suffer major disadvantages which inhibit their rapid development and widespread use as a transport fuel. Large capital investments, long lead times and uncertainties about costs and profitability indicate that the private market system is unlikely to introduce alternative fuels without substantial government co-operation, and a clearly defined government policy on related issues, such as the taxation levels to apply to petrol substitutes. As oil prices continue to rise a number of substitute fuels will become economically competitive. Increasing dependence on imported petroleum and insecurity of supplies, which is thought to be undesirable, may provide justification for subsidising the development and use of petroleum substitutes before these become economically competitive.

The electric vehicle

In considering alternatives to the petroleum dependent internal-combustion automobile, the electric vehicle is one perennial favourite. The possibility of using coal or solar power as the energy source makes the electric car an attractive long term solution. Notable advantages of electrically operated vehicles are the absence of noise and pollution at the vehicle location.[1] This implies that the social and environmental benefits would be great, particularly in urban areas.

At present, the general application of electric vehicles is inhibited by limited range (80-100 km) and deficiencies in performance (slow acceleration and maximum speeds of about 80 km/hr). Present batteries add much to the cost and weight of the car and it is unlikely that electric vehicles will approach the performance characteristics of internal-combustion vehicles in the immediate future. It should be noted however, that the present characteristics of electric vehicles make them suitable for light urban delivery vans and buses, as well as for many intra-urban car trips. A recent study for the Bureau of Transport Economics (Graves 1978) found that 11 per cent of cars could presently be replaced by electric vehicles without significant changes in usage pattern. In order to be a reasonable candidate for replacement a car should belong to a multi-car household, travel less than 40 km on a typical weekday and rarely travel more than 80 km in a day.

In the near future the market potential of electric vehicles would be limited by the performance characteristics of present batteries. However, long-life, high energy-density batteries and fuel cells will probably be available before the end of the century (King 1977) and the market penetration necessary to significantly reduce the dependence of transport on petroleum fuels should then be achievable. Market penetration on a great scale would require electric vehicles to have favourable purchase prices and running costs compared with those of the internal combustion vehicle. However, as Australia's oil reserves diminish and the costs of oil imports rise, the electric vehicle is likely to become economically competitive.

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1 Pollution will generally increase at the electricity generating location.

The main conclusions to be derived from the previous sections are that the car has a considerable potential to adapt to the needs for energy conservation in transport and that the car offers the most important option for conserving transport energy without adversely affecting established travel patterns and preferences.

Reducing Travel Demand

The final set of policy measures to be considered here relates to options for reducing the need to travel. It must be kept in mind that the demand for transport is largely a derived demand. In most situations what is really demanded is access to activities and opportunities at the end destination, rather than transport or mobility per se. (Hensher 1977b). Thus we need to look at the possibilities for conserving energy (and time) by moving opportunities to people, rather than just moving people to opportunities.

Land use patterns and community design

Energy consumption can be reduced by designing or redeveloping cities with accent on accessibility rather than mobility (Owen 1976, Gilbert and Dajani 1974, Edwards and Schofer 1976). There is a need for long term urban (and regional) planning aimed at developing integrated communities combining residential, employment, services and recreational activities. There is considerable scope for re-arranging activities in order to reduce trip making for a given level of activity attainment (Hensher 1977b). Existing urban areas could gradually be re-designed so that travel needs are reduced and transport energy (and time) saved (Owen 1976).

Advanced telecommunications

A potentially powerful means of reducing travel demand is through the substitution of advanced telecommunications for some travel purposes. Modern communications may permit people to have access from home to many services and activities which are now only obtainable by making a trip. Services which have been investigated in this context include remote shopping, remote banking, electronic voting,[1] information retrieval systems, remote medical systems and electronically transmitted mail and newspapers (Day 1973, Harkness 1973). The use of video-telephones, confravision and tele-transmission of printed material could well reduce the need for transacting business in central offices and could become instrumental in reducing the volume of commuting. People might work at home and "telecommute" to work from closed circuit T.V. consoles. Technically, a number of new telecommunication media are already proven, but commercial usage awaits adequate threshold demand and consequent reduction in relative costs.

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1 Electronic voting could potentially contribute to a revival of democracy in so far as it would allow almost instant registration of individual preferences on a vast array of issues.

An important issue to be considered in the context of telecommunication substitution for travel, is the extent to which various trip purposes could be effectively served by telecommunications. Studies in this area (Christie 1974, Connell 1974, Day 1973) have been concerned mainly with the effectiveness of telecommunications as a substitute for business trips. It has been estimated (Christie 1974) that about 50 per cent of present face-to-face business meetings could be conducted by telecommunications without loss of effectiveness. The important issue is not only whether telecommunications are adequate substitutes for travel but, rather, whether their advantages outweigh their disadvantages (Harkness 1973). For example, teleconferencing may eliminate travel time and expense, allow faster information turnaround and decision making, more short unscheduled meetings, more locational freedom and last but not least require less material and energy resources. While the substitution of telecommunications for travel offers substantial potential for conserving transport energy, such substitution on a large scale would involve considerable changes to life styles and interpersonal relations. There will always be situations in business and in people's private lives where the is no substitute for face-to-face contact.

COMPARISON OF CONSERVATION POLICY MEASURES

A useful framework for comparing the policy measures surveyed here could be provided by some form of conservation impact evaluation matrix indicating all the relevant impacts of each policy measure. The matrix could incorporate quantitative measures where available, assign weights according to the direction and importance of particular impacts, or just simply describe the nature of relevant effects. Two matrices constructed for the U.S. have been reproduced in part in tables 1 and 2.

The evaluation matrix is thought to be a useful technique for allowing comparison and evaluation of a wide range of policy measures and for presenting the relevant information to policy makers who bear the responsibility for the final decision. It is recommended that impact evaluation matrices be constructed for Australia to assist policy making in the area of transport energy conservation.

TABLE 1

SUMMARY OF OPPORTUNITIES TO CONSERVE TRANSPORTATION ENERGY

OPTION	FUEL SAVINGS AS % OF TOTAL DIRECT TRANSPORT ENERGY		FUEL SAVINGS IN THOUSANDS OF BBL PER DAY		FUEL SAVINGS PER UNIT OF SERVICE (PM TM OR VM)		INCREMENTAL COSTS (+) OR SAVINGS (-)				YEARS TO OBTAIN MAXIMUM BENEFITS	TRAVEL TIME (% Change)	EMISSIONS IMPLICATIONS	SAFETY IMPLICATIONS	LIKELIHOOD OF ACHIEVEMENT
							CAPITAL INVESTMENT		TOTAL USER COST						
	1980	1990	1980	1990	% at full implementation	Btu	Billion $	% Change	Cents/Unit of Service	% Change					
PASSENGER CARS															
VEHICLE EFFICIENCY															
Future Cars															
Modest off-the-shelf improvements (scenario A)[3]	8 2	15 0	848	1689	21	1968/vm	-0 05	-0 2	-0 9	-6	15	none	neutral	neutral	high
Advanced technology (scenario B)	8 7	24 4	894	2740	34	3168/vm	-1 7	+12	-1 5	-11	25	none	neutral	neutral	medium to high
Maximum "off-the-shelf" (scenario C)	10 9	21 7	1121	2440	31	2829/vm	-0 9	+3	-1 0	-7	15	none	neutral	neutral	high
Advanced technology & shift to small cars (scenario D)	13 1	32	1350	3601	46	4227/vm	-5 3	+17	-1 0	-21	35	none	neutral	negative	medium to high
Existing Fleet															
Radial tires (pre-1975 cars only)	0.5	0	47	0	3	270/vm	0 6	-20	-0 1	-0 7	5	none	neutral	neutral	high
Other retrofits	0.5	0	47	0	3	270/vm	N/A[4]	N/A	0	0	5	none	neutral	neutral	low
LOAD FACTOR															
Carpools (work trips only) at 47% participation	1 9	1 5	200	174	14	780/pm	negative	N/A	(2 to 4)	-(15 to 35)	1	+10 to 40	-14%[11]	neutral	medium
Carpools (work trips only) at 70% participation	4 9	3 8	500	436	29	1617/pm	negative	N/A	(2 to 4)	-(15 to 35)	1	+10 to 40	-30%[11]	neutral	low
OPERATIONAL IMPROVEMENTS															
Speed limits 55 mph	1 2	0 9	121	105	8	588/vm	negligible	N/A	-0 5/vm	-3	1	+18	minor benefit	significant benefit	high
Better maintenance	0 7	0.6	75	65	1 5	140/vm	-1	N/A	+0 2/vm	+1.6	5	none	significant benefit	none	low
Driving habits	2 4	1 9	250	215	5	463/vm	negligible[2]	N/A	-0 4/vm	-2 3	5	negligible	minor benefits	minor benefits	medium
Urban traffic flow	0 4	0 7	98	84	3	318/vm	-1	N/A	-0 2/vm	-1	10	minor benefits	minor benefits	minor benefits	high
SERVICE REDUCTION															
Short-run (emergency)					*As dictated by circumstances*										
Long-run savings from 2.6% annual growth in VMT vs. 4.8% historic rate	7 9	18 9	819	2130	N/A	N/A	N/A	N/A	N/A	N/A	>20	N/A	major benefit	major benefit	high
BUSES															
VEHICLE EFFICIENCY	07	13	7	15	20	121/pm	negligible	N/A	negligible	N/A	10	none	none	none	high
AIR PASSENGER															
LOAD FACTOR IMPROVEMENT[5]	2 3	3 7	231	415	28	2174/pm	negative	N/A	0	0	4	0	Proportional to fuel savings	none	high
OPERATIONAL IMPROVEMENTS															
Cruise speed reduction	0 2	0 4	25	44	3	233/pm	0	0	0	0	0	2	·	·	high

N/A = not available (or not applicable).

1. Total direct transportation energy projections were based on the growth rate projected for the '$11/bbl conservation case" of the "Project Independence" report (8), which anticipates implementation of some of the measures described in Ref. (12)
2. Transportation fuel consumption in bbl/day is projected at 8.9 million bbl/day in 1980 and 9.4 million bbl/day in 1990, consistent with the above and assuming 5 8 million Btu/bbl with 95% of TDTE from liquid fuels in 1980 and 92% in 1990
3. See Ref. (12) for scenario definitions.
4. However, retrofitting entire fleet with fuel-economy meters alone would cost several billion dollars
5. Assuming change is from 50% load factor to 70% load factor.
6. Will require changes to air traffic control procedures and equipment.
7. Preliminary FAA study indicates that the value of the fuel savings would defray capital and operating costs of tow vehicles

TABLE 2

CONSERVATION MEASURE EVALUATION MATRIX

Mode	Conservation Measure	1972 Base Consumption (Thousand Barrels per day)	Potential Saving Volumes* 1974 (Thousand Barrels per day)	Potential Saving Volumes* 1978 (Thousand Barrels per day)	Implementation Values: Methods & Incentives	Implementation Values: Relative Time?	Implementation Values: Relative Costs	Impact Factors & Relative Values§: Social	Impact Factors & Relative Values§: Economic	Impact Factors & Relative Values§: Political	Impact Factors & Relative Values§: Environment	Relative Public Acceptance	Feasibility Factor –Overall–
Highway	A. Passenger Cars												
	1. Car-pooling (To & From Work)	1,832·	92	325	Priority parking, reduced tolls, tax deductions, insurance discounts, employer subsidies, etc	Reasonably short 3	Low 3	Loss of independence, privacy, flexibility, status, etc 1	Longer commuting time loss of revenue to business and government, lower auto sales, lower commuting costs 2	Negligible 2	Less pollution, congestion, & noise, reduced land requirements for roads & parking lots 4	1	16
	2. Travel Characteristics a. Driving Restrictions	3,593	38	46	Auto use restrictions as auto free zones, reduced parking, higher parking rate & tolls, special permits, etc.	Moderate 2	Low 3	Arbitrary nature, loss of personal freedom, discriminatory, changed locations of work & shopping centers 1	Shift of sales patterns higher motoring costs, increased government revenues (tolls, taxes, etc.), reduces low efficiency city driving 2	Requires legislative action 1	Cleaner & less congested cities. Causes more urban sprawl 2	1	12
	b. Four-Day Work Week	2,267	102	125	Employer Options	Reasonably Short 3	Low 3	More leisure time 3	Increased sales of recreational equipment 2	Negligible 2	Reduced congestion & pollution; greater demands on recreational areas 2	[illegible]	17
	c. Walking & Bicycling	850	?	40	Auto disincentives and creation of bicycle & walkways	Substantial 1	Moderate 2	Improved health, increased local awareness, higher accident potential 3	More or less travel time depending on distance & congestion, limited hauling capacity, lower demand for cars 2	Significant implementation requires legislation 2	Reduced pollution & congestion. 3	[illegible]	16
	d. Driver Behavior	5,425	57	70	Driver education & efficiency monitoring devices	Moderate 2	Low 3	Negligible 2	Negligible 2	Government programs & encouragement would be helpful 2	Negligible 2	[illegible]	15
	3. Speed Limits	5,425	168	190	Government Mandate	Immediate 3	Moderate 2	Balance of safety factors, longer driving time vs. lower fatality & injury rates 2	Cost in terms of lost time vs. lower driving costs and lower costs associated with reduced fatality & injury rates 2	Unclear 2	Negligible 2	1	14
	4. Auto Design	4,757	0	236	Economic incentives or mandate	Moderate 2	Moderate 2	Negligible 2	Lower driving costs, higher cost of cars 2	Legislative action might be required 2	Negligible 2	[illegible]	15
	5. Vehicle Maintenance	5,425	142	174	Mandatory requirements or educational programs	Immediate 3	High 1	Discriminates against low income group. Possible safety improvement 1	Higher maintenance cost vs. lower fuel consumption. Increased revenues for auto maintenance industry 2	Legislative action might be required 1	Less pollution 3	1	17
	6. Vehicle Changes (Small Cars)	4,757	73	361	Economic incentives: efficiency or fuel taxation, educational programs	Moderate 2	Moderate 2	Reduced safety 2	Lower driving costs, improve balance of payments, employment and production curtailment during conversion 2	Legislative action might be required 2	Less pollution, lower resource requirements 3	[illegible]	16
	7. Emission Standards and Lead Phasedown	6,164	0	280	Government Mandate	Immediate 3	Negligible 3	Possible adverse health impact 2	Lower driving cost via improved fuel efficiency, lower refining investment & costs, lower cost cars; Higher costs due to pollution 3	Requires legislative action 2	Higher initial levels of pollution 1	[illegible]	16
	8. a. Mode Shifts (From Cars) 1. Urban Bus	4,757	0	33	Auto disincentives; bus lanes; encouragement of greater bus production and scheduling improvements; government subsidies.	Moderate 2	High 1	Loss of independence & flexibility, privacy, status, etc. –greater safety. 2	Longer commuter time & lower costs; lower auto sales; loss of revenues to business & government 2	Subsidies and operating priorities (bus lanes) would require legislation. 3	Less pollution, congestion & lower parking needs 4	[illegible]	15
	b. Intercity: Bus / Train / Air		0 / 0 / 0	31 / 15 / 38	Government policies for encouragement and subsidies, especially for train service, auto disincentives (tolls & taxes), improved service	Bus · Moderate 2 / Train · Long 1 / Plane · Short 3	Bus · Moderate 2 / Train · High 1 / Plane · Low 3	Increased safety, loss of convenience & flexibility on arrival.	Loss of time (except air), expansion would create jobs, lower car sales & associated revenues	Subsidies & disincentives require legislation.	Less pollution, congestion	Bus [illegible] / Train 1 / Air [illegible]	Bus 16 / Train 13 / Air 18

REFERENCES

Australian Transport Advisory Council (1978), Transport and Energy Overview, Issued by Commonwealth/State Transport Secretariat, Dept. of Transport, Canberra, Sept 26, 1978.

Charles River Associates (1976), Price Elasticity of Demand for Transportation Fuels, Report prepared by Charles River Associates (Cambridge, Massachusetts) for the Office of Transportation Research, Federal Energy Administration, Washington, D.C.

Christie, B. (1974), Telecommunication: An alternative to the business trip?, Communications Studies Group, University College of London and London School of Economics (unpublished).

Connell, S. (1974), The 1973 Office Communication Survey, Communications Studies Group, Joint Unit of Planning Research, University College, London.

Day, L.H. (1973), "An assessment of travel/communications substitutability", Futures, October.

Edwards, J.L. and Schofer, J. (1976), "Relationships between transportation energy consumption and urban structure: results of simulation studies". Transportation Research Record 599, TRB, National Academy of Sciences, Washington, D.C.

Ford Foundation (1975), The Energy Conservation Papers, A Report of the Energy Policy Project of the Ford Foundation edited by Williams, R.H., Ballinger Publishing Company, Cambridge, Mass.

Gilbert, G. and Dajani, J.S. (1974), "Energy, urban form and transportation policy", Transportation Research, Vol.8, 267-276.

Graves, J.W., for Bureau of Transport Economics (1978), Urban Passenger Travel: the role of the electric car. AGPS, Canberra.

Hamilton, R.B. (1978), "Mobility and the individual", Paper presented to Society for Social Responsibility in Science National Conference on Energy and People - Social Implications of Different Energy Futures; Canberra 7-9 Sept 1978.

Harkness, R.C. (1973), "Communication innovations urban form and travel demand: some hypotheses and a bibliography". Transportation Vol.2, No.2, 153-193.

Hartgen, D.T.(1975), Individual Travel Behaviour Under Energy Constraints. Preliminary Research Report 86, Planning Research Unit, New York State Department of Transportation, Albany, July.

Hensher, D.A. (1977a), "Re-opening the Tasman Bridge: The effect on mode and route of travel for East-West travel". Research Paper No. 144, Macquarie University, School of Economic and Financial Studies, North Ryde, New South Wales, July.

Hensher, D.A. (1977b), "Formulating an urban passenger transport policy: A re-appraisal of some elements - accessibility, energy and urban form", Research Paper No. 151, Macquarie University, School of Economic and Financial Studies, North Ryde, New South Wales, November.

Hensher, D.A. and Bullock, R. (1977), "Price elasticity of commuter mode choice: effect of 20 percent fare reduction". Research Paper No. 149, Macquarie University, School of Economic and Financial Studies, North Ryde, New South Wales, October.

Institution of Engineers, Australia (1977), Recommendations for An Energy Policy for Australia. Including the Working Papers of the Task Force on Energy discussed at the Conference on Energy, Canberra July 1977, Special Publication, October 1977.

King, K. (1977), "Transport Energy: South Australian Options, 1975-2000", Energy Discussion Paper No. 1, Centre for Environmental Studies, University of Adelaide and South Australian Department of Mines. (Second Edition, March 1978).

Kneebone, D.C. and Wilkins, J.K. (1977), "Energy conservation and transport", Report of Working Party 9 of the Task Force on Energy in Recommendations for an Energy Policy for Australia, Institution of Engineers, Australia. Special Publication, October.

McGillivray, R.G. (1976), "Gasoline use by automobiles", Transportation Research Record 561, Transportation Research Board, National Research Council, Washington D.C.

Mogridge, M.J.M. (1978), "The effect of the oil crisis on the growth in ownership and use of cars", Transportation, Vol. 7, No.1, 45-68.

New South Wales Traffic Authority (1977), Car Pooling on a Geographical Basis, Rosebery, N.S.W., June

Nicholas Clark & Associates (1975a), Transport and Energy in Australia, Part 1 - Review, Report prepared for the Bureau of Transport Economics (Occasional Paper 2) June, AGPS, Canberra.

Nicholas Clark & Associates (1975b), Transport and Energy in Australia Part 2 - Consumption by Categories, Report prepared for the Bureau of Transport Economics (Occasional Paper 4) August, AGPS, Canberra.

Orski, C.K. (1974), the potential for fuel conservation: the case of the automobile", Transportation Research, Vol.8, 247-258.

Owen, W. (1976), "Transport, energy, and community design" Futures, Vol.8, No.2.

Peskin, R.L., Schofer, J.L. & Stopher, P.R. (1975), The Immediate Impact of Gasoline Shortages on Urban Travel Behaviour, U.S. Department of Transportation, April.

Sacco, J.F. and Hajj, H.M. (1976), "Impact of the energy shortage on travel patterns and attitudes", Transportation Research Record 561.

Schou, K. (1978), "Energy and Transport: strategies for energy conservation in urban passenger transport", Research Paper No. 173, Macquarie University, School of Economic and Financial Studies, North Ryde, New South Wales, August.

Schou, K., and Johnson, L.W. (1978), "The short-run price elasticity of demand for petrol in Australia", School of Economic and Financial Studies, Macquarie University, North Ryde, N.S.W. (unpublished)

Skinner, L.E. (1975), The Effect of Energy Constraints on Travel Patterns: Gasoline Purchase Study, U.S. Department of Transportation, July, 1975.

Stuntz, M.S. Jr. and Hirst, E. (1976), "Energy conservation potential of urban public transit", Transportation Research Record 599.

Transportation Research Board, Executive Committee (1976) "The ten most critical issues in transportation", Transportation Research News, No.67, Nov-Dec.

Transportation Research Board (1977), Energy Effects, Efficiencies, and Prospects for Various Modes of Transportation, National Co-operative Highway Research Program, Washington, D.C.

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