SOME POSSIBLE IMPLICATIONS OF RISING PETROLEUM FUEL PRICES FOR ROAD TRANSPORT

J.E. LANE

ABSTRACT: *In this paper consideration is given to some of the possible implications for private automobile travel of Australia adopting import parity pricing for domestic oil and placing an increasing reliance on imported oil supplies, over the next 10-15 years. At the national level anticipated increases in the oil bill and foreign exchange requirements could lead to government policies with significant transport implications. For households rising petrol prices are likely to have their main aggregate effect upon recreational travel. However, of potentially far greater significance are the disaggregated effects upon lower income groups, especially those dependent upon cars for mobility.*

1. INTRODUCTION

Since October 1973 world crude oil prices have risen dramatically through the Organisation of Petroleum Exporting Countries (OPEC) cartel exerting its market power as a supplier (see Fig 1). The repercussion of such price rises have been felt throughout the world and have led to a general reappraisal of most national energy policies.

During this period Australia has received a fair degree of protection through her large indigenous oil reserves (currently supplying some 65% of market demand; see Fig 5), and the maintenance of a domestic pricing policy set under 1970 conditions.

Over the next 10 to 15 years, however, the situation is expected to change considerably requiring Australia to react to the prospects of:-

(a) accommodating a revision of domestic oil prices to parity with world markets; and

(b) the exhaustion of known recoverable reserves of indigenous oil.

The inevitability of these events and the long lead times required for reaction, highlights the need for co-ordinated energy policies throughout the economy. The road transport sector is almost exclusively dependent upon petroleum as a vehicle fuel with very little potential for easy substitution, and is therefore, particularly vulnerable.

Here we first consider the implications at an aggregate level of developing an increased reliance on imported oil, and then set up a framework for considering specific transport implications of rising fuel costs at the household level.

Largely as a result of the biases inherent in presently available information (particularly that from overseas) the implications of rising fuel costs upon private automobile travel in urban areas form the major part of this paper.

2. BASIC FRAMEWORK AND ASSUMPTIONS

2.1 ALTERNATIVE FUEL AND ENGINE TECHNOLOGIES

From a review of available literature (Lane (1976), and Jet Propulsion Laboratory (1975)) it is considered that during the next 25 years road vehicles will continue to be powered by combustion engines* running on liquid petroleum fuel† (i.e. motor spirit, distillate, etc.) derived from:-

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* Many changes are likely to be made in vehicle design over this period to improve overall fuel efficiency. In addition greater use will probably be made of the thermally more efficient stratified-charge and diesel internal combustion engines, together with the eventual introduction (by approximately 1990) of an external combustion engine such as the Stirling or Brayton. Electric vehicles are unlikely to penetrate the automobile market despite likely advance in battery technology.

† The major alternatives would appear to be methanol (from coal), ethanol (from vegetable matter), or hydrogen. Given the availability of oil [including syn-crude from coal] there is unlikely to be any major incentive to adopt alternative fuels on a wide scale before the end of this century.

(a) imported supplies of oil;

(b) known remaining domestic reserves of oil;

(c) yet-to-be-discovered indigenous oil; and/or

(d) domestic coal supplies.

2.2 FUTURE OIL PRICES

Domestic oil pricing policy is now under review by the Australian Government following reports presented by the Industries Assistance Commission (IAC) (1976) and the Royal Commission on Petroleum (1976). It is already government policy that new discoveries of oil and major expansions to existing fields be subject to import parity pricing so as to encourage exploration. The IAC report recommends a gradual trend towards import parity pricing by 1985 for today's major source of oil, Bass Strait. The final 400 x 10^6 bbls of known reserves are likely to prove uneconomic without such a move to import parity pricing. In addition with the need to generate investment capital to fund oil exploration and/or the commercial development of oil-from-coal it is considered that a move to full import parity pricing by the end of 1985 is entirely realistic. (The division of the import parity price between government and producer is not an issue of concern here.)

World market prices will largely depend upon the solidarity of the OPEC cartel, and the particular policies they pursue. The latest round of oil price rises was marked by the decision of Saudi Arabia and the United Arab Emirates (UAE) to adopt only a 5 per cent price rise (as opposed to 10½ per cent); however, the price of Saudi Arabian light crude is now showing a 9½ per cent increase on its previous level, indicating the likely future solidarity of OPEC.

As a lower bound it has been assumed that the real price of oil will be maintained at its current levels. As an upper bound OPEC could well 'tax' the economic growth of the industrialised west (given its recovery) through increasing the price of oil towards the price of its closest substitute. For Australia this would be syncrude from brown coal costing about A$16/bbl at December 1975 values. Fig 1 summarises the likely trends in future oil prices, whilst Fig 7 illustrates the implications of such pricing policies upon the future retail price of petrol.

2.3 FUTURE ENERGY DEMAND

At the broad level of concern at issue here the two major factors likely to influence future energy demand are:-

(a) population growth; and

(b) the level of economic activity.

Australian population growth has tended to decline over the past decade. Between 1966 and 1971 the average rate of growth was c 1.7 per cent per annum, whilst between 1971 and 1976 this had fallen to c 1.25 per cent per annum. The single most important factor in this reduction was the decline of permanent immigration (falling from 185 000 in 1970 to c 45 000 in 1975). Envisaging a return to more normal immigration patterns (c 80 - 100 000 per annum per annum) it is anticipated that future population growth will be

between c 1.7 per cent (after C.B.Rds projection of 1973) and c 1.25 per cent (i.e. the 71-76 intercensal growth); see Fig 2.

Forecasts of future economic activity are also subject to large possible variations and again two options are considered. As a minimum growth option it is assumed that in order to return to satisfactory levels of unemployment and reasonable economic stability an average rate of growth in Gross Domestic Product (GDP) of 3 per cent per annum will be required. (This figure has been derived from the lower population growth rate of 1.25 per cent plus an assumed average rate of growth of GDP per capita of 1.72 per cent*).

A more optimistic forecast of economic conditions can be derived from Department of Minerals and Energy (1975) forecasts of demand for primary energy, plus extrapolation for the period 1985-2000 based on an average rate of growth in GDP of 4.9 per cent per annum.†

Fig 3 depicts past trends in the amount of energy consumed per $GDP (at constant 66/7 prices). The historical upward trend of MJ/$GDP is likely to level off under the natural market pressures of rising energy costs (particularly petroleum fuels) and stabilisation of the rural sector of the economy. However, if strong government policies of energy conservation are introduced (e.g. grants for home and factory insulation, or energy pricing policies aimed at discouraging rather than encouraging consumption at the margin) there is some potential to improve industrial energy utilisation without seriously detracting from the rate of economic growth. The assumed maximum potential of industrial conservation policies is indicated in Fig 3 (the basis for this trend line is drawn from Chapman (1976)).

To summarise there are three alternative 'futures' considered to be of relevant interest:-

A = a 3 per cent per annum average growth in GDP with a 1.25 per cent per annum average growth in population;

B = a 4.9 per cent average growth in GDP with a 1.7 per cent per annum average growth in population; and

C = as for A but assuming strong government policies on energy conservation in industry.

These projections are shown in Fig 4, together with the contribution of the various primary energy sources to this total demand. (Note: the contribution of petroleum fuels to total energy demand is expected to decline from 49.1 per cent in 1973-4, to c 40.5 per cent by 1984-5 and c 36.6 per cent by the end of this century: Department of Minerals and Energy (1975), plus own estimates).

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* This figure was derived from consideration of changes in GDP/capita and non-form GDP/capita at constant 1966-67 prices between 1963-4 and 1975-6.

† It should be noted that no specific reference is made to rates of economic or population growth in Department of Minerals and Energy (1975). However, population estimates supplied by the CBRds were used in predicting motor spirit demand and these are assumed to hold for other estimates of energy demand. From the inter-relationships between energy consumption and growth in GDP (see Fig 3) a figure of 4.9 per cent per annum has been deduced for the average rate of growth in GDP.

From these projections of petroleum fuel demand (Fig 4) and also non-fuel demand (Department of Minerals and Energy, (1975)) estimates of crude oil demand have been derived and are shown in Fig 5. These projections take into account the assumed trend towards saturation levels of per capita vehicle ownership as shown in Fig 10. Table I illustrates how the market demand for petroleum products is structured at present, and how this could be expected to change in the future. The road transport sector now accounts for some 40 per cent of total petroleum demand in the form of vehicle fuels; though this is expected to rise to about 44 per cent by 1990 (primarily because of substitution between natural gas and oil as an industrial fuel) and then decline to about 41 per cent by the end of the century due to the assumed trend towards saturation of vehicle ownership levels (see Table I).

2.4 FUTURE SUPPLIES OF PRIMARY FUELS

Table II summarises the domestic situation as regards known reserves of primary fuels and their anticipated consumption over the period 1975-2000. As such the 'energy crisis' is centred upon the near-term depletion of known petroleum reserves and the longer-term problem of natural gas supply limitations by early next century.

In order to meet the shortfall of domestic production compared to demand (see Fig 5) it will be necessary to undertake one or more of the following:-

(a) increase oil imports;

(b) step-up exploration activity within Australia; or

(c) develop oil-from-coal technology commercially.

Figs 5 and 6 indicate the potential of future exploration in Australia. The development of oil-from-coal technology to a commercial scale is likely to take at least 15 years and a substantial capital investment program. For instance, if oil-from-coal is to contribute, say, 250 x 10^6 bbls to total demand by the end of this century then coal output would have to increase from 60 Mt (in 1975) to around 205-285 Mt and some fourteen 50 000 bbls/day coal refineries would have to be constructed at a capital cost of around A$500-800 M each (in 1975 values). A more realistic possible contribution of 55 x 10^6 bbls by the end of this century is depicted in Fig 5.

The final alternative, increasing oil imports, requires the least capital investment but does place Australia in a vulnerable position in the event of supply restrictions. Global supplies of oil are, however, unlikely to run into natural supply limitations until around 2025.

In summary the next 8-10 years will see an increasing reliance on oil imports to bridge the short fall between domestic supply and demand. Beyond 1985 a successful exploration programme offers the best potential for reducing dependence on imported oil, with oil-from-coal unlikely to become a major contributor until into the next century. Without future discoveries or the development of oil-from-coal Australia will become completely dependent upon oil imports by 1995.

3. SOME NATIONAL IMPLICATIONS

As domestic oil moves to world price parity and there is increased reliance on imported oil, an increasing proportion of Gross National Expenditure (GNE) will be devoted to the purchase of oil coupled with a significant rise in foreign exchange requirements*. (Projected trends in such factors are outlined in Table III and Fig 8).

If a larger proportion of GNE is diverted to the oil bill a corresponding amount would have to be diverted from other areas of the economy. For the road transport sector it would seem reasonable to assume that capital investment funds will continue to be tight for some years to come; thus increasing the emphasis to be placed on low-cost and traffic management options in transport investment.

From a consideration of the likely national economic consequences† it would appear that of the alternative futures considered for Australia, option AIII§ seems to be the most probable with CIII indicating the potential of industrial energy conservation policies.

Beyond 1990 the strong potential influence of future oil discoveries within Australia can be seen. However projections over such a time period are subject to wide sources of variation and are only relevant under the *cater*

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* A stable balance-of-payments situation is seen to be of particular importance to orderly economic expansion. For long-term stability any major increase in the oil import bill will need to be matched by a compensating increase in export revenues, or a decrease in other import demands, or a combination of the two. It has been suggested (Economic Research Unit (1975)) that all Australia needs to do is increase coal export revenues to fund oil imports. This is probably an unduly simplistic solution to a problem which is more likely to pivot upon a major expansion of the domestic manufacturing industry to reduce the substantial levels of imports in that area. These broader implications could have significant feedback effects upon the transport sector (e.g. Brazil's programme of phasing in alcohol as a transport fuel received considerable impetus from the need to reduce the oil import bill to enable continuing economic expansion) and should be taken into account. For Australia this may mean further pressures for devaluation, and hence higher imported oil prices.

† Some mention has been made of potential balance-of-payments problems. Other significant implications will include a dampening effect upon the supply of job opportunities through a diversion of resources to oil purchase, and the contribution of increased oil prices to domestic inflation and relative price movements. Consideration of such factors is beyond the scope of this paper but may well be of significance to the road transport sector. Brief coverage of such factors is given in Industries Assistance Commission (1976).

§ Option AIII refers to the situation where the average rate of growth in GDP between 1976 and 2000 is 3 per cent per annum, the average population growth is 1.25 per cent per annum (i.e. future A) and the price of imported oil f.o.b. rises at 1.5 per cent per annum in 1975 money values. Option CIII is as for AIII but taking into account the assumed maximum contribution of industrial energy savings. Options AI and CI are as for AIII and CIII but with a constant price of imported oil f.o.b., at 1975 money values.

paribus assumptions made. For instance the potential contribution of solar energy cannot yet be realistically assessed from publicly available data, although the long term prospects seem to be rapidly improving.

4. IMPLICATIONS AT THE HOUSEHOLD LEVEL

4.1 PROJECTIONS OF HOUSEHOLD INCOME AND EXPENDITURE

It is of basic interest to assess the likely influence of rising petrol prices upon the behaviour of individual motorists and households.

In this section the basic unit of interest is the household as the micro-scale consumer. Projections of the number of households and persons per household are given in Fig 2, based on census data for 1961-76. In estimating total household disposable income (HDY) consideration has been given to the historical division of the 'economic cake' (GDP) between 'labour' and 'capital'. Although fluctuations have been observed in the ratio (HDY/GDP) due to prevailing economic conditions it is felt that under futures A and C a stable long-term trend can be assumed, (HDY/GDP = .684). The average propensity to consume for households is also depicted in Fig 9, and again the stability of this parameter is assumed as a long-term trend. (Private Final Consumption Expenditure (PFCE)/HDY = .875).

This set of assumptions and projections allows us to simplistically determine the aggregate implications of individual household behaviour patterns, and also to consider how general policies may in return influence or constrain household expenditure patterns.

4.2 PRIVATE VEHICLE OWNERSHIP, USE AND FUEL CONSUMPTIONS

Consumption of motor spirit by households will depend upon:-

(a) the stock of vehicles in use;

(b) the efficiency of their operation (in terms of vehicle km/litre and passenger km/litre); and

(c) the level of utilisation (vehicle-km of travel).

Projections of major factors in these three areas have been derived from a review of available information*, and are summarised in Fig 10. The

* Estimates of vehicles per capita were derived from consideration of similar projections (Economic Research Unit (ERU) (1975), Bureau of Iransport Economics (BIE) (1976) and Commonwealth Bureau of Roads (CBRds) (1975); taking account of the assumptions made where stated. From the population projections adopted in Fig 2 estimates of vehicle stocks were derived, Projections of kms of travel per vehicle were developed (using CBRds (1975) and Commonwealth Bureau of Census and Statistics (CBCS) (1973) which took into account the expected rising costs of vehicle operation. Average fuel consumption for private vehicles was derived (from ERU (1975) and CBCS (1973), taking account of the recent trends in the new vehicle market towards smaller engined cars. Information on the turnover and scrappage rates of vehicles stocks was derived from Thoresen (1977) whilst petrol price estimates were derived from Fig 7.

estimates of overall petroleum demands given earlier (e.g. see Fig 5 and Table I) are consistent with these projections.

By supplementing such information with estimates of the proportion of vehicle operating costs attributable to fuel consumption (from Australian Bureau of Statistics (ABS) 1976*a*; and RACV figures) it is possible to project household expenditure upon both the operation and purchase of motor vehicles (hopefully in a compatible form with the time series aggregate household expenditure information, obtained from ABS (1976*b*) and summarised here in Table IV). Although such estimates are derived via a chain of assumptions and estimates it is felt that they are reasonably realistic.

4.3 EFFECTS OF AGGREGATE HOUSEHOLD EXPENDITURE PATTERNS

Upon consideration of Table IV it would seem that, at the national aggregate level, the trend in proportion of household disposable income devoted to the purchase and operation of motor vehicles is not expected to change substantially in the future. Rather there will be a gradual increase in the proportion from present day levels to those typical of the 1968-71 era by 1985-86 followed by a return to the gradual downward trend.* Such aggregate variations are typically within the fluctuations experienced in household savings and could reasonably be expected not to significantly affect aggregate consumption patterns overall. Of particular interest is the fact that the proportion of vehicle costs (purchase plus operational) attributable to fuel purchase is likely to rise from 25 per cent in 1975-76 to 33-34 per cent in 1999-2000 (see notes to Table IV).

The projections of vehicle utilisation (expressed in kms of travel per vehicle) shown in Fig 10 have been derived taking into account gradually rising motoring costs, post 1975 (see Fig 11). Forecasts of overall petroleum demand, as shown in Fig 5, have been derived taking the associated demand for motor spirit into account. From Table IV we envisage that available household disposable income will be sufficient, in aggregate, to support projected overall motoring expenditures. Thus, for governments to reduce overall petroleum demand even further will require the pursuit of a range of petroleum fuel conservation/substitution policies. Such policies could have significant direct implications for the road transport sector; e.g. a reduction in rural speed limits (after the 55 mph compulsory speed limit in the USA, or the temporary 50 mph speed limit in the UK) or the increased policing of present limits, or changes to the methods of collecting taxation from motorists (from taxes on vehicle ownership to vehicle use). In the medium-term, however, the greatest potential for conserving petroleum would appear to lie in the reduction of non-transport uses, most likely through natural gas substitution. Fig 4 illustrates the impact that increased natural gas use has already had, and is predicted to have, on petroleum demand; though Table II indicates that such policies can only be considered as 'stop-gap' with the eventual supply constraints on natural gas.

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* If the assumed trend towards 'saturation' levels for vehicle ownership per capita does not eventuate and is replaced by a linear extrapolation of the 1980-1985 projections, then the proportion of HDY devoted to the purchase of vehicles is estimated to be 6.44 per cent (1989-90), 6.38 per cent (1995-6) and 6.25 per cent (1999-2000), whilst that for the operation of motor vehicles is expected to be 3.86 per cent (1989-90), 3.72 per cent (1995-6), and 3.59 per cent (1999-2000). Overall, therefore, motor vehicles would be expected to absorb 9.84 per cent of HDY in 1999-2000.

4.4 DISAGGREGATE HOUSEHOLD EFFECTS

Although it is not considered that rising petroleum fuel costs will have a serious retarding impact upon household expenditure patterns in aggregate, there may well be substantial distributional implications. A detailed analysis of household expenditure patterns at a disaggregated level has been undertaken by Morris (1977) and so only a brief consideration is given to this aspect here.

Intuitively we would expect lower income groups to own older (less fuel efficient) and cheaper cars, spend less on insurance (e.g. third party fire and theft cover as against fully comprehensive insurance), and tend to carry out more vehicle maintenance themselves. As a result we would anticipate that fuel purchase would be a more significant proportion of motoring costs. Further we would expect low income households to use their vehicles predominantly for 'essential' (to the household) travel purposes; with discretaionary or non-essential travel being more a function of disposable income. Table V gives a detailed breakdown of patterns of household expendiutre on various aspects of transport and communication, by income group. An important factor not covered in this table is the amount of 'free' travel enjoyed by higher income groups through the provision of company cars (see Morris (1977)).

From the above we would expect a given rise in petrol prices to have a proportionally greater impact upon lower income households; particularly as they may be the group least able to reduce their motor vehicle usage. It is therefore very likely that equity considerations will have to be given special attention in the application of any general policies to reduce petroleum consumption.

As a potential basis for distributional considerations it is likely that detailed analysis of cross-elasticities in expenditure patterns and time usage constraints in household behaviour will become an increasingly important tool for transport and public policy planning. As such, there will be a need for regular cross-sectional surveys of family income and expenditure (adding to the 1966-68 survey, Podder (1971), and ABS (1976*a*)), which could be supplemented by time series national aggregate data on household expenditure (from ABS 1976*b*) provided some consistency between the two data sets could be developed. (Recognising the future importance of household expenditure and time budget analysis ARRB is considering initiating research in this area).

5. POLICY OPTIONS FOR REDUCING PRIVATE AUTOMOBILE PETROL CONSUMPTIONS

With the increases envisaged in the oil import bill and domestic petrol prices it is likely that strategies will need to develop aimed at reducing petrol demand without detracting from the level of mobility achieved, or transport task performed.

In this final section the possibilities for the private automobile to become a more efficient (in energy terms) form of passenger transport are considered, both through individual behavioural response to changing travel costs and also through positive governmental policies.

5.1 BEHAVIOURAL RESPONSES TO RISING FUEL COSTS

Two main avenues of response are open to the individual motorist: one is to use his vehicle more efficiently either by improved driving habits and conditions

(e.g. smoother acceleration, reduced braking, obeying the speed limits, etc.), sharing vehicles, planning travel so as to develop linked trips, improving vehicle maintenance and carburettor adjustments (most vehicles 'run too rich' for maximum fuel economy), or else by reducing recreational or non-essential travel; and the second is to seek greater fuel efficiency when replacing a vehicle

The second option is already evident through the significant rise of the four cylinder car over recent years in the Australian new car market at the expense of V-8's. Further improvements in the fuel efficiency of cars will continue to be made through lighter and better designed car bodies, through engine redesign to reduce emissions by improving the efficiency of combustion*, through improved transmission systems, and also through a changing market preference for greater fuel economy in vehicles. Naturally such changes will take time to filter through the vehicle stock (see Thoresen (1977) and Transportation Research Board (TRB) (1975) pp 5-11) and will therefore have only a gradual impact. Possible negative side effects could include increased accident risk for lighter bodied cars (TRB (1975) pp 23-30) and traffic flow restrictions through slower accelerating vehicles.

An indication of behavioural responses in trip making patterns can be deduced from overseas data (particularly from the USA) documenting responses to the petrol price rises and shortages experienced during 1974-75 (see Stearns (1976), Atkinson (1975), Becker (1976), Behnam (1976), Hooper (1974), Sacco (1976) and McGillivray (1976)).

Overall it would appear that the fuel shortages and price rises had very little aggregate impact upon trip-making patterns after physical supply constraints had passed, although significant effects were noted at finer levels of detail (e.g. recreational trip rate decline).

For the journey to and from work very little overall response to increased fuel costs was noted. Car-pooling had an initial impact but over a period of time there appears to have been a gradual return to more 'normal' auto occupancy levels (Behnam (1976)). Similarly no significant permanent shift from the automobile to transit has been evident; however, there would appear to be a great deal of public support for transit investment for 'other people' to use (Sacco (1976)). Reported effects that were of great interest in the journey to work situation were at the lower income household level where a decrease in automobile use was matched by an increase in walking (see Stearns (1976) and Table VIII). Though this probably reflected the fact that many such households lived near their employment, it does show that the walking mode deserves a far greater degree of attention in future transport and land use planning. (The extent to which this would be appropriate under Australian conditions would need to be verified).

Trip purposes most responsive to fuel shortages or increased travel costs were shopping and recreational trips, and these changes could well reflect changes in the pattern of household activity as well as the mode used. For instance walking to local shops appeared to increase substantially over driving to local or more remote centres. Whilst recreational activity patterns appeared

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* There would seem to be a real danger of a decrease in the fuel efficiency of current model cars as a result of meeting current emission control regulations (ADR27A). This is only expected to be a temporary 'set-back' as the potential exists to redesign engines to meet emission regulation through an improved combustion efficiency (e.g. Honda's CVCC series motor).

to have altered so as to make greater joint use of automobiles, it would also seem (from Sacco (1976)) that staying at home (i.e. the 'no travel' option) contributed significantly to the reduction of automobile use for recreational purposes.

Various studies of the price elasticity of demand for petrol have derived elasticities around .10 for the journey-to-work and around .2 or higher for recreational travel (e.g. see Atkinson (1975), Hooper (1974), and McGillivray (1976). Table VII (drawn from Sacco (1976)) is perhaps indicative of how such petrol consumption reductions have been achieved, and show that it is in discretionary trip making (socio-recreational plus some shopping) that reductions are most likely.

Typically we would expect discretionary travel to be highly dependent upon household income. Lower-income households are therefore more likely to make trips of a largely 'essential nature'. In this respect rising fuel prices would centre upon the lower income households who have to retain much of their trip-making activity, whilst higher income households will have more flexibility to re-arrange trip patterns, and greater financial power to retain them if they wish. Time series family expenditure data is likely to provide a suitable basis for assessing such tendencies.

5.2 GOVERNMENT POLICIES

The prime thrusts for a passenger transport energy policy would appear to be best directed towards:-

(a) improving, or encouraging, the development of a more fuel efficient vehicle fleet (logically greater efficiency would also reduce emissions of pollutants);

(b) improving, or encouraging, the more efficient use of vehicles (e.g. promoting improved driving habits, relieving congestion and smoothening traffic flow, reducing upper speed limits (see TRB (1975) pp 20-22), introducing flexitime or staggered working hours on a wider scale, or restructuring motorist taxation); and

(c) cushioning the distributional effects of rising fuel costs upon lower income groups by either taxation policy or by providing more appropriate mobility services (e.g. flexible route minibuses, and a host of 'para-transit' options).

Policies aimed at reducing vehicle-miles-of-travel for urban area passenger travel (such as car-pooling, improved public transport, or employment location and land-use changes) must bear in mind consumer reaction to them in practice and the major capital costs sometimes involved. With regard to land-use and employment location there is likely to be very little potential to alter the existing form of urban investment. Already we are finding that urban development policies of 10-15 years previously are committing us to often highly inefficient urban travel patterns from an energy utilisation viewpoint. In this respect we need to be most careful about the futures that present land-use policies are committing us to.

Insufficient space is available to consider the energy-saving potential of such policies as 'improving public transport' or 'extending flexitime or staggered hours' (to relieve congestion). Such policies would tend to favour the CBD commuter, particularly if improving transit resulted in an expansion of existing services.

Car pooling is frequently put forward as an energy conservation policy. At present in Australia only about 5.3 per cent of petroleum consumption can be attributable to the urban area car commuting task (ERU (1975), and CBCS (1973)). An overall increase of 10 per cent in auto-occupancy would seem to be far beyond the potential of any likely car-pooling programme (car occupancy rates for the journey-to-work have exhibited a gradual downward trend in Australia, CBRds (1975) p 104). This would be equivalent to about a .6 per cent reduction in total petroleum demand. Evidence from the USA (e.g. see Becker (1976) and Behnam (1976)) would seem to indicate that the effect of car-pooling upon vehicle occupancy rates is more of a temporary phenomena and that many car-poolers revert to their previous mode of travel after a period.

As we anticipate that any reduction in trip-making is likely to centre on the area of recreational and social travel, it is probable that the journey-to-work peak problem will increase further in its relative importance for passenger transport planning. It is in this respect that car-pooling, land-use and employment location policies, flexitime, improved transit and other such policies will be of greatest relevance to Australia. Naturally this will imply significant indirect effects upon energy consumption by reducing the rate of increase that otherwise would have occurred.

6. CONCLUSIONS

The next 10 years will probably see Australia facing of necessity a move to world parity pricing for domestic crude oil and an increasing dependence on imported oil supplies.

The increases in petrol prices that this will bring are unlikely to have any marked effect upon the aggregate level of private automobile travel, although some concern is expressed over the likely distributional implications for lower income groups (with a lower proportion of discretionary trip making).

National economic considerations are likely to require the development of strong petroleum conservation policies; however, in the medium-term the greatest potential for conserving petroleum would appear to lie in the reduction of non-transport uses (most likely through natural gas substitution). These policies can only be 'stop-gap' in nature and will need to be supplemented by a major expansion of oil exploration and alternative fuel research (mainly into the commercial application of oil-from-coal and solar energy).

Higher and middle income groups are unlikely to significantly alter their trip making patterns in response to higher petrol prices, apart from some restructuring of their discretaionary recreational travel patterns. Thus, if petroleum conservation is to become a government objective, there will tend to be a greater onus placed upon car manufacturers to develop more fuel efficient vehicles so that the envisaged demand for personal mobility consumes less petrol.

Further, there could well be a substantial need to protect the mobility of lower income groups. This could be achieved through the provision of a more flexible public transport system, or a variety of other transport and non-transport policy options.

Finally, it is considered that in the future a detailed analysis of household expenditure patterns and time-budget constraints will provide a

highly important information base for transport and land-use planners.

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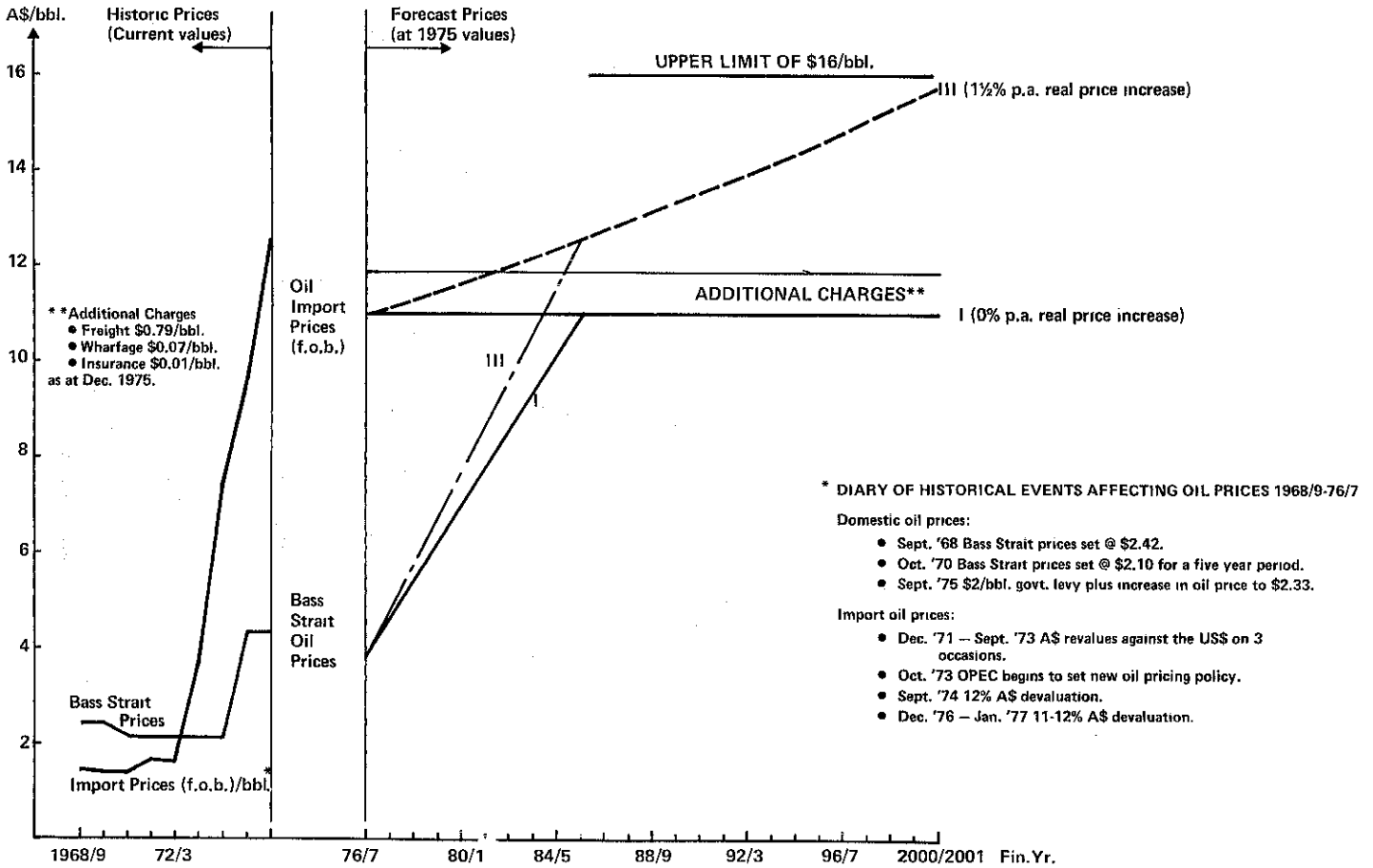


Fig 1 - Forecast oil prices (A$/bbl @ Dec 1975 values)

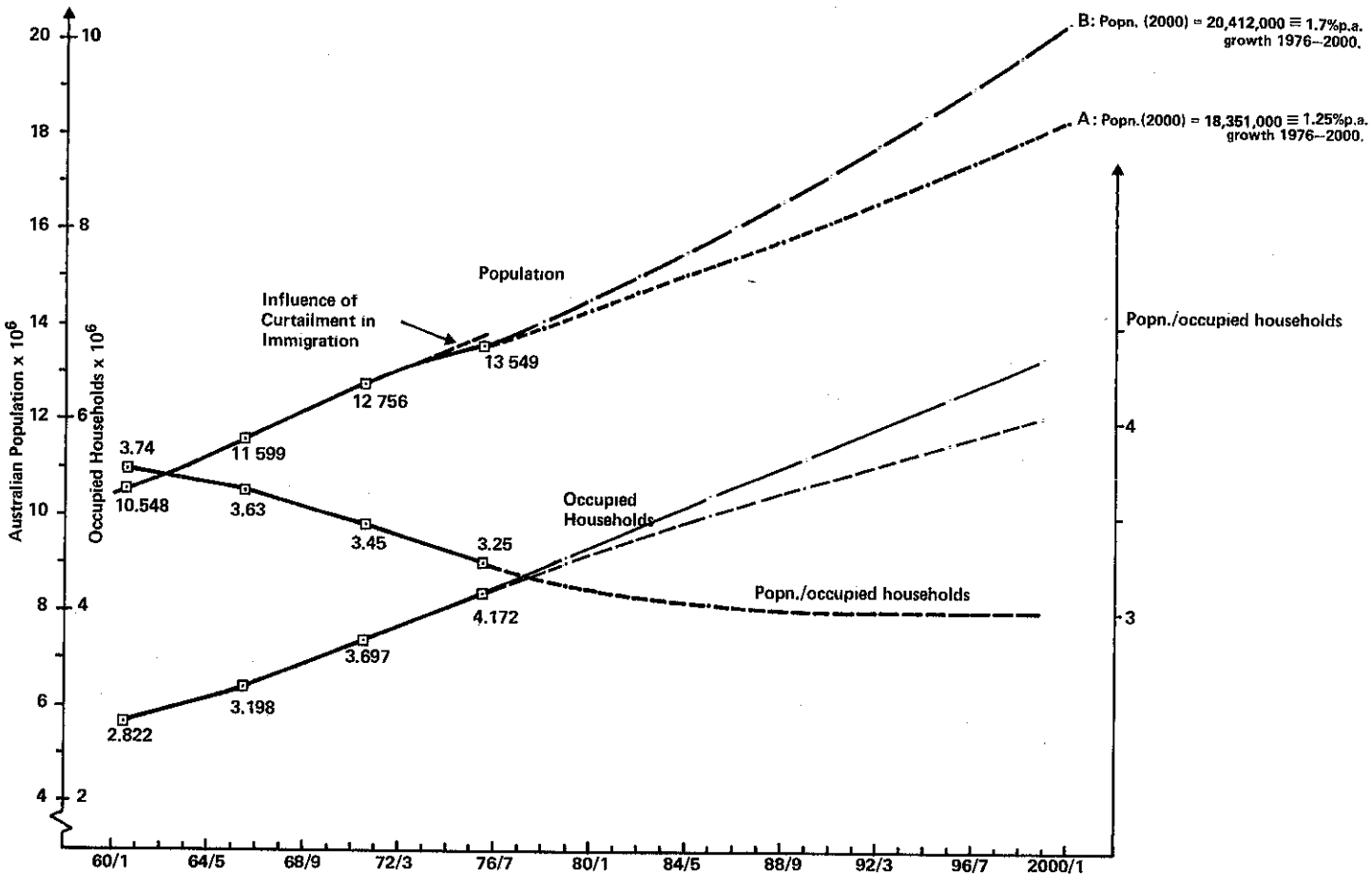


Fig 2 - Australian Population and Households. Source: Australian Census data plus own estimates.

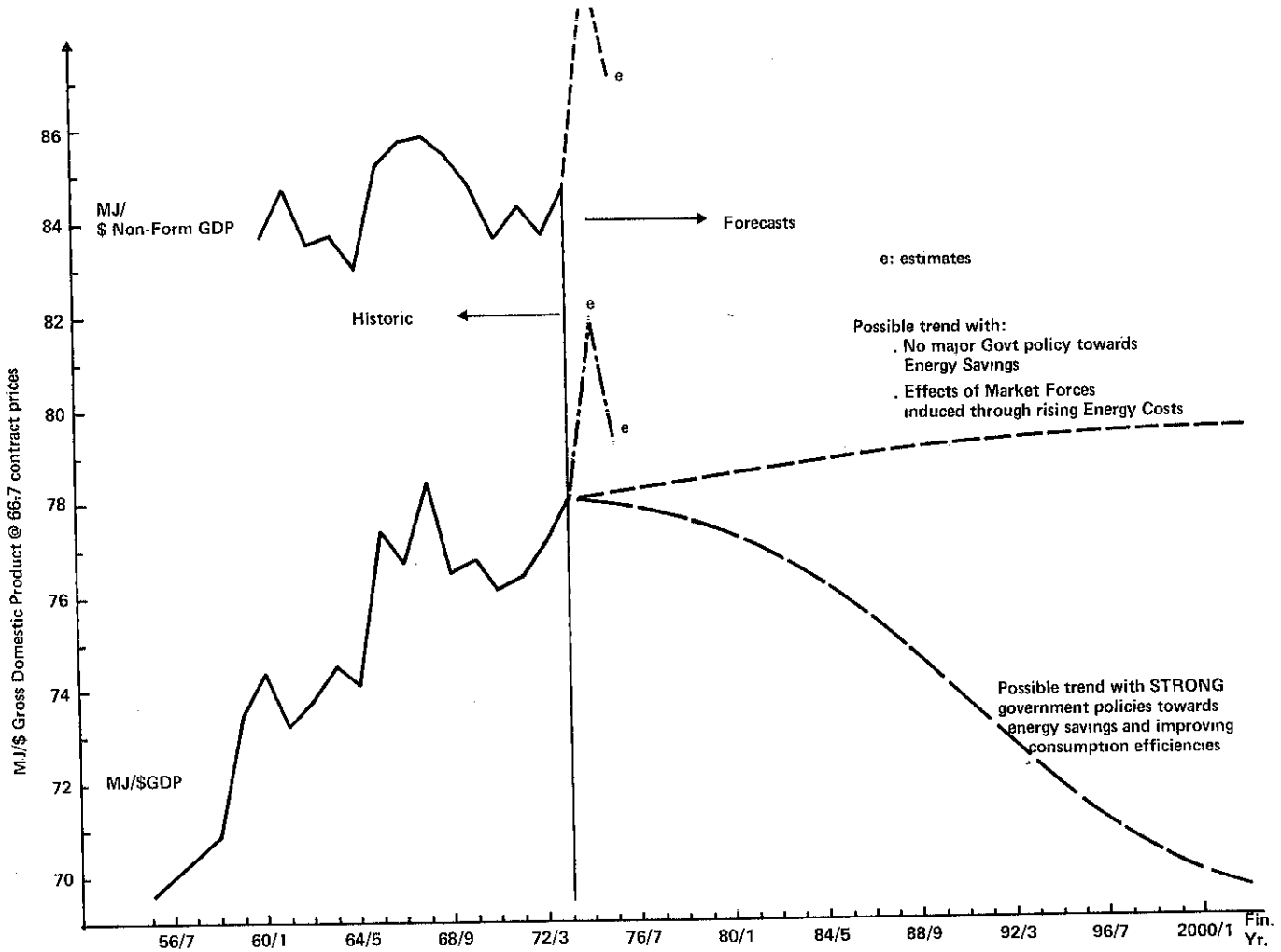


Fig 3 - Trends in the relationships between GDP and energy consumption.

Sources: ABS (1976 b,c), Clark (1975), and Dept. of Minerals and Energy (1975).

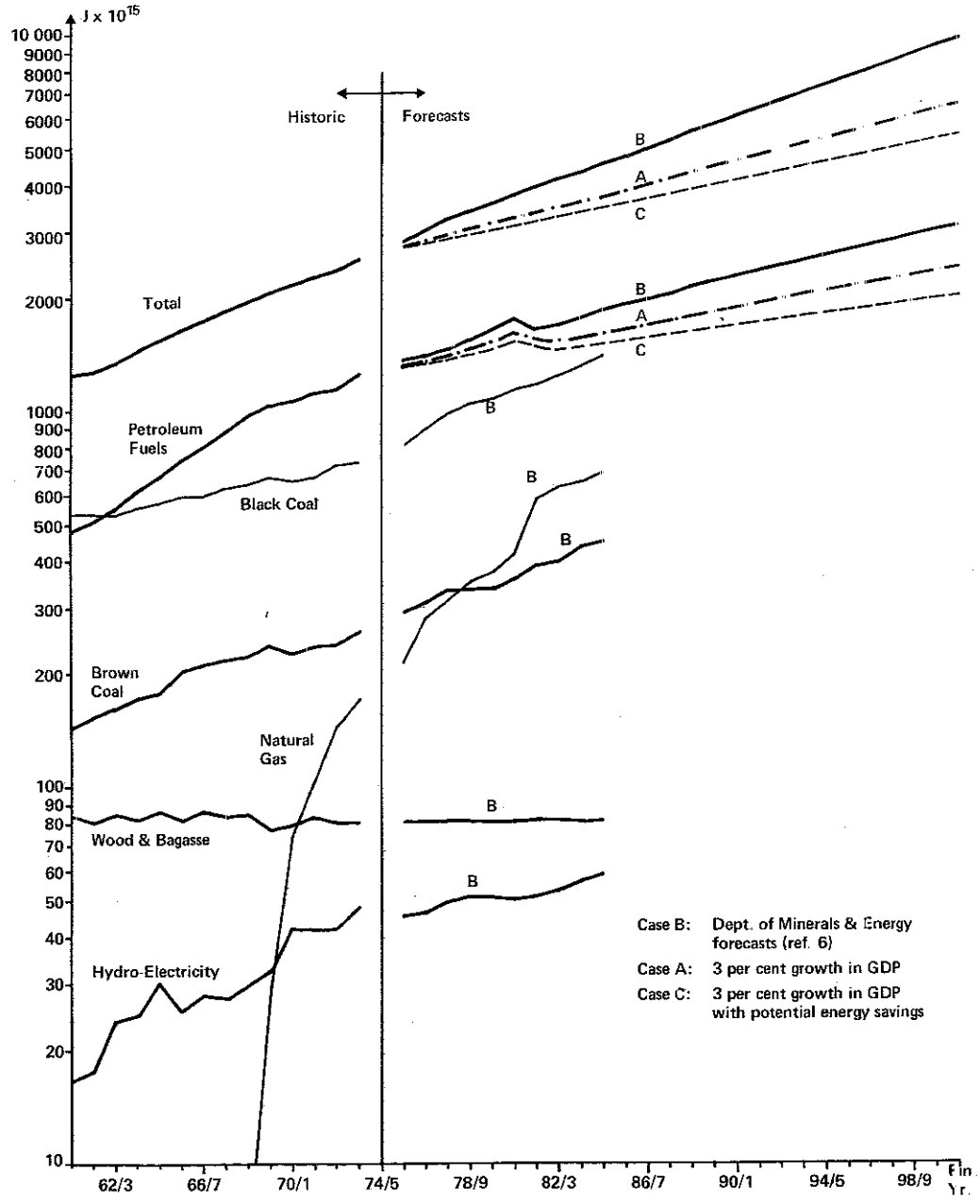


Fig 4 - Forecast Primary Energy demand for 1976 - 2000

Source: Department of Minerals and Energy (1975) plus own estimates.

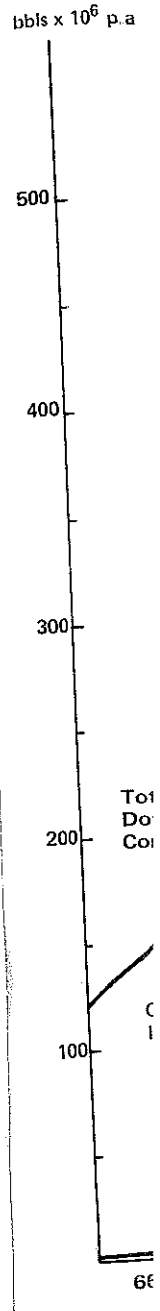


Fig 5
crude

Sour
Miner

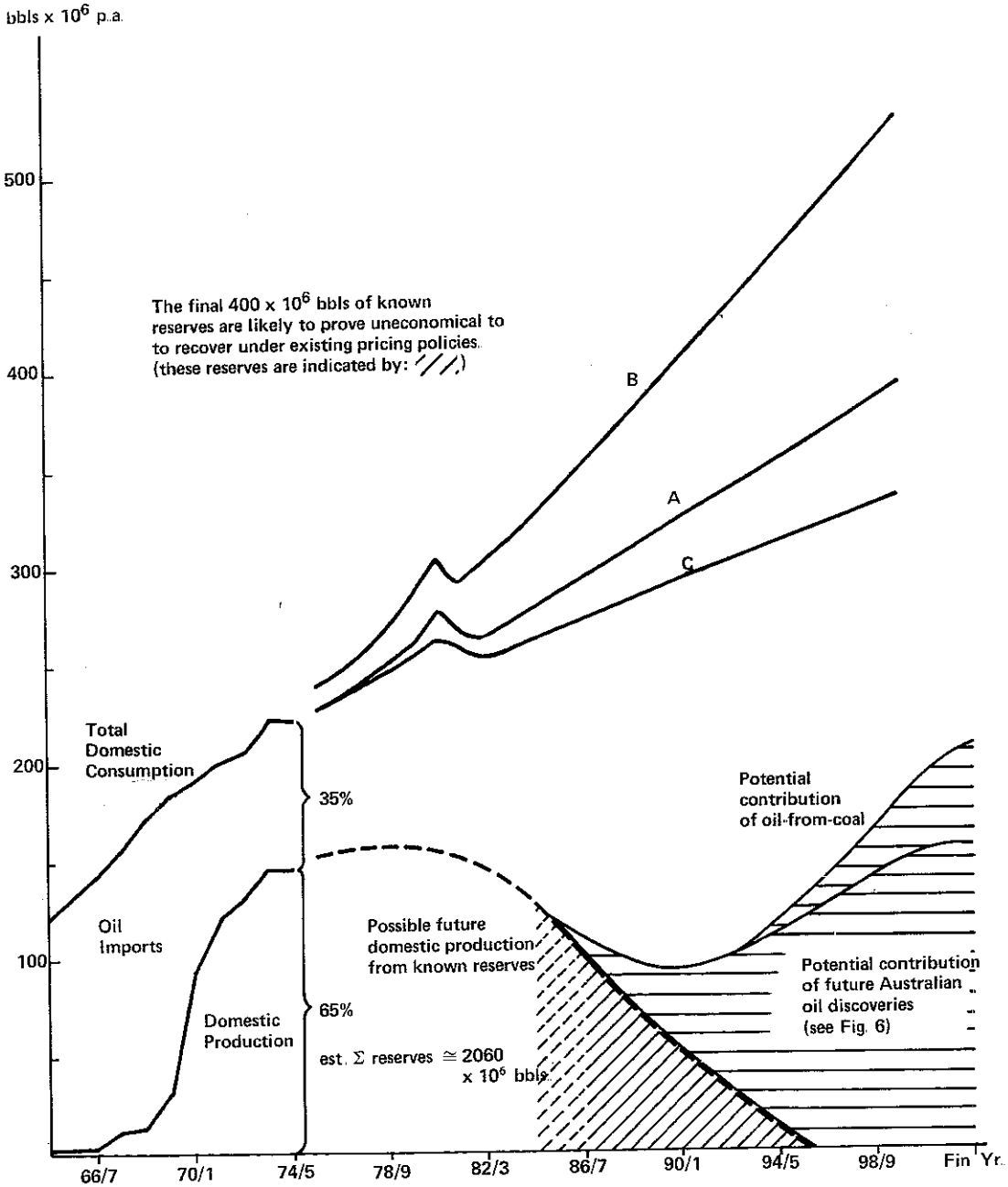


Fig 5 - Australian Domestic Production and consumption of crude oil.

Sources: Royal Commission on Petroleum (1976), Department of Minerals and Energy (1975), figures 6 and 10 plus own estimates.

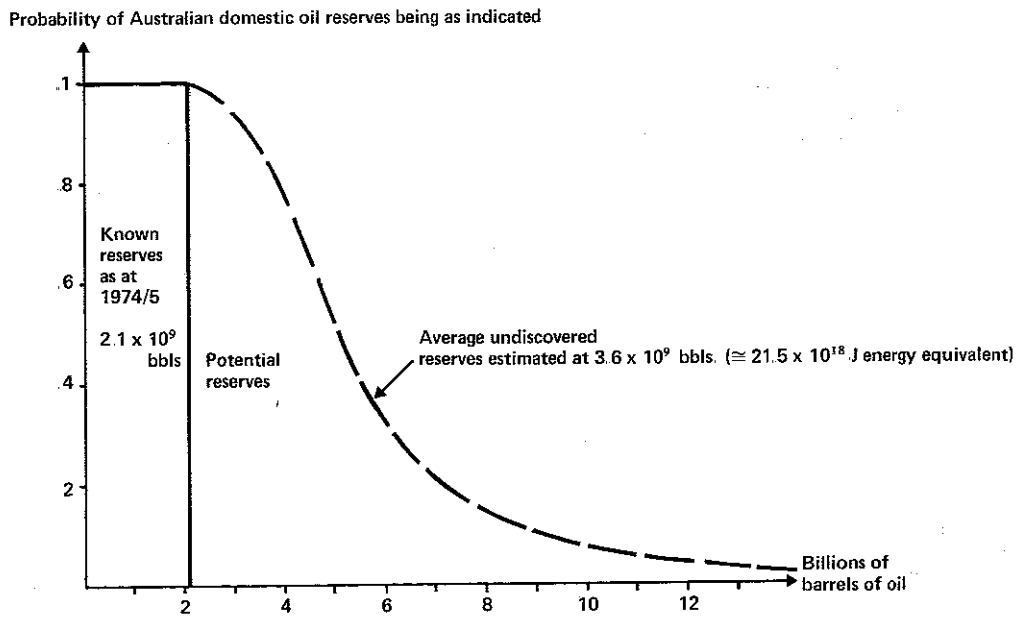


Fig 6 - ESSO Australia's assessment of undiscovered oil resources on the Australian continental shelf.

Source: Search (1976)

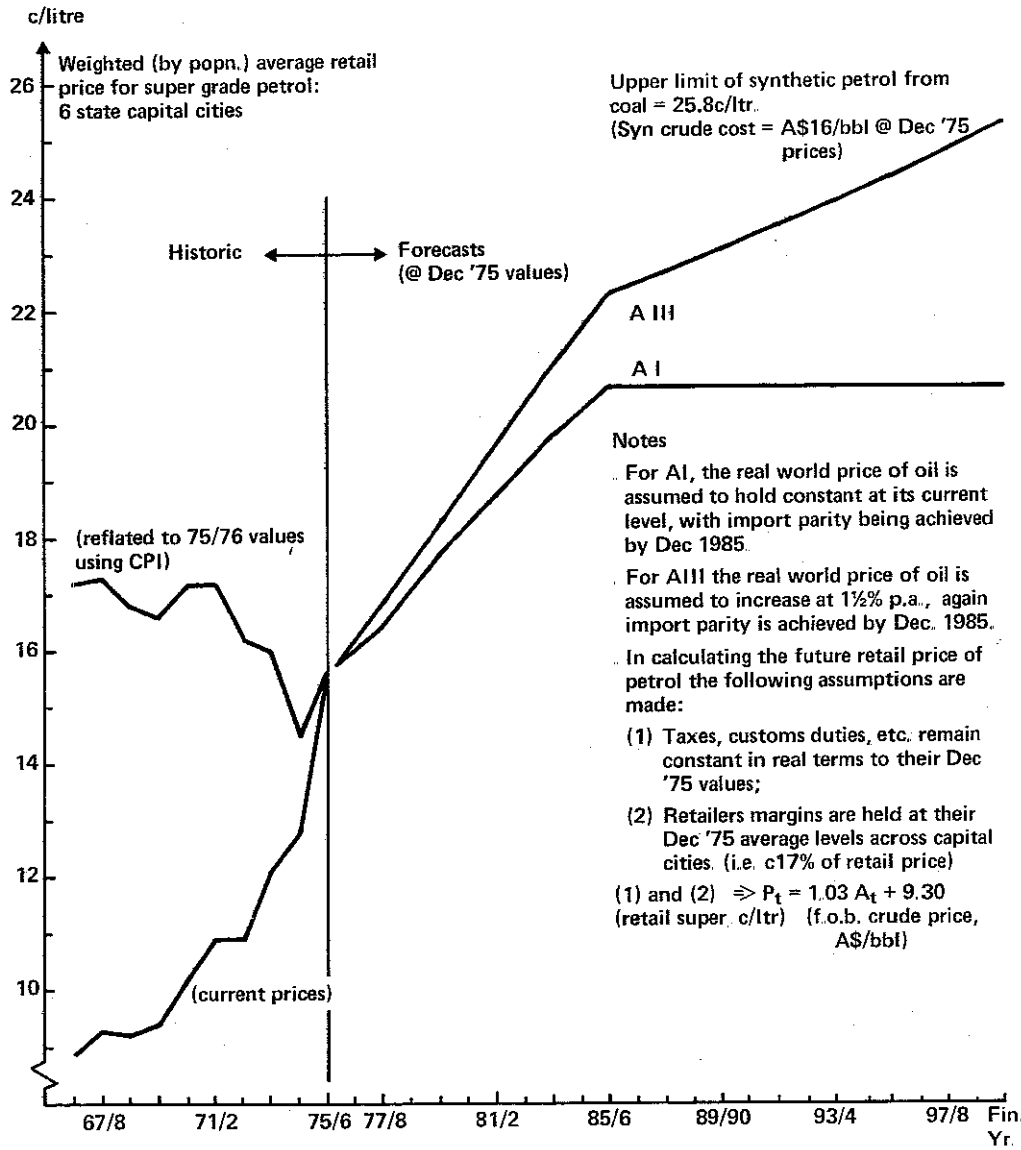


Fig 7 - Effects of import parity pricing and rising oil costs on domestic petrol prices.

Sources: Australian Petroleum Information Bureau data on historic price movements; Consumer Price Index from ABS; projections based on figure 1 and Economic Research Unit (1975)

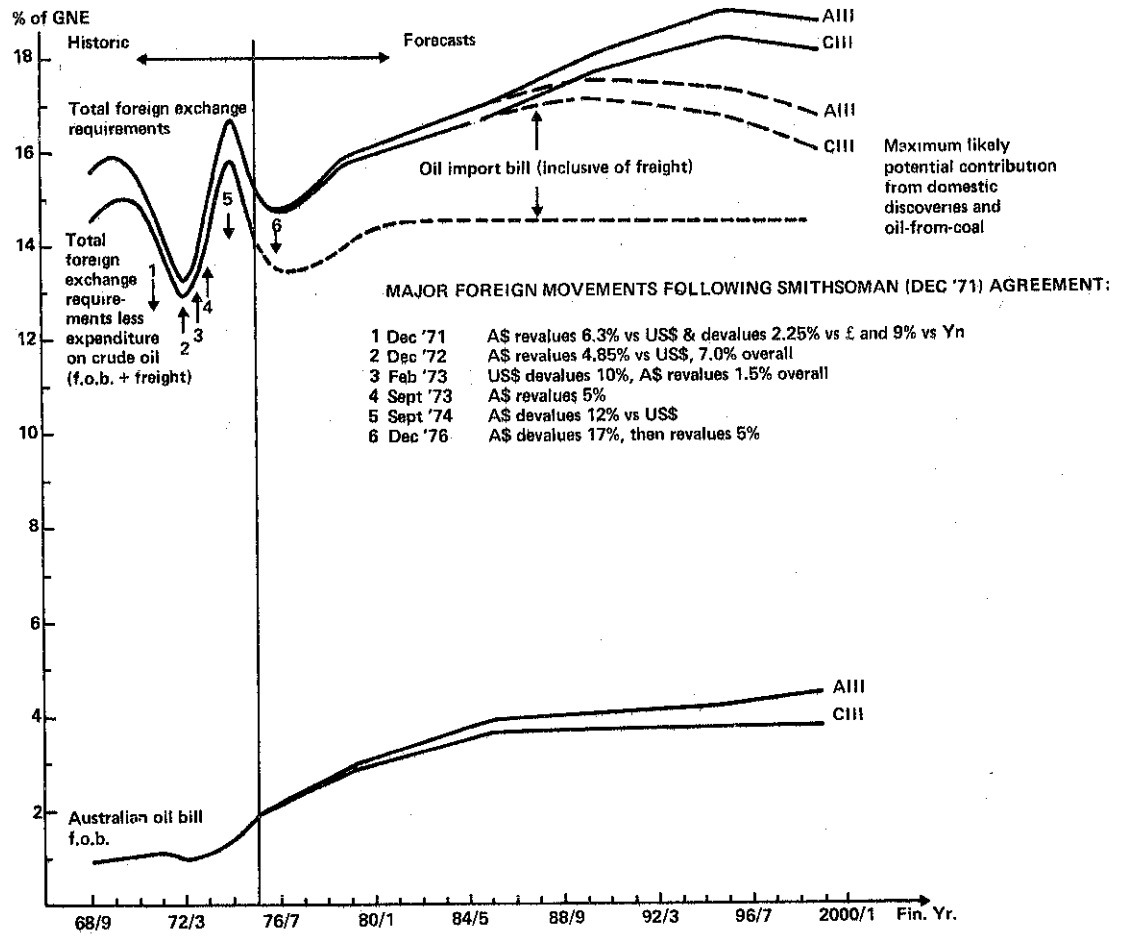


Fig 8 - Trends in components of GNE

Sources: Royal Commission on Petroleum (1976); ABS (1976 b,c); plus own estimates.

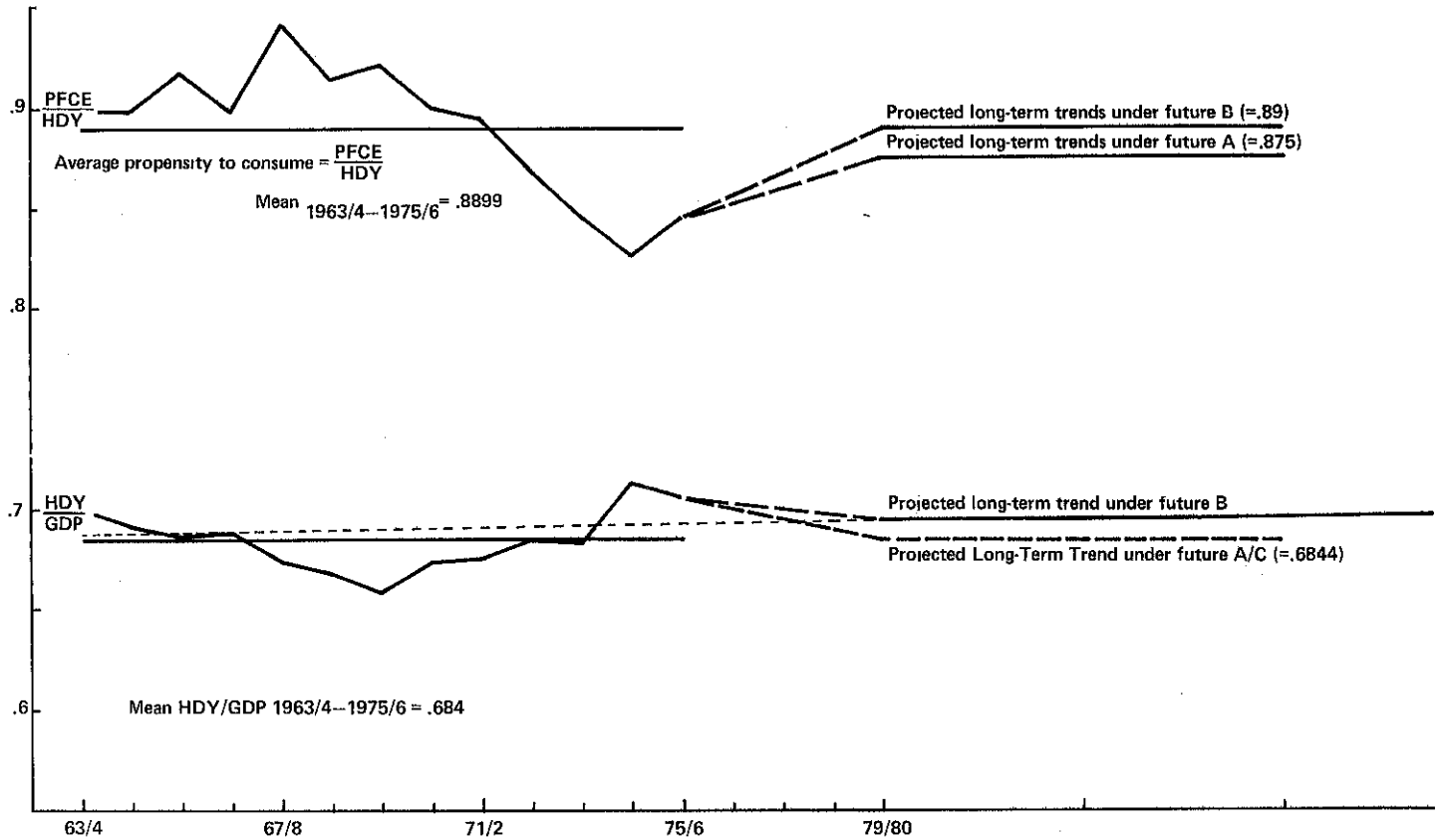


Fig 9 - Trends in Household Disposable Income (HDY) and Private Final Consumption Expenditure (PFCE)

Sources: (A.B.S. 1976 b,c) plus own estimates.

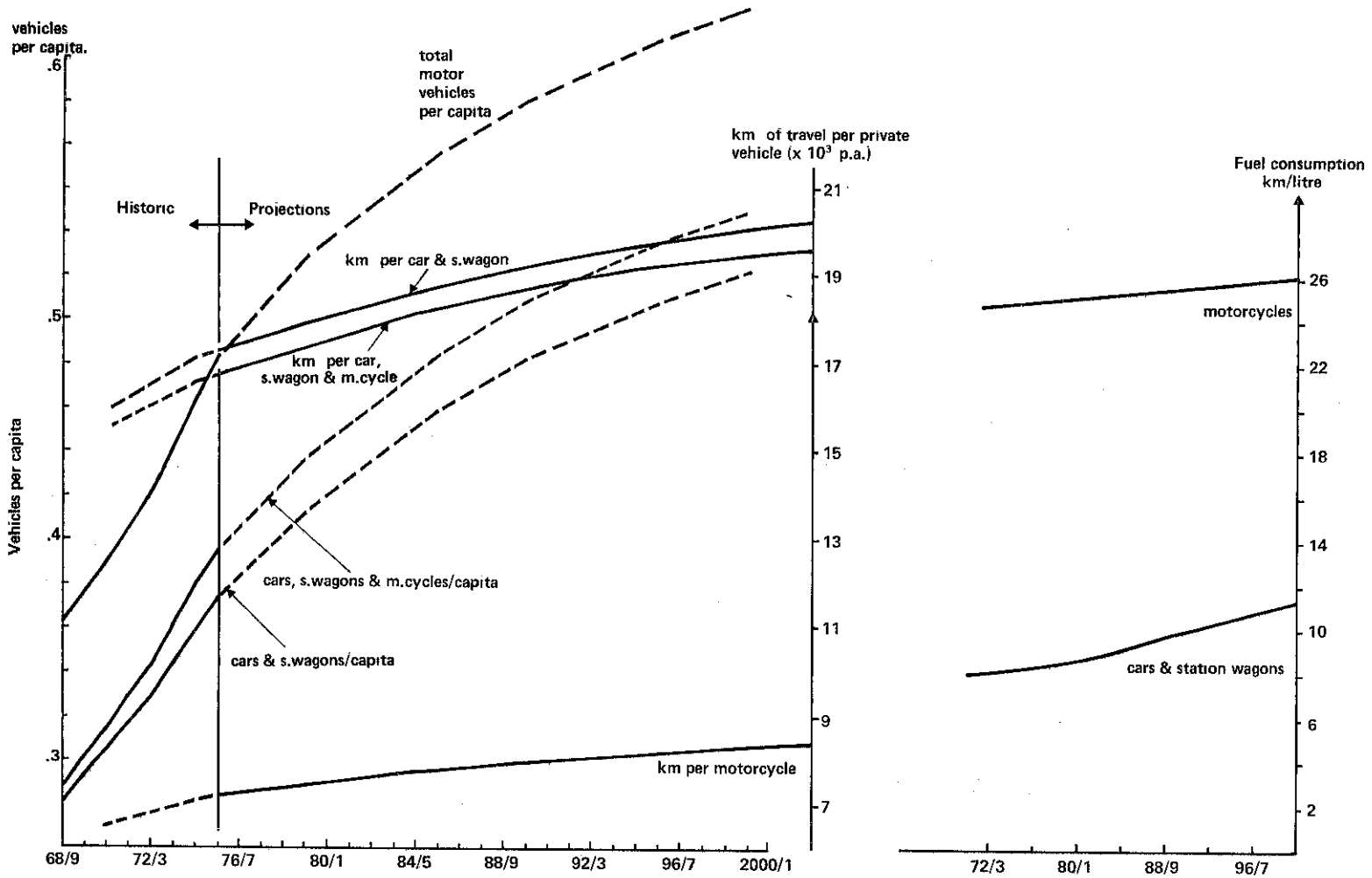
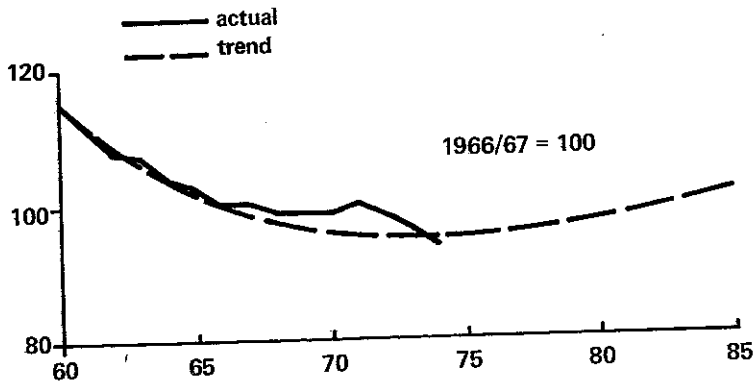


Fig 10 - Projections (under future A/c) of Private Vehicle ownership, use and fuel efficiency levels.
Sources: Commonwealth Bureau of Census and Statistics (1973), Commonwealth Bureau of Roads (1975), Economic Research Unit (1975), Bureau of Transport Economics (1976) plus own estimates.



Source: Bureau of Transport Economics (1976)

Fig 11 - Trend in motoring costs relative to CPI (including operating and capital costs).

TABLE I

AUSTRALIAN DEMAND FOR PETROLEUM

Product	1974/5 Demand '000 bbls	1974/5 Demand % of total	Projected Market Shares 1979/80	1985/6	1987/90	1995/6	1999/2000
LPG	4655	2.1	1.7	1.8	1.8		
Motor Spirit	80296	36.1	36.0	38.8	38.9	36.8[3]	35.2[3]
Automotive Distillate[1]	32177	14.5	14.8	16.4	16.7	5.3[2]	5.4[2]
Aviation Gasoline	647	.3	.3	.3	.3		
Aviation Kerosene	11465	5.2	5.9	7.7	7.8		
Domestic Kerosene	2035	.9	.7	.6	.5		
Heating Oil	5807	2.6	2.4	2.5	2.5		
Fuel Oil	43156	19.4	20.5	14.1	13.5		
Industrial Diesel Fuel	10241	4.6	4.7	4.8	4.9		
Refinery Fuel	16292	7.3	7.6	7.6	7.6		
Other Fuels[2] and Non-fuels	15620	7.0	5.4	5.4	5.5		
Total	222391	100.0	100.0	100.0	100.0	100.0	100.0

NOTES: 1 of total automotive distillate only c25% is currently used as a fuel for vehicles travelling on public roads (i.e. subject to excise payments). Non-road vehicle use of automotive distillate includes off-road /unregistered vehicles, stationary engines, farm machinery, railways and small boats.

2 Automotive distillate used as a road vehicle fuel

3 The proportion of the petroleum market demand devoted to road vehicle fuels is expected to decline after 1990 owing to the assumed trend towards saturation of vehicle ownership levels (see Fig 10).

Source: Department of Minerals and Energy (1975) plus own estimates of how the assumed trend towards saturation of vehicle ownership levels will affect fuel demand.

TABLE II

SUMMARY OF AUSTRALIA'S PRIMARY ENERGY SOURCES, AND KNOWN ECONOMICALLY RECOVERABLE RESERVES (1974/5)

Resource	Comestic Consumption (1974/5 10^{18}J	(% of Total)	Known Reserves (10^{18}J)	Cumulative Consumption 1975/2000* (10^{18}J)	Ratio of Consumption to known Reserves
Black Coal	.78	(31.2)	800	30.5	.04
Brown Coal	.24	(9.6)	400	10.7	.03
Natural Gas	.17	(6.8)	40	15.1	.38
Oil	1.17	(46.8)	12.5	44.5	3.56
Other Petroleum Liquids	.02	(.8)	8	1.4	.18
Other Primary Energy Source	.12	(4.8)		4.2	
Total	2.50	(100.0)		106.4	

Uranium (using thermal fission)	60
Uranium (using FBR)	3000

NOTES: *as estimated under future A (i.e. 3% growth in GDP)

Source: derived from Clark (1975), Department of Minerals and Energy (1975), plus Fig 4

TABLE III

RELATIONSHIPS BETWEEN OIL EXPENDITURES AND GNE

Fin. Yr.	Australian Oil Bill (fob) as a % of GNE				Australian oil Import Bill as a % of GNE (including freight on oil imports)				Total Foreign Exchange Requirements as a % of GNE			
Historic Figs												
1969/70	.98%				.91%				15.9%			
1975/6	1.95%				1.09%				15.2%			
Forecasts	BIII	AI	AIII	CI	BIII	AI	AIII	CI	BIII	AI	AIII	CI
1979/80	3.06	2.75	2.92	2.65	1.94	1.63	1.69	1.52	16.14	15.83	15.89	15.72
1985/6	3.83	3.40	3.89	3.17	2.74	2.23	2.52	1.98	17.24	16.73	17.02	16.48
1989/90	3.88	3.34	4.05	3.05	3.51	2.92	3.50	2.61	18.01	17.42	18.00	17.11
*	-	-	-	-	(3.14)	(2.53)	(3.03)	(2.22)	(17.65)	(17.03)	(17.53)	(16.72)
1995/6	3.82	3.17	4.20	2.78	4.05	3.42	4.46	3.00	18.55	17.92	18.96	17.50
*	-	-	-	-	(2.92)	(2.18)	(2.83)	(1.75)	(17.42)	(16.68)	(17.33)	(16.25)
1999/2000	3.77	3.07	4.32	2.60	2.99	3.32	4.51	2.81	18.49	17.82	18.81	17.31
*	-	-	-	-	(2.62)	(1.78)	(2.45)	(1.27)	(17.12)	(16.28)	(16.69)	(15.77)

Sources: Historic data from Royal Commission on Petroleum (1976) and ABS (1976 *b*, *c*). Projections based on Figs 1, 5 and 8.

*Beyond 1986 potential exists for oil exploration and the development of an oil-from-coal industry to reduce dependance upon oil imports. These figures indicate the maximum likely potential for this.

TABLE IV

COMPOSITION OF HOUSEHOLD EXPENDITURE

Element of Household Expenditure	Historic figures A$ x 10^6 current values (and as a of HDY)								Projections under future A/C @ Dec 1975 values				
	68/9	69/70	70/1	71/2	72/3	73/4	74/5	75/6	79/80	85/6	87/70	95/6	99,200
1-12 PFCE:													
1 Food	3342 (18.52)	3570 (18.10)	3819 (17.20)	4144 (16.72)	4569 (15.96)	5393 (15.59)	6190 (14 59)	7098 (14.43)					
2 Alcohols Tobacco	1570 (8.70)	1696 (8.60)	1865 (8.40)	2024 (8.17)	2271 (7.93)	2590 (7.49)	3021 (7.12)	3678 (7.48)					
3 Clothing	1553 (8.60)	1667 (8.45)	1814 (8.17)	1987 (8.02)	2224 (7.77)	2698 (7.80)	3097 (7.30)	3486 (7.09)					
4 Household durables	1202 (6.66)	1324 (6.71)	1451 (6.53)	1638 (6.61)	1877 (6.56)	2471 (7.14)	3042 (7.17)	3764 (7.65)					
5. Rent	2042 (11.31)	2314 (11.73)	2680 (12.07)	3053 (12.32)	3469 (12.12)	4038 (11.67)	4886 (11.52)	6061 (12.32)					
6 Gas electricity and other fuels	428 (2.37)	454 (2.30)	479 (2.16)	520 (2.10)	548 (1.91)	616 (1.78)	760 (1.79)	910 (1.85)					
7 Health	955 (5.35)	1069 (5.42)	1214 (5.47)	1415 (5.71)	1580 (5.52)	1787 (5.17)	2266 (5.34)	2707[e] (5.50)					
8 Purchase of Motor vehicles	848 (4.70)	975 (4.94)	1040 (4.68)	1120 (4.52)	1210 (4.22)	1435 (4.15)	1715 (4.04)	1875 (3.81)	2117 (3.95)	2423 (3.78)	2600 (3.61)	2844 (3.30)	2955 (3.05)
9. Operation of Motor vehicles	991 (5.49)	1078 (5 47)	1241 (5 59)	1369 (5.52)	1486 (5 19)	1692 (4.89)	2113 (4.98)	2558[e] (5 20)	3030 (5 65)	4160 (6 49)	4579 (6 35)	5235 (6 08)	5594 (5 77)
Items 8 and 9 as a % of HDY	(10 19)	(10 41)	(10 27)	(10 04)	(9.41)	(9 04)	(9 02)	(9 01)	(9 60)	(10 27)	(9 96)	(9 38)	(8 82)
10 Rail and other fares	550 (3.05)	617 (3.13)	677 (3.05)	726 (2.93)	794 (2.77)	913 (2.64)	1064 (2.51)	1281 (2 60)					
11 Post and telephone	157 (.87)	176 (.89)	206 (.93)	252 (1.02)	288 (1.01)	345 (1.00)	445 (1.05)	616 (1.25)					
12 Other consumption items	2858 (15.84)	3218 (16.32)	3505 (15 79)	3943 (15 91)	4520 (15.79)	5255 (15.19)	6475 (15 27)	7487[e] (15 22)					
Total Private Final Consumption	16507 (91.46)	18156 (92.05)	19991 (90.03)	22189 (89 54)	24836 (86 76)	29233 (84 50)	35074 (82 69)	41521 (84 43)	46960 (87 5)	56074 (87 5)	63111 (87 5)	75358 (87 5)	84816 (87.5)
13 Savings	1541 (8.54)	1568 (7.95)	2213 (9.97)	2593 (10.46)	3789 (13.24)	5364 (15.50)	7343 (17.31)	7657 (15.57)	6709 (12.5)	8011 (12 5)	9016 (12.5)	10765 (12 5)	12117 (12.5)
Total household disposable income (1-13)	18048	19724	22204	24782	28625	34697	42417	49178	53669	64085	72127	86123	96933

Source: Historic ABS (1976b, c)

NOTES: Projections or based on Figs 7, 9 and 10 under future AIII; plus ABS (1976a) and Thorensen (1977) regarding the amount of vehicle operating costs attributable to petrol and the turnover rate of vehicle stocks. The projected price of cars is assumed to remain at 1975/76 levels thus falling gradually in relation to household disposable income

With regard to vehicle operating costs non-fuel operating costs are assumed to remain at 1975/76 levels, with fuel costs rising due to projected fuel price increases given in Fig 7 (under future AIII) A detailed breakdown of the projected vehicle operating costs is given in Table IV:.

e : estimated

TABLE IV(a)

	Total Vehicle Operating Costs (A$x10^6)			x10^3	Per Vehicle Operating Costs (A$ per vehicle)				
	Total	Fuel	Non Fuel	Total private vehicles	Total costs per vehicle	Fuel costs per vehicle	% of Total	Non-fuel costs per vehicle	% of Total
Fin Yr	(Under assumptions of Fig 10)			(cars & station) (wagons & motor) (cycles)					
75/6	2558.0	1106.4	1451.6	5301.4	482.5	208.7	(43.3)	273.8	(56.7)
79/80	3029.5	1341.8	1687.7	6163.8	491.5	217.7	(44.3)	273.8	(55.7)
85/6	4160.2	2145.8	2014.4	7356.6	565.5	297.1	(51.6)	273.8	(48.4)
89/90	4579.2	2357.0	2222.2	8115.6	564.2	290.4	(51.5)	273.8	(48.5)
95/6	5234.5	2708.2	2526.3	9226.6	567.3	293.5	(51.7)	273.8	(48.3)
99/2000	5593.8	2902.9	2690.9	9827.6	569.2	295.4	(51.9)	273.8	(48.1)
	(under linear trend of per capita vehicle ownership based on 1980-85 projections)								
89/90	4644.6	2391.8	2252.8	8227.6	564.5	290.7	(51.5)	273.8	(48.5)
95/96	5496.5	2842.6	2653.9	9692.2	567.1	293.3	(51.7)	273.8	(48.3)
99/2000	6062.1	3150.4	2911.7	10633.7	570.1	296.3	(52.0)	273.8	(48.0)

TABLE V

TABLE V

EXPENDITURE ON COMMODITY GROUPS AS A PERCENTAGE OF TOTAL EXPENDITURE, BY WEEKLY HOUSEHOLD INCOME, AUSTRALIA, 1974-75

Commodity Group	Average weekly household income						
	Under $80	$ 80 - 140	$ 140 - 200	$ 200 - 260	$ 260 - 340	$ 340 +	$ ALL
TRANSPORT & COMMUNICATION	12.51	15.92	16.35	17.68	17.90	16.82	16.74
TRAVEL INDEPENDENT	4.65	6.17	6.58	7.03	7.14	6.85	6.67
Car	2.69	3.93	4.46	4.81	4.90	4.70	4.50
Other vehicle	0.39	0.50	0.40	0.36	0.30	0.41	0.23
- Motorcycle	0.05	0.23	0.08	0.15	0.16	0.15	0.14
- Caravan	0.26	0.17	0.10	0.12	0.09	0.18	0.13
- Trailer	0.03	0.00	0.01	0.02	0.01	0.04	0.02
- Bicycle	0.05	0.10	0.06	0.08	0.03	0.04	0.06
Vehicle Registration & Insurance	1.57	1.74	1.88	1.86	1.94	1.75	1.82
TRAVEL DEPENDENT	4.10	6.30	7.03	7.67	7.95	7.24	7.14
Petrol	2.09	2.90	3.20	3.38	3.22	2.99	3.09
Other running expenses	2.01	3.40	3.83	4.29	4.73	4.25	4.05
PUBLIC TRANSPORT	1.34	2.01	1.45	1.71	2.28	1.68	1.66
Rail fares	0.18	0.38	0.39	0.47	0.53	0.41	0.42
Bus/Tram	0.60	0.70	0.52	0.58	0.59	0.47	0.56
Other Public Transport	0.57	0.93	0.54	0.66	0.54	0.80	0.67
Postal/Telephone	2.43	1.45	1.29	1.15	1.15	1.05	1.27
TRANSPORT	10.08	14.48	15.06	16.53	16.75	15.77	15.47

Source: Morris (1977)

TABLE VI

EFFECT OF PETROL SHORTAGE ON TRAVEL FREQUENCY FOR CAR OWNING HOUSEHOLDS IN PORTLAND USA (RESULTS OF QUESTIONNAIRE SURVEY OF HOUSEHOLDS)

Type of Change Reported	No. of Families	Kept New Pattern	Partial Return	Complete Return	Don't Know
		Later behaviour (No. of families)			
No Change	237			237	
Change frequency of travel:					
Switched to other modes*	120	40	61	19	-
Reduced auto travel*	84	15	43	20	6
Miscellaneous changes†	16				16
Total	457	55	104	276	22

Source: Becker (1976). (Results of a household survey undertaken in the summer of 1974 in Portland, Oregon.)

*Including switching from automobile use to:
(a) walking (59), (b) transit (54), (c) car pool (34) and (d) bicycle (25)

†Including bus to car pool

TABLE VII

FREQUENCY OF ADOPTING A PARTICULAR FUEL SAVING METHOD
(Results of Questionnaire Survey)

Method	Frequency of using method (% of total)				
	Frequently	Sometimes	Rarely	Never	Total
Drive Slower	88.6	8.8	1.9	0.7	100.0
Reduce shopping and recreational trips	31.4	45.0	12.6	11.0	100.0
Use car pool	13.6	12.2	10.4	63.8	100.0
Use public transport	0.6	4.4	5.1	89.9	100.0

Source: Sacco (1976). (Results of survey of travel in a middle class suburb of Columbia, USA, period of survey 1973-74.)

TABLE VIII

PERCENTAGE OF MODAL SHIFT BY TRIP PURPOSE AND ECONOMIC GROUP (NOV. 73 - FEB. 74)

Mode	Destination purpose	Above Poverty Level*	Below Poverty level*
Automobile driver	Home	73 to 71	56 to 48
	Work	73 to 75	65 to 57
	Shopping	73 to 67	50 to 35†
	Socio-recreational	61 to 48†	46 to 42
Automobile passenger	Home	16 to 18	23 to 19
	Work	10 to 11	18 to 22
	Shopping	18 to 19	20 to 18
	Socio-recreational	25 to 32	20 to 33
Transit	Home	2 to 3	5 to 5
	Work	4 to 4	1 to 6
	Shopping	1 to 1	1 to 2
	Socio-recreational	1 to 4	6 to 5
Walking	Home	8 to 7	16 to 26
	Work	12 to 9	16 to 9
	Shopping	8 to 13	20 to 41
	Socio-recreational	10 to 13	28 to 20

Source: Stearns (1976)

*The poverty level was defined as:

Household size	Poverty level income (US$)
1 - 2	<3000
3 - 4	<5000
5 - 6	<7000
7+	<9000

†Statistically significant; $p \leq 0.5$