Introduction

The great merit of the Census Data is that they are the only accurate means available of measuring the changing pattern of male and female commutes and the growth of unsustainable car dependence and car ownership. With an effective 97% sample size accurate interstate and inter city comparisons are possible at the macro level. At the micro level, the Census is accurate for even the minor commuting modes of bicycle, motorcycle, taxi and walking in local government areas. Sometimes wet weather reduces the number of walking and cycling commutes but that can be accounted for (Nankervis 1996). Historical trends over 25 years can be accurately quantified which is not possible for transport surveys which have sample sizes as small as 2% of the population and are focused on only one city or state.

The following abbreviations are used in this study:

Census Data = Data shown in or derived from the ABS Basic Community Profiles.
Census Counts = Data shown in or derived from the ABS Classification counts.
Commute = The "*journey to work*" by one, two or three transport methods.
Commuter = Person who "*journeyed to work*" by one, two or three methods.
Dual mode = Commutes by two methods of vehicle travel.
Triple mode = Commutes by three methods of vehicle travel.

The Census Data for the "walking commute", shown in the graphs of the Australian and capital city commutes, is for walking all the way to work. Walking trips to access public transport are not recorded as they are for vehicle access trips to stops or stations. However, walking to access public transport is measured in this paper by adding the total number of public transport commutes to "walking commutes" to provide a conservative estimate. The "Census Counts" of dual and triple mode commutes are only available for Australia, the states and capital cities.

The primary purpose of this study is to show that use of the Census Data and Census Counts provide a valuable diagnostic tool for transport and other planners to monitor and evaluate past and present unsustainable urban transport behaviours and assist them in targeting these behaviours with counter measures. The focus is on the steady growth of car and consequent oil dependence in Australian urban areas. The Census data reveals that the majority of Australians grow up, work, breed and die in car dependent outer suburbs. The secondary purpose is to provide evidence that when cheap oil is no longer available these areas will suffer the most hardship because they have the highest per capita oil consumption

Certain assumptions were made in defining what is and is not sustainable. Australian cities are assumed to be unsustainable because they have the following characteristics: -

1. Per capita depletion of fertile land and freshwater are increasing and destroying the natural resources needed by future inhabitants.
2. Growing car dependence is increasing per capita oil consumption, greenhouse gas emissions and road congestion costs; and has contributed to a very costly obesity epidemic.
3. Without any supportive national energy security policy and effective measures to cope with the peaking and then decline of world oil production, the city's growing dependence on an oil dependent transport system will inevitably destroy the urban economy.
4. That modal substitution for "single occupant car commutes" by sharing cars, using public transport, walking and cycling or choosing to use small cars and petrol electric hybrids, all of which consume less oil, are sustainable transport behaviours.

The following approach has been used in preparing this paper:

1. Provide an overview of employment and working life changes from 1973 to 2003
2. Graph, tabulate and analyse Australian and capital city commuting trends from 1976 to 2001; the growth of capital city multi-modal commutes and the historical decline in the commuting market share of car sharing, walking, cycling and public transport.
3. Estimate and analyse the percentage of incidental exercise, the proportion of the car fleet, and single occupant car commutes in 8 Victorian provincial cities and Melbourne's 16 statistical regions. Graph the relationship between household density and the decline in walking, cycling and public transportation in the 16 Melbourne regions.
4. Argue that as there are 24 times as many female bicycle commutes and 10 times as many male bicycle commutes per 1,000 commuters in the Inner Melbourne region than in the six outer urban regions, most suburban areas are not bicycle friendly or pedestrian friendly.
5. Graph and analyse the relationship between the growth in drive alone car commutes and increasing congestion costs to the year 2011.
6. Summarise new research on the coming peak in world oil production and argue that the synergetic interaction of increasing oil prices and worsening environmental conditions also threaten world food supplies and will create a global economic depression.
7. Summarise the research on the oil conservation measures that need to be adopted worldwide by developed nations to enable their adaptation to the decline in oil production after it peaks.
8. Argue the case for an Australian Energy Security Plan to reduce oil dependence and conserve oil reserves for building the infrastructure needed for a modal shift to the more sustainable transport modes.
9. Recommend specific targets for sustainable commuting be established by government and that they be monitored and evaluated using the Census Data for 2006, 2011 and 2016.

The growth of a car dependent Australian work force 1976-2001

Since the 1960s there have been changes in the kind of jobs available, the location of workplaces and the location of households that have impacted on commuter travel patterns in major cities, where an increasing proportion of people live and work. However, there has been little change in the proportion of the population employed; a small increase from 41% in 1976 to 43% in 2001. There are now proportionally more jobs in the cities than the rural areas and many of these new jobs are following new outer urban housing developments.

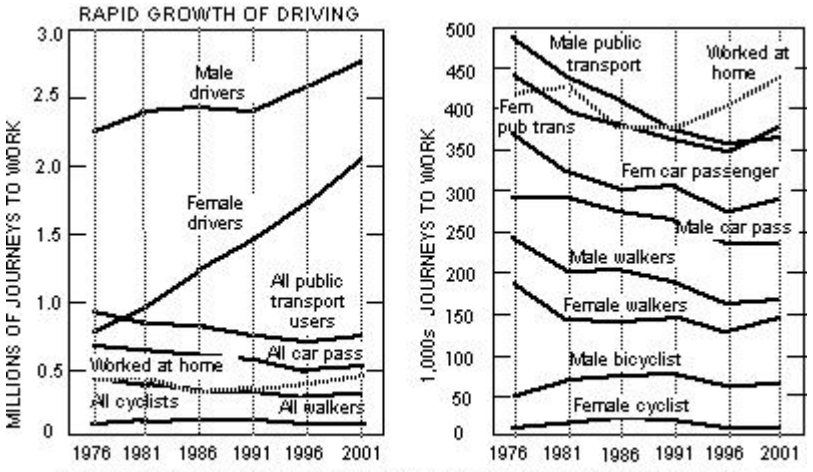
While the proportion of persons employed in the population has not changed significantly, the ratio of males to females has decreased and more women are now employed and fewer men. The changing role of women in society, the decline in manufacturing industry and the growth of service industries have had a significant effect. There are now fewer secure full time male jobs, more part time work and more casual employment. Table 1 shows that the proportion of male full-time jobs dropped from 81% in 1973 to 68% in 2003 and that the proportion of female full-time jobs increased from 39% to 53%.

Table 1 The proportion of persons aged 15 and over employed in Australia
Source ABS surveys 1973 to 2003

Year	1973	1983	1993	2003
Males	81	70	65	68
Females	39	40	46	53
Persons	60	55	55	60

Changes in Australian commuter behaviour 1976 to 2001

Figure 1 shows the 25-year trends in commuting since 1976 in Australia; it excludes commutes to school or educational institutions by students but includes those who went to work in these places on census day. In 2001, 8.3 million Australians were employed on Census Day and of those employed, only 6.8 million (82%) actually commuted to work. The other 1.5 million were sick, on holiday, had a day off, worked at home (5.3%), were part time workers who did not have to go to work on Census Day or did not fill in the census papers properly (3.0%). As working at home is a sustainable work practice, it has not been counted as a commute but has been shown on Figure 1 for the purposes of comparison only.



NOTES: Includes P T multi-modal trips. Motorcycle, truck and taxi modes are omitted
DATA SOURCE: ABS Population Census "Basic Community Profiles" Cat No 2001.0 .

Females accounted for 43% commutes in 2001 compared to 36% in 1976 so it is not surprising that the most dominant trend, shown in Figure 1, has been the increase in female car commuters. There was also a lesser increase of male car commuters. There were only 513,220 car passenger commutes in 2001 compared to 629,100 in 1976; that represents a decline in commuter car fleet passenger occupancy rates from 1.21 to 1.08. In 2001, 54% of car passenger commutes were women.

The number of commuters driving to work increased, from 3 million in 1976 to 4.8 million in 2001. As a consequence, commutes by persons driving increased from 51.6% to 71.8`% and most of this increase was due to women drivers (1.17 million). The number of female drivers has nearly tripled but the number of male drivers has only increased by one fifth. The upward trend of both male and female car commutes suggests that further increases to at least 5.3 million car commutes are likely by 2006. By 2001, public transport and walking had declined and the number of bicycle commutes was almost the same as in 1981. Public transport trips decreased from 920,250 commutes in 1976 to 742,300 in 2001, by which time the numbers of

male and female public transport travellers were nearly equal. Although the number of public transport commutes increased marginally between 1996 and 2001 the market share did not.

Overall, 4.1% of all commutes were dual mode and 0.45% were triple mode. The only sustainable trend was the growing proportion of people who worked at home, from 370,000 in 1986 to 438,000 in 2001; 53.5% of these were women.

Walking all the way to work decreased from 426,000 in 1976 to 287,900 in 1996 but increased to 316,600 in 2001. When expressed as a percentage, it represents a decline from 8% of all commutes in 1976 to 4.7% by 2001; of these 54% were male commutes. These figures indicate a loss of market share with no great difference in male and female walk commutes all the way to work. The decline in walking as part of everyday activity is of concern to the health agencies because Australians have grown fatter since 1976; nearly one million are obese and the medical profession has started to refer to this as a national obesity epidemic (Nador 2004). It is useful to measure the value of "incidental exercise" involved in commuting as a health benefit. The level of incidental exercise is not measured directly in the Census Data but can be conservatively estimated. When walking to access public transport is added to the 2001 walking and cycling data 16.8% of all commutes involving "incidental exercise". This is a less than the 25% in 1976 and far less than the early 1950s.

There are four male dominated commuting modes: powered two wheelers, taxis, trucks and bicycles but only bicycling is shown on Figure 1. Commuting by motorcycle or motor scooter has steadily declined from 81,000 (1.5%) in 1976 to 48,100 (0.7%) in 2001 of which 92% were by males. Taxi commutes also halved from 36,700 taxi trips in 1976 to 21,150 in 2001 of which 62% were by males. For the first time in 2001 the ABS Census Community Profiles included commutes by truck; a significant 134,100 commutes by truck were counted (2.0% of all trips) of which 97% were by males. There has been only a small increase of bicycle commutes all the way to work from 56,300 (1.11% of all commutes) in 1976 to 78,640 (1.15%) in 2001 of which 81% were by males. However, there were also 12,400 dual mode and triple mode bicycle commutes (80% were males) which increased the total proportion of bicycle commutes to 1.34%.

Figure 2 shows the growth of dual or triple mode travel in the capital cities since 1981 and indicates that by 2010 there will be an even higher percentage. In 2001, 4.3 % of all commutes were dual mode or triple mode; up from 3.3% of all trips in 1981. The larger the capital city, the higher is the proportion of these commutes ranging from 8% of all commutes in Sydney to 2.5% in Hobart only 1% in Victorian cities of less than 100,000 population.

Figure 2 Dual and triple mode commutes in the Capital Cities.

Source: ABS Classification counts

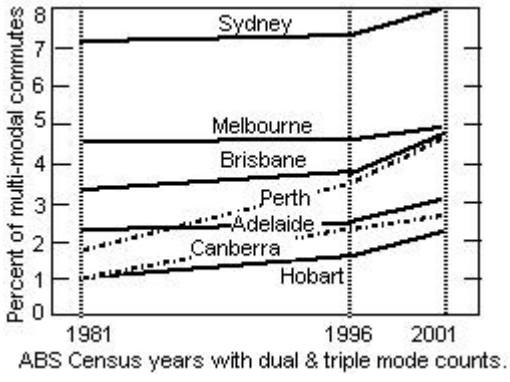


Table 2 shows Australian dual mode commutes involving more than persons 3000 in 2001. 114,000 car drivers or passengers accessing public transport; 9,674 car drivers using motor cycle or truck. 3200 bicycles used with cars and trains. In total there are 149,550 dual mode commuters and 29,100 triple mode commutes including 6,998 train/bus/car passenger commutes and 4,214 train/bus/car driver commutes.

Table 2 Australia 2001: Dual mode commutes of more than 3,000 persons
Source ABS Census "Classification counts" 2001

Dual mode: public transport	Number	Dual mode: private transport	Number
Car driver/ train.	62200	Car driver/passenger	29600
Car passenger/train	26400	Car driver/truck.	6220
Car driver/ bus	12500	Car driver/bicycle	4828
Car passenger/bus	12900	Car driver/motorcycle	3454
Bicycle/ train	3200		

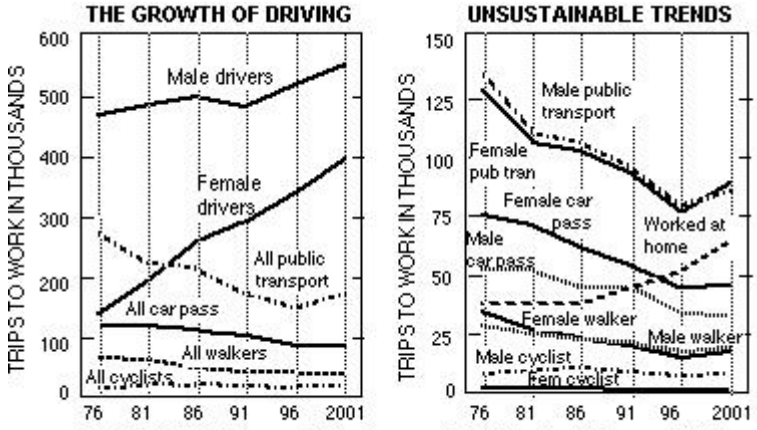
Table 3 Melbourne Dual and Triple mode commutes of more than 750
Source ABS Census "Classification counts" 2001

Dual mode only	Number	%	Dual and triple mode	Number	%
Car driver / train.	18616	1.4	Train / bus / tram	2737	0.2
Bus / train	9425	0.7	Train / bus / car pass	1165	0.1
Tram / train	8919	0.7	Train / bicycle	1032	0.1
Car passenger / train	5623	0.4	Bus / car driver	993	
Car driver/car passenger	2617	0.2	Truck / car driver	831	
Bus / tram	2091	0.2	Bicycle / car driver	786	
Bus / car passenger	1401	0.1	TOTAL Dual/triple mode	62060	4.3

The distribution of multi-modal trips in all the capital cities with a suburban rail system is still car dominated and not sustainable if it is a drive alone car coming from within easy cycling distance. The diverse range of dual and triple mode trips involving more than 750 persons in Melbourne is shown in table 3 and is not so different from other cities with suburban rail systems. Melbourne also has a 300 km tram network and there are 11,650 multi mode commutes involving trams. Since 1976 the use of cars Melbourne to access trains has increased has increased to 25,400. There are 17,810 commutes involving buses used with other modes. 1820 bicycles were used with car or trains. The car-dominated distribution of multi-modal trips to urban stations is quite different to Japan and the Netherlands where bicycle access and bus access are the dominant access modes for intermodal travel and less oil is used in the transport sector as a consequence. (ECMT 2001)

One study of intermodal access to stations and modal interchanges in Brisbane suggests that most car access trips to stations are less than 3km and within easy cycling distance but that the potential of the bicycle/train dual mode is constrained by very high levels of bicycle theft and vandalism in all the capital cities. (Parker 2002) Encouraging the use of bicycles to access trains is world best practice according an EU study which indicates the potential for more bicycles to be parked at stations in Australia than cars (ECMT 2001).

Figure 3 Metropolitan Melbourne: journeys to work 1976 to 2001



SOURCE: ABS Census Basic Community Profiles for Melbourne (SD).
Motorcycle, truck and taxi modes are omitted to clearly show trends.

Commuting to work in metropolitan Melbourne

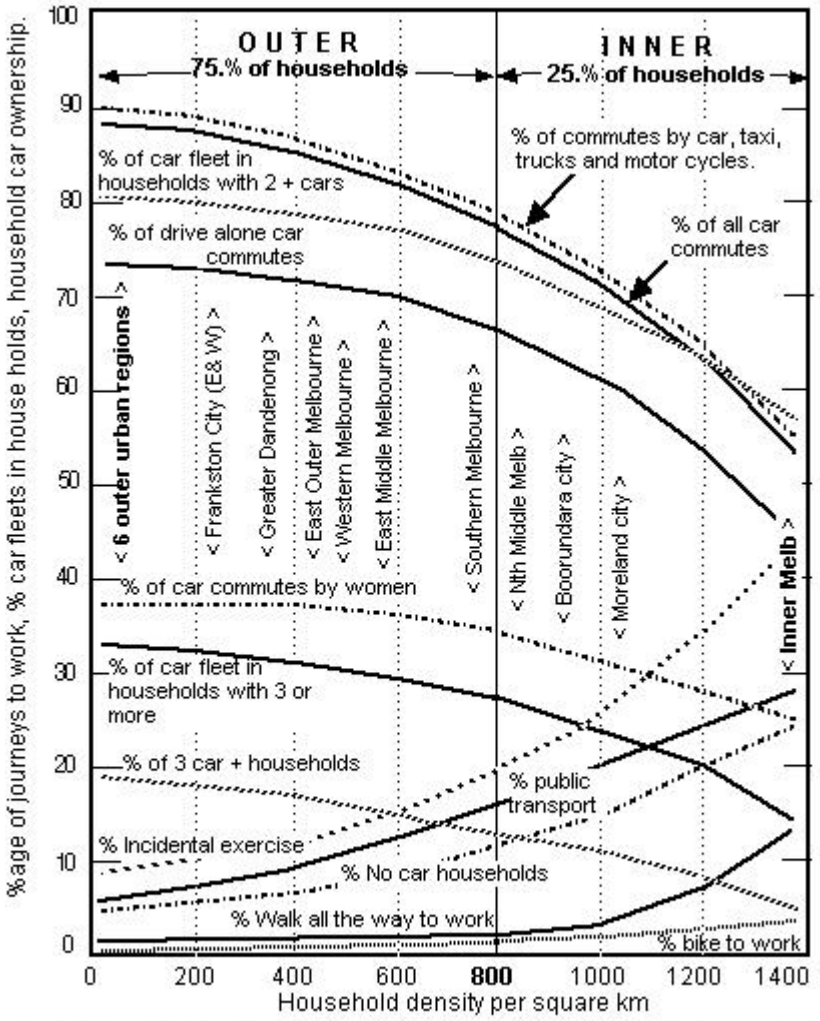
While Melbourne's residential population increased by 850,000 from 2.64 million in 1976 to 3.49 million in 2001, the increase in commuters is far less than that, being only 190,000 or 22% of the population increase. Figure 3 (column 1) shows that since 1976, the Melbourne work force has become far more car-dependent and car commutes (drivers and passengers) have increased from 620,000 in 1976 to 1,033,000 in 2001. By 2001 there were 953,000 commutes by car drivers. Column 2 on figure 3 shows that there has been a decline in the number of public transport users, walkers and car passengers cycling stayed much the same.

Female drivers increased by 268% from 147,000 in 1976 to 394,000 in 2001 whereas male drivers only increased by 19% to 559,000 2001. Women drivers have been the dominant growth element in commuting. Other sources show (VicRoads 2003) that car commutes have also become longer than most other weekday journeys and in 2001 they accounted for around 32% of the total distance travelled by car. Car commutes are concentrated in the congested rush hours, and are subject to stop-start driving conditions and ‘cold starts’ so it is assumed that car commutes are responsible for around 40% of peak hour air pollution, greenhouse gas emissions, fuel consumption and road congestion costs.

Over 25 years, public transport commutes decreased from 265,000 commutes in 1976 to 170,040 in 2001. In particular, tram and bus commutes in total declined from 135,000 in 1976 to 59,500 in 2001.Train commutes in total declined from 134,500 in 1976 to 118,500 in 2001. The large decline in both male and female public transport commutes in Melbourne indicate that the prospects for increasing public transport market share are poor, even though the number of public transport commutes increased since 1996, as it did in the other capital cities.

In terms of market share 80% commutes were made by car and, if we add the 2% of commutes made by truck, van, and motorcycle, 82% of commutes are by motor vehicles. Walking and cycling combined only account for 3.9% all journeys to work in 2001. Cycling has stayed around 1% in the last 25 years. However, most commuter destinations are now well beyond walking distance so walking has declined from 6.3% in 1976 to 2.9%.

FIGURE 4 Melbourne Commutes by 16 urban regions and Household density
Source: Census data for the 16 regions of Metropolitan Melbourne



Notes. The %age of incidental exercise = The total % age of all public transport, cycling and walking journeys. The %age of drive alone car commutes = car driver commutes minus car pass commutes. Curves in outer regions have been statistically smoothed.

The data for Melbourne's statistical regions (See figure 4) show the overall trends, plotted against household density per sq km. for the percentage of commutes: walking, cycling, public transport, single occupant cars, female car drivers and incidental exercise.

The Census Data in figure 4 shows huge differences between the inner and outer regions of Melbourne. Most significant is the Inner Melbourne Region, which has a density of 1,300 households per square km and where commuting is far less car dependent and 43% of commuters benefit from "incidental exercise". When the petrol becomes expensive, most households in this region will survive without petrol as they did from 1940 to 1950.

Figure 4 shows that most of the unsustainable commutes are located in the sprawling outer suburbs with between 20 and 800 households per square kilometre where 75% of Melbournians now reside. In these areas, 80% of households own 2 or more cars; around 85% of those who are employed commute by car and are responsible for 85% of the distance travelled by all Melbourne commuters (VicRoads 2003) and for 70% of the drive alone car

commutes in metropolitan Melbourne. Furthermore, 78% the car fleet resides in households with 2 or more cars. Walking, cycling and public transport account for only 13% of all commutes. The correlation with low household density and car dependence suggests that a similar correlation will exist Brisbane, Perth, Adelaide and Sydney. A study of Sydney's local government areas reveals the same trip pattern with far more cycling commutes in the inner suburbs than the outer suburbs. (Telfer and Rissel 2003)

Table 4. Commutes in 8 Victorian provincial cities with a total population of . 537,000 and low household densities (6.3 to 152 households per sq km)

Percentages of: commutes by mode, occupancy and gender; household car ownership, city car fleet in households with 2 + cars; level of incidental exercise.	Average %age 8 cities.	Lowest city %age	Highest city %age
% of commutes by car, truck, taxi and motor cycle.	90.6	89.2	92.9
% of commutes by car. (drivers and passengers)	88.4	87	91.7
% of city car fleet in households with 2 or more cars.	75.9	73.6	78.8
% of commutes in single occupant cars.	72.3	69.9	76.5
% of female commutes by car. (drivers and passengers)	43.75	42.5	44.8
% of city car fleet in households with 3 or more cars.	28.2	24.8	29.7
% of households with 3 or more cars.	14.5	13.1	15.5
% of households with no cars.	9.5	7.4	10.4
% of commutes involving incidental exercise. +	8.9	6.4	10.7
% of commutes; walking all the way to work.	5	3.4	6.6
% of commutes by public transport (mostly buses #)	2.4	1.4	5.8
% of males & females bicycling all the way to work.	1.5	0.9	2.2
% of females bicycling all the way to work.	0.5	0.2	0.8

Source: 2001Census data for Greater Geelong, Warnambool, Greater Bendigo, Greater Shepperton, Ballarat City, Mildura Rural City, LaTrobe Valley & Wodonga

Notes: # Rail and bus journeys in Geelong, Bendigo, Ballarat and La Trobe Valley.

. + Total of all walking, bicycling and public transport commutes.

. © The ratio of male to female bike commutes varies from 3 to 1 and 9.6 to.

The 2001 Census Data for 8 Victorian provincial cities reveal that the pattern of commutes in these cities was very similar to the low-density areas in outer Melbourne (see table 4). This is surprising as many commuting trips are much shorter than in outer Melbourne.

Unsustainable trends in five capital cities

The percentage share of all commutes from 1986 to 2001 in the five largest Australian capital cities and five NZ cities were analysed and graphed in a paper given at the 26th ATRF (Parker 2003). Figure four in that paper showed the percentage of commutes by the main mode in a form that was useful to make intercity comparisons. All the cities has an overall modal split that was similar, with the growth of female car commutes being the most dominant characteristic as is shown on figures 1 and 3 in this paper. The five percent of those who work at home was similar in all five Australian cities and suggested an increase by 2006.

Table 5 below is focussed on the sustainable commuting modes in the Capital Cities, including Darwin and Canberra, selected Melbourne metropolitan regions and four Victorian

provincial cities. The commuter market share of public transport, walking, bicycling and car passenger commutes are all are ranked by the level of incidental exercise. Data on household density per square km, the percentage households with no cars and the ratio of male to female cyclists are included for purposes of comparison in the next section.

Table5 Percentage of 2001 Sustainable Commutes in all the capital cities and selected Victorian cities, ranked by the total level of incidental exercise.

Sustainable commutes: Australia, Capital Cities, selected City Regions & 4 Victorian provincial cities	% Incid--ental exer- -cise	House--holds per sq.km	% of house- -holds with No cars	% cycle trips all the way	Ratio of male to female cyclists	% of walks all the way	%of all Public transit.1, 2 & 3 methods.	% of car passe--ngers
								% of car pass- -gers
Inner Melbourne Region #	43.2	1351	24.4	3.4	1.7	12.4	27.5	4.4
Metropolitan Sydney	26.6.	118	14.2	0.6	3.8	4.5	21.4	6.6
Moreland City region	26.1	1027	16.2	2.6	1.6	2.6	21	6
Boorundara City Region	23.3	956	9.8	1.3	3.4	3	19	4.5
Metropolitan Brisbane	17.4	129	10.4	1.1	4.2	3	13.1	8
Metropolitan Melbourne	17.2	161	10.2	1	2.5	2.9	13.2	6.1
Australia: all urban & rural	16.8	1.1	10.7	1.2	3.2	4.7	11	7.6
Greater Hobart	14.2	56	11.8	1	3.5	7.1	6.1	9.3
Canberra	13.3	142	7.7	2.3	2.5	4.2	6.8	9.4
Darwin	13.2	12	9.9	3.7	2.1	5.7	3.8	9.9
Metropolitan Perth	13.1	95	8.3	1.1	3.5	2.2	9.8	6.9
Metropolitan Adelaide	12.9	235	11.4	1.2	3.7	2.6	9.1	7.1
Greater Dandenong Reg	12	336	11.8	0.6	7.9	1.9	9.5	8.7
Greater Geelong (Victoria)	10.7	152	10.4	1.5	5.3	3.4	5.8	7.8
Melton & Wyndam Region	10.2	42	**5**	0.3	4.3	1.6	8.2	7.8
Mildura Rural City (Victoria)	9.4	34	9.1	1.2	3	6.3	1.9	8.5
Frankston City Region	9.1	323	9.2	0.5	2.8	1.6	7	7.2
Greater Bendigo City (Vic).	8.5	59	10	1.8	5.3	4.9	2	8.6
Ballarat City (Victoria).	8.4	41	10	1.5	7.5	4.5	2.5	7.5
Mornington Peninsula Rg	8	68	7.1	0.6	4	3.9	3.6	6.7
Sth East Outer Melb. Reg	7.8	43	4.5	0.3	4.9	1.6	6	7

Notes: # Inner Melb. Region = City's of Melbourne, Yarra, Port Phillip & west Stonningham.
Male to female ratio = % of male bicycle commutes divided by % female bicycle commutes

Decline of the sustainable commuting modes and levels of incidental exercise

Table 5 contains 2001 Census Data for all the capital cities; and selected statistical regions of Melbourne and four Victorian provincial cities; the percentage of walking, cycling, public transport, car passenger commutes; households without cars, the ratio of male bicycle commutes to female commutes; household density per sq km and an estimate of the level of incidental exercise for the benefit of health professionals seeking to increase exercise levels.

Table 5 is ranked in order of the percentage of incidental exercise involved in commuting is conservatively estimated by adding the percentages of walking and cycling commutes (all the way to work) to the percentage of public transport. To put this measure of incidental exercise into historical perspective it has greatly declined since petrol ceased to be rationed in

Australia. Using commuter data (Manning 1984) for the year 1951, incidental exercise was estimated to be 50.3 % of all commutes in Melbourne. By 1981, incidental exercise had dropped to 27.1% and dropped again to 17.2% by 2001.

Metropolitan Sydney has a much higher level of incidental exercise (26.6% of commutes) than the other capital cities but much less than the 43.2% in the Inner Melbourne Region (municipalities of Melbourne, Port Phillip, Yarra and the west part of Stonnington). When the commutes for Melbourne, Sydney, Perth, Brisbane and Adelaide are broken down by metropolitan regions (as they are on Figure 4 for Melbourne) these are likely show a similar level of incidental exercise in the inner regions. A study of bicycle commutes in all of Sydney's suburbs showed that those suburbs within 10 km of the CBD had much higher percentages of bicycle commutes (Telfer and Rissel 2003). This indicates that the prospects for substituting bicycle commutes for short car commutes or access to public transport are very poor in many outer suburbs.

In Melbourne, there are proportionally far more male bicycle commuters than female bicycle commuters and 8 times as many men choose to cycle in the Inner Melbourne Region (3.36% of all male commutes) than in the six outer regions (0.42 %). 24 times as many women choose to cycle in the Inner Melbourne Region (2.43% of all female commutes) than in the six outer regions (0.1%). However, these gender statistics which suggest the need for a more secure cycling environment for women in the outer urban suburbs will continue to be ignored by road engineers and planners (Parker 2001).

There are many more male than female bicycle commutes in Australian cities whereas in most Dutch cities, there are an equal proportion of male and females bicycle commutes, that is a male to female ratio of 1.0, compared to the ratio of 2.5 for Melbourne, 3.8 for Sydney and 4.2 for Brisbane. In the Netherlands, 25 % of all commutes are by bicycle or bike/train (Welleman 2000) compared to 2.3% in Canberra, 3.7% in Darwin and around 1% in the other six Australian capital cities. The male to female ratio is much higher in low-density outer Melbourne regions varying from 7.9 in Greater Dandenong to 4.0 on the Mornington Peninsula. This is good indicator that the road network, on and off road bicycle facilities is far from adequate in the outer urban regions which results in commuters choosing not to use a bicycle. Many of the road conditions, such as high speeds and the use of roundabouts on main roads instead of signalised crossings; are also a deterrent to walking.

The data for Melbourne and Sydney (Telfer and Rissel 2003) suggest that there is a safety and distance problem for cyclists in the low-density areas of cities. Sydney and Brisbane cyclists have a lot of hilly terrain to cope with that is absent in nearly all Dutch cities, but the constraint of hilly terrain is not the only reason for the low level of cycling. After all, Dutch cyclists have cope with icy conditions and snow which is far worse for cycling than the summer heat which can be mostly coped with by slowing down the pace of riding In future Australia's population is likely to be even more concentrated in and around the existing capital cities or in provincial cities linked by rail to the capitals.

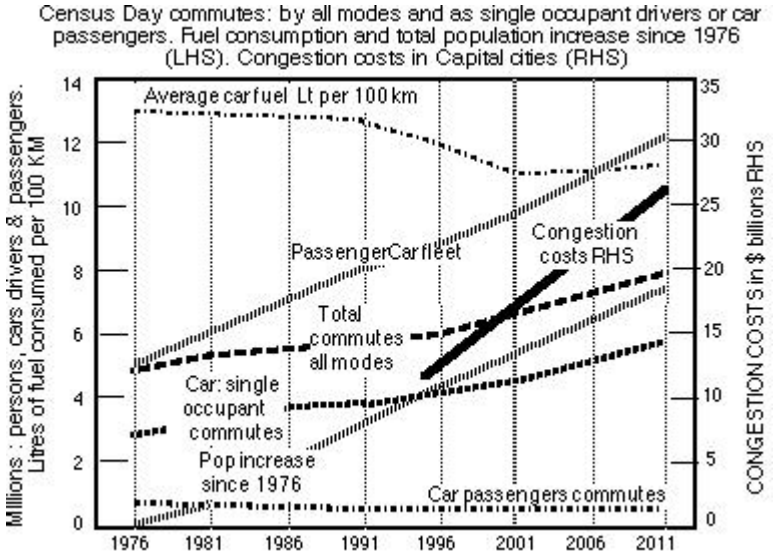
In Melbourne, much of the new housing has been located in outer areas where the growth rate was around 10% in 2001. These outer areas are so poorly serviced by public transport that further increases of single occupant car commutes are inevitable. We conclude that the low level of all bicycle commutes and the high male to female cyclist ratios in the relatively flat outer urban regions of Australian cities clearly indicates that many males and nearly all

females perceive a potentially dangerous or very inconvenient cycling environment with long distances between destinations.

Single occupant car Commutes generate road congestion in Australia

Congestion in Australian cities was generated many years before it was studied. In the early 1980s, it was caused by the growth in the population, which spread into sprawling outer suburbs, where the employed have to commute long distances and have no alternative to the car. As a consequence, the car population doubled between 1976 and 2001, an increase of 5 million cars that parallels the 5.4 million increase in the resident population. Figure 5 uses the Census Data to show the almost parallel growth of human and car populations since 1976.

Figure 5 Unsustainable Australian commutes 1976 to 2011



The costs of congestion in A$ billions (right axis on Figure 5) in Australian cities, particularly Sydney, Brisbane and Melbourne are increasing. The projected growth rate of congestion costs from 1995 to 2011 is higher than the actual and projected growth in the car and human population and is even higher than the number of commutes by all modes. The increase in commutes by all modes would be far less costly if the number of single occupant car commutes could be cut back to what it was in 1991, instead of increasing to 2011.

Figure 5 includes estimates by the CSIRO of car fleet fuel efficiency in litres of petrol per 100 km. Fuel efficiency improved from 1976 to 2001 but is projected to get worse from 2001 to 2011 due to the growing proportion of large cars with more luxury features and four wheel drives (Foran & Poldy 2002) In 2003 85,500 4WDs were sold, 13.8% more than in 2002, and this upward trend is expected to continue in 2004. This will wipe out the benefits of improved fuel consumption in new small and medium sized cars to at least 2011 and make the Australian car fleet less fuel efficient per passenger km. The long life of the average car in Australia, of 9.5 years in 2002, means that half the cars on the roads today will still be on the roads in 2014.

There is a need for a large increase in petrol prices or other tax incentives to encourage the purchase of small cars and energy efficient hybrid cars. Figure 5 show that cost of congestion in Australian capital cities is primarily caused by commuters who use a vehicle, designed to

carry three, four or five people, to drive alone to work. Single occupant car use is encouraged by the introduction of the GST in 2000 which reduced the cost of cars. Furthermore, the absence of import duty on 4WDs is another concession to buy and drive these larger vehicles.

The practice of subsidising car use as part of salary packaging has grown to such an extent that it significantly discourages public transport use and encourages the purchase of vehicles that are larger than they would be if not part of a salary package. New cars in 2003 will have fuel efficiency labels for buyers but there are no fiscal carrots in the form of 'green' tax incentives to buy small energy efficient cars.

Freeway construction underway will only reduce congestion in the very short term but over a few years generates so much extra traffic, particularly single occupant car commuter traffic, that it creates far more congestion and further discourages the use of public transport and cycling. There are no Commonwealth actions in the pipeline that will prevent oil consumption by the car fleet increasing by a minimum of 2.2% per year given current trends.

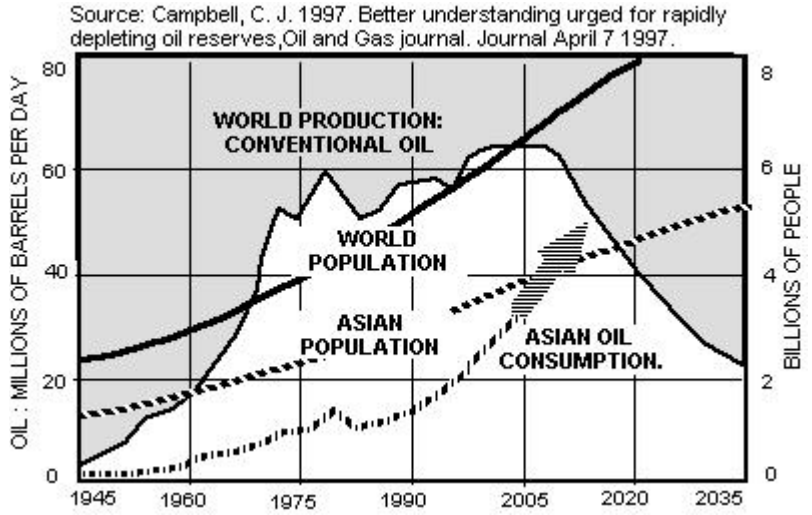
The end of the age of cheap oil: 2008 to 2020

One day we shall be forced to learn to live without cheap oil, also known as conventional oil. Before that day arrives we will have to learn to live with the world oil supply not satisfying world demand for oil, which was 80 million barrels a day in 2003. Demand for oil is growing at the rate of 3.0% per year but that cannot go on for much longer because the oil discovered is not sufficient to meet demand. (Wood and Mackenzie 2004) (Skrebowski 2004)(Samsam Bakhtiari 2004). Around 2008 Australia will be vulnerable to increasing costs of imported oil and it is likely, without new oil discoveries in deep water, that far less oil will be produced in Australia (Geoscience Australia 2004)

Since the mid-1990s the average value of oil discoveries has fallen and discoveries from new fields have replaced only 40% of production. In Saudi Arabia, which has the largest oil reserves, they have not stopped drilling for oil since 1938 but now discover much less. Of the first 60 wells drilled that produced oil from 1938 to 1969 Aramco found 300 giga barrels with 24 fields. Of the last 60 wells drilled that produced oil from 1978 to 2003 Saudi Aramco found only 13 giga barrels within 50 fields. This reduction in the amount of oil discovered and the much smaller oilfields discovered was inevitable. Oil is a finite resource, the more oil that is found the less oil that remains to be found (Laherrere 2004). Another serious problem is that after oil peaks, proportionally more of the oil will be sour oil, which gets more costly to extract and refine as oilfield output drops. Iraq is the one OPEC country with 3 super giant oil fields that have not peaked but is subject to attacks on vulnerable pipelines. (Douglas-Westwood 2004).

The impact of increasing oil consumption and population in Asia is shown of figure 6. Perhaps the best example of what is occurring is China which exported oil as late as 1992, but has become a net importer, due to a steady decline in indigenous oil reserves. By 2003 oil consumption was growing by over 10% per year and reached 5.4 million barrels per day. China is now the world's second largest oil consumer after the US, which is consuming 20 million barrels per day. China will import more oil to fuel its runaway economic boom which will generate a demand for oil of 14 million barrels a day by 2010. This is required for oil-fired electricity generation and for a 75% jump in sales of passenger vehicles in 2003 to 4.5 million.

Figure 6 World population growth and depleting cheap oil reserves



The EU has predicted by 2010 an increase in road traffic of 50% and an increase in air traffic of 90%. Similar increases are expected in the USA. Its also likely that by 2006 many countries in anticipation of oil production peaking will build up strategic stocks of oil, and that will also drive up the price of crude. A silent energy trade war is already going on with the U.S., the EU and Japan competing for access to oil supplies; they all know that the more oil China gets, the less they can take. Oil shortages will hurt all their economies (Cockel 2003).

Around 2008, when the worldwide demand for oil outstrips the global capacity to produce oil production, "the big rollover" as it known will have begun. This is the point at which world oil production goes over the top of a bell shaped curve known in the oil business as the Hubbert curve: named after King Hubbert the Geologist who pioneered the science of predicting the peaking of oil fields in the 1960s and the peaking of mainland US oil production in 1976. (Deffeyes 2003) That production curve for the world is in figures 6 and 7.

Hubbert's techniques have been further refined and by 2003, Hubbert curves had been plotted by researchers for all the 95 countries that have or can produce significant volumes of oil. It is known that 52 of these countries, including the US, are already well past their peak (greater than 5 years), while another 16, including the UK, Norway, Australia, and China, are at peak or will reach it soon. The remainder will peak within the next 25 years (Wood and Mackenzie 2004)(Douglas-Westwood Ltd 2004).

The May 2003 Association for the Study of Peak Oil Conference held in Paris evidenced a growing consensus on the reality of oil depletion. (www.hubbertpeak.com.) Overall there emerged a scenario of world oil depletion of 5-10% per year, a recognition that oil reserves had been deliberately overestimated by the oil industry and that there are unlikely to be more major significant reserves to be found. Most delegates agreed that nearly all of the private multi-national and national oil and gas companies have over estimated their gas and oil reserves to maximise either private company share values or to attract overseas investment into their national economies (Simmons 2004).

The synergetic interaction of environmental problems and oil depletion

Greenhouse warming, water availability/quality, salinity and soil loss/damage are all serious global problems. Sadly, their synergetic interaction worldwide will be far more devastating to human welfare and world food production because they will get worse within the same time frame as a long decline in world oil production (Bright 1999). The synergetic interaction of oil depletion and these other environmental problems in Australia is likely to be the greatest threat to food production since Federation (Flannery 2004). A lot is known about environmental problems in isolation but there is great uncertainty about how they will interact with one another, and how increasing costs of oil will constrain efforts to deal with these problems. The worst-case scenario is that, without an internationally agreed oil conservation program, it is likely that a billion or so people will be reduced to unemployment and poverty between 2010 and 2020. This may well happen and if it does, the economic sectors that will most likely collapse first will be: -

1. Aviation and agriculture due to high prices of jet fuel and nitrogen fertilisers made from gas and oil. (Cochet 2004).
2. A little later road and rail passenger and freight transport, tourism, the petrochemical industry and the car industry will be working part time and will finally go under in a depression as severe as that of the 1930's (Cochet 2004).

We know what will happen to ports through which exports and imports come and go, because for a short period during the oil crisis in 1973, the Dutch Port of Rotterdam had no oil. There was no bunker oil for the ships, no diesel for the trucks and trains that distributed the cargo, and no petrol for people to get to work.

Between 2015 and 2035, it will perhaps get much worse because rising oil prices will not only have collapsed the developed industrial economies but those of the developing world as well. Die-off from starvation and a mass unemployment will reduce greenhouse gas emissions in the most inequitable and barbaric way unless the nations of the world mobilise their people and industries to create the green products and processes to conserve oil and produce food without massive inputs of gas and oil.

The human population increased from 2.2 billion in 1938 to 6.3 billion in 2003. This was the greatest increase in world history and it was only made possible by the production of cheap oil which increased from 2.5 billion barrels of oil in 1938 to 26 billion barrels in 2003. As oil production went up, so did food production and the world's population (see Figure 7).

Cheap oil made possible the green revolution which introduced new strains of higher yielding crops, that could be planted more than once a year, but needed more and cheaper fertiliser made from oil and gas. Cheap oil powers farm machinery such as tractors, refrigerated food storage systems, trucks to take the food to market and ships to export it. Most pesticides are petroleum (oil) based. The world's fleet of tractors, cars trucks and buses increased from around 15 million in 1938 to 800 million today.

Oil shortages could drastically reduce the world population by 2028

Assuming adequate food production the population of the world has been predicted to grow by 1.2% per year from 6.3 billion in 2003 to 8 billion by 2028; or 1.7 billion more mouths to

feed in 25 years. The problem is that world cereal crop production has been shrinking on a per capita basis since 1984 and world tonnage of grain production and grain reserves have been dropping from 1999 to 2004. With a population growth rate of around 70 million per year till 2008 there are far more mouths to feed. By 2008 most grain will be consumed almost as quick as it is produced and the poor nations of the world will suffer from then on, because grain is not equitably distributed. Without an internationally agreed oil conservation program world food production will decline from around 2008 and a billion people could starve to death by 2028. This is likely to happen for the following reasons:

1) Oil to power-assist labour intensive agriculture in the developing world will not be affordable: This will happen when wealthy OECD countries buy all the high cost oil to keep their car dependent transport systems going, and for their oil intensive agricultural practices. For example U.S. food production consumes ten times more fossil fuel energy than it produces in food energy and is one of the most unsustainable agricultural systems in the world, even if it has been highly profitable according to economic rationalists. Four litres of oil are expended each day to feed each American and because power comes out of the end of a gun they will get priority in accessing oil supplies. This will deprive the poor countries of the oil needed, to power assist their labour intensive food production, with small tractors and agricultural machinery, and to transport their food to market. (Simms 2004)

2) Oil for the mitigation of the worldwide depletion or destruction of soil is not affordable. Cheap oil is needed to combat enhanced desertification; salinization of the fresh water supply along the coastal areas due to sea level rises; and enhanced erosion of arable land. Due to desertification, 8,800 square kilometres of formerly productive land each year and 25 billion tons of topsoil will have been lost globally each year, due to misuse or overuse of the land. Arable farmland has been shrinking by over 1% every year, as an ever-larger proportion of the world's population live in cities built on what was formerly productive farmland. As with oil we are depleting the soil at a much faster rate than it is being rejuvenated. Soil's long-term value as a renewable resource that will hold water and produce food, fuel, and fibre has been ignored by free market and totalitarian regimes for over 200 years (CFAN 2003).

3) Water for agriculture in most parts of the world is being used up. Cutbacks in grain harvests will be occurring in many countries due to the ongoing depletion of aquifers and oil fields occurring in the same time frame. Aquifers are being depleted in scores of countries, including China, India, the US, and Australia which collectively account more than half of the world grain harvest. Because it takes a thousand tons of water to produce a ton of grain, fresh water, its acquisition and delivery is already a problem in many countries and will become critical for many more in the next decade. Water scarcity, once a local issue, is now crossing national boundaries. Some of the world's major rivers are being dammed in one country thus depriving countries of water down stream who may then choose to go war to gain access to water (Pearce 2004)(Brown 2003).

4) Climate change warms the earth and the oceans and depletes or destroys more land. Violent cyclones due to warming of seawater will move hundreds of kilometres towards the poles. Floods, drought, cyclones, tornadoes and violent storm surges will increase in frequency and intensity destroying more crops, plantations, terrace agricultural and other irrigation systems that have taken decades to be productive. In low lying coastal areas, sea level rises will, in the longer term poison productive farmland with salt. The interaction of hunger, the drying up or pollution of fresh water and sea-level rise in vulnerable low lying areas in the developing world could produce up to 800 million refugees. (Brown 2003)

5) Climate change warms the earth spreading tropical diseases over more habited areas.
In the present century, these will be enhanced by the diffusion of respiratory disease as the world warms. It has been predicted that around 600 million more people will die. In Australia, airborne vectors carrying malaria and Japanese encephalitis will head south into productive farming areas. Australia has perhaps the most nutrient deficient soils in the world, especially in the south-west corner of W A. Present crop production practices only succeed through extensive use of fertilisers and diesel fuel (Fleay 2004). By 2028, climate change will bring more severe droughts to southern Australia.

Oil dependence is a serious threat to Australian National security

Over the last forty years, Australia has become addicted to cheap oil, especially for transport which uses almost 80% of Australia's petroleum (APPEA, 2002). 55% of road transport fuel is petrol, 39% diesel and 6% is LPG. Australia's growing dependence on cars, particularly single occupant cars and 4WDs for commuting is the subject of this paper. However, Australia is also dependent on cars for inter city and intra state travel: aircraft for long distance passenger travel and tourism; light commercial vehicles and trucks for freight; and shipping for international trade.

Australia has low oil prospectivity. Fields yet to be discovered are likely to be of small to medium size and to be 300 metres or more below the sea. Barry Jones, Executive Director of the Australian Petroleum Production and Exploration Association said, "that the place where you are going to find a really big discovery is in deep water. The most likely new areas in south-east Australia are off the Tasmanian coast" (Trounson 2004). What he refers to as "really big" in an Australia context is of medium sized discovery by world standards.

The decline of Australia's oil production has been documented by Geoscience Australia, the Federal Government's geological survey organisation, which has shown that at the 2003 rate of consumption' remaining economic reserves will only last 11.3 years (Geoscience 2004). This is why the Federal Government has pledged in the 2004 budget to contribute $1.50 for every $1 spent on exploration for new oil fields 400 metres or more below sea level. The estimated cost to the Budget is $17 million which indicates that perhaps the Federal Government believes that there is a minor problem requiring only a token funding gesture.

The bad advice the Federal Government gets from some of its own agencies is that there is enough oil in the world barrel for another 30 years (SESSWG 2004). This bad advice is reflected in the transport budget which provides an extra $1.9 billion for road funding over the next three years. The Census Data and the latest research on oil depletion presented in this paper suggest that it would be prudent to reduce current levels of oil dependence because Australia is not self sufficient in oil and its economy would still be at risk if more offshore oil was found. High levels of car and oil dependence are potentially very serious threats to Australian national security for four reasons: -

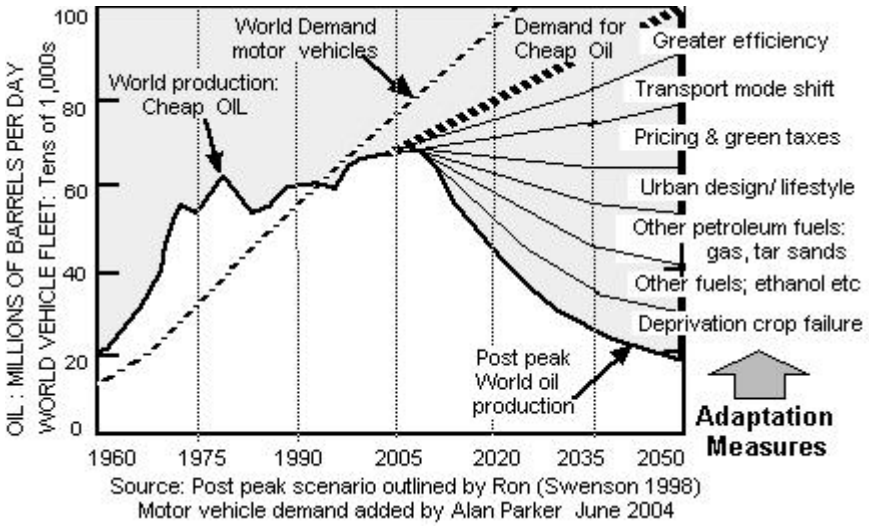
1. According to the Australian Petroleum Production & Exploration Association, by 2010, Australian oil production will cover only half of the country's needs and will cost between $3 billion and $12 billion at today's prices. It is more likely to be at or near the $12 billion mark if significantly more oil is not found in deep water (Trounson 2004).

2. In the unlikely event that major oil fields are found in deep water, providing enough oil for self-sufficiency for the next 30 years with some left over to export, there would still be a serious threat to Australian National security. The risk of the world economy and global food production imploding and bringing the Australian economy down with it is very high because there is no is no practical alternative to cheap oil in the developed countries.

3. A hydrogen economy cannot be created in time to cope with coming oil shortages and the timetable laid out by the Bush administration's $1.2 billion hydrogen economy policy statements is not credible. The “hydrogen economy” is not the quick fix to oil depletion. On the contrary, there are several research studies that have concluded that “under the best case scenario the hydrogen transition will do little to cut oil imports or greenhouse gas emissions during the next 25 years. (Bossel & Eliasson 200)(Forest 2003)(Wald 2004)

4. The 26 developed nations of the world have no plans to replace oil with renewable sources of energy in the transport sector. Even the use of renewable energy to produce electricity has declined from 11% in 1971 to 7% in 2001. World energy trends reveal that without real commitment and substantial subsidies renewable energy resources will never replace our transport fuels. (Hogan and Cohen 2004)

Figure 7 Projections of the demand for oil and motor vehicles and possible oil conservation measures to adapt to future decline in world oil production



The Census data in figures 2, 4 and 5 suggest the need for “urban design/lifestyle” changes and land use changed to accommodate population growth in the capital cities. To implement these changes across the transport sector it will also need “pricing and green taxes”, more “fuel efficiency”, the use of “other fuels” particular gas in the first ten years of a 30 years transition period needed to move from the “age of oil” to the “solar age”. This paper has analysed commuter trends which show a need for “transport mode shift”. Hence, the conclusions and recommendations for behavioural programs that target unsustainable commutes.

National energy security plan needed to Implement the adaptation measures

It would by prudent for the Commonwealth to have an energy security policy as they have had in Japan since the since the 1974 oil crisis, which closed down industries vital to the national economy and demonstrated the vulnerability of the Japanese economy to reduced oil supplies. (Hook 1994)

The Japanese ruling bureaucracy realised in 1974 that national security is about enabling Japan to survive oil shortages and that oil conservation is just as important as having a military capacity and that oil dependence was a serious threat to their way of life. Japan's energy security policy has reduced oil dependence in the transport sector by creating the finest rail system in the world for urban commuting and intercity transportation which is sustainable because it is reliant mainly on hydro electric sources (Hook, W. 1994). Intermodal passenger transport is highly developed with 6 million bicycles being used to access rail stations and very efficient modal interchanges linking buses and trains, with secure bicycle parking.

Japan has introduced legislation requiring the sale of new cars after four years of use, in other countries, so that new energy efficient cars particularly petrol electric hybrids, can in few years recycle their car fleet and make it the most fuel efficient in the world. Petrol is A$1.75 per litre, a price high enough to encourage the sale of smaller cars. Electricity generation is heavily dependent on oil and is the reason for Japan planning to generate 40% of its electricity from nuclear power. This electricity can be used for more high-speed trains and to power electric bicycles which are becoming popular in Japan. (Parker 2004) Japan has almost zero population growth, has no indigenous oil resources and is sensibly planning to survive.

Conclusion and recommendations

The Census Data show very clearly that in urban Australia an increasing percentage of car dependent workers who use a vehicle designed to carry three or four people to drive alone to work are making a significant contribution to Australian vulnerability to predictable shortages of cheap oil in the future. This trend is unsustainable and also creates road congestion, air pollution and excessive noise. The Census Data indicate that oil dependence is not caused by the decreasing proportion of commuters who share cars, use public transport, ride a bike or walk to work. Data from many other sources suggests that Australian vulnerability to predictable shortages of cheap oil is increasing and that the economic viability of urban economies is so at risk that oil dependence will become a serious threat to national security.

It is concluded that there is sound research showing that coping with oil depletion is a risk management problem of global proportions which could trigger the collapse of the worlds urban economies into a long and perhaps permanent economic depression. Not only that but, the Australian car fleet is becoming less fuel-efficient and oil consumption is increasing while indigenous oil production is declining. Furthermore, there is no sound research proving that the peaking of world oil production has not peaked, or will shortly peak; or that sufficient cheap oil will be found in Australian territory to make Australia self sufficient.

The Census data shows that most single occupant car commutes originate in the sprawling outer suburbs, with between 20 and 800 households per square kilometre, where around three quarters of all Australian capital cities dwellers live. In around 80% of these households there are 2 or more cars and around 85% of the employed household occupants commute by car and

are responsible for around 85% of the distance travelled by all capital city commuters. When cheap oil is no longer available these outer suburbs will suffer great hardship.

The Census data suggests a need for behavioural change programs, which target the following specific commuter behaviours: -

1. reduction in drive alone car commutes by women;
2. reduction in drive alone car commutes by men;
3. increased use of public transport;
4. increase in walk and bicycle commutes all the way to work;
5. increased intermodal access to suburban rail systems by bicycle, bus and shared cars;
6. reduced household car ownership via car-pooling, informal car sharing or the development of car clubs to reduce size of the car fleet.

These programs should to be funded by the Commonwealth and implemented by state and local governments. Monitoring and evaluating of these programs should incorporate the use of the Census Data for 2006, 2011 and 2016.

It is concluded that oil dependence, is perhaps, the most dangerous threat to Australian national security since Federation. Therefore, it would be prudent for the Commonwealth to learn from world best practice in reducing oil dependence in Japan. What is needed is an Energy Security Plan to implement necessary adaptation measures and give them a level of priority that reflects the serious risk to national security.

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