SUBMISSION TO THE PRODUCTIVITY COMMISSION RE ENERGY EFFICIENCY

Dr Philip Laird, University of Wollongong October 2004

Introduction

1. This submission will draw on research conducted at the University of Wollongong and supported, in part, by the Rail CRC. However, it does not necessarily reflect the views of either organisation. It also draws on earlier submissions to the Federal Government, a book (Laird, Newman, Bachels and Kenworthy *Back on Track: Rethinking Transport Policy in Australia and New Zealand* UNSW Press 2001) and two papers *Interstate rail track upgrading options to 2014* (Laird and Michell, 2004) Australasian Transport Research Forum, Adelaide and *Australian land transport - is it sustainable ?* (Laird, Adorni-Braccesi and Collett, 2004) Towards Sustainable Land Transport Conference, Wellington, New Zealand.

2. The present inquiry by the Commission into energy efficiency is appropriate given increasing concern about global oil supply and demand, greenhouse gas emissions and the aging condition of some of Australia's infrastructure such as rail track along with electricity distribution and generation networks.

General comments on energy

3. It is submitted that more disclosure of timely information on energy use by both government and industry would be in the national interest. One way to achieve this would simply be for government, through legislation, to require disclosure in the relevant annual reports. This should go further than disclosing the cost of any emission trading costs and ideally include the following: quantities of coal, fuel, gas or electricity used each year, plus the energy equivalents used in both Full Fuel Cycle (FFC or primary) energy and end-use energy.

Put simply, if you are not measuring energy use, or the cost of energy is perceived to be so cheap, then there is little or no incentive for energy conservation.

4. The Senate Committee on Environment, Communications, Information Technology and the Arts Reference Committee in its 2000 report ‘The Heat is On’ and its recommendations, and the limited Government response to these recommendations is of note.

Of the 106 recommendations made by the majority of the Committee, no fewer than 21 addressed transport greenhouse gas emissions (GHG) and solutions. However, only four of these 21 transport recommendations received the full support of the Federal Government (Australian Greenhouse Office, 2001), with a further 11 recommendations being considered, already being supported, or addressed through existing measures. The remaining six recommendations, coupled with a minority party recommendation to replace road funds by transport funds, were noted as not being supported by the Government.

A new approach is required to address the heavy bias to oil-based road transport in Australia. The AusLink White paper released in June 2004 does in effect replace road funds by transport funds from a land freight perspective. However, a new program is also required to shift more people from single occupant cars to urban transport in our cities and regions. This writer suggests that government at a federal and state level will need to do more to reduce transport greenhouse gas, and to assist Australia to adjust to a regime of higher international oil prices in a manner that encourages improved energy efficiency in transport. This would also reduce transport GHG emissions.

The Bureau of Transport and Regional Economics has more than once examined reducing energy use and greenhouse gas emission from transport, including in 2002 with *Greenhouse policy options for transport - Australian trends to 2020*, with some 11 groups of measures. These include reduce vehicle kilometres travelled (VKT), nine measures to reduce emissions per VKT, four road pricing measures (mass-distance charges for heavy trucks, tolls, internalising transport externalities and emission charging), carbon taxes and tradable permits. Optimal road pricing was held to offer the best way forward.

5. The Energy Research and Development Corporation (ERDC) was formed in 1990 to increase commercialisation and the effectiveness of a long standing National Energy Research, Development and Demonstration Council. It was regretfully abolished about 1997. To quote Senator Meg Lees (Hansard, Wed 25th March 1998) in speaking to a disallowance motion after the Government had moved to close down ERDC. "The Energy Research and Development Corporation was set up to manage the federal government's direct investment in energy innovation and research in energy supply and use. The way this works is that it invests in energy projects right from concept through to commercialisation, focusing on traditional energy supply, alternative and renewable energy sources and systems, and sustainable energy use. It covers a range of things, including gas and liquid fuels, electricity generation, distribution and application of energy use in Australian industry, manufacturing, transport, the built environment, appliances, processing and agriculture-in other words, the full gamut.

"The ERDC selects projects and then funds them to meet these priorities. Therefore, it supplies support to the private research sector. It is a big injector of funds in research and development--indeed, the major injector of funds--and was about ensuring that Australia had a leg-up in the new technology field, that we actually got into the sunrise industries and really made a contribution to the future of energy trends and use. "

"It has in its short time developed a very good reputation, a good name in the industry and research institutions, and it was helping to create a lot of jobs, not just jobs directly in the specific research areas but, as processes and procedures came on stream and as products were developed, further jobs down the line. As an Australian it was very good to see the Australian stamp on much of this marketed technology. "

My own comment follows. With a modest Federal outlay of about $12.5 million a year, and a small dedicated professional staff, ERDC supported projects that were mainly funded by industry with the strong prospect of saving energy. The scope of its later projects was wide ranging. One was improved control of electric motors with big power savings, and applications including a sawmill in Tumbarumba, Queensland Rail’s Brisbane-Rockhampton electric tilt train that started running in 1998, and exports to Hong Kong’s Mass Transit Railway. Solar heating and solar power cell development was supported along with energy efficient housing. So also was the use of methane gas drained from NSW coal mines to run bulk haulage trucks, and compressed natural gas to run quieter cleaner garbage trucks for Waverley Council. Another ERDC project (Weekend Australian 17-18 May, 1997 p42) was to make drink vending machines more power efficient with a saving each year for each new machine of $350. The electricity saved meant less carbon dioxide emissions to the greenhouse and less air pollution in our cities.

In short, ERDC actively supported measures to save energy, increase Australia's international competitiveness and to reduce greenhouse gas emissions. There is a clear need for Australia to improve its performance in these areas.

The 1996 State of the Environment Australia report noted that our average energy consumption per head (at 16.2 gigajoules per head in 1993-94) had increased in recent years, and, is a little higher than the OECD average. In a warm country, we should be using below the OECD average. This report also notes that Australia has a high fuel use per capita which is some 20 per cent higher than the OECD urban average, and the relatively poor average fuel efficiency of our car fleet.

Australia also has the highest road freight activity per capita in the world, and road transport uses much more fuel than rail or sea for a given long distance or bulk freight task. Clearly, there is ongoing need for improvement in energy use, and we cannot be 'relaxed and comfortable' about market forces delivering, on their own, the necessary gains.

6. In place of ERDC, other arrangements were made, including an increased reliance on State Governments and private sector, along with Universities working with reduced resources, to advance essential energy research of national significance.

In one sense, the Australian Greenhouse Office (AGO) became the Federal Government's lead agency in energy efficiency. However, issues of energy efficiency and conservation appear to have been subordinated to suggestions that somehow Australia is meeting its agreed Kyoto targets for greenhouse gas emissions.

The Commission is invited to explore the proposition that Australia should reduce its domestic energy use (ie energy use in Australia excluding that directly involved in producing exports) per capita, and, ways of achieving this. This could well include the establishment of a new Energy R and D Corporation.

7. Canada has a One-Tonne Challenge (www.climatechange.gc.ca) which calls on all Canadians to reduce their annual greenhouse gas emissions by one tonne per annum. Canada has also ratified the Kyoto Protocol. Even if Australia, as yet, has not ratified the Kyoto Protocol, it could **at least support a similar challenge for all Australian's to reduce their annual greenhouse gas emissions by one tonne per annum.**

The Canadian Federal Government (like the US Government) also funds urban public transport. Canada's Federal Transport agency, Transport Canada (2004) is involved in funding urban transportation, has a program Moving on Sustainable Transportation or MOST, and a *Sustainable Development Strategy 2004-2006.*

8. The New Zealand Parliament has also ratified the Kyoto Protocol, and approved in February 2002 a Land Transport Package called Moving Forward. Along with increasing petrol tax by 4.7 cents per litre with some proceeds going to alternatives to roads and replacing of road funds with transport funds, the package aims for a transport system that *is 'affordable, integrated, safe, responsive and sustainable.'*

Further initiatives have since been announced, and petrol tax is due to be increased by a further 5 cents per litre in April 2005.

Transport

9. The remainder, and main part, of this submission will focus on energy use in land transport. This will draw on research undertaken at the University of Wollongong for Project 24 'Energy efficiency and rail sustainability' of the CRC in Railway Engineering and Technologies.

A summary of this Project is attached as Appendix A.

10. A literature survey completed for this project in May 2003 appears in Appendix B of this submission. The main findings are that whilst road freight has increased its energy efficiency during the 1990s, so also has rail, and rail is a more energy efficient way of moving freight.

An appendix to this literature survey (also attached) updates an earlier review 'Sustainable Transport: Responding to the Challenges" published in 1999 by Engineers Australia and a book *Back on Track: Rethinking transport policy in Australia and New Zealand* (Laird, Newman, Bachels and Kenworthy, UNSW Press 2001) referred hereinafter as Back on Track.

11. The information in this survey could usefully be updated to include recent relevant publications of:
The Australian Bureau of Statistics (Survey of Motor Vehicle Usage)
Apelbaum Consulting Group
Australasian Railway Association
Australian Trucking Association
The Bureau of Transport and Regional Economics

12. The greatest potential for saving liquid fuel in Australia is in moving people in major Greater Metropolitan Regions in a more energy efficient manner. Or, argued cogently by Prof Peter Newman and others (see, for example, the book *Back on Track* cited above), reducing excessive automobile dependence. This will require better urban public transport (upgraded infrastructure and as well in some cities and particularly Sydney improved service delivery) along with improved road pricing.

Urban Passenger Transport

13. As argued by the Industry Commission (IC) in its 1994 report on Urban Transport, the way people then moved themselves around Australia’s larger cities was in need of reform. Ten years later, the need for reform is even greater in order to reduce high economic, environmental and social costs imposed by excessive automotive dependence.

14. The difficulty in introducing reform in this area was outlined by this and other writers in the book *Back on Track* (pp96-98). In brief, the IC in 1994 gave a good appreciation of “major problems in major cities” (to quote a 1999 report *Sustainable Transport: Responding to the challenges* of Engineers Australia). The IC in its 1994 Urban Transport also gave a carefully considered way of moving forward. The Commission recognised the complexity of the problem and that the important thing was to start the reform process.

15. Ten years after this definitive IC report was released in 1994, we know that passenger vehicle kilometres in our major cities have significantly increased (for example, in the order of 25 per cent in Sydney from 1991 to 2001). However, major Australian cities, (with the notable exception of Perth) have seen very modest growth in urban public transport passenger numbers.

16. There are many factors resulting from much increased car use and little growth in public transport usage. One factor is the introduction of the New Tax System in 2000-01 to not only place a GST on public transport, but also lead to cheaper cars and through a removal of indexation of fuel excise, cheaper petrol. A further factor is a vigorous roll out over the last 10 years of freeways and tollways in major cities, with modest and variable investment in urban rail and bus systems.

17. With the exception of fuel excise, which is offset by Federal funds for roads and the Queensland Fuel Subsidy Scheme, there is a very limited effort to recover external costs from motor vehicle use.

18. The Bureau of Transport and Regional Economics in a 2003 paper *The economic consequences of the health effects of transport emissions in Australian capital cities*, by J Amoaka et al to the Australasian Transport Research Forum, Wellington gave mid-range estimates of the annual health related costs of air pollution from motor vehicles in Australia's capital cities. The mid-range estimate, for the year 2000, was $3.3 billion. This comprises $1228 million from the estimated cost of mortality (premature death as a result of air pollution), and $2460 million for morbidity (quality of life and/or productive capacity of victims impaired or reduced as a result of air pollution). Following a European approach (Kunzli N, Kaiser R and Medina S, Public health impact of outdoor and traffic related air pollution: a European assessment, *Lancet* Vol 356, Sept 2 2000) the BTRE effectively attributes air pollution costs to PM10 (particulate matter of size less than 10 microns) levels.

In a further 2003 BTRE paper (*Urban pollutant emissions from motor vehicles: Australian trends to 2020)* estimates are given of both PM10 emissions in Australia's capital cities and the kilometres driven for various types of motor vehicles. Analysis of this data shows, in part, that the average health cost of air pollution from operations of cars (and other small passenger vehicles) in Australia's capital cities is 1.8 cents per vehicle kilometre. The average health unit cost for within Australia's mainland State capital cities range from 1 cents per vehicle kilometre (Perth) to 2.4 cents per vehicle kilometre (Sydney).

To recover a cost of 1.8 cents per car kilometre in capital cities through fuel taxes would require, assuming an average fuel use of 11.4 litres per 100 km (ABS SMVU 2001 estimate), a **fuel levy of about 16 cents per litre.**

19. An outline of external costs of motor vehicle use and 'road deficits' follow in Appendix C that suggests an annual 'road deficit' now exceeding $13 billion. In regards to the costs of accidents involving motor vehicles it can be argued that some, but not all of these costs fall on other road users. The percentage of road crash costs that should be regarded as an external cost is open to question. Hence, the estimate of 'road deficit' exceeding $13 billion per year is also open to question. However, treating external costs as zero is not a satisfactory policy option.

20. It is submitted that Government should support a move to a "polluter pays" principle, plus to see internalisation of all current external costs, and to put some cost for greenhouse gas emissions.

21. As well, transport policy and taxation measures should be reformulated to be *"consistent with our obligation to current and future generations to sustain the environment"* (as per the AusLink Green Paper). This paper recognises that (p19) [transport] *"greenhouse gas emissions in 2010 are projected to be almost 47 per cent above 1990 levels."*

22. In a similar way, government could well give more support to the National Strategy for Lowering Emissions from Urban Traffic with a National Action Plan, as approved by the Australian Transport Council in August 2002.

To quote from the communique for this meeting: *The Strategy and Action Plan developed by the National Transport Secretariat in collaboration with all states, territories and the Commonwealth government provides a groundbreaking national approach to reducing greenhouse emissions from the transport sector.*

Ministers noted that the National Strategy is the first agreed national approach driven by the transport sector to reducing greenhouse emissions, creating greater momentum than can be achieved via a fragmented approach.

The National Action Plan builds on the large range of activities already underway in each state and territory. The positions are, within the next 5-10 years:

a fully integrated transport system that allows for timely, reliable, accessible and safe travel will be operational.

programs that encourage people to take fewer trips by car will be operational in each jurisdiction and a nationally cooperative approach between jurisdictions will have been developed.

transport costs will have moved from predominantly fixed to predominantly variable costs. This outcome will address cost variations in transport modes and ensure that transport users experience more of the true cost of their travel choices.

a significant improvement in the emissions efficiency of urban vehicles will have been achieved.

nationally developed policy and benchmarking tools for the integration of transport and land use planning will have been implemented. Well-planned urban development reduces the need for car trips and improves the 'liveability' of towns and cities.

a nationally developed transport investment framework for investment decisions across all transport modes of travel will have been trialled and implemented.

23. The issues of urban transport and road pricing are considered sufficiently important as to warrant separate inquiries by the Commission. Indeed, following release in 1994 of the Industry Commission's report on urban transport, the Government of the day agreed for a further inquiry to take place in 1997. This did not proceed. The Commission in its 1999 report on progress in rail reform recommended an inquiry into road provision, funding and pricing. This inquiry was not agreed to by the Howard Government and did not proceed.

24. As argued in the book, *Back on Track*, whilst some gains were made towards more efficient transport arrangements during the 1990s and the early part of the present decade, road pricing has for the most part gone backwards at a national level (cheaper diesel in 2000 and freezing of fuel excise indexation in 2001) and in at least two states (NSW with toll rebates, and Queensland with its Fuel Subsidy Scheme). Moreover, the Fuel Taxation Inquiry recommendations were treated set aside in the 2002 Federal Budget.

25. The Issues Paper for the present inquiry on page 33 mentions transport accounting for 41 per cent of Australia's final energy usage, mostly in road transport. This statement warrants amplification with up to date data giving fuel use (with quantities of fuel used by type) and (for rail) electricity use, with end use energy (in Petajoules) and Primary or Full Fuel Cycle (FFC) energy (in Petajoules) with careful attention to conversion factors between end use and FFC.

The list of questions on this page of the Issues Paper appears limited.

26. As the Issues Paper on page 34 notes, rail freight is more energy efficient than road freight whilst road freight gives flexibility. However, intermodal freight allows energy efficient rail or sea transport for the line haul, with flexible road transport for the pick up and delivery.

Impediments to intermodal transport are currently being addressed by the National Transport Commission.

27. The questions asked on page 34 of the Issues Paper appear to be good ones. However, the answers could well require various scenarios that would make assumptions about both rail infrastructure and road pricing.

One example was in an ARC/Rail Infrastructure Project "Greenhouse gas reductions from mainline rail track upgrading and competitive neutrality" where Sydney-Melbourne intercity land freight was studied. Here, for different rail freight transit times were used (ranging from the current 14 hours which has is too slow for the market down to about 10 hours (after appreciable track straightening) along with four different regimes for road pricing of heavy trucks (ranging from recent NRTC charges ('highway subsidisation') up to recent New Zealand mass-distance pricing (about three times NRTC charges for the heavier long distance semitrailers)).

28. A good approach to energy use in transport was given 25 years ago in a government Australian Transport Advisory Council 1979 publication *Transport and Energy Overview.* This report was prepared, following the second major world oil price shock during the late 1970s. Although the data used in this report is now dated, the approach is commended, as are the conclusions. In part:

"... rail is relatively energy efficient compared to road for long distance freight ... (and) ... does have fuel substitute options, such as coal-oil slurries or electrification .... As far as possible pricing and cost recovery policies should be consistent across the modes so as to encourage use of modes appropriate to particular tasks. Appropriateness may be defined broadly as minimising the total social cost of transport services, including externalities.

29. Another commendable approach was taken during the early 1990s by a Working Group on Ecologically Sustainable Development examining transport. The report made about 30 useful recommendations (which regrettably had only limited application to Government policy and budgets). The 1995 report of the Intergovernmental Committee on Ecologically Sustainable

Development (ESD), Part V Section 2 notes the 1992 National Strategy for ESD and the National Greenhouse Response Strategy recommendation of reducing *"...total energy consumption in transport through:*

* *improved technical and economic efficiency of urban and non-urban transportation*

* *switching to alternative transport technologies or modes where this reduces greenhouse emissions per passenger or unit of freight".*

30. The difficulty by government during the 1990s, and early part of this decade, in making progress on transport in a way to reduce both energy use and significant external costs (economic, social and environmental) is explored in the book *Back on Track*. One the one hand (Chapter 5), there is an 'Institutional Problem' leading to 'Policy Paralysis' and on the other hand (Chapter 6), Australia has no fewer than 60 road lobby groups leading to a formidable 'Political Problem'.

31. There has been progress in some areas in improving energy efficiency in moving people as shown by the production of cars using as little as 5 litres (or less) of petrol per 100 km. However, as per *Back on Track*, due to various factors (including low tariffs for large four wheel drive vehicles with high fuel usage per km) there has been little or no reduction in the average energy efficiency of the overall car fleet. In regards to freight movement, the situation is again mixed, with good overall advances in energy efficiency for articulated trucks and rail (as per the literature survey).

32. However, the bottom line is that Australia is using more energy in transport. In fact, as suggested by the AGO, our energy usage is now some 24 per cent above 1990 levels, and by 2010 could be 44 per cent above 1990 levels.

33. The Commission is invited to support a simple challenge: for Australia to actually reduce, year by year, its total energy use in transport (and electricity). With the relevant 'policy levers', this would give a real incentive to both cut waste and improve energy efficiency.

34. There has been at least one period during the 1990s, as noted by the Apelbaum Consulting Group (Australian Transport Task, Vol B, 1997, p120) where the private rail freight task increased (by 8 per cent - p 44) and the energy use actually declined by 4 per cent from 1990-91 to 1994-95.

A further example from the 1990s is with National Rail's then new fleet of 4000 HP Dash 8 locomotives. This investment coupled with upgraded wagons and incentives for drivers to save fuel allowed National Rail to obtain significant fuel savings. A September 2001 brochure issued by National Rail (pre-sale and to note the advent of a profit in 2001-01) **stated an average fuel use of 4.0 litres per 000 gtkm for 1999-00-01 as against 7.4 litres per 000 gtkm for 1992-93-94.**

35. The condition of Australia's infrastructure has been addressed, in part, by a series of Infrastructure Report Cards released by Engineers Australia (the nation as a whole, 2000 and 2001, NSW 2003 with Queensland to follow). Land transport infrastructure has also been addressed, for example, by the National Committee of Transport of Engineers Australia.

36. As noted above (Item 4), the BTRE has more than once examined reducing energy use and greenhouse gas emission from transport, including in 2002 with *Greenhouse policy options for transport - Australian trends to 2020*. Here, optimal road pricing was held to offer the best way forward.

37. This view was shared by the Parry Inquiry (NSW Ministry for Transport, 2003) that noted, inter alia (p72) *"The thinking underlying the support for road use pricing is that road access is currently 'too cheap' (as distinct from the general cost of motor vehicle use), as motorists are not directly bearing all of the costs associated with their decision to make a journey. For example, driving a vehicle is associated with costs such as congestion, road wear and tear, pollution and accidents."*

The Parry Inquiry (loc.cit, p 74) also noted *"Currently, public transport is disadvantaged compared with private transport by a range of taxation (for example, the fringe benefits tax), expenditure and other policies that encourage private transport use. As a separate issue, and irrespective of the decision made regarding road use pricing, those policies that distort decision making in favour of private transport should be reviewed to ensure that public transport is not disadvantaged."*

38. Various Non-Governmental organisations in Australia have expressed some concern about transport policy. By way of example, the Chartered Institute of Transport in Australia is a conservative body that found it necessary to issue a sternly worded statement at its 1998 National Symposium. This was regarding the oil situation and in order to warn the government, industry and the general public: *"Our greatest ever source of cheap energy may soon contract and the 'Petroleum Age' in which we live now can be seen to be approaching an eventual end.*

"The Symposium heard that a clear consensus is emerging that cheap oil production outside the Middle East will begin permanent decline around the year 2000, to be followed by permanent world decline within 15 years. … 'More of the same' in our current transport plans and ways of thinking is no longer tenable. ..."

39. With recent international events and oil prices, this warning is now more relevant. Also, as found by the Institution of Engineers, Australia (1999) we have major problems in major cities, and, there is a need to respond to the challenges. In brief:

A Taxation and fiscal policy instruments should encourage sustainable transport. At present, these measures encourage car and truck use.

B There is a strong case for increased investment in transport infrastructure that is more sustainable and less greenhouse gas intensive. Where market forces fail, government should intervene.

C More holistic approaches to transport decisions are needed that integrate considerations of impacts on health, sustainability and greenhouse gas emissions.

D There is a need for research to support cleaner transport fuels and technologies, along with transport pricing, economics and demand management technologies.

A ten point transport pricing plan

40. As above, there is increased interest in road pricing. One approach is given by the Railway Technical Society of Australasia (2004 see www.rtsa.com.au and go to publications etc to find a Submission to the House of Representatives Environment and Heritage Committee's inquiry into Sustainable Cities 2025) which proposed a ten point transport pricing plan along the following lines.

1. Re tolls

A. remove toll rebates in Western Sydney, which is a costly scheme to administer.

B. reinstate tolls at Berowra and Waterfall, with the proceeds being used to expedite long-overdue improvements of both the Pacific and Princes Highways.

C. ensure that the Mitcham - Frankston motorway is built as a toll way.

2. Remove the Queensland Fuel Subsidy Scheme, at least from South East Queensland.

3. Impose a congestion charge for access to the Sydney and Melbourne CBDs. It works well in London. And/or impose an environmental fuel levy for motor vehicle use in the Greater Metropolitan Areas of state capital cities and Canberra.

4. Restore fuel excise indexation, with the additional revenue going into improved transport infrastructure. To ensure best use of funds, replace road funds (as enjoyed by the NSW Roads and Traffic Authority) by transport funds (as per Western Australia, New Zealand and as proposed under AusLink).

5. Ensure that the third determination of heavy vehicle road user charges by the National Transport Commission recovers - at least the populous zone - the full road System costs from heavy articulated trucks, B-Doubles and road trains. At present, these vehicles are cross-subsidised by other road users. Ensure that additional revenue is directed towards not only National Highway System maintenance (to compensate for changes under AusLink), but improved intermodal facilities.

6. Increase annual registration fees for the heavier four wheel drive vehicles.

7. Support the recommendation of the Productivity Commission from its 1999 Inquiry into Progress in Rail Reform into an inquiry into road provision, funding and pricing. Also have the Productivity Commission examine urban transport.

8. Increase rail fares, with all proceeds going into a better rail system.

9. Improved land transport data, with publication of accurate, comprehensive and up-to-date information on all modes of transport, with details of energy use and greenhouse gas emissions.

10. Ensure that major airports and seaports are not in receipt of hidden subsidies.

APPENDIX A Rail CRC Project 24 – Rail Transport Energy Efficiency and Sustainability

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ENERGY EFFICIENCY

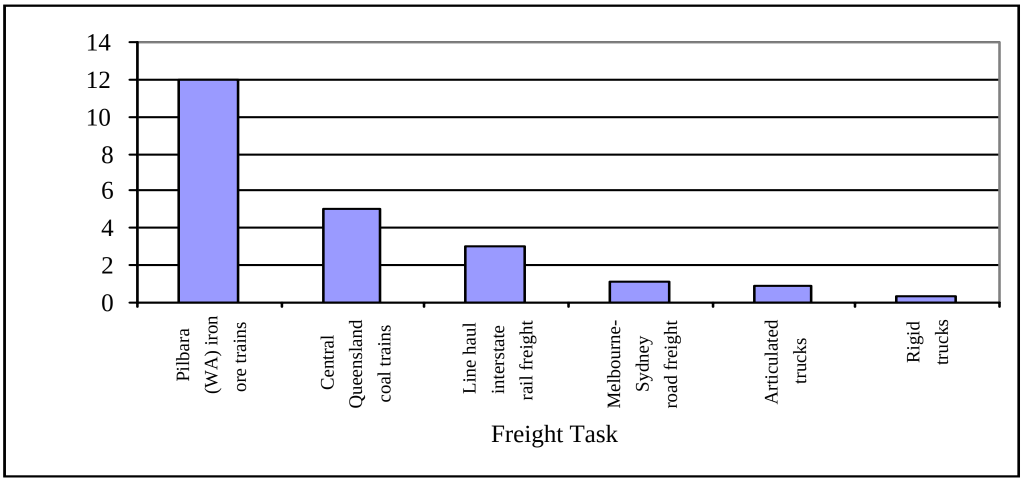
Sources of data re energy use in transport operations in Australia include the Australian Bureau of Statistics (ABS), the Bureau of Transport and Regional Economics (BTRE), the Apelbaum Consulting Group (ACG), the Australasian Railway Association (ARA-Australian Rail Industry Report 2003) and this writer. A common theme is that rail transport is more energy efficient than road transport.

Rail freight In Australia, fuel use per tonne for BHP Iron Ore operations has decreased by 43 per cent between 1980 and 2000 to about 0.75 litres per tonne of iron ore (Darby, 2001 *Technology for profit*, Proceedings 7th International Heavy Haul Conference). This gives a world record energy efficiency of at least 12 net tonne per Megajoule (net tkm/MJ) on a Full Fuel Cycle (FFC) basis where 1 litre of diesel is equivalent to 41.77 MJ.

Queensland Rail (QR) and former government rail systems had an average FFC energy efficiency in rail freight of 2.98 net tkm/MJ in 1997-98 (ACG). This includes the use of electric power for QR where 1 KWh is equivalent to 12 MJ on a FFC basis giving Central Queensland coal trains an energy efficiency of at least 5 net tkm/MJ. CRC project 24 data for 2001-02 suggests an average for non iron ore freight trains of 3.3 net tkm/MJ.

By 2002, US Class I railroads had gained an average energy efficiency of 3.7 net tkm/MJ (primary energy). The Canadian Pacific Railway 2003 Annual Report publishes data implying an impressive energy efficiency of 4.2 net tkm/MJ. There are problems in gaining accurate and up to date land transport data within Australia.

Driving techniques, equipment, train mass, terrain and track alignment all influence rail fuel consumption. With 4000 HP locomotives, upgraded wagons, and incentives for drivers to save fuel, Melbourne - Sydney - Brisbane standard superfreighter average energy efficiency now appears about 2.7 net tkm/MJ on the existing track. Computer simulation from an earlier project for the Rail Infrastructure Corporation has shown that for the entire Sydney - Melbourne track, a major track upgrade (with three major deviations outlined in the ARTC Track Audit and the 2002 ATRF paper cited below) would increase rail freight energy efficiency by 12 per cent. Further Rail CRC work in this area is now underway by the Project for these and other rail deviation sites within NSW and Queensland.



Rail passengers Rail CRC project 24 aggregate data from individual Australian rail passenger operators is given in Table 1. Based on 2001-02 ARA/ ACG FFC estimates, passenger rail had an average energy efficiency of 0.65 passenger (pax) km per Megajoule (MJ) as compared with 0.36 pax km per MJ for passenger road vehicles, 0.71 pax km per MJ for buses and 0.40 pax km per MJ for domestic airlines.

TABLE 1 RAIL PASSENGER ENERGY EFFICIENCIES
Passenger km per MJ (Full fuel cycle)

	Light Rail	Urban Rail	Non-Urban Rail
2000-01	0.60	0.69	1.09
2001-02	0.60	0.68	1.13
2002-03	0.61	0.64	0.99

SUSTAINABILITY

The project has drawn on BTRE data and Queensland Transport Rail Studies. Along with rail's ability to move freight and passengers with significantly less energy inputs than road, rail transport assists Australia in reducing dependence on oil imports, air pollution and greenhouse gas emissions. Rail also has safety advantages, as shown in part by the cost of accidents involving articulated trucks averaging about 0.5 cents per net tonne km as against 0.03 cents per net tonne km for rail freight.
As a result of recent rail reform measures, rail has now demonstrated its potential to move more freight and passengers in Australia. The achievement of this potential will require ongoing land transport policy reform along with investment in track infrastructure.

Selected Conference papers
2004 (with G Adorni-Braccesi and M Collett) *Australian land transport - is it sustainable ?* Towards Sustainable Land Transport" Conference, Wellington New Zealand

2004 (with M Michell) *Interstate rail track upgrading options to 2014* Australasian Transport Research Forum, Adelaide

2004 (with M Michell) *Benefits from curve easing - the straight track study,* CORE Darwin, Papers, p40.1-40.7

2003 (with M Michell and G Adorni-Braccesi*) External costs and evaluation of major track upgrading projects* AusRail Plus

2003 *Australian transport and greenhouse gas reduction targets,* Australasian Transport Research Forum, Wellington New Zealand

Book Chapter 2003 (with P Newman*) Back on Track? Will Australia return to rail?* World Transport Policy and Practice, Earthscan Press, England, pages 99 -104

APPENDIX B LITERATURE SURVEY RE ENERGY USE IN AUSTRALIAN LAND TRANSPORT (June 2003)

Philip Laird, University of Wollongong and CRC for Railway Engineering and Technologies

Project 24 – Rail Transport Energy Efficiency and Sustainability

1 INTRODUCTION

The subject of fuel use in transport operations in Australia has received limited attention from a number of writers over the last 25 years. This includes the Australian Transport Advisory Council (1979), Bureau of Transport (and Communications/Regional) Economics (BTE - 1980, 1981, 1991, 1996, 1999), Railways of Australia (1980), Gentle (1983), Senate Standing Committees (on Industry Science and Technology - 1990 and Environment, Communications, Information Technology and the Arts - 2000), Laird (1990, 1995, 1996, 1998, 2003), the Industry Commission (1991a, 1991b), Laird and Adorni-Braccesi (1993), Moon (1994), Bureau of Industry Economics (1996), Australian Bureau of Statistics (1997), the Australian Bureau of Agricultural and Resource Economics (ABARE - 2001), and, the Apelbaum Consulting Group (ACG-1991, 1993, 1997, 2001). Overseas interest in Australian transport energy use includes that of the International Energy Agency (2001).

A common theme of much of this work, when touching on freight transport, is that sea and rail transport are generally more energy efficient than road transport. More attention has been given to freight than passenger transport in the above references. Further discussion on land freight is given in Section 2 of this report.

More recent publications on energy use in transport include Affleck (2002) and Laird (2003). In addition, attention has been given to the related topic of greenhouse gas emissions transport, including the BTE (1991, 1996, 2002, 2003) and the Australian Greenhouse Office (AGO -see www.greenhouse.gov.au). In addition, the AGO has introduced a 'Greenhouse Challenge' which has received support from sections of the road freight industry, and Queensland Rail (Ramsden and Mack, 2003) which reports a reduction in greenhouse gases in QR rail freight operations of 4.8 per cent per gross tonne -km between 2000-01 and 2001-02.

In regards to passenger transport, we note from Appendix A that; based on 1997-98 ACG estimates, urban rail had an average energy efficiency of 0.68 passenger (pax) km per Megajoule (MJ) as compared with 0.35 pax km per MJ for urban passenger road vehicles, and 0.63 pax km per MJ for urban buses. Non-urban rail had an average energy efficiency of 0.86 pax km per Megajoule (MJ) as compared with 0.45 pax km per MJ for non-urban passenger vehicles, 0.34 pax km per MJ for domestic airlines, and 1.06 pax km per MJ for non-urban buses (ACG, 2001).

The data in Appendix A to this survey also shows that each mode of passenger transport has generally shown increasing energy efficiency over time with the exception during the period from 1994-95 to 1997-98. This was attributed by ACG (2001, page 16) in the case of light rail due to a decline in passenger loadings. Passenger trains with good load factors would have a higher energy efficiency than buses.

It is necessary to note increasing problems in gaining accurate and up to date transport data within Australia. Here, the Australian Bureau of Statistics (ABS) has had problems with its both road and rail data in the late 1990s (Laird et al, 2001).

Other Government agencies analysing land transport data have either effectively been abolished (the Inter-State Commission 1990, the Bureau of Industry Economics in 1996, and the Energy Research and Development Corporation in 1997) or, been down sized (Bureau of Transport Economics and Universities in 1996). A Steering Committee on National Performance Monitoring produced valuable data in the 1990s, but this too was disbanded. Rail privatisation has also made it more difficult to obtain rail transport data in Australia, in part due to the disappearance of Annual Reports. Even such basic annual outputs as freight tasks measured in tonne kilometres have all but disappeared over the last few years. Fuel use data has also become more elusive.

The situation in Australia is in contrast with larger private rail freight operations in both the United States and Canada. Each year, the Association of American Railroads (AAR) publishes the freight tasks of each Class I railroad, and their aggregate fuel use. US Class I railroads by 2001 had gained an average energy efficiency of 3.72 net tkm/MJ (primary energy). North American railroad companies also release useful data.

By way of example, the Canadian Pacific Railway 2002 Annual Report gives no fewer than 12 performance indicators, that note or imply a 207.81 billion tonne gross km (btkm) freight task, a 173 net btkm freight task, and fuel use of 260 million US gallons (or 983 million litres) giving an impressive energy efficiency of 4.2 net km/MJ.

From Annual Report data, the Tokaido Shinkansen operated by JR Central has an energy efficiency of about 2 pax km per MJ.

2 RAIL FREIGHT

An analysis of energy use - either diesel or electricity - for each Government rail system has shown increased energy efficiency in rail freight from 1990-91 to 1994-95 (Laird, 1998) with Queensland Rail and Westrail as the better performers at nearly 3.0 net tonne km per MJ by 1994-95. The data in Appendix A also shows that "Government" (excluding the iron ore railways) rail freight transport in Australia has shown increasing energy efficiency to 1997-98 at 2.98 net tkm/MJ.

The total diesel use for all government rail freight operations in 1994-95 was some 420 million litres (Laird, 1998) and the total use for private rail was 103.7 million litres (ABARE, 1997, pers. comm.). As noted by ACG (1997), Australian railways used 40.6 PJ of energy in 1994 -95 for their growing freight and mixed passenger tasks and this was less than the 42.1 PJ used in 1990-91. The 1997-98 primary energy use by rail was 44.1 PJ (ACG, 2001).

Energy efficiency in rail freight, like road freight, depends on driving techniques. For rail, these can be assisted by computers (see, for example, Howlett and Pudney, 1995).

2.1 Bulk rail haulage

The average energy efficiency of BHP iron ore trains in the Pilbara was noted as about 10 net tonne km per MJ in 1991 (Laird and Adorni-Braccesi, 1993) and is understood to have since attained 12 net tonne per MJ. As noted by Darby (2001), fuel use per tonne for BHP Iron Ore operations has decreased by 43 per cent between 1980 and 2000. This was assisted by heavier axle loads using well built and maintained track with heavy rails, top class maintenance of locos and wagons, and increasing use of aerodynamically designed wagons and new generation locomotives with AC traction motors. Their standard train consists of four locos and 224 wagons with two locos in the middle. On average, it takes just under one litre of diesel to move one tonne of iron ore 426 km and bring the empty wagons back. Although gravity helps the loaded ore trains, its contribution is relatively small.

Queensland Rail is understood during the mid 1990s to have achieved an energy efficiency of about 5 net tonne km per MJ (of primary energy) with use of its 25 000 volt AC electric locomotives in its Central Queensland coal train operations

2.2 Interstate rail freight - existing track

Citations of actual energy efficiency on Australian mainline interstate freight operations are few and far between. The Industry Commission (1991a, Vol II, p.62) noted that Sydney - Melbourne line haul rail freight energy efficiency in the late 1980s was between 1.5 and 2 net tkm/MJ, whilst trains moved freight between Sydney and Adelaide with an energy efficiency of nearly 3 net tkm/MJ. Sydney - Melbourne line haul rail freight energy efficiency in the early 1990s was noted (Laird and Adorni-Braccesi, 1993) at about 2.0 net tkm per MJ for superfreighters using 81 class 3000HP locomotives.

The Bureau of Industry Economics (BIE -1995, p97) gives a discussion on fuel use by freight trains, noting inter alia, a variation from just over 3 litres per thousand gross tonne km (L/000 gtk)"*... for 4000 tonne freight trains hauled by modern locomotives, to over 10 L/000 gtk (for trains crossing the Great Divide"* (eg. Sydney Melbourne). A similar ratio was noted by Railways of Australia (1980). Fuel use in freight train operations in Australia was also examined by Quarterman (BTE, 1981) who, like the BIE (1995), noted energy efficiency increasing with train mass.

However, whereas the BIE (1995, p97) noted that *"...Terrain is the major physical influence on fuel consumption"*, Quarterman (BTE, 1981, p xii) found that *"... The disparity between the efficiencies of different parts of the railway system suggests that there is also considerable potential for lifting the maximum attainable efficiency of some railways by improvements to grading and alignment ..."*.

With their new 4000 HP locomotives, upgraded wagons, and incentives for drivers to save fuel, National Rail were able to obtain significant fuel savings. By 1998, overall National Rail fuel use had been reduced to the range of 4.0 to 4.15 litres per 000 gtkm (Ernst and Young, 1998 ver 2, p 29). A September 2001 brochure issued by National Rail to note the advent of a profit in 2001-01 **stated an average fuel use of 4.0 litres per 000 gtkm for 1999-00-01 as against 7.4 litres per 000 gtkm for 1992-93-94.**

It is understood that the east - west operations (where 1800 metre trains with double stacked containers are possible between Adelaide and Perth) had a target fuel use of 3.5 litres per 000 gtkm as against 4.5 litres per 000 gtkm for north-south train operations The ARTC in its 2000 Annual Report noted (p 6) 26.60 gross btkm and 12.35 net btkm over its network in 1999-2000. This gives a ratio of 2.15. At 4.5 litres per 000 gtkm and 38.6 MJ per litre, with this gross to net tonnes ratio, *an average energy efficiency of 2.68 net tkm/MJ results*.

To assist a Mathematics in Industry Study Group project (Benjamin and Laird, 2001) National Rail advised that one NR locomotive hauling a 1280 tonne maximum trailing load over the *existing* Dynon - Acacia Ridge track (1912 km) would be expected to use *at least* 11,500 litres of diesel. This gives an energy efficiency of 2.84 ntkm/MJ and is an upper limit for freight trains operations on the existing corridor.

On the basis of the above information, Melbourne - Sydney - Brisbane **standard superfreighter average energy efficiency appears to be about 2.7 ntkm/MJ on the existing track.** This is a 35 per cent increase on the above cited 2.0 net tkm/MJ. However, as per trucks, there can be appreciable variations from the average.

In comparing the energy use of intercity land freight using rail or road line haul, it is necessary to include in rail line haul an allowance for road pick up and delivery. One assumption (Laird et al 2002) of this energy use is 77 MJ (about 2 litres) per tonne in pick up and delivery. It should be noted that road line haul using B-Doubles may also require road pick up and delivery using smaller trucks.

In a recent study, Affleck (2002) noted intermodal fuel use by NR locomotives ranging between 0.003 and 0.005 litres per gtkm (ie 3 and 5 litres per 000 gtkm), whilst corridor specific fuel use per ntk and gtk was confidential.

2.3 Interstate rail freight - upgraded track

The Australian Rail Track Corporation (ARTC) National Track Audit reviewed the Australian Transport Council's speed weight targets, examined minimum market improvements (the S1 scenario), significant track improvements (the S2 "stretch" target scenario), and after economic analysis, recommended optimised investment of $507 million with a combined benefit cost ratio of 3.2. The Track Audit also outlined three major deviations (Wentworth, Centennial and Hoare) on the Sydney Melbourne track with a combined length of new construction at about 195 km.

Computer simulation for an ARC - RIC project (Laird et al, 2002) showed that the running time for a standard superfreighter with 2600 tonnes trailing load hauled by two 4000 HP locomotives moving over the existing 940 km Dynon - Chullora track was nearly 12 hours, but that the same train moving over an upgraded route would take about 10 hours. Moreover, the fuel used for this freight task would reduce from about 13, 200 litres on the existing track to some 11,900 litres on the upgraded track, a saving of about 10 per cent. The data shows that for the entire Sydney - Melbourne track, the fuel saving due to the major track upgrade is 12 per cent. This is due to a 6.3 per cent reduction in point to point distance, and a 6 per cent reduction in fuel use per 000 gtkm. The rail deviation offering the largest fuel saving (and time saving) is for the Yass -

Cootamundra section with a fuel saving of 32 per cent. This is due to a 20 per cent reduction in point to point distance, and a 15 per cent reduction in fuel use per 000 gtkm.

Improved and straightened track with its easier ruling grades would also allow a heavier load behind each locomotive, with further fuel savings, plus appreciably lower train transit times. This would improve the competitiveness of intermodal land freight, giving further fuel savings.

It is suggested that superfreighter average energy efficiency could be taken at 3.0 ntkm/MJ on fully upgraded track, with 2.7 ntkm/MJ on existing track, 2.8 ntkm/MJ on track upgraded to S1 standards and 2.9 ntkm/MJ on track upgraded to S2 standards.

Innovations in use, or tried in the Pilbara iron ore railways, but yet to be introduced for interstate rail freight operations, include the use of AC traction diesel electric locomotives, aerodynamically designed wagons, and electronically applied braking. The uptake, over time, of such technology will improve the energy efficiency of rail freight operations. The use of modern high voltage electrification, with regenerative braking, has the capacity to give even higher energy efficiency. A Canadian study (Environment Canada, 2000) found that from 1975 to 1990, the fuel consumption rate per gross ton mile was declining at 1.9 per cent per annum and suggested that it would decline at about 1 per cent per annum to 2005.

3 ROAD FREIGHT

The fuel efficiency of articulated trucks has improved during the 1990s. In 1990-91, the ABS SMVU indicated all articulated trucks used 1997 million litres (ML) of diesel for a 62.9 billion net tkm (btkm) freight task. Thus, the average energy efficiency (at one litre = 38.6 MJ) was 0.82 ntkm/MJ. By 1998-99, the aggregate freight task for articulated trucks had risen to 99.1 btkm, using 2709 ML of diesel, giving an average fuel efficiency of 0.95 ntkm/MJ (end use energy). *This is a 16 per cent increase in the average energy efficiency of all articulated trucks.*

Increases in heavy truck energy efficiency have followed from upgraded roads, improvements in truck technology (including on board truck monitors recording fuel use, braking applications and speed), and the relaxation of mass and dimension limits for heavy trucks. These included raising the GVM of six axle articulated trucks from 38 to 42.5 tonnes by 1988, with some of these heavier trucks showing impressive energy efficiencies. By way of example, ABS 1991 SMVU data showed 47 per cent of six axle articulated trucks with a gross vehicle mass of 41 tonnes or more used fuel at a rate of less than 50 litres per 100 km (Laird and Adorni-Braccesi, 1993, p179) when the average fuel use in 1991 for all six axle articulated trucks was 51.7 litres per 100km, and six - axle articulated trucks in the 1991 SMVU showed a wide range of fuel use in litres per 100 km that did not always relate to Gross Vehicle Mass. More recently Truck and Bus (July 1998) noted one such truck hauling a 27 tonne payload of orange juice with a back load of general freight with a fuel use at 2.18 km per litre: assuming say a 70 per cent back load (by weight) gives an energy efficiency of nearly 1.30 net tonne km per MJ (net tkm/MJ).

Road freight fuel use depends very much on the way a truck is driven, with an older reference (Victoria Department of Minerals and Energy, 1981) giving data showing a 25% increase in speed (from 80 to 100 km per hour) resulted in a 44% increase in fuel usage.

The wider use of B-Double and road trains has also increased overall road freight energy efficiency, and it is of note that ABS (1996) SMVU data shows the freight tasks of these classes of vehicles as 9.1 and 14.9 btkm respectively. However, for the 12 months ended 30 Oct 2000 (ABS, 2001), the B-Double freight task had shown strong growth to 22.1 btkm, road trains had grown to 18.3 btkm, whilst the six axle articulated truck freight task had fallen to 50.4 btkm.

3.1 Road Line Haul Energy Efficiency

The energy efficiency of good line haul articulated truck operations is higher than the above cited averages. This is mainly due to relatively less haulage in congested urban areas, and the larger scope to use B - Doubles on most interstate operations, with the potential to use Road Trains on some corridors such as Adelaide - Perth.

After retaining a company to consult several truck operators for vehicle performance, the ARC-RIC project (Laird et al, 2002) assumed an average of 1.15 net tkm/MJ for current line haul truck operations. With better roads, better trucks and more use of B -Doubles and road trains, offset by more road congestion, an improvement to say 1.25 net tkm/MJ by 2010 could be expected. Like rail, it would be reasonable to assume an annual average increase in energy efficiency of 1 per cent per annum between 2000 and 2020. The BTRE (2002, p 129 and 131) suggests articulated trucks are likely to increase their average loads between 1995 and 2020 by 1.64 per cent per annum (from 17.6 to 26.6 tonnes, with fuel use in litres per truck km remaining constant.

Affleck (2002) notes, after industry consultation, truck fuel consumption rates for six axle articulated trucks, 9 axle B - Doubles, and 11 axle road trains hauling steel and general freight as respectively 0.0224, 0.0173 and 0.0092 litres per net tkm. At 38.6 MJ (end use) per litre of diesel, this gives respective energy efficiencies of 1.16, 1.60 and 2.82 net tkm/MJ. This report also discusses the findings of a European study, and notes for eight Australian corridors on a two way basis, that carbon dioxide emissions for intermodal freight vary from 10 grams to 17 grams of carbon dioxide per ntk; whilst six axle articulated truck emissions range from 31 to 39 grams per ntk and B-Double emissions are between 24 to 30 grams per ntk. Overall, intermodal transport was found to produce 31 to 54 per cent of the emissions of six axle articulated trucks, and 41 to 70 per cent of the emissions of B-Doubles.

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APPENDIX A to Rail CRC Literature Review

This Appendix gives a summary of energy inputs along with passenger and freight transport outputs in Australia to 1997-98, and, updates information given by the Institution of Engineers, Australia (1999, Chapter 10) and Laird et al (2001). Most of the data given in these tables is rounded from data given by Australian Transport Facts 1998 by Apelbaum Consulting Group (ACG - 2001). The report notes some adjustment to data published earlier by ACG (1997), so comparisons between years needs to be undertaken "with care".

Other sources of transport energy data, with discussion, include the Australian Bureau of Agricultural and Resource Economics (ABARE - 2001), the Australian Bureau of Statistics (ABS - 1997) and the Bureau of Transport Economics (BTE - 1996). The ACG data is derived from ABARE, ABS, and BTE data along with other sources. However, the ACG data differs, in many cases, from similar data given by the BTE. In addition, the ACG estimates of energy use are for primary energy, which are necessarily higher than the BTE estimates of end-use energy.

TABLE A.1 AUSTRALIAN DOMESTIC PASSENGER TASKS
billion passenger km

Year	Cars etc	Buses	Trains	Planes	Sea
1970-71	108.4	6.6	12.8	5.2	0.7
1975-76	131.2	7.6	8.2	7.64	-
1984-85	179.2	11.8	8.4	10.34	0.13
1987-88	199.8	17.6	9.7	13.27	0.18
1990-91	211.4	13.8	9.3	14.50	0.20
1994-95	230.8	15.2	9.6	23.69	0.23
1997-98	233.0	18.2	10.0	26.53	0.26

Reference: BTE (1996) for 1970-71, then ACG (1997) for 1975-76, then ACG (2001) Table 2.6, p41, Table 3.2, p61, Table 4.1, p82 and Table 5.3, p102

TABLE A.2 AUSTRALIAN URBAN PASSENGER TASKS

billion passenger km

Year	Cars etc	Buses	Trains	Trams etc	Ferries
1970-71	67	3.5	6.7	0.6	0.16
1975-76	87.8	4.0	5.8	0.53	-
1984-85	116.9	5.7	5.6	0.58	0.08
1987-88	137.4	8.3	6.4	0.66	0.10
1990-91	142.0	6.8	6.8	0.59	0.10
1994-95	155.1	8.7	7.3	0.47	0.12
1997-98	159.2	9.9	7.6	0.45	0.13

Reference: BTE (1996) for 1970-71, ACG (1997) then ACG (2001) Table 2.6, p41, Table 3.6, p65, Table 5.3, p102 and Table 5.3, p102. Note that some rail journeys (eg Newcastle Sydney) earlier classified as non-urban are now urban.
Trams include Adelaide *(0.015 bpkm in 94-95)* and the Sydney Monorail *(0.012 bpkm in 94-95)*. Note that the BTE series gives data that differs from Apelbaum for 1975-76 and later years in some cases, and, their estimate for trams in 1970-71 is broad.

TABLE A.3 AUSTRALIAN NON-URBAN PASSENGER TASKS

billion passenger km

Year	Cars etc	Buses	Trains	Planes	Sea (excl. cruise)
1970-71	41	3	6	5.2	0.54
1975-76	43.4	3.6	2.4	7.65	-
1984-85	62.2	6.1	2.8	10.34	0.05
1987-88	62.4	9.3	3.3	13.27	0.08
1990-91	69.4	7.0	2.5	14.50	0.09
1994-95	72.7	6.4	2.3	23.69	0.10
1997-98	73.9	8.3	2.4	26.53	0.13

Reference: BTE (1996) for 1970-71, ACG (1997) then ACG (2001) Table 2.6, p41, Table 3.6, p65, Table 4.1, p82 and Table 5.3, p102. Note planes refer to scheduled domestic flights, and exclude the unscheduled domestic flights, general aviation and commuter flights, which in 1994-95 amounted to 0.212 bpkm

TABLE A.4 ROAD TRANSPORT AND ENERGY USAGE

Year	Passenger Veh. km. billion km	Total Veh. km billion km	Fuel use by vehicles Petrol billion litres	Diesel billion litres	Energy use by vehicles PJ - FFC
1975-76	78.5	101.5	13.0	1.5	562
1984-85	106.6	141.5	15.7	4.0	758
1987-88	118.4	155.6	16.4	4.7	820
1990-91	127.6	163.7	16.5	4.8	844
1994-95	140.7	185.9	17.4	5.7	944
1997-98	144.8	192.2	17.6	6.7	997

Reference: ACG (1997) for 1975-76, then ACG (2001) Table 2.1, p36 plus Tables 2.12, p47 & 2.14, p49. Note energy used in Petajoules includes gas as well as liquid fuels. One Petajoule (PJ) is 10^{15} Joules, with ABARE conversion factors for energy for recent years including 1 litre of petrol =34.2 MJ (unleaded) and 1 litre of diesel = 38.6 MJ (end use).
Note FFC = Full fuel cycle.

TABLE A.5 AUSTRALIAN URBAN VEHICLE USAGE

Year	Passenger Veh. km. billion km	Total Veh. km billion km	Energy used in urban areas PJ	% of all transport energy
1975-76	51.1	63.3	n.a.	n.a.
1984-85	73.5	91.8	464	61
1987-88	85.7	107.4	535	65
1990-91	89.7	109.2	534	63
1994-95	100.9	127.3	621	66
1997-98	103.4	131.4	649	65

Reference: ACG(1997) for 1975-76, then ACG (2001) Table 2.4, p39 plus Table 2.14 p 49.
Note energy used in Petajoules includes gas as well as liquid fuels.

TABLE A.6 AUSTRALIAN DOMESTIC PASSENGER ENERGY EFFICIENCY passenger km per megajoule (MJ)

Year	Cars etc	Buses	Trains	Planes	Ferries
1975-76	0.35	0.96	0.53	0.20	-
1984-85	0.38	0.79	0.68	0.25	0.11
1987-88	0.39	0.99	0.79	0.26	0.26
1990-91	0.38	0.80	0.77	0.28	0.23
1994-95	0.39	0.91	0.81	0.32	0.23
1997-98	0.38	0.77	0.72	0.34	0.24

Reference: ACG (1997) for 1975-76, then ACG (2001) Table 2.17(b), p54, Table 3.13, p72, Table 5.8, p107
Air passenger energy efficiencies are derived from Table 4.10, p91 which gives energy efficiencies of 0.02 to 0.03 net tonne km per MJ on the additional assumption that each passenger with luggage has an average weight of 90 kg.
Non - urban cars etc have a higher energy efficiency (0.43 pkm per MJ in 1994-95) than urban cars etc (0.36 pkm per MJ)
Note non - urban buses have a much higher energy efficiency (1.50 pkm per MJ in 1994-95) than urban buses (0.72 pkm per MJ), but urban rail in 1994-95 had a higher energy efficiency (0.83 pkm per MJ) than urban buses. In 1990-91, 1987-88, and 1984-85, non-urban rail was more energy efficient than urban rail. Load factors are critical for the energy efficiency of buses and trains as well as cars, planes and ferries.

TABLE A.7 AUSTRALIAN DOMESTIC FREIGHT TASKS
billion tonne km

Year	Road	Govt rail	Private rail	Total Rail	Sea
1970-71	27.2	25.2	13.8	39.0	72.0
1975-76	36.7	30.8	26.3	57.1	110.7
1984-85	74.3	45.0	32.8	77.7	97.3
1987-88	98.0	50.1	35.1	85.3	96.6
1990-91	106.2	53.2	42.5	95.7	96.5
1994-95	126.9	61.8	50.6	112.3	112.0
1997-98	157.3	70.9	57.2	128.1	120.9

Reference: BTE (1996) for 1970-71, then ACG (1997) for 1975-76, then ACG (2001) Table 2.9, p44, Table 3.6, p65, and Table 5.1, p100. Note air freight tasks of about 0.1 btkm in the 1980s, rising to 0.3 btkm in 1994-95 (Table 4.21, p134)

TABLE A.8 AUSTRALIAN ROAD FREIGHT TASKS AND ENERGY USED
billion tonne km / Petajoules

Year	Artic Trucks	Rigid	LCV's	Total	Energy PJ**
1975-76	23.0	12.1	1.6	36.7	173
1984-85	52.7	18.6	3.1	74.3	259
1987-88	68.4	24.6	4.9	98.0	279
1990-91	75.7	24.7	5.7	106.2	266
1994-95	93.8	27.4	5.8	126.9	328
1997-98	119.9	30.7	6.7	157.3	349

Reference: ACG (1997) for 1975-76, then ACG (2001) Table 2.9, p44 and Table 2.14 p49.
* Note ABS estimates are about 5 btkm higher for both articulated trucks and all trucks.
** "Other trucks" use 2 to 3 PJ of extra energy, but no freight tasks are noted.

TABLE A.9 AUSTRALIAN URBAN ROAD FREIGHT TASKS
billion tonne km

Year	Artic Trucks	Rigid	LCV's	Total (% of all road fgt)	Energy used PJ**
1970-71	3.0	5.4	0.7	9.1 (34)	n.a.
1974-75	5.7	6.4	1.0	13.1 (37)	n.a.
1984-85	13.4	9.9	1.8	25.1 (34)	120
1987-88	17.3	15.0	3.1	35.5 (36)	146
1990-91	16.9	14.6	3.4	34.9 (33)	128
1994-95	21.2	16.4	3.7	41.3 (33)	171
1997-98	28.3	18.7	4.6	51.6 (33)	174

Reference: BTE (1996) for 1970-71, then ACG (1997) for 1975-76, then ACG (2001) Table 2.9, p44 and Table 2.14, p49.
* Note ABS estimates are higher
** "Other trucks" use 2 to 3 PJ extra energy, but no freight tasks are noted.
Note Lower implied energy efficiencies of urban freight movements.
ACG and ABS data for 1994-95 differ.

TABLE A.10 ENERGY USED IN AUSTRALIAN FREIGHT TASKS
Petajoules (Full Fuel Cycle)

Year	Artic Trucks	Road freight	Rail freight	Sea Freight	Domestic aviation passengers and freight
1975-76	42.1	173	20.9	39.4	48.5
1984-85	80.2	259	30.8	37.1	51.6
1987-88	86.6	279	29.4	37.0	61.1
1990-91	83.6	266	28.3	24.5	61.0
1994-95	101.6	328	29.1	26.7	83.7
1997-98	117.9	349	29.2	22.9	88.9

Reference: ACG (1997) for 1975-76, then ACG (2001) Table 2.14, p49, Table 3.12, p71, Table 5.7, p106 and Table 4.9, p90.

TABLE A.11 AUSTRALIAN DOMESTIC FREIGHT ENERGY EFFICIENCY
net tonne km (tkm) per megajoule (MJ) (Full Fuel Cycle)

Year	Road	Govt rail	Private rail	Total Rail	Sea
1975-76	0.21	1.60	5.65	2.72	-
1984-85	0.29	1.72	7.10	2.52	2.62
1987-88	0.35	2.06	6.89	2.90	2.61
1990-91	0.40	2.31	8.20	3.39	3.94
1994-95	0.39	2.58	9.86	3.86	4.20
1997-98	0.45	2.98	10.52	4.40	5.29

Reference: ACG (1997) for 1975-76, then ACG (2001) Table 2.18(b), p56, Table 3.14, p73, Table 5.8, p107
Air energy efficiency is given in Table 4.20, p132 which notes energy efficiencies of only 0.02 to 0.03 net tkm per MJ.
Note remarks above re road freight. Line haul intercity road freight can now reach 1.00 or more net tkm/MJ. Line haul intercity rail freight depends on track condition and alignment.
The high energy efficiency of private rail is due to the preponderance of iron ore haulage in the Pilbara using the worlds most efficient trains.

APPENDIX C ROAD TRANSPORT EXTERNAL COSTS

Increasing road vehicle based transport for moving people, and a strong growth in road freight as outlined above comes at a cost. This cost is not only what is directly paid, but external costs that fall on other road users and the community as a whole. For Australia, these hidden costs include:

1. Road crash costs were estimated by the BTRE (2000) at $15 billion in 1996. Only about half of this is covered by insurance with about $7 bn being a cost to other road users and the wider community (*Back on Track*);
2. Road congestion costs in major cities of about $12.8 billion in 1995 (BTRE, 1999);
3. Health related costs from the effects of air pollution from motor vehicles in Australia's capital cities with mid-range estimates for the year 2000 of the BTRE (see item 18) as $3.3 billion;
4. The cost of noise from all motor vehicles in urban areas as $0.7 billion, as per a low range estimate of the Bus Industry Confederation (2001);
5. Net taxation refunds for motor vehicle use of $2.8 billion in 1997-98 (*Back on Track*);
6. A $1.7 bn greenhouse gas cost in 2000-01 (at $25 per tonne);
7. An annual $0.8 bn non-tariff automobile industry assistance programme;
8. An estimated increased health cost of lack of physical activity due to excessive car use of about $0.8 b per annum in Australia
9. A Queensland Fuel Subsidy Scheme payment now costing the Qld Government $0.5 bn per year, and the NSW Government about $40m per year; and,
10. Toll rebates in Western Sydney costing about $60m per year.

These approximate costs add up to $31.3 billion per year. Road system costs are now about $8 billion a year. The total is $39.5 billion per year. Road vehicle specific revenues to Government in 1997-98 were about $12.6 bn in 1997-98 (and only $12.7 bn in 2001-02 - BTRE, 2004). Hence, excluding congestion costs, a case can be made that there is a 'road deficit' that now exceeds $13 billion per year.

There are also subsidy schemes for bus operations in most States. The most expensive subsidy is in New South Wales where funding in 2002-03 (NSW Department for Transport, 2002) for the State Transit Authority which operates bus and ferry services in Sydney and Newcastle was $214.4m (mostly for buses). In addition, funding for school student travel subsidies is $427m; whilst subsidised concessions for pensioners and other travel subsidies was $305m.

A 'road freight deficit' of approximately $2 billion in 1997-98 due to the operation of articulated trucks was identified in *Back on Track* (Appendix D). These trucks include the Australia 'workhorse' of six axle articulated trucks, plus B-Doubles of length up to 25 metres, and road trains which are even longer, and used mostly on remote roads. This 'road freight deficit' is mostly made up of unrecovered road system costs of about $1.3 billion that average out at 1.25 cents per net tonne km. Other costs include about $500m per year for the cost of road crashes involving articulated trucks, and environmental costs of at least $280m per year.

The high unrecovered road system costs result from road user charges for heavy trucks being restricted to fuel taxes and simple annual charges for each type of truck. These charges were determined by the National Road Transport Commission that twice passed over the option of mass distance charges that have been successfully used in New Zealand since 1978.