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Energy Use in Australian Land Freight Transport

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Abstract:

Australia's land freight operations have made mixed energy efficiency gains during the 1980s to meet a growing freight task. Some of these operations including Northern Territory road trains and iron ore railways in Western Australia are of world standard. On the other hand there are many problems to be solved, prompting in 1991 the formation of a National Rail Corporation.

The paper argues that increased rail investment is needed to bring the mainline interstate rail track in Eastern Australia to modern intermodal rail freight standards with improved ruling grades, curvature and clearances.

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1. INTRODUCTION

Australia's land freight task has grown since 1970-71 at an average annual rate of 5.5 per cent per annum, and in 1987-88 was about 164 billion tonne kilometres. Whilst this is a modest land freight task by current world standards, it is a challenging one for a large country with a relatively small population now of some 17 million people. Further challenges over the years have occurred with the containerisation of imported goods and the growth of bulk commodity exports, with annual coal exports rising from about 18 million tonnes in 1970 to over 106 million tonnes in 1990, and a similar growth for iron ore exports.

The use of energy in freight transport has direct implications for both the cost of transport operations and environmental impact. Further considerations of liquid fuel use include Australia's reported declining self sufficiency in proven oil reserves. In addition, the amount of liquid fuel or other forms of energy (eg. electricity from coal fired power stations) used each year in transport will be an important factor as to whether a Government "Toronto" target for a 20% reduction in Greenhouse gas emissions from 1988 levels by the year 2005 will be met.

The subject of the amount of fuel used in transport operations in Australia has received attention from a number of writers over the last 20 years, including the Bureau of Transport (and Communications) Economics (1975, 1980, 1981, 1991), Australian Transport Advisory Council (1979), McDonell (1980), Senate Standing Committee on National Resources (1980), Australian Academy of Science (1981), Railways of Australia (1980), Gentle (1983), the House of Representatives Standing Committee on Transport, Communications and Infrastructure (1989), Australian Road Transport Federation (1990), the Senate Standing Committee on Industry Science and Technology (1990), Australian Bureau of Agricultural and Resource Economics (1991), Laird (1990a, 1991), Laird and Adorni-Braccesi (1991), and Apelbaum (1991). A common theme of much of this work, when touching on long distance or bulk freight transport, is that sea and rail transport are generally more energy efficient than road transport.

In addition, the Industry Commission (1991a, 1991b) has conducted two recent inquiries, one into Rail Transport (with a specific term of reference the identification of efficiencies in the use of energy of rail transport compared with road transport) and the other into the costs and benefits of reducing Greenhouse gas emissions.

Section 2 considers the growth of land freight over the last twenty years along with increases in the energy efficiency of the aggregate road and rail freight transport tasks (measured in tonne-kilometres). We consider a range of recently published fuel efficiencies for various road and rail freight tasks, including the "benchmark" case of rail haulage of iron ore from Mt. Newman to Port Hedland in Western Australia.

Section 3 considers the potential liquid fuel savings available if the recently established National Rail Corporation (NRC) was able to significantly upgrade mainline interstate rail track alignment through a "benchmark capital investment program". If this was done, there would be a marked improvement rail freight efficiency in NSW; and, if the NRC was also to win a modal share of at least 50% of land freight on all main intercapital city corridors, there would be fuel savings in the order of 100 million litres a year. The potential for track upgrading to save fuel in rail freight has been noted in references including the Bureau of Transport Economics (1981) and realized, for example, with track realignment prior to electrification in Queensland during the 1980s.

Section 4 discusses Government intervention in land freight services, including rail freight deficits, road cost recovery from heavy trucks and investment in road and rail track. The paper recommends that consideration be given to upgrading the mainline interstate rail track in Eastern Australia to modern intermodal rail freight standards.

2. IMPROVING LAND FREIGHT ENERGY EFFICIENCY

The increase in Australian domestic freight transport since 1971 is shown in Table 1. From this, we note the slow growth in Government Rail freight (even with the growth in coal exports from Queensland and NSW) and the strong growth in the road freight moved by articulated trucks - that has doubled over each of the last two decades.

Table 1 Australian road and rail freight tasks

	1970-71	1987-88
Total road freight task (billion tonne km)	27	85
Articulated truck freight task (billion tonne km)	15	60
Government Rail freight (billion tonne km)	25	49
Non Government Rail freight (billion tonne km)	14	30

References: For 1970-71 data, ISC (1990) and for 1987-88 road data, Australian Bureau of Statistics (ABS) (1990). Rail data for 1987-88 is from IAC (1989).

In analysis of energy efficiency, it is convenient to use the Megajoule (MJ) as a basic energy unit with a conversion factor of 1 litre of diesel being equivalent to 38.6 MJ, and 1 kilowatt hour equals 3.6 MJ. Data for aggregate direct (end-use) energy use in freight transport is given in Table 2, which shows that overall road and rail freight energy efficiencies have increased from 1975-76 to 1987-88. A discussion of the reasons for these increases in energy efficiencies is given in Laird (1990a). The high values for Non-Government Rail are mainly due to the large iron ore task. An example of iron ore rail transport of world standard is given in Section 2.

Table 2 Use of direct (end-use) energy - Australian land freight transport Net tonne km per MJ

	1975-76	1984-85	1987-88
All trucks	0.36	0.49	0.52
Government Rail	2.07	2.21	2.80
Non-Government Rail	6.20	7.64	7.57

Reference: Apelbaum (1991), based on petroleum conversion factors of primary energy to direct (end-use) energy of 1.097 for 1975-76 and 1.082 for 1984-85 and 1987-88.

Road freight

Quarterman (BTE, 1981) gives data showing a range of energy efficiencies from 0.75 to 1.25 net tkm/MJ for long distance road freight operations at full load factors under then average conditions (with speeds probably lower than current speeds). Most of this long distance freight task was then, and is now, performed by six axle articulated trucks.

A range of GVMs, payloads and fuel use for these trucks used mainly on interstate trips given by the Australian Bureau of Statistics (ABS) as cited by the Inter-State Commission (ISC-1990) and the Australian Road Transport Federation (ARTF-1990) are given in Table 3. This Table also gives the resulting energy efficiencies. The range of fuel use for six axle articulated trucks in mainland states cited by the National Road Transport Commission (NRTC-1992, Table B6) is between 54.5 litres per 100 km for NSW and 58 litres per 100 km for Victoria. On the other hand, there is no shortage of citations in past issues of *Truck and Bus* of long distance fuel use by six axle articulated trucks of less than 50 litres per 100 km.

Clearly, there is a wide variation in resulting fuel efficiencies and this is an area where further research and monitoring is warranted. It is also of note that in 1982, special "Truck Save/Drive Save" trials between Sydney and Melbourne were conducted with two six axle articulated trucks, that demonstrated the fuel saving potential (up to 20 per cent) of certain truck/engine modifications, and speed limiting (Energy Authority of NSW, 1983).

Table 3 Long distance articulated truck fuel use - energy efficiency

	GVM	Payload	Fuel Consumption				Energy Efficiency*
			Loaded		Empty		
		tonnes	mpg	l/100km	mpg	l/100km	net tkm/MJ
ABS/ISC	35.6	16	5.1	55	5.1	55	0.75
ARTF	38	22	6.7	42.2	8.7	32.5	1.06
	42.5	26.5	6.4	44.1	8.7	32.5	1.23

Sources: ISC (1990) and ARTF (1990), with mpg converted to litres per 100km.
* ABS/ISC derived energy efficiency is based on full two way loading for all trucks whilst ARTF (1990) assumes that for 67% of journeys there is two-way loading.

As there is room for considerable variation in fuel use between different trucks, and even the same truck depending on whether it is working in urban areas or highways along with how it is driven, average energy efficiencies should be used with considerable caution. With this in mind, an approximate average energy efficiency for line haulage of interstate general freight by articulated trucks is now taken at 0.9 net tkm/MJ.

Recent gains in heavy truck energy efficiency have followed from the relaxation of mass limits for heavy trucks in the Eastern States from a Gross Vehicle Mass (GVM) 38 to 41 tonnes for six axle articulated trucks in 1987, and 42.5 tonnes from 1988. These increases followed from a Review of Road Vehicle Limits (NAASRA, 1985) which also gave specifications for medium combination vehicles called B-Trains or B-Doubles of up to 23 metres in length and a maximum GVM, under present axle loadings, of 59 tonnes. However, increases in axle loadings, whilst improving energy efficiency, may lead to significantly accelerated road pavement wear and tear.

Impressive energy efficiencies for road trains are attainable. By way of example, triple oil tanker road trains used in the Northern Territory with a tare of about 37 tonnes and a payload of 78 tonnes can now be operated at limited speeds using 75 litres of diesel per 100 kilometres. This gives, with no backloading, an energy efficiency of 1.35 net tonne km per MJ.

Road freight fuel use depends very much on the way a truck is driven. Hordern (Victoria Department of Minerals and Energy, 1981) noted that in trials done between Melbourne and Sydney on a six axle articulated truck, a top speed of 80 km per hour consumes 46.8 litres per 100 km and that at a top speed of 97 km per hour consumes 56.1 litres per 100 km. Thus, in this case, a 25% increase in speed (from 80 to 100 km per hour) resulted in a 44% increase in fuel usage. Savings in the use of diesel fuel in road freight are expected with more use of speed limiters in heavy trucks across Australia, and if the price of diesel fuel increases. The use of tachographs or other vehicle monitors would also be expected to improve fuel efficiency in road freight operations.

Rail freight

Recent citations of fuel use on Australian mainline interstate freight operations are few, and include those given by Australian National (1990, p 72) for the Adelaide-Sydney corridor of 9.546 litres per 1000 net tonne km for rail superfreighters and 8.981 litres per 1000 net tonne km when low tare "spine" type wagons (five packs) are used. This gives energy efficiencies of about 2.7 and 2.9 net tonne km/MJ respectively. However, this rail corridor includes a section from Sydney to Lithgow with steep grades where energy use per 1000 net tonne km would be much higher than that of haulage on the Adelaide-Parkes section. The Industry Commission (1991a, Vol II, p.62) notes that Sydney-Melbourne line haul rail freight energy efficiency between 1.5 and 2 net tonne km/MJ.

Quarterman (BTE, 1981) found variations in rail freight energy efficiencies of a factor of four to one for mainline freight trains with a 1000 tonne trailing load having energy efficiencies which vary from 2 gross tkm/MJ under adverse conditions (including steep grades), to 8 gross tkm/MJ under favourable conditions. This study also notes "... *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 ...*".

Analysis carried out by Railways of Australia (1980) also showed considerable variation between interstate routes for fuel intensities. These included 4.2 L per 1000 trailing tkm for Adelaide-Perth, and 10.2 L per 1000 trailing tkm for Sydney-Melbourne.

The ratio of these fuel intensities is a factor of about 1 to 2.5. The difference is partly accounted for by the fact that the Adelaide-Perth track has gentle ruling (i.e. maximum) gradients of 1 in 100 with curves of minimum radius 400 metres, whereas the Sydney Melbourne track has a steep ruling gradient of 1 in 40 and tight curvature with numerous curves of radius from 280 to 400 metres along with the fact that there is a crossing of the Great Divide at some 740 metres elevation. The Sydney Melbourne mainline track is basically of 'steam age' grading and alignment that has seen no improvement in grades since 1946, and freight operations over much of this track alignment requires extra fuel use over that for optimally located and aligned track.

By way of example, the existing track between Goulburn and Yass was laid down in the 1910s as part of a program of duplication and deviations to ease gradients for north bound trains at the expense of more curves and extra length (some 8 kilometres) and replaced a rail track laid down in the 1870s under the direction of the then Chief Engineer, Mr. Whitton. M - Train computer simulation using data for changes in grades and curvature for both the Whitton track and the existing track indicates that for superfreighters hauled by modern 3000 HP diesel electric locomotives, Whitton's alignment would be 12 per cent quicker, and 12 per cent more fuel efficient than the existing track. If the rail authorities were to revert to the Whitton alignment, but modified (with bulldozers) to a ruling grade of 1 in 75 and ruling curvature of 1200 metres, significant savings in both transit time and fuel use would result when compared with operations over the present track.

In the meantime, the track alignment between Goulburn and Yass is worse from an operational point of view than the alignment in use last century. This section came in for particular attention in a 1981 proposal of the Institution of Engineers, Australia, for a completely new deviation with improved grades and curvature and a spur line to North Canberra so as to allow three hour Sydney Canberra and 6 hour Canberra Melbourne XPT services. The failure of the rail systems to advance this proposal (or the Commonwealth's 1980 offer to electrify the Sydney Melbourne railway) was undoubtably one reason for interest in the Very Fast Train proposal from 1984 to 1991.

Improved Sydney Melbourne route alignment is part of a Fast Freight Train (FFT) proposal that was also included in the "benchmark" capital investment option of the National Rail Freight Initiative. This option also included improving height clearances to 6.6 metres between Sydney and Melbourne to allow for double stacked containers. If the ruling grades, curves and clearances were improved to FFT standards, average rail line haul energy efficiency of 3 net tonne km per MJ should be attainable.

By way of contrast to present Sydney Melbourne rail operations, the Perth Kalgoorlie section was substantially upgraded with deviations to ease grades, curves and clearances as part of gauge standardisation in the late 1960s. Energy consumption for rail freight operations between Kalgoorlie and Adelaide were noted to be as high as 3.54 net tkm/MJ for westbound freight (BTE, 1981).

Subsequent factors enhancing fuel efficiency for rail freight between Adelaide and Perth include new generation locomotives being some 20% more energy efficient than their predecessors (Industry Commission, 1991a, Vol II, p139), Adelaide Crystal Brook gauge standardisation completed in 1982, long crossing loops allowing for the standard use of 1800 metre long trains, and the used of light tare wagons (including "five packs" or "spine cars"). It is suggested that an energy efficiency of 4 net tonne km per MJ is now attainable for most interstate rail freight moved over the "higher efficiency" alignment, with modern locomotives and freight wagons.

It is noted that just as for truck operations, fuel penalties apply for lower rail freight transit times. One way of saving fuel in rail operations include advice from train controllers to the locomotive driver to reduce speed on occasion (V/Line, 1986). This process may be assisted by use of computers (Milroy, 1987).

A benchmark case for bulk rail haulage

The haulage of iron ore from Mt. Newman to Port Hedland is understood to take, on average, a little more than a litre of fuel to move one tonne of ore some 426 km, with one trail giving a range of 0.992 to 1.128 litres of fuel per net tonne. The mid point of this range gives a world class energy efficiency of 10.4 net tonne km/MJ.

These figures include the fuel used to take the empty wagons back. Although gravity helps the loaded ore trains, its contribution is relatively small. The excellent results are not only due to the use of some new (GE Dash 8) locomotives and the use of 240 wagon trains (each with a 105 tonne payload), but also modern track laid in the late sixties. The maximum grade for the loaded trains is 1 in 182 and for the empty trains 1 in 67 whilst there are only 9 curves of radius between 580 and 800 metres.

3. POTENTIAL FUEL SAVINGS

This section considers the amount of liquid fuel used for transporting freight by road and rail on ten mainland Australian transport corridors based on 1989-90 estimates of freight tasks, as given in Table 4. Estimates are also made of the liquid fuel usage that would result with improvements in rail track in South - East Australia to "benchmark" standards and rail obtaining a higher modal share of freight tonnages on these corridors.

Table 4 **1989-90 Freight tonnages and distances**

	Million tonnes		Kilometres	
	Road	Rail	Road	Rail
Sydney Melbourne	4.74	2.10	870	960
Sydney Brisbane	1.63	2.02	1020	989
Sydney Adelaide	0.94	0.84	1430	1692
Sydney Perth	0.25	0.57	3995	3960
Melbourne Brisbane	1.05	0.40	1664	1947
Melbourne Adelaide	1.89	1.51	740	777
Melbourne Perth	0.29	0.61	3535	3357
Brisbane Adelaide	0.26	0.23	2443	2643
Brisbane Perth	0.07	0.04	4320	4948
Adelaide Perth	0.16	0.80	2795	2657
Total	11.28	9.12		

References: For freight tonnages ABS Interstate Freight Movement, Australia, 1989-90 with interstate rail freight movements regarded as inter-capital-city movements and for road freight, note ABS remarks about previous undercoverage and their caveat that *"...the estimates must be treated with caution"*. Note Sydney includes Newcastle and Wollongong whilst Melbourne includes Geelong and Westernport. For distances ISC (1990) except for Melbourne Brisbane, Brisbane Adelaide, Melbourne Adelaide and Brisbane Perth which are given by Laird (1990a).

Previous estimates of the potential savings of diesel with large scale diversion of freight from road to rail have been given by Railways of Australia (1980), Quarterman (BTE, 1981), Gentle (1983), Laird (1990a) and the Industry Commission (1991b).

Analysis of the data in Table 4 with the assumption that rail operations are "more efficient" when between Parkes, Adelaide and Perth, and on all other sections are "less efficient" (due to ruling grades, curvature and clearances), with the distance of Parkes to Sydney taken as 446 kilometres, gives interstate freight tasks as given in Table 5.

If it was assumed that the mainline interstate rail system in Eastern Australia was upgraded to modern intermodal standards (as under the National Rail Freight Initiative Task Force (1991) "Benchmark" or Higher Investment Case), and, if it is further assumed that rails modal share of freight was lifted to 50 per cent on shorter routes (less than 1000 km), 65 per cent on medium distance routes and 80% on longer distance routes (over 2500 km (which are the ones in and out of Perth)), then the freight tasks would be redistributed as in Table 5.

Table 5 Freight tasks 1989-90 - billion tonne km

	Actual	Redistributed
Road	13.7	9.5
Less efficient rail	7.3	10.6
More efficient rail	7.5	8.8

This transfer of freight would involve a reduction in the road freight task of 4.2 billion tonne km and corresponds to a transfer of 3.1 million tonnes of road freight to rail line haul. This may be compared with estimates of Australian National (as quoted by the Industry Commission (1991b, Vol II, p F50) for a reduction by 7 billion tonne km of the road freight task and a transfer of 4.2 million tonnes from road to rail by the year 1998-99, if rail is upgraded to "benchmark" standards.

We now turn to energy use for both the actual 1989-90 inter-capital city freight task, and if the freight task had of been redistributed over an upgraded rail track. This is based on the broad assumptions that the energy efficiency of all interstate road line haulage is 0.9 net tkm per MJ, whilst rail freight over the "more efficient" network is 4 net tkm per MJ, and over the "less efficient" network is currently 2 net tkm per MJ, but would rise to 3 net tkm per MJ on improving ruling grades, alignment and curvature to "benchmark" standards. We also assume that the energy used for road pick up and delivery is 108 MJ per tonne of freight moved by rail for line haul. The actual and potential fuel use is as given in Table 6. This shows fuel savings of about 120 million litres of fuel a year based on 1989-90 tonnages.

Table 6 Fuel use for inter-capital freight 1989-90 - million litres

	Actual	Redistributed
Road	394	273
Rail	143	148
TOTAL	537	421

Rail electrification

This is an attractive option in Europe that is generally overlooked in North America, reflecting the relative price and availability of liquid fuels. In Australia, Queensland Railways electrification at 25,000 volts A.C. of coal and wheat lines in Central Queensland and between Brisbane and Rockhampton (completed in 1989) has resulted in reduced costs for locomotive maintenance and improved locomotive and wagon turn around times, along with a saving of 128 million litres of liquid fuel a year (Read and Drake, 1989).

Electrification options were also considered in 1980 by both the Federal Government for the existing Sydney Melbourne railway with a detailed Australia wide study by ARRDO (1980) that included NSW Hunter Valley electrification. NSW extended its low voltage 1500 volts DC system to Newcastle in 1984 and Port Kembla in 1986, and proposed that the Maldon Port Kembla railway (on which work was suspended in 1988) would be electrified at 25,000 volts AC and operated with dual voltage locomotives. Although coal exports through Newcastle have trebled during the 1980s to reach some 38 million tonnes in 1991, and the economics of Hunter Valley electrification has been re-examined in recent years, it appears that diesel electric locomotives (albeit with some new and larger ones on order) will continue to be used.

Toronto Targets for domestic land freight

The "Toronto targets" adopted by the Federal Government in October 1990 include stabilisation of greenhouse gas emissions at 1988 levels by the year 2000, and their reduction by 20 per cent by 2005. During 1987-88, (BTCE, 1991) freight transport related activity (including refining and distribution of fuel used for freight transport) within Australia produced 21 million tonnes of CO_2 emissions or about 30% of all such transport related emissions (which in turn is about 26% of all 1987-88 CO_2 emissions). Of this, 8.7 million tonnes of carbon dioxide emissions were due to urban freight transport which is almost exclusively done by road vehicles, and offers little option for modal substitution.

Given a projected growth in Australian land freight, it is clear that a "business as usual" approach will not see achievement of the "Toronto targets" in respect of land freight transport.

4. GOVERNMENT INTERVENTION IN FREIGHT TRANSPORT

Earlier sections have shown that rail freight fuel efficiency is generally better than road freight fuel efficiency. From this it follows that Government intervention in road and rail freight will have implications for overall energy usage in land freight transport.

However, it is difficult to estimate precisely the amount of freight that would transfer from road to rail, and from rail to road, if Government policies were changed. Levels of service are crucial in the choice of transport mode for most freight consignments, (see, for example, Rail Industry Council (1990), Industry Commission (1991a) and the Bureau of Industry Economics (1992)). In this respect, rail often suffers due to real or perceived management and customer relations problems, along with physical limitations leading to longer transit times. Shorter transit times, although using more fuel, would allow rail to increase its modal share on Eastern mainland intercapital transport corridors.

Federal and State Government intervention in domestic land freight transport occurs in several ways, including:

Allowed (tolerated) levels of rail freight deficits
Levels of road freight cost recovery
Relative levels of Government investment in roads and rail track
Taxation measures
Safety and environmental regulation
Economic regulation
Import controls and tariffs on road materials, vehicles, rail equipment and fuel.

We consider the first three measures in further detail.

Rail freight deficits

An overall rail deficit of $1676 million for 1987-88 was noted by the IAC (1989), with most of this (about $1000 million) being due to passenger services. Rail freight deficits of about $600 million were then arising mainly in NSW ($302 million for 1987-88) and Victoria (around $200 million). There is also some cross-subsidisation of general freight in Queensland from coal traffics, with the Industry Commission (1991a) estimating "excess" rail freight charges for coal in Queensland and NSW of some $400 million.

Since 1988, State Rail has reduced its subsidies for rail freight, with the 1990-91 NSW State Budget noting a social and environmental rail freight bounty for certain traffics (to offset external costs that would be incurred in certain rail freight traffics were hauled by road instead of rail) at $26.675 million, along with $60.54 million for reduced charges or increased service levels for some rail freight (including some NSW coal exports via Port Kembla), but no general contribution to SRA freight operating losses.

Other references to rail freight deficits include those of the ISC (1986,1987,1990) and the National Rail Freight Initiative Task Force (1991) which noted that Australia's interstate rail freight operations incurred in 1989-90 an estimated combined loss of $377 million, although the contribution to such losses vary considerably between the five different operators. It is of note that information given by the ISC (1987,1990) suggests that average 1987-88 interstate rail freight costs on the East Coast were about 6 cents per net tonne km as against some 3 cents per net tonne km for Adelaide - Perth rail freight. Interstate rail freight losses are expected to be eliminated over the next five years by the National Rail Corporation.

Road freight external costs

References by Government agencies and inquiries to road cost recovery from heavy vehicle operations in Australia are numerous and include McDonell (1980), BTCE (1984, 1988), May et al (1984), ISC (1986, 1987, 1990), the IAC (1989), McColl (1988), the House of Representatives Standing Committee on Transport, Communications and Infrastructure (1987, 1989) and the National Road Transport Commission (NRTC - 1992). Of these references, all but McColl (1988) and the NRTC (1992) found under recovery of road system costs from heavy truck operations. Here, the BTCE (1988) estimated that all articulated truck operations failed to cover their fully allocated road costs when offset by all registration charges and all fuel taxes by some $1283 million in 1985-86, and noted the option of mass - distance taxes. This economically efficient form of road user charge for heavy trucks has been in successful use in New Zealand since 1978 (see ISC, 1986, 1987 and Laird, 1990b).

Recent changes in road cost recovery in Australia include the introduction of the Federal Interstate Registration Scheme in January 1987 with increased fees as of July 1988, and the introduction by New South Wales and Victoria in 1987 of permit fees for vehicles operating at increased mass limits. The Special Premiers Conference held July 1991, agreed, inter alia, to establish a National Road Transport Commission with functions including the attaining of charges in two zones that reflect full cost recovery by July 1995, for all vehicles except road trains.

The NSW Roads and Traffic Authority consider under-recovery of road system costs by heavy trucks in bulk haulage operations on local roads of 3 cents per net tonne km to result and recommend the recovery of such costs for new developments under the NSW Environmental Protection and Assessment Act 1979 (Industry Commission, 1991a, Vol I. p116). This is despite NSW road user charges for heavy articulated trucks being the highest in Australia.

Cost recovery levels in NSW are shown in Table 7 along with ISC recommended levels, the NRTC recommended and the current New Zealand charges.

Table 7 Cost recovery and costing options
1990-91 Cents per vehicle kilometre for 6 axle articulated trucks

Scheme	(Vehicle Mass)		
	38t	41t	42.5t
NSW current levels ARTF	14.4	15.2	16.5
NSW current levels ABS	19.6	20.4	21.7
ISC Recommended charge (ABS)	19.9	23.8	26.3
NRTC Recommended charge (ABS)	20.0	20.0	20.0
New Zealand levels	29.5	36.4	42.1

Note: For the NSW current charges, the ISC and NRTC recommended charges, a total fuel tax of 31 cents per litre is used with an assumed annual haulage of 150,000 km. The NSW levels depend on the assumed fuel use, as given in Table 3.
The New Zealand charges given are after removal of a 12.5% Goods and Service Tax and currency conversion at a rate of $1A=$NZ1.30.

Table 7 clearly shows that the NRTC recommended charges for six axle articulated trucks operating at high load limits are significantly less than current New Zealand Road User Charges. The Industry Commission (1991a, Vol I, p255) notes that *"...some pavement costs will not be captured by (a) national road user charging regime ...because the charges will not recognise that the same heavy vehicle causes more damage to a local road than to an arterial road "* and recommends, inter alia: ... *that State and Territory laws be amended to provide local governments with effective capacity to impose specific pavement damage and externality charges on heavy vehicles.*

Other external costs of heavy vehicle operations including road congestion, noise and air pollution are also considered by McDonell (1980), Bureau of Transport Economics (1984, 1987), May et al (1984), the Inter-State Commission (1986, 1987, 1990), Staysafe (1989) and the Australian Road Research Board (Cairney, 1991).

The cost of all road crashes involving heavy vehicles in NSW was estimated by the NSW Roads and Traffic Authority in 1989 as $218 million a year (Staysafe, 1989). This cost could be high because of a sharp increase in the number of fatal road accidents involving articulated trucks on NSW roads in 1988 (followed by the loss of 250 lives on NSW roads in crashes involving heavy vehicles in 1989 that included two major crashes on the Pacific Highway): since then, the Federal Government has required speed limiters for all new articulated trucks and the NSW Government has also required the compulsory installation of tachographs in all new articulated trucks. Australia wide, Cairney (1991) has conservatively estimated the total cost of all road accidents involving trucks as $500 million a year. With an 85 billion tonne road freight task in 1987-88, the average road crash risk involving all trucks is 0.59 cents per net tonne km.

With regards to noise and air pollution, the Inter-State Commission (1990) estimated the total 1989-90 cost in Australia for noise and air pollution from all vehicles as in the order of $534 million and $730 million respectively, and, notes that whilst such estimates should be treated with caution, *"... it is increasingly important that an attempt be made to include these costs in road cost allocation"*. To this end, the ISC (1990) recommended that Federal fuel taxes include a charge for noise and air pollution, with the charge initially being 8.5 cents a litre for diesel and 5.1 cents a litre for petrol. The NRTC does not intend to apply such charges to heavy vehicles.

The total external costs of line haul road freight, including unrecovered road system costs, are broadly assessed at 1.5 cents per net tonne kilometre. We have noted in Section 3 upgrading the rail system to "benchmark" standards has the potential to reduce the interstate line haul road freight task by 4.2 billion tonne km on 1988-89 tonnages, and 7 billion tonne km on 1998-99 tonnages. This would reduce road freight external costs by $63 million and $105 million respectively.

Road and rail track investment

The current level of road investment by government is about $5 billion a year, whilst the the Industry Commission (1991a, Vol II, p22) gave data showing that total capital expenditure by government railways has declined from $1237 million in 1985-86 to $901 million in 1988-89. The level of Federal funding on rail during the 1980s is considered

to have been low, with the House of Representatives Standing Committee on Transport, Communications and Infrastructure (1989) noting the diversion of some rail fuel taxes into road works.

A National Rail Freight Initiative (1991) report considered a "Benchmark" capital investment option that included improvements in track grading and alignment along with higher clearances on the east coast corridor (Melbourne-Sydney-Brisbane) and Adelaide-Melbourne gauge standardisation. The cost of upgrading the interstate rail freight system to Benchmark standards is about $2700 million, as against a currently and conditionally approved program of investment over ten years in the order of $2000 million (including some $450 million noted in the Prime Minister's Economic Statement of February 1992). However, the level of funding approved in 1991, compared with the Benchmark case may result in various penalties for East Coast corridor rail operations, including a reduction in average train speeds of 20%, a reduction in train size of 30%, and, a reduction in market share of about 20% by 1998-99.

It is suggested that in view of the national benefits, including fuel savings and lower rail operating costs, that would result from the upgrading of interstate mainline track in South East Australia, the full costs and all benefits of upgrading to a "Benchmark" level be evaluated. This would be consistent with a recommendation of the Ecologically Sustainable Development (ESD) Transport Working Group Report (1991) *"...to the extent indicated by investment appraisal procedures taking full ESD benefits into account, increased investment in interurban rail be undertaken, in conjunction with improved work and management practices to achieve best international standards of rail operational efficiency..."*.

The ESD Transport Working Group also notes (1991) *"...Government funding of interurban road and rail infrastructure development, including the National Highway system and the National Rail Corporation's network, should be brought onto an even-handed basis that incorporates ESD principles, by assessing both roads and rail projects according to a single set of criteria covering national and local economic, social and environmental benefits and costs."*

Conclusions

Australia's land freight operations have made mixed energy efficiency gains during the 1980s to meet a growing freight task. Some of these operations including Northern Territory road trains and iron ore railways in Western Australia are of world standard. Queensland Railways electric narrow gauge coal haulage operations and Adealide - Perth rail freight operations also rank high in energy efficiency by world standards.

On the other hand, there are many problems in interstate rail freight operations in Eastern Australia. Although the formation in 1991 of a National Rail Corporation will assist these operations, it is recommended that consideration be given to upgrading the mainline interstate rail track in Eastern Australia to modern intermodal rail freight standards with improved ruling grades, curvature, and clearances. Such an investment has the potential to save at least 100 million litres of diesel a year, along with reducing rail freight costs in Eastern Australia and significant road freight external costs.

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Alternative Transport Fuels

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Abstract:

Alternative fuels have the potential to reduce greenhouse gas emissions from transport, and to reduce urban air pollution and noise. This paper reviews recent research findings on emissions from these fuels, as well as safety, costs and other aspects relating to both vehicles and fuels, which influence market acceptance. New motor vehicle technology optimised to account for the characteristics of each fuel would need to be implemented to achieve maximum benefit. The effects of taxes and charges on fuel price are noted. The paper emphasises that any decision about whether to promote or encourage the take-up of alternative fuels is rendered extremely difficult in the environment of changing technology, changing vehicle emission standards, developments in gasoline vehicle fuel efficiency, and the effect of these on new vehicle costs.

The views expressed in this paper are those of the authors, and do not necessarily represent those of the Bureau of Transport and Communications Economics.

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