Rail Research
Industry Report

Project 24 Rail Transport Energy Efficiency and Sustainability

Project background Commenced July 2002 - Completed December 2006

Results and Outcomes:

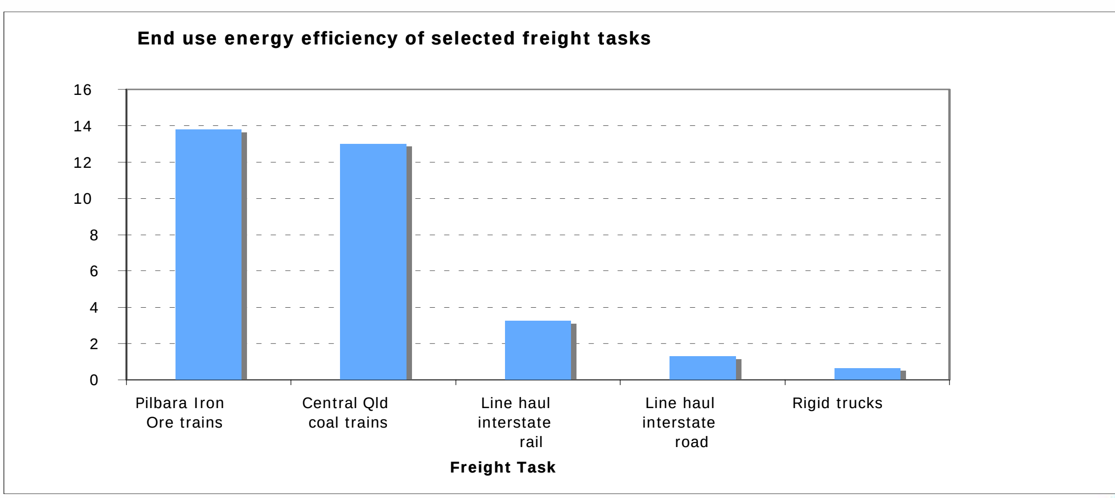
1. Energy efficiency

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 2004) and this project. A common theme is that rail transport is more energy efficient than road transport.

1.1 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 km 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 3 net tkm/MJ in 1997-98 (ACG). This includes the use of electric power for QR where 1 kiloWatt hour (kWh) is equivalent to 12 MJ on a FFC basis giving Central Queensland coal trains an energy efficiency of at least 4.5 net tkm/MJ (ie 13.5 net tkm/MJ end use energy efficiency using 1 kWh =3.6MJ). CRC project 24 data for 2001-02 gave an average FFC energy efficiency for non iron ore freight trains of 3.3 net tkm/MJ.



By 2005, US Class I railroads had gained an average energy efficiency of 3.82 net tkm/MJ (FFC). The Canadian Pacific Railway 2005 Annual Report publishes data implying an impressive energy efficiency of 4.05 net km/MJ (FFC). Driving techniques, equipment, train mass, terrain and track alignment all influence rail fuel consumption. There are problems in gaining accurate and up to date land transport data within Australia. The difficulty in getting energy data from some freight systems led to the project concentrating on passenger systems.

Computer simulation by Mr M Michell of Samrom Pty Ltd from the project has shown that for Sydney - Melbourne, constructing 197 km of new track built to modern engineering standards would reduce transit times by 1 hr 45 min and fuel use per freight train (2 NR locos) by 1340 litres along with a cost saving per train conservatively estimated at some $1700 per train and lower track maintenance costs. Other rail deviation sites within NSW and Queensland have also been analysed.

1.2 Rail passengers

Rail CRC project 24 aggregate data from individual Australian rail passenger operators in confidence over five years is given in Table 1. This assumes older FFC electrical energy equivalents of 1 kWh equals 15 MJ in Vic, 12 MJ in Qld and WA, 9.73 MJ in NSW and 8.78 MJ in SA. 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.

The JR Central 2005 Data Book shows the Tokaido Shinkansen with an average energy of 2.86 pax km per MJ.

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
2003-04	0.50	0.67	0.88
2004-05	0.52	0.68	0.83

2. Sustainability

This part of the project has drawn on BTRE data, the ARTC 2001 Track Audit, Queensland Transport Rail Studies and other sources to provide more information on external costs. External costs in transport include real costs that are borne by society as a whole but not paid for by those who consume transport services. Along with subsidies to urban rail transport, they include accidents, air pollution, noise pollution, greenhouse gas emissions, congestion, and under-recovery of road system costs from B-Doubles etc.

Urban car use default externality values, amounting to over 3 cents per car kilometre are given in the Australian Transport Council 2004 National Guidelines for Transport System Management in Australia Vol 2, page 87. Urban rail external costs are not provided but would be appreciably lower.

TABLE 2	Australian urban land freight externality 2000 unit costs (articulated trucks and freight trains)	
Measure	**Road (c/ntkm)**	**Rail (c/ntkm)**
Accident costs	0.60	0.03
Air pollution	0.65	0.22
Noise pollution	0.22	0.12
Greenhouse gases	0.18	0.06
Road congestion	0.10	n/a
Increased road maintenance	1.00	n/a
TOTAL	**2.75**	**0.43**

Reference Laird (2005d)

For land freight, Table 2 shows that on the basis of cents per net tonne kilometre (c/ntkm), rail freight is some twenty times safer than road freight. In addition, in urban areas, rail has less than one sixth of the external costs of road freight.

Air pollution, noise and congestion costs are lower in rural areas (total road 1.98, rail 0.17 c/ntkm as in Table 2) than in urban areas. However, road maintenance costs for rural roads are higher than for arterial roads, also rail track subsidies need to be taken into account.

3. Methodology for evaluating rail deviation benefits

This methodology was initially developed for Queensland Transport (Rail Studies 2003) and used extensively in Rail CRC Project 24. For a detailed discussion see Michell and Laird (2002b), Laird and Michell (2004c) and Laird et al (2005c).

Project applications of this methodology have comprised major NSW Main South deviations identified in an earlier project for the Rail Infrastructure Corporation of New South Wales, Hexham - Stroud Road in NSW, and, Grandchester Gowrie and the North Coast Line in Queensland.

In brief, the inputs and steps for the multi stage process are as follows:

Step 1A Obtain track file data for an existing section of track specifying grades, curvature and track related speed restrictions.

1B Obtain track file data for the potential new deviation(s).

1C Obtain details of the predominant freight train, other freight trains (and if relevant passenger trains) in terms of motive, power, mass, length, energy efficiency and braking characteristics that are typical of the route under review. Also obtain future train configurations that might be adopted over a re-aligned route.

Step 2. Simulate train movements for each type of train over the existing track and its potential deviation. Obtain outputs of transit time, energy use (either litres of diesel or kWh of power), and braking work (kWh) for each train on each track.

Step 3. Using updated unit costs for time, energy and braking work for each train, evaluate the cost for each train movement over the existing and potential new track. Using the present traffic task converted to annual train movements, calculate annual operating costs for the existing and new track.

Step 4. Evaluate track maintenance costs for each train movement over the existing and potential new track and hence the annual costs.

Step 5. Evaluate external costs for each train movement over the existing and potential new track and hence the annual costs.

Step 6. Using the simulated improvements in transit time, and if appropriate, any reduction in rail freight charges, estimate the likely amount of freight tonnages to move from road to rail and over what distance the freight will move. Calculate the road freight external costs and compare with line haul rail freight and road pick up delivery.

Step 7. Evaluate the annual reductions in train operating, track maintenance and external costs. If need be give sensitivity estimates for different oil prices and use indexation as appropriate for calculating benefits in future years.

Industry benefits and implementation process:

Rail CRC project 24 has provided rail passenger operators with reliable data on the energy efficiency of their own operations with Australian averages and world best practice. The sustainability part of Project 24 provided data and analysis on land transport externalities and quantifying rail's ability to move freight and passengers with significantly less safety risks and energy inputs than road. Rail transport also assists Australia in reducing dependence on oil imports, air pollution and greenhouse gas emissions.

Rail deviations between Menangle and Junee with a combined length of 197 km could replace 257 km of track on “steam age” alignment, with time and fuel savings as noted above. With rail gaining an expected 8.2 per cent increase in modal share of Sydney - Melbourne intercity freight - now about 11 mtpa - an estimated reduction in external costs of $15 million per annum would result. As noted by QR, citing project results (Laird et al 2005c), potential upgrades from Gowrie to Grandchester have the ability to straighten and shorten the line from 107km to 67km with coal train simulation showing a reduction of *"… fuel usage by half and travel times from three hours to one hour."*

As a result of 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. Submissions to this effect have been made citing project results from the University of Wollongong and also the Railway Technical Society of Australasia (RTSA) to Parliamentary and government inquiries.

Related reference documents:

A full list of papers is on the Rail CRC Website, which also includes an extensive literature survey prepared in 2002. This list of papers also includes railway magazine articles and recent submissions. In addition, an Australasian Railway Association flyer due early 2007 outlines selected project results.

Selected conference proceeding papers from the project

2006 *Freight transport cost recovery in Australia*, Australasian Transport Research Forum, Gold Coast

2005 a *Australian commodity exports and land transport* Paper for WESTAC Freight Forecasting Forum, Vancouver

2005 b *The Sydney to Melbourne Railway: Yesterday, today and tomorrow*, Second International Engineering Heritage Conference, Sydney, Engineers Australia

2005 c (with M Michell, A Stoney, and G Adorni-Braccesi) *Australian freight railways for a new century* AusRail Plus

2005 d *Revised Land Freight External Costs In Australia*, Australasian Transport Research Forum, Sydney

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

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

2004 c (with M Michell) *Benefits from curve easing - the straight track study*, Conference on Railway Engineering, Darwin, Papers, p40.1-40.7

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

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

2002 a (with M Michell and G Adorni-Braccesi) *Sydney–Canberra–Melbourne High Speed Train Options*, Australasian Transport Research Forum, Canberra, Papers, Volume 25

2002 b (with M Michell) *Smooth running - a route of cost reduction* Conference on Railway Engineering, Wollongong Proceedings page 227-237

For further information:

Project Leader: Dr. Philip Laird, University of Wollongong, NSW, 2522
Phone 02 4221 3421 plaird@uow.edu.au

Rail CRC:
Building 70 Central Queensland University
Bruce Highway
North Rockhampton Qld 4702
Phone: (07) 4930 9597
Fax: (07) 4923 2161
Web: www.railcrc.com.au

RAIL CRC