CRC for Rail Innovation

Transforming Rail: A Key Element in Australia's Low Pollution Future

Final Report

DOCUMENT CONTROL SHEET

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Executive Summary

To achieve Australia's climate goals sharp reductions in transport emissions are necessary; this requires going beyond emissions trading to a new generation of transport policies.

The Australian Government's recent White Paper implies that Australia can achieve its climate change goals to 2030 without major change in the transport sector. This presumption is incorrect: a sharp reduction in transport emissions will be required if Australia is to pursue even the modest global stabilisation target of 550 ppm CO_2-e. Reducing transport emissions will in turn require a substantial modal shift from road to rail, as well as lower emissions intensity in all transport modes. These changes will not be achieved by emissions trading alone, but need a new generation of transport policies.

There are three reasons why the reduction in transport emissions is necessary. First, the Treasury modelling understates the task of achieving a given stabilisation level, and all countries will need to make bigger cuts than implied to achieve, say, 550 ppm CO_2-e. Secondly, the modelling implies that 30-40% of the reduction in Australia's emissions allocation will be achieved by purchasing permits overseas rather than by reducing emissions in Australia. This level of overseas purchases is unlikely to be either achievable or morally sustainable. Thirdly, the generous free permit allocation provisions in the White Paper for energy intensive trade exposed industries (EITEs) mean that the allocations available for other industries are correspondingly reduced, falling by 30-50% over 2010-20. Transport is responsible for about 27% of non-EITE industries emissions; these will need to be reduced sharply if such reductions in non-EITE emissions are to be achieved.

A modal shift from road to rail will have large economic, social and environmental benefits

The economic and social costs to Australia of current transport patterns are immense. The social costs arising from transport are estimated at A$52 billion or 5.6% of GDP in Australia in 2005, before including congestion costs. These social costs are mainly due to road transport, and rail contributes only 9% of them. Modernised and efficient rail can also provide lower cost movement of freight between major urban centres than road transport, and move people in cities at a lower average cost per kilometre. Thus a modal shift to enhanced rail will have major economic and social benefits for Australia.

Rail is typically a more energy efficient form of transport than road, with lower energy use per passenger kilometre or per tonne kilometre. Rail's energy intensity can be reduced further by a range of measures, from lighter and more advanced vehicles and improved vehicle/track interactions to more efficient engines and regenerative braking. In the long term rail offers the possibility of virtually zero emissions transport, when rail transport is fully electrified and powered by electricity from renewable sources.

Carbon prices are necessary but not sufficient; other policies are required to support the massive private and public investment implied

The transport system is riddled with market failures, especially externalities, sunk costs and coordination failures. For example, the social benefits created by a new rail system are widely spread, and cannot be fully captured by those who build and run it; heavy sunk costs are required in track, rolling stock and other systems, with uncertain returns; issues of coordination, such as between infrastructure providers and operating companies, are often critical to the returns on investment. This means that, while setting a carbon price through emissions trading is a necessary condition of change, prices alone will have a limited role in driving structural change and reducing emissions in transport. Strong complementary policies are necessary, and the economic and social benefits arising from such change provide a powerful justification for decisive government action. Policies in the following areas seem most important:

- In freight transport, the costs generated by large long distance trucks are not passed through fully to users. There is a widely recognised case for *mass-distance-location charging* to be introduced, as in other countries, to correct this market failure.

- Direct public investment is required in *major rail infrastructure* (such as rail track and associated works and equipment) which suffers from all three forms of market failure. Support for private and public investment in areas such as *signalling and control systems, advanced modal interchanges and other forms of coordination is* required. There is also a need for the development and implementation of *standards for rolling stock and infrastructure* to improve transport system performance.

- To modernise Australia's rail system, massive investment will be necessary by operating companies, whether public or private, and by firms in supplier industries. Given market failures, *public initiatives in the form of R&D support programs and enhanced depreciation allowances for certain classes of expenditure* are necessary.

- Finally, *investment in the electrification of large scale rail systems*, such as those of the North-South corridor, linked to sources of renewable energy, should be given serious consideration in the light of the long term social returns that can be generated.

High social returns, and lower emissions, will accrue from transforming rail.

The process of reversing the dramatic modal shift to road that took place over 1945-85, and of modernising the Australia rail industry, will be a long term one requiring sustained action. It would involve, by say 2030, the majority of Australia's non-bulk freight movements outside capital cities occurring in modern, highly efficient trains; a significant share (20-25%) of all passenger kilometres travelled in Australia being by rail; and the overall rail system being largely electrified and increasingly powered by renewable energy. Using the model developed by the study team, the economic, social and environmental benefits arising from achieving real progress towards these goals by 2020 have been quantified.

The overall benefits from moving along this path are very high. Using a real discount rate of 10% per annum, the net present value in 2010 of the benefits accruing over 2010-20 is A$27.4 billion. While there are wide margins of error around these estimates, the basic finding of very large total benefits is beyond dispute. This figure only includes benefits out to 2020, and benefits will continue to accrue for many subsequent years. It has not been possible to undertake a detailed assessment of the investment necessary, by both the public and private sectors, to achieve these goals, but the broad dimensions are known. Taking an upper bound for that investment of A$20 billion over 2010-20, (or A$2 billion per annum) the implied social rate of return on this investment is 50%. Again this is the return achieved only from the benefits to 2020, and further benefits will accrue after that time.

Most of Australia's transport emissions come from road transport. Even so, if the path described above is continued to 2030, total transport emissions are about 11% lower than in the base case by 2030. If they are supplemented by further action to reduce the emissions intensity of road and air transport, total transport emissions begin to decline after about 2025 and are close to their 2010 level by 2030. Thus the actions discussed in this report not only generate large economic and social benefits, and high social returns to investment, but also contribute significantly to reducing greenhouse gas emissions. This would represent a major contribution to the achievement of Australia's broader climate change goals.

List of Figures and Tables

Abbreviations and Acronyms

AR4	Fourth Assessment Report of the IPCC
ARTC	Australian Rail Track Authority
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BTRE	Bureau of Transport and Regional Economics
C/ntkm	Cents per net tonne kilometre
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
CPRS	Carbon Pollution Reduction Scheme
CSES	Centre for Strategic Economic Studies
DCC	Department of Climate Change
DIRN	Defined Interstate Rail Network
EITE	Energy intensive trade exposed
GDP	Gross domestic product
GHG	Greenhouse gases
GT	Gigatonnes
HDV	Heavy duty vehicle
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
LDV	Light duty vehicle
MDV	Medium duty vehicle
MWh	Megawatts hour
N_2O	Nitrous oxide
Ntkm	Net kilometre
Pkm	Passenger kilometres
Ppm	Parts per million
QR	Queensland Rail
REC	Renewable Energy Certificate
Tkm	Tonne kilometres
TPC	Train Protection and Control Systems
Vkm	Vehicle kilometres

1. Introduction

This document constitutes the final report of a project, undertaken for the CRC for Rail Innovation by the Centre for Strategic Economic Studies at Victoria University, to study the implications of the introduction of an emissions trading scheme, and of potential responses to climate change more generally, on the rail industry in Australia. The purpose of this final report is to summarise the main arguments, conclusions and recommendations of the study. The analysis reported here is backed up by more detailed work contained in ten supporting papers, which are also available from the CRC for Rail Innovation. A list of those papers is provided in Appendix.

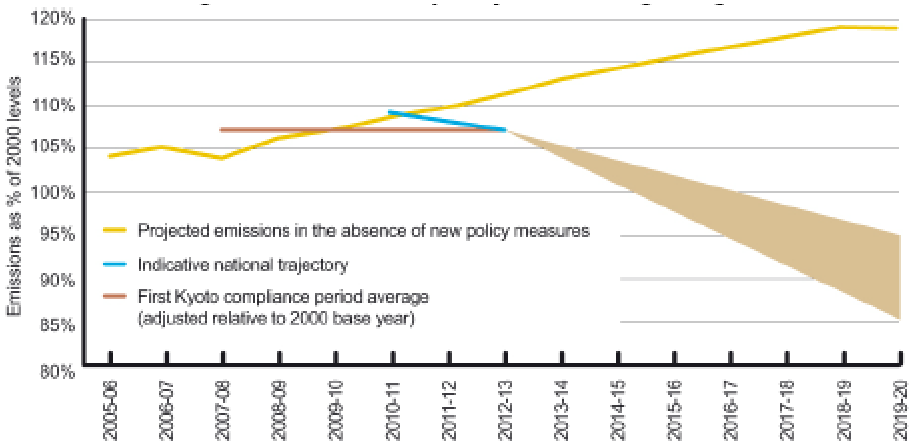
2. The Role of Transport in Australia's Low Pollution Future

2.1. The Australian Government's White Paper Proposals

On the 15 December 2008 the Australian Government released the details of the Carbon Pollution Reduction Scheme (CPRS) that it will submit to the Australian Parliament for approval in 2009. The main features of the CPRS are as summarised below.

The target is for emissions reductions of between 5-15% by 2020 relative to 2000, with the final decision to be made after the 2009 UNFCCC conference in Copenhagen. The 15% target will be adopted if all major countries commit to restrain emissions and developed countries accept comparable targets. A trajectory involving a 1% per annum reduction in total emissions has been established for the first three years starting with 2010-11, with subsequent trajectories to 2020 to be set when the final target is established. As shown in Figure 1, the impact of these targets relative to business as usual emissions will be substantial – if the 15% target for reduced emissions is adopted post Copenhagen then, taking account of expected growth in the business as usual case, the emissions allocation for 2020 will be about 28% below that unchanged policy base.

Figure 1: Indicative trajectory and 2020 target range



Source: DCC (2008, Chapter 4, Figure 4.4).

Permits will be either auctioned or given freely in some cases, to be fully tradeable and bankable, with a 5% per annum borrowing allowance. The permit price will be determined in the market, subject to a price cap on permits of A\$40 per tonne of CO_2-e in 2010, rising by 5% per annum in real terms. Emissions will be internationally tradeable, both through Kyoto mechanisms and through linkage to other defined trading schemes.

There is a high formal coverage, with about 75% of emissions included, but this is reduced by the effect of other provisions. Permits will be issued freely to energy intensive trade exposed (EITE) industries, at two levels (90% and 60%) based on the energy intensity of production, with the eligible base declining by 1.3% per annum, and will be available for new or increased production. They can grow by up to 5% a year, and at that rate would account for 57% of emissions by 2020. Substantial support has also been provided for coal based generators through the issue of free permits, subject to maintaining their generation capacity.

Transport is included in the CPRS, but the arrangements to offset the impact of the CPRS on fuel prices for heavy road vehicles, on-road business users and private vehicle use are retained as in the Green Paper, as are those for assistance to households and for the Climate Change Action fund. This offset has not been extended to rail. The offsets for passenger cars and for trucks will be reviewed after three years and one year respectively. The Government has decided that all shipping (international and domestic) that carries domestic cargo will face an equivalent carbon cost to that emerging from emissions trading.

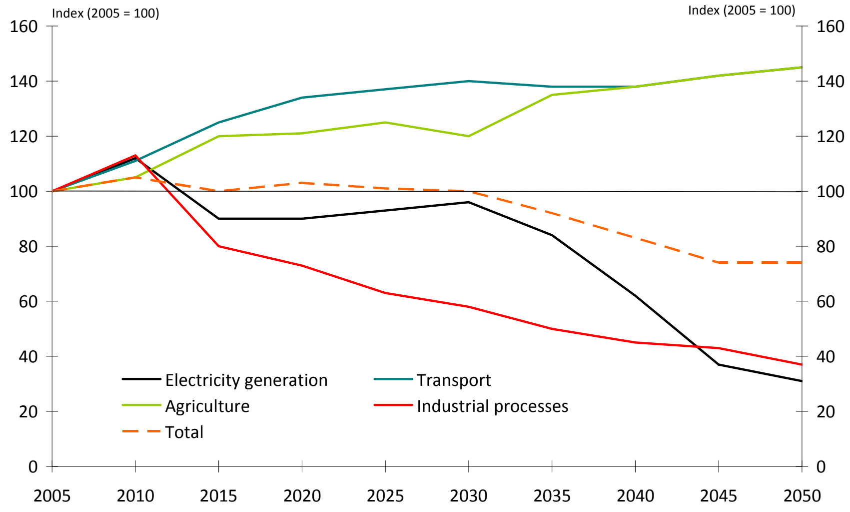
2.2. The Apparent Implications for Transport

Even though transport is responsible for 17-18% of Australia's emissions on a full life cycle basis, the reduction in transport emissions plays a limited role in expected CPRS outcomes over the next few decades, and there is limited discussion of transport issues in the White Paper, although a supplementary paper is provided (BITRE and CSIRO 2008).

While transport providers – in road, rail and air modes – will be affected by emissions trading in many ways, its impact on the overall level and structure of transport activity in Australia is presented as being modest through to 2030. This impact will be through prices, but even a carbon price of A\$50 per tonne of CO_2-e amounts to an increase of only about 20 cents per litre on the fuel price, a modest change in terms of recent price movements. The elasticity of motor vehicle use with respect to the fuel price is low, in part because of limited alternatives in many areas and also because fuel costs are only a small proportion of the overall cost of owning and using a car.

Given the much higher impact on electricity prices (a carbon price of A\$50 per tonne of CO_2-e will lead to an increase of about A\$50/MWh in wholesale electricity prices, an approximate doubling) than petrol prices, in some cases rail's competitive position vis-à-vis road could deteriorate. There is likely to be a substantial impact on individual owner-operators in the road freight industry, where margins are very tight and higher costs could force many out of the industry. But with lags in the adoption of new technologies for motor vehicles, transport emissions are unlikely, on proposed policies, to deviate much from the unchanged policy case through 2020 if the only policy mechanism at work is the carbon price generated through emissions trading.

Figure 2: Industrial sector emissions for Australia, CPRS-5 scenario, 2005-2050



Source: Adapted from Treasury (2008).

This conclusion about the impact of emissions trading per se is confirmed by the modelling undertaken by the Australian Treasury and released prior to the publication of the White Paper (Treasury 2008). Figure 2 summarises the Treasury projections for domestic emissions for the 5% reduction target, with emissions by industry expressed as an index with 2005 levels equal to 100. By 2030 total Australian domestic emissions will be at the 2005 level, with the required reduction in emissions relative to 2005 levels achieved by purchases of emissions overseas. By 2020 emissions from industrial processes are projected to be more than 40% below 2005 levels and those from electricity generation nearly 10% lower, but transport emissions are projected to be nearly 40% higher and still very close to the business as usual case. Thus the modelling of this case implies no substantial reduction in transport emissions relative to unchanged policies prior to 2030.

2.3. Three Reasons for a Larger Impact in the Transport Sector

Nevertheless, there are, in our view, three related reasons why Australia will need to, and probably will be forced to, achieve a much greater reduction in domestic emissions, and hence in transport emissions, than is implied in this analysis. The first is that the Treasury modelling starts from an unrealistically low base of current global emissions, so that any given stabilisation path (say 500 ppm CO_2-e) is more difficult to achieve, in the sense of requiring deeper cuts in emissions. The second is that the modelling framework allows up to 50% of Australia's reduction in emissions relative to the base case to be achieved by net purchases of emissions permits overseas, rather than by reductions in domestic emissions, and in the CPRS-5 cases about 40% of the reduction is achieved in that manner by 2030. Especially in the context of a more difficult global challenge than anticipated in the modelling, this outcome seems unrealistic and Australia is likely to be required to achieve a substantial reduction in domestic emissions. Thirdly, the White Paper proposals for the issue of free permits to energy intensive trade exposed

(EITE) industries are extremely generous, amounting to up to 57% percent of all permits available in 2020 on some assumptions. This generous EITE allocation, which was not included in the Treasury modelling, means that the reduction in emissions required from other industries for a given emissions target is much greater than would otherwise have been the case.

Table 1 provides a number of estimates of total global greenhouse gas emissions for 2005. The Fourth Assessment Report of the International Panel on Climate Change (IPCC 2007) published an estimate of total global greenhouse gas emissions in 2004 of 49.0 Gt CO_2-e, of which some 44.3 Gt CO_2-e were for all emissions other than CO_2 emissions from biomass decay and peat, and about 4.7 Gt CO_2-e from that latter source. The International Energy Agency (IEA 2008) provides estimates of all emissions (excluding CO_2 emissions from biomass decay and peat) on which the IPCC draws, and has provided updated estimates for 2005. Other non-Treasury estimates shown in the table include unpublished estimates prepared by the present authors for the Garnaut Review (Garnaut et al. 2008).

Table 1: Estimates of global greenhouse gas emissions, 2005 (Gt CO_2-e)

	IPCC AR4[1]	**IEA**	**Treasury**	**Garnaut et al.**	**CSES**
			(Gt CO_2-e)		
CO_2					
Energy use					
Fuel combustion (including fugitive emissions)	27.7	27.3	27.0	26.7	27.3
Industrial processes and waste	1.4	1.3	1.2	1.0	1.3
Land use and forestry	3.8	3.3	2.8	3.5	3.5
Total CO_2 *(excluding biomass and peat)*					
CH_4	7.0	6.8	5.3	6.6	7.1
N_2O	3.9	3.9	2.4	3.3	4.1
Other Kyoto gases	0.5	0.8	0.4	na	0.8
Total (ex biomass and peat)	44.3	43.4	39.1	41.1	44.1
CO_2 biomass decay and peat	4.7	na		4.0	4.0
Total emissions	49.0	na	39.1	45.1[2]	48.1

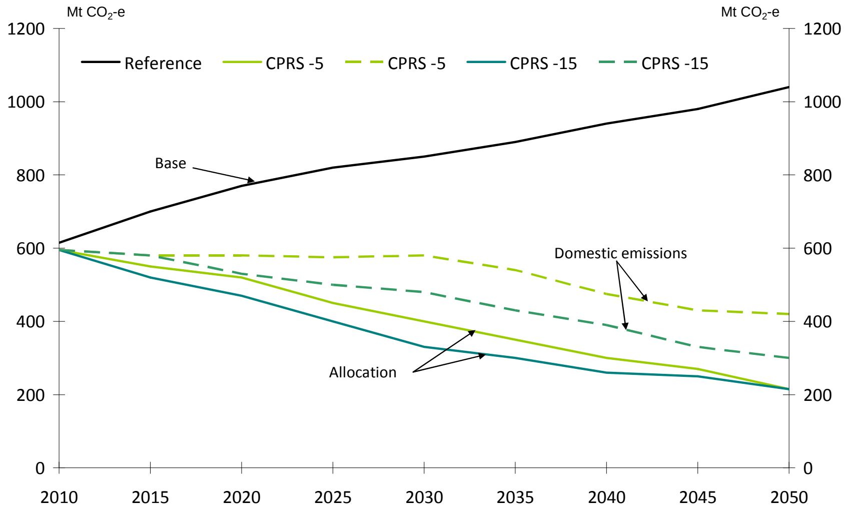
Notes: 1. For 2004. 2. Excludes other Kyoto gases.
Sources: IPCC (2007), IEA (2008), Treasury (2008), Garnaut et al. (2008) and unpublished estimates of the authors prepared for the Garnaut Review.

While there remains considerable uncertainty about total global emissions, Table 1 suggests that the best available estimates of all emissions excluding CO_2 emissions from biomass decay and peat are in the region of 43-44 Gt CO_2-e. With CO_2 emissions from biomass decay and peat put at 4-5 Gt CO_2-e, the best estimate of total global greenhouse gas emissions in 2005 is 47-49 Gt CO_2-e. By comparisons, and for reasons that remain unclear in the document, the Treasury base figure for 2005 is 39.1 Gt CO_2-e. The best estimate range is 20-25% higher than this figure, with the IPCC figure for 2004 25% above the Treasury figure for 2005.

This underestimation of the base emissions level in the Treasury modelling has many important ramifications. A particular atmospheric concentration level for greenhouse gases is related to the total historical stock of emissions and other factors (such as decay and absorption rates). This means that if the underlying path of emissions is higher than projected then the reductions that must be made relative to that path, by all countries, to achieve a given concentration level (say 550 ppm CO_2-e) will be larger than anticipated. Not only does this mean that Australia will probably be required to accept a greater reduction in its emissions allocation than currently planned, but it also implies that global carbon prices will be higher than modelled for a given concentration target, as countries are required to achieve more rigorous reductions.

For this and other reasons it is unlikely that Australia will be able to achieve all of the actual reduction in its emissions allocation by purchasing overseas permits, as is implied by the Treasury modelling of the CPRS-5 case (Figure 3). Australia is likely to be under great pressure to adopt a stronger target, at least the CPRS-15 case of a 15% reduction by 2020, and to achieve much of this by a reduction in absolute emissions levels domestically.

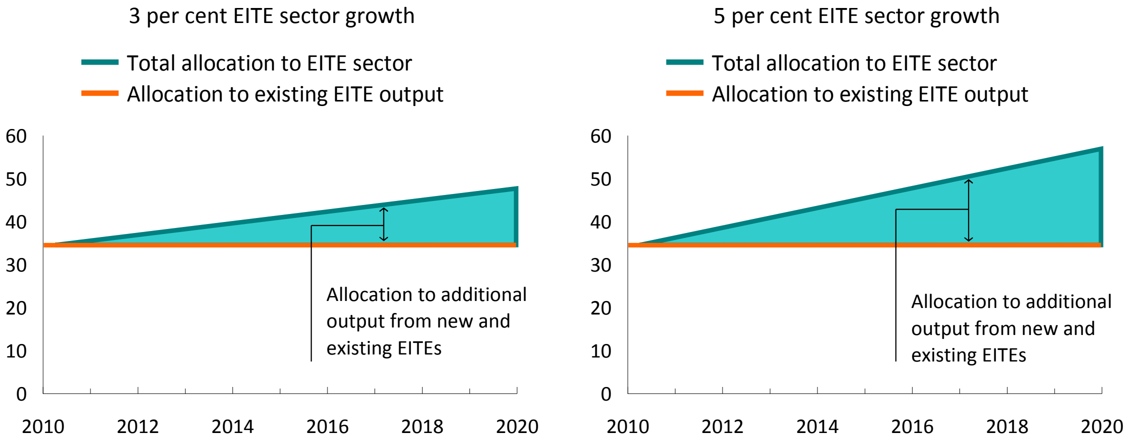
Figure 3: Australian emissions: Reference case and two scenarios, domestic emissions and emissions allocation, 2005-2050 (Gt CO_2-e)



Source: Adapted from Treasury (2008).

The third relevant consideration arises from the arrangements proposed in the White Paper to assist EITE industries, which are much more generous than those included in the Treasury modelling. Figure 4, taken from the White Paper, shows the rising share of permits allocated to the EITE sector (including agriculture, and assuming as the White Paper does that agriculture is admitted to the EITE scheme) on two assumptions about the average annual growth of these industries (3% and 5%, where 5% is the maximum growth rate for which free permit allocation will be provided from this scheme). The chart uses the White Paper specification of a 1.3% per annum carbon productivity contribution, so that entitlement to free permits per unit of EITE output falls by 1.3% per annum. (The Treasury modelling assumed that assistance per unit of output fell by 3% per annum, which would reduce the impact of the scheme significantly.)

Figure 4: Share of permits allocated to the EITE sector, for different growth rates (per cent)



Source: Reproduced from DCC (2008).

One implication of such a generous EITE scheme is that an increasing share of Australia’s emissions allocation is given to these industries over time, with the extent of that increasing share depending on the growth rate of these industries and of Australia’s final target for emissions in 2020. As shown in Table 2, if the EITE industries grow at 3% per annum over 2010-20 and Australia’s target is for a 5% reduction in emissions by 2020 relative to 2000, the allocation for all other industries falls by 29.4% between 2010 and 2020, an annual reduction of 3.4% per annum. If the EITE growth rate is 5% per annum and the target is for a 15% reduction the fall in the allocation for all other industries is 57%, or 8% per annum over 2010-20, which would constitute a very difficult challenge.

Table 2: Implied change in emissions allocations for non-EITE industries, 2010-20, for given emissions reduction targets and ETIE industry growth rates (per cent)

	5% reduction target		15% reduction target	
Growth rate of EITE industries	**3%**	**5%**	**3%**	**5%**
	Change in allocation in 2020 relative to 2010 (%)			
Total allocation	-12.8	-12.8	-22.0	-22.0
Free permits for EITE industries	18.1	43.2	18.1	43.2
Allocation for other industries	-29.4	-42.9	-43.5	-57.0

Source: Estimates of the authors based on DCC (2008).

2.4. A Major Transport Response is Required

These three factors – the underestimation of the current level of global emissions, the difficulties in shifting virtually all of the absolute reduction in Australia’s emissions up to 2030 offshore and the profound implications of the EITE scheme for other industries – imply that large scale reductions in domestic non-EITE emissions will be required in Australia over the decade to 2020. Even allowing for some cushioning of the domestic adjustment process by purchase of permits overseas, reductions of 20%-40% in non-ETIE emissions are likely to be required over the decade to 2020 if the EITE scheme remains unchanged.

In such a situation the benign world of Figure 1, in which transport emissions effectively continue on a business as usual basis until 2020 and are about 40% higher than 2000 levels in 2030, will no longer apply. On a full life cycle basis transport contributes about 27% of non-ETIE emissions. If non-ETIE emissions are to fall by 20%-40% over 2010-20 substantial efforts will need to be made to reduce transport emissions, not only relative to the business as usual case but in due course in absolute terms.

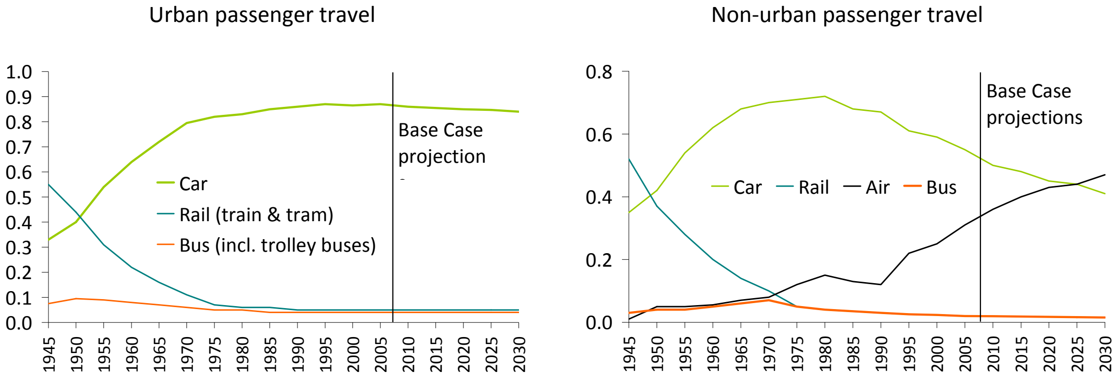
This report addresses the steps that need to be taken to reduce transport emissions, and on the costs and benefits of those steps, but focusing only on those related to rail. That is, the emphasis in on achieving a reduced emissions intensity of rail transport and particularly on achieving lower emissions (and other benefits) through a sustained modal shift to an enhanced, low pollution rail transport system. This is not to deny the great importance also of further steps to reduce the emissions intensity of road transport.

3. Modal Shifts in Australian Transport: Past and Future

If a significant reduction in transport emissions, even relative to business as usual, is to be achieved this will require steps to reduce the emissions intensity of all transport modes – road, rail, sea and air – as well as a sharp modal shift from road to rail transport. Substantial improvement in the emissions intensity of road transport, over and above that likely to be driven by the price mechanisms of CPRS, is both necessary and achievable. But this is beyond the scope of this report, which is focused on rail, as noted above.

The first four decades after the Second World War saw the rise of the car and the truck reshape Australia's transport patterns. Between 1945 and 1985 the rail share of both urban and non-urban passenger kilometres fell sharply and continuously, from over 50% to about 5%, and remained close to that level in 2005 (Figure 5). The BITRE business as usual projections shown in the figure envisage that over 80% of urban passenger kilometres will be travelled by car through to 2030, while the share of rail in non-urban passenger journeys will decline further, with air travel ultimately becoming the dominant mode.

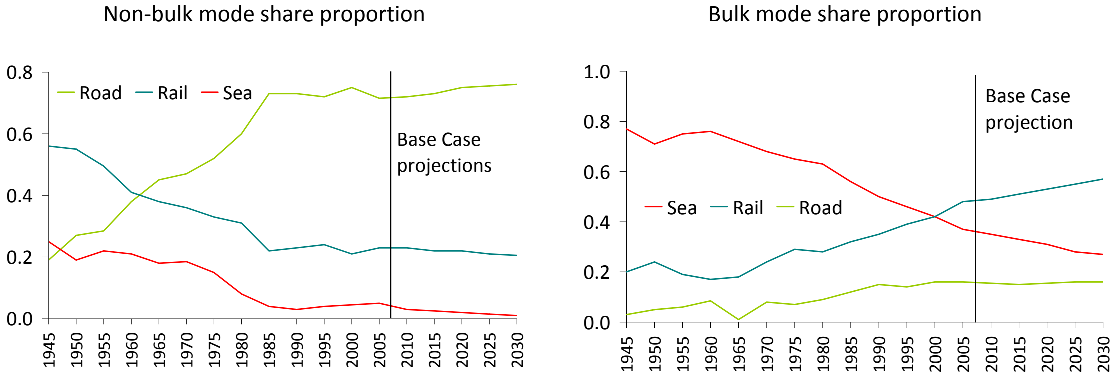
Figure 5: Modal share, Australian passenger travel (proportion of passenger kms)



Note: Urban passenger travel has' Other road' and 'Ferries' not shown. Non-urban passenger travel has 'Other' not shown. Each of these items is small.
Source: Adapted from Cosgrove (2008).

Over the same period the rail share of non-bulk domestic freight traffic fell from 56% to 22%, and was at about that level in 2005, with the BITRE projecting a further small decline to 2030. Only in the bulk freight area did the rail share rise (from 20% to nearly 50%), as new dedicated rail lines were built to take coal, iron ore and other commodities to port, and this trend is projected to continue. Outside the bulk freight area, this shift from road to rail has been supported by massive public investment in road networks over the postwar period, while rail systems were allowed to deteriorate over most of the country.

Figure 6: Modal share, Australian domestic freight


Non-bulk mode share proportion

Bulk mode share proportion

Note: Non-bulk domestic freight has ‘Air’ not shown.
Source: Adapted from Cosgrove (2008).

Recent years have seen some signs of renewal in the position of rail – passenger demand has risen strongly in some major cities; new rail investment has been undertaken in Queensland and Western Australia, and foreshadowed elsewhere; rail has captured a high share of non-bulk freight traffic on some long haul routes, such as Melbourne-Perth. But if transport is to contribute its share to meeting Australia’s emissions challenge much more will be required, involving a sharp reversal of the historical trend and a substantial modal shift to rail, in both the passenger and the freight areas.

4. The Economic, Social and Environmental Advantages of Rail

In spite of the dominance of road transport in Australia and in many other countries, there is substantial evidence that rail is, in many circumstances, the transport mode with the lowest full economic cost, as well as having much lower social and environmental costs. By ‘economic cost’ we mean the full financial cost of a given transport mode, measured in the relevant units (such as cents per net tonne kilometre or per passenger kilometre), excluding social or environmental costs. We also speak of social costs rather than externalities, and hence do not consider the extent to which the social costs of a given transport mode are borne by the user (that is are internalised) or borne by society as a whole (that is, constitute an externality).

4.1. The Economic Costs of Freight Movement

For most of the freight tasks currently undertaken by rail, in the movement of bulk goods, rail is so significantly cheaper than road that there is almost no competition. Bulk goods currently represent 84% of the rail freight task and that share is rising, so issues of relative cost are not further considered here. For the remaining freight traffic, in the non-bulk market, the main difficulty is to get estimates of full economic costs on a comparable basis, preferably on a door to door basis.

Table 3 summarises the cost data available from BITRE, which shows that the average rail freight cost per net tonne kilometre (tkm) from terminal to terminal is much lower than that of road (and very much lower than air) on a door to door basis. True comparisons will clearly depend on the costs, to be added to the rail figure, for the pick up and delivery cost of door to door service. These additional costs are influenced by many factors, such as the pickup and destination markets, the nature of the freight and the scale and efficiency of the freight terminal and delivery process.

Table 3: Unit prices for non-bulk freight, various bases (c/ntkm)

	Air	Road	Rail	Shipping (Perth)
2000–01	111.73	5.66	2.75	2.08
2001–02	117.15	5.72	2.81	2.15
2002–03	121.63	5.93	2.90	2.21
2003–04	126.19	6.04	2.99	2.30
2004–05	131.48	6.58	3.10	2.37
2005–06	135.39	6.98	3.24	2.22
2006–07	136.35	7.10	3.41	2.45
2007-08	135.88	7.53	3.52	2.80

Notes: c/ntkm = cents per net tonne kilometre.
The basis of the rates is: AIR door to door; SHIPPING FCL wharf to wharf; ROAD FCL door to door; RAIL FCL terminal to terminal (i.e. excludes pick-up and delivery).
Source: BITRE (2008a).

A full costing of rail compared with road freight was conducted by Port Jackson Partners (2005), and the results are shown in Table 4. These figures indicate that rail is less than half the cost of road for the East West corridor, where it has about an 80% market share. However, at current efficiency levels it is more than the cost of road freight for the North South corridor. Port Jackson Partners identify a set of initiatives, both of a capital and operating nature, which could reduce its cost to below that of road. Many of these have subsequently been proposed by the ARTC and some are in the process of being implemented (ARTC 2008).

Table 4: Total cost comparison: Road and rail freight, 2004 (cents per ntk)

	Road	Rail (current)	Rail (reduced)
Sydney – Brisbane	6.4	6.6	4.3
Melbourne – Sydney	6.0	6.9	5.5
Melbourne – Brisbane	5.8	5.9	3.8
Melbourne – Adelaide	6.6	3.8	3.8
Adelaide – Perth	6.3	2.6	2.6
Melbourne – Perth	6.1	2.8	2.8
Sydney – Perth	5.7	3.5	2.5

Source: Port Jackson Partners (2005).

The Port Jackson Partners estimates demonstrate that rail would become quite competitive commercially on the various North South routes, and unit costs might be expected to fall significantly if the market share of rail increased substantially and other operationally efficiencies were made. Perhaps more importantly, the figures demonstrate that the total transport cost is significantly lower for efficient rail than road transport on all intercity corridors.

In the body of this study we examine the likely implications of a more wide-ranging set of investments in rail modernisation and expansion than are considered in the Port Jackson study. For our modelling we assume that, subsequent to that investment being undertaken, by 2020 the average full cost of rail freight (door-to-door) is 2.5 cents per ntk lower than for road freight.

4.2. The Economic Costs of Passenger Transport

Travel by car is the overwhelmingly dominant mode for passenger transport for all capital cities, ranging from 90.7% in Adelaide to 82.2% in Sydney. Rail/light rail accounts for only 1% of passenger kilometres in Adelaide and about 9% in Sydney, as shown in Table 5. Nonetheless this may be beginning to change with rail passenger growth of around 10% per annum being experienced in a number of capital cities over the last few years.

Table 5: Travel by mode, 2003/04

Mode	Sydney	Melbourne	Brisbane	Adelaide	Perth
			Proportion by mode		
Car	82.2%	88.4%	85.6%	90.7%	86.9%
Rail/Light rail	8.9%	5.8%	4.5%	1.1%	2.9%
Total public transport	13.3%	8.0%	8.3%	5.3%	7.2%

Source: BITRE (2008b). No consistent data beyond 2003-04 are currently available.

Although the cost of public transport is subsidised to a level below the cost of car travel, it tends to cater best for peak hour travel to the CBD and the car provides superior amenity for many trips in a dispersed suburban or country environment. A comparison of the estimated full costs of both providing public transport, average fare revenue and the full financial cost of car travel is given in Table 6.

Table 6: Estimated travel costs, train and car (A$ per pkm and A$ per vkm)

	Sydney	Melbourne	Brisbane	Adelaide	Perth
			(A$ per passenger km)		
Train (system cost)	0.45	0.41	0.48	0.66	0.63
Average train fare revenue per passenger km	0.11	0.12	0.28	-	0.04
			(A$ per vehicle km)		
Car (a)	0.67 (b)	0.71	0.72	0.71	0.72

Notes: (a) Full private costs. (b) 2007 data. Other capital cities 2008.

Source: State motoring organisations, state transport authority and departmental annual reports, state budget papers and BTRE (2008b).

These estimates indicates that the full cost of providing rail public transport ranges from a low of about 41 cents per passenger km in Melbourne and 45 cents in Sydney to over 60 cents in Adelaide and Perth, indicating again that scale and occupancy levels significantly affect unit cost levels. Average fare revenue ranges from 28 cents per passenger km in Brisbane to only 4 cents for the newly extended, but highly subsidised Perth urban train system. Table 6 also shows the available estimates of the full private cost of travel by car, expressed in A$ per vehicle km. Data on average car occupancy is limited, and occupancy rates probably vary between cities, but the available data suggest average car occupancy is about 1.4-1.5 persons per vehicle (Ironmonger 2008; Transport Data Centre 2008). Using an average occupancy rate of 1.4, car costs consistent with Table 6 are about A$0.50 per passenger km, 10-20% higher than those in Melbourne and Sydney but lower than those for Adelaide and Perth. Further information on this issue is provided in Paper 5.

There are good reasons for thinking that passenger road costs per pkm may rise relative to those of rail over the next decade, in a context of carbon pricing, higher fuel costs and increasing urban congestion. For the modelling we take a conservative assumption, that by 2020 average rail costs per passenger kilometre are 10% lower than the equivalent average cost for cars. It should be noted that, whereas extensive research has been conducted on the social costs of different transport modes, only limited information is available about the full economic costs of the two modes. Given the importance of an understanding of the full economic costs of road and rail transport modes, further research in this area would be valuable.

4.3. The Social and Environmental Costs of Transport Modes

As just noted, there has been extensive research, both in Australia and overseas, on the social and environmental costs of different transport modes, and these estimates are reviewed in Paper 2 prepared for this report. The main costs included in our estimates are accidents, noise, air pollution and GHG emissions. There has been substantial debate about whether social costs arise from congestion affects and, if so, how such costs should be calculated. In our view there is no doubt that bona fide social costs arise from increased traffic congestion, but in the light of the lack of agreement about both principles and methods they are not included in this study. Our preferred working estimates of the extent of such social costs, which are summarised in Tables 7 and 8 and illustrated in Figure 7, do not include congestion costs.

Table 7: Social and environmental costs of passenger travel ($A/1000 passenger km)

	Road by vehicle type				Rail	Aviation	Overall
	Car	**Bus**	**Motor cycle**	**Road total**			
Accidents	60.3	4.7	367.8	63.2	1.6	0.8	43.5
Noise	10.1	2.5	31.2	10.0	7.6	3.5	8.2
Air pollution	24.8	40.4	7.4	25.7	13.5	4.7	19.5
Climate change	4.9	2.3	3.3	4.7	1.8	12.9	6.6
Other (ex congestion)	18.9	9.8	12.1	17.8	10.3	3.5	13.7
Total	119.0	59.7	421.8	121.3	34.7	25.4	91.5

Note: 2008 Australian prices @ 1 euro =$A1.7 and CPI 1.147 from June 2000 to June 2004.
Source: Infras/IWW (2004).

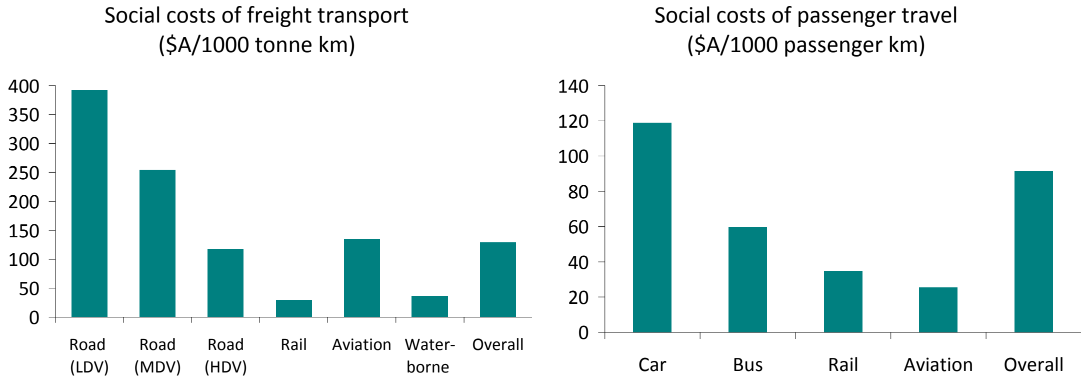
Table 8: Social and environmental costs of freight transport ($A/1000 tonne km)

	Road by vehicle type				Rail	Aviation	Water borne	Overall
	LDV	MDV	HDV	Road total				
Accidents	68.3	38.8	9.4	14.8	0.0	0.0	0.0	12.7
Noise	63.2	36.4	9.6	14.4	6.2	17.4	0.0	13.9
Air pollution	169.5	122.1	74.7	83.5	16.2	30.4	27.5	75.1
Climate change	16.0	9.8	3.5	4.7	1.0	65.7	1.2	4.7
Other	75.1	47.8	20.5	25.8	6.3	21.8	8.0	23.2
Total	392.0	254.8	117.6	143.1	29.6	135.3	36.7	129.5

Note: 2008 Australian prices @ 1 euro = A$1.7 and CPI 1.147 from June 2000 to June 2004.
Source: Infras/IWW (2004).

One feature of all estimates of social and environmental costs (which here include an estimate of the cost of emissions, using A$50 per ton of CO_2-e, the 2020 estimate of the carbon price in the Treasury modelling of the CPRS-5 scenario) are that they are much higher for road than for rail. For passenger travel (Table 7) social and environmental costs so defined are estimated at about A$90 per thousand passenger kilometres. Average social costs for rail passenger transport are about 30% of both the figure for cars and for all road transport.

Figure 7: Social costs of freight transport and passenger travel



Notes: LDV = Light duty vehicle. MDV = Medium duty vehicle. HDV = Heavy duty vehicle.
Source: Infras/IWW (2004).

The picture is similar, and indeed somewhat more striking, for freight transport. Overall, the social costs of freight transport are estimated at about A$130 per thousand tonne kilometres. The unit social cost figure for rail, of about A$30, is 23% of the unit social cost for all freight, about one fifth of the figure for all road freight and about one quarter of that for large trucks, the road mode with which rail freight is most directly competitive. Overall the total social and environmental costs of transport in Australia are estimated at A$52 billion or **5.6**% of GDP in 2005, before including congestion costs, of which rail contributes only about 9%.

5. The Role of Electrification and Renewable Energy

Rail is typically a more energy efficient form of transport per unit than road, with lower energy use per passenger kilometre or per tonne kilometre. As discussed in the supporting papers to this report, rail's energy intensity can be reduced further by a range of measures. But rail's current lower energy intensity means that even if, as in Australia, both road and rail are powered primarily by fossil fuels (that is, by petroleum or coal-based electricity) rail has a lower emissions intensity. But one of the advantages of rail is that it offers the possibility of virtually zero emissions transport, when rail transport consists of fully electrified rail powered by electricity generated from renewable sources. In France, for example, about 80% of electricity is generated from renewable sources and there is a nationwide grid of electrified rail transport, with an official objective of complete electrification within 20 years. This provides France with an efficient, low emissions component of its overall transport system. Here we examine some of the issues concerning the possible future role of low-emissions rail transport in the Australian transport system.

5.1. Cleaner Rail with the Existing Fuel Mix

Current trends in both passenger and freight vehicles show that a major thrust of the future development effort will be to make vehicles lighter and increase the usable volume. In addition to the obvious measures of exploiting new materials and manufacturing processes, together with intelligent use of the payload space, a major contribution can be made by improvements to the suspension and drive. The suspension and drive will become more compact and lighter, provide good ride quality with lighter car bodies, cope with larger variations of tare to laden mass, and maximise the use of structural clearance gauge.

Other likely initiatives include improvements to vehicle/track interaction, more powerful and energy efficient diesel engines and electric motors, more effective power converters, and the introduction of regenerative braking as a means of supplementing the supply of electricity from on-board generators. Train Protection and Control Systems (TPC) will be one of the most important initiatives. Improving traffic control of trains can increase infrastructure network capacity by allowing more trains to run on the tracks without compromising safety, and reduce fuel usage through trains not being required to stop as frequently.

The pace of implementation of this technological change in railway rolling stock is fairly slow, because railway rolling stock has a long life. Also, Australian railway rolling stock needs to be custom built to make it smaller and lighter due to limitations in the Australian rail network. This limits the adoption of new technology, increases its costs and significantly delays the implementation of existing more efficient technology. However with the correct policy settings this range of both emerging and existing rail technologies could be brought forward to substantially reduce energy use, and hence greenhouse gas emissions for a given fuel mix, and also reduce costs, increase speed and achieve greater reliability. Available estimates suggest that for freight a combination of improved load factors, energy efficiency and operational improvements could reduce greenhouse gas emissions per tkm by 25% by 2020, and reduce emissions per pkm in passenger rail by up to 40%.

5.2. The Competitive Position of Electrified Rail

Operational advantages. One advantage of electrification is greater tractive power output. Electric locomotives can deliver as much as 2½ times the tractive power output of an equivalent diesel. Electric traction is particularly efficient for ascending gradient, and can generally provide faster acceleration than that of trains using diesel power. Electric traction also means it is possible to further increase efficiency through regenerative braking. In general, electric trains are simpler and cheaper to maintain. For passengers, the advantages of electric traction include less vibration and smoother, quieter journeys.

Local environment benefits but increased accident rates. Electric trains are environmentally cleaner than diesel, especially at fully enclosed stations, where complex waste extractions systems need to be installed for diesel engines. Taking into account life cycle analysis, electric traction also has the advantages of almost completely eliminating emissions of carbon monoxide and hydrocarbon particles, and has a smaller impact via noise levels. But there is also a higher accident risk, arising from the live power line.

Lower fuel and other operating costs, but high capital costs. In principle, as oil prices rise and the cost of carbon comes to be fully reflected in fuel costs, electric rail offers significant savings in fuel and other operating costs. For some freight applications the benefit of lower fuel costs could be increased as a result of time-of-day pricing through the electricity grid. In such applications much of the traffic can take place overnight, in periods of low electricity demand and hence low electricity prices.

But the capital costs are high. The cost of electrifying existing lines is high, although costs vary markedly with conditions and whether what is involved is a greenfield project or the electrification of an existing line. A 2007 report by the UK Rail Safety and Standards Board (RSSB 2007) found that the cost to electrify an existing route was £550,000 to £650,000 (A$1.2-1.4 million) per single track kilometre, but higher estimates have been cited in Australia. Electric locomotives are more expensive than diesel ones, but in some case there can be savings in capital costs, as fewer electric locomotives may be needed to pull a given volume of freight.

Lower greenhouse gas emissions. Electric traction can generate lower greenhouse gas emissions than diesel traction, in many contexts, even when electricity is generated from coal. If an electrified passenger service carries a passenger load near to optimal levels, its energy efficiency will be significantly higher than for cars or diesel rail services.

Importance of market size and network issues. Given the scale of the capital infrastructure costs, electrification requires significant traffic volumes if these costs are to be recouped. In addition there are important network coordination issues, so that operators may need incentives to switch to electric locomotives and uniform electrification standards are also necessary. Thus electrification needs to be applied to whole, coherent network segments in a coordinated way, and cannot be adopted piecemeal.

5.3. The Existing Pattern of Electrification in Australia

At the present time rail systems in all of the major cities are electrified, but only in Queensland are there major electrified routes in non-urban areas. Queensland Rail has about 1000 kilometres of electrified track, including the line from Brisbane to Rockhampton and the coal routes of central

Queensland. The major new electrified passenger line in recent years has been the Perth to Mandurah railway, and some extensions to electrified lines are planned for Melbourne. Both Victoria and NSW have withdrawn electric locomotives from regional lines over the past two decades. In both cases this seemed to reflect problems with incorporating electric locomotives into a predominantly diesel network, together with low fuel costs at the time of the decision.

5.4. The Role of Renewables in Powering Rail

Two factors influence the potential for the use of renewable energy sources to power rail. One is the fact that rail demand for electricity is intermittent over the full 24 hours of any day and the other is that it is often located in remote or regional areas. This means that power must normally be provided through a grid, although stand-alone generation systems may be viable for large, remote rail networks if the time-of-day issues can be addressed (e.g. by combined systems involving solar and gas power). It would also be possible for dedicated renewable power systems to be connected to the grid, and hence both buy from and sell to the grid. Another approach to ensuring that electricity used by electrified railways is effectively renewable is to purchase Green Power or Renewable Energy Certificates. Green Power is nationally accredited to ensure that electricity accredited by Green Power is renewable and beyond business as usual.

5.5. Options for Further Examination

Four options to increase the use of low-emissions electrified rail in the Australian transport system seem worthy of further analysis.

The ARTC track. Considerable work is underway to upgrade the ARTC track, and this has been supported by a A$1.2 billion injection of equity into the ARTC under the Government's Nation Building announcement on 12 December 2008. Given the network issues involved, the case for including electrification in the rebuilding process should be given urgent consideration. Time-of-day pricing could offer substantial cost savings to operators (and returns to the ARTC), while electrified track and some renewable power generation to feed into the grid could offer substantial benefits to regional communities.

The Pilbara mining network. Given the likely future cost of diesel fuel, including the cost of carbon, there may be a case for electrifying this 1000 km railway and powering it by gas or gas/renewable energy sources. While this would be primarily a commercial decision, it may be influenced by appropriate public policy settings.

Urban rail systems. Rapid rail passenger growth is occurring in many Australian cities, in part because many are looking for cleaner methods of travel. This advantage of rail could be enhanced if operators purchased Renewable Energy Certificates to ensure that urban rail was low emissions. Such action could assist the renewables industry in the State in question.

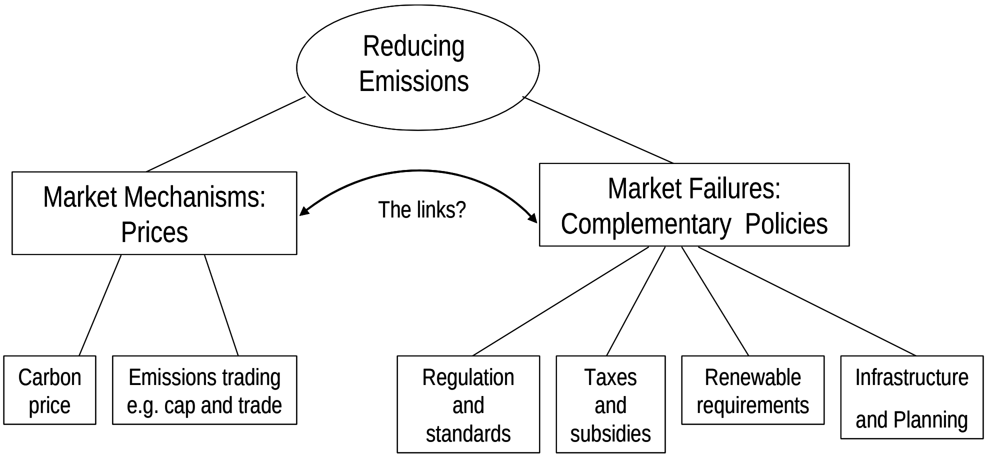
The Queensland rail network. QR has led the way in electrification in recent years, and the issue of reducing the emissions intensity of the power used in that network is now an important one.

6. Climate Policies, Transport and Growth

6.1. Two Approaches to Climate Policy: Prices and Complementary Measures

In the debate about climate policy, as in other areas of economic and social change, there are within a market-based approach two main streams of policy: prices and complementary policies, where by a complementary policy we simply mean a policy designed to influence patterns of energy use or to reduce emissions other than through price mechanisms. This would include policies to promote the development of renewable energy and to encourage a modal shift from road to rail transport by non-price means. As illustrated in Figure 8, prices are an effective instrument to the extent to which markets work effectively. To the extent that markets fail, then complementary policies are necessary to achieve the best outcomes.

Figure 8: Policy options for reducing emissions: Prices and complementary policies



This is a critical issue for climate policy and emissions trading. Many economists argue that if an emissions trading scheme is established there is no place for such policies, and hence that the role of complementary policies is limited in the CPRS. This is an important issue in the case of transport for, as we have seen, the medium term impact of carbon prices on transport emissions will be limited, and a sharper reduction in emissions is likely to require complementary policies in transport, such as infrastructure and other spending, to support a modal shift.

This report argues the contrary case, that complementary policies are necessary to facilitate the most efficient adjustment to a lower emissions path, and to achieve a given reduction in emissions at least cost and with the lowest carbon prices. Some of the various types of market failure involved and of their relevance to emissions reductions, especially in transport, are reviewed below. These issues are further discussed in Paper 4.

6.2. Relevant Types of Market Failure

In a fully competitive market, individual utility or profit maximising agents take decisions on the basis of price, in the face of demand and supply functions, that clear markets and which generate outcomes that are individually and socially optimal. Market failures occur when these results cannot be achieved – that is, prices do not clear markets and/or the outcomes are not both individually and socially optimal. Four types of market failure are most important in the current context:

(i) *Externalities:* An externality occurs when the costs or benefits of an action are not fully borne by, or cannot be fully appropriated by, the agent concerned. One classic type of externality arises from public goods (goods which are non-rival and non-excludable) such as clean air – if one person uses the air this does not stop others from doing so, and it is difficult to stop others making use of the clean air. One response to externalities is to internalise the costs or benefits, so these costs are borne, or the benefits accrue to, the agent undertaking the activity in question. Emissions trading is an attempt to internalise the external costs of greenhouse gas emissions, by setting a carbon price and making those who produce the emissions bear the cost.

(ii) *Sunk costs*: A sunk cost is a non-operational expenditure that has been made and cannot be recovered, even if the firm goes out of business. Examples of sunk costs include spending on product innovation or R&D or on fixed assets which have no value outside of their current use (such as railway track or locomotives). Sunk costs are rife in the transport and energy area. For example, much of the spending on tracks, customised vehicles and power stations is sunk, and the assets have little value other than in their current use.

When one participant in a market needs to incur a (new) sunk cost that other participants do not need to incur there will be a market failure – the market clearing price may be well above the marginal costs of the existing producers without being sufficient to induce new entry. In such a situation a significant increase in price might occur without generating any new entry, or any increase in supply. Sunk costs are also relevant to consumer purchase decisions. If an individual already has an (inefficient) car, the market value of which is low so the costs are largely sunk, then even in the face of sharply rising fuel prices she may be reluctant to incur the new sunk costs of purchasing a more fuel efficient vehicle.

(iii) *Coordination failures*: Coordination failures occur when the decisions of agents, or their activities in separate markets, are interdependent and some factors hinder the coordination of these decisions or activities. In the theory of free markets the agents are independent of one another, but when they are in fact interdependent and the coordination of their activities fails then price adjustment through markets may generate less than optimal outcomes.

Interdependence between agents and markets is central to the energy and transport industries, and hence there is a good deal of scope for coordination failures. For example, alternative energy supplies can only be added to the grid (and hence supplied to the national energy market) if adequate distribution infrastructure is available; freight operators can shift from road to rail only if rail track and facilities (such as intermodal exchanges) are available, and consumers can shift from road to rail for the journey to work only if there is a train line in their area. Sunk costs can also exacerbate problems of coordination. For example, if there are sunk costs in the electricity distribution industry these may inhibit the provision of the new distribution infrastructure necessary to facilitate the operation of the energy market in the face of a carbon price.

(iv) *Information asymmetries and principal-agent problems*: These market failures occur when participants in markets have access to different levels of information or when a principal is represented in a transaction by an agent, who may have different information or objectives than the principal or may face different incentives.

6.3. The Key Role of Complementary Measures

As is evident above, the transport system is riddled with market failures, especially those of the first three types – externalities, sunk costs and coordination failures. Some of these have been illustrated in the brief discussion above. Some of the social and environment costs of road transport, studied in Section 4 above, are internalised through taxes and charges, but many are not. For example, it is widely acknowledged that the full costs incurred by large, heavy haulage trucks are not fully passed on to users. Many of the key assets involved in transport, such as rail track, locomotives, signalling and other systems and R&D to create relevant know-how, involve sunk costs. This means that market mechanisms driven by prices alone are unlikely to provide sufficient incentive to generate the optimum level of investment in these assets. As, as noted above, coordination failures can be particularly acute in transport generally, and in rail transport in particular, hence limiting the level of investment in any particular component of the system unless these failures are addressed.

In some instances the specific design of the CPRS will exacerbate existing market failures in the transport system. For example, when a traveller has to choose between using his or her car or taking the train, most of the costs of travelling by car are sunk, and the only marginal cost is the fuel cost, which is compared to the train ticket cost. In the initial years of the CPRS road fuel costs will be held unchanged but railway costs will rise, worsening the impact of this market failure.

The presence of such pervasive market failures means that prices will have only a limited role in facilitating structural change and reduced emissions in transport. If such failures are not addressed the carbon price will be higher than necessary for a given reduction in emissions and that a less than optimal set of emissions reductions will be chosen by the market. By contrast, substantial programs to eliminate market failures will both reduce the carbon price required and generate a more efficient response. Thus a carbon price is necessary but not sufficient to achieve an optimal outcome in the transport sector.

In analysing the impact of measures to reduce carbon emissions on the economy, the focus is often on the impact of relative prices within a given industry structure with defined production and investment functions. In such a context introducing a carbon price will inevitably reduce economic activity, as the existing low cost but polluting technologies are taxed and activity is shifted to higher cost but less polluting ones. But if the focus is on the role of complementary policies in creating new goods and industries through R&D, revitalised infrastructure and new investment, then action to reduce emissions may well be a source of growth.

This point is particularly important in the context of the global financial crisis and its aftermath, especially the sharp recession in the USA and some parts of Europe, and the inevitable impact of that on Australia and other countries. New or higher carbon prices alone may indeed tend to slow growth, but strong complementary policies may be growth enhancing, both by reducing the market-based carbon price and also by supporting investment in R&D, new infrastructure and plant and equipment. Thus many of the measures necessary to address key market failures would be strongly expansionary and could be a central part of an appropriate fiscal response to the current slowdown.

Achieving rapid change in transport thus requires strong but appropriate complementary policies, and such policies will both reduce the carbon price necessary for a given reductions in emissions and stimulate growth. An appropriate complementary policy is one that addresses an important market failure in a demonstrably cost-effective manner.

7. Current Issues in Australia’s Transport System

7.1. The Freight Sector

The freight sector is divided into two markets – bulk and non-bulk. As measured by tonne kilometres, bulk is most (84.4%) of the total task and in this task rail predominates. It consists of the transport of single products such as minerals and agricultural products. Rail enjoys a substantial cost advantage and undertakes most of the freight task. However, in some freight, such as grain and timber, road transport provides strong competition and has continued to gain market share over many years.

In discussions about rail freight the focus is on the remaining 15.6%, the non-bulk market, which is divided between general and containerised freight, and competes directly with road transport.

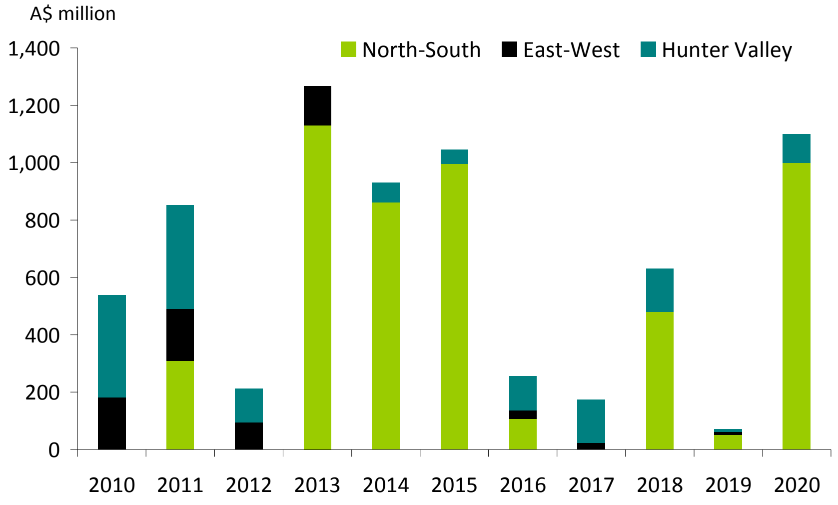
To achieve a modal shift to rail in the non-bulk market a number of issues of costs and reliability need to be addressed. As discussed above rail is generally cheaper on a ntkm basis, but not necessarily so once door to door delivery charges are added on. One means of helping to address this is to increase the efficiency of modal transfers through the establishment of specialist intermodal exchange terminals. Costs can also be reduced by double stacking, longer trains and better train management and communications systems.

Changing the rail network so that it can take USA standard rolling stock will allow greater rail productivity by increasing the payload of a train, allow the quick and cheaper acquisition of more energy efficient rolling stock and allowing the Australian rail industry to quickly capitalise on innovations in the large American rail market.

A second closely related issue is reliability. Freight trains can be subject to unscheduled hold-ups and delays. While better train management systems also help to improve reliability, addressing this issue requires significant infrastructure investment, particularly for the North-South corridor linking Melbourne, Sydney and Brisbane, of the sort outlined in the ARTC submission to Infrastructure Australia (ARTC 2008). The costs of the proposed rail system enhancements include A$4.9 billion to address the deficiencies of the North-South corridor. The proposed works include duplicating the Seymour – Tottenham line, increasing the capacity of the Sydney – Newcastle link and clearing the Melbourne – Sydney line for double stacking.

Expenditure on the proposed works is scheduled over a 10 year period as indicated in Figure 9. It shows however that many of the major works in the North-South corridor would not be completed until 2015.

Figure 9: Total cost of proposed ARTC enhancements by year of expenditure



Source: Authors estimates based on ARTC (2008).

Infrastructure Australia in its report to the Council of Australian Governments has listed these projects (Infrastructure Australia 2008, pp. 68-69), along with others for 'further analysis'. The Australian Government also announced in December 2008 that it would provide an added A$1.2 billion equity investment into the ARTC to help finance these projects (Australian Government 2008).

7.2. The Passenger Sector

Rail passenger travel has grown rapidly in recent years in most state capitals in response to recently increased petrol costs and growing road congestion. There has been large increase in patronage in Melbourne (10.0% in 2006/07 compared with 2005/06) and Brisbane (9.0%) and a more modest increase in Perth (5%). In Sydney, on the other hand, patronage growth has been constrained, apparently by capacity limitations, to an increase of only 2.8% for 2006/07.

Table 9: Travel by mode, 2003/04, passenger kilometres

Mode	Sydney	Melbourne	Brisbane	Adelaide	Perth
Passenger cars	47.83	46.53	19.11	13.34	16.73
Light commercial vehicles	2.37	1.73	1.17	0.52	1.04
Motor cycles	0.29	0.19	0.18	0.06	0.07
Rail	5.19	2.33	1.01	0.14	0.55
Light rail	0.02	0.75	n.a.	0.01	n.a.
Bus	2.38	1.12	0.83	0.62	0.84
Ferry	0.13	n.a.	0.01	n.a.	0.00
Total	58.20	52.65	22.31	14.70	19.24
Proportion by mode					
Car	82.2%	88.4%	85.6%	90.7%	86.9%
Rail/Light rail	8.9%	5.8%	4.5%	1.1%	2.9%
Total public transport	13.3%	8.0%	8.3%	5.3%	7.2%

Source: BITRE (2008b).

Most passenger travel in the State capitals however is undertaken by car. The proportion ranges from a high of 90.7% in Adelaide to a low of 82.2% in Sydney as shown in Table 9. The proportion of passenger kms by car in Melbourne is second only to Adelaide and almost as high in absolute terms to Sydney despite a somewhat smaller population. A significantly higher proportion of total passenger kms in Sydney are undertaken by train, 8.9 % in 2003/04 compared with only 4.4% and 4.5% respectively for Melbourne and Brisbane (BTRE 2008b).

The increase in projected patronage has resulted in state governments planning significant capacity increases, but implementation is often problematic. One example of planned increases in capacity is in Victoria. Following the recommendations of the East-West Link Needs Assessment (EWLNA), the Victorian Transport Plan[1] adopted a range of proposed initiatives to increase the capacity of the rail network, most notably a new 17km tunnel from Melbourne's west to south west estimated to cost more than A$4.5 billion. Analysis provided by the EWLNA demonstrated that based on even quite modest patronage growth and after the maximum possible timetabling and operational efficiencies, capacity on two groups of lines to the north and south would be exceeded by 2013 and 2019 respectively (EWLNA 2008, p. 81). A new tunnel would represent a step change in Melbourne's rail track network which had not been substantially increased since the 1980s. Significantly the tunnel was justified on forecast patronage growth rates of between only 2.1% p.a. and 6.6% p.a., significantly below the actual rate experienced since 2004 of 7.6% p.a. The lower range projections would result in a modest modal shift to public transport from 8% to 9% (EWLNA 2008, p. 77). Thus achieving a significant modal shift consistent with reducing greenhouse gas emissions would require a major investment in increased capacity.

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[1] See http://www4.transport.vic.gov.au/vtp/

Other States have undertaken passenger rail improvements or are planning to do so. Perth has recently opened network extensions including a 72km extension to Mandurah and introduced new rolling stock. Adelaide is planning to electrify its urban rail system. The NSW government committed to the extensive Clearways program, although progress has been slower than planned, but the Epping-Chatswood rail link has now opened. There are several rail projects occurring in South-East Queensland including rail networks extensions including the Gold Coast.

7.3. The Key Industry Players

Two national rail operators, Queensland Rail (QR) and Pacific National dominate rail freight. QR, while Queensland based, is becoming an integrated national carrier and has significant state government support. Pacific National, which is part of the Asciano Group, is a national train operator but is saddled with high debt levels following the split with Toll Holdings in 2007. SCT Logistics is a niche operator specialising in the Melbourne to Perth link. It has experienced very high rates of growth, over 20% per annum for the period 2002/03 to 2006/07.

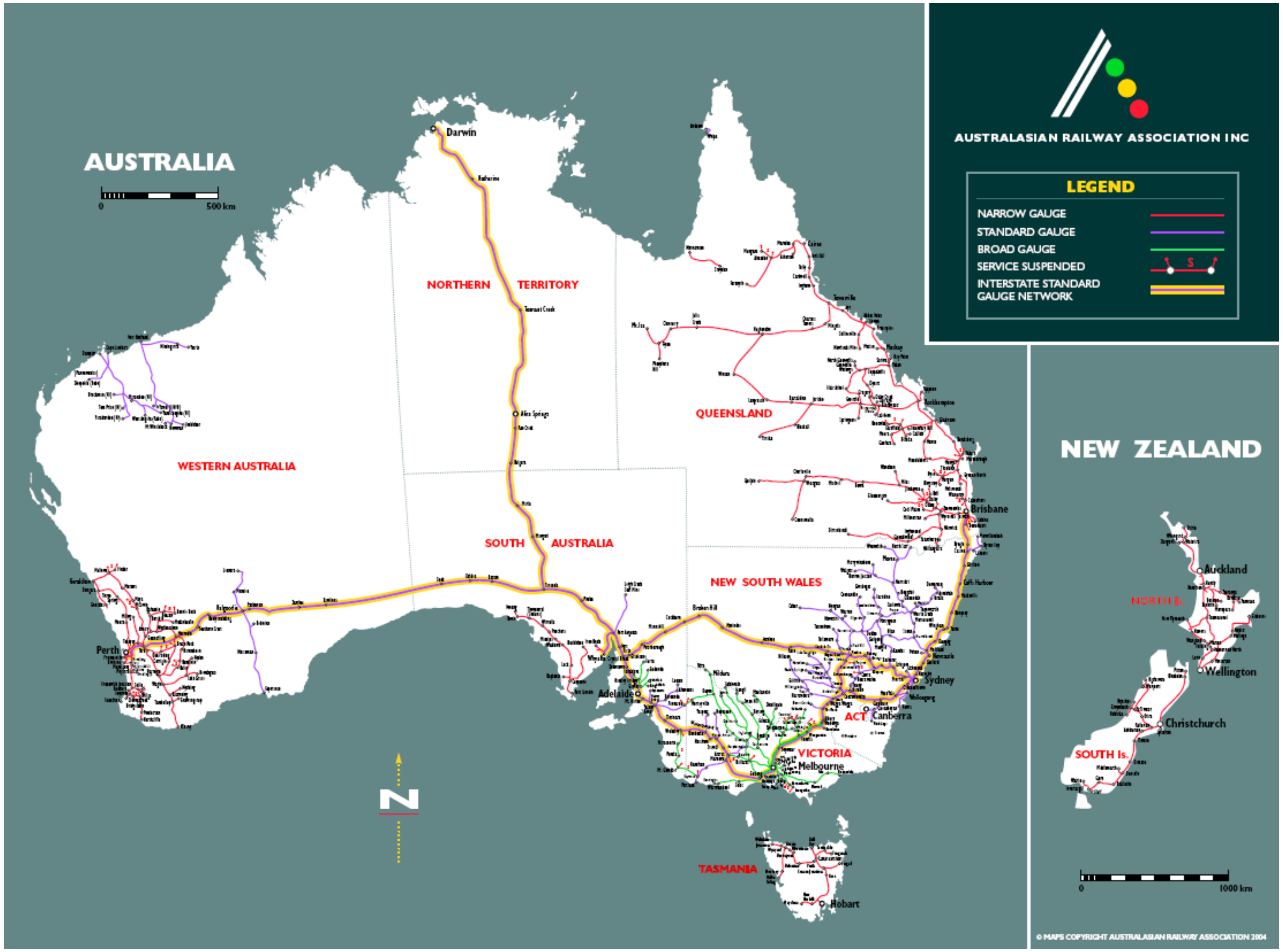
The other key participant is the Commonwealth owned, Australian Rail Track Corporation (ARTC). The Australian freight rail network is complex. It consists of an interstate standard gauge network and a number of independent state based regional networks each with different gauges as shown in Figure 10. The east coast regional links are each owned by their respective state authorities but a number of the others are privately owned.

The ARTC has integrated the key interstate rail links under its control and is now responsible for access and maintenance to the majority of the Defined Interstate Rail Network (DIRN) (the intercapital network) linking Brisbane to Perth.

However at a number of key locations access remains problematic for freight trains. Freight traffic passing through Sydney is accorded a lower priority than passenger traffic which can result in long delays. Also maintenance activity is sometimes poorly coordinated with train operators. Access to Brisbane along track owned by QR can also sometimes be subject to hold ups. QR is in the process of reorganising into separate companies for management of the network, operations and passenger rail which may help overcome these conflicts. However the east west link generally operates effectively with the added bonus that double stacking is possible from Adelaide to Perth

Other key rail participants are the rail track owners in Western Australia and in New South Wales. WestNet is the manager for the Western Australia network and is responsible for the Perth – Kalgoorlie section of the key Perth – Adelaide interstate route. This introduces another party with its own commercial, regulatory, planning and operating priorities, which means that total control and management of this key route is held by two parties.

Figure 10. Australian rail network



Source: Australasian Railway Association.

RailCorp, who own the network in Sydney, are primarily responsible for passenger train operations. This network is critically placed at the junction of key freight routes between Melbourne – Sydney, Sydney – Brisbane, Melbourne – Brisbane. Again, different priorities and procedures, political drivers and significant network congestion impact on the key interstate non-bulk freight routes and also impact on ARTC's ability to effectively manage the interstate corridors.

Toll Holdings is the largest road freight operator with about 6.8% of the market share. It has been growing rapidly (over 15% per annum). It is an acquisitive company and has been able expand into China and Singapore through strategic purchases. It provides complex logistics solutions for some of Australia's largest companies as part of its freight services. Linfox, the next largest road freight operator, remains a private company and less is known of its operations. However it also provides supply chain management services for its major customers.

Each of the states has adopted different structures to deliver public transport. Victoria is the only state to have adopted a partly privatised model for rail passenger travel. Detailed data about rail passenger travel is difficult to obtain. However both Queensland and Victoria provide reasonably disaggregated information. In Queensland after a number of years of zero increase in subsidy levels, the Queensland government increased its subsidy by 16.9% in 2006/07. Together with the higher fare revenue this increased the segment result for QR passenger operations from A$43.9 million in 2005/06 to A$91.8 million in 2006/07. This trend continued in 2007/08, when the segment result for passenger climbed to A$168.3 million, more than offsetting a loss of A$8.2 million in the freight segment.

Victoria adopted franchise arrangements for rail and train transport in 1999 and achieved a significant improvement in reliability and punctuality of its services. However after the failure of one of the operators the arrangements were renegotiated with the remaining operators in 2004. This introduced many changes sought by the operators while retaining the performance targets previously achieved. While increasing congestion has meant that penalty payments have been levied because of performance failures, offsetting some of the fare revenue gains, total payments to the operators have increased by 13.6% per annum for Connex and 8.6% per annum for Yarra Trams for the period 2004/04 to 2007/08. As illustrated by the QR result, the shift to rail passenger transport has made operating such businesses at current subsidy levels a very profitable activity.

8. Achieving the Transformation of Transport in Australia

It has been demonstrated above that achieving a sharp modal shift to an enhanced, low pollution rail transport system is likely to generate substantial economic and social benefits, but will require not only a carbon price but also a wide range of complementary policies. These policies will address market failures in the transport system at key points directly related to the challenges that this industry faces in modernising and competing more effectively with other transport modes. Consistent with the previous argument, and with the more detailed analyses provided in the supporting papers, policy initiatives are needed in the following areas.

Pricing. Where possible, an effective response to an externality is to introduce a price or a tax to internalise the costs and/or benefits involved, as is occurring with the internalisation of the social costs of greenhouse gas emissions through emissions trading. In freight transport the costs, both social and infrastructure, which are generated by large, long distance trucks are not passed through fully to the users of this form of transport. There is a widely recognised case for mass-distance-location charging to be introduced, as in other countries, to correct this market failure. Mass-distance-location charging also corrects some of the limitations of the existing road charging regime, including averaging of charges, whereby trucks which are more heavily used pay relatively lower charges, and the fact that the full social and environmental costs generated by large trucks are not fully passed on to users.

Infrastructure investment. Major rail infrastructure (such as rail track and associated works and equipment) suffers from all three forms of market failure highlight previously, as does road infrastructure. Constructing a new or enhanced railway involves a heavy sunk cost and provides benefits to many (including, for example, property and business owners) that cannot by fully appropriated by the owner of the infrastructure. The value of a railway system is also highly dependent on its coordination with other systems and facilities (e.g. rail or road connections) and coordination failures can greatly reduce its value. As argued above and in the detailed papers, major investment in the extension and upgrade of Australia’s rail infrastructure is necessary, and there is a strong case for public support for this activity. Further steps towards standardisation of rail networks are also required, as these would generate many efficiency and capital cost benefits.

Standards for rolling stock. Uniform standards for rolling stock, perhaps in line with the US AAR (American Association of Railroads) standards, are highly desirable. These standards would require increasing the width and height of the rail corridor to accommodate larger rolling stock and increasing the strength of the rail track to accept heavier rolling stock. This would remove the current impediment of all new rolling stock having to be redesigned and specially built for the Australian market, which prevents the rail market from responding to market growth, increases equipment costs, reduces competitiveness with road, and delays the introduction of new technology. The current waiting time for a purchase of a new locomotive in the USA is 2 months, compared to 2 years in Australia for equipment based on an older design. Significant productivity and energy efficiency gains from carrying a greater mass per train would also be achieved.

Investment in systems, facilitation and coordination. Some similar considerations apply to investments in, for example, signalling and control systems, advanced modal interchanges and many aspects of intermodal and intramodal coordination. Large scale investments will be needed both to make rail transport more efficient and to facilitate the modal shift. Both private and public investment will be required, in many cases in joint projects to achieve simultaneously both public and private goals.

Investment in R&D, new technology and plant and equipment. To modernise Australia's rail system and to increase its scale of operations, massive investment will be necessary by operating companies, whether public or private, and by firms in supplier industries in these areas. The prospects for an adequate return on such investments would be greatly increased by the other investments outlined above (such as track extension and upgrading). But in view of the difficulties of appropriability and sunk costs, public initiatives in the form of R&D support programs and enhanced depreciation allowances for certain classes of expenditure are likely to be necessary.

Investment in electrification and renewable energy. Finally, investment in the electrification of large scale rail systems, such as those of the North-South corridor, and the linking of those systems to sources of renewable energy will involve massive sunk costs the returns on which will be difficult to capture fully and will be heavily influenced by the actions of others. Again this will in many cases require public leadership, when adequate long term social returns can be generated.

The massive modal shift to road transport described above, and illustrated in Figures 5 and 6, took place over 40 years or more, and the quality of much of Australia's rail network and rolling stock has also declined over a long period. Hence partially reversing that modal shift, and modernising the Australia rail industry, will also require long term, sustained action. But given vigorous action it is possible to consider that, within 20-30 years:

- the majority of Australia's non-bulk freight movements outside capital cities would occur in modern, highly efficient trains;
- a significant share (20-25%) of all passenger kilometres travelled in Australia would be by rail; and
- the overall rail system would be largely electrified and increasingly powered by renewable energy.

In the final sections of this report we provide a summary of modelling results on the economic, social and environmental benefits of moving towards these goals, and set these benefits in the context of the likely costs involved. We also explore how moving towards these goals can contribute to the stabilisation, and ultimately the reduction, in transport industry emissions.

9. Scenarios

9.1. Modelling Strategy

The actions that are required to achieve these goals are complex and diverse, as are the interactions between the different parts of the transport system. It is not possible to provide, at this stage, detailed costing of all of these elements, nor is it possible to construct a model that takes adequate account of all of the linkages within the transport system. Thus for the purposes of this report a different modelling strategy is adopted, one that focuses particularly on quantifying the benefits of particular steps towards these goals, and uses this quantification as a guide to the likely returns to the investment required. The model that has been constructed to undertake this analysis is documented in Paper 10.

More specifically, the strategy adopted involves four main elements. First, three scenarios to 2020 are established, as specific defined steps towards achieving these goals. Secondly, using the model constructed for this purpose and consistent with the cost-benefit assessment guidelines of Infrastructure Australia, we estimate the economic, social and environmental benefits arising from each of these three scenarios. Thirdly, while detailed estimates of the required investment to achieve these scenario outcomes are not available, we can calculate, for a range of social rates of return, the level of investment expenditure that would earn a given rate of return in terms of these benefits. This 'permitted' level of investment can then be compared with what is known about the level of investment that is likely to be required. Fourthly, the implications of these scenarios for transport emissions are explored, including a simple extension of the model results to 2030.

9.2. The Three Scenarios

The first scenario, Scenario 1, involves a significant shift of long-haul freight to rail, and is broadly consistent with the ARTC's medium case scenario (ARTC 2008). Starting from the BITRE (2008c) projections, it assumes that after 2010 the volume of non-bulk freight carried by articulated trucks is fixed at its 2010 level (162.3 billion tkms), with the growth implied by the BITRE projections transferred to rail. It is also assumed that there is no change in any other freight allocations or variables, such as average loads. The increased rail task is split according to the split of the rail freight task in the base case.

The second scenario, Scenario 2, involves increased passenger movements by rail. The focus here is only on passenger movements, and freight movements have remained as they are in the base case. In this scenario a shift of motorists out of their cars and into public transport is assumed. Over 2010-20 the growth in passenger vehicle kilometres for cars is constrained to grow at 50% of the base case rate in the BITRE (2008c) projections, with the other half of the growth shifted to public transport, with an assumed split of 70% to trains and 30% to buses. Standard occupancy rates are used to convert these assumptions into vehicle movements.

The third scenario, Scenario 3, is one in which both the freight and passenger changes occur and in addition there is increased electrification and increased use of renewable energy to provide the electricity. To model this, two steps are undertaken. First the renewable energy component would lessen the impact of coal, so the greenhouse gas emission factor for electricity used in rail is reduced by 50%. Secondly, the increase in electrification sees urban passenger trains become totally electrified, and a significant portion of the freight network electrified resulting in a total of 60% of the total rail network being electrified (an increase from 38.5%).

Table 10: Summary of the rail tasks in the three scenarios

	Passenger			Freight			
	Non-urban	Urban (heavy rail)	Urban (light rail)	Hire & reward non-bulk	Hire & reward bulk	Ancillary	Total
Year	pkm	pkm	pkm	tkm	tkm	tkm	tkm
1990	2.35	7.18	0.48	19.49	35.36	33.06	87.91
1995	2.22	7.51	0.50	21.69	40.71	43.79	106.19
2000	2.38	8.34	0.56	27.39	57.17	49.00	133.56
2005	2.20	9.40	0.58	39.28	72.24	77.73	189.25
2010	2.39	10.56	0.64	48.92	82.63	114.49	246.04
Growth rate 2000-2010	*0.1%*	*2.4%*	*1.4%*	*6.0%*	*3.8%*	*8.9%*	*6.3%*
				Base Case			
2020	2.75	12.61	0.79	61.66	106.74	169.62	338.02
Growth rate 2010-2020	*1.4%*	*1.8%*	*2.1%*	*2.3%*	*2.6%*	*4.0%*	*3.2%*
				Scenario 1: Increased rail freight			
2020	2.75	12.61	0.79	75.41	130.55	207.46	413.42
Growth rate 2010-2020	*1.4%*	*1.8%*	*2.1%*	*4.4%*	*4.7%*	*6.1%*	*5.3%*
				Scenario 2: Increased passenger traffic			
2020	4.62	21.17	1.32	61.66	106.74	169.62	338.02
Growth rate 2015-2020	*6.8%*	*7.2%*	*7.5%*	*2.3%*	*2.6%*	*4.0%*	*3.2%*
				Scenario 3: Increased rail freight and passenger traffic with increased renewable electricity			
2020	4.62	21.17	1.32	75.41	130.55	207.46	413.42
Growth rate 2015 - 2020	*6.8%*	*7.2%*	*7.5%*	*4.4%*	*4.7%*	*6.1%*	*5.3%*

Source: Actual data and projections to 2010, BITRE (2008c); estimates of the authors.

The rail tasks implied by the three scenarios are summarised in Table 10. Over the decade to 2020 total passenger kilometres travelled by rail rise by 7.1% per annum, a substantial increase in the BITRE projection for the decade to 2010. But overall passenger traffic has been rising at close to this rate in recent years, in spite of capacity constraints in some cities, and it may be that the BITRE projections to 2010 underestimate this growth. Total freight traffic carried by rail is projected to grow by 5.3% per annum over 2010-20, which is actually lower than the estimated figure of 6.3% per annum over 2000-10. But the high growth in rail freight is heavily influenced by rapid growth in the bulk commodity trade (evident in the 8.9% growth in ancillary freight), and excluding that element the growth rate falls to less than 5%. Nevertheless both the passenger and freight scenarios have some grounding in the trends that have been underway in recent years, although massive investment will be needed to continue these growth rates to 2020.

10. Modelling Modal Change Scenarios

10.1. The Model

The modelling of the costs and benefits of different policies is a standard practice in the discipline of economics for project evaluation. This procedure allows for the efficiency, defined as net benefits per net cost, to be determined for a project allowing projects to be ranked in order of an efficiency criteria or rule. The model produced by CSES starts from the type of base model used by the BTRE model for reporting greenhouse gas emissions to the Department of Climate Change, and is consistent with the cost-benefit guidelines issued by Infrastructure Australia. The reason why this model was chosen is based on the fact that it is a bottom up model which is transparent, with full details provided in reports from the department responsible for transport matters (BTRE 2002, 2006; BITRE 2008c).

In simple form the model derives activity in vehicle kilometres for different types of vehicle in different scenarios. These activity numbers are used to calculate estimates of operating costs and social costs, drawing on parameters estimates developed in Papers 2 and 5. Three types of social cost are included, for each vehicle type: accidents, noise and air pollution. As noted above, congestion costs are not included in this version of the model. In addition the emissions associated with a given scenario are calculated by applying fuel efficiency coefficients to estimates of the amount of fuel consumed, and then computing the greenhouse gas emissions by fuel using an emissions factor for that fuel.

10.2. The Estimated Benefits

Table 11 below provides a summary of the estimated overall annual benefit from the three scenarios by 2020, expressed in constant price dollars in that year. Overall the estimated benefits are very high, with a total annual benefit from all sources in Scenario 3 of about A$10 billion in 2020. The benefits from lower operating costs and the social benefits are of comparable magnitudes, while the benefits from emissions savings are smaller (about A$340 million by 2020).

Table 11: Summary of benefits: Annual benefits in 2015 and 2020 ($A billion)

	Scenario 1	Scenario 2	Scenario 3
Total reduction in economic costs			
2015	0.94	1.34	2.28
2020	1.88	2.44	4.32
Total reduction in social costs (ex. climate change costs)			
2015	2.18	0.68	2.85
2020	4.06	1.23	5.30
Total reduction in climate change costs			
2015	0.08	0.05	0.14
2020	0.19	0.12	0.34
Total benefits			
2015	3.20	2.06	5.27
2020	6.14	3.79	9.96

The estimated benefits are expressed in net present value terms in 2008 in Table 12, using discount rates of 4%, 7% and 10% respectively. Again the numbers are very large, with Scenario 3 having gross benefits with an NPV in 2010 of A$27.4 even at a discount rate of 10%. While it must be realised that there are large margins of error around these estimates, the basic finding of very large total benefits is beyond dispute. It should also be noted that the benefits included in the net present value calculations in Table 12 only extend to 2020, and these benefits will also accrue for many subsequent years.

Table 12: Net present value in 2010 of total benefits over 2010-20, relative to the base case (A$ billion, constant prices)

Discount rate	Scenario 1	Scenario 2 (A$ billion)	Scenario 3
4%	25.6	16.1	41.7
7%	20.6	13.0	33.7
10%	16.8	10.6	27.4

These figures again illustrate the magnitude of the economic and social costs being imposed on Australia by the transport patterns that have built up since the Second World War, and hence the benefits that can be gained by even partially reversing those trends.

10.3. Investment to Achieve the Benefits

The investments that need to be undertaken if these benefits are to be achieved are many and varied, covering both public and private participants in the industry and involving investment in track and equipment, in locomotives and many business service activities, and in rail electrification and perhaps in renewable energy generation. It has been not been possible in this study to quantify the costs of these investments, although some important components (the rail freight track component for the North-South corridor) have been costed by the ARTC at A$4.9 billion. Overall it is likely that an investment of the order of A$15-20 billion (in constant prices) over 2010-20 will be required to achieve the outcomes specified for Scenario 3.

Table 13: Annual justified investment to achieve total benefits, for different discount rates (A$ billion per annum over 2010-20)

Rate	Scenario 1	Scenario 2	Scenario 3
4	2.9	1.8	4.8
7	2.7	1.8	4.5
10	2.6	1.8	4.2

As one way of approaching this matter, Table 13 reports calculations of the constant, real level of investment outlay per annum over the period 2010-20 that would be justified by these benefits, at different discount rates. Thus, for example, even at 10%, the justified annual level of investment is A$4.2 billion, or an undiscounted total of A$42 billion over the period. This is well above the actual level of investment that is likely to be necessary in practice to achieve the benefits.

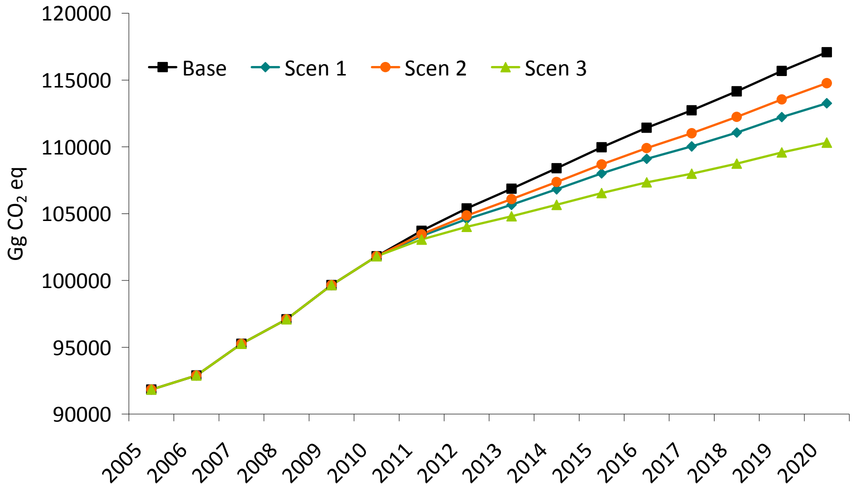
Another way of approaching these figures is to calculate the implied social rate of return in 2010 to an upper bound of the likely constant annual level of investment during the decade to achieve these benefits. Taking that upper bound as A$20 billion, or A$2 billion per annum, the implied social rate of return on this investment is 50%.

10.4. Impact on Transport Emissions

Finally, we report the model results for the impact of the three change scenarios on total transport emissions (further details are provided in Paper

10). These results are summarised in Figure 11, and show are reduction of about 7% in total transport emissions relative to the BITRE base case by 2020. Most of Australia's transport emissions come from road transport, while emissions from air transport are a small but rapidly growing component. Road and air emissions are held at the base case in these simulations, except for the reduction in road emissions that take place as a result of the modal shift from road to rail. Having regard to this, and to the limited period (to 2020) covered, the emissions reductions shown in Figure 11 are quite significant.

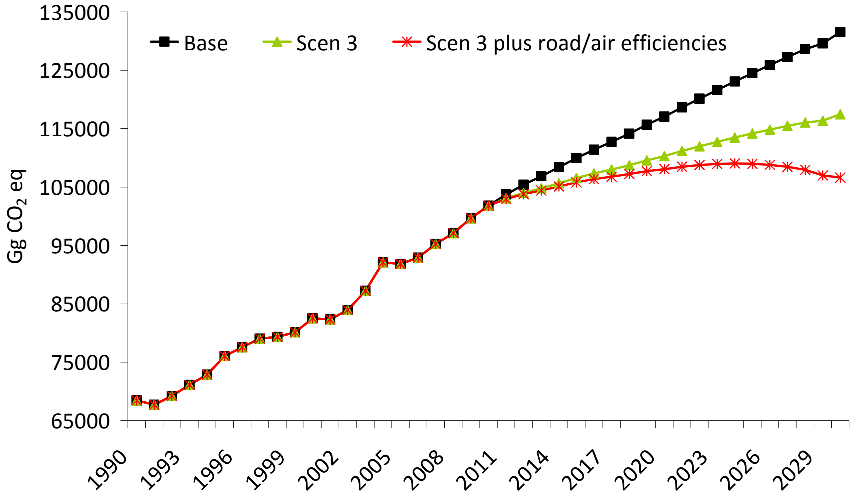
Figure 11: Total transport emissions to 2020, base case and three scenarios (Gg CO_2-e)



Source: Actual data and projections to 2010, BITRE (2008c); estimates of the authors.

In Section 1 of this paper we argued that, given a proper understanding of the climate change context in which Australia is placed, it will be necessary that transport emissions are declining in absolute terms before 2030. To examine the prospects for this outcome in the light of the scenarios discussed here, we have extended the model, in simple terms, to 2030 and also considered the implications of further improvements in the emissions intensity of road and air transport. The results are presented in Figure 12. The specific assumption used for the road and air sectors is that the emissions intensity per unit of activity in all components of these industries is 10% lower in 2030 than in the BITRE base case for that year, with the rate of reduction gathering pace over time.

Figure 12: Total transport emissions to 2030, base case, scenario 3 and increased fuel efficiency in road and air transport (Gg CO_2-e)



Source: Actual data and projections to 2010, BITRE (2008c); estimates of the authors.

Figure 12 shows that, taking account of the Scenario 3 effects only, total transport emissions are about 11% lower than in the base case by 2030. If account is also taken of further action to reduce emissions intensity levels in road and air transport, relative to the base case, by 10% by 2030, then total transport emissions are about 19% lower than the base case by 2030. Total transport emissions peak in 2024, and are less than 5% above their 2010 level in 2030.

Thus the actions discussed in this report not only generate large economic and social benefits, and high social returns to investment, but they also contribute significantly to reducing greenhouse gas emissions. If they are supplemented by further action to reduce the emissions intensity of road and air transport, total transport emissions can begin to decline after about 2025 and be brought close to their 2010 level by 2030. This would represent a major contribution to the achievement of Australia’s broader climate change goals.

11. Conclusion

In this final section we provide a summary of the main argument and conclusions of this report.

Substantial reductions in transport emissions are required

The Australian Government’s White Paper released on 15 December 2008 – *Australia’s Low Pollution Future* – takes it for granted that Australia can achieve its climate change goals without any major change in the transport sector over the next two decades, and does so on the basis of modelling undertaken for the Garnaut Review and for the Australian Treasury. This presumption is almost certainly incorrect, for three reasons.

First, the Treasury modelling understates the task of achieving a given stabilisation level (e.g. 550 ppm CO_2-e) for atmospheric concentrations of greenhouse gases (GHGs). The best available estimate of total global GHG emissions in 2005 is 20-

25% higher than the starting point used in the modelling. As a result the modelling understates the cuts that all countries, including Australia, will need to achieve to reach a given stabilisation level.

Secondly, the modelling implies that 30-40% of the reduction in Australia's emissions allocations relative to business as usual will be achieved by purchasing permits overseas rather than by reducing emissions within Australia. In the modelling of the Government's CPRS-5 scenario (which implies an emissions allocation 25% lower than emissions in 2000 by 2030), actual emissions within Australia are still above 2000 levels in 2030, with all of the absolute reductions being from purchases emissions. This level of overseas purchases is unlikely to be either achievable or morally sustainable, especially given the first point above.

Thirdly, the generous free permit allocation provisions in the White Paper for energy intensive trade exposed industries (EITEs) mean that the allocations available for other industries are correspondingly reduced. For example, if Australia ultimately adopts a 15% reduction target and EITE industries grow by 3% per annum, then the available emissions allocation for other industries will fall by 43.5%, or over 5% per annum, over 2010-20.

Australia's target is for a 5% reduction in emissions by 2020 relative to 2000, the allocation for all other industries falls by 29.4% between 2010 and 2020, an annual reduction of 3.4% per annum. If the EITE growth rate is 5% per annum and the target is for a 15% reduction the fall in the allocation for all other industries is 57%, or 8% per annum over 2010-20, which is a seriously difficult challenge.

These three points imply that, if Australia is to participate in an international process to achieve even the modest stabilisation target of 550 ppm CO_2-e, a significant reduction in domestic emissions will be necessary, concentrated on non-EITE industries. Transport is responsible for about 27% of non-EITE industries emissions, but in the CPRS-5 modelling transport emissions are 40% higher in 2020 than in 2000. This cannot be permitted if substantial reductions in non-EITE emissions are to be achieved. Transport must be brought seriously into the emissions policy mix, with large scale reductions in emissions relative to business as usual over the next two decades.

This will involve reversing the long shift to road transport

Achieving a significant reduction in transport emissions, even relative to business as usual, will require steps to reduce the emissions intensity of all transport modes – road, rail and air – as well as a sharp modal shift from road to rail transport. However, this report is focused on rail, both in terms of increased efficiency within the sector, but most importantly in terms of a modal shift to an advanced, low pollution rail system.

The first four decades after the Second World War saw the rise of the car and the truck reshape Australia's transport patterns. Between 1945 and 1985 the rail share of both urban and non-urban passenger kilometres fell from over 50% to about 5%, and remained close to that level in 2005. Over the same period the rail share of non-bulk domestic freight traffic fell from 56% to 22%, and was at about that level in 2005. Only in the bulk freight area did the rail share rise (from 20% to nearly 50%), as new dedicated rail lines were built to take coal, iron ore and other commodities to port. This shift from road to rail has been supported by massive public investment in road networks over the postwar period, while rail systems were allowed to deteriorate over most of the country.

Recent years have seen some signs of renewal in the position of rail – passenger demand has risen strongly in some major cities; new rail investment has been undertaken in Queensland and Western Australia, and foreshadowed elsewhere; rail has captured a high share of non-bulk freight traffic on some long haul routes. But if transport is to contribute to meeting Australia's emissions challenge much more will be required, involving a sharp reversal of the historical trend and a substantial modal shift to rail, in both passenger and freight.

There will be large scale benefits from a modal shift to rail

The mobility of people and goods is highly prized in modern societies, but the economic, social and environmental costs of current transport patterns are immense. Modernised and efficient rail can provide lower cost movement of freight between major urban centres than road transport, and move people in cities are a lower average cost per kilometre. The social costs incurred by current transport patterns have been widely studied and are very large, being estimated at about A$52 billion or 5.6% of GDP in Australia in 2005. On average the social costs arising from rail transport per unit of activity are about 30% of those from road transport, so a modal shift should generate sharp reductions in social costs.

Rail efficiencies and electrification with renewable energy offers low emissions transport

Rail is typically a more energy efficient form of transport per unit than road, with lower energy use per passenger kilometre or per tonne kilometre. Rail's energy intensity can be reduced further by a range of measures, from lighter and more advanced vehicles and improved vehicle/track interactions to more efficient engines, regenerative braking and the introduction of train protection and control systems. But one of the advantages of rail is that it offers the possibility of virtually zero emissions transport, when rail transport is fully electrified rail and powered by electricity generated from renewable sources.

Carbon prices are necessary but not sufficient; complementary policies are crucial and can support growth

The transport system is riddled with market failures, especially externalities, sunk costs and coordination failures. The presence of such pervasive market failures means that prices will have only a limited role in facilitating structural change and reduced emissions in transport. If such failures are not addressed the carbon price will be higher than necessary for a given reduction in emissions and that a less than optimal set of emissions reductions will be chosen by the market. By contrast, substantial programs to eliminate market failures will both reduce the carbon price required and generate a more efficient response. A carbon price is necessary but not sufficient to achieve an optimal outcome in the transport sector.

Introducing a carbon price will tend to reduce economic activity, as the existing low cost but polluting technologies are taxed and activity is shifted to higher cost but less polluting ones. But if complementary policies create new goods and industries through R&D, revitalised infrastructure and new investment, then action to reduce emissions may well be a source of growth. This point is particularly important in the context of the global financial crisis and its aftermath, especially the sharp recession in the USA and some parts of Europe, and the inevitable impact of that on Australia and other countries. Strong complementary policies would be growth enhancing, both by reducing the market-based carbon price and also by supporting investment in R&D, new infrastructure and plant and equipment. Thus many of the measures necessary to address key market failures would be strongly expansionary and could be a central part of an appropriate fiscal response to the current slowdown.

The economic, social and environmental advantages of rail

There is substantial evidence that rail is, in many circumstances, the transport mode with the lowest full economic cost, as well as having much lower social and environmental costs.

Overall total social and environmental costs of transport in Australia are estimated at A$52 billion or 5.6% of GDP in 2005, before including congestion costs. Of this only 9% is due to rail transport despite it providing a substantial proportion of the transport task.

A full costing of rail compared with road freight demonstrates that rail would become quite competitive commercially on the various North South routes, and unit costs might be expected to fall significantly if the market share of rail increased substantially and other operationally efficiencies were made. Perhaps more importantly, the figures demonstrate that the total transport cost is significantly lower for efficient rail than road transport on all intercity corridors. However a considerable proportion of the benefits accrue to environment and the general community which are not realized financially by the commercial railways. Therefore there is a sound justification for governments to support railways so that the non-commercial benefits can be realized for the good of Australia as a whole.

Key challenges facing the rail industry

To achieve a modal shift to rail in the non bulk market many issues of cost, reliability, commercial certainty and service levels need to be addressed. In freight area increasing the efficiency of modal transfers through the establishment of specialist intermodal exchange terminals is important, and costs can also be reduced by double stacking, longer trains and better train management and communications systems. Freight train reliability is affected by unscheduled hold-ups and delays. While better train management systems also help to improve reliability, addressing this issue requires significant infrastructure investment, particularly for the North-South corridor linking Melbourne, Sydney and Brisbane, of the sort outlined in the ARTC submission to Infrastructure Australia (ARTC 2008). Improved infrastructure also provides a basis for investment in more advanced vehicles and systems.

Rail passenger travel has grown rapidly in recent years in most state capitals in response to recently increased petrol costs and growing road congestion. There has been large increase in patronage in Melbourne (10.0% in 2006/07 compared with 2005/06) and Brisbane (9.0%) and a more modest increase in Perth (5%). In Sydney, on the other hand, patronage growth has been constrained by capacity limitations to an increase of only 2.8% for 2006/07. Capacity constraints are now a key issue, and several state governments are planning significant capacity increases but these can carry substantial costs and implementation is typically problematic.

Policies for achieving a modal shift to advanced rail transport

Achieving the necessary sharp modal shift to an enhanced, low pollution rail transport system will require not only a carbon price but also a wide range of complementary policies. These policies will address market failures in the transport system at key points directly related to the challenges that this industry faces in modernising and competing more effectively with other transport modes. Policies in the following areas seem most important:

- In freight transport, the costs both social and infrastructural, which are generated by large long distance trucks, are not passed through fully to the users of this form of transport. There is a widely recognised case for *mass-distance-location charging* to be introduced, as in other countries, to correct this market failure.

- Invest in *major rail infrastructure* (such as rail track and associated works and equipment) which suffers from all three forms of market failure highlighted previously, as does road infrastructure. Large scale investment in the extension and upgrade of Australia's rail infrastructure is necessary, and there is a strong case for public support for this activity. Some similar considerations apply to investments in, for example, *signalling and control systems, advanced modal interchanges,* as well as many aspects of intermodal and intramodal coordination, where both private and public investment will be required, in many cases in joint projects to achieve simultaneously both public and private goals. Develop and implement *Standards for rolling stock and infrastructure* to improve asset utilisation, reduce purchase costs and maintenance costs, and improve transport system performance.

- To modernise Australia's rail system and to increase its scale of operations, massive investment will be necessary by operating companies, whether public or private, and by firms in supplier industries in these areas. In view of the difficulties of appropriability and sunk costs, *public initiatives in the form of R&D support programs and enhanced depreciation allowances* for certain classes of expenditure are likely to be neces*sary.*

- Finally, *investment in the electrification of large scale rail systems*, such as those of the North-South corridor, and the linking of those systems to sources of renewable energy, will in many cases require public leadership, when adequate long term social returns can be generated.

The massive modal shift to road transport took place over 40 years or more, and the quality of much of Australia's rail network and rolling stock has also declined over a long period. Partially reversing that modal shift, and modernising the Australia rail industry, will also require long term, sustained action which could result in:

- the majority of Australia's non-bulk freight movements outside capital cities occurring in modern, highly efficient trains;

- a significant share (20-25%) of all passenger kilometres travelled in Australia being by rail; and

- the overall rail system being largely electrified and increasingly powered by renewable energy.

Three scenarios for modelling the benefits to 2020

The modelling strategy is based on the establishment of three scenarios to 2020 are established, as specific defined steps towards achieving the goal of a sustained modal shift to an enhanced rail system. The first scenario, Scenario 1, involves a significant shift of long-haul freight to rail, with no increase in the volume of freight carried on articulated trucks after 2010. The second scenario, Scenario 2, involves increased passenger movements by rail, with half of the total increase in vehicle kilometres for cars over 2010-20 transferred to public transport, with an assumed split of 70% to trains and 30% to buses. The third scenario, Scenario 3, is one in which both the freight and passenger changes occur and in addition there is increased electrification and increased use of renewable energy.

High social returns from transforming rail

The central finding is that, as expected, the overall benefits produced by the three scenarios are very high, with a total annual benefit from all sources in Scenario 3 of about A$10 billion per annum by 2020. The benefits from lower operating costs and the social benefits are of comparable magnitudes, while the benefits from emissions savings are smaller. The estimated benefits, expressed in net present value terms in 2008, were shown in Table 12, using discount rates of 4%, 7% and 10% respectively. Again the figures are very large, with the net present value in 2010 of the benefits from Scenario 3 being A$27.4 billion even at a discount rate of 10%. While it must be realised that there are large margins of error around these estimates, the basic finding of very large total benefits is beyond dispute. It should also be noted that the benefits included in the net present value calculations in Table 12 only extend to 2020, and these benefits will also accrue for many subsequent years.

The figures in Table 12 again illustrate the magnitude of the economic and social costs being imposed on Australia by the transport patterns that have built up since the Second World War, and hence the benefits that can be gained by even partially reversing those trends.

The investments that need to be undertaken if these benefits are to be achieved are many and varied, covering both public and private participants in the industry and involving investment in track and equipment, in locomotives and many business service activities, and in rail electrification. It has been not been possible in this study to quantify the costs of these investments, although some important components (the rail freight track component for the North-South corridor) have been costed by the ARTC at A$4.9 billion. Overall it is likely that an investment of the order of A$15-20 billion (in constant prices) over 2010-20, or $1.5-2.0 billion per annum, would be required to achieve the outcomes specified for Scenario 3.

Table 13 showed the constant, real level of investment outlay per annum over the period 2010-20 that would be justified by these benefits, at different discount rates. Thus, for example, even at 10%, the justified annual level of investment is A$4.2 billion, or an undiscounted total of A$42 billion over the period. This is well above the actual level of investment that is likely to be necessary in practice to achieve the benefits. Another way of approaching these figures is to calculate the implied social rate of return in 2010 to an upper bound estimate of the constant annual level of investment during the decade to achieve these benefits. Taking that upper bound as A$2 billion per annum (at total of A$20 billion) the implied social rate of return on this investment is 50%.

Transport emissions can be significantly reduced

Most of Australia's transport emissions come from road transport, while emissions from air transport are a small but rapidly growing component. Road and air emissions are held at the base case in the scenario simulations, except for the reduction in road emissions that take place as a result of the modal shift from road to rail. As was illustrated in Figure 12, taking account of the Scenario 3 effects total transport emissions are about 11% lower than in the base case by 2030. If account is also taken of further action to reduce emissions intensity levels in road and air transport, relative to the base case, by 10% by 2030, then total transport emissions are about 19% lower than the base case by 2030. Total transport emissions peak in 2024, and are less than 5% above their 2010 level in 2030.

Thus the actions discussed in this report not only generate large economic and social benefits, and high social returns to investment, but also contribute significantly to reducing greenhouse gas emissions. If they are supplemented by further action to reduce the emissions intensity of road and air transport, total transport emissions can begin to decline after about 2025 and be brought close to their 2010 level by 2030. This would represent a major contribution to the achievement of Australia's broader climate change goals.

References

Australian Government 2008, *Nation Building: Rail, Road, Education & Research and Business*, Commonwealth of Australia, Canberra.

Australian Rail Track Corporation (ARTC) 2008, '2008-2024 Interstate and Hunter Valley Rail Infrastructure Strategy', Adelaide.

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2008a, 'Freight Rates in Australia, 1964 65 to 2007-08', Canberra.

BITRE, 2008b, *Australian Transport Statistics Yearbook 2007*, Canberra.

BITRE 2008c, 'Greenhouse Gas Emissions From Australian Transport: Year 2007 Projections to 2020', BITRE Working Paper 73, Canberra.

BITRE and CSIRO 2008, Modelling the Road Transport Sector: Appendix to *Australia's Low Pollution Future: The Economics of Climate Change*, October, Canberra, at http://www.bitre.gov.au/publications/81/Files/Modelling_the_road_transport_sector.pdf

Bureau of Transport and Regional Economics (BTRE) 2002, 'Greenhouse Gas Emissions from Transport: Australian Trends to 2020', Report 107, Canberra..

BTRE 2006, 'Greenhouse Gas Emissions from Australian Transport: Base case projections to 2020', Canberra.

Cosgrove, D. 2008, 'Long-term Emission Trends for Australian Transport', paper presented at the 31st Australasian Transport Research Forum, Gold Coast, 2-3 October.

Department of Climate Change (DCC) 2008, *Carbon Pollution Reduction Scheme: Australia's Low Pollution Future*, White Paper, Volume 1, December, Canberra.

EWLNA 2008, *Investing in Transport: Main Report*, East West Links Needs Assessment Study Team, Victorian Government, Melbourne.

Garnaut, R. et al. 2008, *The Garnaut Climate Change Review: Final Report*, Cambridge University Press, Melbourne.

INFRAS/IWW (2004), 'External Costs of Transport. Update Study'. Final Report, Zurich/Karlsruhe.

Infrastructure Australia 2008, *A Report to the Council of Australian Governments,* Canberra, December.

Intergovernmental Panel on Climate Change (IPCC) (2007), *Climate Change 2007: Mitigation of Climate Change*, Contribution of Working Group III to the Fourth Assessment Report of the IPCC, Cambridge University Press, New York.

International Energy Agency (IEA) 2008, *Energy Technology Perspectives: Scenarios and Strategies to 2050,* OECD and IEA, Paris.

Ironmonger, D. 2008, *A System of Time Accounts for Melbourne*, 2nd edn, Report to Department of Transport (VIC), Households Research Unit, Department of Economics, The University of Melbourne, Melbourne.

Port Jackson Partners 2005, *The Future for Freight 2005*, Australian Railway Association, Canberra.

Rail Safety and Standards Board (RSSB) 2007, *Study on Further Electrification of Britain's Railway Network, Final Report*, T633, London.

Transport Data Centre 2008, *2006 Household Travel Survey: Summary Report*, New South Wales Ministry of Transport, Sydney.

Treasury 2008, Australia's Low Pollution Future: The Economics of Climate Change Mitigation, Commonwealth of Australia, Canberra.

Appendix: List of Supporting Papers

Paper 1: The Australian Transport Sector and Climate Change

Paper 2: Social, Economic and Environmental Impacts of Transport Modes

Paper 3: Emissions Trading and Transport

Paper 4: The Case for Complementary Policies with Emissions Trading Systems

Paper 5: The Transport Operators

Paper 6: Freight Infrastructure Issues

Paper 7: Operational and Transport Issues in Rail Passenger Transport

Paper 8: Powering Rail: Electrification and Emissions Intensity

Paper 9: Technology and Commercialisation Developments

Paper 10: Modelling of Modal Shifts in the Transport Sector