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Dennis Trewin
Acting Australian Statistician

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INQUIRIES

- For information about other ABS statistics and services, please refer to the back page of this publication.
- For further information about these statistics, contact Graeme Oakley on Canberra (06) 252 7369.

CONTENTS

PREFACE

The impact of transport activities on the environment has attracted the attention of the general public, politicians and decision-makers. It is high on international agendas, with the Organisation for Economic Co-operation and Development (OECD) selecting this sector as one for further research concerning sustainability issues. Transport systems have special importance in Australia's economy and social life.

To obtain a better understanding of these issues, a comprehensive set of statistical information is needed. This publication presents an overall picture of Australia's transport activities with some information about the state of relevant environmental media impacted by those activities, along with the response of government, business and individuals to the degradation of environmental quality by transport activities.

The Australian Bureau of Statistics (ABS) has extensive data on many aspects of the Australian transport system. External sources have been used to provide as complete a picture as possible. A framework for environmental reporting developed by the OECD is used here to provide the basis of the presentation. This framework places emphasis on the interaction between economic activity and the state of the environment, as well as human responses to any changes.

Many individuals and organisations provided data for inclusion in this publication. The use of their published and unpublished material is specifically acknowledged at their point of use and in the reference list for each chapter.

The ABS is also indebted to many people who willingly provided their time to referee the draft manuscript. They are: Anne Holmes, John Streeter, Jennifer Bransky, Winton Brocklebank (Department of Transport); Ian Carruthers, Sarah Bloustein (Environment Protection Group); Franzi Poldy (Commonwealth Scientific and Industrial Research Organisation Division of Wildlife Ecology); David Cosgrove (Bureau of Transport and Communications Economics); Albert Ofei-Mensah (Department of Primary Industry and Energy); Paul Mees (Australian National University); Paul Nelson (Australian Marine Safety Association); Mike Vasey, Peter Dutaillis (Roads and Traffic Authority).

In Australia, environmental reporting is still a relatively new endeavour. Suggestions and comments, particularly on future ABS publications in this field, would be greatly appreciated and should be sent to the Director, Environment and Energy Statistics Section, Australian Bureau of Statistics, PO Box 10, Belconnen ACT 2616.

Dennis Trewin
Acting Australian Statistician

June 1997

INTRODUCTION

ORGANISING FRAMEWORK—'PRESSURE-STATE-RESPONSE'

Transport systems play a major role in the economic life of industrialised countries and in the daily lives of their citizens. The transport industry accounted for 6.0% of total Gross Domestic Product (GDP) in Australia in 1995–96, and for 4.6% of total employment at February 1997. Transport is also a vital component of other industries and has substantial importance in international trade, in business operations, household consumption expenditure, and in public expenditure.

Yet transport also has significant detrimental effects on the Australian environment. These may include detriment to air quality, land and marine resources, energy resources, human and wildlife environments.

In order to address any statistical description of a complex and broad issue, such as the relationship between transportation and the environment, it is necessary to have a conceptual framework to provide an order to the boundaries of the task and to present information within accepted concepts and standards.

The Organisation for Economic Co-operation and Development (OECD) has published several issues of a report on transport and the environment using the 'Pressure—State—Response' (PSR) framework. The OECD reports relate to member countries and the level of geographic aggregation is at the country level.

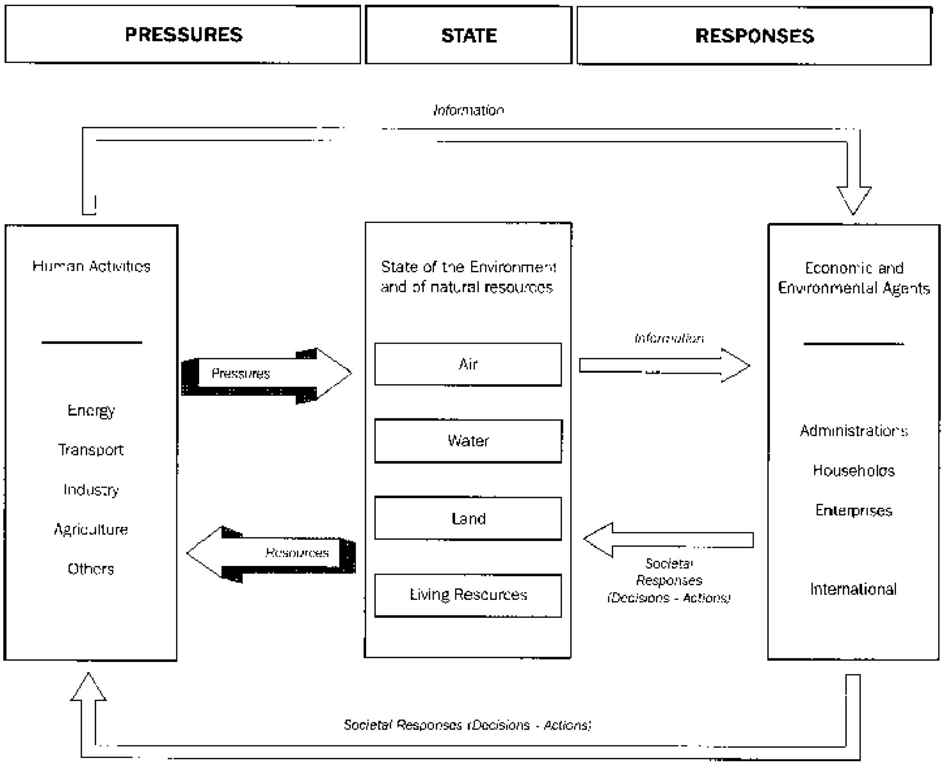
The Australian Bureau of Statistics has adopted the OECD's PSR framework for this publication, as part of its investigations into research and presentational models for reports about the impact and interrelationship between economic and social activities and the environment. However, there have been some departures from the basic model and these are discussed below.

THE OECD FRAMEWORK

Diagram 1A provides a schematic description of the OECD's PSR framework, which is based on a concept of causality: human activities exert *pressures* on the environment and change the quality and the quantity of natural resources (the *state* box). Society responds to these changes through environmental, general economic and sectoral policies (the *societal response*). The latter form a feedback loop to pressures through human activities. It is acknowledged that the PSR framework tends to suggest direct relationships in the human activity-environment interaction. The OECD view is that the more complex relationships in ecosystems and in human activity-environment interactions need not be obscured by this presentation and may still be explored at other levels.

The three parts of the PSR model form the basis for the sections of this publication. Part 1 describes the various transportation activities which place pressures on the environment, according to mode of transport. Part 2 examines the impact of transportation activity on the state of environmental media, and other related issues. The chapters cover the air pollutants and greenhouse gas emissions, wastes generated by transport activities, impacts of transport on people, and other impacts on the natural environment. Part 3 of the publication deals with society's responses to the environmental issues associated with transport activity. These include governmental vehicle emission standards and controls, technological initiatives in new vehicle technology and fuel modifications, and policy responses, programs and initiatives.

1A PRESSURE—STATE—RESPONSE MODEL



Source: OECD Environmental Data 1993.

ABS VARIATION TO THE OECD MODEL

The ABS has not made any fundamental change to the basic OECD model as it appears in relevant OECD references. The few minor changes are as follows:

- In Part 1, in order to preserve a balance between benefits and environmental impacts, it was necessary to provide an indication of the economic significance of the sector and the service performed.
- Information and indicators related to state in the PSR model are described as being related to the condition of environmental media, namely, the quality of those media and the quantity and quality of natural resources. In Part 2, the ABS has also included information about the direct impacts of transportation on the state of the environmental media by describing aspects such as emissions of gases, oil spills, and ballast discharge from ships.

COMPARISON OF DATA FROM SELECTED COUNTRIES

The OECD has compiled a few summary indicators related to transportation and the environment which provide some guide to international relativities. They are presented here to demonstrate the different components of the PSR approach.

1B OECD TRANSPORT— Environment Indicators

Indicator	Australia	Canada	USA	UK	Japan	NZ
PRESSURE						
Road Traffic Volume (billion vehicle-km)						
1983	129	204	2 634	258	465	19
1993	141	248	3 701	444	708	25
Change (%)	9.3	21.6	40.5	72.1	52.3	31.6
Road Network Length ('000 km)						
1983	820	930	6 242	344	1 123	93
1993	853	930	6 287	365	1 131	92
Change (%)	4.0	0.0	0.7	6.1	0.7	–1.1
Total final energy consumption by transport (Mtoe)						
1985	19.6	39.8	449.9	36.8	57.7	2.7
1993	23.4	45.6	513.6	47.7	84.2	3.8
Change (%)	19.4	14.6	14.2	29.6	45.9	40.7
Proportion of total final energy consumption (%)						
1985	39	26	35	27	23	34
1993	37	27	37	31	27	36
STATE						
Carbon dioxide emissions from tranport sources (million tonnes)						
1980	51.7	129.6	1 251.4	98.9	160.3	7.3
1993	68.0	129.9	1 489.8	139.0	244.1	11.0
Change (%)	31.5	0.2	19.1	40.6	52.3	50.7
Proportion of total carbon dioxide emissions from energy use (%)						
1980	24.0	29.8	26.2	16.7	17.4	40.6
1993	24.0	29.3	29.2	24.9	22.4	39.3
RESPONSE						
Fuel price(a)						
Leaded petrol						
1985	0.44	—	—	0.79	—	0.75
1993	0.49	—	—	0.85	—	0.66
Change (%)	11.4		—	7.6		–12.0
Unleaded petrol						
1985	—	0.43	0.35	—	0.64	—
1993	0.53	0.49	0.34	0.78	0.67	0.63
Change (%)	—	14.0	–2.9	—	4.7	

(a) $US per litre at current prices and purchasing power parities.

Source: OECD 1995, tables 2.3A, 2.3B, 8.5A, 9.1A, 9.3A, 9.4, 9.5B.

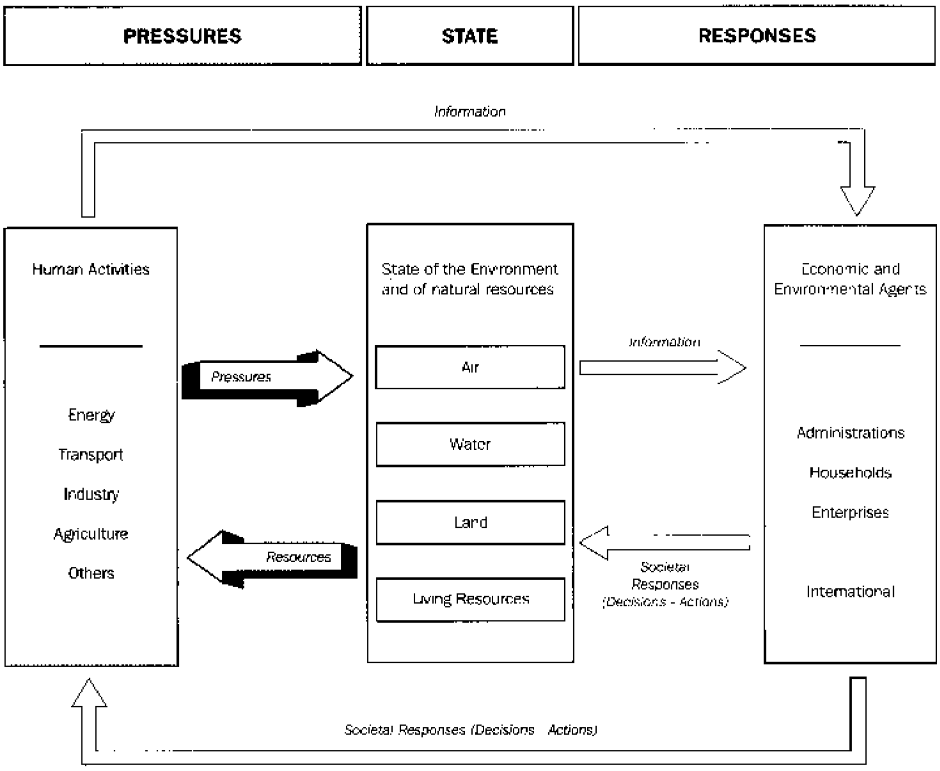
REFERENCES

OECD 1993, *Environmental Data Compendium 1993*, OECD, Paris.

OECD 1995, *Environmental Data Compendium 1995*, OECD, Paris.

PART **1**

PRESSURES



The pressures on environmental media that result from transport activities include: restructuring of the environment; consumption of natural resources, such as land, materials and energy; the generation of pollution and nuisances, such as air pollution and noise; and other detrimental effects on the quality of life due to congestion and accidents.

The OECD distinguishes between indicators of 'indirect pressures' (a range of human activities) and the direct or 'proximate' pressures on the environment, such as consumption of natural resources and emissions, for which the human activities are responsible. The statistics in Part 1 relate mainly to indirect pressures, although some data on consumption of natural resources are also included. Direct pressures in the form of emissions are addressed in Part 2.

Part 1 presents chapters on road, rail, sea and air transport. An additional chapter provides comparative data about the various transport sectors.

Through the statistics presented about pressures on the environment, it is possible to identify trends over time and relate these to the known events and policy changes presented in Part 3. Details relating to the economic contribution by transport activities to the overall economy is provided in the final section of each chapter in order to reflect the balance between the contribution to the economy and society, and the impact of those activities in terms of consumption of natural resources and degradation of environmental media.

Chapter 1 presents data on roads and related infrastructure including length of road network, value of work done on roads, number and age of vehicles; as well as the usage of such infrastructure such as distances travelled by type of vehicle and purpose of travel, freight carried by type of vehicle and distances travelled. Usage of natural resources (e.g. types of fuel and fuel consumption) are also presented. Finally, figures are given for employment in road transport and related businesses and on the economic contribution of the road transport industry.

Chapter 2 addresses trains, trams and railways, with data on the length and coverage of rail network, (including tramways), rail freight movements (government and private), and distance travelled and passenger numbers (urban/non-urban). Energy consumption by the rail sector and employment in the rail sector are also covered.

Chapter 3 details shipping infrastructure (number of ports, existing and projected port facilities, number of ships), number of visits to ports and freight movements and tonnages (domestic and international). There is also data on fuel consumption and fuel efficiency, employment in the shipping sector and the economic significance of the shipping sector.

Chapter 4 provides information on air transport, including hours flown, airport infrastructure, aircraft stocks and international, domestic and regional flight data (number of services, passengers, freight and mail carried). Also detailed are general aviation activities, fuel and energy consumption by air transport and employment in air transport.

Chapter 5 provides comparisons between the various transport sectors, in terms of energy consumption, passenger journeys (urban/non-urban), commuting choices, domestic freight carried (government/private, urban/non-urban), employment in transport sectors and the economic significance of transport industries.

CHAPTER 1 MOTOR VEHICLES AND ROAD NETWORKS....

Motor vehicle transportation dominates the movement of people and is a very significant carrier of freight. Both activities are increasing. Urban design tends to cater for the use of motor vehicles, with freeways and dispersed housing and infrastructure. The convenience of motor vehicles is offset by their major contribution to atmospheric pollutants.

Data presented in this chapter have been drawn predominantly from two ABS collections: the Survey of Motor Vehicle Use and the Motor Vehicle Census. Statistics from the survey relate to motor vehicle use in Australia for the 12 months ended 30 September 1995, whereas data from the census relate to vehicles which were on register at 31 May 1995 with a vehicle registration authority. Other ABS data sources include the Engineering Construction Survey, Australian National Accounts, the Australian and State Year Books, and the Business Register. Road and traffic authorities in each State and Territory also contributed data for this chapter.

INFRASTRUCTURE

Length of road network

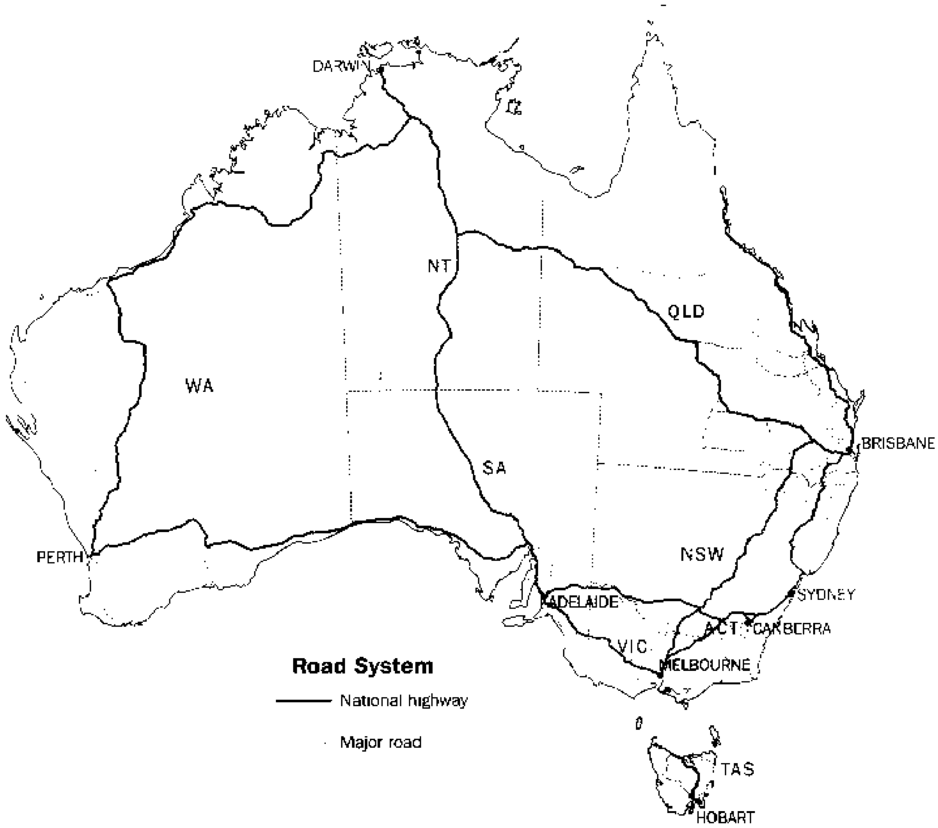
The length of Australia's road network is listed in table 1.1. The national highway system refers to the main transport roads linking the mainland capital cities of Australia, and also includes road links between Brisbane and Cairns, and Hobart and Burnie (see map 1.2).

1.1 LENGTH OF ROAD NETWORK—1995

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
Type of road	km	km	km	km	km	km	km	km	km
National highways	2 900	1 031	3 898	2 910	4 640	320	2 677	15	18 400
Rural arterials	30 162	18 536	18 438	8 690	15 616	2 540	2 837	20	96 840
Urban arterials	4 237	2 978	1 482	1 250	1 815	190	84	188	12 232
Rural locals	121 400	115 500	127 900	75 700	107 300	14 500	25 210	280	587 700
Urban locals	20 100	22 100	13 400	7 500	8 200	1 200	580	2 100	75 200
All road types	**178 000**	**160 100**	**165 100**	**96 100**	**137 500**	**18 800**	**31 390**	**2 600**	**790 300**

Source: Austroads 1997, p. 18.

1.2 NATIONAL HIGHWAY AND MAJOR ROAD SYSTEM



Source: ABS 1996a, p. 340.

Value of road construction

The value of work done in the construction of roads, highways and subdivisions has increased considerably over the last decade. Increasingly, the private sector is responsible for road construction. Table 1.3 shows value of construction in constant 1989–90 prices.

1.3 VALUE OF ENGINEERING CONSTRUCTION ON ROADS

Year	Private sector $m	Proportion of total %	Public sector $m	Proportion of total %	Total $m
1987–88	1 388.3	52	1 279.5	48	2 667.8
1988–89	1 672.9	56	1 301.2	44	2 974.1
1989–90	1 942.0	58	1 395.0	42	3 337.0
1990–91	1 859.8	58	1 345.9	42	3 205.7
1991–92	1 787.0	61	1 156.4	39	2 943.4
1992–93	2 010.5	58	1 440.4	42	3 450.9
1993–94	2 262.5	61	1 473.3	39	3 735.8
1994–95	2 096.9	59	1 446.3	41	3 543.2
1995–96	2 154.6	60	1 448.8	40	3 603.4

Source: ABS 1996d.

STOCK

Motor vehicles on register

There were 10,947,530 motor vehicles on register in Australia at 31 May 1995 . This represented a net increase of 443,380 vehicles (4.2%) from the previous census for 30 June 1993. Between censuses, the number of registrations increased in all States and Territories, ranging from a 0.2% increase in Victoria to a 9.0% increase in Queensland. The number of passenger vehicles increased by a similar percentage to the total vehicle fleet (4.2%), with similar variations across States and Territories. Passenger vehicles accounted for 8,628,806 million vehicles (78.8% of the total) at the 1995 census. The Australian Capital Territory had the highest percentage of passenger vehicles (85.2%), while the Northern Territory had the lowest (65.2%). The Northern Territory recorded the highest percentage of motor cycles (4.3%), light commercial vehicles (23.8%), articulated trucks (1.2%), and buses (2.1%). Western Australia recorded the highest percentage of rigid trucks (3.7%) and Western Australia and South Australia shared the highest percentage figure for non-freight carrying trucks (0.7%).

1.4 MOTOR VEHICLES ON REGISTER—31 May 1995

Type of vehicle	NSW no.	Vic. no.	Qld no.	SA no.	WA no.	Tas. no.	NT no.	ACT no.	Aust. no.
Passenger vehicles	2 684 847	2 315 310	1 513 291	777 249	885 527	237 129	58 880	156 573	8 628 806
Light commercial vehicles	430 786	357 773	339 951	115 274	187 195	57 217	21 499	17 517	1 527 212
Rigid trucks	103 109	84 652	63 593	26 451	43 044	11 056	2 834	2 682	337 421
Articulated trucks	15 028	16 516	11 710	5 309	6 748	1 646	1 069	296	58 322
Non-freight carrying trucks	9 461	11 289	6 681	6 398	8 606	3 479	276	781	46 971
Buses	13 473	13 770	9 328	3 525	7 125	2 145	1 883	921	52 170
Motor cycles	75 757	70 570	68 326	28 618	37 242	7 201	3 929	4 985	296 628
Total	**3 332 461**	**2 869 880**	**2 012 880**	**962 824**	**1 175 487**	**319 873**	**90 370**	**183 755**	**10 947 530**

Source: ABS 1996b, pp. 6–7.

VEHICLES AND POPULATION

At 31 May 1995 there were 606 vehicles per 1,000 persons, an increase of 2.0% from the 1993 census. The rate of increase between the 1991 and the 1993 censuses was also 2.0%. Western Australia had the highest rate of vehicle ownership (679 vehicles per 1,000 people) and the Northern Territory had the lowest (520 per 1,000 people). All States and Territories except Victoria recorded increased rates of ownership.

1.5 MOTOR VEHICLES ON REGISTER PER 1 000 PERSONS

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
Year(a)	no.	no.	no.	no.	no.	no.	no.	no.	no.
1982(b)	509	531	591	559	582	568	467	472	540
1985	529	575	579	622	628	607	472	499	567
1988	524	598	567	616	608	634	(c)389	511	567
1991	525	622	569	637	653	643	507	556	582
1993	529	642	593	638	665	661	497	591	595
1995	545	637	614	653	679	676	520	604	606

(a) For years to 1991, registration data are at 30 September. 1993 registrations data are at 30 June and 1995 data are at 31 May; 1991 population data are at 30 September; 1993 and 1995 population data are at 30 June.

(b) Up to and including 1982, Commonwealth government-owned vehicles excluded.

(c) 1988 data understated the number of vehicles on register for the Northern Territory.

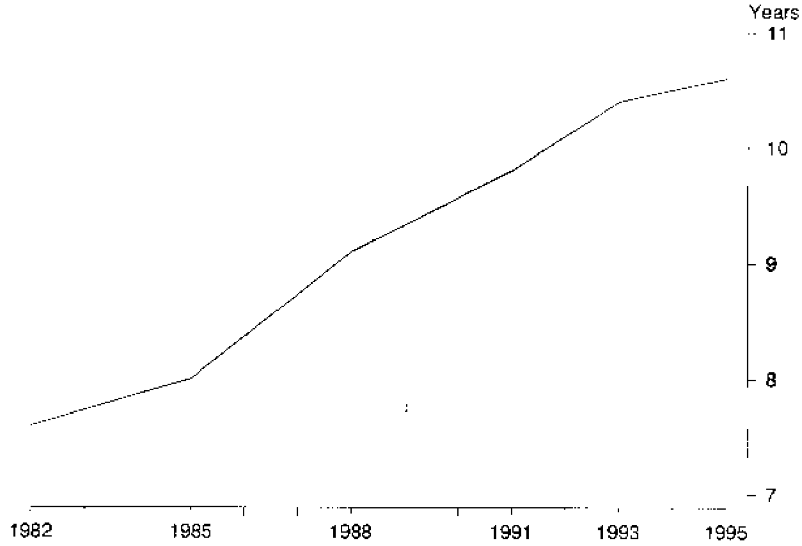
Source: ABS 1996b, p. 8.

Age of vehicle fleet

The average age of the vehicle fleet increased from 9.8 years in 1991 to 10.4 years at 30 June 1993, and 10.6 years at 31 May 1995. In 1995, Tasmania (12.1 years), South Australia (11.8 years) and Victoria (11.2 years) had the oldest vehicles. The Northern Territory (average age 9.4 years), New South Wales (9.6 years) and the Australian Capital Territory (9.9 years) had the newest vehicles.

The oldest vehicles, on average, were non-freight carrying trucks (average age 15.2 years), followed by rigid trucks (13.7 years). Buses (8.9 years) and motor cycles (10.0 years) had the lowest average ages. Passenger vehicles had an average age of 10.4 years.

1.6 AVERAGE AGE OF VEHICLE FLEET—Census Years



Source: ABS 1996b, p. 3.

Table 1.7 shows years of manufacture for the vehicle fleet. Motor cycles account for the different totals between tables 1.4 and 1.7. Vehicles not registered for normal road use are not included in census counts.

1.7 MOTOR VEHICLES ON REGISTER(a), By Year of Manufacture

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
Year of manufacture	no.	no.	no.	no.	no.	no.	no.	no.	no.
To 1970	84 969	123 981	60 996	47 397	46 468	17 155	1 720	5 197	387 883
1971–86	1 600 481	1 578 618	1 049 272	549 947	617 290	189 501	43 494	91 119	5 719 722
1987–95	1 554 015	1 094 717	824 839	336 816	474 451	105 902	41 218	82 450	4 514 408
Not stated	17 239	1 994	9 447	46	36	114	9	4	28 889
Total	**3 256 704**	**2 799 310**	**1 944 554**	**934 206**	**1 138 245**	**312 672**	**86 441**	**178 770**	**10 650 902**

(a) Motor cycles not included.

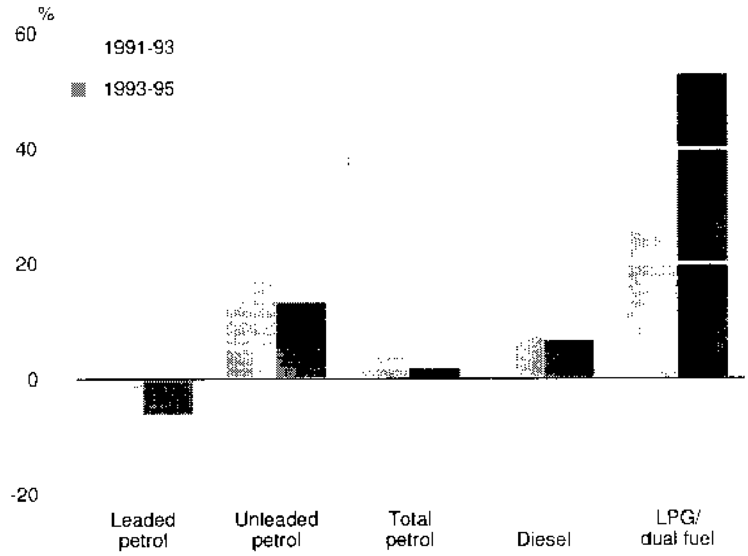
Source: ABS 1996b, p. 11.

New South Wales (47%), the Northern Territory (46%) and the Australian Capital Territory (45%) have the highest percentages of vehicles manufactured after 1986, when manufacture and importing of vehicles using leaded petrol ceased in Australia.

Type of fuel

Since the 1993 census, the number of vehicles using unleaded petrol increased by 13.3% per year, while the number using leaded petrol decreased by 6.0% per year. At the time of the 1995 census, the number of vehicles using leaded petrol still exceeded those using unleaded petrol, except in New South Wales, the Australian Capital Territory and the Northern Territory. However, more unleaded petrol was used than leaded petrol. The number of unleaded petrol powered vehicles would have been expected to overtake those using leaded petrol in the first half of 1996, if the relative increase in unleaded versus leaded vehicles experienced between 1993 and 1995 continued. The number of Liquefied Petroleum Gas (LPG) and/or dual powered vehicles more than doubled from 60,574 to 136,734 between censuses, but they still remained a small proportion of the total vehicle fleet (0.6% in 1993 and 1.2% in 1995). The number of diesel powered vehicles also increased at a faster rate than the overall fleet. Fewer trucks (rigid, articulated and non-freight carrying) used petrol in 1995 than in 1993.

1.8 PERCENTAGE CHANGES IN TYPE OF FUEL USED



Source: ABS 1996b, p. 2.

Fuel consumption

Total fuel consumption by all vehicles for the 12 months ended 30 September 1995 was estimated at 22,815 million litres. Passenger vehicles accounted for 62% (14,193 million litres) of total fuel consumed, followed by freight-carrying vehicles with 35% (8,055 million litres). Passenger vehicles were the major users of all fuel types except diesel. More articulated trucks, rigid trucks and buses run on diesel than any other fuel type.

1.9 TOTAL FUEL CONSUMPTION—Year ended 30 September 1995

	CONSUMPTION BY TYPE OF FUEL					
	Leaded petrol	*Unleaded petrol*	*Total petrol*	*Diesel*	*LPG/LNG/ dual fuel*	*Total*
Type of vehicle	million L	million L	million L	million L	million L	million L
Passenger vehicles	5 288	7 462	12 750	490	952	14 193
Motorcycles	43	46	88	—	—	88
Light commercial vehicles	1 141	1 135	2 276	826	555	3 658
Rigid trucks	98	8	106	1 668	44	1 818
Articulated trucks	**	n.a.	**	2 573	n.p.	2 579
Non-freight carrying trucks	n.p.	12	n.p.	33	n.p.	64
Buses	10	11	21	378	15	415
Total	**6 594**	**8 674**	**15 268**	**5 969**	**1 578**	**22 815**

Source: ABS 1996b, p 14.

Unleaded petrol is now used more than leaded petrol. In 1988, unleaded petrol accounted for 21% (3,337 million litres) of all petrol consumption, rising to 38% (5,764 million litres) in 1991 and 57% (8,674 million litres) in 1995. Together, leaded and unleaded petrol accounted for 67% (15,268 million litres) of total fuel consumption in 1995, down from 72% in 1991 and 75% in 1988.

Consumption of diesel in the 12 months ended 30 September 1995 was 5,969 million litres. This was 26% of total fuel consumed and represented an increase of 23% from the corresponding period in 1991. Consumption of LPG, Liquefied Natural Gas (LNG) and dual fuels, at 1,578 million litres (7% of total consumption), increased by 39% from 1991.

In 1994 road transport consumed 836.7 petajoules of energy (table 1.10). Cars consumed 66%, while light and heavy trucks used approximately 14% each. Petrol was the most significant fuel, accounting for 70% of total road transport energy consumption. Passenger cars used 86% of this petrol.

1.10 ENERGY CONSUMPTION OF ROAD TRANSPORT—1994

	FUEL TYPE				
	Petrol	*ADO*	*LPG*	*Natural gas(a)*	*Total*
Vehicle type	PJ	PJ	PJ	PJ	PJ
Passenger cars	500.7	23.0	31.2	0.1	555.0
Motorcycles	3.0	—		—	3.0
Light trucks	80.6	29.5	10.1	0.1	120.3
Medium tucks	—	23.2	0.3	0.1	23.6
Heavy trucks	0.2	119.1	0.2	—	119.5
Buses	0.4	16.9	0.1	0.7	18.1
Total	**584.9**	**211.7**	**41.9**	**1.0**	**839.5**

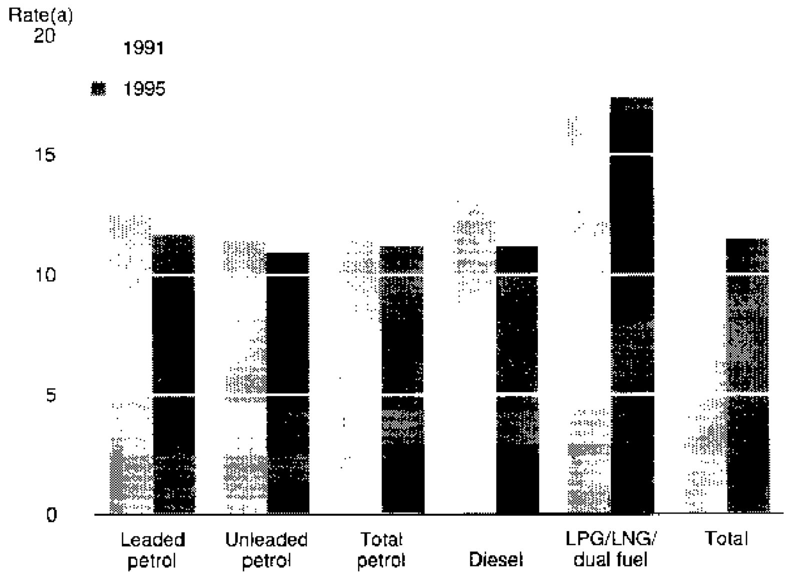
(a) Very approximate.

Source: National Greenhouse Gas Inventory Committee 1996, pp. 62–63.

The average rate of fuel consumption by all vehicles for all fuel types in the 12 months ended 30 September 1995 was 13.7 litres per hundred kilometres, down from the 1991 estimate of 14.2 litres per hundred kilometres. The average rate of fuel consumption for passenger vehicles was 11.5 litres per hundred kilometres. For those passenger vehicles using unleaded petrol, consumption averaged 10.9 litres per hundred kilometres, while leaded consumption averaged 11.7 litres per hundred kilometres.

Consumption of diesel fuel in the 12 months ended 30 September 1995 averaged 24.9 litres per hundred kilometres for all vehicles, with articulated trucks averaging 50.6 litres, rigid trucks 27.2 litres, light commercial vehicles 11.9 litres and passenger vehicles 11.2 litres per hundred kilometres. Consumption of LPG/LNG and dual fuels averaged 17.5 litres per hundred kilometres for all vehicles, with passenger vehicles averaging 17.4 litres and light commercial vehicles averaging 16.7 litres per hundred kilometres.

1.11 FUEL CONSUMPTION, Passenger Vehicles—Year ended 30 Sep 1995



(a) Litres per 100 kilometres

Source: ABS 1996c, p. 4.

USE OF INFRASTRUCTURE AND STOCK

Distance travelled by motor vehicles

While freight-carrying vehicles and buses on average travel greater distances, there are far more passenger vehicles on the road and this category shows the greatest aggregate distance travelled. Passenger vehicles accounted for 74% (123,691 million kilometres) of total distance travelled in Australia and freight-carrying vehicles 24% (39,570 million kilometres). Since 1976, the total distance travelled by passenger vehicles and freight-carrying vehicles has increased by 58% and 95% respectively.

The total distance travelled by all motor vehicles increased by 11% to 166,514 million kilometres from 1991 to 1995 and the average distance increased by 2% to 15,200 kilometres for the same period. However, the average for 1995 is still lower than the peak of 16,400 kilometres for the 12 months ended 30 September 1988.

Articulated trucks recorded the largest increases in average kilometres travelled, rising 12% from 1988 and 16% from 1991. Vehicles registered in Queensland recorded the highest distance travelled per vehicle at 17,000 kilometres, while Tasmania recorded the lowest average distance travelled.

1.12 TOTAL AND AVERAGE KILOMETRES TRAVELLED, By Type of Vehicle—Year ended 30 Sep 1995

Type of vehicle	*NSW*	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
TOTAL DISTANCE TRAVELLED (million kilometres)									
Passenger vehicles	36 562	32 832	24 727	10 315	12 847	3 091	808	2 510	123 691
Motor cycles	450	331	402	144	127	29	16	27	1 526
Light commercial vehicles	7 831	6 521	6 486	2 021	3 315	841	387	349	27 751
Rigid trucks	2 261	1 583	1 399	460	718	159	68	76	6 725
Articulated trucks	1 244	1 493	1 042	538	501	142	102	30	5 094
Other trucks	59	63	56	22	*39	4	*4	*2	249
Buses	405	315	304	137	188	44	55	29	1 479
Total	**48 812**	**43 140**	**34 417**	**13 636**	**17 735**	**4 311**	**1 441**	**3 023**	**166 514**
AVERAGE DISTANCE TRAVELLED(a) ('000 kilometres)									
Passenger vehicles	13.7	14.2	16.3	13.4	14.6	13.0	13.8	16.4	14.4
Motor cycles	6.1	4.7	5.9	5.1	3.5	4.0	4.2	5.3	5.2
Light commercial vehicles	17.5	17.9	19.2	16.7	16.8	14.2	18.1	19.5	17.7
Rigid trucks	22.0	19.2	21.9	16.9	17.2	14.6	19.0	26.9	20.0
Articulated trucks	83.3	85.8	92.5	103.2	79.9	86.9	108.3	109.5	87.9
Other trucks	22.5	14.9	19.4	11.5	14.0	4.4	17.1	*15.4	15.9
Buses	33.7	27.1	34.0	41.5	35.6	22.7	34.5	36.7	32.5
Total	14.7	15.1	17.1	14.2	15.2	13.5	16.0	16.8	15.2

(a) Average of all registered vehicles.

Source: ABS 1996c, p. 13.

Area of operation of motor vehicles

Of the total kilometres travelled by all vehicles in the 12 months ended 30 September 1995, an estimated 96% (159,148 million kilometres) was within the State/Territory of registration of the vehicle. This was the same proportion as that recorded for 1991.

About 53% (89,043 million kilometres) of aggregate kilometres driven by all vehicles was in a capital city area, similar to the 55% for 1991. In the Australian Capital Territory, all driving is regarded as capital city travel. Western Australia and South Australia also have population concentrated in their capital cities, and this is reflected in table 1.13. Queensland, with a relatively dispersed population, registered the greatest percentage of kilometres travelled outside the capital city area.

1.13 TOTAL AND AVERAGE KILOMETRES TRAVELLED, By Area of Operation—Year ended 30 Sep 1995

	AREA OF OPERATION					
State/Territory of registration	*Capital city*	*Other urban areas*	*Other areas*	*Intrastate total*	*Interstate*	*Total*
	TOTAL KILOMETRES TRAVELLED (million kilometres)					
New South Wales	27 633	8 682	10 683	46 998	1 814	48 812
Victoria	25 547	4 330	11 419	41 295	1 844	43 140
Queensland	12 279	9 936	10 471	32 685	1 731	34 417
South Australia	8 190	. .	4 487	12 677	959	13 636
Western Australia	10 786	. .	6 796	17 583	*153	17 735
Tasmania	1 611	1 557	1 071	4 239	*71	4 311
Northern Territory	645	. .	673	1 318	123	1 441
Australian Capital Territory	2 352	. .	. .	2 352	671	3 023
Australia	**89 043**	**24 505**	**45 600**	**159 148**	**7 367**	**166 514**
	AVERAGE KILOMETRES TRAVELLED(a) ('000 kilometres)					
New South Wales	11.8	7.5	6.6	14.4	3.5	15.0
Victoria	12.0	5.1	7.8	14.9	5.1	15.6
Queensland	10.3	8.5	7.8	16.3	5.5	17.2
South Australia	10.6	. .	9.4	13.8	6.9	14.7
Western Australia	11.5	. .	11.3	15.4	7.4	15.6
Tasmania	8.4	9.3	6.4	13.5	5.1	13.7
Northern Territory	11.0	. .	12.1	15.1	11.7	16.4
Australian Capital Territory	13.1	. .	. .	13.1	5.0	16.8
Australia	11.4	7.3	8.0	14.9	4.9	15.6

(a) Average does not include vehicles which travelled zero kilometres; therefore State and Australian averages vary from those in table **1.12**.

Source: ABS 1996c, p. 16.

PURPOSE OF TRAVEL

Business use accounted for an estimated 34% (56,312 million kilometres) of the total distance travelled in the 12 months ended 30 September 1995, 36% (20,076 million kilometres) of which involved carrying freight (table 1.14).

Business vehicles registered in Victoria and the Northern Territory recorded the highest average business kilometres travelled in the 12 months ended 30 September 1995, with 18,000 kilometres. Tasmania and the Australian Capital Territory recorded the lowest average with 13,000 kilometres.

Vehicles used partly or wholly for private purposes travelled an average distance of 8,000 kilometres. Vehicles registered in the Australian Capital Territory recorded the highest average usage for private purposes.

1.14 TOTAL AND AVERAGE KILOMETRES TRAVELLED, By Purpose(a)

	PURPOSE					
State/Territory of registration	*Laden*	*Unladen*	*Total business(b)*	*To and from work*	*Private*	*Total*
			TOTAL KILOMETRES TRAVELLED (million kilometres)			
NSW	5 685	2 088	16 812	10 607	21 393	48 812
Vic.	4 976	1 615	14 451	10 295	18 304	43 140
Qld	4 798	1 571	12 305	8 710	13 401	34 417
SA	1 568	589	4 368	2 747	6 521	13 636
WA	2 092	1 017	5 428	4 854	7 453	17 735
Tas.	456	196	1 416	815	2 080	4 311
NT	245	137	647	297	497	1 441
ACT	256	64	795	863	1 366	3 023
Aust.	**20 076**	**7 277**	**56 312**	**39 188**	**71 015**	**166 514**
			AVERAGE KILOMETRES TRAVELLED(c) ('000 kilometres)			
NSW	16.2	8.1	14.3	6.2	7.9	15.0
Vic.	17.0	8.4	18.0	6.2	7.8	15.6
Qld	18.9	9.6	16.9	8.2	8.3	17.2
SA	15.4	7.6	13.8	5.7	8.4	14.7
WA	15.2	9.0	14.1	7.4	8.1	15.6
Tas.	12.7	7.2	13.2	5.3	7.9	13.7
NT	17.9	12.4	18.0	6.0	7.8	16.4
ACT	18.8	7.6	12.6	6.8	8.9	16.8
Aust.	16.7	8.5	15.5	6.6	8.0	15.6

(a) Year ended 30 September 1995.

(b) Including the business travel of non-freight carrying vehicles, as well as the total business kilometres for some light commercial vehicles where the laden business kilometres could not be obtained.

(c) Average does not include vehicles which travelled zero kilometres.

Source: ABS 1996c, p. 18.

Travel to work/study

Table 1.15 shows that the majority of people travel to work/study as a single driver in a car, with 85% as either a driver or passenger in a car. New South Wales has the lowest percentage of car users with 80%, while Western Australia has the highest percentage (90%).

1.15 PERSONS TRAVELLING TO WORK/STUDY BY ROAD—April 1996(a)

	Car/truck/van as driver		*Car/truck/van as passenger*		*Bus*		*Motor bike/scooter*		*Bicycle*		*Total travelling to work/study*
	'000	%	000	%	'000	%	'000	%	'000	%	'000
New South Wales	1 917.3	73.4	161.2	6.2	235.9	9.0	27.0	1.0	54.2	2.1	2 610.8
Victoria	1 579.7	80.4	108.8	5.5	86.5	4.4	18.2	0.9	57.6	2.9	1 965.5
Queensland	1 074.1	79.2	111.0	8.2	74.6	5.5	27.0	2.0	49.1	3.6	1 356.7
South Australia	486.0	78.5	59.6	9.6	57.3	9.3	12.2	2.0	23.6	3.8	618.8
Western Australia	608.2	80.4	73.2	9.7	53.0	7.0	9.0	1.2	17.6	2.3	756.6
Tasmania	154.4	79.9	17.5	9.0	15.1	7.8	**1.4	**0.7	**4.0	**2.1	193.2
Northern Territory	56.0	80.8	**6.1	**8.8	**3.6	**5.2	**1.0	**1.5	**4.2	**6.0	69.3
Australian Capital Territory	116.3	76.4	15.4	10.1	19.8	13.0	**3.4	**2.2	**4.9	**3.2	152.2
Australia	**5 991.9**	**77.6**	**552.8**	**7.2**	**545.7**	**7.1**	**99.4**	**1.3**	**215.2**	**2.8**	**7 723.1**

(a) Totals for States/Territories do not necessarily equal the sum of items in a row because more than one mode may be specified.

Source: ABS 1997, p. 47.

Bus use

An estimated 1,435 million kilometres were travelled by all buses used for work purposes in the 12 months ended 30 September 1995, an increase of 2% from the 1991 survey. Route services accounted for 39% (562 million kilometres) of the total distance travelled, dedicated school bus services contributed 21% (302 million kilometres) and charter services 14% (198 million kilometres). Total passengers carried by buses in the 12 months ended 30 September 1995, excluding passengers carried for exclusively private purposes, were estimated at 1,013 million, an increase of 14% over the corresponding figure for 1991. About 70% (711 million passengers) of total passengers were carried by route services, and a further 21% (208 million passengers) were carried by dedicated school bus services.

1.16 BUSES, Total Kilometres Travelled and Passengers Carried(a)

State/Territory of registration	MAIN TYPE OF SERVICE: Route service	Dedicated school bus service	Charter service	Other(b)	Total(c)
TOTAL KILOMETRES TRAVELLED (million kilometres)					
New South Wales	172	98	66	61	397
Victoria	93	74	51	79	298
Queensland	101	62	36	100	299
South Australia	79	23	19	*15	136
Western Australia	74	28	*12	69	182
Tasmania	17	10	4	9	40
Northern Territory	*7	n.p.	n.p.	37	54
Australian Capital Territory	20	n.s.	n.p.	*4	28
Australia	**562**	**302**	**198**	**374**	**1 435**
TOTAL PASSENGERS(d) (million passengers)					
New South Wales	306	95	*19	*5	425
Victoria	129	46	*18	*10	203
Queensland	104	38	9	12	163
South Australia	61	11	*5	*2	78
Western Australia	59	8	*3	6	76
Tasmania	14	9	*1	1	24
Northern Territory	*12	n.p.	n.p.	3	16
Australian Capital Territory	25	n.s.	**	*1	28
Australia	**711**	**208**	**57**	**38**	**1 013**

(a) Year ended 30 September 1995.

(b) Includes tour service operations.

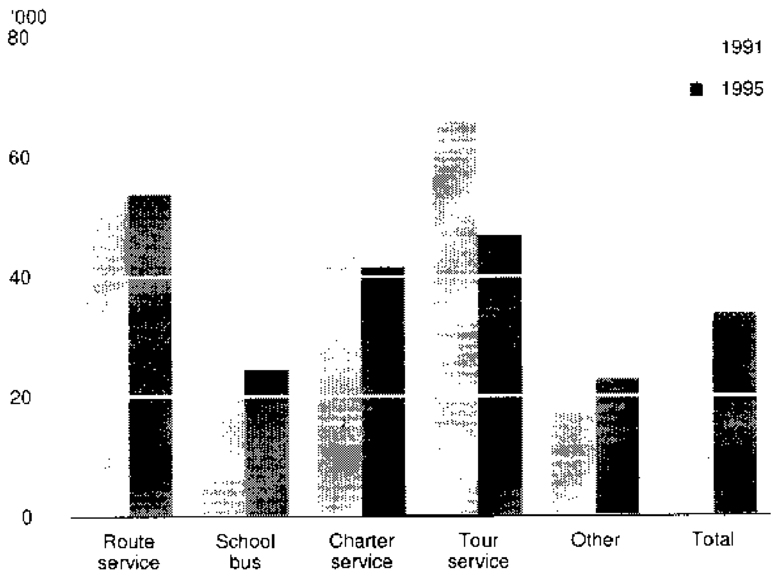
(c) Excluding distance travelled by buses used exclusively for private purposes, as well as travel by some buses where main type of service could not be obtained.

(d) Excludes passengers carried by buses used exclusively for private purposes.

Source: ABS 1996c, pp. 28–29.

The average distance travelled by all buses used for work purposes in the 1995 survey period was 33,900 kilometres. Buses registered in South Australia recorded the highest average distance travelled (43,100 kilometres) and Tasmanian registered buses travelled the lowest average distance (23,700 kilometres). Buses used for route services and tour services recorded the highest average distance travelled with 53,700 kilometres and 46,900 kilometres respectively.

1.17 AVERAGE ANNUAL BUS KILOMETRES TRAVELLED, By Type of Service

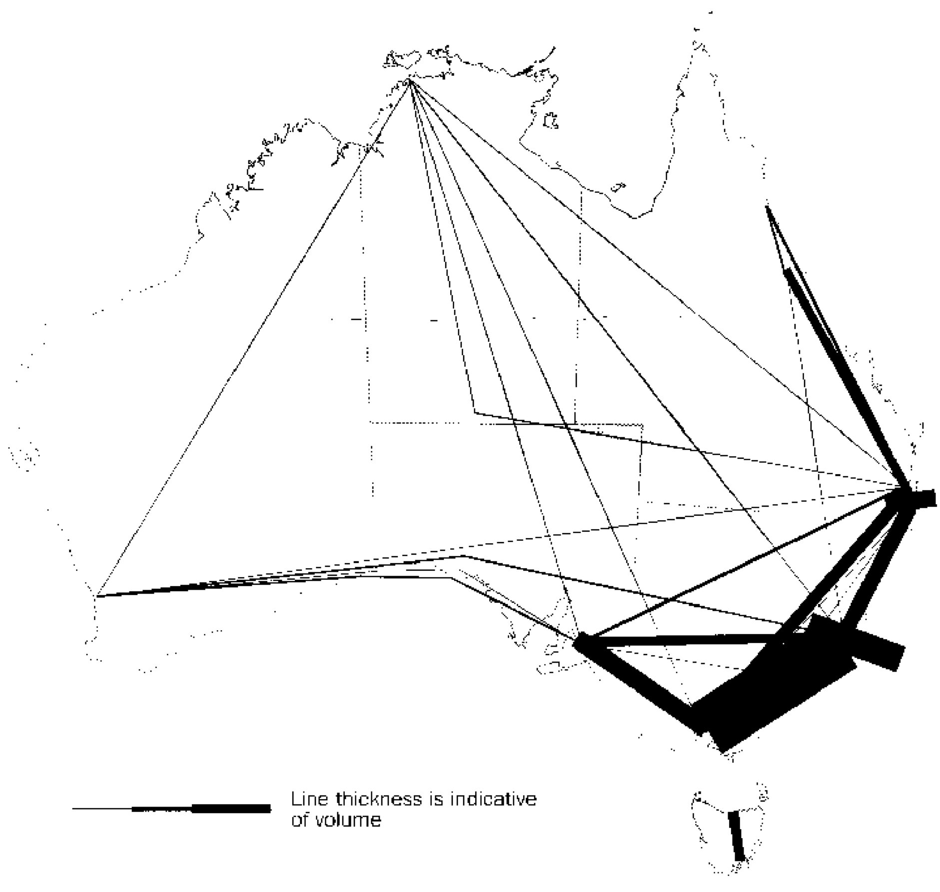


Source: ABS 1996c, p. 9.

FREIGHT VEHICLES

Map 1.18 gives a diagrammatic representation of the major road freight movements within Australia for 1994-95.

1.18 ROAD FREIGHT TASK—1994–95



Source: Bureau of Transport and Communications Economics 1994, p. 17.

Freight-carrying vehicles travelled an estimated 20,076 million laden kilometres for business purposes during the 12 months ended 30 September 1995, a rise of 18% from the corresponding period in 1991.

Vehicles used for freight-carrying purposes averaged 17,000 laden kilometres. Vehicles registered in Queensland and the Australian Capital Territory recorded the highest average laden business distance travelled.

Two measures of freight movements are included in the Survey of Motor Vehicle Use. The first, measured in tonne-kilometres, is obtained by multiplying the average weight of loads carried by the distance travelled while laden, to provide a measure of the freight borne by the roads system.

The second indicator, the mass of freight moved, measured in tonnes, provides an estimate of the total weight of freight moved by road in Australia.

Total tonne-kilometres travelled by freight carrying vehicles was estimated to be 119,229 million tonne-kilometres for the 12 months ended 30 September 1995, an increase of 35% from 1991 and 60% from 1985. This large rise is in contrast to the 3% increase from 1988 to 1991.

Articulated trucks had the largest proportion of the total tonne-kilometres travelled with 75% (89,384 million tonne-kilometres). Rigid trucks accounted for 21% (25,044 million tonne-kilometres) and light commercial vehicles for 4% (4,799 million tonne-kilometres). Articulated trucks travelled an average of 1,592,000 tonne-kilometres, rigid trucks 82,000 tonne-kilometres and light commercial vehicles 6,000 tonne-kilometres. Articulated trucks showed an increase of 28% in average tonne-kilometres travelled from the 1991 estimate.

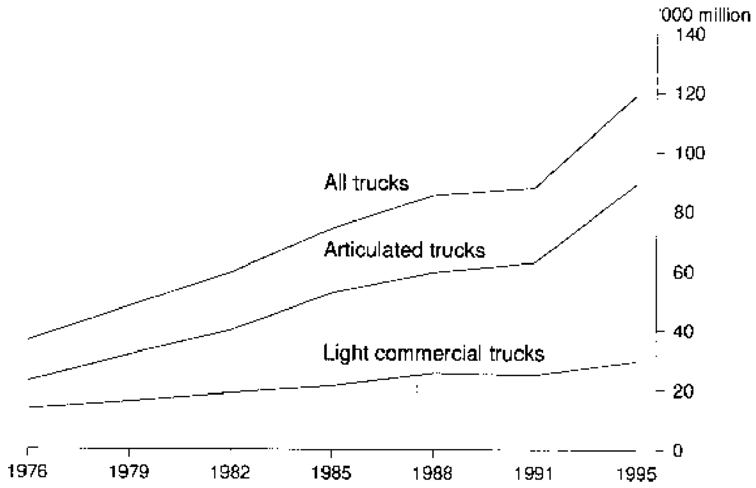
It has been estimated that 1,222 million tonnes of goods were carried by freight-carrying vehicles in the 12 months ended 30 September 1995, an increase of 19% from 1991. Vehicles registered in New South Wales carried the largest proportion of tonnes with 27% (331 million tonnes), followed by vehicles registered in Queensland and Victoria, with 24% (289 million tonnes) and 22% (273 million tonnes) respectively.

1.19 LADEN BUSINESS KILOMETRES TRAVELLED AND TONNES CARRIED—Year ended 30 Sep 1995

	STATE/TERRITORY OF REGISTRATION								
Type of vehicle	*NSW*	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
TOTAL KILOMETRES TRAVELLED (million kilometres)									
Light commercial vehicles	3 208	2 711	2 998	808	1 266	261	128	177	11 558
Rigid trucks	1 608	1 110	1 006	322	488	101	48	57	4 740
Articulated trucks	868	1 156	794	438	337	93	69	23	3 778
Total	*5 685*	*4 976*	*4 798*	*1 568*	*2 092*	*456*	*245*	*256*	*20 076*
AVERAGE KILOMETRES TRAVELLED ('000 kilometres)									
Light commercial vehicles	13.3	13.4	16.3	11.3	13.5	10.2	13.4	16.6	13.8
Rigid trucks	16.7	15.1	16.9	13.0	13.1	11.7	15.1	21.0	15.5
Articulated trucks	60.2	68.0	73.2	85.5	56.3	58.9	73.6	84.0	67.3
Total	*16.2*	*17.0*	*18.9*	*15.4*	*15.2*	*12.7*	*17.9*	*18.8*	*16.7*
TOTAL TONNE-KILOMETRES TRAVELLED (million tonne-kilometres)									
Light commercial vehicles	1 217	1 202	1 246	330	582	105	43	74	4 799
Rigid trucks	7 737	5 599	5 291	1 749	3 473	630	* 305	259	25 044
Articulated trucks	18 758	23 770	19 129	10 632	11 201	2 081	3 583	500	89 384
Total	*27 713*	*30 571*	*25 666*	*12 442*	*15 256*	*2 816*	*3 932*	*833*	*119 229*
AVERAGE TONNE-KILOMETRES TRAVELLED ('000 tonne-kilometres)									
Light commercial vehicles	5.1	6.0	6.8	4.6	6.2	4.1	4.5	7.0	5.7
Rigid trucks	80.3	76.3	88.9	70.5	92.9	72.4	*95.7	96.5	81.8
Articulated trucks	1 302.2	1 399.5	1 762.6	2 023.0	1 867.9	1 314.1	3 849.1	1 862.9	1 592.0
Total	*78.9*	*104.7*	*101.3*	*101.3*	*111.2*	*78.4*	*287.1*	*61.4*	*99.5*
TOTAL TONNES CARRIED (million tonnes)									
Light commercial vehicles	23	26	23	9	14	3	1	1	100
Rigid trucks	173	120	162	43	82	24	5	6	614
Articulated trucks	134	127	104	35	75	20	10	2	508
Total	*331*	*273*	*289*	*87*	*171*	*47*	*16*	*10*	*1 222*
AVERAGE LOAD CARRIED (kilograms)									
Light commercial vehicles	386	402	390	394	392	387	291	368	391
Rigid trucks	3 960	3 970	4 198	4 995	5 646	4 521	3 833	3 286	4 307
Articulated trucks	19 856	17 959	22 339	21 319	26 117	21 162	41 608	21 314	20 969
Total	*2 170*	*2 320*	*2 230*	*2 572*	*2 959*	*2 310*	*3 950*	*1 360*	*2 359*

Source: ABS 1996c, pp. 20, 21, 25.

1.20 TONNE-KILOMETRES TRAVELLED BY FREIGHT-CARRYING VEHICLES



Source: ABS 1996c, p. 7.

Of the total tonnes of goods carried in the 12 months ended 30 September 1995, rigid trucks accounted for 50% (614 million tonnes), while articulated trucks accounted for 42% (508 million tonnes). The average load carried per trip was 21.0 tonnes for articulated trucks, 4.3 tonnes for rigid trucks, and 0.4 tonnes for light commercial vehicles.

ECONOMIC SIGNIFICANCE

Associated businesses

Road transport activity in Australia is supported by a range of businesses. Their primary activities include: the manufacturing of vehicles and parts; the construction of roads and bridges; the wholesale and retail trade of related products and services; the transport and storage of goods and vehicles; and property and business services such as vehicle hire. At 30 June 1995, there were 70,230 business locations on register whose primary activities were associated with road transport. Table 1.21 shows numbers of businesses involved in various transport-related activities.

1.21 TRANSPORT-RELATED BUSINESSES—30 June 1995

Business	*NSW*	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
MANUFACTURING									
Motor vehicle manufacturing	18	44	24	9	8	1	0	0	104
Motor vehicle body manufacturing	137	147	103	34	61	9	1	1	493
Automotive electrical and instrument equipment manufacturing	19	24	10	10	5	1	0	0	69
Automotive component manufacturing n.e.c.	209	276	151	86	105	9	2	4	842
Total manufacturing locations	*383*	*491*	*288*	*139*	*179*	*20*	*3*	*5*	*1 508*
CONSTRUCTION									
Road and bridge construction(a)	336	362	341	107	101	84	45	19	1 395
WHOLESALE TRADE									
Petroleum product wholesaling	502	334	378	128	192	63	24	13	1 634
Car wholesaling	154	82	78	29	40	5	0	5	393
Commerical vehicle wholesaling	70	47	49	22	20	5	5	0	218
Motor vehicle new car dealing	1 193	839	686	257	307	63	32	51	3 428
Motor vehicle dismantling and used part dealing	248	221	166	106	106	24	7	5	883
Total wholesale trade locations	*2 167*	*1 523*	*1 357*	*542*	*665*	*160*	*68*	*74*	*6 556*
RETAIL TRADE									
Car retailing	1 309	892	718	376	339	114	44	52	3 844
Motor cycle dealing	258	180	201	59	93	26	16	8	841
Trailer and caravan dealing	66	79	78	31	28	16	4	1	303
Automotive fuel retailing	2 465	1 826	1 505	568	880	307	81	79	7 711
Automotive electrical services	507	347	258	88	125	26	13	21	1 385
Smash repairing	2 110	1 600	1 170	497	583	150	44	75	6 229
Tyre retailing	549	433	412	201	239	46	25	22	1 927
Automotive repair and services n.e.c.	3 853	3 247	2 404	881	1 113	243	130	156	12 027
Total retail trade locations	*11 117*	*8 604*	*6 746*	*2 701*	*3 400*	*928*	*357*	*414*	*34 267*
TRANSPORT AND STORAGE									
Road freight transport	6 872	5 253	4 319	1 357	1 438	541	169	179	20 128
Long distance bus transport	154	88	114	40	48	25	17	5	491
Short distance bus transport(b)	582	354	372	114	227	91	25	12	1 777
Taxi and other road passenger transport	683	454	696	181	66	59	21	48	2 208
Parking services	85	84	74	35	34	7	3	2	324
Services to road transport n.e.c.	45	32	23	24	4	1	3	0	132
Road freight forwarding	170	172	87	40	67	15	8	3	562
Total transport and storage locations	*8 591*	*6 437*	*5 685*	*1 791*	*1 884*	*739*	*246*	*249*	*25 622*
PROPERTY AND BUSINESS SERVICES									
Motor vehicle hiring	224	135	282	32	97	62	38	11	(c)882
Total property and business service locations	*224*	*135*	*282*	*32*	*97*	*62*	*38*	*11*	*(c)882*
ALL BUSINESSES									
Total	**22 818**	**17 552**	**14 699**	**5 312**	**6 326**	**1 993**	**757**	**772**	**70 230**

(a) Sole category.

(b) Includes tramways.

(c) Includes business location count from 'Other territories'.

Source: ABS 1995.

Employment

Table 1.22 shows employed persons in road transport between 1987 and 1997. Refer to chapter 5 for a comparison of employment figures between transport modes.

1.22 EMPLOYED PERSONS IN ROAD TRANSPORT

Year(a)	NSW	Vic.	Qld	SA	WA	Tas.	Aust.(b)
			ROAD FREIGHT TRANSPORT				
1987	52 548	30 890	20 680	7 409	10 081	3 521	126 890
1988	46 542	33 459	21 434	9 242	12 944	4 148	129 739
1989	41 327	33 496	25 808	8 759	14 074	3 293	128 809
1990	44 996	34 196	23 994	10 574	13 032	3 585	132 676
1991	54 714	25 680	23 125	11 011	13 467	4 380	135 280
1992	48 540	33 084	21 798	9 768	15 123	2 185	132 599
1993	45 848	33 683	21 052	10 977	15 004	2 656	130 547
1994	45 983	36 263	24 667	9 905	14 911	3 100	136 579
1995	43 001	33 013	23 431	8 966	10 255	2 505	122 231
1996	39 532	33 104	27 039	8 210	10 228	3 519	123 064
1997	44 595	31 670	26 049	8 839	11 507	3 443	127 486
			ROAD PASSENGER TRANSPORT				
1987	20 981	15 533	8 514	4 730	5 158	1 279	58 075
1988	25 407	14 566	9 720	3 508	5 777	2 194	65 393
1989	22 471	13 253	10 059	5 222	5 956	869	60 041
1990	19 471	13 991	8 603	4 468	5 659	2 236	57 289
1991	19 820	13 495	11 610	5 515	3 945	1 740	58 568
1992	22 709	16 430	12 676	4 794	3 457	2 371	64 210
1993	22 659	14 578	12 767	6 309	4 920	1 531	64 603
1994	21 992	12 918	13 125	4 711	5 920	1 236	62 854
1995	18 382	15 583	12 816	5 666	6 119	2 150	63 624
1996	25 587	16 984	15 784	6 368	5 815	1 552	75 145
1997	21 000	14 835	16 091	5 529	5 536	1 245	66 191

(a) Data as at February for each year.

(b) Australia total includes the Australian Capital Territory and the Northern Territory.

Note: Due to the highly disaggregated nature of these data, many of the State cells in this table, particularly for the smaller States, will have a Relative Standard Error of 25% or more and should therefore be used with caution. Please refer to the Technical Notes from the ABS publication *Labour Force, Australia* (Cat. no. 6203.0), for further information about standard errors for Labour Force Survey data.

Source: ABS n.d.

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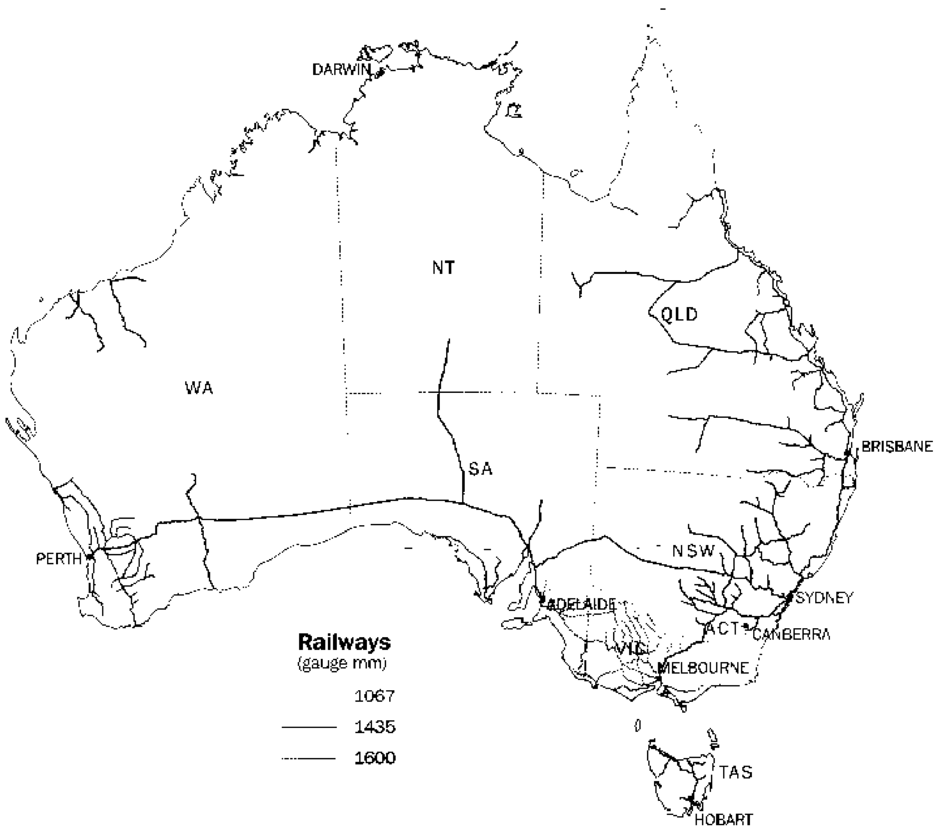
CHAPTER 2 TRAINS, TRAMS AND RAILWAYS

INFRASTRUCTURE AND PASSENGERS

Railway infrastructure

Australia's government railway network is shown in map 2.1. In 1995, this network comprised 36,026 kilometres, but there were also important private railways constructed for conveying specific freight such as mineral ores and sugar cane . The main importance of rail is for intrastate bulk freight. It is no longer important for long-distance passenger travel due to the growth of long-distance car travel, competition from air transport and, to a lesser extent, an increase in long-distance coach services. However, suburban railways play an important role in the major capital cities even though most private journeys in urban areas are undertaken by car. The physical impacts of railways are localised, and the use of electric power on suburban railways in Sydney, Melbourne and Brisbane reduces the potential air pollution levels in those cities.

2.1 AUSTRALIAN RAILWAY NETWORK



Source: ABS 1996a.

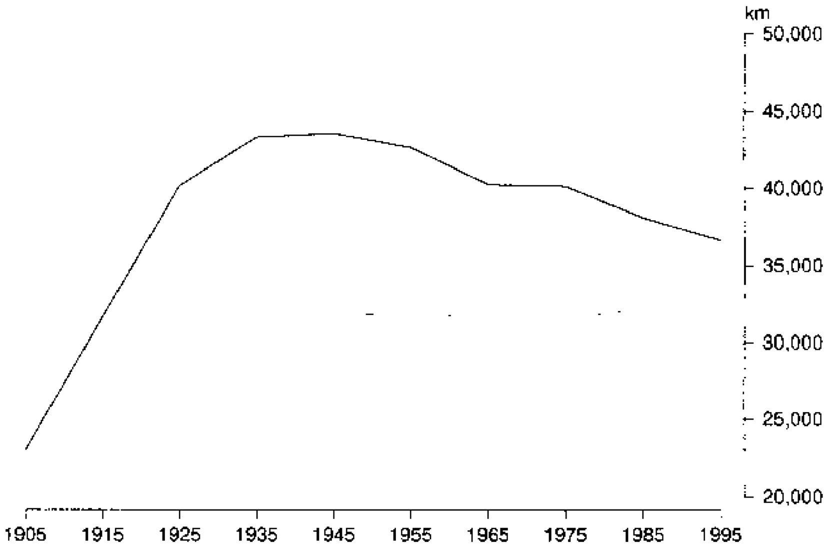
Table 2.2 shows that in 1995 New South Wales had the greatest number of route-kilometres open for activity by government railways, with 9,810 kilometres (27% of the network). New South Wales also has the most extensive urban rail system (see table 2.4). Government railways in Tasmania and the Northern Territory are under national control, as is most of South Australia's rail network. Australia's government rail system reached its greatest extent—approximately 44,000 kilometres—in 1941 (see graph 2.3).

2.2 GOVERNMENT RAILWAYS, Route-Kilometres Open—By System

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*National*	*Aust.*
Year	km	km	km	km	km	km	km
1985	9 908	5 894	10 231	153	5 563	7 465	39 214
1986	9 909	5 518	10 224	153	5 553	7 333	38 710
1987	9 909	5 403	10 210	149	5 553	7 315	38 539
1988	9 917	5 289	10 089	127	5 553	7 187	38 162
1989	7 755	5 200	10 094	125	5 553	7 050	35 777
1990	7 747	5 196	10 107	125	5 554	6 757	35 486
1991	9 810	5 179	10 015	125	5 554	6 612	37 295
1992	9 810	5 179	10 011	120	5 554	6 559	37 233
1993	9 810	5 107	9 797	120	5 583	6 235	36 652
1994	9 810	5 107	9 357	120	5 583	6 235	36 212
1995	9 810	4 917	9 452	112	5 583	6 152	36 026

Source: ABS 1997 p. 531; 1996c p. 559; 1992 p. 593.

2.3 GOVERNMENT RAILWAYS, Route-Kilometres Open—By Year



Source: ABS 1996a.

2.4 SUBURBAN RAIL SYSTEMS, Principal Features—1988–89

	NSW	VIC		QLD	WA	SA	
Features	CityRail	Met	V/Line	QR	Trans-Perth	STA	Total
Track-kilometres	730	391	n.a.	202	64	128	n.a.
Kilometres travelled ('000)	32 473	13 800	2 866	6 746	2 333	2 500	60 718
Carriages	2 068	919	191	306	102	131	3 717

Source: Industry Commission 1991, p. 16.

Railway passengers

Table 2.5 provides a split for suburban and country rail passengers. While New South Wales had the most suburban passengers, Victoria had the most country passengers.

2.5 GOVERNMENT RAILWAYS, Passenger Journeys

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*National*	*Aust.*
Year	'000	'000	'000	'000	'000	'000	'000
1992–93							
Suburban	229 814	106 015	39 404	7 540	10 315	—	393 088
Country	1 540	5 309	988	—	269	200	8 306
1993–94							
Suburban	234 800	100 955	38 392	8 720	22 500	—	—
Country	2 100	6 196	947	—	246	223	9 712
1994–95							
Suburban	250 000	105 360	37 026	8 400	23 500	—	—
Country	2 200	6 390	895	—	247	191	9 923

Source: ABS 1997 p. 531; 1996c p. 559.

2.6 GOVERNMENT RAILWAYS, Train-Kilometres(a) Travelled—1992–93

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*National*	*Total*
Passenger	'000	'000	'000	'000	'000	'000	'000
Suburban	31 291	15 981	7 090	n.a.	7 957	—	n.a.
Country	3 874	7 036	2 488	—	957	1 078	15 433

(a) One train travelling one kilometre for revenue purposes.

Source: ABS 1995, p. 650.

In April 1996, approximately 655,000 people (8.5% of the total) reported that they commuted by train to their place of work or study. Almost all of these were commuters on the urban rail systems in the five largest cities. The State with the highest proportion of rail commuters was New South Wales, with 12.9% of the State total. Between them, New South Wales and Victoria accounted for 80% of rail commuters.

2.7 RAIL COMMUTERS—April 1996

	NSW	Vic.	Qld	SA	WA	Aust.
	'000	'000	'000	000	'000	'000
Number of rail commuters	337.3	183.9	65.8	21.5	46.0	654.5
Total commuters	2 610.8	1 965.5	1 356.7	618.8	756.6	7 723.1
Proportion of total commuters (%)	12.9	9.4	4.8	3.5	6.1	8.5

Source: ABS 1996b, p. 47.

Tram infrastructure and passengers

Tram services operate in Melbourne and, to a limited extent, in Adelaide. In 1990–91, the Melbourne tram fleet was upgraded with 20 new light rail vehicles, which operate on selected lines throughout the system and on the former train lines to St Kilda and Port Melbourne. In Adelaide, a service operates between the city and the suburb of Glenelg.

Table 2.8 shows that the numbers of people travelling by tram has fallen, but that patronage is higher per kilometre of route available. Most of these figures relate to Melbourne (see table 2.9).

2.8 TRAMWAYS, Operation Statistics

	1987–88	1988–89	1989–90	1990–91	1991–92	1992–93
Route-kilometres at 30 June	343	351	239	239	246	247
Vehicle-kilometres	24 621	24 971	24 940	23 183	23 425	22 113
Rolling stock at 30 June	641	651	684	626	656	637
Passenger journeys ('000)	117 876	121 444	97 593	109 343	113 721	102 127

Source: ABS 1995, p. 648.

2.9 TRAMWAYS—1992–93

	Melbourne	Adelaide
Route-kilometres at 30 June	236	11
Vehicle-kilometres	21 380	773
Rolling stock at 30 June	616	21
Passenger journeys ('000)	100 658	1 469

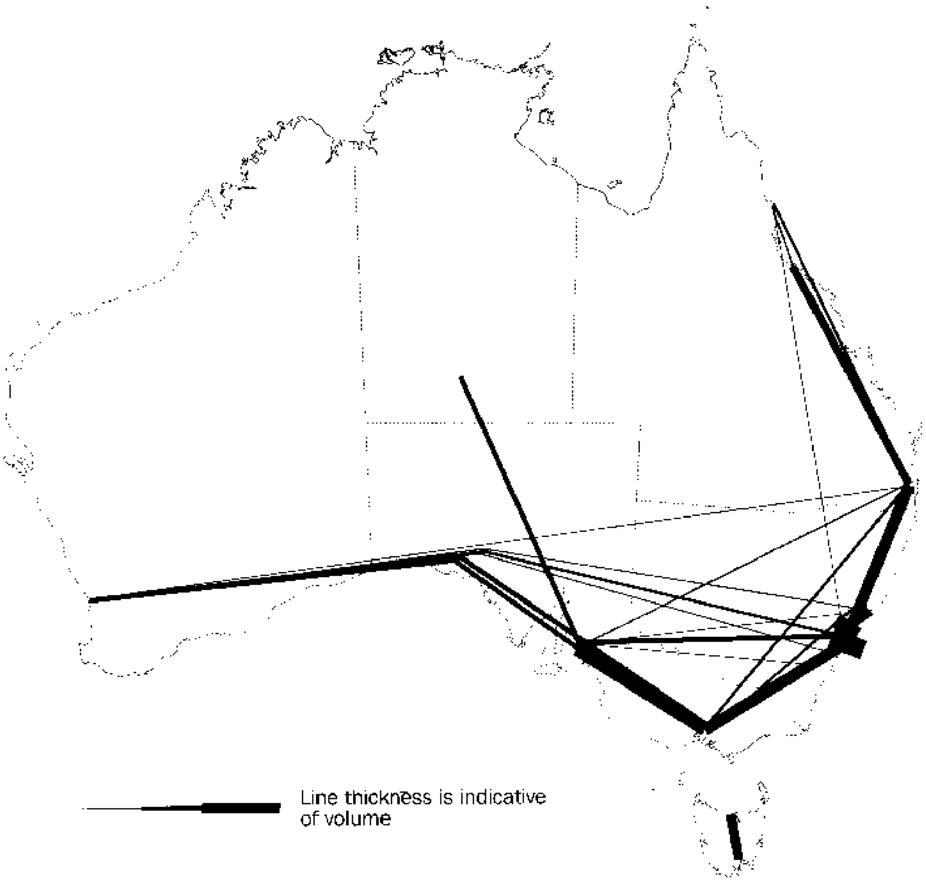
Source: ABS 1995, p. 647.

RAIL FREIGHT

Freight movements

The vast majority of rail freight movement is intrastate. In the June quarter 1995, almost 94% of all rail freight was carried within Western Australia, Queensland and New South Wales. In these States, mine railways in particular account for the large tonnages carried. Sugar cane and grain freight movements are also significant. Much of this raw material is taken directly to export ports within the States, so there is limited interstate freight. Other modes—road, sea and air—tend to show higher proportions of interstate freight movements. For rail freight moved interstate, New South Wales was the principal origin and Victoria the principal destination.

2.10 RAIL FREIGHT TASK, Government Railways—1994–95



Source: Bureau of Transport and Communications Economics 1994, p. 20.

2.11 RAIL FREIGHT MOVEMENTS—June quarter 1995

	DESTINATION							
	NSW and ACT	*Vic.*	*Qld*	*SA*	*WA*	*NT*	*Tas.*	*Aust.*
Origin	'000 t	'000 t	'000 t	'000 t	'000 t	'000 t	'000 t	'000 t
NSW and ACT	15 769	332	253	205	140	11	n.a.	16 710
Vic.	169	962	112	112	139	3	n.a.	1 496
Qld	117	47	27 492	11	16	—	n.a.	27 684
SA	119	257	45	2 788	144	75	n.a.	3 428
WA	41	57	17	47	39 839	1	n.a.	40 002
Tas.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	609	609
NT	3	1	1	19	—	—	n.a.	25
Aust.	**16 218**	**1 656**	**27 920**	**3 182**	**40 278**	**90**	**609**	**89 954**

Source: ABS 1996d, p. 11.

Table 2.12 shows details of rail freight carried on government railways from 1984–85 to 1994–95. During this period, freight carried increased by 34% across Australia. In 1994–95, the government railway system in Queensland carried the most freight (96.8 million tonnes) and recorded the highest net tonne-kilometres, reflecting the importance of the government-owned mine railways in that State. In Western Australia, where the important iron ore railways are privately owned, a much smaller proportion of bulk freight is carried on government railways than in Queensland and New South Wales.

2.12 GOVERNMENT RAILWAYS, Freight Carried and Net Tonne-Kilometres

Year	*NSW*	*Vic.*	*Qld*	*WA*	*Australian National*	*National Rail*	*Total*
			FREIGHT CARRIED (million tonnes)				
1984–85	48	12	65	22	13	—	160
1985–86	54	11	74	21	13	—	172
1986–87	55	11	75	21	13	—	174
1987–88	54	11	75	22	11	—	173
1988–89	54	10	81	24	14	—	179
1989–90	54	10	83	25	14	—	186
1990–91	58	10	83	24	13	—	188
1991–92	57	8	91	26	13	—	195
1992–93	62	10	90	27	14	1	203
1993–94	66	8	92	28	15	9	217
1994–95	65	6	97	29	8	10	215
			NET TONNE-KILOMETRES (million)				
1984–85	12 393	3 543	18 438	4 328	6 270	—	44 972
1985–86	13 415	3 094	20 450	4 005	7 081	—	48 045
1986–87	13 540	3 588	20 871	4 062	6 873	—	48 934
1987–88	14 212	r3474	20 676	4 203	7 165	—	49 730
1988–89	13 552	r3365	20 884	4 881	8 082	—	50 764
1989–90	14 100	r3672	22 579	4 872	8 115	—	53 338
1990–91	14 222	3 700	22 869	4 583	7 789	—	53 163
1991–92	13 811	2 704	24 719	4 878	7 799	—	53 911
1992–93	14 813	3 678	24 614	4 970	8 480	—	56 555
1993–94	16 200	4 212	25 175	5 447	9 159	13 900	74 093
1994–95	15 300	1 790	26 498	6 235	1 500	16 714	68 037

Source: ABS 1997 p. 532; 1996c p. 560; 1992 p. 594.

Non-government railways contribute considerably to the movement of rail freight. Tables 2.12 and 2.13 show that in 1994–95, they carried 45% of freight tonnage and travelled 36% of the total tonne-kilometres. In 1994–95 iron ore railways carried 122 million tonnes (31% of rail freight carried in Australia) for a total of 37.2 thousand million tonne-kilometres (35% of the Australian total).

2.13 NON-GOVERNMENT RAILWAYS, Freight Carried & Net Tonne-Kilometres

Year	*Iron ore railways*	*Sugar tramways*	*Coal railways(a)*	*Other non-government railways*	*Total(a)*
			TONNES CARRIED (million)		
1984–85	87	24	8	11	130
1985–86	87	22	8	10	127
1986–87	91	23	8	11	133
1987–88	95	24	9	11	137
1988–89	91	24	7	14	136
1989–90	104	24	9	13	150
1990–91	114	22	8	14	158
1991–92	111	19	9	12	151
1992–93	113	26	9	12	159
1993–94	118	29	9	12	167
1994–95	122	32	8	12	173
			TONNE-KILOMETRES (million)		
1984–85	27 649	408	98	223	28 378
1985–86	28 517	368	116	201	29 202
1986–87	29 552	393	116	220	30 281
1987–88	30 218	425	126	230	30 999
1988–89	27 866	425	106	274	28 671
1989–90	31 654	438	123	263	32 478
1990–91	34 533	400	114	299	35 347
1991–92	34 362	334	123	259	35 078
1992–93	34 929	468	117	253	35 767
1993–94	36 849	527	122	248	37 747
1994–95	37 177	572	111	250	38 110

(a) Includes transfers to and from government railways.

Source: ABS 1997 p. 532; 1996c p. 560; 1992 p. 594.

RESOURCE USE

In the decade from 1985–86 to 1995–96, total energy used by rail transport decreased. Auto diesel oil, although still the predominant fuel, is being used less, as is industrial diesel fuel. The use of electricity increased during the decade.

2.14 ENERGY CONSUMPTION, By Rail Transport

	1985–86	*1987–88*	*1989–90*	*1991–92*	*1993–94*	*1995–96*
Rail transport	PJ	PJ	PJ	PJ	PJ	PJ
Auto diesel oil	24.9	25.3	23.3	22.3	21.8	22.3
Electricity	4.0	4.7	5.7	5.9	6.0	6.6
Industrial diesel fuel	2.6	2.6	1.7	1.7	1.1	0.0
Other fuels(a)	0.0	0.1	0.0	0.1	0.1	0.1
Total	**31.6**	**32.6**	**30.7**	**29.9**	**29.0**	**28.9**

(a) Includes natural gas and black coal.

Source: Australian Bureau of Agricultural and Resource Economics 1997, p. 121.

EMPLOYMENT

Table 2.15 shows the numbers of persons employed in rail transport between 1987 and 1997.

2.15 EMPLOYED PERSONS IN RAIL TRANSPORT

Year(a)	*NSW*	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*Aust.(b)*
1987	28 151	16 112	23 388	5 300	6 371	1 459	80 780
1988	32 626	17 243	19 999	5 520	3 837	957	80 429
1989	30 135	16 587	19 364	3 844	2 935	568	73 434
1990	21 981	11 600	17 880	4 938	3 340	230	59 969
1991	26 575	13 396	20 092	2 919	4 724	165	67 870
1992	22 302	12 945	14 598	2 263	5 113	525	57 745
1993	19 908	12 591	15 596	1 051	6 978	678	56 801
1994	14 946	11 697	14 486	2 781	5 747	662	50 320
1995	22 104	8 519	15 329	2 915	3 212	248	52 327
1996	19 362	11 083	14 695	1 699	1 798	250	48 967
1997	19 380	7 452	20 221	2 198	2 053	141	51 566

(a) Employment data are for February of each year.

(b) Australia total includes the Australian Capital Territory and the Northern Territory.

Note: Due to the highly disaggregated nature of these data, many of the State cells in this table, particularly for the smaller States, will have a Relative Standard Error of 25% or more and should therefore be used with caution. Please refer to the Technical Notes from the ABS publication *Labour Force, Australia* (Cat. no. 6203.0), for further information about standard errors for Labour Force Survey data.

Source: ABS n.d.

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CHAPTER **3**

SHIPPING

PORT INFRASTRUCTURE

Most of the 118 Australian ports load and receive both bulk and containerised freight. Some, such as Geelong, Gladstone and Whyalla deal almost exclusively with bulk freight. These include commodities such as petroleum products, coal, grain, chemicals and molasses. Others load and/or receive primarily containerised freight.

3.1 NUMBER OF PORTS—1997

State/Territory	no.
New South Wales	14
Victoria	5
Queensland	25
South Australia	18
Western Australia	23
Tasmania	15
Northern Territory	18
Australia	**118**

Source: Department of Transport 1997, pers. comm.

Table 3.2 shows various components of Australia's seaport infrastructure (the berths and storage area) for the major ports. The majority of non-bulk berths and international container berths are held by Melbourne, with Sydney having the next largest number of international berths. Adelaide and Fremantle have the next largest number of non-bulk berths, but they have far fewer international container berths.

Newcastle has the most dry bulk berths, with most of the cargo handled at the designated coal berths. Sydney and Brisbane operate the largest number of liquid bulk berths.

Table 3.3 shows significant projects likely to be undertaken at Australian ports in the period to 2014–15.

3.2 SEAPORT INFRASTRUCTURE OF MAJOR PORTS(a)—1994

Seaport	International container berths(b)	Other non-bulk berths	Dry bulk berths	Liquid bulk berths	Uncovered area
	no.	no.	no.	no.	ha
New South Wales					
Sydney	10	8	7	8	142
Newcastle	0	3	14	0	10
Port Kembla	0	5	7	2	n.a.
Victoria					
Melbourne	13	20	7	4	85
Queensland					
Brisbane	5	7	8	7	56
Cairns	0	9	1	1	1
Townsville	0	3	4	1	7
South Australia					
Adelaide	2	17	6	2	128
Western Australia					
Fremantle	4	15	5	4	31
Tasmania					
Hobart	0	6	1	1	5
Launceston	0	2	6	1	9
Devonport	0	3	2	2	6
Burnie	0	3	1	1	3
Northern Territory					
Darwin	0	3	1	1	n.a.

(a) Seaports which handle significant quantities of coastal bulk and non-bulk freight.

(b) Dedicated container berths with container cranes.

Source: Bureau of Transport and Communications Economics 1995.

3.3 FUTURE PROJECTS PLANNED TO 2014–15

Seaport	*Significant projects underway, planned or committed to 2014–15*
New South Wales	
Sydney	New general cargo, liquid and dry bulk berths at Botany Bay, dependent on closure of operations in Sydney Harbour.
Newcastle	Development of Basin Area for general cargo and possibly new berths at Kooragang Island.
Port Kembla	Extension of coal terminal.
Victoria	
Melbourne	Further development at Webb and Swanson Dock container terminals and possible relocation of Coode Island liquid bulk facility.
Queensland	
Brisbane	Further development at Fisherman Islands.
Cairns	Further development of general cargo facilities.
Townsville	Additional outer harbour berths and channel deepening.
Tasmania	
Burnie	Expansion of general cargo facilities.
Devonport	Lengthen swinging basin and East Devonport general cargo berth.
Launceston	New general cargo berth.
Hobart	New cold store.
Northern Territory	
Darwin	Relocation of port to East Arm.

Source: Bureau of Transport and Communications Economics 1995.

STOCK OF SHIPS

Registered ships

Table 3.4 presents details of ships registered in Australia at 30 June 1985, 1990, and 1995. At 30 June 1995, Queensland had the highest number of ships registered (2,341), closely followed by New South Wales (2,056). Most registered ships were recreational vessels (4,543), followed by fishing vessels (2,094).

There has been an increase of 26% in registered ships over the 10 year period 1985 to 1995. Most of this is a result of a large increase in registrations in Queensland (109% for recreational vessels and 144% for vessels used for commercial purposes. The Northern Territory also recorded a large increase (100%) in recreational vessels over the same period.

3.4 SHIPS REGISTERED(a) IN AUSTRALIA—30 June

Location	*Recreational* no.	*Fishing* no.	*Other commercial* no.	*Government* no.	*Demise chartered(b)* no.	*Total* no.
			1985			
NSW	1 385	323	232	1	6	1 947
Vic.	396	152	109	20	1	678
Qld	616	576	146	30	6	1 374
SA	189	223	41	9	—	462
WA	339	455	123	4	6	927
Tas.	165	204	87	3	—	459
NT	109	68	15	2	—	194
Aust.	**3 199**	**2 001**	**753**	**69**	**19**	**6 041**
			1990			
NSW	1 357	272	239	3	6	1 877
Vic.	453	177	104	5	4	743
Qld	944	628	284	28	5	1 889
SA	210	262	40	3	—	515
WA	427	382	126	3	5	943
Tas.	170	214	56	4	—	444
NT	159	56	18	1	2	236
Aust.	**3 720**	**1 991**	**867**	**47**	**22**	**6 647**
			1995			
NSW	1 537	277	230	4	8	2 056
Vic.	537	197	118	—	3	855
Qld	1 289	667	356	26	3	2 341
SA	244	279	39	1	—	563
WA	518	405	122	1	1	1 047
Tas.	200	217	54	4	1	476
NT	218	52	23	1	—	294
Aust.	**4 543**	**2 094**	**942**	**37**	**16**	**7 632**

(a) Any Australian ship longer than 24 metres must be registered. Any Australian ship travelling overseas must be registered regardless of length. A ship less than 24 metres may be registered, but this is not required by law.

(b) A demise chartered ship is a foreign owned ship chartered by way of a charter party to an Australian based operator, who is an Australian national and who under the charter party has whole possesion and control of the ship, including the right to appoint the master and crew of the ship.

Source: ABS n.d.(b).

Australian trading fleet

Table 3.5 shows that between 1986 and 1996, the Australian trading fleet decreased from 97 to 79 ships. Dead weight tonnage decreased substantially for overseas owned and Australian registered ships (892,758 in 1986 down to 381,329 in 1996), as well as for overseas owned and registered (407,274 in 1986 down to 22,231 in 1996). These reductions were largest for Australia's overseas fleet, and Australia's overseas owned and registered coastal fleet.

3.5 AUSTRALIAN TRADING FLEET OF SHIPS, 150 Gross Tonnes or More

	Coastal fleet			*Overseas fleet*			*Total(a)*		
	no.	DWT(b)	Gross tonnes	no.	DWT(b)	Gross tonnes	no.	DWT(b)	Gross tonnes
1986									
Australian owned and registered	56	1 423 860	913 490	18	1 037 996	609 520	74	2 461 856	1 523 010
Overseas owned, Australian registered	6	87 623	63 406	7	805 135	460 306	13	892 758	523 712
Overseas owned and registered	3	100 149	58 773	7	307 125	186 381	10	407 274	245 154
Total	**65**	**1 611 632**	**1 035 669**	**32**	**2 150 256**	**1 256 207**	**97**	**3 761 888**	**2 291 876**
1996									
Australian owned and registered	34	895 604	645 880	21	1 519 992	1 153 116	69	2 418 734	1 802 514
Overseas owned, Australian registered	2	45 098	25 808	4	336 231	208 793	6	381 329	234 601
Overseas owned and registered	3	18 121	12 036	1	4 110	2 815	4	22 231	14 851
Total	**39**	**958 823**	**683 724**	**26**	**1 860 333**	**1 364 724**	**79**	**2 822 294**	**2 051 965**

(a) For 1996, trading fleet of less than 2 000 DWT have been included in total but not in Coastal/ Overseas split.

(b) Dead weight tonnage.

Source: Department of Transport 1996; ABS n.d.(b).

USAGE OF MARINE VESSEL STOCK AND INFRASTRUCTURE

Table 3.6 shows the number of ship visits to Australian ports by trading ships between 1993–94 and 1995–96. Total number of ship visits in 1995–96 was 17,656, an increase of 18% on 1994–95 visits, but slightly less than 1993–94. The ports most frequently visited included Melbourne, the Queensland ports of Brisbane and Thursday Island, Western Australia's Fremantle, and the New South Wales' ports of Botany Bay, Newcastle and Sydney.

3.6 PORT VISITS BY TRADING SHIPS(a)

	1993–94	1994–95	1995–96
Port	no.	no.	no.
Melbourne	2 439	1 799	2 350
Brisbane	1 385	1 348	1 312
Fremantle	1 387	1 233	1 309
Thursday Island	1 117	1 248	1 279
Botany Bay	1 155	872	1 012
Newcastle	1 001	894	915
Sydney	903	798	856
Dampier	765	731	744
Gladstone	563	378	584
Port Hedland	569	506	547
Darwin	461	443	512
Townsville	459	441	496
Port Kembla	646	305	483
Hay Point	537	548	464
Adelaide	488	417	443
Burnie	452	395	405
Devonport	429	29	379
Geelong	407	241	333
Launceston	376	139	289
Hobart	318	117	253
Cairns	241	134	240
Bunbury	218	225	220
Geraldton	178	200	210
Weipa	187	72	200
Hastings	264	53	179
Portland	180	118	173
Port Walcott	163	187	144
Mackay	142	110	124
Gove	97	112	99
Esperance	64	68	86
Albany	86	88	85
Port Stanvac	77	48	69
Thevenard	47	17	58
Port Lincoln	73	40	56
Port Pirie	70	44	52
Wyndham	77	55	51
Whyalla	51	31	48
Abbot Point	59	64	46
Milner Bay	50	47	44
Karumba	3	4	40
Other	512	378	467
Total	**18 696**	**15 007**	**17 656**

(a) A trading ship is defined as a commercial vessel over 200 gross tonnes. Many vessels made more than one port call per voyage.

Source: Department of Transport 1997, pers. comm.

Domestic cargo

Table 3.7 summarises coastal freight loaded and discharged, and table 3.8, coastal freight loaded by major commodity, from 1990–91 to 1994–95. The majority of domestic freight loaded and discharged is interstate freight, which increased over the period (by 20% for freight loaded, and 22% for freight discharged). Map 3.9 shows domestic sea freight task for 1992–93, as a graphical representation of the major movements within Australia.

In terms of tonne-kilometres, iron ore is the most freighted commodity, having increased by 35% from 1990–91 to 1994–95. Most iron ore is loaded at the Western

Australian port of Port Hedland and despatched to New South Wales (Department of Transport 1995). Petroleum oil decreased by 31% over the same period.

3.7 COASTAL FREIGHT SUMMARY

	LOADED			DISCHARGED		
	Interstate	*Intrastate*	*Total*	*Interstate*	*Intrastate*	*Total*
Year	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes
1990–91	28 175	16 011	44 186	28 015	16 097	44 112
1991–92	29 366	14 209	43 575	29 513	14 449	43 962
1992–93	29 342	14 890	44 232	29 072	15 853	44 925
1993–94	30 769	14 505	45 274	31 748	14 228	45 976
1994–95	33 692	15 498	49 190	34 180	16 286	50 466

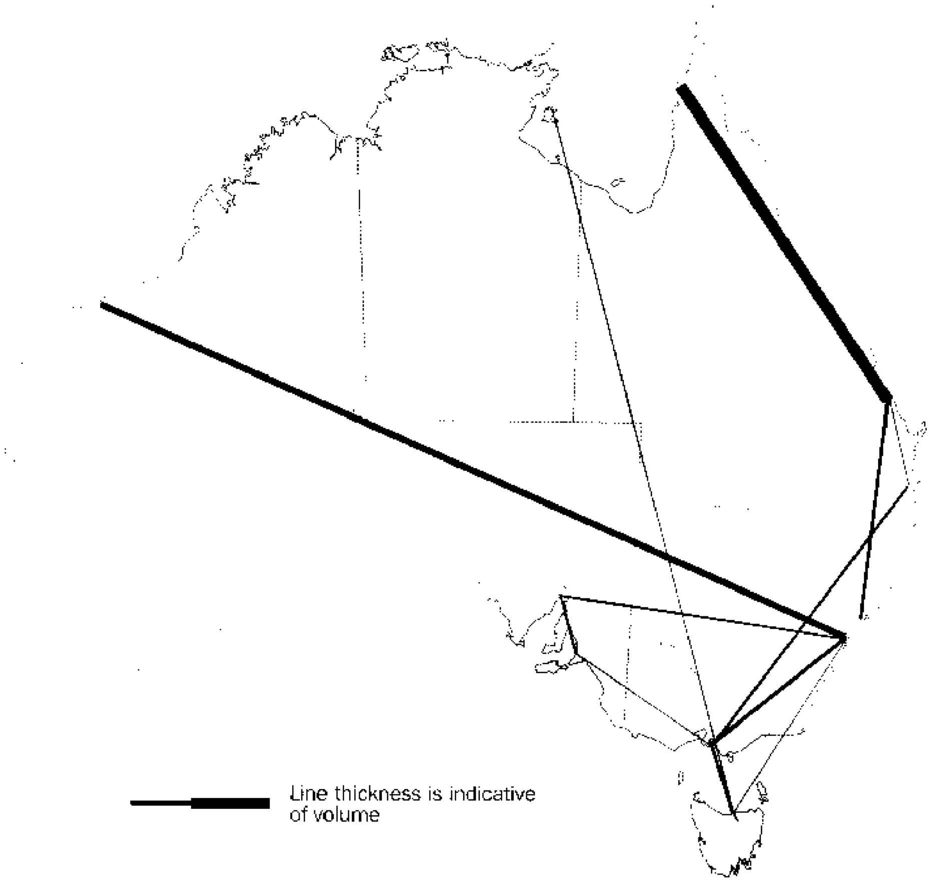
Source: Department of Transport 1995.

3.8 COASTAL FREIGHT LOADED

Year	*Iron ore*	*Bauxite/ alumina*	*Petroleum oil*	*Petroleum products*	*Other cargo*	*Total*
			TONNES ('000)			
1990–91	5 700	10 200	9 100	6 300	12 800	44 200
1991–92	7 400	9 100	7 700	5 900	13 600	43 600
1992–93	7 000	9 900	7 100	5 700	14 500	44 200
1993–94	8 100	9 600	6 100	5 800	15 600	45 300
1994–95	8 400	10 200	7 200	6 300	17 100	49 200
			TONNE-KILOMETRES ('000 million)			
1990–91	28.6	23.2	19.1	7.9	14.9	93.8
1991–92	36.3	20.3	17.5	9.2	16.2	96.5
1992–93	31.5	22.3	14.6	9.1	18.4	96.0
1993–94	37.3	21.5	10.7	9.2	20.2	98.8
1994–95	38.7	22.5	13.2	10.3	24.5	109.2

Source: Department of Transport 1995.

3.9 DOMESTIC SEA FREIGHT TASK—1992–93



Source: Bureau of Transport and Communications Economics 1994.

Table 3.10 details the most frequently used ports in terms of tonnages of coastal cargo loaded and discharged for 1994–95. The largest tonnage of coastal cargo was loaded in Queensland (12,555,000 tonnes), with the majority of this occurring at Weipa (8,326,000 tonnes of bauxite/alumina). The Western Australian port of Port Hedland loaded the next most, at 6,324,000 tonnes, most of which was iron ore.

New South Wales' ports discharged the largest tonnage of coastal cargo (19,196,000 tonnes), followed by Queensland (15,193,000 tonnes). The Queensland port of Gladstone discharged the largest tonnage (8,718,000 tonnes), followed by two New South Wales' ports (Port Kembla and Newcastle).

3.10 COASTAL CARGO LOADED AND DISCHARGED, By Port—1994–95

Seaport	*Loaded* '000 tonnes	*Discharged* '000 tonnes
New South Wales		
Sydney	56	2 432
Botany Bay	756	3 765
Newcastle	338	5 157
Port Kembla	2 603	7 742
Other	1 205	100
Total	*4 957*	*19 196*
Victoria		
Melbourne	1 859	3 471
Geelong	1 219	971
Hastings	5 248	917
Other	33	653
Total	*8 360*	*6 011*
Queensland		
Brisbane	1 830	4 188
Gladstone	1 418	8 718
Weipa	8 326	53
Other	981	2 234
Total	*12 555*	*15 193*
South Australia		
Adelaide	785	1 772
Ardrossan	967	—
Klein Point	1 444	—
Port Stanvac	691	230
Thevenard	1 062	—
Whyalla	1 087	1 206
Other	1 081	176
Total	*7 117*	*3 384*
Western Australia		
Fremantle	1 874	1 546
Exmouth/Onslow	1 381	—
Port Hedland	6 324	361
Other	1 701	846
Total	*11 280*	*2 753*
Tasmania		
Hobart	560	968
Burnie	1 016	705
Devonport	1 061	603
Launceston	312	1 266
Port Latta	1 223	17
Other	28	40
Total	*4 200*	*3 599*
Northern Territory		
Darwin	79	259
Groote Eylandt	628	20
Other	14	51
Total	*721*	*330*
Australia	**49 190**	**50 466**

Source: Department of Transport 1995.

Most coastal cargo comprises bulk commodities, most of which are dry (table 3.11). In 1994–95, Queensland ports loaded the largest tonnage of dry bulk goods (10,654,000 tonnes) and New South Wales discharged the most (13,426,000 tonnes). New South Wales' ports also discharged the greatest volume of liquid freight (5,542,000 tonnes), with Victoria loading the most of this freight type.

The greatest volume of coastal containerised cargo moves between Melbourne and Tasmania (Bureau of Transport and Communications Economics 1995, p.17), with

705,000 tonnes loaded from Victorian ports and 885,000 tonnes discharged in Tasmania in 1994–95.

3.11 COASTAL FREIGHT, By Pack Type—1994–95

	BULK		NON-BULK		TOTAL
	Dry	Liquid	Container	Other	
State/Territory	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes
LOADED					
New South Wales	2 983	800	192	982	4957
Victoria	64	7191	705	399	8360
Queensland	10 654	1 801	17	83	12555
South Australia	6 042	1 027	9	39	7117
Western Australia	7 674	3518	71	18	11 280
Tasmania	2 451	214	743	792	4 200
Northern Territory	622	—	4	95	721
Australia	**30 480**	**13 944**	**2 349**	**2 408**	**49 190**
DISCHARGED					
New South Wales	13426	5 542	53	175	19 196
Victoria	2 169	1 698	751	1 392	6 011
Queensland	10 528	4 530	36	99	15 193
South Australia	2 730	617	0	37	3 384
Western Australia	381	2 152	211	10	2 753
Tasmania	1 426	960	885	327	3 599
Northern Territory	3	204	25	97	330
Australia	**30 663**	**15 703**	**1 962**	**2 138**	**50 466**

Source: Department of Transport 1995.

Overseas ship and cargo movements

Merchandise trade by sea represents almost the entire quantity of international merchandise transported between Australia and other countries (table 3.12). Exports account for the vast majority of overseas merchandise trade by sea. Merchandise sea exports increased by 39% between 1988–89 and 1995–96, from 269.3 million tonnes to 373.6 million tonnes. The gross weight tonnage of merchandise imported by sea has also increased over recent years (from 32.2 million tonnes in 1988–89 to 47.3 million tonnes in 1995–96).

3.12 INTERNATIONAL MERCHANDISE TRADE

	SEA		TOTAL	
	GWT	*Change per year*	*GWT*	*Change per year*
Year	'000 tonnes	%	'000 tonnes	%
		IMPORTS		
1988–89	32 249	n.a.	n.a.	n.a.
1989–90	32 195	–0.2	n.a.	n.a.
1990–91	34 416	6.9	n.a.	n.a.
1991–92	n.a.	n.a.	n.a.	n.a.
1992–93	39 459	n.a.	39 636	n.a.
1993–94	41 819	6.0	42 020	6.0
1994–95	45 901	9.8	46 141	9.8
1995–96	47 061	2.5	47 303	2.5
		EXPORTS		
1988–89	269 332	n.a.	270 164	n.a.
1989–90	285 883	6.1	286 666	6.1
1990–91	307 290	7.5	308 261	7.5
1991–92	316 602	3.0	318 901	3.4
1992–93	327 952	3.5	329 118	3.2
1993–94	342 841	4.5	344 118	4.6
1994–95	363 065	5.9	364 611	6.0
1995–96	373 582	2.9	375 491	3.0

Source: ABS, unpublished data, International Trade.

Table 3.13 presents international sea merchandise statistics by State. In 1995–96 New South Wales received the largest volume of imports (13.5 million tonnes), followed by Queensland (12.0 million tonnes). Between 1988–89 and 1995–96, the largest increase in merchandise sea imports was recorded by Queensland, with a 213% increase over this period.

With respect to sea merchandise exports, Western Australian ports loaded the greatest volume (177.2 million tonnes in 1995–96). This represented nearly half (47%) of total exports by sea in this year. The largest increase in exports since 1988–89 was recorded by New South Wales' ports, with a 52% increase in tonnage up to 1995–96.

3.13 SEA MERCHANDISE TRADE

Year	NSW GWT '000	Vic. GWT '000	Qld GWT '000	SA GWT '000	WA GWT '000	Tas. GWT '000	NT GWT '000	Aust.(a) GWT '000
IMPORTS								
1988–89	10 743	7 497	3 816	2 711	6 766	466	1 157	33 156
1989–90	10 590	6 625	4 682	2 062	6 514	586	1 190	32 249
1990–91	10 197	4 948	7 056	3 005	5 546	420	1 017	32 189
1991–92	10 826	5 128	8 041	3 185	5 878	277	1 081	34 416
1992–93	11 649	6 540	8 449	3 938	7 465	326	1 092	39 459
1993–94	12 205	7 271	10 041	3 481	7 152	433	1 235	41 818
1994–95	13 598	8 605	10 946	3 029	7 995	455	1 273	45 901
1995–96	13 510	9 073	11 963	3 146	7 940	388	1 042	47 062
EXPORTS								
1988–89	47 831	8 159	72 827	5 492	122 526	6 420	5 264	269 332
1989–90	52 555	8 080	77 450	6 787	127 360	5 052	8 070	285 883
1990–91	62 794	7 740	78 154	7 662	137 397	4 919	8 006	307 290
1991–92	62 843	6 680	84 202	7 939	142 733	4 565	6 838	316 602
1992–93	67 590	9 175	85 725	7 331	145 618	4 379	6 718	327 952
1993–94	69 261	11 035	86 436	7 989	156 253	4 541	5 946	342 841
1994–95	68 086	8 163	92 892	5 839	175 711	5 015	5 862	363 065
1995–96	72 906	10 662	93 869	7 248	177 224	4 569	5 647	373 582

(a) Includes tonnage where State not recorded.

Source: ABS, unpublished data, International Trade.

Coastal shipping passenger task

Over the 10 year period between 1984–85 and 1994–95, total passenger task increased by 31%, whereas total passenger kilometres decreased by 33% (table 3.14). The large decrease in passenger kilometres was due to a decrease in cruises taken over this period. Both interstate and ferry voyages increased considerably.

3.14 COASTAL SHIPPING PASSENGER TASKS

	TYPE OF VOYAGE			
Year	Cruise	Interstate	Ferry(a)	Total
PASSENGERS ('000)				
1984–85	80.6	121.0	11 366.7	11 568.3
1987–88	49.2	183.2	14 765.0	14 997.4
1990–91	44.0	214.2	14 557.0	14 815.2
1994–95	41.3	248.3	14 812.5	15 102.1
PASSENGER KILOMETRES (million)				
1984–85	569.3	49.9	77.8	697.0
1987–88	327.4	75.6	99.8	502.8
1990–91	312.0	88.4	101.4	501.8
1994–95	244.0	102.5	117.1	463.6

(a) Excludes some small private operators.

Source: Apelbaum Consulting Group Pty Ltd 1997.

Offshore exploration and development

In 1996 there were 55 ships engaged in offshore exploration and development (table 3.15). Thirty-eight of these were service ships providing maintenance services to offshore oil and natural gas rigs in Bass Strait and the North West Shelf off the coast of Western Australia.

3.15 OFFSHORE EXPLORATION AND DEVELOPMENT—1996

Type of ship	*no.*
Semi-submersible rigs	4
Jackup rigs	3
Offshore production vessels	4
Seismic survey ships	5
Antarctic resupply and research	1
Rig service ships	38
Total	**55**

Source: Department of Transport 1996.

USAGE OF RESOURCES

Liquid petroleum consumption by water transport decreased by 42% between 1982–83 and 1993–94 (from 73.8 petajoules to 43.0 petajoules), but increased to 59.7 petajoules in 1995–96 (table 3.16). Liquid petroleum consumption by water transport as a proportion of total consumption by the transport industry decreased from 8.9% to 5.2% over this period. About 78% of total energy used by shipping was in the form of fuel oil.

3.16 LIQUID PETROLEUM CONSUMPTION, Water Transport

	Auto diesel oil	*Industrial diesel oil*	*Fuel oil*	*Total water transport*	*Proportion of total transport*
	PJ	PJ	PJ	PJ	%
1982–83	6.1	9.5	58.1	73.8	8.9
1983–84	5.0	6.7	52.8	64.5	7.6
1984–85	4.9	7.0	49.1	61.0	6.9
1985–86	4.2	5.8	41.4	51.4	5.8
1986–87	7.0	5.5	41.4	53.9	5.9
1987–88	7.1	5.0	43.3	55.4	5.8
1988–89	7.0	4.3	44.2	55.5	5.6
1989–90	6.2	4.2	41.7	52.1	5.2
1990–91	4.8	3.1	36.7	44.6	4.5
1991–92	5.7	3.1	35.1	44.0	4.4
1992–93	5.6	2.7	32.4	40.7	4.0
1993–94	7.1	2.3	33.6	43.0	4.1
1994–95	9.9	3.1	44.6	57.6	5.4
1995–96	11.3	1.8	46.6	59.7	5.2

Source: Adapted from Australian Bureau of Agricultural Resource Economics 1995, ABS 1996.

Table 3.17 shows the average fuel efficiency of Australian flag coastal fleet between 1975 and 1987. Fuel efficiency has improved for each of the ship types over this period, with the largest change occurring for dry bulk vessels (50% improvement in fuel efficiency).

3.17 CHANGES IN FUEL EFFICIENCY, By Vessel Type

	1975	1980	1985	1987
Ship type	Tonnes/day/ '000 DWT	Tonnes/day/ '000 DWT	Tonnes/day/ '000 DWT	Tonnes/day/ '000 DWT
General cargo	3.68	4.13	3.22	2.97
Dry bulk	1.04	0.92	0.74	0.52
Tankers	1.23	1.14	0.86	0.75

Source: Bureau of Industry Economics 1994.

ECONOMIC SIGNIFICANCE

Expenditure by governments on water transport amounted to $359 million in 1994–95 (table 3.18). This compares with a total of $10,873 million spent by all levels of government on the transport industry in that year. Since 1989–90, this was a drop of 31%, whereas outlays by all levels of government on the total transport industry over this period remained stable.

3.18 TOTAL OUTLAYS BY ALL LEVELS OF GOVERNMENT

	1989–90	1990–91	1991–92	1992–93	1993–94	1994–95
Industry	$m	$m	$m	$m	$m	$m
Water transport	519	488	461	367	529	359
Total transport	10 976	10 675	11 009	10 335	9 373	10 873

Source: ABS 1996.

In economic terms, water transport has contributed between $1.71 billion and $1.74 billion to total GDP over the years 1989–90 through to 1992–93. Since then, water transport has increased to $1.94 billion towards GDP, representing 0.5% of Australia's GDP for 1994–95. See Chapter 5 for a comparison of the transport modes and their contribution to GDP.

In addition to these economic indicators, water transport contributes in terms of employment in the industry and the transport of valuable trade merchandise.

Value of trade

Tables 3.12 and 3.13 show the gross weight tonnage of international merchandise trade by sea as an indication of the physical volume of goods imported and exported from Australian ports. The value of such goods is shown in tables 3.19 and 3.20.

Whereas the volume of international trade merchandise was almost entirely transported by sea in recent years (tables 3.12 and 3.13), the value of such merchandise trade accounted for about 70% of the total value of imports and 80% of exports (table 3.19).

Although the rate of increase in the value of sea trade merchandise has varied between 1989–90 and 1995–96 for both imports and exports, there was an overall increase of 45% for imports by sea, and 44% for exports.

3.19 VALUE OF MERCHANDISE TRADE

	Sea		Total	
Year	$m	% change per year	$m	% change per year
		IMPORTS		
1989–90	38 083.9	n.a.	51 333.4	n.a.
1990–91	35 096.0	–7.8	48 912.2	–4.7
1991–92	36 480.4	3.9	50 984.0	4.2
1992–93	43 419.0	19.0	59 575.4	16.8
1993–94	47 317.7	9.0	64 469.7	8.2
1994–95	54 232.2	14.6	74 619.0	15.7
1995–96	55 280.2	1.9	77 791.7	4.2
		EXPORTS		
1989–90	41 462.4	n.a.	49 078.4	n.a.
1990–91	43 422.9	4.7	52 398.9	6.8
1991–92	44 506.9	2.4	55 026.9	5.0
1992–93	49 239.3	10.6	60 702.3	10.3
1993–94	50 929.1	3.4	64 548.4	6.3
1994–95	52 936.6	3.9	67 052.0	3.9
1995–96	59 822.6	13.0	76 080.4	13.4

Source: ABS unpublished data, International Trade.

Table 3.20 details the value of international merchandise trade by State. Together, New South Wales and Victorian ports discharged 72% of sea merchandise imports in value terms in 1995–96 ($39,970 million). Western Australian ports experienced the largest increase in value of imports received between 1988–89 and 1995–96, from $2,944 million to $5,320 million (an increase of 81% over this period).

The value of merchandise trade exported by sea was more evenly distributed across the States, with New South Wales, Victoria, Queensland and Western Australia all exporting goods to the value of $10,000 million or more from their ports in 1995–96. The largest increase in value of exports was experienced by Western Australia (78%) between 1988–89 and 1995–96, followed by South Australia (77%) and New South Wales (65%).

3.20 VALUE OF SEA MERCHANDISE TRADE, By State

Year	NSW $m	Vic. $m	Qld $m	SA $m	WA $m	Tas. $m	NT $m	Aust.(a) $m
				IMPORTS				
1988–89	14 365.0	13 017.4	3 221.5	1 641.8	2 943.8	333.6	272.6	35 801.3
1989–90	15 003.4	13 402.3	3 620.5	1 764.8	3 531.8	326.8	425.8	38 083.9
1990–91	14 277.6	11 460.0	3 725.9	1 926.7	3 131.7	281.5	286.2	35 096.0
1991–92	14 794.6	11 883.7	4 249.4	1 994.4	2 976.6	268.0	309.1	36 480.4
1992–93	16 981.3	13 904.0	4 988.2	2 627.0	4 374.2	315.5	220.6	43 419.0
1993–94	18 513.6	16 024.8	5 560.1	2 417.2	4 136.8	428.9	232.2	47 317.7
1994–95	21 011.2	18 310.1	6 611.3	2 671.5	5 064.0	323.2	239.7	54 232.2
1995–96	21 389.7	18 580.2	6 840.0	2 542.6	5 320.0	326.1	281.1	55 280.2
				EXPORTS				
1988–89	8 192.2	7 456.0	8 836.4	2 282.0	8 071.1	1 414.7	924.5	37 765.4
1989–90	8 931.4	7 167.9	10 251.5	2 604.5	9 112.8	1 376.3	1 305.0	41 462.4
1990–91	9 275.7	7 131.2	10 489.5	2 752.8	9 987.2	1 290.6	1 700.1	43 422.9
1991–92	9 967.8	7 056.9	10 386.9	3 146.1	10 245.4	1 368.9	1 382.4	44 506.9
1992–93	11 063.0	8 255.1	11 322.8	3 445.6	11 079.9	1 436.2	1 226.9	49 239.3
1993–94	11 900.1	8 855.9	11 580.5	3 511.7	11 087.5	1 487.7	1 042.3	50 929.1
1994–95	12 036.7	9 337.1	12 043.1	3 394.1	12 291.6	1 520.5	945.5	52 936.6
1995–96	13 496.3	10 607.4	13 050.3	4 037.7	14 388.6	1 525.9	1 087.5	59 822.6

(a) Includes trade where State information not available.

Source: ABS unpublished data, International Trade.

Employment

Table 3.21 shows persons employed in water transport between 1988 and 1997. Chapter 5 gives a comparison of employment within the various transport industries.

3.21 EMPLOYED PERSONS IN WATER TRANSPORT

Year(a)	Australia no.	RSE %
1988	9 459	15.3
1989	8 575	16.0
1990	10 908	14.2
1991	10 757	14.3
1992	4 693	22.7
1993	7 422	18.1
1994	7 017	18.6
1995	9 932	16.1
1996	9 392	16.4
1997	12 698	13.9

(a) Employment data are for February of each year.

Note: Please refer to the Technical Notes from the ABS publication *Labour Force, Australia* (Cat. no. 6203.0), for further information about standard errors for Labour Force Survey data.

Source: ABS n.d.(a).

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CHAPTER 4

AIR TRANSPORT

Australian aviation performs a significant role in the movement of people and the transport of high value, time sensitive freight. Air transport services are mainly used by the household sector (e.g. domestic and international tourists), with the services sector (retail and banking) the second largest user (Bureau of Industry Economics 1994). Air transport is comprised of two distinct types of services, the scheduled public flights operated by the international, domestic and regional airlines, and a wide range of non-scheduled services which are described as general aviation.

International airlines include Australian and overseas operators which fly passengers and cargo between Australia and foreign destinations. Almost all international passenger traffic to and from Australia is by air. In contrast, only about 0.1% of international freight tonnage is carried by air. However, this is high value freight, representing about 25% of the value of all imports and exports (Department of Transport 1993).

The domestic and regional airlines provide scheduled services within Australia. The domestic carriers operate mainly between the major cities using high capacity jets, while the regional airlines link smaller centres with larger ports, generally using aircraft of a maximum 38-seat capacity. General aviation is made up of predominantly light aircraft carrying out a variety of commercial and non-commercial activities, including flying training, charter, agricultural and private/business use. Table 4.1 shows the relative intensity of the various operations within Australian aviation, by hours flown during 1995–96.

4.1 AVIATION ACTIVITY, By Hours Flown—1995–96

	Hours flown	
Activity	'000	%
Scheduled public transport		
Major Australian airlines		
International operations(a)	239	8
Domestic operations	451	15
Regional airlines	242	8
Total scheduled flights	932	31
Non-scheduled flights—general aviation		
Private	262	9
Business	185	6
Training	439	15
Agriculture	98	3
Aerial work	309	10
Test and ferry	28	1
Charter	477	16
Total non-scheduled flights	1 799	60
Other flying activities including ultralights, gliders, hang gliders and autogyros	268	9
Total	**2 998**	**100**

(a) Data is provisional.

Source: Department of Transport and Regional Development 1997.

INFRASTRUCTURE

In June 1996, there were about 400 licensed airports in Australia and its Territories. Of these, 12 were operating as international airports. The majority of licensed airports were owned and operated by local councils, State government departments and private companies. The Federal Airports Corporation (FAC) owned and operated 22 airports and 15 were on Royal Australian Air Force bases (ABS 1996, 1997; Civil Aviation Safety Authority, pers. comm).

Airports are comprised of interdependent component areas—the airspace, the runway/taxi system, the apron/parking areas, the passenger and freight terminals and the land transport interface. Some airports have additional land area to allow for future expansion. Sydney is Australia's largest airport in terms of operational areas (although not in terms of total land area), followed by Melbourne and Brisbane, which are comparable in size. In addition to the main airport in these cities, the smaller airports such as Bankstown (Sydney), Moorabbin and Essendon (Melbourne) and Archerfield (Brisbane) play a major role in air cargo, regional and general aviation services (Bureau of Transport and Communications Economics 1995). Table 4.2 shows the infrastructure of the FAC primary and regional airports and Cairns airport, which is managed by the Cairns Airport Authority.

4.2 MAJOR AIRPORT INFRASTRUCTURE—1994

Airport	*Area under FAC control* ha	*Runways(a)* '000 m²	*Terminals(b)* '000 m²	*Parking positions(c)* no.	*Aerobridges(d)* no.
Sydney(e)	881	400	215	63	55
Melbourne(e)	2 365	267	113	43	39
Brisbane(f)	2 685	213	126	32	22
Adelaide	753	188	23	19	1
Perth	2 110	289	65	18	10
Darwin	309	247	31	10	3
Cairns(g)	—	143	26	14	3
Hobart	499	101	6	7	0
Canberra	149	196	9	6	3
Coolangatta	358	103	11	9	0
Townsville	82	143	10	7	0
Launceston	180	125	3	1	0
Alice Springs	323	130	5	10	0
Tennant Creek	(h)	167	1	1	0
Mt Isa	431	143	n.a.	4	0

(a) Runway total area, usually includes several runways.

(b) Terminal total area — gross, undifferentiated floor space of the terminal buildings.

(c) The number of apron stands for regional public transport aircraft, not including apron areas for general aviation.

(d) The number of terminal gate positions to which passenger access is through an elevated, covered walkway.

(e) Includes 1994–95 infrastructure projects — the parallel runway in Sydney and development of Sky Plaza in Tullamarine.

(f) Includes 1995-96 infrastructure projects — the new international terminal building at Brisbane.

(g) Partial total.

(h) Area of Tennant Creek included in Alice Springs figure.

Source: National Transport Planning Taskforce 1995 and Federal Airports Corporation 1995 (for area under FAC control).

AIRCRAFT STOCKS

Apart from military aircraft, Australia's aircraft stocks reached 9,758 aircraft in June 1996. Table 4.3 shows the number of aircraft registered for each level of aviation from 1990–91 to 1995–96. During this period, overall aircraft stocks increased by 5%, with the greatest growth (21%) in the larger aircraft used in the international and domestic sectors, while stocks of aircraft used for regional and general aviation increased by 5%. The changes in stocks of individual aircraft types generally reflects the upgrading process and the relative growth rates within the aviation sectors.

4.3 AIRCRAFT STOCKS

		NUMBER OF AIRCRAFT						
		1990–91	*1991–92*	*1992–93*	*1993–94*	*1994–95*	*1995–96*	*% change 1990–91 to 1995–96*
INTERNATIONAL AND DOMESTIC AVIATION								
Airbus	A300	7	4	4	4	4	4	-43
	A320	11	12	12	12	12	15	36
Boeing	727	15	13	6	6	5	5	–67
	737	36	40	47	54	56	59	64
	747	27	31	33	31	33	34	26
	767	20	24	25	27	28	32	60
BAE	146	12	16	16	16	20	22	83
Douglas	DC9	2	2	0	0	0	0	–100
Fokker	F28	14	14	14	13	11	8	–43
	F27	5	5	5	6	6	1	–80
Other		0	2	0	0	0	0	—
Total		*149*	*163*	*162*	*169*	*175*	*180*	*21*
REGIONAL AND GENERAL AVIATION(a)								
Fixed Wing—single engine		6 512	6 618	6 655	6 676	6 748	6 811	5
Fixed Wing—multi engine		1 795	1 787	1 770	1 743	1 749	1 776	-1
Rotary wing —helicopters and gyroplanes		650	683	695	701	713	737	13
Balloons and airships		192	194	201	221	229	254	32
Total		*9 149*	*9 282*	*9 321*	*9 341*	*9 439*	*9 578*	5
TOTAL AIRCRAFT								
Total		**9 298**	**9 445**	**9 483**	**9 510**	**9 614**	**9 758**	**5**

(a) Number of aircraft covered by the Department's series of General Aviation Activity Surveys.

Source: Department of Transport and Regional Development 1997, tables 6, 7, 8 and 9.

The Bureau of Transport and Communications Economics has estimated the economic life of civil aircraft at between 15 and 30 years, with the possibility that increasing fuel costs in the future may mean that aircraft are replaced in the shorter timeframe by more fuel efficient models. Table 4.4 shows that the average age of the Australian domestic fleet has increased from 5.7 years in 1991 to 7.7 years in 1996.

4.4 AVERAGE AGE OF PASSENGER AIRCRAFT FLEET

	December 1991....		*December 1995....*	
Model	no.	average age	no.	average age
Airbus A300	4	10	4	15
Airbus A320	11	2	18	5
Boeing 727	14	13	4	15
737	40	4	60	6
747	29	6	33	9
767	24	4	34	8
BAE 146	16	3	24	8
Fokker F28	14	13	5	13
F27	4	4	—	—
Total	**156**	**6**	**182**	**8**

Note: Average age rounded to nearest year, figures do not include aircraft used as freighters.

Source: Calculated from unpublished Aircraft Database, Department of Transport and Regional Development.

INTERNATIONAL AVIATION

At 31 December 1995, 49 international airlines were operating regular scheduled passenger air services to and from Australia (ABS 1997). The emphasis in international air transport is on passengers, with freight activities generating only 10% to 15% of airline revenue in 1992 (Bureau of Industry Economics 1994). Sydney is Australia's busiest airport for international travel, with 49% of passengers passing through in 1995–96. Melbourne (16.5%), Brisbane (16.2%), Perth (9.7%) and Cairns (5.5%) were the next most frequented airports (Department of Transport and Regional Development 1996b).

International aviation activity has grown significantly over the past quarter century. In the 20 years from 1973 to 1993, international passenger movements increased more than five-fold, with an average annual growth of 8.6%. Freight and mail carriage during this period rose at a faster rate to show an annual average growth of 11.4% (Department of Transport 1993). Table 4.5 shows the increases in activity during the period between 1985–86 and 1995–96, and table 4.6 compares the passenger traffic through Australia's 12 international airports.

4.5 INTERNATIONAL REGULAR PUBLIC TRANSPORT AIR SERVICES

Year	Aircraft takeoffs and landings	Passenger arrivals and departures	Freight inbound and outbound	Mail inbound and outbound
	no.	'000	tonnes	tonnes
1985–86	44 572	5 424	235 785	12 692
1986–87	51 023	6 195	268 395	12 963
1987–88	56 368	7 212	296 067	13 928
1988–89	63 931	7 931	324 646	15 239
1989–90	69 660	8 253	353 898	15 957
1990–91	73 641	8 425	357 506	16 774
1991–92	76 680	9 043	379 843	17 281
1992–93	84 801	9 759	432 810	17 173
1993–94	87 042	10 622	476 335	18 665
1994–95	91 448	11 574	544 448	18 193
1995–96	98 608	12 713	567 122	19 714
	%	%	%	%
Increase over 10 years	121	134	141	55

Source: Department of Transport and Regional Development 1996a.

4.6 PASSENGER TRAFFIC, Australian International Airports

Airport	1992–93	1993–94	1994–95
	'000	'000	'000
Sydney	4 648	5 019	5 603
Melbourne	1 789	1 872	1 931
Brisbane	1 429	1 599	1 838
Perth	950	1 068	1 156
Cairns	600	688	641
Adelaide	214	217	213
Darwin	97	114	138
Christmas Island(a)	—	12	27
Norfolk Island	18	16	15
Hobart	9	8	7
Port Hedland	5	4	2
Townsville(b)	3	6	2
Total	**9 759**	**10 622**	**11 574**

(a) International operations commenced November 1993.

(b) International operations ceased March 1991, recommenced November 1992 and ceased again in October 1994.

Source: Department of Transport and Regional Development 1996b.

DOMESTIC AVIATION

Domestic airlines provide the scheduled public passenger services between Australia's larger airports. During the 20 year period from 1973 to 1993, domestic airline passenger carriage increased more than two-fold, with an average annual growth rate of 5.5%. Table 4.7 shows the changes in domestic aviation for the decade from 1985–86 to 1995–96; passenger departures increased by 93% over the period and mail movements increased by 84%. Although air freight movements appear to have declined by 9%, this is understood to be the result of an increase in carriage of freight on all-cargo aircraft for which statistics are not recorded.

4.7 DOMESTIC REGULAR PUBLIC TRANSPORT AIR SERVICE

Year	*Aircraft departures*	*Passenger departures*	*Freight outbound*	*Mail outbound*
	no.	'000	tonnes	tonnes
1985–86	216 075	12 100	150 289	18 058
1986–87	216 923	12 507	135 572	18 726
1987–88	214 900	13 648	143 446	20 793
1988–89	210 408	14 050	146 723	21 585
1989–90	127 554	9 876	84 371	11 432
1990–91	187 445	14 739	118 394	21 252
1991–92	213 514	18 476	117 668	20 235
1992–93	224 381	18 578	120 605	23 512
1993–94	226 671	19 997	129 573	23 992
1994–95	250 441	22 114	140 032	28 595
1995–96	257 039	23 406	137 472	33 308
	%	%	%	%
Increase over 10 years	19	93	–9	84

Note: The domestic pilots' strike caused considerable disruption to scheduled operations into the early part of 1990.

Source: Department of Transport and Regional Development 1996a, 1996b.

REGIONAL AVIATION

Regional airlines provide scheduled services between major airports and the smaller regional centres. During the 20 year period from 1973 to 1993, regional airlines activity expanded markedly, achieving an average annual growth rate of 14.8% in passengers carried. Legislation changes over time have allowed the regional airlines to operate higher-capacity aircraft, and to compete with the major domestic airlines (Department of Transport 1993). Table 4.8 shows the changes in regional aviation for the decade from 1985–86 to 1995–96; passenger departures increased by 201% over the period, however reported mail movements and freight decreased.

4.8 REGIONAL REGULAR PUBLIC TRANSPORT AIR SERVICES

Year	*Aircraft departures*	*Passenger departures*	*Freight outbound*	*Mail outbound*
	no.	'000	tonnes	tonnes
1985–86	210 375	1 102	3 297	390
1986–87	210 227	1 169	3 422	305
1987–88	220 722	1 224	3 597	268
1988–89	242 025	1 333	3 208	263
1989–90	237 041	1 498	2 244	203
1990–91	256 738	1 798	2 508	153
1991–92	277 226	2 049	2 462	176
1992–93	298 498	2 345	2 253	111
1993–94	307 700	2 672	2 369	125
1994–95	316 430	2 983	2 345	110
1995–96	324 410	3 311	2 280	110
	%	%	%	%
Increase over 10 years	54	200	–31	–72

Source: Department of Transport and Regional Development 1996a, 1996b.

GENERAL AVIATION

General aviation includes the wide range of non-scheduled services provided mainly by light aircraft, including private, business, agricultural and charter flights. During the 20 year period from 1973 to 1993, general aviation activity, measured by the number of flying hours, grew by 53.5%, giving an average annual growth of 2.2% (Department of Transport 1993). Table 4.9 shows the growth in general aviation over the period from 1985–86 to 1995–96, which was considerably lower than in the international and domestic sectors. While significant increases were seen in charter services, training and aerial work; decreases were seen in the business, agricultural, private, and test and ferry services.

4.9 HOURS FLOWN IN GENERAL AVIATION OPERATIONS, By Flying Activity

Year	Private(a) '000	Business(b) '000	Training(c) '000	Agriculture(d) '000	Aerial work(e) '000	Test/ ferry(f) '000	Charter(g) '000	Total '000
1985–86	275	253	319	107	266	29	323	1 572
1986–87	265	236	322	102	265	28	328	1 545
1987–88	272	250	370	127	277	32	370	1 697
1988–89	269	240	403	144	281	34	391	1 761
1989–90	302	285	481	151	300	34	485	2 038
1990–91	276	269	469	122	295	31	367	1 828
1991–92	257	212	435	92	269	28	398	1 689
1992–93	259	215	425	79	262	30	387	1 656
1993–94	262	203	434	94	295	26	413	1 727
1994–95	249	192	419	80	295	27	448	1 710
1995–96	262	185	439	98	309	28	477	1 799
	%	%	%	%	%	%	%	%
Increase over 10 years	–5	–27	38	8	16	3	48	14

(a) Flying for personal pleasure, sport or recreation.

(b) Flying by the aircraft owner or employees for own purposes, not directly for hire or reward.

(c) Flying under instruction for licensing purposes.

(d) Carriage and/or spreading of agricultural chemicals, seeds, fertilisers or other substances, including for pest and disease control.

(e) Includes aerial surveying and photography, spotting, stock mustering, search and rescue, ambulance, towing, advertising, cloud seeding, fire fighting, parachute dropping and coastal surveillance.

(f) Flying to test or deliver and aircraft to another location for maintenance, hire or other planned use.

(g) Carriage of cargo or passengers on non-scheduled flights for hire or reward.

Source: Department of Transport and Regional Development 1997.

ENERGY CONSUMPTION BY AVIATION

Two types of fuel are important for aviation. Jet engine craft—which include those servicing international and domestic routes and some regional flights—use aviation turbine fuel, while light planes without jet engines, used for general aviation, use gasoline. Table 4.10 shows that during the decade from 1985–86 to 1995–96, the use of aviation turbine fuel increased from 2,420 megalitres to 4,665 megalitres (84%); while the use of aviation gasoline decreased from 108 megalitres to 102 megalitres (6%). The total energy consumed by aviation increased from 92.8 petajoules to 175.5 petajoules (89%). These changes reflected the large increases in international and domestic air travel as opposed to the fairly static nature of general aviation.

The energy efficiency of aviation has been increasing steadily in OECD countries since the mid-1970s. Energy efficiency and the associated fuel savings have been attributed to improvements in engines and operating procedures; increases in aircraft size; better load factors and the gradual replacement of older aircraft by newer, more fuel efficient models (Bureau of Transport and Communications Economics 1992).

4.10 FUEL AND ENERGY CONSUMPTION

	AVIATION GASOLINE		AVIATION TURBINE FUEL		TOTAL FUELS	
	Fuel used	*Energy used*	*Fuel used*	*Energy used*	*Fuel used*	*Energy used*
Year	ML	PJ	ML	PJ	ML	PJ
1985–86	108	4	2 420	89	2 528	93
1987–88	118	4	2 795	103	2 913	106
1989–90	129	4	2 843	104	2 972	109
1991–92	99	3	3 459	127	3 558	131
1992–93	101	3	3 685	136	3 786	139
1993–94	103	3	3 823	141	3 926	144
1994–95	104	3	4 302	159	4 406	162
1995–96	102	3	4 665	172	4 767	176
	%	%	%	%	%	%
Increase over 10 years	–6	–3	93	93	89	89

Source: Australian Bureau of Agricultural and Resource Economics 1997, pp. 121, 161.

EMPLOYMENT IN AIR TRANSPORT

The figures for employed persons in air transport between 1987 and 1997 are shown below. Chapter 5 provides a comparison between the various transport modes.

4.11 EMPLOYED PERSONS IN AIR TRANSPORT

Year(a)	*NSW*	*Vic.*	*Qld*	*SA*	*WA*	*Tas*	*Aust.(b)*
1987	12 665	10 004	5 118	1 237	2 414	595	33 460
1988	13 558	8 205	4 072	1 585	3 196	608	32 093
1989	16 996	8 335	5 493	728	4 252	306	38 547
1990	20 694	13 278	7 008	1 851	1 590	378	46 382
1991	19 144	12 115	4 610	1 446	2 184	319	41 527
1992	16 174	8 525	4 781	624	2 927	238	34 244
1993	19 179	7 822	3 928	1 096	2 763	625	36 953
1994	14 207	7 809	4 822	1 302	3 685	641	32 996
1995	18 179	10 237	7 599	2 959	4 100	641	44 670
1996	20 077	14 633	6 099	2 821	3 518	400	48 041
1997	20 314	14 825	3 259	1 878	1 919	103	44 171

(a) Data as at February for each year.

(b) Australia total includes the Australian Capital Territory and the Northern Territory.

Note: Prior to 1995 figures refer to ASIC industry class, which included only air transport. From 1995 onwards figures refer to ANZSIC class, which includes both air and space transport.

Due to the highly disaggregated nature of these data, many of the State cells in this table, particularly for the smaller States, will have a Relative Standard Error of 25% or more and should therefore be used with caution. Please refer to the Technical Notes from the ABS publication *Labour Force, Australia* (Cat. no. 6203.0), for further information about standard errors for Labour Force Survey data.

Source: ABS n.d.

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CHAPTER **5** **COMPARISON OF TRANSPORT MODES**

ENERGY CONSUMPTION

Australia's total energy consumption in 1995–96 was 4,495 petajoules. Transport was the largest energy end-use industry, consuming 26% of energy used. Australia's energy production was 10,877 petajoules in 1995–96, with 10% of this production being crude oil. However, 1,045 petajoules (99.8%) of Australia's energy imports were petroleum products and crude oil. Petroleum products account for nearly 50% of final energy consumption, reflecting the heavy use of petroleum in the transport industry (Australian Bureau of Agricultural and Resource Economics 1997).

The relative fuel consumption for the main transport modes for the period 1973–74 to 1995–96 is shown in table 5.1. Over this period the energy consumption of road and air transport increased markedly, with road transport rising by 91%, and air by 71%. In contrast, water transport energy consumption decreased by 48% during the period, although in recent years it has begun to increase, rising by 39% between 1993–94 and 1994–95. Energy consumption by rail transport fluctuated only slightly over the period.

5.1 ENERGY CONSUMPTION, By Mode and Fuel Type

	1973–74	*1979–80*	*1985–86*	*1987–88*	*1989–90*	*1991–92*	*1993–94*	*1995–96*
	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Road transport								
Leaded petrol	422.5	506.9	527.6	482.6	427.6	359.3	304.2	243.1
Unleaded petrol	0.0	0.0	18.4	82.3	161.3	219.5	290.9	365.0
Auto diesel oil	47.6	101.1	161.3	179.3	200.1	197.5	213.1	235.3
LPG	1.0	3.8	12.4	17.6	22.4	33.1	43.8	56.1
Natural gas	0.0	0.0	0.0	0.0	0.0	0.5	0.7	1.0
Total	*471.1*	*611.8*	*719.6*	*761.9*	*811.4*	*809.7*	*852.8*	*900.4*
Rail transport								
Auto diesel oil	25.0	28.1	24.9	25.3	23.3	22.3	21.8	22.3
Electricity	2.5	2.7	4.0	4.7	5.7	5.9	6.0	6.6
Ind. diesel fuel	0.0	0.0	2.6	2.6	1.7	1.7	1.1	0.0
Other fuels(a)	0.3	0.2	0.0	0.1	0.0	0.1	0.1	0.1
Total	*27.8*	*31.0*	*31.6*	*32.6*	*30.7*	*29.9*	*29.0*	*28.9*
Water transport								
Auto diesel oil	4.7	9.7	4.2	7.1	6.2	5.7	7.0	11.3
Ind diesel fuel	17.0	15.7	5.8	5.0	4.2	3.1	2.3	1.8
Fuel oil	99.5	72.3	41.4	43.3	41.7	35.1	32.6	46.6
Other fuels	0.0	0.0	3.3	3.5	3.5	4.0	3.9	3.8
Total	*121.3*	*97.6*	*54.8*	*58.9*	*55.6*	*47.9*	*45.9*	*63.6*
Air transport								
Aviation gasoline	3.5	3.8	3.6	3.9	4.3	3.3	3.4	3.3
Aviation turbine fuel	60.9	76.8	89.3	102.5	104.3	127.3	141.1	172.1
Total	*64.4*	*80.6*	*92.8*	*106.4*	*108.6*	*130.6*	*144.4*	*175.5*
Total(b)	**684.6**	**821.0**	**898.8**	**959.8**	**1 006.3**	**1 018.1**	**1 072.1**	**1 168.4**

(a) Other fuels include black coal and natural gas.

(b) Other transport, services and storage not included.

Source: Australian Bureau of Agricultural and Resource Economics 1997, p. 121.

PASSENGER TASKS

From 1974 to 1993, the total urban passenger kilometres travelled (urban passenger task) increased by 72%, with 157.5 billion passenger kilometres travelled in 1993. During this time, when the use of road transport vehicles for urban journeys rose by 77%, there was also an increase from 92.9% to 95.3% in the proportion of urban passengers using road transport. This rise was largely due to an 80% increase in the use of cars for urban journeys. At the same time, there was a decrease in the proportion of urban passengers using rail transport, with only 4.5% rail passenger kilometres in 1993, compared with 6.9% in 1974. Throughout the period, ferry transport consistently accounted for approximately 0.2% of the total urban passenger kilometres travelled.

5.2 URBAN MOTORISED PASSENGER TASK, Passenger Kilometres(a)

	ROAD						RAIL	FERRY	TOTAL
	Car(b)	*LCV(c)*	*Truck*	*Bus*	*Motor-cycle*	*Total*	*Total(d)*	*Total*	
Year ending June	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km
1974	76.34	3.60	0.44	3.80	0.85	85.03	6.30	0.15	91.48
1975	80.54	4.13	0.44	3.89	0.91	89.91	6.01	0.18	96.10
1976	82.62	4.71	0.44	3.91	1.07	92.75	5.96	0.19	98.91
1977	88.07	5.21	0.41	3.97	1.05	98.71	5.86	0.18	104.76
1978	91.14	5.59	0.39	4.00	1.09	102.21	5.71	0.15	108.06
1979	92.84	6.10	0.36	4.06	1.11	104.47	5.67	0.14	110.27
1980	93.36	5.69	0.39	4.19	1.20	104.83	6.13	0.13	111.09
1981	94.67	5.59	0.42	4.16	1.29	106.13	6.29	0.15	112.57
1982	100.06	5.62	0.44	4.19	1.36	111.67	6.46	0.17	118.30
1983	100.29	5.44	0.42	4.17	1.40	111.72	6.30	0.18	118.19
1984	104.53	5.85	0.39	4.15	1.43	116.35	6.35	0.19	122.89
1985	(e)113.88	6.38	0.37	(e)4.26	1.47	126.36	6.43	0.20	132.99
1986	117.76	6.24	0.38	4.34	1.43	130.15	6.97	0.20	137.32
1987	123.33	6.32	0.37	4.43	1.40	135.85	7.18	0.23	143.25
1988	(e)131.32	6.75	0.37	(e)4.51	1.35	144.30	7.47	0.24	152.03
1989	134.53	6.61	0.34	4.66	1.41	147.55	7.67	0.24	155.48
1990	136.34	6.52	0.31	4.55	1.35	149.07	7.47	0.26	156.82
1991	(e)133.72	6.65	0.26	(e)4.62	1.06	146.31	7.52	0.26	154.11
1992	134.52	6.41	0.26	4.96	1.09	147.24	7.52	0.25	155.04
1993	137.49	6.52	0.27	4.72	1.09	150.09	7.18	0.25	157.55
1995	155.87	n.a.	n.a.	4.36	n.a.	n.a.	7.89	n.a.	n.a.

(a) Passenger kilometres are a measure of the product of the number of passengers in a given vehicle on a given journey and the distance in kilometres travelled by that vehicle on that journey.

(b) Includes taxis. In 1990–91, taxis comprised around 1.7% of the urban car task.

(c) Light Commercial Vehicle.

(d) Includes trams. Between 1970–71 and 1992–93, the tram passenger task was of the order of 0.6 billion passenger kilometres per year, that is, around 8% of the urban rail task.

(e) These figures differ from those reported in Apelbaum Consulting Group Pty Ltd 1997 due to differing methodologies.

Note: Figures refer only to unlinked passenger trips; urban figures refer to travel wholly within cities of population greater than 40,000. 1994 data not available.

Source: Bureau of Transport and Communications Economics 1996, p. 340; Apelbaum Consulting Group Pty Ltd 1997, table 6.1.

Since 1974 the total non-urban passenger task has risen by 63%, with 106.4 billion passenger kilometres travelled in 1993, as shown in table 5.3. Air transport accounted for much of this increase, rising by 175% during the period. The total non-urban passenger kilometres travelled using road transport rose by 56%, whilst for rail and sea transport they decreased by 42% and 30% respectively. In 1993 rail accounted for 78.6% of non-urban passenger kilometres travelled, air 18.9%, rail 2.1% and sea 0.4%.

5.3 NON-URBAN MOTORISED PASSENGER TASK, Passenger Kilometres(a)

	ROAD						RAIL	AIR(b)	SEA(c)	TOTAL
	Car	*LCV(d)*	*Truck*	*Bus*	*Motorcycle*	*Total*	*Total*	*Total*	*Total*	
Year ending June	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km	billion p-km
1974	45.71	3.76	0.46	3.20	0.58	53.71	3.80	7.34	0.54	65.39
1975	48.22	4.12	0.46	3.20	0.63	56.63	3.20	7.93	0.54	68.30
1976	49.47	4.50	0.46	3.30	0.74	58.47	2.60	7.74	0.55	69.36
1977	49.52	4.76	0.44	3.30	0.79	58.81	2.70	7.46	0.54	69.51
1978	51.25	4.84	0.42	3.30	0.82	60.63	2.70	8.15	0.54	72.02
1979	52.20	4.98	0.40	3.30	0.83	61.71	2.70	8.58	0.54	73.53
1980	53.02	4.84	0.45	3.70	0.89	62.90	2.60	9.49	0.54	75.53
1981	53.76	5.01	0.50	4.20	0.91	64.38	3.00	9.57	0.55	77.50
1982	56.82	5.22	0.54	4.70	1.00	68.28	2.90	10.06	0.55	81.79
1983	56.95	5.13	0.49	6.10	1.02	69.69	3.00	9.25	0.55	82.49
1984	59.36	5.50	0.45	7.60	1.05	73.96	2.90	9.81	0.55	87.22
1985	(e)57.26	6.04	0.41	(e)9	1.03	73.74	3.00	10.59	0.61	87.94
1986	59.49	5.55	0.38	9.90	0.88	76.20	2.70	11.47	0.57	90.94
1987	57.61	5.26	0.34	10.90	0.80	74.91	2.70	12.28	0.49	90.38
1988	(e)55.83	5.23	0.31	(e)11.8	0.77	73.94	2.90	13.57	0.40	90.81
1989	60.16	5.45	0.31	12.50	0.79	79.21	2.90	14.15	0.40	96.66
1990	62.47	5.60	0.30	12.90	0.76	82.03	2.50	10.41	0.41	95.35
1991	(e)61.27	5.93	0.23	(e)12.3	0.72	80.45	2.50	15.66	0.39	99.00
1992	63.75	5.75	0.23	11.40	0.74	81.87	2.30	20.24	0.38	104.79
1993	65.16	5.84	0.24	11.70	0.74	83.68	2.20	20.15	0.38	106.41
1995	69.46	n.a.	n.a.	12.81	n.a.	n.a.	1.92	26.96	0.35	n.a.

(a) Passenger kilometres are a measure of the product of the number of passengers in a given vehicle on a given journey and the distance in kilometres travelled by that vehicle on that journey.

(b) Includes general aviation. The strong decline in 1989–90 was due to the airline pilots' dispute.

(c) Cruises and Bass Strait ferries.

(d) Light Commercial Vehicle.

(e) These figures differ from those reported in Apelbaum 1997 due to differing methodologies.

Note: Figures refer to unlinked trips; non-urban figures refer to all domestic passenger movements except those wholly within cities of population greater than 40 000 each year. 1994 data not available.

Source: Bureau of Transport and Communications Economics 1996, pp. 342–3; Apelbaum Consulting Group 1997, table 6.1.

The results of an ABS household survey conducted in 1996 showed that most people travelling to work or study do so as a single driver in a car (about 64%). People in New South Wales use public transport (primarily trains and buses) most as a means of travelling to work or study (22%), while people in Tasmania use it least (5%). A larger proportion of the Australian Capital Territory residents use the bus system as a means of getting to work or study than do residents in other States and Territories (ABS 1997a).

5.4 PERSONS WHO TRAVEL TO WORK/STUDY, Means of Transport—April 1996(a)

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
				NUMBER ('000)					
Train	337.3	183.9	65.8	21.5	46.0	n.a.	n.a.	n.a.	654.5
Bus	235.9	86.5	74.6	57.3	53.0	15.1	***3.6	19.8	545.7
Car/truck/van as driver	1 917.3	1 579.7	1 074.1	486.0	608.2	154.4	56.0	116.3	5 991.9
Car/truck/van as passenger	161.2	108.8	111.0	59.6	73.2	17.5	***6.1	15.4	552.8
Motorbike or motor scooter	27.0	18.2	27.0	12.2	9.0	***1.4	***1.0	***3.4	99.4
Bicycle	54.2	57.6	49.1	23.6	17.6	***4.0	***4.2	***4.9	215.2
Walk	168.3	122.1	87.2	34.7	40.3	20.6	***5.1	9.0	487.4
Other	40.6	80.5	16.5	***5.8	***6.1	***1.5	***2.2	***	153.1
Total	*2 610.8*	*1 965.5*	*1 356.7*	*618.8*	*756.6*	*193.2*	*69.3*	*152.2*	*7 723.1*
				PROPORTION (%)					
Train	12.9	9.4	4.8	3.5	6.1	n.a.	n.a.	n.a.	8.5
Bus	9.0	4.4	5.5	9.3	7.0	7.8	***5.2	13.0	7.1
Car/truck/van as driver	73.4	80.4	79.2	78.5	80.4	79.9	80.8	76.4	77.6
Car/truck/van as passenger	6.2	5.5	8.2	9.6	9.7	9.0	***8.8	10.1	7.2
Motorbike or motor scooter	1.0	0.9	2.0	2.0	1.2	***0.7	***1.5	***2.2	1.3
Bicycle	2.1	2.9	3.6	3.8	2.3	***2.1	***6.0	***3.2	2.8
Walk	6.4	6.2	6.4	5.6	5.3	***10.7	***7.4	5.9	6.3
Other	1.6	4.1	1.2	***0.9	***0.8	***0.8	***3.1	***	2.0

(a) Totals do not equal the sum of items in each column because more than one transport mode may be specified.

Source: ABS 1997a, p. 47.

This study also revealed that people on lower incomes made greater use of public transport than those on higher incomes. People with high incomes were most likely to use a car as a driver. Around 23% of people with incomes of less than $159 per week used the train, compared with 9% of those whose incomes were greater than $1,500 per week. People with low household incomes also reported a higher usage of bicycles, with 4% of people with incomes between $160 and $299 per week using a bicycle compared with a total usage rate of 2.8%.

5.5 PERSONS WHO TRAVEL TO WORK/STUDY, Transport Mode By Income Level—April 1996(a)

	Less than $159	*$160–299*	*$300–499*	*$500–699*	*$700–999*	*$1 000–1 499*	*More than $1 500*	*Not stated/ known*	*Total*
	%	%	%	%	%	%	%	%	%
Train	23.3	10.6	8.5	6.9	7.6	8.8	9.2	9.2	8.5
Bus	12.7	10.3	8.7	6.3	6.5	5.1	7.1	11.1	7.1
Car/truck/van as driver	59.0	65.5	70.9	77.3	79.8	80.9	81.1	73.7	77.6
Car/truck/van as passenger	***3.7	7.9	8.5	7.1	6.6	7.7	6.0	7.4	7.2
Motorbike or motor scooter	***0.6	***1.0	1.3	1.4	1.9	0.8	1.3	***0.6	1.3
Bicycle	***4.1	4.3	3.6	3.5	2.5	2.3	2.0	2.8	2.8
Walk	***6.4	11.7	10.7	6.1	5.9	4.6	4.7	6.8	6.3
Other	***4.6	***1.1	1.8	2.2	1.1	2.6	1.7	2.8	2.0

a) Totals do not equal the sum of items in each column because more than one transport mode may be specified.

Source: ABS 1997a, p. 54.

Australian cities have double the per capita car use of European cities and less than half the public transport use. In fact, Australian cities have the highest per capita level of road provision of any cities in the world—8.8 metres per capita, compared to United States' cities at 6.6 metres, European cities at 2.1 metres and Asian cities at 1.0 metres per capita. Correspondingly, the proportion of people using public transport in Australia has been declining for some time—a trend which stands in sharp contrast to trends of increasing public transport use in European cities (Newman 1994). The average number of per capita public transport trips in Australian cities declined markedly between 1961 and 1981, as shown in table 5.6. This trend appeared to slow during the 1980s in most cities, and in fact it reversed in Sydney, Melbourne and Canberra where public transport use increased again by 1991. Overall however, the average annual number of public transport trips per capita in Australian cities is still declining, from 176 in 1961 to 91 in 1991.

5.6 AVERAGE PUBLIC TRANSPORT TRIPS PER CAPITA

Year	*Sydney*	*Melbourne*	*Brisbane*	*Adelaide*	*Perth*	*Canberra*	*Australia*
1961	253	222	232	143	136	73	176
1971	204	142	126	82	97	55	118
1981	142	95	79	83	71	87	93
1991	160	101	69	76	54	89	91

Source: Newman 1994.

FREIGHT TASKS

The vast majority of the freight tonnes load in Australia is borne by road transport. In 1991, road transport vehicles carried 71% of the total domestic freight task tonnage, followed by rail transport with 24%. However, road transport vehicles have the shortest average hauls, at 8.6 kilometres, whilst ships travel an average of 2,124.7 kilometres per voyage.

5.7 DOMESTIC FREIGHT TRANSPORT TASKS(a)—1991

Task	*Tonnes carried* million	*Transport market share* %	*Average length of haul* km
Road	1 029.5	70.9	8.6
Rail	347.1	23.9	253.5
Sea	(b)44.1	3.1	2 124.7
Air(c)	0.1	0.0	1 071.4
Total	**1 420.8**	**97.9**	—

(a) Excludes pipelines.

(b) Mass tonnes.

(c) Excludes non-scheduled aviation.

Source: Bureau of Industry Economics 1994.

In gigatonne-kilometre terms, the total domestic freight task has increased over the past two decades by 58%, from 182.7 gigatonne-kilometres in 1974 to 288.7 gigatonne-kilometres in 1993. During this time, the proportion of the freight task borne by road transport has increased from 17.4% to 33.7% of the total gigatonne-kilometres travelled, whilst the sea transport's share has dropped from 52.6% to 33.3%. The proportions borne by the rail and air transport industries have remained about 30% and 0.05% respectively of the total domestic freight task.

5.8 DOMESTIC FREIGHT TASK(a)

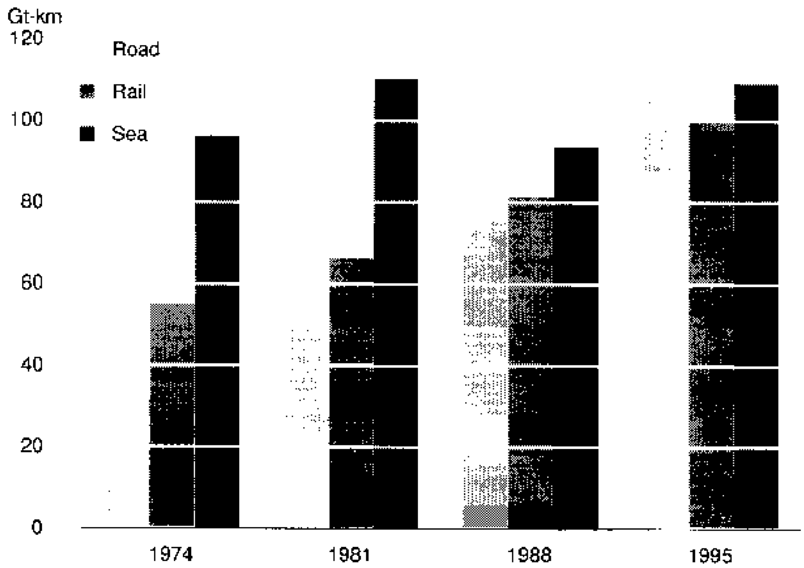
	ROAD			RAIL			SEA	AIR	TOTAL
Year ending June	*Urban*	*Non-urban*	*Total*	*Govt*	*Private*	*Total*	*Total*	*Total*	*Total*
	Gt-km	Gt-km	Gt-km	Gt-km	Gt-km	Gt-km	Gt-km	Gt-km	Gt-km
1974	11.0	20.7	31.7	28.3	26.5	54.8	96.1	0.1	182.7
1975	11.9	21.9	33.8	29.8	30.2	60.0	101.2	0.1	195.1
1976	13.1	23.6	36.7	30.8	26.3	57.1	104.6	0.1	198.5
1977	13.9	25.7	39.6	32.0	27.3	59.3	102.3	0.1	201.3
1978	14.7	27.6	42.3	31.5	28.4	59.9	105.1	0.1	207.5
1979	16.4	31.8	48.2	33.4	25.6	59.0	104.7	0.1	212.0
1980	17.8	34.5	52.3	35.4	27.8	63.2	105.1	0.1	220.7
1981	18.6	35.8	54.4	37.4	28.9	66.3	110.3	0.1	231.1
1982	20.6	38.8	59.4	38.0	27.4	65.4	97.8	0.1	222.7
1983	20.5	39.3	59.8	34.0	25.0	59.0	80.9	0.1	199.8
1984	22.4	43.4	65.8	40.1	23.3	63.4	94.3	0.1	223.6
1985	25.1	49.2	74.3	44.2	28.4	72.6	96.3	0.1	243.4
1986	26.3	50.1	76.4	48.2	29.2	77.4	101.8	0.1	255.7
1987	28.2	51.6	79.8	49.6	30.3	79.9	95.2	0.1	255.0
1988	31.0	54.5	85.5	50.5	31.0	81.5	93.6	0.1	260.7
1989	31.4	58.7	90.1	51.9	28.7	80.6	90.7	0.1	261.6
1990	31.1	60.3	91.4	54.4	32.5	86.9	94.2	0.1	272.6
1991	29.0	59.2	88.2	54.8	35.3	90.1	93.8	0.1	272.2
1992	29.6	63.6	93.2	56.7	35.1	91.7	96.4	0.1	281.5
1993	30.8	66.6	97.3	59.4	35.8	95.2	96.0	0.1	288.7
1995	37.1	77.3	114.4	61.8	38.1	99.9	109.2	0.3	323.8

(a) Pipelines excluded. Gigatonne-kilometres are the product of the weight of the freight of a given vehicle on a given haul and the distance of that haul.

Note: Figures refer to unlinked freight movements. Urban figures refer to freight moved wholly within cities of population greater than 40 000 in the relevant year. Non-urban figures refer to all other domestic freight movements.

Source: Bureau of Transport and Communications Economics 1996, p. 337; Apelbaum Consulting Group Pty Ltd 1997, table 6.2.

5.9 DOMESTIC FREIGHT TASK



Source: Based on Bureau of Transport and Communications Economics 1996.

Rail transport is used primarily to move freight which is destined for intrastate locations. Use of sea transport to move freight differs between States. Whilst Queensland's major use of sea freight is in intrastate transport, in most other States it is primarily for the interstate transportation of goods.

Rail is used to transport commodities from a broad range of industries, with the largest tonnage carried in the June quarter 1995 being metalliferous ores, metal scrap, coal, coke and briquettes. The majority of freight carried by sea in the same quarter was comprised of metalliferous ores, metal scrap, petroleum oil, motor spirit and other light oils (ABS 1996).

5.10 DOMESTIC FREIGHT, Origin and Destination—June quarter 1995

	DESTINATION						
	NSW and ACT	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*
Origin	'000 t	'000 t	000 t	'000 t	'000 t	000 t	'000 t
			RAIL				
NSW and ACT	15 769	332	253	205	140	n.a.	11
Vic.	169	962	112	112	139	n.a.	3
Qld	117	47	27 492	11	16	n.a.	—
SA	119	257	45	2 788	144	n.a.	75
WA	41	57	17	47	39 839	n.a.	1
Tas.	n.a.	n.a.	n.a.	n.a.	n.a.	609	n.a.
NT	3	1	1	19	—	n.a.	—
			SEA				
NSW and ACT	298	369	183	262	30	96	2
Vic.	974	90	406	35	63	360	13
Qld	354	101	2 542	32	22	—	1
SA	558	229	222	312	34	133	—
WA	2 150	273	—	21	576	3	79
Tas.	403	416	—	13	8	179	—
NT	64	—	—	—	8	180	22
			AIR				
NSW and ACT	1	5	4	2	2	—	—
Vic.	6	—	2	2	3	2	—
Qld	3	1	3	—	—	—	—
SA	1	1	—	—	1	—	—
WA	1	2	—	—	—	—	—
Tas.	—	2	—	—	—	—	—
NT	—	—	—	—	—	—	—

Note: Road freight data to acceptable standard not available.

Source: ABS 1996.

EMPLOYMENT

As at February 1997, the transport industry as a whole employed a total of 382,399 persons. Road transport employed the most people, accounting for 51% of total transport industry employees. The next largest employer, employing 19% of the total, was services to transport. This arm of the industry includes services to road transport (parking services and other services), water transport (stevedoring, water transport terminals, port operators, and other services), air transport (airport operation and navigation services), and other services (including travel agency services, freight forwarding, customs agency services and other services).

5.11 EMPLOYED PERSONS, Transport Industry—February 1997

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*Aust.(a)*
Road transport	65 594	46 504	42 140	14 368	17 043	4 688	193 677
Road freight	44 595	31 670	26 049	8 839	11 507	3 443	127 486
Road passenger	21 000	14 835	16 091	5 529	5 536	1 245	66 191
Rail transport	19 380	7 452	20 221	2 198	2 053	141	51 566
Water transport	5 279	—	4 279	771	1 152	1 217	12 698
Air and space transport	20 314	14 825	3 259	1 878	1 919	103	44 171
Other transport	907	3 270	222	608	2 350	..	7 692
Services to transport	18 051	21 822	14 977	4 887	8 630	934	72 595
Total	**129 525**	**93 873**	**85 098**	**24 710**	**33 147**	**7 083**	**382 399**

(a) Australia total includes the Australian Capital Territory and the Northern Territory.

Note: 'Other transport' includes pipeline transport, and transport not elsewhere classified.

Due to the highly disaggregated nature of these data, many of the cells in this table will have a Relative Standard Error of 25% or more and should therefore be used with caution. Please refer to the Technical Notes from the ABS publication *Labour Force, Australia* (Cat. no. 6203.0), for further information about standard errors for Labour Force Survey data.

Source: ABS n.d.

CONTRIBUTION OF TRANSPORT SECTORS TO GROSS DOMESTIC PRODUCT

In 1995–96, the transport industry as a whole contributed $25.46 billion to the total Australian GDP (6%). Of the four major modes of transport, road transport contributed the greatest portion of this total ($14.7 billion), followed by air transport ($5.8 billion).

5.12 TRANSPORT'S CONTRIBUTION TO GDP(a), At Average 1989–90 Prices

	1989–90	*1990–91*	*1991–92*	*1992–93*	*1993–94*	*1994–95*	*1995–96*
Mode	$ billion	$ billion	$ billion	$ billion	$ billion	$ billion	$ billion
				VALUE ($ billion)			
Road(b)	11.87	11.64	11.90	11.75	12.55	13.86	14.70
Air and space	3.12	3.61	4.19	4.60	5.02	5.49	5.81
Water	2.49	2.53	2.56	2.52	2.71	2.83	2.78
Rail	1.96	1.96	1.97	2.02	2.11	2.08	2.14
Total	**19.44**	**19.74**	**20.62**	**20.88**	**22.39**	**24.25**	**25.46**
GDP	370.19	365.47	363.73	373.44	388.89	406.02	423.39
				PROPORTION (%)			
Transport as proportion of GDP	5.25	5.40	5.67	5.59	5.76	5.97	6.01

(a) Gross Domestic Product (Production) figures shown.

(b) Includes other transport and storage.

Source: ABS 1997b, tables 56 and 49.

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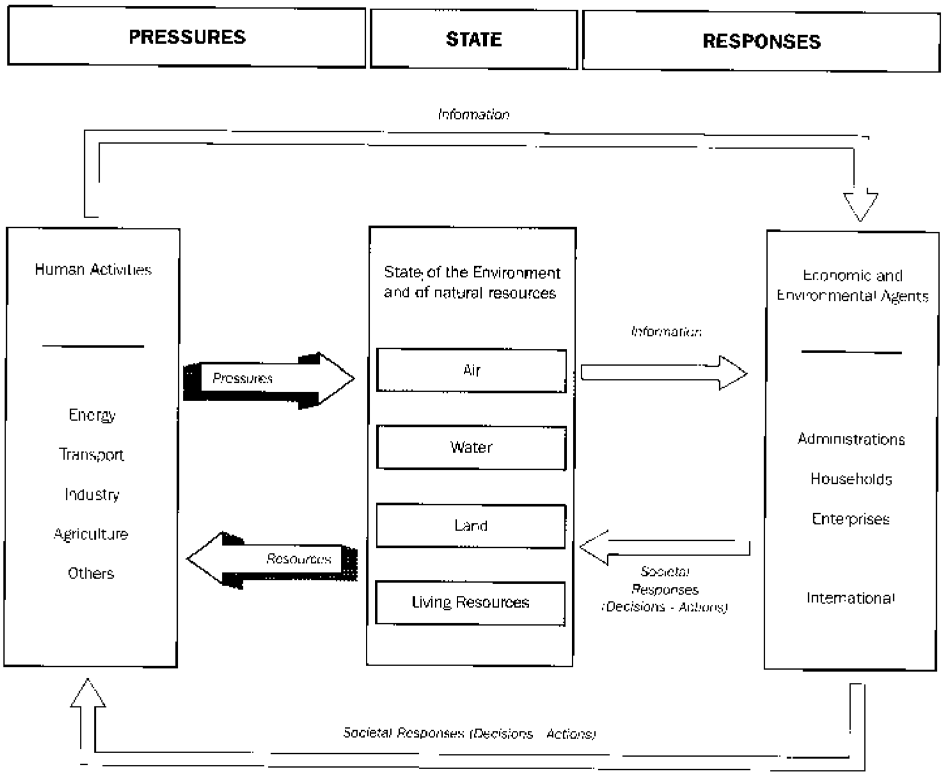
PART 2 **STATE**



Part 2 examines the impact on the state or condition of environmental media as a result of activity in the road, rail, shipping and air transport modes. Reporting on the state of the environment involves a description of the environmental effects of human activities, and of the corresponding implications for human health and economic well-being.

Chapter 6 examines the impact of transport on the atmosphere. Estimates have been made of transport's contribution to air pollutant and greenhouse gas emissions, including emissions of CO_2, NO_x, N_2O, CO, non-methane volatile organic compounds (NMVOCs), methane, SO_x, lead and particulates.

In Chapter 7, the wastes generated by transport are addressed. Road vehicles produce an array of wastes, including waste oils, vehicle bodies and parts, used tyres, batteries, and chloroflourocarbon discharges from vehicle air-conditioning systems. Wastes from the rail, shipping and aviation sectors are also discussed.

The effects of transport on people are discussed in Chapter 8. Data is presented on accidents and their associated costs in the road, rail, shipping and water transport industries. Other health effects caused by emissions, and costs thereof, are explored. Information is presented on traffic and aircraft noise, noise costs, traffic congestion, urban sprawl and loss of community.

In Chapter 9, impacts on the natural environment are examined, including habitat loss and fragmentation caused by road and rail construction, impacts of off-road vehicles, and impacts of urban run-off. The effects of shipping on the marine environment are also explored, including oil pollution, ballast water, anti-fouling practices and marine debris.

MAJOR IMPACTS OF TRANSPORT ON THE NATURAL ENVIRONMENT

Transport mode	*Air quality*	*Wastes*	*Social impacts*	*Other environmental impacts*
Road	CO_2, CO, NO_x, NMVOC, lead and particulate emissions	Waste oils, vehicle bodies and parts, tyres and batteries	Death and injury from accidents, traffic noise, traffic congestion, urban sprawl, loss of community	Wildlife habitat loss and fragmentation, depletion of land resources, risk associated with transportation of hazardous materials, urban stormwater pollution, impacts of off-road vehicles
Rail	CO_2, CO and NO_x emissions	Abandoned infrastructure and rolling stock	Death and injury from accidents, noise and vibration from terminals and along lines	Wildlife habitat loss and fragmentation, depletion of land resources, risk associated with transportation of hazardous materials
Shipping	CO_2, CO and NO_x emissions	Scrapped vessels and craft	Death and injury from accidents	Risk associated with transportation of hazardous materials, oil spills, ballast water discharges, destruction of marine life, marine debris
Air	CO_2, CO and NO_x emissions	Scrapped aircraft, and dumped fuel	Death and injury from accidents, aircraft noise pollution, congestion on routes to airports	Depletion of land resources used for infrastructure, modification of water tables and river courses in airport construction

Source: Based on OECD 1988.

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CHAPTER 6 GREENHOUSE GAS EMISSIONS AND AIR POLLUTANTS

Atmospheric pollutants can cause a range of effects on human health and on the environment. On a global level, the main impact on air quality is caused by greenhouse gas emissions such as CO_2. The major issues on the regional and local scale include photochemical smog, fine particle pollution, CO, sulphur dioxide, and lead and other air toxics. This chapter addresses the contribution of the transport sector to many of these issues, by each of the transport modes where possible.

GREENHOUSE GAS EMISSIONS

Increased atmospheric greenhouse gas concentrations are primarily the result of increased fossil fuels usage, as well as changes in land use over the last couple of centuries (Bureau of Transport and Communications Economics 1996). Once released into the atmosphere, these gases persist for tens to hundreds of years. The presence of additional greenhouse gases will affect the radiation balance of the atmosphere and lead to a warming at the earth's surface. The International Panel for Climate Change (IPCC) projects an increase in global mean surface temperature relative to 1990 of about 2 °C by 2100 and a corresponding increase in sea level of about 50 centimetres. The actual impact on global climate is likely to be complex, and only broad indications of potential change on a regional scale are currently available (Department of Environment, Sport and Territories 1996, p. 5–13).

The greenhouse gases which contribute to this effect include: water vapour; CO_2; methane (CH_4); NO_x including N_2O, nitric oxide (NO) and nitrogen dioxide; tropospheric ozone (O_3); and chlorofluorocarbons (CFCs). CO and various NMVOCs also play an indirect role by influencing the levels of other greenhouse gases. That is, they do not have a strong radiative effect themselves, but influence atmospheric concentrations of CO_2, CH_4 and N_2O.

The emissions covered here include CO_2, CH_4, N_2O, carbon monoxide (CO), NO_x, and NMVOC. Based on 1990 data, table 6.1 shows the contribution of transport vehicles to total Australian greenhouse gas emissions (CO_2 equivalent) to be just under 12%. This takes into consideration all non-energy-sector sources such as methane emissions from agriculture, coal mines etc.

6.1 AUSTRALIAN GREENHOUSE GAS EMISSIONS(a)—1990

		HUMAN-SOURCED EMISSIONS		CONTRIBUTION OF TRANSPORT VEHICLES TO EMISSIONS(b)	
	Contribution to CO_2 equivalent emissions	*Energy use*	*Total(c)*	*Energy use*	*Total(c)*
Gas	%	kilotonnes	kilotonnes	%	%
Direct					
CO_2	58.6	288 353	426 088	23.2	15.7
CH_4	21.0	1 054	6 244	2.1	0.4
N_2O	2.7	3.7	60.3	61.4	3.8
CFCs	(d)9.5	. .	13	. .	(e)5.0
Indirect(f)					
CO	3.6	4 470	26 082	85.4	14.6
NO_x	2.1	1 276	1 949	39.0	25.5
NMVOCs	2.5	628	2 238	82.9	23.3
Total CO_2 equivalent	**100.0**	**335 100**	**(d)727 000**	**25.4**	**11.7**

(a) The major greenhouse gas is water vapour. However, water vapour is not normally considered in greenhouse gas inventories because human output is negligible when compared to the day-to-day precipitation cycle.

(b Includes emissions from military transport and emissions due to Australian bunker fuel consumption by international transport.

(c) Includes all man-made sources and sinks for emissions from energy use, industrial processes, agriculture, land use change and forestry, and waste disposal.

(d) The net warming effect of CFCs is uncertain, since CFC-induced depletion of stratospheric ozone results in negative (global average) radiative forcing. Since the late 1970s, the negative indirect effect has been of a similar magnitude to the positive direct effect. Estimated total CO_2 equivalent emissions less CFCs for Australia in 1990 are 658,000 Gg, of which CO_2 accounts for 65%.

(e) Emissions during vehicle operation would account for around 5% of national CFC output. The share is considerably higher (up to 18%) when allowance is made for CFC release due to vehicle servicing, accidents, manufacture and disposal.

(f) Includes warming effects due to the production of O_3. Does not include indirect effects due to carbon emitted as CH_4, CO or NMVOCs (which are eventually converted to CO_2 in the atmosphere) since CO_2 estimates are made on the assumption of total conversion of fuel carbon content to CO_2.

Source: Adapted from Bureau of Transport and Communication Economics 1996.

Table 6.2 details greenhouse gas emissions contributed by the different transport modes, as compiled in the Australian National Greenhouse Gas Inventory. These figures clearly show road transport to emit the largest volume of greenhouse gases by the transport sector. CO_2 emissions by road transport totalled 55.2 million tonnes in 1994, compared to the next highest (air transport) at 9.2 million tonnes. This represented an increase of 11.4% in CO_2 emissions for road transport since 1988, and a 36.1% increase for air transport. Both rail and marine transport CO_2 emissions decreased over this period by 17.6% and 20%, respectively.

Non-CO_2 emissions have variously increased and decreased between 1988 and 1994, depending on transport mode and particular greenhouse gas. However, there has been a drop in each of the non-CO_2 greenhouse gas emissions, except N_2O, for road transport (the largest emitter of non-CO_2 greenhouse gases of all the transport modes) over this period.

6.2 AUSTRALIAN GREENHOUSE GAS EMISSIONS, By Mode

Mode	CO_2 kilotonnes	CH_4 kilotonnes	N_2O kilotonnes	NO_x kilotonnes	CO kilotonnes	NMVOC kilotonnes
1988						
Road	49 518	25.0	2.8	372.0	5 161.5	639.8
Rail	1 927	0.1	0.1	42.6	5.6	2.0
Marine	4 556	2.4	0.1	103.9	119.3	22.5
Air	6 745	1.1	0.2	50.3	91.4	5.1
1990						
Road	52 766	25.2	5.0	371.3	4 901.6	620.1
Rail	1 704	0.1	0.1	37.8	5.0	1.8
Marine	4 280	2.4	0.1	97.6	123.5	23.0
Air	6 900	1.1	0.2	51.3	104.2	5.5
1992						
Road	52 615	21.9	6.9	328.4	3 840.0	523.4
Rail	1 635	0.1	0.0	36.3	4.8	1.7
Marine	3 727	2.4	0.1	82.2	121.0	22.3
Air	8 663	1.3	0.3	65.3	85.5	5.9
1994						
Road	55 168	20.7	8.7	316.3	3 241.2	477.6
Rail	1 587	0.1	0.0	35.2	4.6	1.6
Marine	3 646	2.4	0.1	79.6	124.3	22.7
Air	9 178	1.4	0.3	69.2	88.8	6.2

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

Table 6.3 shows projected greenhouse gas emissions from the transport industry through to 2009–10. Based on these calculations, road transport greenhouse gas emissions will continue to increase between 1999–2000 and 2009–10 by 9.2%. This compares with an 11.1% increase by other domestic transport, and a 50% increase by international transport, although emissions by other domestic and international form only a small part of total emissions.

6.3 PROJECTED GREENHOUSE GAS EMISSIONS FROM TRANSPORT

Activity	1999–2000 kilotonnes	2004–2005 kilotonnes	2009–2010 kilotonnes
Road transport	65 000	69 000	71 000
Other domestic transport	9 000	10 000	10 000
International transport	8 000	10 000	12 000
Total energy sector	366 000	392 000	410 000

Source: Adapted from ABS 1996.

CO_2 emissions

Australian figures show CO_2 to be the most significant contributor to the enhanced greenhouse effect. Based on the calculations in table 6.1, transport vehicles contributed 15.7% of Australian emissions of CO_2.

Total CO_2 emissions by the Australian transport industry are relatively low in terms of total tonnes emitted (67 million tonnes, compared with the United States 1,527 million tonnes, Japan 214 million tonnes, and Canada 145 million tonnes). Australia has the third highest per capita level of CO_2 emissions for transport, with per capita emissions being exceeded only by Canada and the USA.(table 6.4).

6.4 CO_2 EMISSIONS(a) FOR SELECTED COUNTRIES—1990

Country	*Population* million	*Transport emissions* kilotonnes	*Transport emissions per capita* tonnes
Australia	17.1	67 000	3.9
Belgium	10.0	36 300	3.6
Bulgaria	8.8	11 800	1.3
Canada	26.5	144 900	5.5
Denmark	5.1	15 000	2.9
Finland	5.0	15 000	3.0
France	56.4	116 700	2.1
Hungary	10.6	10 400	1.0
India	850.0	66 000	0.1
Indonesia	178.0	30 700	0.2
Italy	57.7	101 600	1.8
Japan	124.0	214 000	1.7
New Zealand	3.4	10 300	3.0
Nigeria	115.5	6 200	0.1
Philippines	61.5	13 500	0.2
Poland	38.2	34 600	0.9
Sri Lanka	17.0	2 100	0.1
Sweden	8.6	24 300	2.8
Switzerland	6.7	16 900	2.5
Turkey	56.1	21 600	0.4
United Kingdom	57.4	120 700	2.1
United States	250.0	1 527 000	6.1
OECD	839.0	2 800 000	3.3
World	5 292.0	4 370 000	0.8

(a) Emissions include those due to bunker fuel consumed by international transport.

Note: Many of the estimates are based on limited or preliminary data and are therefore very approximate.

Source: Bureau of Transport and Communications Economics 1996.

Black coal has the highest CO_2 emission factor (90 grams per megajoule), followed by fuel oil (73.6 grams per megajoule). Natural gas has the lowest emission factor with 54.4 grams per megajoule. Tables 6.4 to 6.7 detail CO_2 emissions by transport mode and fuel type, from 1988 to 1994.

CO_2 emissions from the transport industry totalled 69,579 kilotonnes in 1994, with 62,339 kilotonnes derived from domestic sources and 7,240 kilotonnes from international traffic.

In 1994, road transport produced 55,168 kilotonnes of CO_2—79.3% of total transport CO_2 emissions (table 6.5). Passenger cars released 36,137 kilotonnes or 65.5% of CO_2 emissions from road vehicles, with petrol accounting for 32,716 kilotonnes or 90.5% of this. Passenger cars manufactured after 1985 accounted for 18,969 kilotonnes, or 58%, of petrol-derived emissions.

Heavy duty trucks were the next greatest source of CO_2 emissions, releasing 8,205 kilotonnes or 14.9% of road vehicle emissions in 1994.

6.5 CO_2 EMISSIONS FROM ROAD VEHICLES

		1988	*1990*	*1992*	*1994*
Vehicle type	*Fuel type*	kilotonnes	kilotonnes	kilotonnes	kilotonnes
Passenger cars					
	Petrol	29 372	31 322	31 475	32 716
	Post-1985	6 069	10 732	14 657	18 969
	1976–1985	16 812	15 813	13 718	11 798
	Pre-1976	6 491	4 777	3 100	1 950
	Diesel-ADO	640	1 026	1 321	1 580
	LPG	751	967	1 452	1 833
	NG	0	0	4	7
	Total	*30 763*	*33 315*	*34 252*	*36 137*
Motorcycles	Petrol	253	234	201	192
Light goods vehicles					
	Petrol	5 245	5 338	5 118	5 159
	ADO	1 330	1 657	1 806	2 028
	LPG	147	239	433	593
	NG	0	0	4	8
	Total	*6 721*	*7 234*	*7 362*	*7 787*
Medium goods vehicles					
	Petrol	904	550	155	0
	ADO	1 514	1 616	1 522	1 592
	LPG	75	60	38	16
	NG	0	0	4	7
	Total	2 493	2 227	*1 719*	*1 615*
Heavy goods vehicles					
	Petrol	289	187	71	15
	ADO	7 829	8 334	7 827	8 176
	LPG	59	48	30	12
	NG	0	0	1	3
	Total	*8 178*	*8 568*	*7 929*	*8 205*
Buses					
	Petrol	109	78	42	26
	ADO	997	1 106	1 086	1 160
	LPG	3	4	5	6
	NG	0	0	20	40
	Total	*1 109*	*1 188*	*1 153*	*1 232*
Total		**49 518**	**52 766**	**52 615**	**55 168**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

Rail, marine and air transport accounted for only 2.3%, 5.2% and 13.2% of CO_2 emissions respectively by the transport industry in 1994. Emission estimates since 1988 are detailed in tables 6.6, 6.7 and 6.8.

Although overall CO_2 emissions from marine transport have decreased since 1988, CO_2 emissions from international sources increased to 51.7% of the total in 1994.

Of the 9,178 kilotonnes of CO_2 emitted by air transport in 1994, international flights produced 5,354 kilotonnes, or 58.3%, of these emissions. International air transport increased its CO_2 emissions by 55.4% between 1988 and 1994, the largest percentage increase of all transport sources in that six year period.

6.6 CO_2 EMISSIONS FROM RAILWAYS

	1988	*1990*	*1992*	*1994*
Fuel type	kilotonnes	kilotonnes	kilotonnes	kilotonnes
ADO	1 739	1 587	1 518	1 511
IDF	179	118	117	76
Coal	9	0	0	0
Total	**1 927**	**1 704**	**1 635**	**1 587**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

6.7 CO_2 EMISSIONS FROM SHIPPING

		1988	*1990*	*1992*	*1994*
Vehicle type	*Fuel type*	kilotonnes	kilotonnes	kilotonnes	kilotonnes
Domestic					
	Petrol	369	385	378	389
	ADO	179	66	29	83
	Fuel oil	1 792	1 369	1 080	907
	Coal	312	310	354	335
	NG	3	2	3	3
	IDF	121	92	95	43
	Total	*2 776*	*2 224*	*1 939*	*1 760*
International					
	ADO	192	187	195	233
	Fuel oil	1 364	1 672	1 474	1 539
	IDF	224	197	120	115
	Total	*1 779*	*2 056*	*1 789*	*1 886*
Total		**4 556**	**4 280**	**3 727**	**3 646**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

6.8 CO_2 EMISSIONS FROM AIRCRAFT

Vehicle type	Fuel type	1988 kilotonnes	1990 kilotonnes	1992 kilotonnes	1994 kilotonnes
Domestic					
	Avtur	3 060	2 279	3 655	3 604
	Avgas	239	276	212	220
	Total	*3 299*	*2 555*	*3 868*	*3 824*
International	Avtur	3 446	4 345	4 796	5 354
Total		**6 745**	**6 900**	**8 663**	**9 178**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

Non-CO_2 greenhouse gas emissions

The two next most important direct greenhouse gases for Australia are CH_4 and N_2O. However, overall transport vehicle contributions to Australian greenhouse gas emissions are relatively small for these gases.

Most non-CO_2 greenhouse gas emissions are emitted by road transport. The principal contributor to emissions to air in city and urban areas is fossil fuel combustion, particularly by motor vehicles. These account for the bulk of CO and NO_x (table 6.9).

6.9 RELATIVE CONTRIBUTION TO CO AND NO_x(a), By Source

	CO		NO_x	
Source	*Average* %	*Range* %	*Average* %	*Range* %
Motor vehicles	86	82–89	67	54–80
Other mobile	3	2–3	5	4–5
Waste combustion	1	1–2	<1	<1
Fuel combustion	7	4–12	21	9–34
Petroleum/solvent	<1	<1	4	2-5
Miscellaneous	2	<1–3	4	1–6

Note: Extrapolated from Air Emission Inventories (1985) for the Australian Capital Cities—Australian Environment Council Report No. 22. Percentages quoted are indicative only and are an arithmetic average of the values for Sydney, Melbourne, Brisbane, Perth and Adelaide. The range values shown are the lowest and highest percentage from the 5 cities.

(a) In major Australian cities.

Source: Adapted from ABS 1996.

Other indirect greenhouse gas emissions for CO, NO_x and NMVOCs are presented below for each transport mode. Cars which use diesel fuel emit significantly less NO_x and CO than post–1985 petrol powered cars, while LPG–powered cars emit more CO and NMVOCs than either post-1985 petrol cars (64% more CO and 70% more NMVOCs) and diesel cars (95% more CO and 69% more NMVOCs).

Buses using petrol, diesel oil or LPG emit more NO_x, CO and NMVOCs than cars using these same fuels. Vehicles using natural gas emit the least volume overall of the air pollutant emissions examined.

NO_x emissions

In 1994 an estimated 500 kilotonnes of NO_x were released from Australian transport. A large proportion of this (316 kilotonnes) came from road transport (table 6.10). The highest source of these oxides was passenger cars with 204 kilotonnes or 64.6% of road vehicle NO_x emissions.

6.10 NO_x EMISSIONS FROM MOTOR VEHICLES

		1988	*1990*	*1992*	*1994*
Vehicle type	*Fuel type*	kilotonnes	kilotonnes	kilotonnes	kilotonnes
Passenger cars					
	Petrol	228.4	229.4	200.3	185.3
	Post-1985	28.0	44.4	58.2	75.3
	1976–1985	144.1	143.6	115.2	93.0
	Pre-1976	56.3	41.4	26.9	16.9
	ADO	2.1	3.1	3.8	4.3
	LPG	5.5	7.4	11.4	14.9
	NG	0.0	0.0	0.0	0.0
	Total	*236.0*	*239.9*	*215.5*	*204.5*
Motorcycles	Petrol	0.4	0.4	0.3	0.3
Light goods vehicles					
	Petrol	42.5	40.0	32.8	29.0
	ADO	4.9	6.0	6.5	7.3
	LPG	1.2	2.1	3.9	5.5
	NG	0.0	0.0	0.0	0.0
	Total	*48.6*	*48.1*	43.2	*41.8*
Medium goods vehicles					
	Petrol	8.4	4.6	1.2	0.0
	ADO	44.7	43.3	35.1	35.1
	LPG	0.9	0.8	0.5	0.2
	NG	0.0	0.0	0.1	0.2
	Total	54.0	*48.7*	36.9	35.5
Heavy goods vehicles					
	Petrol	1.8	1.0	0.3	0.1
	ADO	24.2	25.8	24.6	25.8
	LPG	0.3	0.3	0.2	0.1
	NG	0.0	0.0	0.0	0.1
	Total	*26.4*	*27.1*	*25.2*	*26.0*
Buses					
	Petrol	1.0	0.8	0.4	0.3
	ADO	5.7	6.5	6.5	7.1
	LPG	0.0	0.0	0.0	0.1
	NG	0.0	0.0	0.5	0.9
	Total	*6.7*	*7.2*	7.4	*8.3*
Total		**372.0**	**370.9**	**328.4**	**316.3**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

In 1994, railway operations released 35 kilotonnes of NO_x, 5.5% of the total NO_x (table 6.11). Marine transport emitted 80 kilotonnes of NO_x with domestic services accounting for 29 kilotonnes (table 6.12). Aircraft emitted 69 kilotonnes of NO_x to the atmosphere, with international flights accounting for 60% (table 6.13).

6.11 NO_x EMISSIONS FROM RAILWAYS

	1988	*1990*	*1992*	*1994*
Fuel type	kilotonnes	kilotonnes	kilotonnes	kilotonnes
Diesel	38.6	35.2	33.7	33.5
IDF	4.0	2.6	2.6	1.7
Total	**42.6**	**37.8**	**36.3**	**35.2**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

6.12 NO_x EMISSIONS FROM SHIPPING

		1988	*1990*	*1992*	*1994*
Vehicle type	*Fuel type*	kilotonnes	kilotonnes	kilotonnes	kilotonnes
Domestic					
	Petrol	1.4	1.5	1.5	1.5
	ADO	2.9	1.1	0.5	1.3
	Fuel oil	49.2	37.6	29.6	24.9
	Coal	0.7	0.7	0.8	0.7
	IDF	2.8	2.1	2.2	1.0
	Total	*57.0*	*42.9*	*34.5*	*29.5*
International					
	ADO	4.4	4.3	4.5	5.3
	Fuel oil	37.4	45.9	40.5	42.2
	IDF	5.1	4.5	2.8	2.6
	Total	*47.0*	*54.7*	*47.7*	*50.2*
Total		**103.9**	**97.6**	**82.2**	**79.6**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

6.13 NO_x EMISSIONS FROM AIRCRAFT

		1988	*1990*	*1992*	*1994*
Vehicle type	*Fuel type*	kilotonnes	kilotonnes	kilotonnes	kilotonnes
Domestic					
	Avtur	23.6	17.5	28.1	27.7
	Avgas	0.3	0.3	0.2	0.3
	Total	*23.8*	*17.9*	*28.4*	*28.0*
International	Avtur	26.5	33.4	36.9	41.2
Total		**50.3**	**51.3**	**65.3**	**69.2**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

CO emissions

Engines used for transport activities are responsible for almost all CO pollution (Federal Office for Road Safety 1996, p. A-6). For 1994, the Australian Greenhouse Gas Emission Inventory recorded CO emissions from transport in Australia as totalling 3,459 kilotonnes.

3,241 kilotonnes of CO were emitted to the atmosphere by road transport in 1994 (table 6.14). This represents 92% of the total carbon monoxide emitted into the atmosphere by Australian transport. The greatest source of road vehicle emissions was from passenger cars, which released 2,496 kilotonnes or 77% of the total CO generated by road transport. Of these vehicles, 93% of emissions were from petrol powered cars.

Railways emitted 4.7 kilotonnes, or 0.13% of total CO emissions from transport in 1994. Automotive diesel oil accounted for 4.4 kilotonnes or 95% of the total (table 6.15).

In 1994, shipping operations accounted for 124 kilotonnes, or 3.5% of total CO emissions, with domestic usage responsible for 123 kilotonnes or 98% of those emissions (table 6.16). For domestic marine vehicles the greatest proportion of emissions came from small, petrol-powered craft, which released 121 kilotonnes.

In 1994, aircraft operations accounted for 89 kilotonnes, or 2.5% of total transport CO emissions (table 6.17). Of this, 80 kilotonnes was from domestic flights. Aviation gasoline, used principally by piston aircraft, accounted for 74 kilotonnes of domestic operation emissions.

6.14 CO EMISSIONS FROM MOTOR VEHICLES

Vehicle type	Fuel type	1988 kilotonnes	1990 kilotonnes	1992 kilotonnes	1994 kilotonnes
Passenger cars					
	Petrol	3 627.6	3 564.6	2 781.6	2 325.7
	Post-1985	274.3	413.0	530.4	686.4
	1976–1985	2 070.9	2 106.2	1 642.9	1 294.4
	Pre-1976	1 282.4	1 045.5	608.2	344.9
	ADO	2.2	3.3	4.0	4.5
	LPG	61.7	81.9	127.1	165.8
	Total	*3 691.5*	*3 649.8*	*2 912.6*	*2 496.0*
Motorcycles	Petrol	36.4	34.4	30.2	29.5
Light goods vehicles					
	Petrol	586.9	540.8	396.3	316.5
	ADO	4.4	5.5	5.9	6.6
	LPG	11.8	19.9	37.3	52.9
	Total	*603.1*	*566.2*	*439.5*	*376.1*
Medium goods vehicles					
	Petrol	189.6	87.8	18.8	0.0
	ADO	23.9	25.7	22.5	22.5
	LPG	4.3	3.8	2.6	1.2
	Total	*217.8*	*117.2*	*44.0*	*23.7*
Heavy goods vehicles					
	Petrol	41.2	18.9	5.2	0.7
	ADO	548.6	496.5	395.9	305.9
	LPG	6.7	5.1	3.1	1.1
	Total	*596.4*	*117.2*	*404.2*	*307.6*
Buses					
	Petrol	12.9	9.5	5.2	3.3
	ADO	3.3	3.8	3.8	4.2
	LPG	0.1	0.2	0.4	0.7
	NG	0.0	0.0	0.1	0.2
	Total	*16.4*	*13.5*	*9.5*	*8.3*
Total		**5 161.5**	**4 901.6**	**3 840.1**	**3 241.2**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

6.15 CO EMISSIONS FROM RAILWAYS

Fuel type	1988 kilotonnes	1990 kilotonnes	1992 kilotonnes	1994 kilotonnes
ADO	5.1	4.7	4.4	4.4
IDF	0.5	0.3	0.3	0.2
Total	**5.6**	**5.0**	**4.8**	**4.7**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

6.16 CO EMISSIONS FROM SHIPPING

		1988	1990	1992	1994
Vehicle type	*Fuel type*	kilotonnes	kilotonnes	kilotonnes	kilotonnes
Domestic					
	Petrol	114.7	119.6	117.5	120.8
	ADO	0.6	0.2	0.1	0.3
	Fuel oil	1.1	0.8	0.7	0.6
	IDF	0.3	0.2	0.2	0.1
	Coal	0.8	0.8	0.9	0.8
	Total	*117.5*	*121.6*	*119.4*	*122.6*
International					
	ADO	0.5	0.4	0.5	0.6
	Fuel oil	0.8	1.0	0.9	0.9
	IDF	0.5	0.5	0.3	0.3
	Total	*1.8*	*1.9*	*1.6*	*1.8*
Total		**119.3**	**123.5**	**121.0**	**124.3**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a. 1996b, 1996c, 1996d.

6.17 CO EMISSIONS FROM AIRCRAFT

		1988	1990	1992	1994
Vehicle type	*Fuel type*	kilotonnes	kilotonnes	kilotonnes	kilotonnes
Domestic					
	Avtur	4.9	3.7	5.9	5.8
	Avgas	81.0	93.5	72.0	74.4
	Total	*85.9*	*97.2*	*77.8*	*80.2*
International	Avtur	5.5	7.0	7.7	8.6
Total		**91.4**	**104.2**	**85.5**	**88.8**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

NMVOC EMISSIONS

Volatile organic compounds, or 'air toxics', are air pollutants, including heavy metals and organic compounds, separate from, and in addition to the class of pollutants described previously. Traditionally, research on air toxics has focused on the collective role of a range of volatile organic compounds as precursors of photochemical smog formation. Some of the chemicals consistently presenting concern include benzene, 1,3-butadiene, carbon tetrachloride, chloroform and formaldehyde (ECOS 1994).

For 1994, the Australian Greenhouse Gas Emission Inventory recorded NMVOC emissions from transport in Australia as totalling 508 kilotonnes. Of this, road transport accounted for 478 kilotonnes (90.7%) of NMVOC emissions in 1994 (table 6.18).

Passenger cars generated 391 kilotonnes or 81.8% of the road transport tally, with motor vehicles running on petrol responsible for 376 kilotonnes or 96% of passenger car emissions.

6.18 NMVOC EMISSIONS FROM ROAD VEHICLES

Vehicle type	*Fuel type*	*1988* kilotonnes	*1990* kilotonnes	*1992* kilotonnes	*1994* kilotonnes
Passenger cars					
	Petrol	493.2	487.4	413.7	375.6
	Post-1985	60.3	98.1	98.1	150.8
	1976–1985	266.2	259.7	214.5	177.5
	Pre-1976	166.8	129.7	79.3	47.3
	ADO	1.1	1.6	2.0	2.2
	LPG	4.8	6.4	9.9	13.0
	Total	*499.1*	*495.5*	*425.6*	*390.8*
Motorcycles	Petrol	10.1	9.5	8.4	8.2
Light goods vehicles					
	Petrol	69.1	65.7	53.2	47.0
	ADO	2.2	2.7	2.9	3.3
	LPG	0.9	1.6	2.9	4.1
	Total	*72.2*	*70.0*	*59.0*	*54.4*
Medium goods vehicles					
	Petrol	16.1	8.1	1.9	0.0
	ADO	6.3	5.8	4.6	4.5
	LPG	0.8	0.7	0.5	0.2
	Total	*23.1*	*14.6*	*6.9*	*4.7*
Heavy goods vehicles					
	Petrol	3.5	1.8	0.5	0.1
	ADO	28.0	25.3	20.1	16.7
	LPG	0.3	0.3	0.2	0.1
	Total	*31.9*	*27.3*	*20.8*	*16.9*
Buses					
	Petrol	1.6	1.2	0.6	0.4
	ADO	1.8	2.1	2.1	2.3
	LPG	0.0	0.0	0.0	0.1
	NG	0.0	0.0	0.0	0.0
	Total	*3.4*	*3.2*	*2.7*	*2.7*
Total		**639.8**	**620.1**	**523.4**	**477.6**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

In 1994, rail transport released 1.6 kilotonnes of NMVOCs, mostly from diesel powered vehicles (table 6.19). Marine transport emitted 23 kilotonnes, domestic operations contributing 93% of NMVOCs in 1994 (table 6.20). Domestic voyages released 21 kilotonnes or 93.1% of the total. Six kilotonnes were released by air transport activities (table 6.21).

6.19 NMVOC EMISSIONS FROM RAILWAYS

Fuel type	*1988* kilotonnes	*1990* kilotonnes	*1992* kilotonnes	*1994* kilotonnes
ADO	1.8	1.6	1.6	1.6
IDF	0.2	0.1	0.1	0.1
Total	**2.0**	**1.8**	**1.7**	**1.6**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

6.20 NMVOC EMISSIONS FROM SHIPPING

Vehicle type	Fuel type	*1988* kilotonnes	*1990* kilotonnes	*1992* kilotonnes	*1994* kilotonnes
Domestic					
	Petrol	18.3	19.1	18.8	19.3
	ADO	0.2	0.1	0.0	0.1
	Fuel oil	1.6	1.2	0.9	0.8
	IDF	0.1	0.1	0.1	0.0
	Coal	0.9	0.9	1.0	1.0
	Total	*21.0*	*21.3*	*20.8*	*21.2*
International					
	ADO	0.1	0.1	0.1	0.2
	Fuel oil	1.2	1.5	1.3	0.1
	IDF	0.2	0.1	0.1	1.3
	Total	*1.5*	*1.7*	*1.5*	*1.6*
Total		**22.5**	**23.0**	**22.3**	**22.7**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

6.21 NMVOC EMISSIONS FROM AIRCRAFT

Vehicle type	Fuel type	*1988* kilotonnes	*1990* kilotonnes	*1992* kilotonnes	*1994* kilotonnes
Domestic					
	Avtur	1.6	1.2	1.9	1.8
	Avgas	1.8	2.1	1.6	1.7
	Total	*3.4*	*3.3*	*3.5*	*3.5*
International	Avtur	1.8	2.2	2.4	2.7
Total		**5.1**	**5.5**	**5.9**	**6.2**

Source: Adapted from National Greenhouse Gas Inventory Committee 1996a, 1996b, 1996c, 1996d.

Table 6.22 presents an estimate of a number of these toxic air pollutants from motor vehicles in Melbourne for 1990 and predicted 2005. According to this study, diesel particulates are expected to increase by 15% over this period.

6.22 TOXIC AIR POLLUTANTS, By Motor Vehicle Fleet—Melbourne

	1990	*2005*
	mg/km	mg/km
Benzene	153	80–110
1,3-Butadiene	17	8
Formaldehyde	52	21–26
Acetaldehyde	9	4–5
Diesel particulate	101	116
Petrol particulate	34	8

Source: Coffey Partners International Pty Ltd 1996.

Photochemical smog

The essential ingredients of photochemical smog formation are NO_x, reactive volatile organic compounds (mostly hydrocarbons), and sunlight (DEST 1996). Motor vehicles, and related industries in the transport and storage of fuels, are the principal source of these two common urban pollutants (table 6.23). Under certain conditions, hydrocarbons (HC) and NO_x will react chemically to form ozone, the principal constituent of photochemical smog. At low concentrations, this gas can affect human and animal health, and damage plants and buildings (ECOS 1992).

6.23 RELATIVE CONTRIBUTION TO HCs AND NO_x(a), By Source

	HCs................		NO_x................	
	Average	*Range*	*Average*	*Range*
Source	%	%	%	%
Motor vehicles	45	41–50	67	54–80
Other mobile	2	2–3	5	4–5
Waste combustion	1	1–2	<1	<1
Fuel combustion	10	6–16	21	9–34
Petroleum/solvent	35	30–38	4	2–5
Miscellaneous	5	4–8	4	1–6

(a) In major Australian cities.

Note: Extrapolated from Air Emission Inventories 1985 for the Australian Capital Cities—Australian Environment Council Report No. 22. Percentages quoted are indicative only and are an arithmetic average of the values for Sydney, Melbourne, Brisbane, Perth and Adelaide. The range values shown are the lowest and highest percentage from the 5 cities.

Source: Adapted from ABS 1996.

HCs control the rate of smog formation. Hence, lowering HC emissions can be an effective way of controlling photochemical smog . Table 6.24 shows HC emissions data from the Melbourne Statistical Division vehicle fleet, estimated largely from Environment Protection Authority projections. Total HC emissions are expected to decrease to 49.2 kilotonnes per year by 2015, with the major decreases since 1980 occurring as a result of reduced evaporative and crankcase emissions.

In large cities, however, control of photochemical smog also requires a lowering of NOx emissions. The process of ozone formation continues as long as both sunlight and NO_x are available. In Sydney, motor vehicles contribute about 85% of NO_x emissions, with trucks and buses contributing about one third (ECOS 1992).

6.24 HC EMISSIONS FROM CARS, Melbourne Statistical Division

	Exhaust(a)	*Evaporation*	*Car crankcase*	*Total*
Year	kilotonnes/year	kilotonnes/year	kilotonnes/year	kilotonnes/year
1980	42.1	24.4	7.7	74.2
1988	45.0	19.7	1.4	66.1
1990	44.9	17.1	0.6	62.8
1995	46.6	12.4	0.0	59.0
2000	44.8	9.8	0.0	54.6
2005	41.9	8.8	0.0	50.7
2015	39.8	9.3	0.0	49.2

(a) Includes new Australian Design Rules.

Source: Nairn and Partners, Leonie Segal Economic Consultants, Dr Watson 1994.

LEAD EMISSIONS

Engines used in transport are responsible for almost all the lead in major urban areas, with motor vehicles contributing around 90% of airborne lead in these areas. As shown in table 6.25, lead emissions have decreased substantially since 1980. It has also been estimated that over the life of the car about 75% of the tetra-alkyl lead added to fuel is emitted from the exhaust system of the vehicle as a diverse mixture of inorganic lead salts. In addition, approximately 2% of the lead in petrol may escape unchanged to the atmosphere due to evaporation from the fuel tank, carburettor or spillage during transport and refuelling, with the major portion of the remaining lead being retained in the vehicle's engine, exhaust system and sump oil .

6.25 LEAD EMISSIONS(a) FROM LEAD-FUELLED MOTOR VEHICLES

	NSW(b)	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*Aust.*
Year	GWT	GWT	GWT	GWT	GWT	GWT	GWT	GWT
1980	n.a.	1 431	n.a.	854	n.a.	147	n.a.	n.a.
1990	n.a.	769	1 431	536	n.a.	124	n.a.	n.a.
1995	n.a.	306	346	151	178	59	15	n.a.

(a) Calculation based on sales of leaded petrol and amount of lead in each litre of petrol.
(b) Includes ACT.

Source: Derived from Department of Primary Industries and Energy and Australian Institute of Petroleum data.

During the early stages of the introduction of unleaded petrol from February 1986 this fuel continued to contain a small amount of lead. Table 6.26 shows the maximum permissible lead content in leaded petrol. Current unleaded fuel is considered to have a nil or negligible lead content. Metals used in the catalytic converters fitted to the exhaust systems of unleaded vehicles are progressively destroyed by the presence of lead, thus removing the pollution control properties that the converter provides.

6.26 MAXIMUM PERMISSIBLE LEAD CONTENT IN LEADED PETROL(a)

Year	NSW(b) g/L	Rest of NSW g/L	Vic. g/L	Qld g/L	SA g/L	WA g/L	Tas. g/L	NT g/L	ACT g/L
1980	0.40	0.84	0.45	n.a	0.80	n.a.	0.45	n.a.	0.84
1990	0.40	0.84	0.30	0.84	0.65	n.a.	0.45	n.a.	0.84
1995	0.20	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.20
1996	0.20	0.20	0.20	0.20	0.30	0.20	0.20	0.20	0.20

(a) Covers city petrol only.

(b) Sydney, Newcastle, Wollongong.

Source: Australian Institute of Petroleum 1996.

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CHAPTER 7

WASTES FROM TRANSPORT

ROAD VEHICLE WASTES

Road transport vehicles produce solid and liquid wastes as a result of day-to-day running and maintenance of vehicles (e.g. lubricating oils and greases, brake and clutch fluids, antifreeze and air conditioning gases, which need to be replaced at intervals).

Wastes are also generated as vehicle components are replaced and repaired, for example, ignition parts, tyres, batteries and panels. These parts can contain recyclable materials (such as the metals used in exhaust systems, batteries and panels), as well as potentially dangerous materials such as the asbestos used in the brake linings of older vehicles. When an entire vehicle is no longer serviceable, disposal is complicated by the wide range of different materials and components used in its manufacture.

The volume of motor vehicles requiring disposal annually is indicated by the attrition rate of the national motor vehicle fleet. Table 7.1 shows attrition rates over the 20 year period from 1974–75 to 1994–95. In 1994–95, 345,800 passenger cars were removed from registration. In recent years the vehicle attrition rate for all vehicles has been around 3–4% of the total fleet.

7.1 ESTIMATED MOTOR VEHICLE ATTRITION RATE—Selected Years

	Passenger vehicles expired registration		*Total motor vehicles expired registration(a)*	
Year	no.	% fleet	no.	% fleet
1974–75	234 100	5.1	319 600	5.6
1979–80	308 600	5.5	375 500	5.3
1984–85	304 600	4.6	380 100	4.5
1989–90	262 100	3.5	340 700	3.6
1990–91	369 100	4.8	504 300	5.2
1991–92	258 000	3.3	381 400	3.9
1992–93	313 000	4.0	356 200	3.6
1993–94	317 200	4.0	306 570	3.0
1994–95	345 800	4.2	408 109	3.9

(a) Excludes motor cycles, plant and equipment, caravans and trailers.

Source: ABS 1995.

Since the types of materials, assembly processes and pollution controls used in vehicles have changed over time, the age of the national fleet will affect the recyclability of vehicle materials as well as emission levels. Table 7.2 shows that the estimated average age of the vehicle fleet has been increasing, rising from 6.1 years in 1961 to 10.6 years in 1995. The highest average vehicle age occurred in Tasmania (12.1 years), while the lowest was in the Northern Territory (9.4 years). The oldest vehicle types were non-freight carrying trucks, with an average age of 15.2 years, while buses (8.9 years) had the lowest average age (ABS n.d.).

7.2 ESTIMATED AVERAGE AGE OF THE VEHICLE FLEET

	1971	*1976*	*1979*	*1982*	*1985*	*1988*	*1991*	*1993*	*1995*
Average age (years)	6.1	6.5	7.1	7.6	8.0	9.1	9.8	10.4	10.6

Source: ABS 1995.

VEHICLE BODIES AND PARTS DISPOSAL

Motor vehicles are comprised of a range of materials, including ferrous metals (about 80% by weight), other metals, plastics, rubber and glass. The manufacturing processes of motor vehicles have increasingly been designed to allow easier assembly, with fastening systems such as welding and adhesive bonding which are intended to be permanent. This creates difficulties for recycling the vehicle at the end of its useful life, when separation of the components into basic materials is required (SAE 1992, p. 41).

When they reach the end of their useful life, either through accident damage or age, most vehicles (70–80%), are dismantled into their component parts by licensed automobile recyclers , where the useable parts are removed and sold for reuse in other vehicles (APRAA 1995). The remaining shell and unwanted parts are shredded into small chunks, which are then sorted into ferrous scrap, non-ferrous scrap and a residue which is mainly plastics, rubber, foam and fibres. The metal scrap can be recycled but the plastic residues are usually consigned to landfill (SAE 1992, p. 42).

Despite increasing community involvement in recycling and reducing waste, a proportion of discarded vehicle bodies and parts are illegally dumped, mainly along roadways and in bushland. Volunteers participating in the annual Clean Up Australia Day collect tyres, batteries, car parts and even whole vehicle bodies during their community clean up. Table 7.3 shows the numbers of discarded vehicle parts collected over three consecutive national clean ups.

7.3 VEHICLE PARTS COLLECTED DURING CLEAN UP AUSTRALIA DAY

Discarded items	*1993*	*1994*	*1995*
Car bodies	224	2 000	n.a.
Car/boat parts	907	1 345	464
Batteries	74	n.a.	69
Tyres	1 141	865	255

Note: The number of volunteers and hence intensity of rubbish collection varies from year to year. In 1994, vehicle batteries were listed with other types of batteries. In 1995, the number of car bodies collected was not listed.

Source: Clean Up Australia 1993; 1994; 1995.

Internationally, vehicle manufacturers are moving towards new design and manufacturing procedures which allow easier dismantling of vehicle components, identification markers for different materials to allow reuse, and recycling processes for plastics and other synthetic materials.

USED TYRE DISPOSAL

Tyres consist of about 60% HCs, principally synthetic rubber, and 40% other materials such as carbon black, pigments, steel, fabric and clay. A new tyre requires about 23 litres of crude oil equivalent for raw materials and 9 litres for processing. The bonding and setting process, vulcanisation, is irreversible and new tyres cannot be produced from old tyres.

In 1989–90, around 14.4 million road vehicle tyres were replaced in Australia. Table 7.4 shows the sources for the replacement tyres included: new Australian made (37%); new imported (32%); retreads (27%); and imported second hand (4%). Although the life of a retread is shorter than for a new tyre the life of the tyre carcass is extended, thus deferring final disposal. It has been estimated that up to 40% of used tyres could be retreaded. Passenger vehicle tyres can generally be retreaded only once.

In 1990, the majority of used tyres were consigned to landfill (66%), where they constituted a significant management problem for landfill operators. Tyres stockpiled together in large quantities can pose a potentially serious fire hazard, with uncontrolled burning tyres having a major air pollution impact. Stockpiled tyres also provide ideal breeding grounds for disease carriers such as mosquitos. The remaining 7% of used tyres were given over to other uses, mainly as a fuel source (ANZECC 1991, pp. 17, 27).

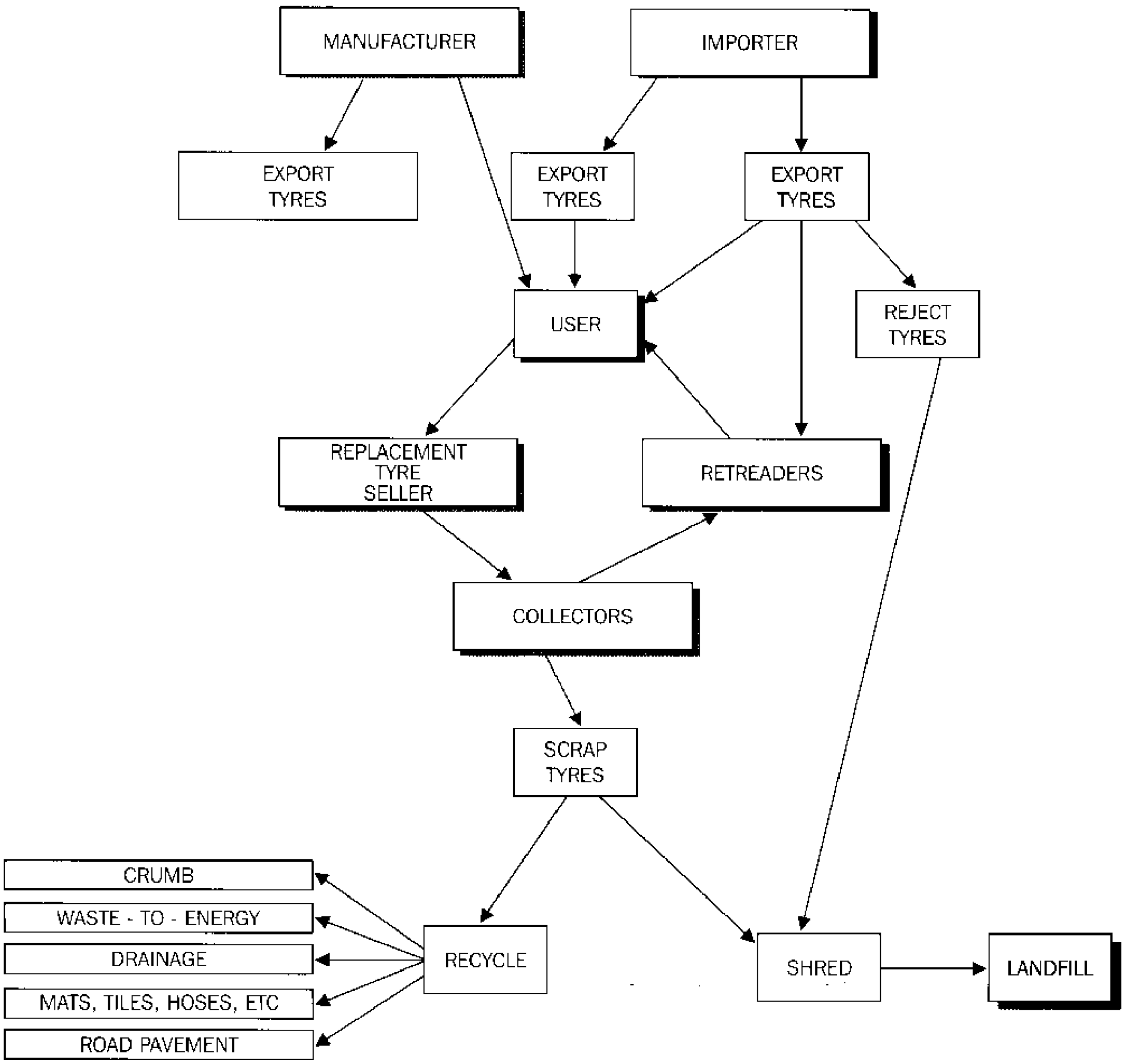
7.4 SOURCES AND FATES OF TYRES—1990

Sources of replacement tyres	%	*Used tyre disposal*	%
New, Australian made	37	Landfill or stockpile	66
New, imported	32	Retreading	27
Retreads	27	Other uses	7
Secondhand, imported	4		
Total	**100**	**Total**	**100**

Source: Australia and New Zealand Environment Conservation Council 1991, pp. 17, 27.

During the past five years, most States have legislated to prevent whole used tyres from being dumped directly into landfill, and tyres must now be shredded finely before disposal. Other uses are being developed—in Victoria, about one and a half million tyres per year are used in cement kilns as fuel, thus reducing the other fuel intake of the kilns. Limited amounts of used tyres are broken down into rubber crumb which is the raw material for rubber goods such as paving for playgrounds and soaker hoses. Diagram 7.5 shows the usual pathways that tyres travel from manufacture to disposal.

7.5 SOURCES AND FATES OF MOTOR VEHICLE TYRES



Source: Maunsell Pty Ltd 1994, p. 82.

USED LEAD ACID BATTERY DISPOSAL

During the early 1990s, around 3.8 million lead acid batteries were disposed of annually in Australia. As table 7.6 shows, around 61% of these batteries or 2.3 million were recycled, with 25,000 tonnes of lead and 1,800 tonnes of plastics recovered for recycling annually (Kinhill Engineers Pty Ltd 1994, pp. 2–4,2–5). Most of the remainder were exported for recycling . The volume of exports in 1993 was 23,900 tonnes, worth $6.5 million (Thompson Environmental Services 1994, p. 18).

7.6 USED BATTERY DISPOSAL

Lead acid batteries	*million*
Recycled in Australia	2.3
Exported for recycling	1.3
Disposed of in landfill	0.2
Total	**3.8**

Source: Kinhill Engineers Pty Ltd 1994.

An ABS survey of householders' views and practices on environmental issues, found that for the 824,000 surveyed households in March 1996, the most common method of disposing of used vehicle batteries was to take them to a business or shop (41%). Table 7.7 shows the range of householders' disposal methods for used vehicle batteries.

7.7 HOUSEHOLD DISPOSAL OF USED VEHICLE BATTERIES—March 1996

	'000	%
Taken to a business or shop	339	41
Dump—special area	163	20
Collection point other than dump	107	13
Special service from home	67	8
Dump—general area	62	8
With usual gabage collection	46	6
Buried	12	2
Other	35	4
Total	(a)824	—

(a) Total does not equal the sum of column because more than one method may be specified.

Source: ABS 1997.

Used vehicle batteries are the major source (90%) of lead scrap recycled in Australia (Bureau of Industry Economics 1995, p. 15). The process of recycling involves the breaking up of each battery into its plastic and lead material components, the neutralisation and disposal of waste sulphuric acid, and the collection of lead for furnace use and plastic for granulation and reuse (Kinhill Engineers Pty Ltd 1994, pp. 2–3,2–4).

WASTE OIL DISPOSAL

Lubricating oils are used in engines, transmissions, bearings and hydraulics systems. They consist of a base oil blended with specific additives for each performance requirement. Table 7.8 shows the demand for lubricating oils in Australia, which for transport is 301 megalitres per year, with a further 193 megalitres being used by various parts of industry.

7.8 LUBRICATING OIL SALES

Product	1990 ML	1993 ML
Automotive	288	269
Other transport	29	32
Industrial	112	96
Grease	14	13
Other lubricants	72	84
Total	**515**	**494**

Source: Maunsell Pty Ltd 1994.

Lubricating oils collect a range of impurities during their service life, including carbon deposits, water, grit, petrol, metal particles, alcohols, aldehydes and acids. In hydraulic systems very little oil volume is lost over time and therefore a high proportion is available as waste oil. On the other hand lubricating oil in 2-stroke engines is consumed along with the fuel. Around 49% of all oils sold are consumed, lost or otherwise not available for collection. The waste oil available to be reused or recycled in some manner amounted to about 51% of total sales, or 262 megalitres in 1990 and 251 megalitres in 1993. Waste oils from transport and other industries are often not handled separately at collection. Table 7.9 shows the total waste oil available for recycling or reprocessing. Around 35% of available waste oil was collected for reuse in 1990, with the figure increasing to 45% in 1993. Recent national data is not available, so it is not known whether the Australia and New Zealand Environmental Conservation Council target of 70% collection by 1995 has been achieved.

7.9 WASTE OIL AVAILABILITY AND COLLECTION

	1990		1993	
	ML	%	ML	%
WASTE OIL AVAILABLE				
Sales	515	100	494	100
Consumed, loss, not available	253	49	243	49
Total available	**262**	**51**	**251**	**51**
WASTE OIL DISPOSED				
Collected by Industry	91	35	113	45
Own use/disposal	171	65	138	55
Total disposed	**262**	**100**	**251**	**100**

Source: Maunsell Pty Ltd 1994; Australia and New Zealand Environment Conservation Council 1991.

An ABS survey of householders' views and practices on environmental issues, found that for the 653,000 surveyed households who disposed of used motor oil in March 1996, the most common means of disposal were for the oil to be taken to a special area at a dump (23%) or to be taken to a business or shop (23%). Table 7.10 shows the range of householders' disposal methods for used motor oil.

7.10 HOUSEHOLD DISPOSAL OF WASTE MOTOR OIL—March 1996

	'000	%
Dump—special area	151	23
Taken to a business or shop	150	23
With usual garbage collection	70	11
Collection point other than dump	68	11
Dump—general area	44	7
Special service from home	30	5
Buried	26	4
Other	125	19
Total	(a)654	—

(a) Total does not equal the sum of column because more than one method may be specified.

Source: ABS 1997.

Once the waste oil has been collected, it can be either reprocessed or re-refined. Reprocessing involves the removal of contaminants by a variety of filtration methods. The oil is then generally used as fuel oil. Re-refining involves the removal of contaminants and oil additives, allowing the oil to be reused as a lubricant. Most (57%) collected waste oil in 1990 was used as a fuel source. Waste oil is also exported for reprocessing or reuse, with an estimated 18 million tonnes exported in 1994 (Thompson Environmental Services 1994, p. 13).

CFCs FROM VEHICLE AIR CONDITIONING SYSTEMS

Prior to 1994, car air conditioning systems were run using a refrigerant called R12 which is an ozone depleting CFC. Since 1994, all refrigerant gases in air conditioning systems were required to be non-ozone depleting and so cars manufactured since that year use a replacement gas, R134A, as the refrigerant. Air conditioning repairers and specialists are required to remove R12 from systems under repair and refill the system with the non-ozone depleting replacements. Licensed automobile recyclers are required to collect any R12 remaining in cars being dismantled.

An average vehicle air conditioning system contains about 200–400 grams of refrigerant gases. These gases tend to leak from air conditioning systems at the rate of up to 50% over 1–2 years. As the majority of Australian vehicles include air conditioning, the leakage rates over the past decades have been considerable (Commonwealth Environment Protection Agency, pers. comm.).

RAIL WASTE

The major wastes from rail are the rolling stock, which is eventually recycled as scrap metal, and waste infrastructure, i.e, old rail lines and power wiring. Waste oil is recovered by rail authorities and recycled.

SHIPPING WASTE

The major wastes from shipping activities in Australia's coastal waters comprises ballast water, anti-hull fouling chemicals, ocean litter and oil from accidental spills. These are described in detail in Chapter 9.

AVIATION WASTE

The long service life and relatively small number of aircraft result in a comparatively low level of waste in terms of the disposal of aircraft bodies. Larger aircraft operated by Australian international and domestic carriers are often sold overseas when the local fleet is upgraded. Aviation fuel is occasionally dumped from aircraft when unusual flight conditions, such as a malfunction, require the aircraft to land unexpectedly, and with a load heavier than the structure can safely bear. Such dumped fuel evaporates into the atmosphere, and no data about the quantities of dumped fuel are available.

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ANZECC Australian and New Zealand Environment and Conservation Council

APRAA Automobile Parts Recycling Association of Australia

BIE Bureau of Industry Economics

SAE The Engineering Society for Advancing Mobility Land Sea Air and Space

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CHAPTER **8**

IMPACTS OF TRANSPORT ON PEOPLE........

Although transport makes an important contribution to human society, there are also costs to human health and welfare. This chapter looks at traffic accidents, adverse health effects associated with transport, noise, congestion and some of the social and economic costs associated with these impacts.

ROAD TRAFFIC ACCIDENTS

Road traffic accidents are costly in terms of deaths and injuries to people and damage to vehicles and property. They constitute a major social issue both in terms of years of potential life lost and in the cost to the community.

In 1994, 22,154 people were admitted to hospital as a result of a road crash involving injuries or fatalities. Australia-wide, 1,934 people were killed in road accidents and the rate of fatalities was 10.8 per 100,000 people, with the Northern Territory having the highest fatality rate (24) and the Australian Capital Territory the lowest (5.7).

8.1 PERSONS HOSPITALISED AND KILLED IN ROAD ACCIDENTS(a)—1994

			PER 100 000 POPULATION......		PER 10 000 MOTOR VEHICLES REGISTERED(b)	
State/Territory	*Killed*	*Hospitalised*	*Killed*	*Hospitalised*	*Killed*	*Hospitalised*
NSW	647	6 287	10.7	104	1.98	19.3
Vic.	378	6 023	8.4	135	1.35	21.4
Qld	422	4 576	13.2	143	2.14	23.2
SA	159	1 514	10.8	103	1.77	16.5
WA	211	2 660	12.4	156	1.85	23.3
Tas.	59	523	12.5	111	1.83	16.5
NT	41	386	24.0	226	4.46	42.0
ACT	17	185	5.7	61	0.93	10.1
Aust.	1 934	22 154	10.8	124	1.81	20.7

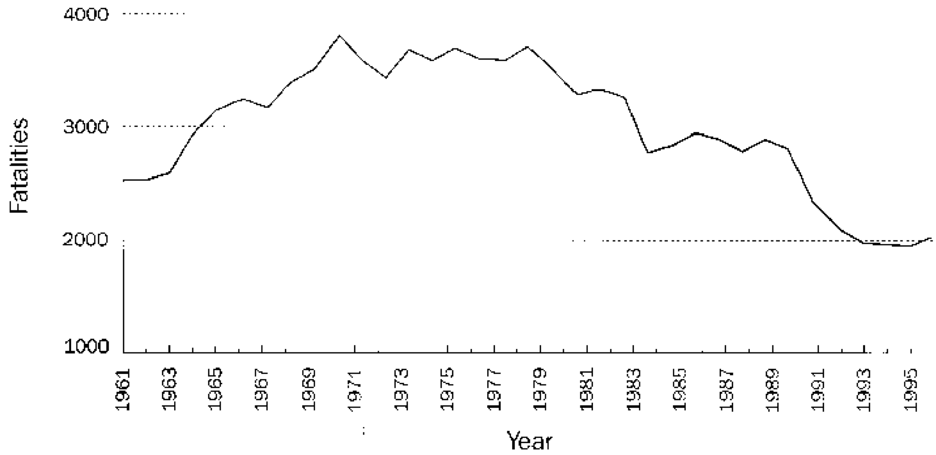
(a) Accidents reported to the police or other relevant authority which occurred in public thoroughfares and which resulted in death within thirty days or personal injury to the extent that the injured person was admitted to hospital.

(b) Number of motor vehicles (excluding tractors, plant and equipment) on register at 30 June 1993.

Source: Federal Office of Road Safety 1995.

The rate of road traffic accidents is decreasing. Figure 8.2 shows the trend in road fatalities between 1961 and 1995. Significant reductions in fatalities occurred from 1989 (2,801) to 1994 (1,934), however the road toll rose to 2,017 in 1995 (Department of Transport and Regional Development 1996, p.45). The introduction of legislation making the wearing of seat belts compulsory and random breath testing have played a major role in reducing the rate of deaths due to traffic accidents (ABS 1996, p. 170).

8.2 ANNUAL ROAD FATALITIES



Source: Department of Transport and Regional Development 1996, p. 45.

Table 8.3 shows the number of motor vehicle accidents and fatalities by State and Territory for the period 1988–95. Between 1990 and 1995, the rate of accident reduction was around 2.3%, with a reduction in deaths of 2.9% over the same period.

8.3 TRAFFIC ACCIDENTS INVOLVING FATALITIES

Year	*NSW*	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
				ACCIDENTS INVOLVING FATALITIES					
1988	912	627	483	206	199	68	46	31	2 572
1989	783	681	376	201	214	68	57	26	2 406
1990	702	492	347	187	181	63	54	24	2 050
1991	585	435	359	166	187	66	60	16	1 874
1992	576	365	363	142	171	59	42	18	1 736
1993	518	381	357	191	190	47	41	11	1 736
1994	553	346	368	143	195	52	36	15	1 708
1995	563	371	408	163	194	53	56	14	1 822
	%	%	%	%	%	%	%	%	%
Change 1994–95	1.8	7.2	10.9	14.0	–0.5	1.9	55.6	–6.7	6.7
Average change 1990–95(a)	–4.3	–5.5	3.3	–2.7	1.4	–3.4	0.7	–10.2	–2.3
				PERSONS KILLED					
1988	1 037	701	539	223	230	75	51	31	2 887
1989	960	776	428	222	242	80	61	32	2 801
1990	797	548	399	226	196	71	68	26	2 331
1991	663	503	395	184	207	77	67	17	2 113
1992	649	396	416	165	200	74	54	20	1 974
1993	581	435	396	218	209	58	44	12	1 953
1994	647	378	422	159	211	59	41	17	1 934
1995	620	418	456	181	209	57	61	15	2 017
	%	%	%	%	%	%	%	%	%
Change 1994–95	–4.2	10.6	8.1	13.8	–0.9	–3.4	48.8	–11.8	4.3
Average change 1990–95(a)	–4.9	–5.3	2.7	–4.3	1.3	–4.3	–2.1	–10.4	–2.9

(a) Average annual exponential change between the 1990 and 1995 accounts.

Source: Federal Office of Road Safety 1995.

The rate of road traffic accidents which occur in any country is due to a range of factors including the quality of road transport systems, vehicle safety standards, safety legislation, road conditions and modes of transport. Table 8.4 shows that in 1991, of the eleven countries listed, Australia had the lowest rate of road traffic accident injury. However, Australia was ranked eighth highest for road traffic accident fatalities (ABS 1996, p. 173).

8.4 ROAD TRAFFIC INJURIES AND FATALITIES(a)—1991

Country	*Injuries rate* per 100 000 population	*Fatalities rate(b)* per 100 000 population
Australia	129.9	12.2
Canada	934.5	13.8
France	362.6	16.9
Great Britain	555.8	8.2
Greece	282.0	17.4
Italy	423.9	13.2
Japan	652.7	8.9
Malaysia	141.8	23.8
New Zealand	489.4	18.9
Sweden	208.7	7.2
United States of America	1 353.9	16.3

(a) Population as at 31 December.

(b) Refers to deaths within 30 days of accident, except France (6 days), Italy (7 days), Japan (24 hours).

Source: ABS 1996, p. 173.

AIR TRANSPORT ACCIDENTS

In 1993, there were 320 aviation accidents in Australia. An accident is defined as an occurrence associated with the operation of an aircraft in which a person is fatally or seriously injured and/or the aircraft sustains serious damage or structural failure. The majority of these accidents occurred during general aviation activities, which include mainly lighter planes on non-scheduled services, notably in private/business (118), and air charter flights (43). There was one fatal accident (7 fatalities) and 5 other accidents causing 4 serious injuries and 24 minor injuries in the low capacity regular public transport, i.e. regional aviation. No fatalities or injuries were sustained in operations involving high capacity regular public transport aircraft, i.e. in international and domestic aviation (Bureau of Transport and Communications Economics 1995a).

General aviation accidents during the 1985–95 period are described in table 8.5. Flight training experienced low accident numbers (329) and a low accident rate (7.3 per 100,000 hours), relative to the other categories. Agricultural flying had the lowest total number of accidents over the period (324). However it had the highest accident rate (25 per 100,000 hours), reaching a peak of 31.3 accidents per 100,000 hours in 1992.

8.5 GENERAL AVIATION ACCIDENTS AND ACCIDENT RATES PER 100 000 HOURS OF FLYING

	Charter		Agriculture		Training		Other aerial		Private/ business		Total	
Year	no.	rate	no.	rate	no.	rate	no.	rate	no.	rate	no.	rate
1985	32	10.0	24	20.1	23	7.4	20	7.3	106	19.7	205	13.1
1986	20	6.1	33	28.9	30	9.2	31	11.1	96	18.9	210	13.5
1987	29	8.3	26	22.2	25	7.2	33	11.9	111	21.6	224	14.0
1988	37	9.4	36	24.5	24	6.0	34	11.7	114	21.6	245	13.9
1989	43	9.3	45	28.3	38	8.4	31	10.0	93	17.0	250	13.0
1990	39	9.7	38	23.6	33	6.8	43	14.2	116	20.1	269	13.9
1991	32	8.3	25	22.7	30	6.6	35	12.0	137	27.2	259	14.8
1992	37	9.1	28	31.3	25	5.9	32	12.1	111	24.0	233	14.1
1993	44	11.1	24	24.6	36	8.1	34	11.9	118	24.6	256	15.0
1994p	49	11.5	16	18.5	28	6.6	27	8.8	86	18.8	206	12.1
1995p	43	9.3	29	30.6	37	8.4	20	6.5	94	21.4	223	13.1

Source: Bureau of Air Safety Investigation 1996.

General aviation fatalities during the period 1985–95 are shown in table 8.6. There were a total of 511 fatalities over the period, with the majority occurring in flights for private and business purposes (274) and charter flights (107). The highest rates over the period were 2.3 deaths per 100,000 hours flying time in the private and business flights and agricultural flying.

8.6 GENERAL AVIATION FATALITIES AND RATES OF FATALITIES PER 100 000 HOURS FLYING

	Charter		Agriculture		Training		Other aerial		Private/ business		Total	
Year	no.	rate	no.	rate	no.	rate	no.	rate	no.	rate	no.	rate
1985	9	1.3	0	0.0	0	0.0	2	0.7	30	1.9	41	1.0
1986	3	0.6	3	2.6	3	0.6	10	1.4	24	1.6	43	1.2
1987	7	0.6	1	0.9	0	0.0	9	1.8	14	1.8	31	1.1
1988	11	0.5	6	4.1	7	0.5	8	1.7	26	2.5	58	1.6
1989	16	1.1	6	3.8	7	0.7	7	1.0	10	1.3	46	1.2
1990	18	1.2	2	1.2	6	0.8	14	3.0	24	1.7	64	1.6
1991	3	0.5	2	1.0	4	0.7	1	0.3	35	2.8	45	1.2
1992	2	0.5	3	3.4	2	0.2	1	0.4	41	3.9	49	1.5
1993	8	1.0	1	1.0	0	0.0	3	1.0	34	2.9	46	1.3
1994p	22	1.4	4	4.6	4	0.5	5	1.3	16	2.0	51	1.5
1995p	8	0.7	2	2.1	1	0.2	6	1.3	20	2.7	37	1.3

Source: Bureau of Air Safety Investigation 1996.

WATER TRANSPORT ACCIDENTS

Maritime accidents statistics include water transport accidents within Australian waters, ports, harbours and adjacent inland waters, including passenger and goods carrying watercraft and small boats. A total of 73 fatalities occurred in 1993, most involving occupants of small boats. There were 901 injuries requiring hospitalisation. A large proportion of accidents occurred during recreational activities; about one-third of injuries requiring hospitalisation involved water skiers and one-quarter the occupants of small boats.

8.7 MARITIME ACCIDENTS

Year	*Fatalities*	*Hospital injuries*
1988	69	680
1993	73	901

Source:. Bureau of Transport and Communication Economics 1995c.

RAIL TRANSPORT ACCIDENTS

In 1993, there were 49 rail transport fatalities (37 males and 12 females). Rail suicides, (65 in 1993) were excluded from the analysis. A total of 689 injuries were recorded during 1993. Of these, 88 were serious injuries requiring hospitalisation. Boarding or alighting from trains is the most frequently documented cause of injury to train passengers.

8.8 RAIL ACCIDENTS

Year	*Fatalities*	*Hospital injuries*	*Medical injuries*	*Minor injuries*
1988	96	154	61	1 111
1993	49	88	113	488

Source: Bureau of Transport and Communication Economics 1995b.

COST OF TRANSPORT ACCIDENTS

Apart from the emotional pain and suffering caused by transport accidents to victims and their families, there are also considerable economic costs to the victims, their families and the community. It has been estimated by the Bureau of Transport and Communications Economics that in 1993 the costs attributed to transport accidents totalled almost $6.6 billion.

Table 8.9 shows the costs of accidents across the transport industry in 1993. Road transport generated the majority of accidents and the highest accident costs, $6.1 billion. The largest components of this total were due to damage to vehicles ($1.87 billion), pain and suffering of the victims ($1.46 billion) and loss of earnings ($829 million).

Maritime accidents in 1993 cost Australia $316 million, and accounted for approximately 4% of transport-related accident costs in Australia. The 320 aviation accidents in 1993 cost Australia $76 million, just over 1% of transport-related accident costs. Rail accidents in the same year cost $69 million.

8.9 COST OF TRANSPORT ACCIDENTS—1993

	ROAD		AIR		RAIL		SEA		ALL MODES	
Cost categories	$m	%	$m	%	$m	%	$m	%	$m	%
Lost earnings of victims	829.1	14	30.4	40	24.4	35	25.2	8	909.4	14
Family and community losses	587.8	10	16.0	21	11.5	17	13.8	4	629.1	10
Pain and suffering	1 463.3	24	3.9	5	5.7	8	57.7	18	1 530.6	23
Vehicle damage	1 868.2	30	16.4	22	22.0	32	157.2	50	2 063.8	31
Insurance administration	571.1	9	6.9	9	n.a.	—	56.9	18	634.9	10
Other(a)	816.4	13	2.4	3	5.4	8	5.2	2	829.4	13
Total	**6 135.8**	**100**	**76.0**	**100**	**69.0**	**100**	**316.0**	**100**	**6 597.2**	**100**

(a) Other costs included hospital and rehabilitation costs, medical costs, losses to non-victims, accident investigation, search and rescue.

Source: Bureau of Transport and Communications Economics 1994, 1995a, 1995b, 1995c.

HUMAN HEALTH EFFECTS

Apart from accidents, a major adverse health impact of transport is through vehicle emissions. A recent OECD publication cited these emissions as a significant contributor to health risk, mentioning several probable or definite carcinogens, such as benzene, formaldehyde, acetaldehyde, 1,3-butadiene and particles, which are present in vehicle exhausts. The US Environmental Protection Agency has estimated that these substances could account for about half of the cancers caused by outdoor sources of air toxins (OECD 1996, p. 159).

Fossil fuel combustion, particularly by motor vehicles, has been identified as the largest single contributor to atmospheric pollution in Australia, so vehicle emissions are a focus of several current initiatives. The pollutants NO_x, CO and SO_2 do not currently, and are not expected in the foreseeable future to exceed 'acceptable levels', for which the evidence indicates no health risk. However, ozone and air toxins are at levels that potentially pose a health risk. For air toxins there is assumed to be no safe level, while for O_3, evidence suggests that one hour concentrations above 0.12 parts per million (ppm) confer a definite health risk, while rates of less than 0.08 ppm are not believed to pose a health risk. During the period 1989–93 there was an average of three days per year when levels exceeded 0.12 ppm in Sydney and Melbourne (National Roads Transport Commission 1995, p. 1).

The exposure of children to lead remains a health problem. Research has shown a strong correlation between concentrations of lead in the blood of young children and neurological malfunction, learning disability and retarded mental development. The major source of airborne lead in most Australian urban areas is leaded fuel used in motor vehicles (aside from residential areas in close proximity to lead smelters). The Australian Institute of Health and Welfare recently conducted the first national survey of blood lead levels in young children and found that 7% of children tested exceed the target level of under 10 micrograms per decilitre (Department of Environment, Sport and Territories 1996, p. 3–33). A summary of the health effects of vehicle pollution is given in table 8.10.

8.10 HEALTH EFFECTS OF VEHICLE POLLUTION

Pollutant	*Source*	*Health effect*
NO_2	One of the nitrogen oxides emitted in vehicle exhaust.	May exacerbate asthma and possibly increase susceptibility to infections.
SO_2	Some SO_2 is emitted by diesel engines.	May provoke wheezing and exacerbate asthma. It is also associated with chronic bronchitis.
Particulates PM10 Total suspended particulates, black smoke	Includes a wide range of solid and liquid particles in air. Those less than 10 micrometres in diameter (PM10) penetrate the lung fairly efficiently and are most hazardous to health.	Associated with a wide range of respiratory symptoms. Long-term exposure is associated with an increased risk of death from heart and lung disease. Particulates can carry carcinogenic material into the lungs.
Acid aerosols	Airborne acid formed from common pollutants including sulphur and nitrogen oxides.	May exacerbate asthma and increase susceptibility to respiratory infection. May reduce lung function in those with asthma.
CO	Mainly from petrol car exhaust.	Lethal at high doses. At low doses can impair concentration and neuro-behavioural function. Increases the likelihood of exercise related heart pain in people with coronary heart disease. May present a risk to the foetus.
O_3	Secondary pollutant produced from nitrogen oxides and volatile organic compounds in the air.	Irritates the eyes and air passages. Increases the sensitivity of the airways to allergic triggers in people with asthma. May increase susceptibility to infection.
Lead	Additive present in leaded petrol to help the engine run smoothly.	Impairs the normal intellectual development and learning ability of children.
Volatile organic compounds (VOCs)	A group of chemicals emitted from the evaporation of solvents and the distribution of petrol fuel. Also present in vehicle exhaust.	Benzene has given most cause for concern in the group of chemicals. It is a carcinogen which can cause leukemia at higher doses than are present in the normal environment.
Polychromatic aromatic hydrocarbons (PAHs)	Produced by incomplete combustion of fuel. PAHs become attached to particulates.	Includes a complex range of chemicals, some of which are carcinogens. It is likely that exposure to PAHs in traffic exhaust poses a low cancer risk to the general population.
Asbestos	May be present in brake pads and cloth linings, especially in heavy duty vehicles. Asbestos fibres and dust are released into the atmosphere when vehicles brake.	Asbestos can cause lung cancer and mesothelioma, cancer of the lung lining. The consequences of the low levels of exposure from braking vehicles are not known.

Source: NSW Health Department 1995, cited in ABS 1996, p. 64.

COSTS OF VEHICLE EMISSIONS

Based on average emissions rates for Australian road vehicles and the results of a range of studies into the social costs of vehicle emissions, the Bureau of Transport and Communications Economics has estimated that the average cost to society from emissions generated by the Australian motor vehicle fleet is 0.11 cents per kilometre (with a likely range of 0.02–0.35) (Bureau of Transport and Communications Economics 1996b, p. 459). Studies commissioned by the Victorian Environment Protection Authority (EPA) into the costs of motor vehicle emissions in Melbourne, estimated that ozone-related health effects cost between $0.3 million and $4.4 million in 1992–93, while cancers cost between $26.0 million and $45.2 million in 1990 (Victorian EPA 1994, p. 12).

A 1995 National Road Traffic Commission review of studies into the costs of road vehicle emissions estimated that the annual cost of road vehicle emissions to Australia is likely to be between $10 million and $200 million, with $50 million suggested as a reasonable point estimate (National Roads Transport Commission 1995, p. 6).

NOISE

Increasing noise is one of the undesirable consequences of the growth of transport and mobility. The effects of noise include:

- amenity effects, sleep interference, annoyance;
- health effects—hearing impairment, tension, headaches and fatigue may contribute to cardiovascular and digestive system ailments; and
- communication effects—interference with business and social communication, reduction in enjoyment of activities (Department of Environment, Sport and Territories 1996, p. 3–45).

ROAD TRAFFIC NOISE

The Australian Environment Council commissioned a National Noise Survey in 1986 to assess the extent of disturbance to the community from the many different sources of noise pollution in Australia. A total of 2,332 people were interviewed in all States and Territories. The survey found that 45% of the population heard traffic noise from within their homes. Activity disturbance is regarded as an important indicator of the impact of noise on the community and the major disturbances assessed in the survey were to listening activities and to sleep. Table 8.11 shows the survey responses for transport noise: 21% of respondents stated that they were moderately annoyed by the sound of road traffic noise, while 6% were highly annoyed by the intrusion of traffic noise.

8.11 DISTURBANCE RESULTING FROM TRANSPORT ACTIVITY NOISE—1986

Type of noise	*Noise heard* %	*Disturbs listening* %	*Disturbs sleep* %	*Moderately annoyed* %	*Highly annoyed* %	*Most like to eliminate* %
Road traffic	45	13	12	21	6	17
Aircraft	24	9	2	8	2	5
Railway	17	5	3	6	2	3
Trail bikes	13	4	2	7	4	5

Source: Australian Environment Council 1988, p. 6.

Table 8.12 shows the rates of disturbance from motor vehicle noise by State. The highest concern (for 30% of respondents) was about noise from cars which were modified to increase their level of performance. This was followed by noise from motorbikes and the squealing of brakes. For people who lived on main roads the greatest concern was about noise from heavy trucks (32%). Compared to the total survey population, those living on main roads rated higher concern about noise generated by squealing brakes, general traffic, car horns, buses, and delivery vans.

8.12 DISTURBANCE FROM MOTOR VEHICLE NOISE—1986

Type of noise	*Total survey population* %	*People with homes on main roads* %	*NSW* %	*Vic.* %	*Qld* %	*SA* %	*WA* %	*Tas.* %
Engine modified cars	30	30	31	31	27	31	32	26
Motorbikes	24	24	25	24	24	26	19	12
Squealing brakes	19	26	18	22	11	25	20	12
Heavy trucks	17	32	19	16	17	11	17	9
General traffic	14	22	14	16	13	13	11	11
Car horns	9	12	9	10	6	9	9	5
Buses	3	5	4	2	4	1	1	—
Delivery vans	2	3	3	2	2	1	1	—
Other noises	2	2	2	2	2	—	3	2

Source: Australian Environment Council 1988.

Noise from vehicles is caused by both engines and road noise, such as tyre noise. At low speed, the major noise source is the engine and exhaust, whilst at high speed, noise from tyres dominates. Other sources of vehicle noise include: brake squeal, airbrake exhaust hiss, body and suspension rattle on goods vehicles, noise from refrigeration units, auxiliary motors on liquid concrete delivery vehicles, machinery noise on municipal vehicles used for rubbish collection, street sweeping and street cleaning. These noises can have as much impact as the basic vehicle but the European Conference of Ministers of Transport reports that there is relatively little that can be done to a vehicle to reduce rolling noise. Current trends towards wider tyres for automobiles and ribbed traction tyres for goods vehicles will probably increase rolling noise (European Conference of Ministers of Transport 1990, p. 49).

In 1991, it was estimated that more than 1.5 million Sydney residents were exposed to outdoor traffic noise levels defined by the OECD as ***undesirable*** (between 55 and 65 dB(A)), where sleep and amenity are affected. Of these, 350,000 people were estimated to be suffering from noise levels judged to be ***unacceptable*** (greater than 65 dB(A)), where behaviour patterns are constrained and health effects are demonstrable. These levels apply to European conditions, where insulation designed for the cooler climate also provides better attenuation against traffic noise. In Australia, where housing is generally designed with greater ventilation and therefore has less protection against external noise, internal noise levels are probably proportionally higher than those in Europe for the same external noise levels (NRMA 1991, p. 4).

AIRCRAFT NOISE

Noise generated from aircraft creates considerable community concern in Australia. In addition to the noise of aircraft taking off and landing, there are other noise sources associated with aircraft and airports, including:

- noise from ground running of aircraft engines;
- noise from aircraft taxiing;
- noise from power generating equipment on aircraft which operates while the aircraft is at a terminal; and

- noise from vehicles and general plant and equipment at the airport (Mitchell McCotter 1994, p.6).

The Australian Noise Exposure Forecast (ANEF) is the index currently used in Australia to measure aircraft noise. ' The ANEF system provides, in a single formula, a scientific measure of noise exposure from aircraft takeoffs, landing approaches, and reverse thrust after landing, for known or forecast frequencies of aircraft types and movements on various flight paths. For practical reasons, noise generated on the airport from aircraft during taxiing or from ground running of aircraft engines is not included.' (Federal Airports Corporation, 1990, p. 22-4).

ANEF maps are produced for most airports throughout Australia, showing noise exposure contours of 20,25,30,35 and 40 ANEF for the airports and the surrounding areas. Maps 8.13 to 8.17 show the extent of airport noise impact in Sydney, Melbourne, Brisbane, Adelaide and Perth.

The contours define the areas affected by noise, the increase in ANEF corresponding to the increase in noise effect. 'At lower values of ANEF, the calculation procedure becomes increasingly sensitive to variations in aircraft flight paths, pilot operating techniques and the effects of meteorological conditions. For this reason the location of the contours at or below 20 ANEF are difficult to define accurately' (Federal Airports Corporation, 1990, p. 22-5). The 20 ANEF contour is shown on ANEF charts as a dotted line, due to these difficulties in accurately defining the extent of noise effect.

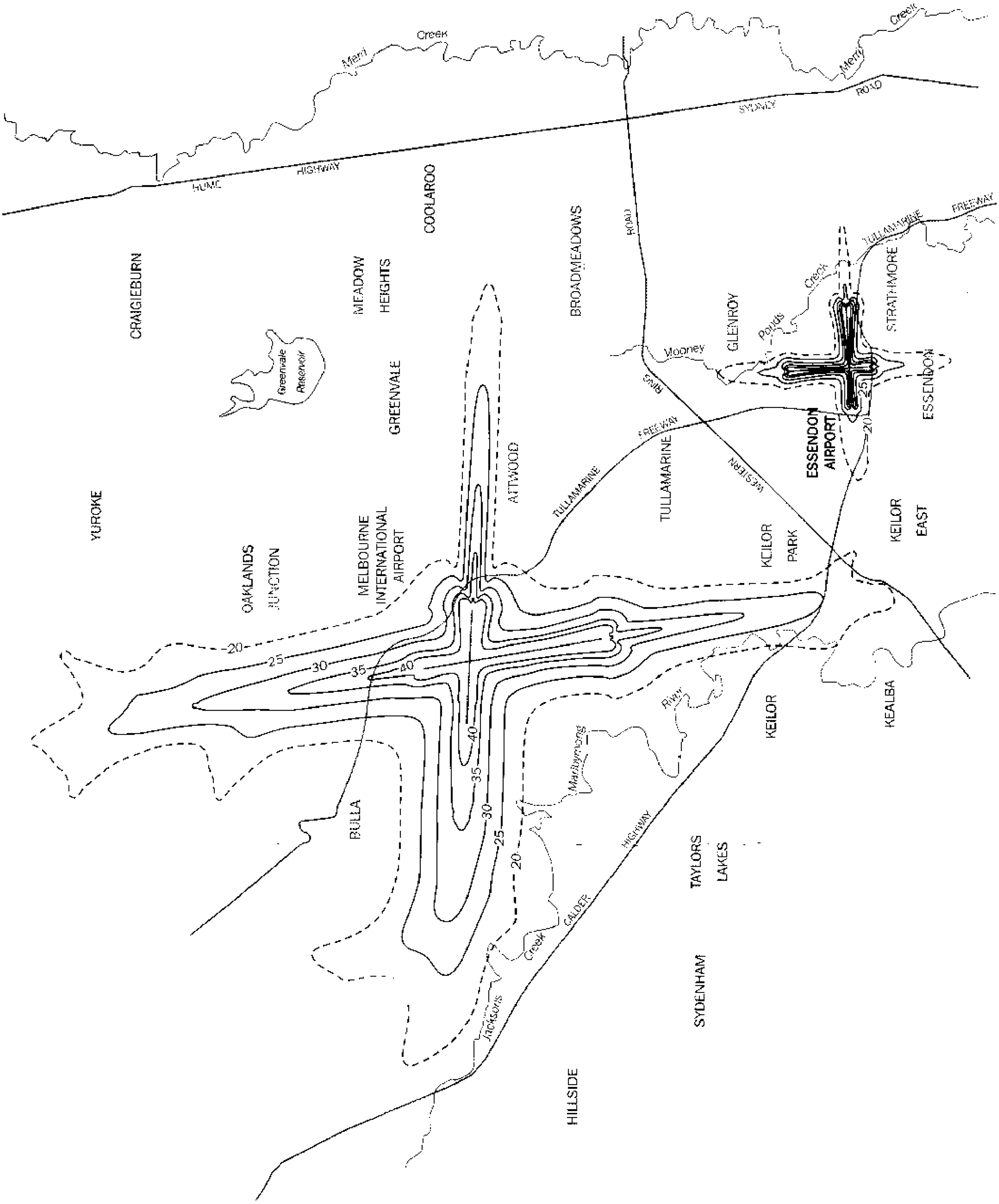
For any given ANEF level, there are a range of reactions to aircraft noise. It has been estimated that at 20 ANEF, approximately 10% of people are seriously affected by aircraft noise, whereas at 40 ANEF approximately 55% of people are seriously affected (Mitchell McCotter 1994, p. 5).

When the third runway at Sydney's Kingsford Smith airport opened in late 1994, noise levels to the north and south of the airport intensified, leading to considerable public reaction. Monitoring of the noise levels in nearby suburbs by the NSW Environment Protection Authority in December 1994 indicated that both inside and outside amenity was greatly affected by aircraft noise, including the interruption of lessons in schools. Outside noise levels as high as 107 dB(A) were recorded and average maximum levels of over 80 dB(A) were common. Adverse reactions to aircraft noise are believed to occur at lower levels than for road and rail traffic, mainly because buildings provide shielding from noise at ground level which is not effective against noise from an elevated source (NSW Environment Protection Authority 1995, p. 230).

8.13 AIRCRAFT NOISE EMISSION IMPACT, Sydney—1995

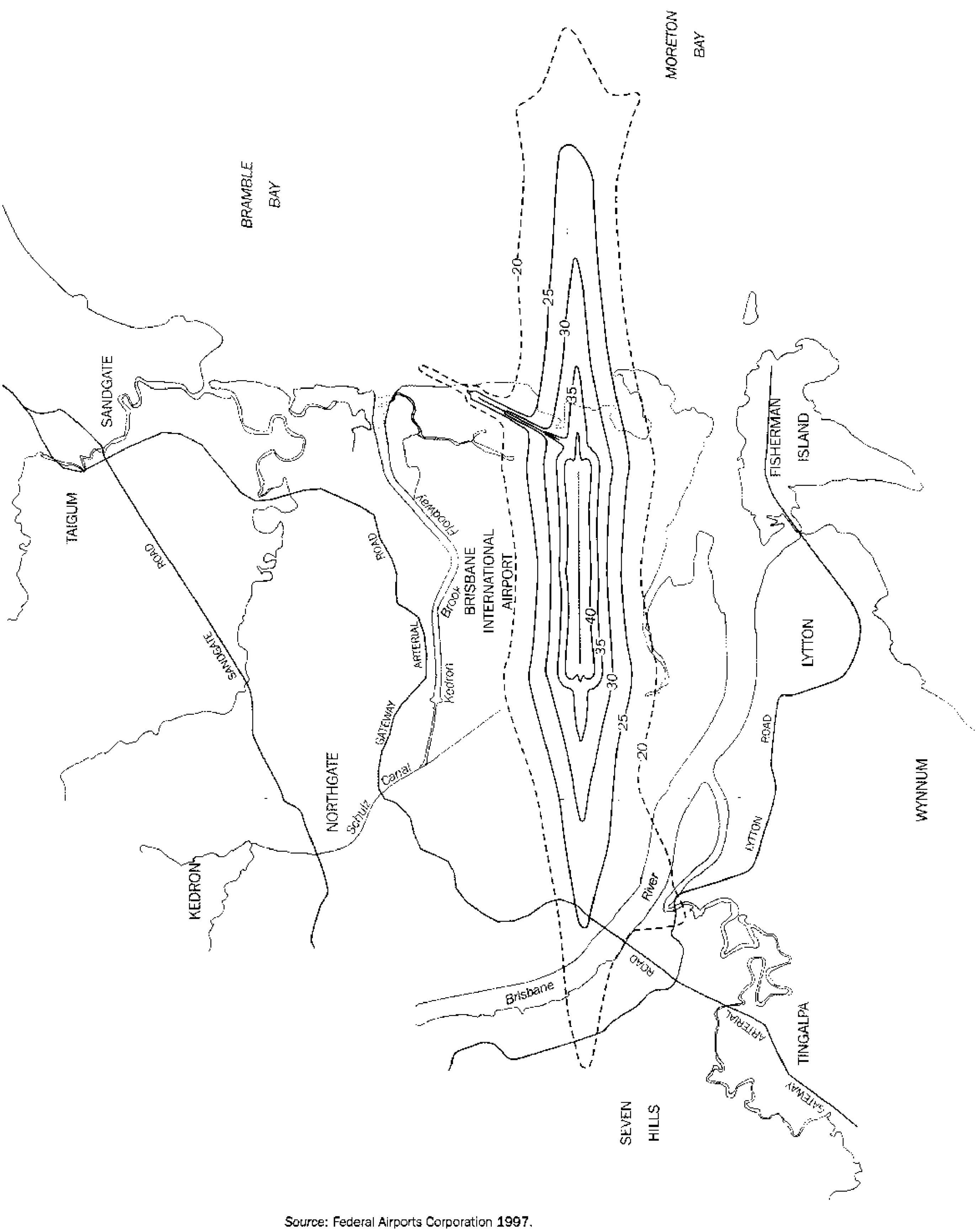
Source: Air Services Australia 1997.

8.14 AIRCRAFT NOISE EMISSION IMPACT, Melbourne—1994



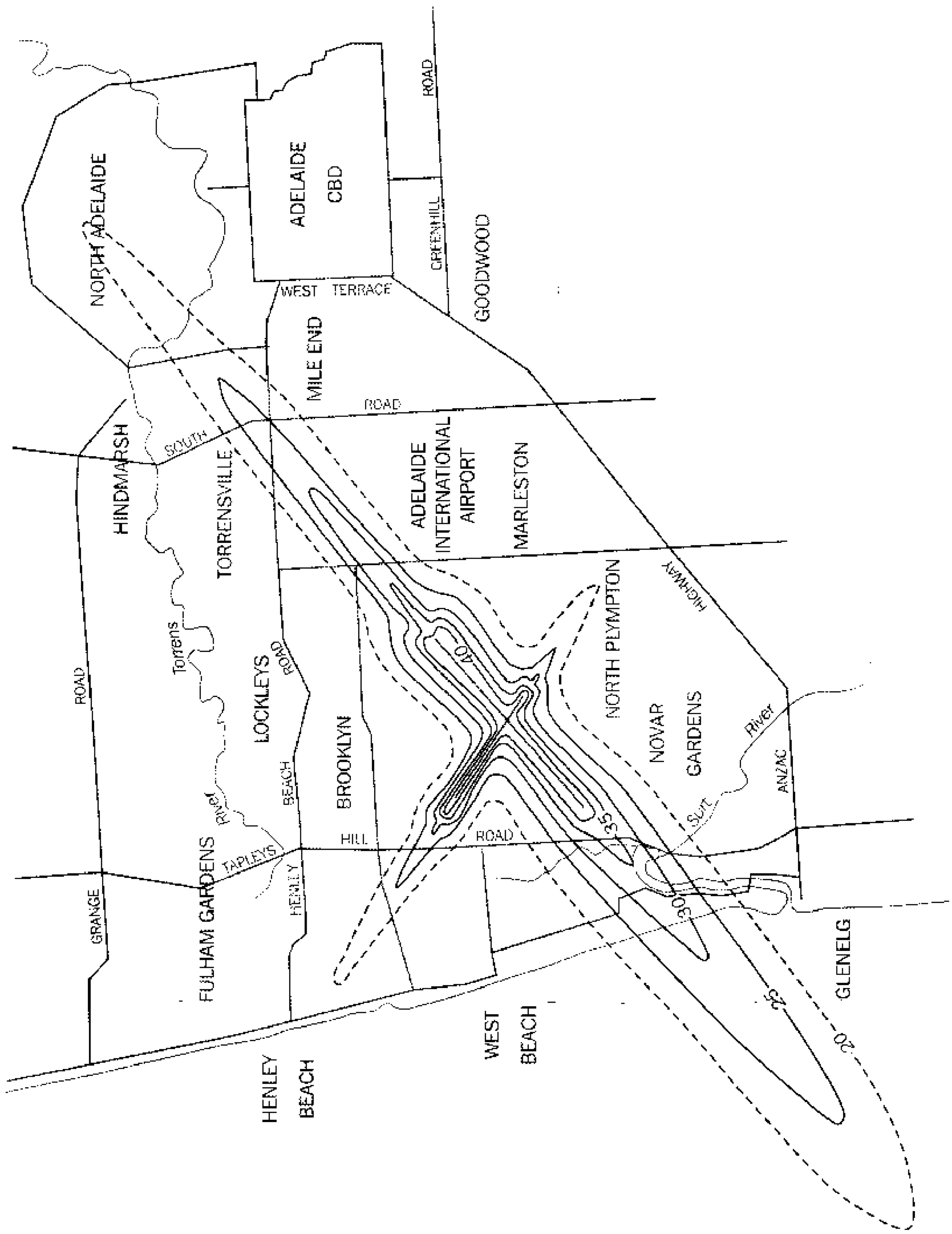
Source: Air Services Australia 1997.

8.15 AIRCRAFT NOISE EMISSION IMPACT, Brisbane—1994



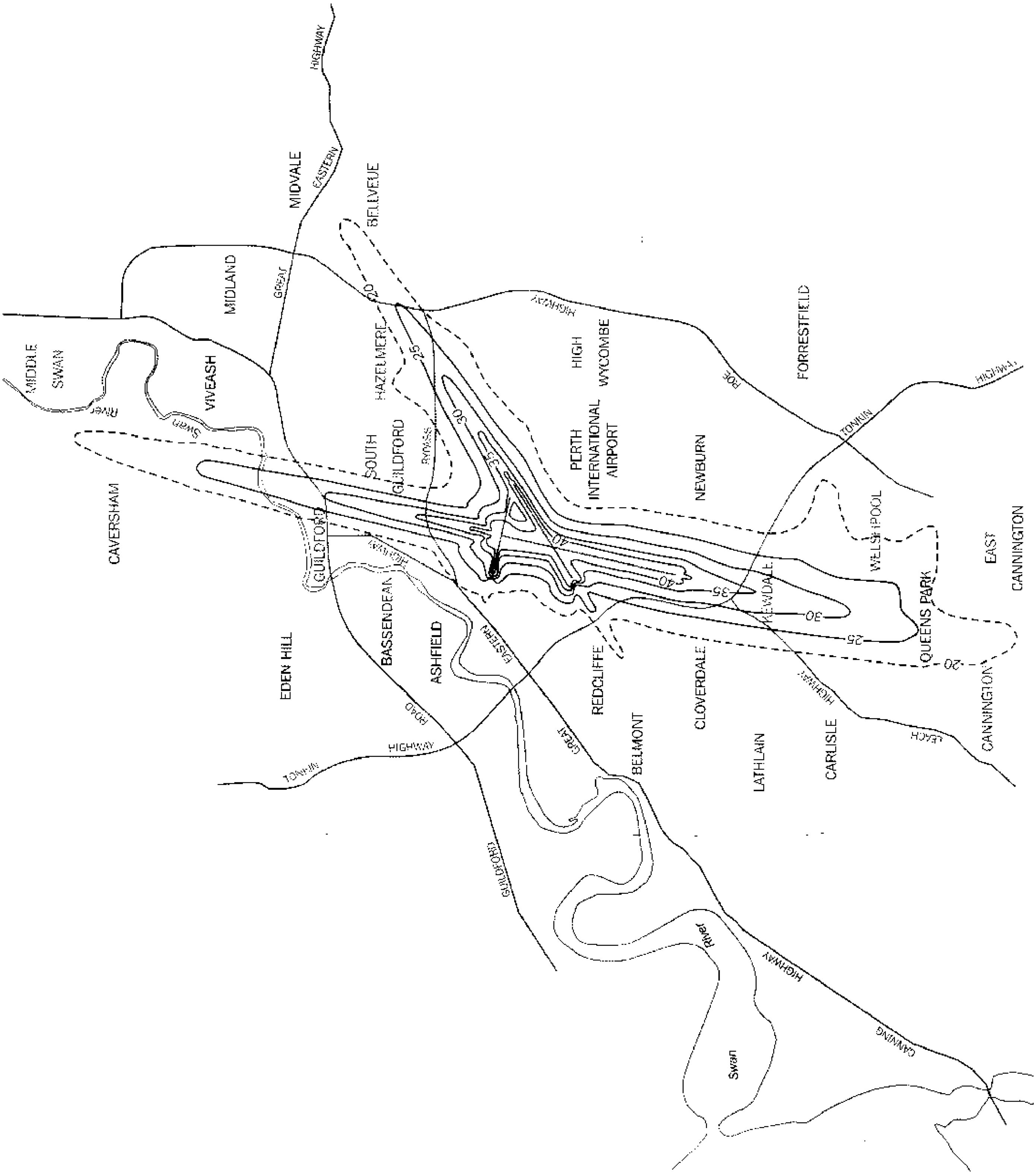
Source: Federal Airports Corporation **1997**.

8.16 AIRCRAFT NOISE EMISSION IMPACT, Adelaide—1995



Source: Federal Airports Corporation 1997.

8.17 AIRCRAFT NOISE EMISSION IMPACT, Perth—1994



Source: Air Services Australia 1997.

RAIL NOISE

Noise from rail services can be considerable, but affects a far smaller group of the population than noise from road and air traffic, as it is generally confined to residents living along rail lines in urban areas.

COST OF NOISE

The costs of noise to the community can include those involved in building noise barriers alongside major transport routes, insulating affected buildings, and the lowering of property values for homes and commercial buildings adjacent to main roads. Noise costs are difficult to determine and so estimates can vary widely.

The National Roads Transport Commission (1995) estimated annual noise costs to be between $200 and $400 million. The report also quotes an estimate made by the Interstate Commission in 1990 of $534 million. This higher figure would correspond with the estimated costs per vehicle kilometre listed in table 8.18. Large trucks with three axles or more were estimated to make the largest contribution to noise costs at 5.1 cents per kilometre.

8.18 ESTIMATED COST OF MOTOR VEHICLE ROAD NOISE

Vehicle type	*Noise cost* cents/vehicle km
Cars/station wagons	0.1
Light commercial	0.1
Rigid trucks	
2 axles to 12 t	1.5
> 12 t	3.5
3 axles or more	5.1
Articulated trucks	3.8
Buses	
< 5 tonnes	1.8
> 5 tonnes	1.8

Source: National Roads Transport Commission 1995.

The Victorian EPA commissioned a study to produce a preliminary estimate of the levels and costs of noise on the arterial road system in Melbourne, based on the effects of transport noise on property values. The estimated annual cost ranged from $43 million to $86 million for 1992, including only residential properties which were adjacent to an arterial road (Victorian EPA 1994).

In 1991, it was estimated that if traffic noise in Sydney could be reduced so that all residences were to experience traffic noise at levels close to the OECD recommended level 57 dB(A), it would require major amelioration measures at the roadside or in houses at an estimated cost of $750–880 million (NRMA 1991, p. 4).

TRAFFIC CONGESTION

With the number of road vehicles continually increasing, the problem of traffic congestion arises, lowering average travel speeds and increasing journey times. In the late 1980s, the average travel speed on southern California's vast freeway systems was reported to be around 50 kilometres per hour (Renner 1988, p. 47). In the early 1990s, travel speeds were even lower in major cities, e.g. Athens (7–8 kilometres per hour), Paris (18 kilometres per hour) and London (20 kilometres per hour) (Button 1993, p. 38). Peak hour travel speeds on some of Brisbane's arterial roads were averaging 25 kilometres per hour in the mid-1990s (Queensland Government 1995, p. 9). While private car ownership continues to grow, these speeds can be expected to reduce even further.

Although the building of new roads infrastructure initially relieves the congestion, traffic usually increases to fill the available space within a brief timeframe. Traffic congestion has significant economic and environmental effects. In the United States in 1984, an estimated 4% of the nation's annual fuel consumption was consumed due to traffic congestion (Renner 1988, p. 47).

A New South Wales government report estimated that, without changes in transport planning directions, the results for Sydney in 20 years time would be: 67% increase in travel demand; 600% increase in congestion; 23% increase in fuel consumption and 36% deterioration in air quality (NSW Government 1993, p. 14).

COSTS OF TRAFFIC CONGESTION

It can be difficult to determine the costs of traffic congestion, and estimates vary. The NSW State Chamber of Business has quoted an estimate of $5 billion per year for Australia (NRMA 1997, p. 40). Table 8.19 shows a summary of estimates for congestion costs in Australian cities reported by BTCE (1995d). Table 8.20 shows the estimated costs of road traffic congestion in Melbourne in 1991 by type of cost.

8.19 ESTIMATED COST OF TRAFFIC CONGESTION

City	*Annual cost* $m
Sydney	2 040
Melbourne	1 910
Brisbane	400
Perth	368
Adelaide	275
Canberra	105
Hobart	42
Darwin	24
Total	**5 164**

Note: these figures are averages of the figures given by Bureau of Transport and Communications Economics' summary of earlier research.

Source: Bureau of Transport and Communications Economics 1995d.

8.20 ESTIMATED ANNUAL TRAFFIC CONGESTION COSTS, Melbourne—1991

Travel type	*Vehicle operating costs* $m	*Travel time costs* $m	*Total costs* $m
Private	96	486	582
Business	54	1 395	1 449
Total	**150**	**1 881**	**2 031**

Note: figures given in 1992 dollars.

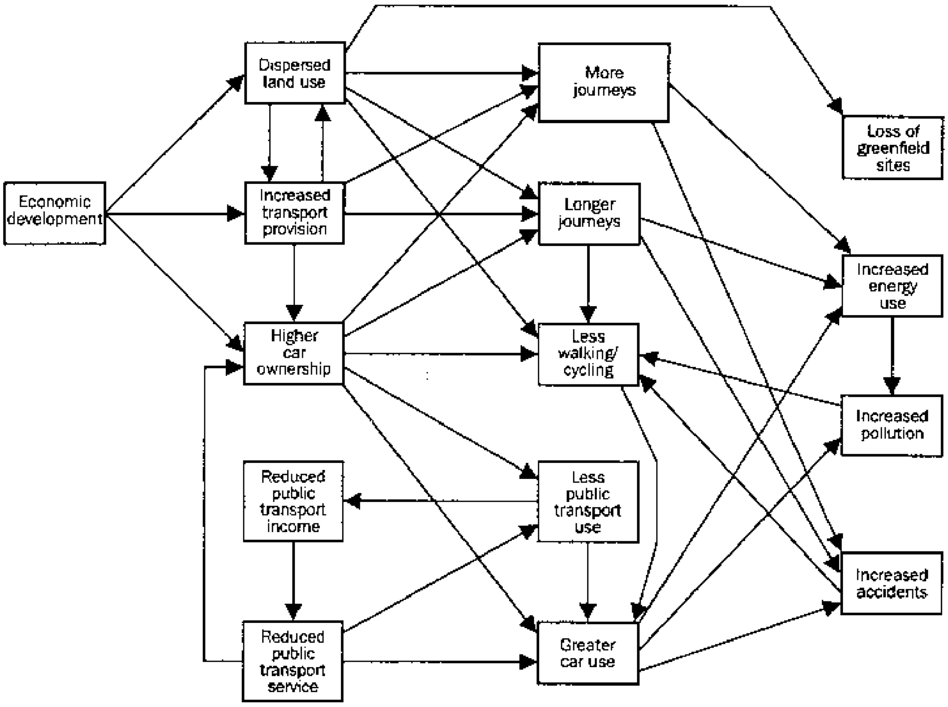
Source: Victorian EPA 1994, vol. 4:16.

Airport congestion is emerging as an important issue for aviation. The demand for access to all major Australian airports continues to increase with the growth in the use of air transport, while airport capacity remains fixed in some cases. Sydney airport is capped at 80 aircraft movements per hour. When demand exceeds capacity, congestion results incurring substantial costs. Aircraft operators, faced with unplanned landing delays, are required to maintain holding patterns which increase fuel usage and upset network schedules. Passengers experience inconvenience and extended travel times, while communities under the 'holding' flight paths are subjected to increased air and noise pollution (Bureau of Transport and Communications Economics 1996a).

URBAN SPRAWL AND LOSS OF COMMUNITY

The relationship between increasing transport use and urban sprawl is cyclic—the increasing number of cars leads to increasing construction of infrastructure such as roads, bridges and car parks, which leads to a spreading of the city and a consequent increase in travel distances. These factors flow through to increased car use and a reduction in public transport patronage, leading to reduced public transport income and hence declining service. This process results in increased consumption of rural land, increased energy use—costs which the community has to carry. Diagram 8.21 illustrates the interactions contributing to unsustainability in urban travel and the resulting process of urban sprawl.

8.21 INTERACTIONS CONTRIBUTING TO UNSUSTAINABLE URBAN TRAVEL



Source: Banister & Button 1993.

A comparative study of 32 cities around the world during the 1980s found striking differences in patterns of energy and land use between those which relied mainly on road transport and those with extensive public transport systems. The more space devoted to cars, freeways and parking lots, the more sprawling and energy-consuming the city. In general, American cities had the highest per capita energy consumption, European and Asian cities had the lowest, while Australian cities fell in between (Newman & Kenworthy 1992).

Cars require a great deal of space. It has been estimated that a car can take up to 30 times more space to move each person than public transport. The faster cars travel the more room they need in terms of highway space and buffer zones. Cars also require a significant amount of space for parking spaces near homes, shopping centres, work places and educational and recreational facilities. It has been estimated that cars can take up to three times the space of the average family home (Engwicht 1992).

In the 15 years to 1992, Australia lost an estimated one million hectares of land to cities. Problems associated with urban sprawl include the high costs of providing infrastructure and services over large areas with low population densities and higher energy costs. The deterioration of public spaces, loss of pedestrian access, loss of amenity, social isolation and social inequity have all been observed as consequences of increasing road vehicle usages within cities (Newman & Kenworthy 1992).

Such loss of community and social inequity has been illustrated by Engwicht (1992), who describes how as traffic increases through a neighbourhood, its impact on residents can be seen as going through a process whereby streets become less available to pedestrians, contacts between neighbours diminished and local shops decline as fewer pedestrians are prepared to cross busy streets. Gradually those who can move away do so, leaving those who have no option but to stay, in many cases the elderly, disabled or those who cannot afford to relocate.

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CHAPTER 9 IMPACTS ON THE NATURAL ENVIRONMENT

In this chapter, several ways in which the natural environment is affected by transport are discussed. The construction of roads and railways can have substantial and devastating impacts on wildlife habitats. Urban roads in particular, contribute to the pollution of stormwater run-off. Motor vehicles are responsible for a variety of environmental damage; off-road motor vehicles especially can cause significant damage to the natural environment. Shipping is also responsible for significant environmental damage, including marine oil pollution, species introduction through ballast water discharges, and damage to marine life as a result of the use of anti-fouling paints and marine debris.

USE OF LAND RESOURCES

Transport infrastructure uses a significant amount of physical space. The construction of roads, railways, shipping ports and airports all involve the use of considerable land resources, which must be cleared.

Wildlife habitat loss

Road corridors intersect natural vegetation forms and wildlife habitats and fauna corridors. The construction of roads, with the associated land clearing, extraction and deposition of soils and road building materials, can lead to large changes to vegetation, wildlife habitats and catchments, and the interruption of fauna corridors. Fragmentation of habitats can reduce populations of native fauna while also causing them to become genetically isolated, thus reducing their ability to adapt to changes in the environment. In the first year of the construction of a bridge in Coffs Harbour in northern New South Wales, nearly 50 koalas were killed on the Pacific Highway. At Iluka near Grafton, one-third of the local koala population was estimated to have been killed within one year of a road being upgraded (NSW EPA 1993, pp. 106–107).

Data on animal injuries is often difficult to obtain. This chapter presents data from two sources. The collection methods for these two sources vary widely, but have both been presented to give a comprehensive view of the available information. Table 9.1 shows the total number of incidents reported to the NSW Wildlife Information and Rescue Service (WIRES) involving a native animal being struck by a motor or rail vehicle. This data represents only a small fraction of the total wildlife affected by road and rail transport. Table 9.2 presents the results of a study conducted by NSW National Parks and Wildlife Service of animals killed in a four month period in Kosciusko National Park.

Between July 1993 and June 1994, 3,086 animal deaths and injuries were reported to WIRES in New South Wales. Birds were the species most often reported struck by vehicles, making up 61% of the total number of animals reported to WIRES, and 63% of the total deaths. Of the total number of animals struck by a vehicle reported to WIRES, 62% died, 27% survived the impact, whilst the fate of the remaining 11% is unknown.

9.1 NATIVE SPECIES DEATHS/INJURIES BY VEHICLES, NSW—1993–94

	FATE OF ANIMAL(a)				
Species	*Killed*	*Injured/ treated*	*Not requiring treatment*	*Fate unknown*	*Total*
Birds(b)	1 215	522	13	138	1 888
Kangaroos	154	45	1	96	296
Wallabies	115	20	1	52	188
Koalas	11	4	—	2	17
Possums	247	124	4	35	410
Wombats	19	10	1	9	39
Echidnas	10	5	5	—	20
Reptiles	123	52	11	10	196
Other(c)	25	5	—	2	32
Total	**1 919**	**787**	**36**	**344**	**3 086**

(a) Animals classified as killed are those that were found dead on arrival, died after being taken into care or those euthanased whilst in care. Injured and treated are those animals which were taken into care by WIRES, rescuer, vet or another wildlife group, and were either released, taken into permanent care, reunited with parents or owner or were still in long-term rehabilitation. Animals not requiring treatment were those that were left and observed or animals which were relocated without being taken into care. Fate unknown refers to those animals that had disappeared before rescue or those that escaped whilst in care.

(b) Includes wildfowl, waterbirds, owls, seabirds, and other native birds.

(c) Includes species such as bandicoots, bats, flying foxes, and quolls.

Source: WIRES 1997.

9.2 ANIMAL DEATHS, Kosciusko National Park(a)—7 June–7 October 1996

Species	*Number killed*
Eastern grey kangaroo	15
Swamp wallaby	13
Red necked wallaby	12
Wombat	40
Common brushtail possum	3
Other(b)	9

(a) Areas surveyed were the Alpine Way, Kosciusko Road, and Guthega Road.

(b) Includes birds, echidnas, etc.

Source: Kosciusko National Park, Roads Unit, NSW 1997.

IMPACTS OF OFF-ROAD VEHICLES

The use of four-wheel drive vehicles, trail-bikes, dune buggies and other off-road vehicles is an established form of leisure activity across the Australian landscape, but it can be extremely damaging to the natural environment.

Table 9.3 shows a variety of adverse environmental impacts associated with unrestricted off-road vehicle use. The actual impacts experienced in any one place depend on the level of usage and the environmental characteristics of that place.

9.3 EFFECTS OF OFF-ROAD VEHICLES ON THE ENVIRONMENT

Soils and landscape	*Water courses*	*Vegetation*	*Fauna*	*Human*
Soil compaction	Damage to physical boundaries	Devegetation	Displacement of fauna	Damage to management tracks including fire trails
Soil erosion		Alteration of ecosystems	Restrictions on faunal movement	Damage to areas under rehabilitation
Gullying of tracks through repeated use		Increase in the frequency of bush and forest fires	Increase in the frequency of bush and forest fires	Increase in the frequency of bush and forest fires
Dust generation	Turbidity	Spread of exotic plant species	Spread of exotic animal species	Visual impairment of the landscape
Track rutting in wet weather	Siltation	Spread of plant diseases	Death of fauna through collisions	Loss of 'wilderness experience'
	Pollutants from vehicle emissions		Noise	Prejudice to future land uses and users
				Noise
				Damage to Aboriginal heritage and cultural values
				Damage to European heritage

Source: State Pollution Control Commission 1979.

Small-scale surveys of wildlife indicate that off-road vehicle use has been harmful. On Ten Mile Beach, in Bundjalung National Park, there has been a marked decline in the population of pied oyster catchers, a bird which nests on the foredunes, and is therefore particularly susceptible to four-wheel drive use. Between 1987 and 1997 the population was observed to decline from 44, to just 5. Whilst this decline is the result of a number of a contributing factors, including commercial pippi-catching, four-wheel drive vehicles are deemed to be partly responsible (Moffatt, pers. comm.).

During the 1980s the use of off-road vehicles was extensively reviewed by governments. In New South Wales the *Recreation Vehicles Act 1983* regulates the use of off-road vehicles on public land, and provides for the setting aside of land for use as Recreation Vehicle Areas (RVAs). These areas are created with a view to minimising environmental damage and intrusion on private property. Land which is not a public road or an RVA is declared 'restricted land' by the Act, and its occupier can prohibit the use of off-road vehicles thereon. Access by off-road vehicles to New South Wales beaches is often denied by coastal councils due to their environmental impact.

IMPACTS ON WATER RESOURCES

Ground and surface water systems

Land-clearing involved in constructing transport infrastructure can mean that drainage patterns and water tables are significantly affected, in turn bringing impacts for wildlife and agricultural production. Roads are often constructed in natural floodways and former wetlands, causing potential deterioration in drainage patterns and loss of habitat for aquatic species, although attempts are made in road construction projects to mitigate impacts on drainage.

Several major airports (for example, Brisbane, Sydney and Cairns) have been built on former wetlands, as these areas are generally flat and remain undeveloped despite close proximity to city centres.

Transport also generates particulates and other matter which directly pollutes water courses, and indirectly leads to soil acidification and pollution through drainage (Button 1993, p. 37).

Urban stormwater pollution

Polluted stormwater run-off has been identified as one of the major causes of poor water quality in Sydney's urban waterways, estuaries and beaches. Streets and gutters, which cover around 30% of the catchment, contribute litter, sediment, heavy metals, and oils and greases left by motor vehicles as well as pollutants from other sources including domestic wastes and sewerage overflow. Urban run-off is a major pollutant of the coastal environment, and contributes the major portion of the annual loads of heavy metals such as zinc and copper in Port Jackson (NSW EPA 1995, pp. 217–218).

The washing of motor vehicles on driveways and streets contributes to nutrient loads, while erosion from roadways increases the sediment load in urban run-off (NSW EPA 1993, pp. 42–43).

Soils adjacent to roadways can consist of 2% of tyre wear products, including the trace elements found in tyres (listed in table 9.4). This material can be a source of lead in soils, although the contribution of lead from vehicle emissions is far greater. These soils can be washed into storm water systems and contribute to the pollutant load in urban run-off (NSW EPA 1993, p. 102).

9.4 TRACE METAL CONCENTRATIONS IN ROADS FROM VEHICLE MATERIALS

Material	*Lead* µg/g	*Chromium* µg/g	*Copper* µg/g	*Nickel* µg/g	*Zinc* µg/g
Brake linings	1 050	2 200	30 600	7 450	124
Rubber	1 110	182	247	174	617
Gasoline	663	15	4	10	10
Undercoating	116	0	0	476	108
Asphalt, pavement	102	357	51	1 170	164
Diesel oil	12	15	8	8	12
Motor oil	9	0	3	17	1 060

Source: NSW EPA 1993, p. 102.

IMPACTS ON THE MARINE ENVIRONMENT

Oil pollution

Shipping is a significant source of oil pollution in Australian waters, as a result of accidental discharges and spills by vessels. Accidental discharges occur where vessels discharge oil in excess of the permitted rate (generally 15 parts per million oil in water). Spilling of oil can be caused by such incidents as groundings, collisions, or during bunkering resulting from overflow of tanks, burst hoses, and so on. In 1995–96 the Australian Maritime Safety Authority (AMSA) recorded 349 sightings of oil discharges and spills in Australian waters (including the Exclusive Economic Zone, extending 200 nautical miles from shore). As table 9.5 shows, this figure has increased in the past five years. However AMSA suggests that this increase, for the most part, results from an increase in reporting, attributable to raised public awareness, rather than an actual rise in incidences. Reporting practices have been promoted by extensive education programs conducted by AMSA and State and local marine authorities in recent years, and by increased legislative penalties which have provided incentive for ships to report spills that they might otherwise be suspected of committing. AMSA also estimates that the strict legislative preventative safety measure requirements have also reduced the risk of spills (AMSA, pers. comm.). The maximum penalties under the Commonwealth legislation were increased four-fold in 1993 to $1 million. States have also increased legislative penalties.

9.5 TOTAL OIL DISCHARGE SIGHTINGS(a)

Year	*no.*
1991–92	186
1992–93	231
1993–94	263
1994–95	336
1995–96	356

(a) The AMSA records reported sightings from sources including: the responsible vessel, coast watch surveillance, civil aviation, commercial and private vessels, State authorities, the general public, and Royal Australian Air Force. Whilst AMSA makes every effort to ensure that data is as complete as possible, the completeness of information cannot be guaranteed, as only those incidents reported are included.

Source: Australian Maritime Safety Authority 1997a.

Of the instances where the source was identifiable, the most common single source type of discharges over the past five years was fishing vessels. Over 74% of reported discharges occurred within port limits. The vast majority of spills and discharges involved small quantities, as shown in table 9.6 (Australian Maritime Safety Authority 1997b, p. 13). Approximately 85% of all reported spills involve less than 10 litres of oil.

Australia has only experienced one major oil spill (over 1,000 tonnes) in the five years since 1991–92. The spill occurred off Cervantes in Western Australia when the *Kirki* lost 17,700 tonnes of oil in 1991. Most recently, the *Iron Baron* went aground off the Tasmanian coast in July 1995, spilling around 325 tonnes of oil which covered over 15 kilometres of coastline.

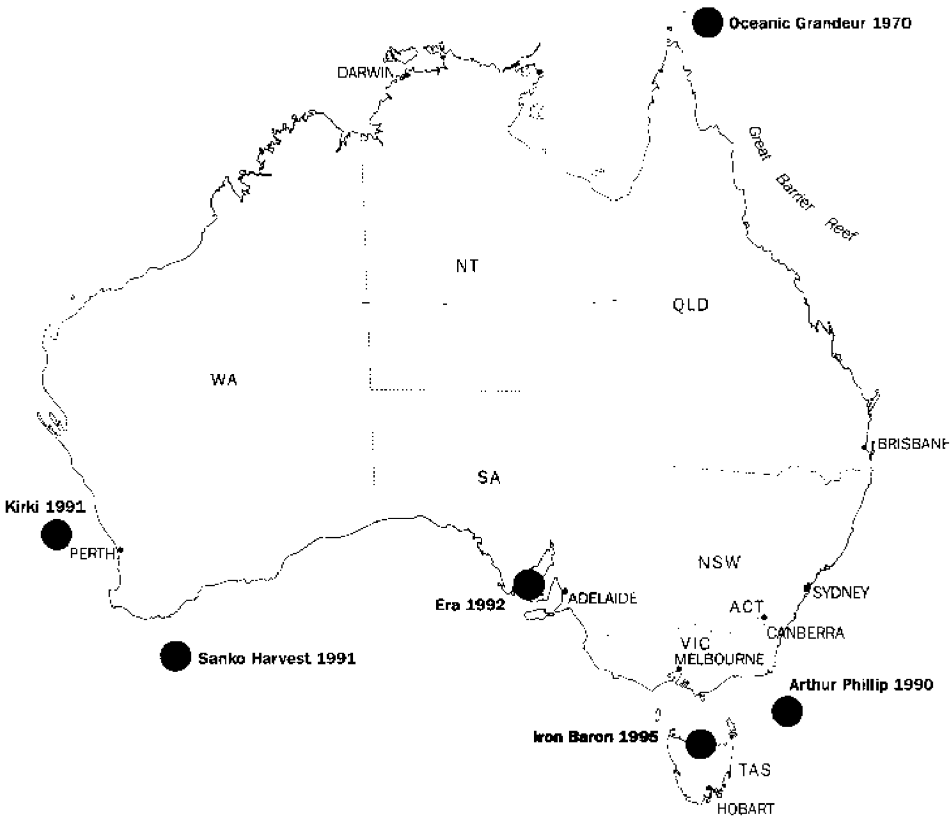
9.6 OIL DISCHARGE SIGHTINGS, By Quantity

Year	Up to 1t	>1t to 10t	>10t to 100t	>100t to 1000t	>1000 t	Total spill sightings
	ESTIMATED QUANTITY OF DISCHARGE					
1991–92	22	6	3	—	1	186
1992–93	8	6	—	2	—	231
1993–94	14	10	1	—	—	263
1994–95	14	8	3	—	—	336
1995–96	6	5	—	1	—	356
Total	**64**	**35**	**7**	**3**	**1**	**1 372**

Source: Australian Maritime Safety Authority 1997a.

Shipping oil discharges can often have serious impacts on marine wildlife. The *Iron Baron* disaster resulted in the oiling of more than 2,000 penguins, 300 of which died, and 60 cormorants, of which 30 died (Australian Maritime Safety Authority, in Department of Environment, Sport and Territories 1996, p. 8–18). Seals often suffer, as they ingest oil by grooming and by taking oiled prey. The extent of environmental impact of an oil spill will depend to a large degree on its timing, location and prevailing weather conditions. In the case of the *Iron Baron*, for example, fortuitous timing meant that migratory waders were yet to arrive in the area, and the breeding season was still some way off (Bayly-Stark 1996).

9.7 LOCATION OF MAJOR OIL SPILLS



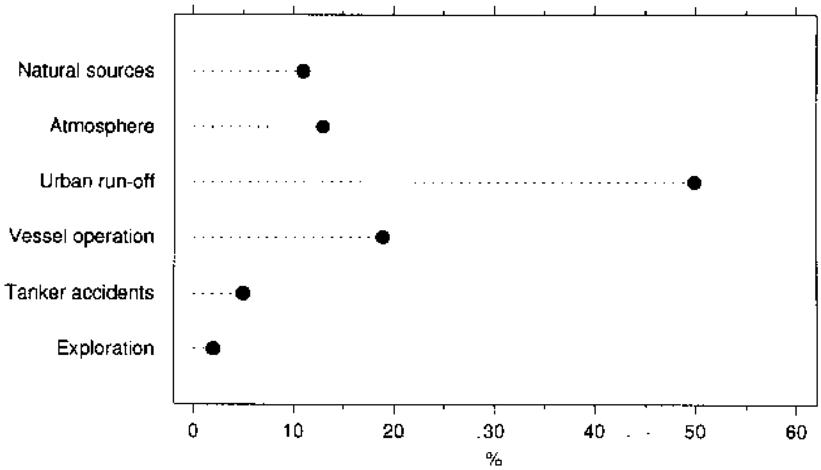
Source: Department of Environment, Sport and Territories 1996, p. 8–18.

A study by the international Joint Group of Experts on the Scientific Aspects of Marine Pollution concluded that oil pollution from shipping operations decreased during the past three decades (Australian and New Zealand Environment and Conservation Council 1996, p. 23). However, risk of a major spill of oil from shipping in Australian waters remains high. The probability of a major oil spill (over 1,370 tonnes) occurring for tankers has been estimated at 37% in any five-year period, and 84% in a 20-year period (Bureau of Transport and Communications Economics 1991, p. 8).

Australia has adopted five international conventions which specifically deal with pollution from ships. These conventions are given effect in Australia by Commonwealth and State legislation. The discharging of substances into the sea is controlled by the International Convention for the Prevention of Pollution from Ships 1973 and its 1978 Protocol (MARPOL 73/78). Other conventions authorise governments to take intervention measures to protect the coastline, civil liability, and compensation for oil pollution damage.

It is interesting to note that shipping is responsible for less than a quarter of marine oil discharges. As graph 9.8 shows, it is estimated that shipping contributes only 24% of total oil discharges, compared to a 50% contribution by urban run-off (Australian Maritime Safety Authority 1997, p. 12).

9.8 SOURCES OF OIL ENTERING THE MARINE ENVIRONMENT



Source: Australian Maritime Safety Authority 1997b, p. 12.

Marine debris

Marine debris is an increasing global problem affecting marine and coastal amenity and marine wildlife. Plastics in particular are a threat to wildlife, which may mistake it for food. Commercial and government vessels, recreational vessels and discharges from urban and rural coastal catchments are identified as the primary sources of marine debris, according to United States' research. The degree to which shipping contributes to marine debris varies, depending on the location. In areas remote from urban centres, shipping may contribute as much as 100% of debris. The Australian and New Zealand Environment and Conservation Council (ANZECC) notes that in the South Atlantic, the MARPOL Annex banning plastic disposal is having little effect (Australian and New Zealand Environment and Conservation Council 1996, p. 19).

Some research has been conducted on the extent to which fishing activity contributes to marine debris, set out in table 9.9 below.

9.9 BEACH DEBRIS ATTRIBUTABLE TO FISHING—1992

Location	Proportion from fishing %	Proportion from commercial fishing %	Proportion from recreational fishing %
NSW Marley Beach	11.2	10.2	1.0
Qld Nudgee Beach	15.2	9.1	6.1
Coochiemudlo Island	46.2	7.7	38.5
Bribie Island	13.0	9.0	4.0
Redcliffe	2.4	0.5	1.9
Point Talburpin	45.9	4.2	41.7

Source: Jones 1994.

Marine debris can be a fatal hazard for marine wildlife. Table 9.10 shows entanglement of Australian fur seals in waters off Tasmania and in Bass Strait. In 1991–92, 62 fur seals were found entangled. Of these, 21 were entangled by trawl net, 7 by gillnet, 3 by rope and 13 by packaging bands. Compared with previous records, the number of entanglements of Australian fur seals had reduced.

9.10 ENTANGLEMENT OF FUR SEALS—Waters Off Tasmania

COMPOSITION OF NECK COLLARS ON ENTANGLED ANIMALS......

Year	Unknown	Trawl net	Gillnet	Rope	Packaging bands	Other(a)	Total
1989–91	15	24	9	9	18	—	75
1991–93	6	21	7	3	13	12	62

(a) Includes steel loops and rubber rings.
Source: Jones 1994.

Ballast water

Each year about 121 million tonnes of ballast water are imported and discharged into Australian waters. An additional 34 million tonnes move between Australian ports (Department of Environment, Sport and Territories 1996, p. 261). Ballast water is seawater taken on board ships and carried in dedicated ballast tanks and cargo holds, which causes the ship to lie deeper in the water, ensuring vessel stability. The water is discharged when the ship reaches the Australian port where cargo is to be loaded. Ballast taken on in shallow waters often contains a large amount of sediment, which is home to marine organisms which can enter the ship.

Ballast waters can introduce non-native and environmentally harmful organisms, diseases, toxins and parasites that may affect humans, animals and plants. The introduction of marine fish, invertebrates, plants and algae is a serious quarantine problem. At least 55 species of fish and invertebrates, plus a number of seaweeds, have been introduced into Australia in this manner. Approximately one-quarter of the introduced fish, invertebrates and algae in Australian marine waters come either from the off-loading of ballast water by international ships (e.g. with the North Pacific Seastar, Sabella worms, and Japanese Kelp), or from hull-fouling communities often found on those ships (e.g. the European Shore crab) (ABS 1996, p. 261).

Displaced and introduced species have the potential to replace native species, to cause widespread environmental damage, to endanger human health and to damage fisheries and aquaculture through predation, competition and their impact on seafood quality.

In Australia five ports, Hay Point, Port Hedland, Newcastle, Dampier and Gladstone, receive more than 50% of the total ballast water discharged into Australia. Half of the ballast water comes from Japan and over 20% from ports in other parts of Asia.

9.11 SPECIES INTRODUCTIONS ATTRIBUTED TO BALLAST WATER DISCHARGE

Region	*Species*
Swan River–Fremantle	Fish *Tridentiger trigonocephalus* (Striped goby) *Sparidentex hasta* (Sobaity sea bream) Crustaceans *Pyromaia tuberculata* (crab) Molluscs *Musculista senhousia* (Asian mussel) *Theora lubrica* (Asian semelid bivalve) *Polycera hedgepethi* *Godiva quadricolor* Microalga *Alexandrium minutum* (toxic dinoflagellate)
Port Pirie	Crustaceans *Tanais dulongi* (tanaid)
Adelaide	Crustaceans *Eurylana arcuata* (slater) *Carcinus maenas* (European shore crab) Polychaete worms *Pseudopolydora paucibranchiata* *Sabella* cf *spallanzanii* (fan worm) Microalga *Alexandrium minutum* (toxic dinoflagellate)
Port Phillip Bay	Fish *Tridentiger trigonocephalus* (Striped goby) Microalga *Alexandrium catanella* (toxic dinoflagellate)
Bass Strait	Polychaete worms *Mercierella enigmatica* *Boccardia proboscidea* *Pseudopolydora paucibranchiata*
Hobart–Triabunna region	Crustaceans *Carcinus maenas* (European shore crab) Macroalga (seaweed) *Undaria pinnatifida* (Japanese giant kelp) Microalga *Gymnodinium catenatum* (toxic dinoflagellate) Echinoderms *Asterias amurensis* (North Pacific sea-star)
Port Kembla–Sydney–Newcastle region	Fish *Acanthogobius flavimanus* (Yellowfin goby) *Tridentiger trigonocephalus* (Stiped goby) *Lateolabrax japonicus* (Japanese sea bass) Crustaceans *Eurylana arcuata* (slater) *Neomysis japonica* (mysid shrimp)
Brisbane	Molluscs *Aeolidiella indica* (sea slug) Polychaete worms *Mercierella enigmatica* *Pseudopolydora paucibranchiata*

Source: Department of Environment, Sport and Territories 1996, p. 8–17.

Anti-fouling practices

Anti-fouling hull paints are designed to leach slowly into water, preventing organisms such as barnacles from growing on the hulls of commercial and recreational ships. These paints contain toxic substances, the most notable of which is tributyl tin (TBT), although they can also contain heavy metals such as lead and copper, organic substances and antibiotic compounds. Their use is of particular concern in enclosed waters such as mooring areas and marines, and semi-enclosed water bodies such as bays and estuaries. TBT in particular has been found to affect the growth of oysters and other molluscs. In 1989 its use was banned in New South Wales for ships under 25 metres in length, with most other States applying similar bans. Larger vessels are exempt from these regulations, as they do not stay in ports for extended periods (Department of Environment, Sport and Territories 1996, p. 8–17).

ANZECC reports that the use of anti-fouling paints is still a major cause of environmental concern in Australia. Australian governments are in the process of developing controls on organotins in these paints, with a view to promoting alternative less toxic anti-foulants. In New Zealand, the sale and use of organotin-based anti-foulants is prohibited (Australian and New Zealand Environment and Conservation Council 1996, p. 18).

Alterations to coasts and waterways

The construction of port facilities and boat ramps usually requires alteration of the banks and beds of rivers, estuaries and bays. Coastal engineering works such as seawalls, and ongoing dredging activities to keep waterways clear for watercraft, can alter coastal sediment patterns and result in the loss of seagrass beds and other important nursery habitats for marine and estuarine species.

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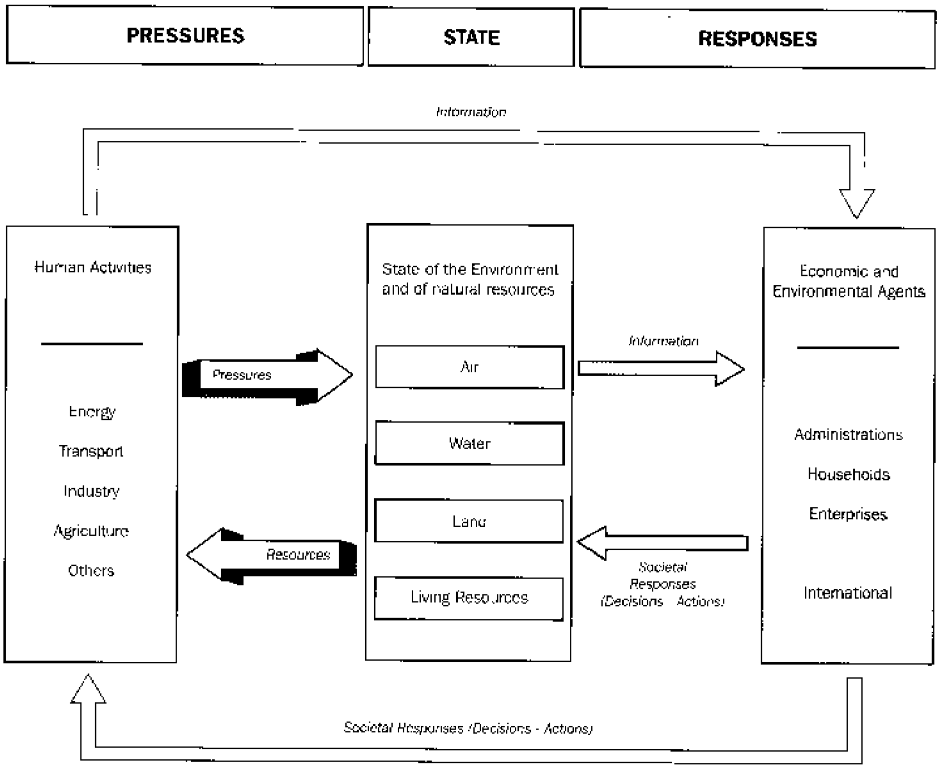
PART 3

RESPONSES



Part 3 deals with society's responses to the environmental issues associated with transport activity, and addressed in Part 2. These include a range of research findings, policies, amelioration programs and regulations. Information in the response category is frequently unavailable in quantitative terms so a more qualitative and descriptive presentation is necessary.

Agents involved are governments, households and businesses, and this part addresses their actions to mitigate, adapt to or prevent human-induced negative impacts on the environment. There are several ways in which authorities attempt to minimise the impact of vehicles on the environment. These include:

- legislation and standards for exhaust and noise emissions;
- control of fuel contents;
- new fuel and engine technologies; and
- transport planning and management.

Chapter 10 primarily explores government regulation as a response to addressing emissions by transport to the environment. In Australia, transport-related issues are often the responsibility of the States. As such, legislation and standards relating to transport and the environment can vary widely, and it is not within the scope of this publication to document each State's legislation, rules and guidelines with respect to this issue. Thus, Chapter 10 has focused on Australian Design Rules (ADRs) for new vehicle exhaust and noise emissions, as well as exploring in-service vehicle emission controls.

Chapter 11 deals with responses by the industry sector in the development of alternative and new fuel and engine technologies. In particular, systems designed to promote self-sufficiency and energy independence, economic efficiency, vehicle performance, reduction in emissions, and energy sustainability are discussed in this chapter.

Finally, chapter 12 looks at policy, planning and management in relation to transport and environment issues, as well as indicators of societal response. These measure both the degree to which society is responding to environmental changes and concerns, as well as to planning and management decisions which influence the former.

Policy responses have included programs of infrastructure development, including expressways, noise barriers, etc. as well as those which attempt to develop an integrated approach to reducing transport impacts, by focusing on the interactions between patterns of transport usage and urban form, trade, employment and recreation.

CHAPTER 10 VEHICLE EMISSION STANDARDS AND EMISSION CONTROLS

This chapter contains information on regulations and standards relating to transport emissions to the environment, with an emphasis on Australian Design Rules (ADRs) for new motor vehicle exhaust and noise emissions.

For emissions legislation and standards to be effective, they must address both the new motor vehicle market and vehicles already in service at the time of introducing the new standards. It has been estimated that tighter standards on new motor vehicles will only have a small impact on today's urban air quality problem because it can take up to seven years from the time a change is implemented for that change to significantly penetrate up to 50% of the fleet (Department of Transport and Communications 1993, p. 4).

Most industrial countries have implemented standards for air pollution and noise emissions. Exhaust and noise emissions standards have been progressively tightened internationally and in Australia over the past several decades. However, growth in the volume of transport also has implications for both noise and exhaust emissons.

Clearly, reducing emissions at the source by developing cleaner and more efficient technologies, as well as addressing environmental issues at the policy level through improved transport management and planning, is a vital complement to these standards and regulations. These issues are explored in Chapters 11 and 12.

EXHAUST EMISSION STANDARDS FOR NEW MOTOR VEHICLES

Rules and regulations relating to permissible exhaust and noise emissions from motor vehicles in Australia are specified in the ADRs, which are an integral part of the Australian motor vehicle standard systems.

Table 10.1 details past emission standards for motor vehicles in Australia. The introduction of ADR 37 in 1986 was expected to reduce the potential for high ozone formation, focusing on restricting the emissions of hydrocarbons to 0.93 grams per vehicle kilometre. Current updated and future emission standards are displayed in tables 10.2 to 10.4.

In Australia, ADR 37 does not include a requirement for exhaust particulate emission control. Particulate emissions from petrol engined vehicles in Australia are relatively low.

10.1 EMISSION STANDARDS FOR MOTOR VEHICLES

Year of introduction	HCs g/km	CO g/km	NO_x g/km	ADR
Pre-1972	2.7	23.6	2.1	No controls
Jan 1972		Must not exceed 4.5% by volume of exhaust gas at idle		ADR 26
Jan 1974	Limit for vehicle of given weight	Limit for vehicle of given weight		ADR 27
July 1976	1.9	17.5	1.9	ADR 27A
Jan 1978	1.7	15.9	1.9	ADR 27B
Jan 1986	0.93	9.3	1.93	ADR 37

Source: McFarlane 1987.

Current requirements for emission control for light motor vehicles (ADR 37/01) are set out in table 10.2. The function of this standard is to limit 'fuel evaporative emissions' and 'exhaust emissions' from motor vehicles in order to reduce air pollution. It applies to the design and construction of all petrol fuelled vehicles. This ADR is currently under review.

10.2 EMISSION STANDARDS FOR LIGHT MOTOR VEHICLES

	FUEL EVAPORATIVE EMISSIONS.....	EXHAUST EMISSIONS–MAXIMUM LEVELS PERMITTED UNDER ADR 37/00 AND 37/01...........................			
	HCs	HCs	CO	NO_x	
Vehicle category	g/test	g/km	g/km	g/km	Applicability
Passenger cars	2.0	0.26	2.1	0.63	For new model vehicles from 1 Jan 1997 For all vehicles from 1 Jan 1999
Forward control passenger vehicles MB1	2.0	0.5	6.2	1.4	All new vehicles from 1 Jan 1998
Off-road passenger vehicles MC1	2.0	0.5	6.2	1.4	All new vehicles from 1 Jan 1998
Light bus MD5	2.0	0.5	6.2	1.4	All new vehicles from 1 Jan 1998
Light goods vehicles NA1	2.0	0.5	6.2	1.4	For new model vehicles from 1 July 1997 For all vehicles from 1 Jan 1999

Source: Federal Office of Road Safety 1996 (ADR 37/00 and 37/01).

Table 10.3 sets out heavy duty vehicles to which ADR 36/00 (requirements for exhaust emission standards for heavy duty vehicles) apply. These requirements are detailed in table 10.4.

10.3 HEAVY VEHICLES AS DETERMINED BY ADR36/00

Vehicle category	*Manufactured on or after*
Forward-control passenger vehicle over 2.7 tonnes GVM	1 Jul 1988
Off-road passenger vehicle over 2.7 tonnes GVM	1 Jul 1988
Light omnibus over 2.7 tonnes GVM	1 Jul 1988
Heavy omnibus	1 Jul 1988
Light goods vehicles over 2.7 tonnes GVM	1 Jul 1988
Medium goods vehicles	1 Jul 1988
Heavy goods vehicles	1 Jul 1988

Source: Federal Office of Road Safety 1989 (ADR 36/00).

10.4 EXHAUST EMISSION STANDARDS FOR HEAVY DUTY VEHICLES

Gas	*Must not exceed*
HCs	180 ppm, expressed as hexane equivalent
CO	1.00% by volume

Note: In addition to the limits specified in table 10.4, the emission stabilisation period shall be less than 125 hours and shall be recorded (ADR 36/00).

Source: Federal Office of Road Safety 1989 (ADR 36/00).

The mandatory operation of motor vehicles on unleaded petrol (ADR 41/00) applies to the design and construction of all petrol fuelled vehicles in table 10.5 below, except those equipped to use liquefied petroleum gas as an alternative fuel.

10.5 MANDATORY OPERATION ON UNLEADED PETROL(a)

Vehicle category	*Manufactured on or after*
Moped 2 wheels	1 Jul 1988
Moped 3 wheels	1 Mar 1991
Motor cycle	1 Jul 1988
Motor cycle and side car	1 Jul 1988
Motor tricycle	1 Mar 1991
Passenger car	. .
Forward-control passenger vehicle	
up to 2.7 tonnes GVM	. .
over 2.7 tonnes GVM	1 Jul 1988
Off-road passenger vehicle	
up to 2.7 tonnes GVM	. .
over 2.7 tonnes GVM	1 Jul 1988
Light omnibus	
up to 2.7 tonnes GVM	. .
over 2.7 tonnes GVM	1 Jul 1988
Heavy omnibus	1 Jul 1988
Light goods vehicles	
up to 2.7 tonnes GVM	. .
over 2.7 tonnes GVM	1 Jul 1988
Medium goods vehicles	1 Jul 1988
Heavy goods vehicles	1 Jul 1988

(a) Unleaded petrol means petrol containing not more than 0.013 grams of lead per litre and not more than 0.0013 grams of phosphorus per litre.

Source: Federal Office of Road Safety 1989 (ADR 41/00).

ADR 70/00 is a 'first step' in reducing the noxious emissions from diesel engined vehicles. Standards must comply with either:

- ECE R83/01—'Uniform Provisions Concerning the Approval of Vehicles with Regard to the Emission of Pollutants According to Engine Fuel Requirements', incorporating the 01 series of amendments which entered into force on 30 December 1992, as per the limit values for vehicles equipped with compression-ignition engines; or
- ECE R49/02—'Uniform Provisions Concerning the Approval of Compression Ignition (CI) Engines and Vehicles Equipped with CI Engines with Regard to the Emissions of Pollutants by the Engine', incorporating the 02 series of amendments which entered into force on 30 December 1992.

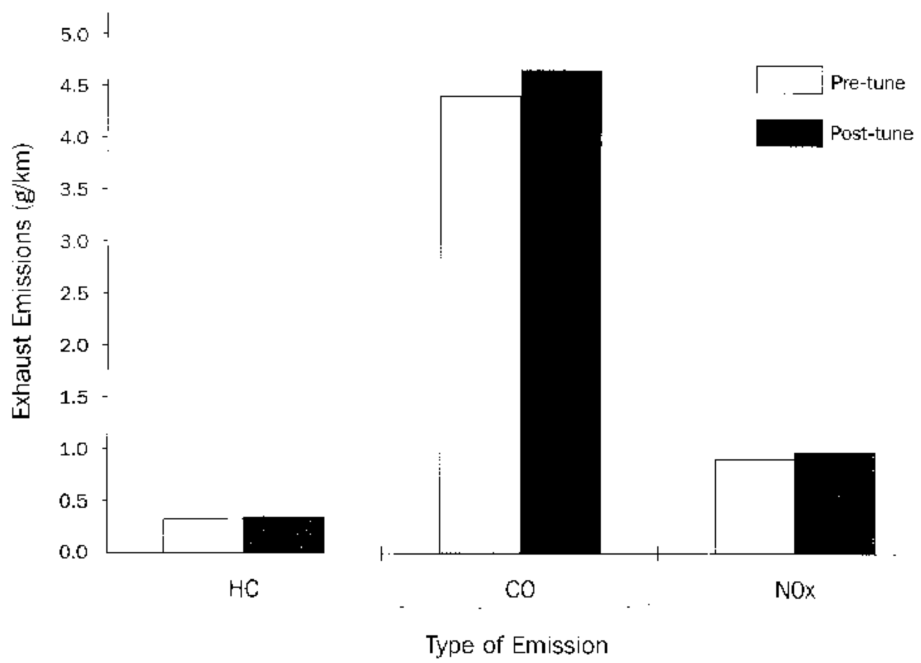
This ADR is under review with the intention of deciding on a single international standard which would form the basis of a revised ADR to take effect towards the end of the 1990s.

EMISSION CONTROL

ADRs for limiting exhaust emissions from both petrol and diesel engines addresses only one aspect of the problem of emission control. Other control measures include government certification of vehicles before sales; recall of faulty vehicles; and manufacturers warranties. Another consideration is the extent to which pollution control systems deteriorate while vehicles are in service. Measures used in addressing this issue include inspection and maintenance of vehicles in use through control programmes of in-use compliance; compulsory periodic inspections and on the spot inspections.

Tests on exhaust and evaporative emission conducted by the Federal Office of Road Safety between 1994 and 1995 have found that routine maintenance of a car's engine can make an impact on emissions. Vehicles then aged between 10 and 16 years had the greatest impact for hydrocarbons and carbon monoxide tailpipe emissions. However, testing of newer cars showed tuning had the net effect of increasing these emissions (graph 10.6).

10.6 EXHAUST EMISSIONS BEFORE AND AFTER SERVICING



Source: Federal Office of Road Safety 1996, p. 34.

Legislation

In Australia, in-service testing of motor vehicles is not enforced in all States. Where it is enforced there is variation in the level of enforcement, between country and metropolitan areas (European Conference of Ministers of Transport 1990, p. 19). For example, the Victorian Environmental Protection Authority requires car owners and sellers to maintain pollution control equipment and enforces this requirement through a random checking and spotting programme, involving random roadside vehicle checks, inspections of used car dealerships to ensure vehicles being sold are complying with the legislation, and a campaign of identifying smoky vehicles on the road and notifying owners of the requirement for repairs. In contrast, New South Wales is considering a regulatory approach requiring regular emissions testing for all vehicles.

Cost effective policies for pollution control will rely on a carefully balanced combination of new car standards and workable in-service maintenance programs.

NOISE EMISSION STANDARDS

Based on data presented in Chapter 8, motor vehicle traffic ranks highest in terms of noise annoyance for the Australian population. Much of this section details sound level limits for motor road vehicles, but control measures and standards for aircraft noise emissions are also discussed

International progress on noise emission standards has been slow. Australia, along with Switzerland, has implemented some of the strictest noise emission standards (European Conference of Ministers of Transport 1990, p. 181). Noise emission standards in Australia are specified in ADRs 28/01—External Noise of Motor Vehicles. ' The function of this ADR is to define limits on external noise generation by motor vehicles in order to limit the contribution of motor traffic to community noise' (ADR 28/01). The permissible decibel levels vary depending on the type and size of the light motor vehicles. Tables 10.7 to 10.9 present the current recommended levels by ADR28/01 for sound level limits for passenger vehicles, buses and goods vehicles.

Control measures for transportation noise in Australia are implemented through complementary actions at the Federal and State levels, which implement the ADRs. The controls on 'in-service' vehicles are the responsibility of the separate State departments for the environment or for transport.

10.7 SOUND LEVEL LIMITS, Passenger Vehicles(a)

	VEHICLES IN MOTION...........		
	Direct injection diesel engines	*Spark ignition engines and indirect injection diesel engines*	*Stationary vehicles*
	dB(A)	dB(A)	dB(A)
Passenger cars/ forward control passenger vehicles			
On road use	78	77	90
Off road use	79–80	78–79	90
Off road passenger vehicles	78–80	77–79	90

(a) ADR28/01.

Source: Federal Office of Road Safety 1995.

10.8 SOUND LEVEL LIMITS, Buses

	VEHICLES IN MOTION...		STATIONARY VEHICLES...			
	Direct injection diesel engines	*Spark ignition engines and indirect injection diesel engines*	*Spark ignition engines EOH(a) <1500mm*	*Spark ignition engines EOH(a) 1500+mm*	*Diesel engines EOH(a) <1500mm*	*Diesel engines EOH(a) 1500+mm*
	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
Light buses						
GVM(b)<3.5 tonne						
On road use	79–80	78–79	89	85	99	95
Off road use	81–82	80–81	89	85	99	95
GVM(b) 3.5–5 tonne						
On road use	80–83	80–83	95	91	101	97
Off road use	81–85	81–85	95	91	101	97
Heavy buses						
GVM(b) 5–12 tonne						
On road use	80–83	80–83	95	91	101	97
Off road Use	81–85	81–85	95	91	101	97
GVM(b) 12+ tonne						
On road use	80–86	80–86	95	91	103	99
Off road use	81–86	81–86	95	91	103	99

(a) Exhaust Outlet Height.

(b) Gross Vehicle Mass.

Source: Federal Office of Road Safety 1989 (ADR28/01).

10.9 SOUND LEVEL LIMITS, Goods Vehicles

	VEHICLES IN MOTION...		STATIONARY VEHICLES...			
	Direct injection diesel engines	*Spark ignition engines and indirect injection diesel engines*	*Spark ignition engines EOH(a) <1500mm*	*Spark ignition engines EOH(a) 1500+mm*	*Diesel engines EOH(a) <1500mm*	*Diesel engines EOH(a) 1500+mm*
	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
Light goods vehicles(b)						
On road use	79–82	78–81	89	85	99	95
Off road use	81–82	80–81	89	85	99	95
Medium goods vehicles(b)						
On road use	81–84	81–84	95	91	101	97
Off road use	82–86	82–86	95	91	101	97
Heavy goods vehicles						
On road use						
NEP(c)<150 kW	81–83	81–83	95	91	103	99
NEP(c) 150+kW	84–87	84–87	95	91	103	99
Off road use						
NEP(c)<150 kW	82–84	82–84	95	91	103	99
NEP(c) 150+kW	86–87	86–87	95	91	103	99

(a) Exhaust Outlet Height.

(b) GrossVehicle Mass: Light—<3.5 tonne, Medium—3.5–12 tonne.

(c) Net Engine Power.

Source: Federal Office of Road Safety 1995 (ADR28/01).

Heavy goods trucks are the noisiest road vehicles, in terms of both their permitted noise levels and their actual noise in service. Noise from heavy vehicles can be reduced by:

- quieting the engine;
- quieting the transmission, improving silencers on the exhaust and air intake;
- quieting the cooling system;
- fitting low noise tyres;
- shielding the top and side of the engine with the cab and additional noise absorbing panels; and
- enclosing the engine, cooling air; or encapsulating the engine and gearbox in a sealed noise insulating box and fitting a remote cooling system (European Conference of Ministers of Transport 1990, pp. 70–71).

AIRCRAFT NOISE EMISSION STRATEGIES

Whereas other noise sources are dispersed in nature, aircraft noise exposure is concentrated in a relatively small area. The most important airport in terms of its noise effects is Sydney.

Governments address the problems of aircraft noise in a number of ways. Regulations control the levels of noise which can be emitted from aircraft and airports. The siting and location of new buildings in areas near airpports is also subject to controls. In addition, curfews apply for arrivals and departures at major airports.

Air navigation regulations introduced in 1984 required all new aircraft to be certified to noise emission standards set by the International Civil Aviation Organisation (Department of Transport and Communications 1990–91, pp. 28–29).

In 1991, the Federal Airports Corporation and Civil Aviation Authority Acts were amended to extend the functions of these organisations to include activities to protect the environment from the effects of aircraft operations. Regulations to phase out old generation noisy jet aircraft over the period 1995 to 2002 came into effect on 19 December 1991 (Department of Transport and Communications 1991–92, p. 2).

Australian Standard AS 2021

AS 2021–1994, 'Acoustics—Aircraft Noise Intrusion—Building Siting and Construction', provides guidance to State and local authorities and others associated with urban and regional planning on the location and construction of new buildings and on the adequacy of new buildings with respect to aircraft noise intrusion in areas near airports.

In Australia, noise exposure levels are calculated in Australian Noise Exposure Forecast (ANEF) units. The ANEF system is based on survey evidence of the reaction of Australian communities to aircraft noise, and incorporates a number of variables including:

- the noise levels produced by the various aircraft operating at an airport; and
- a logarithmic function of the daily average number of aircraft noise events.

Noise exposure contours of 20, 25, 30, 35 and 40 ANEF units define land areas around the airport which are affected by aircraft noise, increasingly so with increasing ANEF value (Civil Aviation Authority 1988).

Table 10.10 shows the zones for which 'Acceptable', 'Conditional' or 'Unacceptable' categories apply, and table 10.11 shows maximum external noise levels for selected building categories due to aircraft overflights, calculated as recommended in AS 2021.

In the areas outside 20 ANEF it is generally accepted that noise exposure is not of significant concern. Between 20 to 25 ANEF, aircraft noise exposure starts to emerge as an environmental problem, whilst above 25 ANEF the noise exposure becomes progressively more severe (Civil Aviation Authority 1988).

10.10 BUILDING SITE ACCEPTABILITY BASED ON ANEF(a) ZONES

	ANEF ZONE OF SITE		
Building type	*Acceptable*	*Conditional*	*Unacceptable*
House, home unit, flat, caravan park	Less than 20(b)	20 to 25(c)	Greater than 25
Hotel, motel, hostel	Less than 25	25 to 30	Greater than 30
School, university	Less than 20(b)	20 to 25(c)	Greater than 25
Hospital, nursing home	Less than 20(b)	20 to 25	Greater than 25
Public building	Less than 20(b)	20 to 30	Greater than 30
Commercial building	Less than 25	25 to 35	Greater than 35
Light industrial	Less than 30	30 to 40	Greater than 40
Other industrial	All	—	—

(a) Australian Noise Exposure Forecast.

(b) The actual location of the 20 ANEF contour is difficult to define accurately, mainly because of variation in aircraft flight paths. Because of this, the procedure in Clause 2.3.3 (for 'conditional' sites) may be followed for building sites outside but near to the 20 ANEF contour.

(c) Some people may find that the land is not compatible with residential or educational uses. Land use authorities may consider that the incorporation of noise control features in the construction of residences or schools is appropriate.

Source: McCotter, M. and Associates Pty Ltd 1994.

10.11 MAXIMUM AIRCRAFT NOISE LEVEL, By Building Category

Category	*ANEF zone*	*Maximum aircraft noise level, dB(A)*
Education facility	>30	87–93
	25–30	83–88
Internal design sound levels		
Libraries, study areas	—	50
Teaching areas, assembly areas	—	55
Workshops, gymnasia	—	75
Health care facilities	>30	98
	25–30	85–90
Internal design sound levels		
Wards, theatres, treatment and consulting rooms	—	50
Laboratories	—	65
Service areas	—	75

Source: McCotter, M. and Associates Pty Ltd 1994.

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CHAPTER 11 NEW VEHICLE SYSTEMS AND ALTERNATIVE FUELS

The development of new vehicle systems and alternative fuels is one way in which the environmental impacts of the transport industry are being addressed. In particular, alternative engine systems and fuels can contribute substantially in reducing greenhouse gas and toxic pollutant emissions, improving urban air quality, and improving energy security.

The available range of alternative engine systems and fuels is extensive. Evaluation of each option depends to a great degree on the desired outcome. Amongst the list of competing outcomes are the goals of self-sufficiency and energy independence, economic efficiency, vehicle performance, reduction in emissions, and energy sustainability. The identification of the most desirable engine systems and fuels will necessarily involve the balancing of all these factors.

New vehicle systems fall into two broad categories: the conventional combustion engine, and non-combustion models.

NEW COMBUSTION VEHICLE SYSTEMS

Research in the area of new engine systems has developed alternatives to the traditional Otto cycle engine, the prevalent automotive internal combustion engine. Newer systems offer improved performance, improved fuel economy, reduced emissions or a combination of all three.

Two-stroke engine

In the mid-1980s, Ralph Sarich designed the Orbital two-stroke combustion engine. The engine produces a lean-burn situation, good for both emissions and fuel consumption. The direct fuel injection system and parallel compressed air supply provide a dose of very finely atomised mixture, which forms a stratified charge within the combustion chamber. There is no oil filter, and routine servicing requires only a cleaner filter and new spark plugs. The engine permits emissions of only minimal levels of hydrocarbons, carbon monoxide and nitrogen oxides (Motor Industry Journal 1993b, pp. 34–38).

If it is possible to take advantage of two stroke engines, cost and fuel economy may be two of the savings. The cost saving will be realised by the elimination of engine components such as valve trains, cam shafts and complex cylinder heads. Savings in relation to fuel economy will be possible due to the reduced weight and improved aerodynamics (The Economist Intelligence Unit Ltd 1993, pp. 18–19).

Hydrogen

Hydrogen can be produced from renewable fuels, generally either by the process of electrolysis, involving the passing of an electric current through water, thereby separating the hydrogen from the oxygen atoms, or by gasification of biomass. Electricity for electrolysis can be provided from solar, wind or hydro-power sources. Electrolysis of water is already well established and commercially used. Solar energy as a power source for electrolysis may be available after 2000 (Nelson English, Loxton & Andrews 1996, p. C13).

Hydrogen combustion is virtually non-polluting, and vehicles powered by such a system have obvious environmental appeal. The main combustion by-product is water, along with some NO_x emissions. If hydrogen were used in a fuel cell, rather than an internal combustion engine, these NO_x emissions could be virtually eliminated (OECD 1993, p. 10). Hydrogen-powered vehicles therefore have the potential, in the long term, to significantly reduce transport emissions. Whether an appropriate non-polluting technique is used to generate the fuel in the first place should be considered (Nadis & McKenzie 1993, p. 85).

Infrastructure and transportation inadequacies, storage difficulties and high costs are some of the issues which need resolving before the use of hydrogen as a viable alternative fuel source would be possible.

Although it seems the hydrogen-powered vehicle is further away from commercial production than the electric vehicle, there have been considerable research and development initiatives which have resulted in the production of prototype models.

Gas turbine

The gas turbine engine model is a continuous burning engine in which hot gases produced by the burning air-fuel mixture are expanded to provide power. The engine was thought to have the potential to provide excellent fuel savings, low emissions and high adaptability to different fuels. However, high initial costs were associated with its development, including complex manufacturing, and its torque and response characteristics did not meet modern road requirements (OECD 1988, p. 117).

Stirling engine

The Stirling engine is a continuous combustion engine which transfers heat from the burning air-fuel mixture to a separate closed system containing a non-condensible working fluid. The working fluid is alternatively cooled during compression and heated during expansion in producing power. The system offers high fuel efficiency with the possibility of low emissions, depending on the fuel type used. However, it also involves high costs (OECD 1988, p. 117).

NON-COMBUSTION VEHICLE SYSTEMS

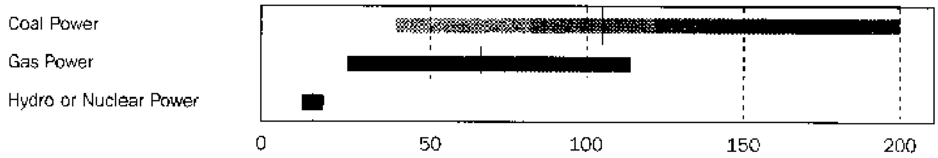
Electric vehicles

The development of electric vehicles is perhaps the most advanced work in the area of alternative vehicle systems. These vehicles involve a system to direct electrical energy from rechargeable batteries through an electric motor to power the car.

A dedicated electric vehicle (i.e. one that operates solely on electric power, without auxiliary fuel tanks) offers the promise of zero emissions. However, its pollution characteristics are determined by the electricity generating facility. Thus, the use of solar-powered stations, or plants, to recharge batteries would cut carbon dioxide emissions by 100%; using nuclear-powered plants would reduce emissions by 90%; and using natural gas-fired plants would result in a reduction of carbon dioxide emissions by 20%. However, use of coal-fired plants would result in a 30% increase in greenhouse gas emissions (Nadis & MacKenzie 1993, p. 73).

Diagram 11.1 indicates the large possible range of greenhouse gas emissions per kilometre for electric vehicles using electricity produced by coal-powered, gas-powered and hydro- or nuclear-powered generating plants. The wide ranges are also a result of uncertainties about vehicle technologies.

11.1 GREENHOUSE GAS EMISSION RANGES FOR ELECTRIC VEHICLES(a)



(a) Deviation from a base of 100.
Source: OECD 1994, p. 159.

Whilst dedicated electric power vehicles offer the advantage of zero tail-pipe emissions, they suffer the disadvantage of limited range, as a result of battery weight and the requirement for regular recharging. The type of battery used in an electric vehicle plays a key role in determining the vehicle's performance, driving range and long-term operating costs. The traditional lead-acid traction battery continues to offer the best combination of cost, cycle life, power density (which determines range), charge/discharge efficiency and safety, for use in electric vehicles, although it suffers from extremely low energy density.

Considerable research has been put into developing better alternative batteries, although many of these batteries are still in an experimental stage of development. The sodium/sulphur battery offers the best medium-term prospect as an alternative power source. It has an energy density two to three times higher than lead acid, although its operating temperature is high.

The relevant performance characteristics of the four most likely near term alternative batteries for use in electric vehicles are shown in table 11.2.

11.2 COMPARISON OF ELECTRIC VEHICLE BATTERY TECHNOLOGY

	Estimated life	*Approximate price*	*Range*	*Energy density*	*Construction*
	years	A$/kW hour	km	Wh/kg	sealed/ unsealed
Lead-acid	5–6	200	100–110	18–33	sealed
Nickel-iron	5–6	400	140–180	50	unsealed
Sodium-sulphur	1–1.5	1 600	240–270	90	sealed
Aluminium iron sulphide	2	n.a.	240–270+	90	sealed

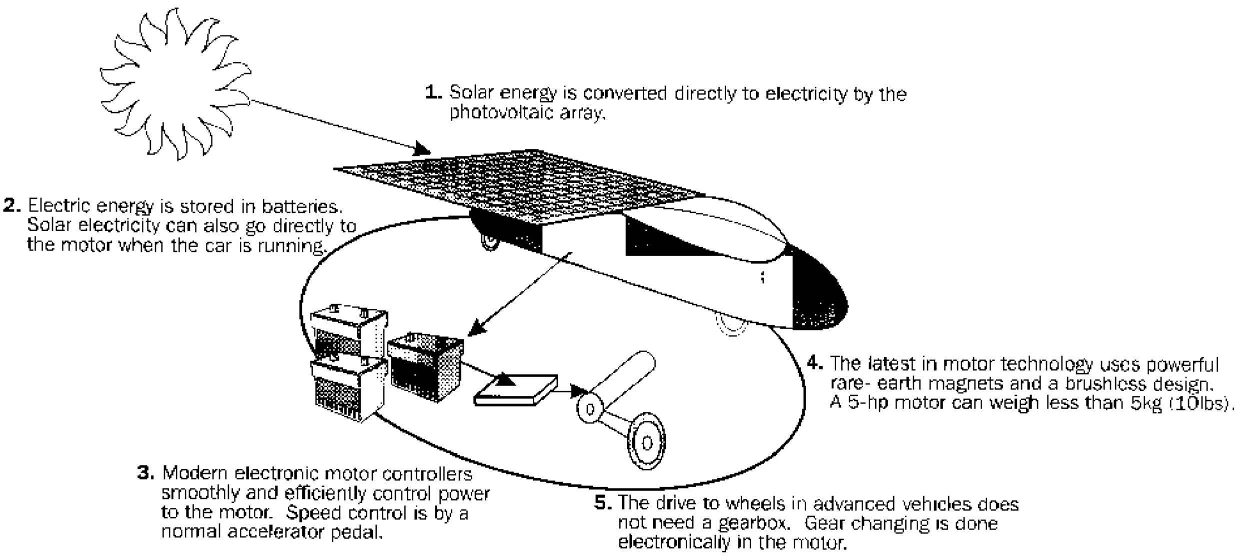
Source: Department of Minerals and Energy 1991, p. 15.

'Hybrid' vehicles have auxillary fuel tanks which aim to overcome limited range while operating as a zero emission vehicle in areas of high pollution. It is expected that hybrid electric vehicles will be available between 2005 and 2010, which will have very low emission rates and increased fuel efficiency. Hybrid vehicles are expected to be a decade closer to commercial viability than hydrogen driven vehicles (Nadis & MacKenzie 1993, p. 73). It is anticipated that electric vehicles with lead acid battery power may be available by 2001. They are however unlikely to be commercially viable due to high costs and limited ranges available in these vehicles. Advanced second generation electric vehicles modified to overcome these problems are expected to be available between 2005 and 2010 (Nelson English, Loxton & Andrews 1996, p. 22).

Solar vehicles

Solar cars derive a proportion of their energy from the sun. Solar cars utilise the 'photovoltaic effect', which produces electricity when light falls on the solar cells. The key components of a solar car are an array of solar cells on the upper surfaces of the vehicle, electric motors and batteries (see diagram 11.3). Solar-powered electric cars are 'zero-emission' vehicles. Solar technology is still developmental, and a dedicated solar car is yet to be produced commercially. Nelson English, Loxton and Andrews (1996, p. 22) estimate that photovoltaic energy may not be available as a general transport fuel for fifty years.

11.3 COMPONENTS OF THE SOLAR CAR



Source: Department of Primary Industries and Energy 1992, p. 2.

A leading model in solar car technology is the General Motors Sunraycer. This model uses both solar and voltaic cells, combines solar cells made of silicon and gallium arsenide into a solar array of 8,800 solar cells. This array is able to operate at 150 volts, providing 1,500 watts of power depending on the intensity of the sun, cloud cover and temperature. The Sunraycer also uses 68 rechargeable silver-zinc cells which provide a total of 102 volts when additional power is required for acceleration or hillclimbing, or in conditions of low sunlight. These silver-zinc cells are a new type of battery initially developed for use in space travel and satellite communication systems, are one-fifth the weight of a lead-acid battery of equivalent capacity, rechargeable and have a high energy-to-weight ratio (General Motors 1996).

FUEL MODIFICATIONS AND ALTERNATIVES

Alternative fuels can offer benefits of less pollution and in some cases increased fuel economy, but their development and adoption will be significantly affected by changes to pricing of traditional fuels, most recently observed in the tax changes to leaded petrol.

Unleaded petrol

Lead has conventionally formed an important ingredient in petrol, as a means of raising the octane rating of fuel and as a lubricant of engine valves. Lead emissions from motor vehicles contribute approximately 90% of airborne lead in Australia's urban areas (Department of Environment, Sport and Territories 1996a, p. 1). Human health can be significantly damaged by lead, most notably in young children where increased lead levels are associated with reduced intellectual development. In the broader population, lead is also known to damage the kidneys, liver, reproductive system, blood formation and basic cellular processes. There are also suspected carcinogenic effects of lead on people (European Conference of Ministers of Transport 1990, p. 31).

From February 1986, all new cars produced in Australia were required to operate on unleaded fuel. The 1993 Federal Budget also introduced a 1 cent per litre excise differential on leaded fuel, in an attempt to create an incentive for the population to change over to newer, unleaded vehicles. The price differential has since risen to 2 cents per litre. These measures, combined with the reduction of lead levels in leaded petrol to 0.2 grams per litre, have done much to reduce environmental lead levels.

At 31 May 1995, 42% of Australia's total motor vehicle fleet were unleaded vehicles (ABS 1996, p. 9). Industry estimates are that by the year 2000, 90% of petrol sales will be unleaded fuel (Motor Industry Journal 1993a, p. 56).

Reformulated gasoline (RFG)

With the exception of unleaded petrol, the most significant development in the area of improved and extended fuels is the development of reformulated gasoline (RFG) in the United States, although this fuel is not currently available in Australia. The Bureau of Transport and Communications Economics estimates that in Australia, RFG would cost perhaps 5 to 10 cents per litre more than petrol to produce, and would require some form of subsidy if its use were to be encouraged (Bureau of Transport and Communications Economics 1993, p. 24).

Reformulated gasoline has been designed with the intention of reducing the automotive contribution to ozone depletion, through the reduction of hydrocarbon emissions. Production of the fuel involves adjustments to reduce pollution, improve fuel combustion, reduce evaporation and remove impurities. A common technique is to increase the oxygen content of the fuel, to enable more complete combustion, thereby reducing emissions of carbon monoxide and unburned hydrocarbons.

Reformulated fuels offer significant advantages, if the aim of a country's transport policy is to minimise dislocation from changes in the supply of transport fuel. Unlike alternative fuels such as methanol or ethanol, RFG can be used by cars already in service without any power loss or mechanical adjustments. Such refinements to the fuel mix can offer reductions in emissions, but in the longer term, RFG is not a solution for reducing reliance on fossil fuels (although while fossil fuels are in use, it does reduce emissions to the lowest level technically possible).

Liquefied Petroleum Gas (LPG)

At present, LPG is the primary alternative transport fuel in Australia. The Australian LPG Association (ALPGA) estimates that approximately 3 to 4% of the motor vehicle fleet was an LPG dedicated or dual fuel vehicle in 1996 (approximately 400,000 vehicles). The ALPGA estimates that converted and new LPG vehicles are entering the register at a rate of about 60,000 to 70,000 per year (Nelson English, Loxton & Andrews, 1996, p. C14). LPG accounts for approximately 6% of total energy used by road transport (Commonwealth of Australia 1996, p. 59).

In 1994 the average blend used in LPG automotive fuel was 67% propane and 33% butane (Nelson English, Loxton & Andrews 1996, p. C14). The LPG used in spark ignition engines produces greenhouse gas emissions 20% lower than gasoline. NO_x emissions are a function of the air-fuel ratio. LPG offers some advantages over natural gas, such as higher energy density and easier transportation.

There are around 2,500 retail refuelling sites nationally. While refuelling infrastructure is well-distributed in all but the most remote parts of Australia, LPG vehicles are most suitable in centralised fleets where re-fuelling is convenient.

Natural gas

Natural gas can be used as motor vehicle fuel compressed in cylinders as either compressed natural gas (CNG) or liquefied natural gas (LNG). These fuels emit levels of NO_x similar or higher than those produced by petrol, and less non-methane hydrocarbons (OECD 1993, pp. 9–10). CNG has similar advantages to LPG and can be used in most vehicles with modifications. LNG is much less common than the compressed form, as it is more expensive and difficult to handle.

Despite its relative cheapness, current usage of natural gas as a transport fuel is negligible (Nelson English, Loxton & Andrews 1996, C4). Market penetration of natural gas vehicles (NGVs) is improving but remains low. Currently in Australia there are over 1,200 NGVs, of which most of these are heavy urban fleet vehicles (for example, buses).

CNG is better suited to use in buses and trucks than in cars due to the fact that CNG provides about one-quarter as much energy on a volume basis as petrol. While 45 litres of petrol weigh only about 30 kilograms, the fuel equivalent in CNG, including pressurised tanks, would weigh about 136 kilograms (Nadis & McKenzie 1993, p. 70).

Over $30 million has been invested by industry and government bodies like the Energy Research and Development Corporation in Australia since 1988 on natural gas technology and hardware (engine, storage cylinders, re-fuelling), and technology has been established for all road transport tasks, from private cars to heavy duty trucks (Australian Gas Association 1996, p. 6, 11). Natural gas bus programs have also been developed by a number of State governments:

- ACTION in Canberra is currently conducting a trial of two dedicated natural gas vehicles, which have been specifically built to avoid any compromise of the core business of a public transport vehicle, such as passenger capacity and access.
- The State Transit Authorities in Adelaide, Sydney, Perth and Brisbane are currently running fleets of natural gas buses.
- Victoria has two companies running a small number of natural gas buses in Melbourne and Geelong (Payne, R., pers. comm. 1997).

Dedicated natural gas vehicles can also be purchased direct from manufacturers, removing the need for conversions after purchase (Bureau of Transport and Communications Economics 1993, p. 23).

The main environmental concerns in natural gas production and transmission are minimisation of sulphur emissions from gas processing plants, and the reduction of the impacts of pipelines on the land. The production of synthetic natural gas by the gasification of coal brings more severe environmental impacts, causing mining impacts and solid waste problems, and emissions of air pollutants, some of them toxic (OECD 1993, p. 10).

Infrastructure costs for suppliers also present a significant barrier to increasing the market share of this fuel, with the Australian Gas Association estimating that the infrastructure to meet the re-fuelling requirements of a 10% penetration of the petrol market by CNG would cost $7,000 million (Bureau of Transport and Communications Economics 1993, p. 25).

Ethanol

Ethanol fuel is a renewable fuel currently produced in Australia from bio-mass, using raw materials of molasses, bagasse and to a lesser degree, wheat starch. There is also the potential to create ethanol through the conversion of ligno-cellulose. Its production generally requires the harvest of agricultural crops. As a fuel, it has a high octane quality, and is used primarily in blends with petrol. Its importance for improving air quality has been re-assessed since it was found that ethanol blended with petrol actually increases evaporative losses from the fuel, and is consequently contributing to the formation of photochemical smog (OECD 1993, p. 9). The composition of emissions from ethanol are not well known, but are believed to be high in unburned ethanol, acetaldehyde and other aldehydes. NO_x emissions are higher than for methanol but lower than from conventional diesel engines with particulate emissions being very low (OECD 1993, p. 36).

The main limitation to the widespread use of ethanol is that the production of this fuel requires large quantities of biomass resources. Nadis and McKenzie (1993, p. 67) note that 'it takes two acres of corn to run an automobile for a year on ethanol: yet the same area of solar (thermal electric troughs) could power more than 80 electric vehicles'. Studies have suggested that the energy required to grow and harvest the corn needed to produce a given quantity of ethanol fuel may be considerably higher than the energy subsequently yielded from using that quantity of ethanol to power vehicles. That is, ethanol production may result in a net loss of energy (Nadis & McKenzie 1993, p. 67).

The Commonwealth Government recently discontinued the bounty scheme for domestically produced ethanol fuel, which was part of its lead abatement strategy. The scheme was intended to encourage production, distribution and use of fuel ethanol. However production has been well below anticipated levels. The success of the scheme has been limited by uncertainty in long-term feedstock supply and price fluctuations (Department of Primary Industries and Energy 1996, p. 1–5, 1–6). The scheme has been held to have been ineffective in meeting its objective of leading the development of a commercially viable fuel ethanol industry in Australia (Commonwealth of Australia 1996, p. 60).

Potential new developments, such as ligno-cellulosic technology and refinery blending, that could improve the cost competitiveness and ecological sustainability of the fuel ethanol industry are in research and development stages and it is too early to assess their value. Nelson English, Loxton and Andrews (1996) estimate that ligno-cellulose based ethanol could be commercially viable beyond 2005, if sufficient research, development and plant construction are undertaken. The risks however, will be in securing adequate research and development funding, and in assuring a sufficient feedstock supply.

Some advances have been made in blends with petrol and diesel. In Canberra the ACTION bus fleet trialed a diesohol program in 1993, using a blend of 85% diesel and 15% ethanol (Department of Environment, Sport and Territories 1996b, p. 1). However, after a two year trial it was concluded that the use of diesohol considerably reduced smoke and NO_x emissions, but did not render any significant differences in emissions of CO_2, unburned hydrocarbons, or aldehydes. At the same time, CO emissions increased. Diesohol use also produced a loss in fuel economy, and caused a loss in engine power and tractive effort (Department of Environment, Sport and Territories 1996b, p. 3). Research and development into diesohol use and production are continuing.

Methanol

Methanol fuel is usually produced using natural gas, although renewable feedstocks can also be used. Methanol fuel has two main advantages when compared with petrol. First, methanol fuel has potential to reduce impacts on the ozone layer. Second, the emissions of benzene and other polycyclic aromatic hydrocarbons from pure methanol are relatively low.

However, there is some debate over the benefits of methanol fuel in terms of ozone emissions. Some studies have shown that methanol produces reduced carbon monoxide and unburned hydrocarbon emissions, whilst others show the fuel contributing to higher ozone levels than those produced by standard petrol (Nadis & McKenzie 1993, p. 65). Methanol-powered vehicles also emit considerably more formaldehyde than petrol powered ones. Formaldehyde is a toxic chemical known to contribute to the formation of smog. While a number of major car manufacturers are conducting research to develop technology to remove formaldehyde from the exhaust of methanol powered vehicles, no commercial product is yet available (Nadis & McKenzie 1993, pp. 65–66).

The environmental merits of using methanol fuel are also affected by how the fuel is produced. Use of natural gas to produce methanol fuel is usually the most economic option, but there is a wide margin in estimates of the reduction in greenhouse emissions from natural gas produced methanol, varying from 1% to 11% compared with petrol. Yet if methanol fuel were produced from coal, greenhouse emissions associated with use of this fuel for cars would be likely to increase in the order of 50% due to emissions of carbon dioxide from the coal used in producing the fuel (Nadis & McKenzie 1993, p. 65–66).

While the emissions associated with the production and use of methanol fuel remain problematic, it has the advantage of being relatively easy to adopt. Petrol engines can readily be modified to run on methanol, and it has been found to operate effectively and provide improved acceleration when used as the fuel for racing cars. However, more widespread usage may be limited by the fact that vehicles powered by pure methanol can be hard to start in cold weather. To overcome this problem it is usually necessary to install a fuel system that permits use of a blend of pure methanol and petrol, thereby diluting the environmental benefits of using a methanol fuel. Methanol is also more toxic than petrol and produces less power than petrol when compared on a litre by litre basis (Nadis & McKenzie 1993, p. 65).

Methanol is currently being considered as an alternative liquid fuel in Australia due to our extensive reserves of natural gas. Methanol produced from natural gas is considered to be cost effective with petrol when the crude oil price is about $30 per barrel (Department of Minerals and Energy 1991, p. 10). However, disadvantages such as poor cold starting, low driving range (typically 40% less than petrol vehicles), and problems with smog-forming aldehyde emissions, need to be addressed before methanol finds wide application as an alternative fuel.

The variability of environmental impact of alcohol fuels such as methanol and ethanol is considerable, depending on the vehicle of use, the emission which is being targeted, the quality of the vehicles conversion, the source of the fuel, how (if applicable) the fuel stock was grown and the impact on greenhouse gas levels if the fuel stock were left in situ. It is expected that both ethanol and methanol have the potential to reduce greenhouse gas emissions, provided that the fuels are produced from bio-mass (Bureau of Transport and Communication Economics 1994, p. 76).

AN OVERVIEW: WEIGHING THE ALTERNATIVES

A report prepared for the Department of Environment, Sport and Territories in July 1996 concludes that LPG will be the dominant alternative fuel in the period to 2010, with methanol and first generation electric vehicles also to be introduced during the period to 2005 (Nelson English, Loxton & Andrews 1996, p. ES-2). Ligno-cellulose based ethanol could be commercially viable beyond 2005, if sufficient research, development and plant construction are undertaken. The report estimates that methanol fuel cells will be available after 2010, and states that electricity from coal is not a viable fuel option at present due to the high level of greenhouse gas emissions involved.

The report concludes that all alternative fuels perform better than petrol, with respect to both greenhouse gases and pollutants (Nelson English, Loxton & Andrews 1996, p. ES-5). In relation to the latter criteria, gaseous fuels and methanol in fuel cells were judged to perform better than liquid alternative fuels.

Table 11.4 shows a projection of the evolving fuel/vehicle use combinations beyond 2016.

11.4 PROJECTED FUEL/VEHICLE USE COMBINATIONS BEYOND 2016

Time period	*Prevailing vehicle technology*	*Available alternative fuel technology*
1996–2001	Conventional spark ignition	LPG CNG
2001–2006	Improved control (7 l/100km) flexible fuelled vehicle(a) 1st generation electric vehicle	LPG CNG Methanol Electricity
2006–2011	Advance control (6 l/100km) flexible fuelled vehicle 2nd generation electric vehicle	LPG CNG Methanol Electricity Lignocellulose based ethanol
2011–2016	Very advanced control flexible fuelled vehicle 2nd generation electric vehicle Fuel cell	LPG CNG Methanol Electricity Lignocellulose based ethanol
2016+	Very advanced control flexible fuelled vehicle 2nd generation electric vehicle Fuel cell	LPG CNG Methanol Electricity Lignocellulose based ethanol Hydrogen from solar

(a) Flexible fuelled vehicles will accept both petrol and alternative fuels.

Source: Nelson English, Loxton & Andrews 1996, p. ES-8.

There is considerable dispute about the exact impact of various alternative forms of transport in terms of environmental impact and fuel emissions. The results of such comparisons often depend on driving speed, engine condition, road conditions and a range of other variables. A more generalised, quantitative approach to comparison of the alternatives provides a less controversial overview.

Although no one alternative fuel satisfies all requirements, some offer major advances in some areas such as long term sustainability and low greenhouse emission levels. Until a complete solution can be achieved, petrol and diesel fuels derived from crude oil will remain the major power source for motor vehicles (Department of Minerals and Energy 1991, p. 11).

Australia's gaseous transport fuels industry has established a range of niche transport applications and is providing more than 95% of the nation's current alternative transport fuel market. In the short and medium term, LPG will continue to serve the light commercial and passenger vehicle market, with natural gas vehicles concentrating on the replacement of diesel for buses and heavy vehicles.

Table 11.5 illustrates the potential trend towards more environmentally benign transport options in the future, especially if the development of electric vehicles powered from renewable sources and renewable fuel hydrogen vehicles become commercially competitive. Both these forms of transport would have minimal impact on air quality and other aspects of the environment, as well as much less of an impact on CO_2 emissions than the petrol-fuelled car. For the present, the picture is less clear cut—most forms of transport appear to offer possible reductions in CO_2 than the petrol-fuelled car. Other environmental impacts are minimised by the methanol (produced from natural gas feedstock) and LPG technologies, but as with all the other present day technologies, would still be powered by non-renewable fossil fuels.

If alternative fuels are to achieve a wider market, technological improvements reducing vehicle and equipment costs, as well as the implicit costs, will be important, as will expectations about the price of these fuels relative to petrol. Prices will depend on policy on the fuel excise, road user charges and possible adjustment of prices to reflect environmental effects. Other major factors will be the availability of refuelling infrastructure, original equipment manufacture vehicles offering better performance and maintenance services, as well as full warranties for vehicles and equipment.

11.5 ALTERNATIVE FUEL VEHICLE CHARACTERISTICS WITH RESPECT TO PETROLEUM VEHICLES

Fuel/vehicle	*Urban air quality impact*	*Other environmental impacts*	*Consumer acceptance*
	TODAY'S OPTIONS		
Ethanol ICEV(a)			
corn feedstock (coal fired distillation)	Less NMVOCs, O_3 much less air toxics	Land use, soil management	
Methanol ICEV(a)			
natural gas feedstock	Same as above but more formaldehyde	Minimal	
coal feedstock	Same as above	SO_x, PM emissions	
CNG or LNG-ICEV(a)			
Natural gas	Same to less CO, less NMVOCs, much less air toxics	CH_4 emissions	Less refuelling, less range
CNG or LNG			
Coal feedstock	Same as above	CH_4, SO_x, PM	Same as above
LPG	Same as above	Minimal	Less refuelling
Electric vehicle (produced from fossil fuels)	Minimal	SOx, PM, NO_x	Less refuelling, much less range
	FUTURE BEST OPTIONS		
Ethanol ICEV(a)			
Cellulose feedstock	Less NMVOCs, O_3, much less air toxics	Land use, soil management	
Methanol ICEV(a)			
Cellulose feedstock	Less NMVOCs, O_3, much less air toxics	Land use, solid management	
Synthetic natural gas–Wood	Same to less CO_2, less NMVOCs, much less air toxics	Land use, soil management	Less range, less re-fuelling
Advanced electric vehicle (LDV)			
From US power mix	Minimal	SO_x, PM, NO_x	Less re-fuelling, much less range
From renewables	Minimal	Minimal	Same as above
Hydrogen ICEV(a)			
From nuclear power	Much less NMVOCs, O_3, CO, air toxics	Nuclear specific risks	Less range, less safety, less re-fuelling
From renewables	Same as above	Minimal	Same as above
Fuel cells			
Ethanol (cellulose)	Minimal	Land use, soil management	
Natural gas	Minimal	CH_4 emissions	Less, refuelling, less range
Hydrogen (renewables)	Minimal	Minimal	Same as above

(a) ICEV: internal combustion engine vehicle.

Note: all evaluations are the most optimistic, based on further technological advances, and are subject to major uncertainties.

Source: OECD 1993, p. 12.

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CHAPTER **12** POLICY RESPONSES TO THE IMPACTS OF TRANSPORT

The search for solutions to traffic-related problems such as traffic noise, congestion and unwelcome changes to the appearance of the landscape has a long history. This search has accelerated during the past few decades, due to the huge rise in the global vehicle population, which exceeded 500 million in 1990, 10 times more than in 1950 (European Conference of Ministers of Transport 1990). Past policy responses have tended to be developed in isolation from policies for land use, economic development and environmental protection. In attempting to reduce congestion and noise, transport policies usually focused on increasing infrastructure development, including expressways, road widening, noise barriers, etc. These responses placed 'an emphasis on mobility — the act of moving — rather than accessibility — the business of getting there with minimum effort and at an affordable economic, social and environmental cost' (NSW Government 1995).

With the growth in private car use and in road freight during the 1970s and 1980s, other environmental concerns such as air pollution and urban sprawl became apparent. During the 1990s, the more global impacts of transport, especially the contribution of transport emissions to the enhanced greenhouse effect have become increasingly apparent. Responses to these problems have included legislation and regulation to reduce noise, air pollutants and ballast water discharges (see Chapter 10), and technological innovations to improve fuel efficiency and reduce emissions (see Chapter 11). These measures have mainly focused on changes to individual vehicles.

An essential complement to technological and regulatory responses are policy responses which attempt to develop an integrated approach to reducing transport impacts, by focusing on the interactions between patterns of transport usage and urban form, trade, employment and recreation. Such policy responses have been developed by governments, groups representing industry and the community, and transport users.

The role of finding solutions to the environmental and social impacts of transport is spread across all levels of government in Australia. The Commonwealth Government takes direct responsibility for the National Highway, National Rail, aviation policy, international maritime policy, and takes a coordinating role in matters such as road safety. State and Territory Governments are responsible for developing and implementing their own policies and programs in planning transport systems, urban design and consolidation, and the integration of modes of transport. Local government has the major responsibility for managing rural and minor roads and verges. The solid and liquid wastes associated with transport, such as waste oil and used tyres are usually addressed at the local government level.

A complete description of all policies and strategies which address the impacts of transport and the environment would require more space than this publication can allow. This chapter outlines selected policies and strategy responses under the following headings:

- national responses:
  - ecologically sustainable transport
  - integrating transport and urban planning
  - reducing energy consumption and greenhouse gas emissions
  - environment protection
  - road safety
- State, Territory and local responses
  - integrating transport and urban planning
  - environment protection
- community responses.

NATIONAL RESPONSES

In recent years several national overview responses to improving the sustainability of transport have been made. The national Ecologically Sustainable Development (ESD) process of the early 1990s sought to propose ways to reduce transport's adverse impacts and to integrate transport planning, urban planning and environmental protection into a coherent set of recommendations. The Better Cities Program and Australia's Land Transport Strategy followed, with the objectives of better integrating the various modes of transport while improving economic efficiency and reducing environmental impact.

Reducing greenhouse gas emissions is a matter which is currently receiving considerable attention from all levels of government in Australia. A new National Greenhouse Strategy is being developed to update the earlier National Greenhouse Response Strategy which followed Australia's international commitment to address greenhouse-related matters.

Air quality issues remain high on the list of public concerns about the environment. The first National Environment Protection Measure, outlined below, focuses on improving air quality. Road safety policy and programs are developed at the national level, incorporating the cooperative efforts of ministerial councils, all levels of government and community groups.

ECOLOGICALLY SUSTAINABLE TRANSPORT

International acknowledgment of the need to integrate protection of the environment and economic development was expressed in the 1987 report of the World Commission on Environment and Development which defined *sustainable development* as 'development that meets the needs of the present without compromising the ability of future generations to meet their needs ' (World Commission on Environment and Development 1987). In Australia, a national process to define and outline a way forward for ESD was undertaken in 1990. Nine working groups based on industry sectors met to explore future directions for Australia. The Transport ESD Working Group attempted to identify the role transport would play in an ecologically sustainable society, and how transport itself could promote the achievement of ESD. The group generated 40 policy recommendations, mostly directed to governments, which are summarised in table 12.1 below.

12.1 SUMMARY OF RECOMMENDATIONS, ESD Transport—1991

Topic area	*Transport Working Group Recommendations*	
Education and information	1	Improve community understanding of ESD.
	9	About the benefits of good driving practices and regular vehicle maintenance.
	11	Label all new cars to indicate fuel consumption rates, all vehicle advertising to include fuel consumption rates.
	13	Increase understanding in all sectors of the community about the benefits of higher urban densities and alternate urban forms.
	26	Advice and training for municipal engineers and planners on traffic demand management, traffic calming and bicycle facilities.
Research	3	How to incorporate full costs into energy prices; merits and impacts of carbon tax and tradeable emissions.
	6	Air quality in major population centres, ways to reduce petrol vapours while refilling, review air quality objectives.
	8	Determine use of pollution control equipment, undertake an Australia-wide study into emissions from in-service vehicles.
	12	How to achieve a transport system more in line with ESD principles.
	17	The ESD consequences of decentralisation.
	21	The development of real time information systems to advise drivers of the best routes and speeds at any given time.
	27	Identify the full range of benificiaries of urban public transport and seek appropriate contributions to costs of infrastructure.
	28	Identify sources and levels of investment in urban public transport to assist in achieving modal shifts.
Traffic planning strategies	18	Reduce the demand for transport services and calm traffic flow.
	19	Encourage car and van pooling.
	20	Evaluate the potential of road pricing mechanisms as an alternate to providing additional road facilities, enhance public transport.
	22	Develop equitable ESD oriented car parking facilities serving retail and commercial areas.
	23	Give priority to high occupancy vehicles where transit and road traffic are competing.
	24	Include traffic calming in local road planning and urban road funding.
	25	Develop a national bicycle strategy to encourage cycling, develop dual mode facilities for cyclists.
	29	Improve efficiency and encourage increased patronage of public transport.
	30	Investigate freight terminal linking; strategically placed freight terminals; potential of metropolitan rail for urban freight tasks.
	31	Provide freight and passenger corridors, intermodal exchanges and other infrastructure with high social and environmental benefit.
Land use strategies	14	Consolidate Australian cities, reduce urban sprawl.
	15	Ensure affordable housing accessible to public transport, employment and community facilities.
	16	Encourage new suburban employment on transport nodes, with access to medium density affordable housing.
	34	Provision for revegetation of arterial roads and other transport corridors and open space with native vegetation.
	35	Prepare regional plans to meet ESD objectives.
Financial approaches	4	Increase sales tax on new high fuel consumption vehicles, reduce sales tax on new low fuel consumption vehicles.
	5	Eliminate fringe benefits that encourage provision of company cars, downsize government car fleets, encourage public transport.
	32	Increase investment in interurban rail, in conjunction with improved efficiency of services.
Legislation and standards	7	Introduce tighter emissions limits, modify ADR emissions specifications.
	10	Establish a voluntary forward schedule to reduce fuel consumption of new vehicles.
	33	Uniform regulations for freight vehicles and a uniform traffic code to apply throughout the nation.
Government processes	2	Include ESD considerations in decision making about investment in transport infrastructure.
	26	Strengthen national mechanisms for coordinating and integrating transport planning in line with ESD.
	37	Review existing urban transport and land use planning arrangements to achieve better integration.
	38	Apply environmental impact assessment to transport policies, programmes and projects.
	39	Establish a consultative process to include all transport stakeholders to examine problems and assist the transition to ESD.
	40	Develop mechanisms at all government levels to monitor the implementation of ESD and inform the public of progress.

Source: Ecologically Sustainable Development Working Groups 1991.

The ESD Intersectoral Issues Report (Ecologically Sustainable Development Working Groups 1992) brought together transport and related land use issues, noting that low population densities in our cities have resulted in urban sprawl, which has contributed to increased dependence on the private motor vehicle as the main means of urban transport. The report reiterated many of the above recommendations and noted that there was room for improvement in the operational efficiency and coordination of existing public transport systems, which would assist in reducing reliance on the private motor vehicle. Increased investment in public transit systems would also be necessary to ensure the development of options such as light-rail. Traffic demand strategies were highlighted as having a role in ensuring better use of existing road facilities. Such strategies included peak spreading, measures to promote increased vehicle occupancy, traffic calming, parking restraints in central business districts, and road pricing measures. The report also suggested consideration of other options such as a review of the likely economic and environmental effects of removing perceived transport tax inequalities, such as tax concessions for company cars.

INTEGRATING TRANSPORT AND URBAN PLANNING

The integration of transport and urban planning on the national level has mainly been addressed through the former Better Cities Program and Australia's Land Transport Strategy.

Better Cities Program

The Better Cities Program was a national response by the Commonwealth, State and local governments to concerns about the environmental sustainability, economic efficiency and social equity of Australian cities. The program, which operated between 1991–92 to 1995–96, aimed to demonstrate through a series of area strategies in both inner city and outer suburban locations, the advantages of integrated urban development, medium density housing and improved public transport. Table 12.2 shows the major public transport components of the Better Cities Program.

12.2 PUBLIC TRANSPORT INVESTMENTS, Better Cities Program

State	*Area strategy*	*Location*	*Mode*	*Type of expenditure*
NSW	Ultimo/Pyrmont	CBD/Inner City	Light rail	Conversion of existing heavy rail freight line
	Transit West	Second CBD (Parramatta)	Heavy Rail	New connection and enhancement
			Intermodal transfer	New facilities
			Bus	New access route
Vic.	Southeast Area	Outer corridor	Heavy rail	Extension and upgrading.
	Inner Melbourne and Rivers Area	CBD	Light rail	Extension of existing system
	South-West Area	Corridor	Heavy rail	Upgrading
	Plenty Road Area	Corridor	Light rail	Extension and upgrading
Qld	Inner North-East	Inner Area	Light rail	New line
	Brisbane-Gold Coast	Corridor	Heavy rail	Extension of new line
			Intermodal interchanges	New facilities
WA	Perth Central	CBD/Inner Area	Various	New systems
	Stirling	Corridor	Intermodal interchange	New facility

Source: National Capital Planning Authority 1993.

Australia's Land Transport Strategy

In 1993, the Commonwealth Government published Australia's Land Transport Strategy, which sought to contain the cost of transport and to increase Australia's economic efficiency and competitiveness, while contributing to the attainment of environment objectives by optimising use of society's scarce or non-renewable resources (Department of Transport and Communications 1993). The Strategy sought to reform and improve land transport by developing the following:

- a more balanced and integrated system, with better links between road, rail and sea and a more efficient interface, particularly at the waterfront. This has involved a Commonwealth Government commitment to assume financial responsibility for an extended National Highway network providing access to most capital city ports and to fund key road/rail freight transfer depots;
- a standard gauge interstate rail freight system capable of competing effectively in freight markets, including links to major sea ports. All interstate freight operations to be under the control of a single management;
- urban public transport systems that meet user requirements at a time when the road systems in major cities are becoming congested and the effects of transport on the environment are better understood;
- reduction of the personal, social and economic cost of road trauma through the provision of safer vehicles, safer practices, better enforcement and a safer travelling environment; and
- a better economic return on the community's major investment in land transport infrastructure through development of better management practices and a concentration on providing facilities, such as access roads to ports and freight transfer depots, that allow greater interaction of transportation between the modes.

Table 12.3 outlines the component strategies of the national Land Transport Strategy.

12.3 LAND TRANSPORT STRATEGY COMPONENTS

Strategy	*Description*
Environment strategy	Reduced and more efficient use of private vehicles. Enhancement of public transport services. Improvements in fuel economy Research into alternative fuels Strategies to reduce greenhouse gas emissions
Rail strategy	Establishment of National Rail to conduct all interstate freight on a commercial basis. Standard gauge link connecting Brisbane, Sydney, Melbourne, Adelaide and Perth.
Urban public transport strategy	Improving public transport systems, especially in outer suburbs of metropolitan cities. Improve public transport access, improve equity. Reduce problems associated with pollution, congestion and safety by reducing use of private cars.
National bicycle strategy	Integrating cycle ways into transport system. Addressing safety issues. Integrating bicycle use into town planning. Promoting bicycle use.

Source: Adapted from Department of Transport and Communications 1993.

REDUCING ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS

Potential strategies to reduce energy consumption and greenhouse gas emissions have been the focus of considerable research during recent years. The Bureau of Transport and Communication Economics (1996) outlines and evaluates a variety of approaches that could be adopted to achieve these objectives. Some of these options have been included into the drafts for the Sustainable Energy Policy and the National Greenhouse Strategy outlined below.

Sustainable Energy Policy

The Commonwealth Government is currently developing a sustainable energy policy for Australia. The Green Paper, released in 1996, reports that in Australia, the transport industry accounts for a higher share of final energy demand than in any International Energy Agency nation apart from the United States. Geographical factors such as the size of the country and the area of cities contribute to this high level of energy usage. The Green Paper (Commonwealth of Australia 1996) outlines the following approaches towards achieving sustainable energy use which are relevant to reducing the impacts of transport:

- harnessing market forces—developing open and competitive markets to encourage the emergence of new technologies, alternative fuels and services, identifying and addressing distortions and impediments in the market, and including social and environmental costs in pricing;
- improving energy efficiency—there are a number of programs in place to encourage energy efficiency for example the cooperative agreements with industry under the Greenhouse Challenge program, incentives to undertake energy auditing, and information about the relative fuel efficiency of vehicles;
- investing in research and development—into alternative fuels which can be produced at a lower cost than conventional fuels and with lower greenhouse or other environmental effects;
- working with the international community—cooperating in international forums and research projects towards improving technologies;
- mitigating risk—in contrast to other sources of energy, most of Australia's transport fuels are imported, leading to an emphasis on increased exploration for domestic reserves, improvement in fuel efficiency and the development of alternative fuels; and
- strengthening institutions—ensuring that all levels of government work together to ensure that policy responses are effective in achieving sustainable energy usage, through forums such as the Australian and New Zealand Minerals and Energy Council, ANZECC and the Council of Australian Governments.

National Greenhouse Gas Inventory

The National Greenhouse Gas Inventory (NGGI) was set up to provide a quantitative account of Australia's greenhouse gas emissions sources and sinks by greenhouse gas and by sectors of the economy. The NGGI comprises a comprehensive database which allows analysis of patterns of emissions across the economy and can assist in identifying trends. The NGGI Committee comprises Commonwealth, State and Territory representatives to oversee the development and compilation of the inventory.

National Greenhouse Strategy

A new National Greenhouse Strategy is currently being developed for Australia. This follows the earlier National Greenhouse Response Strategy which was developed in 1992 to provide a nationally coordinated approach to undertaking measures which would reduce greenhouse gas emissions in line with Australia's commitments under the international agreement, the Framework Convention on Climate Change.

As part of the process of developing the new national greenhouse strategy, the Intergovernmental Committee on Ecologically Sustainable Development released its discussion paper *Future Directions for Australia's National Greenhouse Strategy* in March 1997. The discussion paper includes proposed strategies for reducing greenhouse gas emissions in each of the industry sectors which contribute significantly to Australia's emissions, including transport.

Transport is responsible for 12% of Australia's total greenhouse gas emissions, with a growth rate of 1.7% per year, almost treble the rate of total national emissions which is growing at the rate of 0.6% per year. Without measures to reduce emissions, levels by the year 2015 are projected to increase by 42% on 1994 levels.

About 85% of Australia's population lives in urban areas, which are characterised by low population and residential densities, relatively inexpensive land available for development at the urban fringe, high overall per capita energy consumption and high rates of transport energy demand. Low density urban design, together with an emphasis on road transport infrastructure and the growth in ownership of private vehicles have jointly contributed to high travel usage of private cars (about 85% of urban passenger kilometres).

The discussion paper proposes the following objectives to reduce the greenhouse gas impacts of transport:

- Encourage transport providers and users to take account of the greenhouse emissions implications of their activities.
- Promote integrated policy development and decision-making to achieve greenhouse gas emissions abatement in the transport industry.
- Promote urban forms that maintain or improve accessibility and which seek to reduce greenhouse gas emissions by: reducing growth in the number and length of motorised trips; encouraging alternative means of travel; and reducing reliance on the private motor car.
- Promote a reduction in transport greenhouse gas emissions through travel demand management.
- Promote public transport use in urban areas.
- Promote non-motorised transport use (walking and cycling) in urban areas.
- Promote greenhouse emissions reductions in the transportation of freight by encouraging modal shift or the use of more 'greenhouse efficient' vehicle configurations.
- Improve fuel economy in all modes of transport.
- Encourage a greater market share for less greenhouse intensive transport fuels.
- Reduce greenhouse gas emissions and damage to sinks (i.e. vegetation which absorbs carbon dioxide) from the construction of transport infrastructure.

ENVIRONMENT PROTECTION

National strategies and initiatives which address the environmental impacts of transport, directly or indirectly, include the National Biodiversity Strategy, State of the Environment Reporting, National Environment Protection Measures, and the National Plan to Combat Pollution of the Sea by Oil. A number of these are outlined below.

State of the Environment Reporting

The first comprehensive assessment of Australia's environment, *Australia: State of the Environment 1996,* was published in late 1996. Independent experts, and Commonwealth, State and Territory agencies contributed to the report, which identified aspects of the impacts of transport on humans and the environment. The set of environmental indicators identified in the report is being built on to establish a framework for future state of the environment reporting. This project commenced through the ANZECC State of the Environment Reporting Taskforce and the Australian Local Government Association.

National Environment Protection Measures

National Environment Protection Measures (NEPMs) are broad framework setting statutory instruments, which outline agreed national objectives for protecting particular aspects of the environment. NEPMs are developed by the National Environment Protection Council, composed of Ministers from the Commonwealth, States and Territories.

The Council stems from the Special Premiers' Conference held in October 1990, where the Prime Minister, Premiers and Chief Ministers agreed to develop an Intergovernmental Agreement on the Environment which came into effect in May 1992. This agreement included provision for the establishment of a national body (the Council), with responsibility for making environment protection measures, with the objectives of ensuring:

- that the people of Australia enjoy the benefit of equivalent protection from air, water and soil pollution and from noise; wherever they live; and
- that decisions by businesses are not distorted and markets are not fragmented by variations between jurisdictions in relation to the adoption of implementation of major NEPMs.

In 1996, the Council commenced developing a NEPM for ambient air quality standards. This NEPM will establish ambient air quality standards, and monitoring and reporting protocols for the following six pollutants: carbon monoxide, nitrogen dioxide, photochemical oxidants, sulfur dioxide, lead and particles. In order to establish these standards, the Council has undertaken a number of consultancy projects: health effects review, monitoring and reporting protocols, exposure evaluation, health risk evaluation, air quality management options, and impact assessment. The results of these projects will inform the Council in its decisions over appropriate standards for the above pollutants.

A second NEPM has been proposed, to develop a National Pollutant Inventory (NPI), which is expected to help create an informed community, promote achievement of waste minimisation and cleaner production objectives by industry and government and assist in planning and priority setting by governments. Core elements of the NPI to be considered in preparing the NEPM are:

- a list of substances or pollutants and a process for amending that list;
- a method for determining when a facility will report directly (a reporting threshold) and, where appropriate, emissions will be estimated by governments;
- a method for collecting the data from facilities and estimating diffuse sources (such as motor vehicles); and
- processes to ensure reporting, to identify commercial-in-confidence issues and to ensure community access to the information (National Environment Protection Council 1996a, b, c).

National Plan to Combat Pollution of the Sea by Oil

This national plan is managed by the Australian Marine Safety Authority and involves the Commonwealth Government, State and Territory Governments, and the shipping, oil and exploration industries in order to maximise Australia's oil spill response capability. Pollution response equipment is stockpiled at strategic ports and oil terminals, with a major industry stockpile in Geelong in Victoria. The stockpile has the capability of controlling an oil spill of up to 10,000 tonnes (Department of Environment, Sport and Territories 1995).

NATIONAL ROAD SAFETY

Policy development for national road safety is a collaborative process across all levels of government. While the Commonwealth Government does have responsibility for new vehicle design standards, the State and Territories have responsibility for vehicle registration and in-service roadworthiness. Diagram 12.4 shows the bodies which participate in developing policy for national road safety.

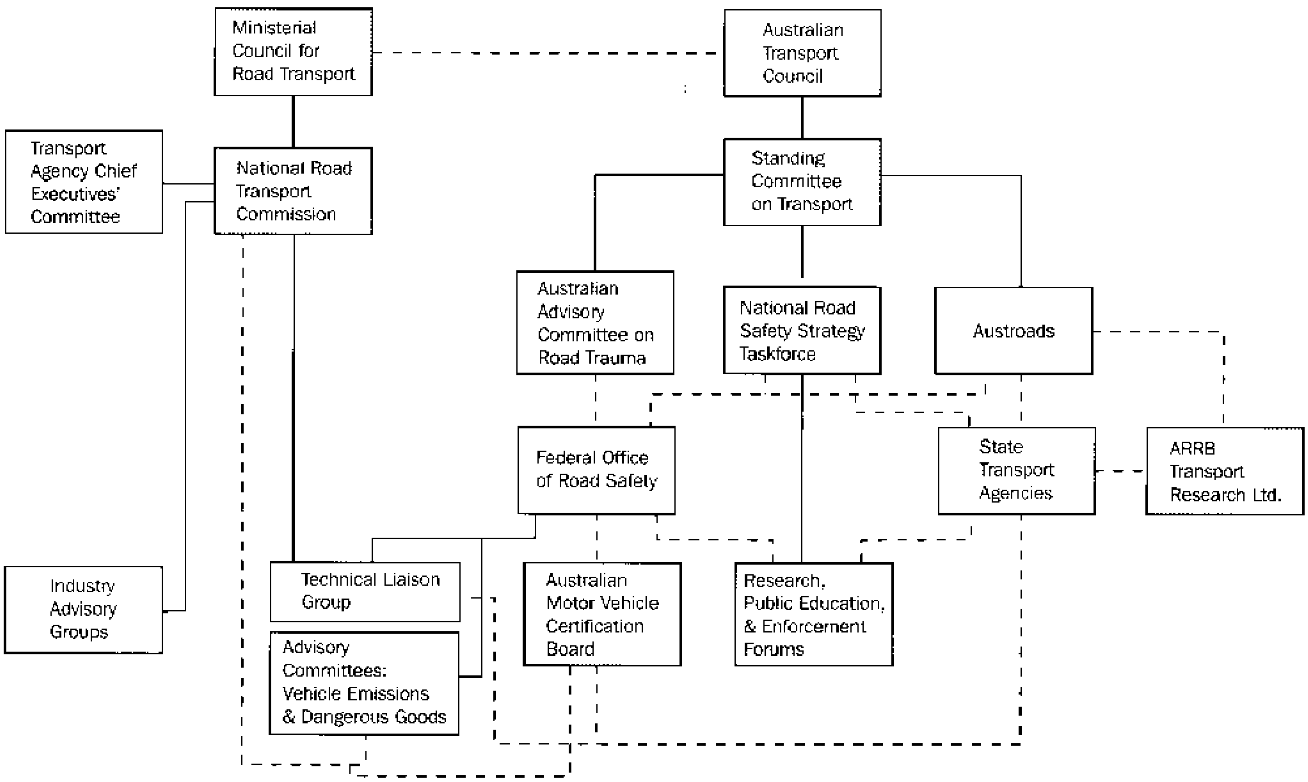
The policy making structure is overseen by the Australian Transport Council (ATC), which consists of the ministers responsible for transport, roads and marine and port matters from the Commonwealth, States and Territories. The ATC is mostly concerned with the achievement of broad national objectives for all transport modes and focuses on economic efficiency and inter-modal integration.

The Federal Office of Road Safety (FORS) is the Australian Govenment's policy adviser on road safety issues. Its objectives are to minimise deaths and injuries on the roads and to minimise the social and economic costs of road trauma. FORS has a central role in coordination, integration and liaison about road safety, and in addition to developing and monitoring motor vehicle standards, participates in developing strategies and initiatives to improve road safety, the following are some examples of these:

- the 1996 National Road Safety Action Plan and the National Rural Plan which covers rural and remote areas, stronger enforcement and publicity, compliance with speed limits, drink driving and driver fatigue, young drivers and vulnerable road users;
- the development of administrative arrangements for a new Black Spot Program which targets crash locations throughout Australia;
- through AUSTROADS, a proposal for a 50 kilometre speed limit in residential areas; and working towards national medical guidelines to assess fitness to drive when drivers apply for or renew their licences;

- public education, including with local government organisations to encourage the development of local Community Road Safety Plans and part-sponsored the booklet *Safer Roads for Your Community*, and with the Federal Chamber of Automotive Industries, published the *Emergency Rescuers Guide to Cars Fitted with Airbag Supplement Restraint Systems*; and
- research and workshops on a wide range of safety issues (Department of Transport and Regional Development 1996).

12.4 NATIONAL TRANSPORT POLICY FRAMEWORK FOR ROAD SAFETY



Source: Department of Transport and Regional Development 1997, pers. comm.

STATE, TERRITORY AND LOCAL RESPONSES

State, Territory and local governments play a major role in transport policy in Australia. These governments have taken up the recommendations in the National ESD Strategy to move towards integrating planning and management of transport, land use, economic development and environmental protection. Most States have established an Environmental Protection Agency and developed a State of the Environment reporting framework as a basis for addressing environmental problems.

INTEGRATING TRANSPORT AND URBAN PLANNING

The 1994 Industry Commission *Report on Urban Transport* identified a number of problems with Australia's urban transport systems, including:

- high cost to taxpayers;
- increasing road congestion in the larger cities;
- inefficient delivery of public transport services and road infrastructure;

- major environmental impacts, especially on local air quality, noise and risks to life and limb; and
- difficult access to transport by the disadvantaged.

These problems have been addressed in recent plans, such as the *Integrated Transport Strategy for Greater Sydney*, the *Integrated Regional Transport Plan for South East Queensland* and the *Perth Metropolitan Transport Strategy*, which emphasise the need to achieve environmental protection and social equity as well as economic efficiency in transport planning.

Recent strategies have attempted to integrate and coordinate the components of urban transport systems which include the road system, public transport systems (buses, suburban passenger trains, trams and ferries, taxis, community transport services), private cars, rail and road freight and commercial delivery services, cyclists, walkers, airports and seaports. Infrastructure associated with the transport system includes roads, railways, parking lots, bus and rail stations, cross walks and overpasses, cycle ways, dual use paths and footpaths. In the past, these components of the system have tended to be managed by a plethora of different, often unconnected agencies. These recent strategies adopt some or all of the following approaches to integrating the many aspects of transport and alleviating its adverse impacts.

Improving public transport

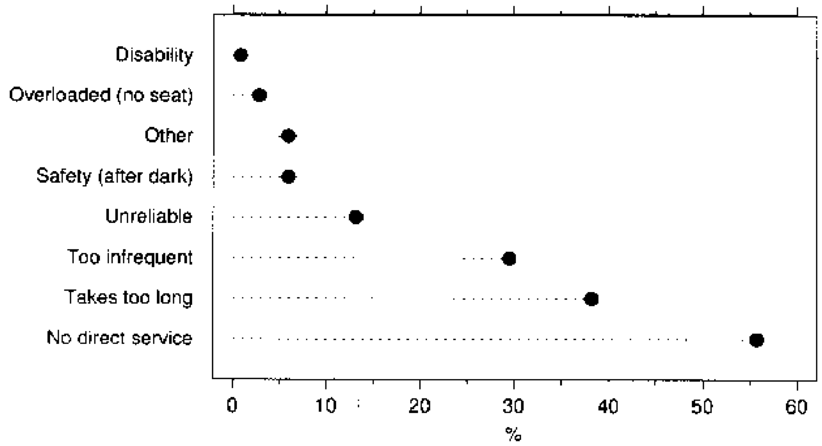
Well patronised public transport compares favourably with individual private vehicles as a means of moving passengers and freight with more efficient use of energy, less pollution and emissions, greater safety and lower demands on land and infrastructure. Improving and increasing public transport has therefore been seen as an important means of addressing environmental impacts.

Most Australian cities developed around public transport infrastructure, especially rail and trams lines. However, public transport patronage has declined over recent decades as private car ownership increases, and currently accounts for between 8% and 14% of motorised journeys in the major capitals (National Capital Planning Authority 1993). One reason for the decline is that our public transport networks are still largely based on the radial pattern which suited the 1950s, while travel journeys in the 1990s have shifted markedly towards cross-suburban with fewer journeys into the city centres (Lowe 1995). Urban public transport systems have been found wanting in other ways. The 1994 Industry Commission Report found that:

- public transport systems were generally inflexible;
- service delivery was often inefficient and short on innovation; and
- users complain that public transport was often unreliable, infrequent, uncomfortable and insecure.

These problems were reflected in the findings of the recent ABS survey of transport patterns and preferences in New South Wales. Graph 12.5 shows the reasons for not using public transport given by 403,400 people who usually travel to work by motor vehicle/cycle.

12.5 REPORTED PROBLEMS WITH PUBLIC TRANSPORT, NSW—1996



Source: ABS 1996.

Strategies to make public transport systems more attractive to urban travellers can include:

- improving the integration of transport and land use planning;
- new forms of transport such as multi-hire on-demand services;
- acceleration of key long distance services and the introduction of high frequency feeders;
- new approaches to linking the customer to the system;
- new ways to integrate public transport systems through central 'information broker' systems;
- a new network of major public transport routes and services which link employment and business centres outside the major CBDs;
- public transport priority 'right of way' rules such as peak hour transit lanes, queue-jumping lanes and priority traffic light signalling to speed up bus journeys.
- new light-rail services, especially to link with high density routes, such as to airports, ports, universities and major hospitals;
- integrated ticketing allowing ease of travel across transport modes (available in Adelaide and Melbourne).

Public transport managers are taking up these and other ways to improve services, and the long term trend of declining use of public transport in Australian cities appears to be reversing. The Victorian Public Transport Corporation reported an average increase in patronage of 4% on metropolitan passenger services for 1994–95 (Victorian Public Transport Corporation 1995).

Integrating transport and land use planning

There is increasing awareness of the ways that the outcomes of transport and land use decisions impact on each other. The demand for transport is affected by the distance to be travelled, time of travel, length of journey, and so on. Urban form and density underlay many of these considerations. Accordingly, recent urban strategies have focused on concentrating commercial and employment growth in designated centres. Higher densities of residential, recreational and community activities, developed in sequence with the appropriate infrastructure and services are also recommended. The South East Queensland Plan suggests five ways that better integration between transport and urban planning can be achieved:

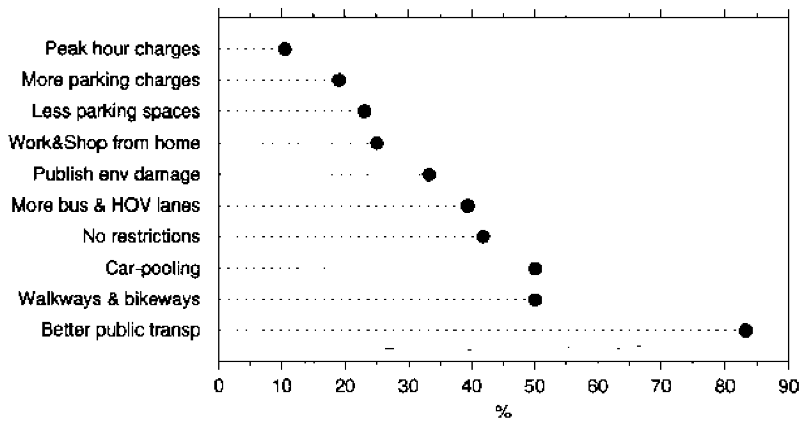
- planning an overall transport network for the region including identifying key transport corridors and protecting them from inappropriate development;
- directing transport and urban investment to areas identified in strategic plans;
- making quality public transport a fundamental requirement for all major new developments;
- restricting car parking and car access to urban centres with adequate public transport services ; and
- making transport corridors work better by focusing development along them.

Managing travel demand

Trips made by car account for the large majority of urban travel in Australian cities and average peak hour vehicle occupancy rates are low, e.g 1.3 persons in Brisbane; 1.2 persons in Perth, and are declining. There are a number of strategies which can encourage drivers of private cars to reduce trips, especially if only the driver is travelling. These include encouraging employers to foster ride-sharing schemes, reduced parking fees for shared journeys, parking space restrictions, reductions in speed and access in residential and commercial areas, transit lanes and bus priority signals on major roads.

Public support for various options to reduce travel in private vehicles in south–east Queensland is shown in graph 12.6.

12.6 PUBLIC SUPPORT TO DECREASE PRIVATE VEHICLE USE, Qld—1996



Source: Queensland Government 1996.

Encouraging non-motorised transport

Increased walking and cycling can contribute to reducing the environmental impacts of transport. There is potential for bicycle substitution of some motorised trips; one-third of car trips are estimated to be 3 kilometres or less, with such trips likely to be to transport nodes or for convenience shopping. For many of these trips, cycling could be substituted, as the average bicycle trip is 2.5 kilometres (NSW Government 1995). Cycling and walking rates can be increased by integrating them into the design of urban form and transport systems. Traffic congestion and dispersed employment and activity centres are disincentives to walking and cycling as transport options.

Developing strategic freight networks

Freight transport is expected to increase markedly in the near future, and managing the social and environmental impact of heavy vehicles is a high priority for planners. Options include restricting heavy vehicles to a designated network of key arterial and sub-arterial roads, by-passes and ring roads, curfews and restricted hours for heavy trucks using certain roads. The development of new freight rail lines and options such as pipelines are being examined.

ENVIRONMENT PROTECTION

Most State and Territory Governments have established Environment Protection Agencies to develop strategies and policies to deal with a wide range of environmental concerns. Transport-related issues such as noise control, reduction of waste oil and tyres going to landfill and roadside revegetation are managed by these agencies.

Rail authorities are increasingly aware of the need to reduce the environmental impact of the infrastructure and operations of rail services. As an example, the State Rail Authority in New South Wales has prepared an Environmental Management Strategy which will allow the ongoing measurement of progress made in environmental improvement, including:

- the commencement of rail noise reduction works at several sites, e.g. the Sydney Harbour Bridge;
- studies and implementation plans about all aspects of fuelling, to reduce environmental risk and improve response times in the case of spills;
- a review of locomotive exhaust emissions and a testing program on fuel additives to improve bulk carrier performance;
- the evaluation and analysis of environmental incidents, an expanded audit protocol; and
- training programs to raise environmental awareness among staff and the integration of environmental performance into job descriptions and performance targets (State Rail Authority of NSW 1995).

Port authorities are also developing programs and strategies to improve environmental management practices and move towards sustainable operation of port facilities. As an example, the Environment Policy for Queensland Ports addresses:

- port planning - port and land use planning, coastal management, environmental impact assessment, public participation;
- environmental management - staff and education, environmental monitoring, environmental auditing, budgeting;
- port operation - pollution control, dredging and dredged materials, port users, cargo facilities and cargo in transit, navigation factors (Queensland Transport, pers comm).

Roadside vegetation management

Road reserves often contain significant areas of indigenous vegetation. The retention of native vegetation and revegetation projects which involve State and local government agencies and community groups are aimed at improving the environmental quality and biodiversity of road verges. In some areas the development of vegetation plans is reducing the need for slashing and herbicide spraying of roadsides. Selection of appropriate native species can reduce soil erosion of verges while ensuring safe levels of visibility. As an example of revegetation rates, during 1995–96, the following revegetation was undertaken by the South Australian Department of Transport:

- Direct seeding—100 hectares;
- Planting—tubestock—100,000 plants; and
- Planting—advanced trees—500 trees (South Australian Department of Transport 1996).

Wildlife protection schemes

Roads and traffic authorities have developed a number of initiatives to reduce the impact of the construction of new roads and expressways on wildlife corridors. As an example, the programs utilised by the NSW Road Transport Authority (Southern and Northern Regions) include:

- creation of compensatory wetlands;
- construction of fauna underpasses and fencing to channel animals under roads;
- use of wildlife reflectors on roadsides;
- construction of frog acoustic walls to avoid interference with breeding cycles;
- habitat replacement programs, involving relocation of wildlife and vegetation;
- purchasing of significant fauna areas for use as relocation conservation areas;
- signposting of fauna movement corridors and speed restrictions;
- erection of temporary poles for glider squirrels to enable crossing of highways;
- preservation of roadside vegetation (Dutaillis, pers. comm.).

COMMUNITY RESPONSES

Community responses to addressing the environmental impacts of transport have included:

- the practical work done by community groups, such as the annual Clean Up Australia Day, where volunteers retrieve dumped car bodies, batteries and waste oil;
- participation in roadside revegetation projects and rescue of injured wildlife, e.g. the NSW Wildlife Information and Rescue Service;
- development of policy approaches to improve sustainability, e.g. the Australian Conservation Foundation's *Towards an Ecologically Sustainable Transport Sector;*
- detailed analyses of specific transport needs and proposals for alternative solutions, such as the Public Transport Users Association's *Environmentally Friendly Transport for Melbourne's Outer East*, which examines the future transport needs of part of metropolitan Melbourne, based on population and anticipated travel need; presents criticisms of current government proposals; provides overseas examples of successful approaches; and presents an alternative strategy based on increased use of public transport, including costing for the proposal;
- sponsoring of cooperative processes to address specific environmental problems, e.g. the NRMA's *Shaping Sydney's Transport*, part of the Clean Air 2000 project which takes a broad policy approach to the reforms needed to reduce air pollution in urban areas; and
- the Australian Scrap Tyre Management Council's submission to the Australian and New Zealand Environment and Conservation Council, *Solving Australia's Scrap Tyre Disposal Problem*, which presents suggestions for reducing the volume of used tyres going to landfill and proposes Australia-wide standards for disposal.

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LIST OF ABBREVIATIONS AND OTHER USAGES

ABBREVIATIONS

ABS	Australian Bureau of Statistics
ADO	Automotive Diesel Oil
ADR	Australian Design Rules
ALPGA	Australian LPG Association
AMSA	Australian Maritime Safety Authority
ANEF	Australian Noise Exposure Forecast
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZSIC	Australian and New Zealand Standard Industrial Classification
APRAA	Automobile Part Recycling Association of Australia
AS	Australian Standard
ASIC	Australian Standard Industrial Classification
ATC	Australian Transport Council
Avgas	Aviation Gasoline
Avtur	Aviation Turbine Fuel
BIE	Bureau of Industry Economics
BTCE	Bureau of Transport and Communications Economics
CNG	Compressed Natural Gas
DEST	Department of Environment, Sport and Territories
DOT	Department of Transport
DOTAC	Department of Transport and Communications
DPIE	Department of Primary Industries and Energy
ECMT	European Conference of Ministers of Transport
EPA	Environment Protection Authority
EPAV	Environmental Protection Authority Victoria
ERDC	Energy Research and Development Corporation
ESD	Ecologically Sustainable Development
FAC	Federal Airports Corporation
FORS	Federal Office of Road Safety
GDP	Gross Domestic Product
GDP(P)	Gross Domestic Product (Production)
GMH	General Motors Holden
HOV	High-occupancy vehicle

ABBREVIATIONS continued

ICAO	International Civil Aviation Organisation
ICEV	Internal Combustion Engine Vehicle
IDF	Industrial Diesel Fuel
IPCC	International Panel for Climate Change
LCV	Light Commercial Vehicle
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
Met.	Metropolitan
NEP	Net Engine Power
NEPM	National Environmental Protection Measure
NG	Natural Gas
NGGI	National Greenhouse Gas Emissions Inventory
NGV	Natural Gas Vehicles
NMVOC	Non-methane Volatile Organic Compound
NPI	National Pollutant Inventory
OECD	Organisation for Economic Co-operation and Development
PSR	Pressure-State-Response
QR	Queensland Rail
RVA	Recreational Vehicle Area
RFG	Reformulated Gasoline
SAE	The Engineering Society for Advancing Mobility Land, Sea, Air and Space
SNG	Synthetic Natural Gas
SoE	State of the Environment
UNCED	United Nations Conference of Environment and Development
USEPA	United States Environmental Protection Authority
WIRES	Wildlife Information and Rescue Service

SYMBOLS

μ	micro (10^{-6})
billion	1 000 000 000
CFC	Chlorofluorocarbons
c	centi (10^{-2})
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
dB(A)	Decibels (Audible)

SYMBOLS continued

DWT	Dead weight tonnage
G	Giga (10^9)
g	grams
g/km	grams per kilometre
Gt-km	Gigatonne kilometres
GWT	Gross weight tonnes
h	hours
ha	hectares
HC	Hydrocarbon
J	joules
k	kilo (10^3)
L	litres
M	Mega (10^6)
m	milli (10^{-3})
m/s	metres per second
m^2	square metre
m^3	cubic metre
Mtoe	Mega tonnes of oil equivalent
NO	Nitric oxide
NO_X	Nitrogen oxides
N_2O	Nitrous oxide
O_3	Ozone
P	Peta (10^{12})
PAN	Peroxyacetyl nitrate
p-km	passenger kilometres
PM	Particulate matter
ppm	parts per million
pphm	parts per hundred million
SO_X	Sulfur oxides
SO_2	Sulfur dioxide
TBT	Tributyl tin
t	tonnes
W	Watt
Wh	Watt hours
Wh/kg	Watt hours per kilogram (energy density)

OTHER USAGES

n.a.	not available
n.c.	not collected
n.e.c.	not elsewhere classified
n.d.	no publishing date
n.p.	not available for publication but included in totals where applicable
p	provisional data
*	relative standard error of between 25% and 49.9%
**	relative standard error of 50% or more
***	subject to sampling variability too high for most practical purposes
. .	not applicable
—	nil or rounded to zero

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