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Bureau of Transport and Regional Economics

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Greenhouse Gas Emissions From Australian Transport: Base Case Projections to 2020

Report for the Australian Greenhouse Office
Department of the Environment and Heritage
August 2005

GREENHOUSE GAS EMISSIONS FROM AUSTRALIAN TRANSPORT:
Base Case Projections to 2020

Bureau of Transport and Regional Economics (BTRE)
http://www.btre.gov.au/

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FOREWORD

This report presents the results of a Bureau of Transport and Regional Economics (BTRE) study to update base case projections of greenhouse gas emissions from the Australian transport sector. This work updates previous projections provided to the Australian Greenhouse Office (AGO) in July 2003 as an unpublished consultancy report - *Aggregate Greenhouse Gas Emissions from Australian Transport: Base Case Projections (Bottom-Up Approach) to 2020*.

These latest projections extend and update base case projections of transport sector greenhouse gas emissions published in BTRE 2002 Report 107, *Greenhouse Gas Emissions From Transport: Australian Trends To 2020.* Report 107 had in turn updated previous Bureau projections of transport sector emissions, published in Bureau of Transport and Communications Economics (BTCE) Report 88 (*Greenhouse Gas Emissions from Australian Transport: Long-term projections*, BTCE 1995) and Report 94 (*Transport and Greenhouse: Costs and options for reducing emissions*, BTCE 1996). This current work has again been undertaken on behalf of the Australian Greenhouse Office and forms part of AGO's preparation of Australia's Fourth National Report under the United Nations Framework Convention on Climate Change (see AGO 2005a).

The BTRE estimates greenhouse gas emissions from the transport sector using a suite of different demand models. Through various modelling approaches (e.g. structural, econometric and dynamic fleet models), projections of task levels, fuel consumption and consequent emissions output are made for the various transport sub-sectors, and are then aggregated to obtain sector totals (often termed a '*bottom-up*' modelling approach).

The following document describes the results of using the BTRE's bottom-up modelling approach to estimate base case projections of Australian transport for 2005 to 2020. This summary report serves as a distillation of a large amount of numerical detail (covering the major inputs and outputs of the various BTRE models), a compendium of which has been provided to the AGO (in spreadsheet form). This accompanying (Excel) spreadsheet is available on the BTRE website.

The study was undertaken by Dr David Cosgrove and Dr David Gargett.

Bureau of Transport and Regional Economics
Canberra
March 2006

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EXECUTIVE SUMMARY

This report, compiled on behalf of the Australian Greenhouse Office (AGO), presents the results of a detailed Bureau of Transport and Regional Economics (BTRE) study into the modelling and forecasting of greenhouse gas emissions from the Australian transport sector.

This work updates previous projections provided to the Australian Greenhouse Office in July 2003 as an unpublished consultancy report - *Aggregate Greenhouse Gas Emissions from Australian Transport: Base Case Projections (Bottom-Up Approach) to 2020*. These latest projections extend and update base case projections of transport sector greenhouse gas emissions published in BTRE Report 107, *Greenhouse Gas Emissions From Transport: Australian Trends To 2020* (BTRE 2002). Report 107 had in turn updated previous Bureau projections of transport sector emissions, published in Bureau of Transport and Communications Economics (BTCE) Report 88 (*Greenhouse Gas Emissions from Australian Transport: Long-term projections*, BTCE 1995) and Report 94 (*Transport and Greenhouse: Costs and options for reducing emissions*, BTCE 1996). The two projection update studies subsequent to Report 107 have used results from another detailed study, conducted by Dr David Cosgrove, into the modelling of road vehicle emissions (*Urban Pollutant Emissions From Motor Vehicles: Australian Trends To 2020*, BTRE 2003a).

The emission projections are estimated using a *base case* scenario for the next 15 years. The specific scenario assumed could be more fully described as a '*base case with measures*' - i.e. based on current trends, the scenario adopts what is considered the most likely future movements in travel behaviour, vehicle technology, economic indicators and demography, and also incorporates the impact of the likely progress, over the period, of meeting the greenhouse gas abatement measures that Australian governments have currently committed to.

Emission results are generally given in terms of carbon dioxide (CO_2) equivalent *direct* emissions - i.e. are weighted totals (relative to an equivalent mass of CO_2) which include only the directly radiative gases CO_2, CH_4 (methane) and N_2O (nitrous oxide), and do not include the indirect effects of gases such as CO (carbon monoxide), NO_x (nitrogen oxides) and NMVOCs (non-methane volatile organic compounds). Emission estimates also generally refer to energy *end-use* (i.e. are from the direct combustion of fuel in the transport vehicles, and do not include further energy used to extract, refine or otherwise provide that fuel for the vehicles' use).

Emissions from Australia's civil domestic transport sector in 2010 are projected, under such *base case* assumptions, to be around 57.5 per cent above the level for 1990, reaching 94.1 million tonnes of CO_2 equivalent. By 2020, the BTRE projects base case emissions to be close to 78 per cent above 1990 levels (at 106.3 million tonnes of CO_2 equivalent).

These latest Bureau projections exhibit a similar trend to the projections provided to the AGO in 2003 (BTRE 2003b) – with all the major sectoral contributions exhibiting reasonably comparable rates of projected growth. However, the aggregate emissions growth to 2020 is somewhat higher in these projections, in comparison to the 2003 results - the 2020 sector total of 106.3 million tonnes CO_2 equivalent is around 3.6 per cent higher than the BTRE 2003 result for year 2020. The BTRE 2005 aggregate projections are higher than the previous results due to a wide variety of factors. These include:

- slightly higher projections of underlying economic activity (such as GDP growth) and of population growth;
- recent strong growth in motor vehicle sales (and various other indicators such as iron ore production) serving both to raise the base level from which the projections are taken and to strengthen the income elasticities for some of the transport demand models; and
- fuel intensity measures for some tasks have not been declining as rapidly in recent years as assumed under the original base case scenario compiled for BTRE Report 107.

Given these revisions to the underlying methodology and assumptions, the projections would probably have been a reasonable amount higher than previously, if not for two countervailing effects.

- Firstly, recent high oil prices have served to dampen overall transport demand slightly. Prices for petroleum fuels will likely remain higher than average for the near future, and the BTRE 2005 projections are consequently based on a medium-term oil price scenario that is substantially higher than the scenarios used for Report 107 and the BTRE 2003 projections. Yet the current projections are not based on the assumption that the current high price levels will be maintained forever – but that crude oil prices will probably return to a more long-term average (of around US$37 per barrel, in real terms), before 2010.

- Secondly, the projected fuel intensity for light motor vehicles have been considerably lowered in the 2005 base case. The 2003 base case was a 'business-as-usual' scenario that specifically did not include the effects of abatement measures. Since the 2005 base case is a 'with measures' scenario, it allows for the fuel efficiency targets negotiated with motor vehicle manufacturers, as part of the policy measures comprising the Environmental Strategy for the Motor Vehicle Industry (ESMVI). The National Average Fuel Consumption (NAFC) targets are predicted to accelerate trend improvement in the average fuel efficiency of new light vehicle sales.

The scale of the increases in aggregate transport emissions (which, as mentioned, are similar in magnitude to previously released Bureau projections of transport emissions) points to the fact that Australian transport demand is highly dependent on underlying economic and population growth. Performance of the Bureau models has been well demonstrated over time – with their outputs being widely used. In fact, current levels of transport demand for most major sectors appear to be within a few per cent of values forecast for 2004 to 2005 in Bureau projections made 10 or more years ago. The aggregate long-term growth projected for total transport sector emissions has not changed appreciably in Bureau studies since at least 1995 (and for a comparison of the two latest Bureau projection studies see figure ES.2). The greatest uncertainty concerning the projections is probably whether there will be any significant disruptions to oil supply during the forecast period, with any consequent increases in fuel prices impacting on transport activity levels.

Within the aggregate forecast growth in domestic transport emissions over the projection period (at about 1.6 per cent per annum, 2005 to 2020), aviation and commercial road vehicles are projected to have the strongest rates of growth (both averaging about 2.6 per cent per annum). The passenger car fleet will remain the single largest contributor to total sector emissions (48 per cent of domestic output), but is expected to exhibit a slower rate of growth (of around 0.8 per cent per annum between 2005 and 2020). The sum of emissions from all other transport activities (accounting for less than 10 per cent of total transport emissions) is forecast to grow at around 1 per cent per annum (2005–2020).

Table ES.1 and figure ES.1 summarise the BTRE base case projections (where the table focuses on expected emissions growth to 2010 and 2020), along with an indication of the possible sensitivity range in the projections (assuming all the major input assumptions are varied simultaneously to either increase or decease total emission estimates).

TABLE ES.1 EMISSION PROJECTIONS FOR ENERGY END-USE BY AUSTRALIAN DOMESTIC CIVIL TRANSPORT, BTRE 2005 BASE CASE

(Gigagrams of direct CO_2 equivalent)

Year	*Cars*	*Road freight vehicles*	*Air*	*Rail*	*Coastal Shipping*	*Other*	*Total*	*Per cent change from 1990*
1990	34214	17493	2564	1741	1868	1902	59783	..
2004	45556	26006	5581	2016	1545	2136	82841	+38.6%
2010 base case *('with measures')*	49553	31297	7173	2244	1519	2363	94148	+57.5%
2020 *base case ('with measures')*	51510	39298	8716	2523	1531	2672	106251	+77.7%
2020 low case *('optimistic' sensitivity)*	44220	31925	7334	2151	1340	2283	89253	+49%
2020 high case *('pessimistic' sensitivity)*	60106	47036	10136	2920	1730	3077	125005	+109%

Notes: Energy supply emissions are not included (i.e. rail does not include emissions from electricity generation).

CO_2 equivalent emission values include only contribution of direct greenhouse gases (CO_2, CH_4, N_2O).

The base case projections allow for the likely effects of Australian government policy measures (aimed at abating greenhouse emissions from the transport sector) that have already been put in place.

The high projections consist of the highest level of emissions likely without major structural change to the Australian transport sector ('pessimistic' sensitivity scenario).

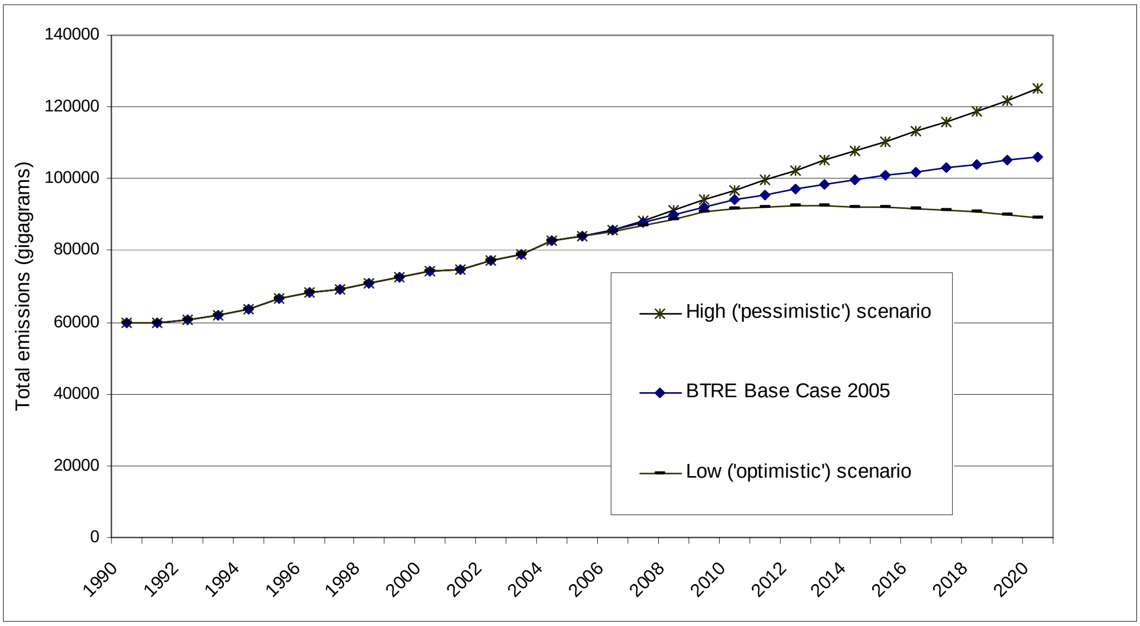
The low projections consist of the lowest level of emissions likely without major structural change to the Australian transport sector ('optimistic' sensitivity scenario).

'*Air*' is total civil domestic aviation (i.e. including general aviation).
'*Coastal Shipping'* includes some emissions due to fuel uplifted outside Australia but consumed by vessels undertaking a domestic shipping task. This component of the coastal estimates makes a contribution of less than 0.5 per cent to total transport emissions.
'*Other*' includes buses, motorcycles, small marine pleasure craft, ferries and unregistered off-road motor vehicles (used for recreational purposes).

All results for all tables and graphs refer to financial year data (i.e. to 'year ending 30 June').

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTCE (1996b, 1995a), Cosgrove (2003).

Figure ES.1 Projections of CO_2 equivalent emissions from Australian civil domestic transport, 1990–2020



Notes: Emissions relate to energy end-use, and include only direct greenhouse gases.

The Base Case projections allow for the likely effects of Australian government policy measures (aimed at abating greenhouse emissions from the transport sector) that have already been put in place.

The High projections consist of the highest level of emissions likely without major structural change to the Australian transport sector ('pessimistic' sensitivity scenario).

The Low projections consist of the lowest level of emissions likely without major structural change to the Australian transport sector ('optimistic' sensitivity scenario).

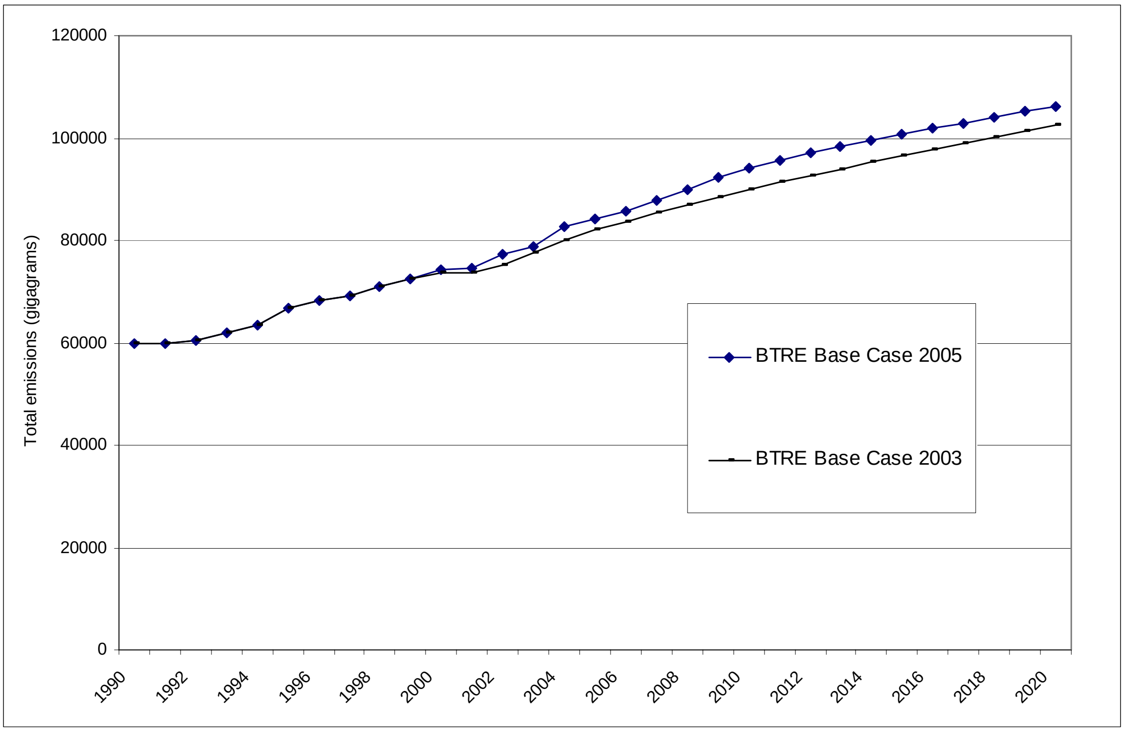
Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTCE (1996b), Cosgrove (2003).

The sensitivity scenarios shown in the above graph are provided at AGO's request – to demonstrate how much the projections are altered if the major input assumptions are varied in combination, to yield the highest and lowest potential estimates (given the current base case model formulation). For example, the *Low* scenario is the result of running the BTRE emission models using the AGO input specifications of low forecast economic growth, low population growth, a higher rate of fuel intensity improvements than the base case, high oil prices and lower future urban traffic congestion than in the base case. The *High* and *Low* trends are therefore supplied more as indicators of the models' dependence on the input assumptions, rather than necessarily as *plausible* scenarios for the future in their own right.

Given the wide range covered by the input variable settings for these two scenarios, it is highly likely that any *realistic* base case scenario to 2020 (run on the current BTRE model framework) would fall between these bounds. In fact, most choices of credible *alternatives* to the current base case settings (i.e.

scenarios where the input parameter trends are varied, but not to the synchronised extent assumed for the compound *High* and *Low* settings), would tend to give results well within about 10 per cent of the provided base case.

Figure ES.2 Comparison of current transport projections (BTRE 2005) with previous aggregate base case (BTRE 2003 projections)



Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), Cosgrove (2003).

CHAPTER 1 AGGREGATE BASE CASE PROJECTIONS

This Bureau of Transport and Regional Economics (BTRE) report presents projections to 2020 of greenhouse gas emissions from Australian domestic (civil) transport. The underlying projections of vehicle fuel consumption are derived from BTRE 'base case' projections of transport demand, and the consequent levels of vehicle activity (allowing for differing vehicle operating conditions for metropolitan and non-metropolitan travel).

This work extends and updates base case projections of transport sector greenhouse gas emissions published in BTRE Report 107 (*Greenhouse Gas Emissions From Transport: Australian Trends To 2020*, BTRE 2002) and subsequent projections provided to the Australian Greenhouse Office (AGO) in July 2003 - *Aggregate Greenhouse Gas Emissions from Australian Transport: Base Case Projections (Bottom-Up Approach) to 2020.*

These 'bottom-up' base case projections have been developed using detailed Bureau modelling of Australian vehicle fleets, estimates of likely trends in new vehicle fuel efficiency, long-term projections of national and state populations by the Australian Bureau of Statistics (ABS) and Treasury projections of long-term economic growth. See the Appendix tables for details of the projection parameters, and the following Bureau studies for descriptions of the various modelling approaches: BTCE (1991) Working Paper 2, BTCE (1995a) Report 88, BTCE (1995b) Working Paper 22, BTCE (1995c) Working Paper 24, BTCE (1996a) Report 92, BTCE (1996b) Report 94, BTCE (1997) Working Paper 35, BTE (1998) Working Paper 38, BTE (2002) Information Sheet 18, BTRE (2002) Report 107, BTRE (2003) Working Paper 51, and two consultancy reports prepared for Environment Australia by D. Cosgrove - BTE (1999) and BTRE (2003a), *Urban Pollutant Emissions From Motor Vehicles: Australian Trends To 2020*.

The specific *base case* scenario used for this study could be more fully described as a '*base case with measures*' - i.e. based on current trends, the scenario adopts what is considered the most likely future movements in travel behaviour, vehicle technology, economic indicators and demography over the next 15 years, and also incorporates the impact of the likely progress, over this period, of meeting the greenhouse gas abatement measures currently proposed (or already committed to) by Australian governments.

This is somewhat different to the base case scenario used for the 2003 BTRE projections – which was a 'business-as-usual' scenario that specifically did not include the effects of abatement measures. The 2005 base case ('with measures') scenario, allows for impacts of the fuel efficiency targets negotiated with motor vehicle manufacturers, as part of the policy measures comprising the Environmental Strategy for the Motor Vehicle Industry (ESMVI). The National Average Fuel Consumption (NAFC) targets are predicted to accelerate trend improvement in the average fuel efficiency of new light vehicle sales.

National vehicle kilometres travelled (VKT), by all Australian vehicles, are projected to increase by around 1.9 per cent per annum between 2000 and 2020 (see Road section of Chapter 2 and the Appendix tables for details of the base case projections of Australian motor vehicle fleet activity).

The revised base case estimates of direct greenhouse gas emissions (CO_2 equivalent) from road transport are given, by vehicle type, in table 1.1. Total road emissions are projected to grow by 42.3 per cent between 2000 and 2020 (around 1.78 per cent per annum). Projections of road emissions are given by gas emitted (i.e. for carbon dioxide, methane and nitrous oxide) and vehicle type in Appendix tables A.7 to A.9.

Total transport emissions to 2020 (direct CO_2 equivalent from energy end-use) are presented by mode in table 1.2, and the trends for the various direct gases are given in tables 1.3 to 1.5.

Relative to the 1990 base year, emissions from the Australian civil domestic transport sector are projected (under the base case assumptions) to increase 57.5 per cent by 2010, reaching 94.1 million tonnes of CO_2 equivalent. By 2020, the BTRE projects base case emissions to be close to 78 per cent above 1990 levels (at 106.3 million tonnes of CO_2 equivalent).

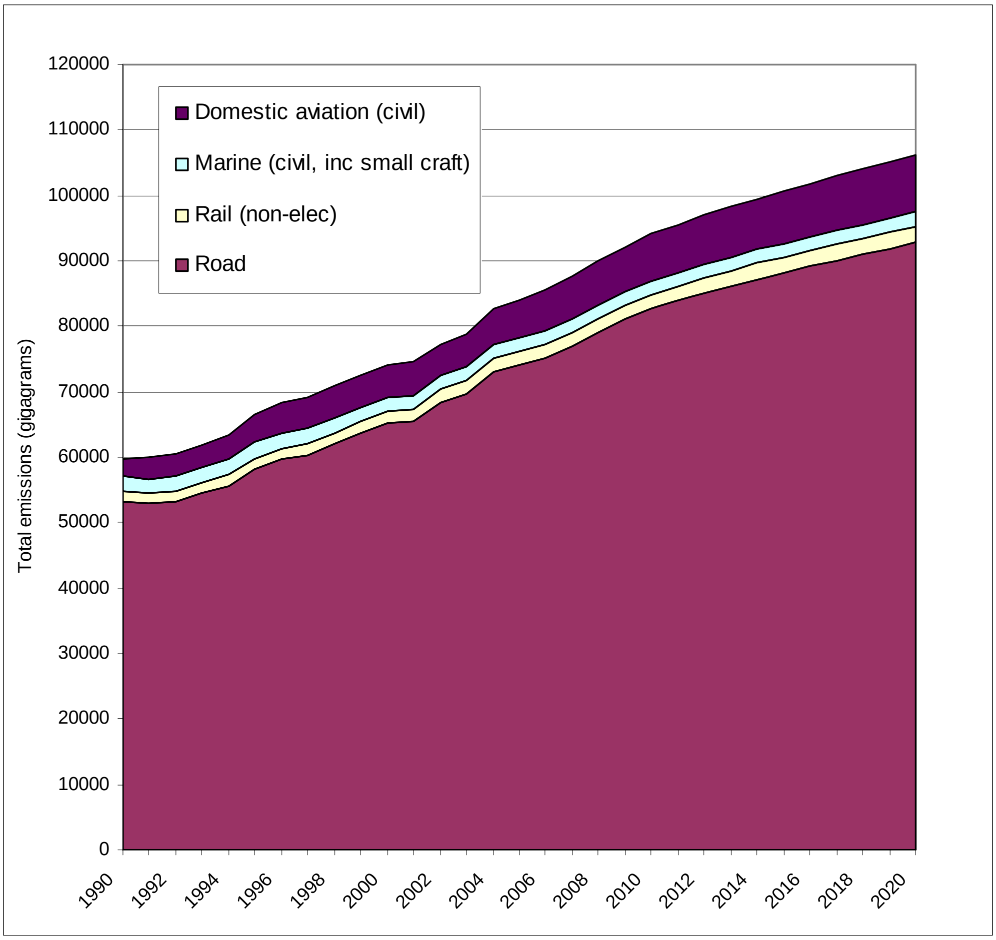
Referring to figure 1.1, major points of note include:

- total transport sector growth in direct CO_2 equivalent emissions (2000-2020) projected to be 43.1 per cent (around 1.81 per cent per annum), similar to the road sector growth in emissions of 1.78 per cent per annum;

- aviation sub-sector growth in emissions (2000-2020) at 74 per cent (around 2.8 per cent per annum); and

- slower emissions growth for the remaining sub-sectors (with direct CO_2 equivalent emissions by non-electric rail transport increasing by around 1.5 per cent per annum over the period, and maritime transport emissions exhibiting little change).

Figure 1.1 Base case projections of direct greenhouse gas (carbon dioxide equivalent) emissions for Australian transport, 1990 - 2020



Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), Cosgrove (2003), BTCE (1996b, 1995a).

TABLE 1.1 BASE CASE PROJECTIONS OF DIRECT GREENHOUSE GAS (CARBON DIOXIDE EQUIVALENT) EMISSIONS FOR AUSTRALIAN ROAD TRANSPORT BY TYPE OF VEHICLE, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Cars*	*Light Commercial Vehicles*	*Articulated trucks*	*Rigid and other trucks*	*Buses*	*Motor cycles*	*Total Road*
1990	34214	7016	5569	4908	1181	239	53128
1991	34399	7076	5493	4541	1120	220	52848
1992	34917	7030	5570	4398	1086	220	53222
1993	35783	7119	5986	4332	1075	225	54520
1994	36476	7202	6165	4479	1111	221	55654
1995	37904	7622	6636	4582	1133	219	58097
1996	38898	7884	6841	4691	1163	206	59683
1997	39089	8001	7082	4793	1193	206	60363
1998	39675	8431	7568	4887	1224	198	61984
1999	40522	8852	7868	5062	1255	190	63749
2000	41238	9196	8062	5265	1271	191	65223
2001	41087	9388	8160	5398	1299	195	65527
2002	42752	9907	8507	5753	1303	198	68420
2003	43285	10277	8677	5905	1326	208	69676
2004	45556	10793	9035	6177	1337	223	73123
2005	45827	10983	9278	6378	1363	239	74069
2006	46023	11370	9547	6586	1384	258	75166
2007	46819	11808	9924	6784	1404	269	77009
2008	47762	12249	10325	6948	1420	281	78985
2009	48872	12633	10690	7081	1445	284	81005
2010	49553	13073	11066	7158	1462	289	82600
2011	49980	13485	11430	7214	1483	294	83886
2012	50327	13882	11843	7253	1504	296	85106
2013	50596	14260	12248	7274	1525	301	86204
2014	50834	14618	12625	7324	1546	304	87251
2015	51053	14963	12997	7369	1561	309	88253
2016	51176	15305	13354	7442	1584	311	89172
2017	51279	15689	13715	7507	1611	313	90114
2018	51350	16063	14077	7565	1628	315	90999
2019	51420	16435	14422	7665	1652	320	91915
2020	51510	16787	14760	7751	1684	323	92816

Note: Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (i.e. do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results for all tables refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), Cosgrove (2003), BTE (1999), BTCE (1996b, 1995a).

TABLE 1.2 BASE CASE PROJECTIONS OF DIRECT GREENHOUSE GAS (CARBON DIOXIDE EQUIVALENT) EMISSIONS FOR AUSTRALIAN CIVIL TRANSPORT BY MODE, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75234	2103	2053	6219	85609
2007	77077	2142	2054	6411	87684
2008	79054	2176	2056	6674	89961
2009	81075	2210	2057	6929	92272
2010	82671	2244	2061	7173	94148
2011	83957	2277	2064	7312	95611
2012	85178	2310	2069	7522	97079
2013	86276	2339	2073	7716	98405
2014	87324	2367	2079	7803	99573
2015	88326	2394	2085	7967	100773
2016	89246	2421	2090	8114	101871
2017	90189	2447	2097	8262	102995
2018	91075	2473	2104	8412	104064
2019	91991	2498	2112	8564	105164
2020	92892	2523	2119	8716	106251

Note: Emission estimates are for direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (i.e. do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

Emission estimates relate to energy end-use (i.e. do not include emissions from fuel supply and processing, or from power generation for electric railways).

'Motor Vehicles' category includes all road vehicles plus off-road recreational vehicles (which account for roughly 70 Gg per annum).
'Aviation' includes emissions from general aviation.
'Maritime' includes emissions from small pleasure craft and ferries. 'Maritime' also includes some emissions due to fuel uplifted outside Australia but consumed by vessels undertaking a domestic shipping task. This component of the coastal shipping estimates makes a contribution of less than 0.5 per cent to current total transport emissions.

Emissions due to military transport are excluded.

All results refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTE (1999), BTCE (1996b, 1995a).

TABLE 1.3 BASE CASE PROJECTIONS OF DIRECT CARBON DIOXIDE EMISSIONS FOR AUSTRALIAN TRANSPORT BY MODE, 1990-2020

(gigagrams emitted)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	51992	1722	2227	2537	58478
1991	51567	1714	2087	3108	58475
1992	51801	1667	2135	3357	58960
1993	52935	1641	2130	3516	60221
1994	53903	1773	2173	3668	61517
1995	56131	1725	2401	4230	64486
1996	57544	1678	2204	4592	66017
1997	58124	1711	2196	4788	66820
1998	59623	1739	2200	4796	68358
1999	61244	1789	2063	4733	69828
2000	62589	1854	2048	4948	71439
2001	62821	1821	1954	5084	71680
2002	65527	1906	2010	4678	74122
2003	66681	1956	1988	4989	75613
2004	69901	1995	1985	5526	79407
2005	70800	2038	1982	5887	80707
2006	71869	2081	1982	6158	82090
2007	73652	2119	1983	6348	84103
2008	75558	2153	1985	6609	86305
2009	77496	2187	1985	6862	88529
2010	79036	2220	1988	7102	90347
2011	80281	2253	1992	7241	91766
2012	81465	2286	1995	7448	93194
2013	82533	2315	2000	7641	94488
2014	83551	2342	2004	7727	95625
2015	84524	2369	2010	7890	96793
2016	85414	2395	2015	8035	97859
2017	86328	2421	2021	8181	98952
2018	87179	2446	2028	8330	99983
2019	88058	2471	2035	8480	101045
2020	88919	2496	2042	8632	102089

Note: Emission estimates for carbon dioxide relate to full fuel combustion of carbon, with typically a 1 per cent allowance for uncombusted material (i.e. includes carbon actually released from the engine as carbon monoxide and volatile organic compounds, which eventually oxidises to CO_2, but excludes 1 per cent of fuel carbon that is assumed to be converted into solid products such as soot).

Emission estimates relate to energy end-use (i.e. do not include emissions from fuel supply and processing, or from power generation for electric railways).

'Motor Vehicles' includes all road vehicles plus off-road recreational vehicles. 'Aviation' includes emissions from general aviation. 'Maritime' includes emissions from small pleasure craft and ferries, and from some fuel uplifted outside Australia but consumed by vessels undertaking a domestic shipping task. Emissions due to military transport are excluded.

All results refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

TABLE 1.4 BASE CASE PROJECTIONS OF DIRECT METHANE EMISSIONS FOR AUSTRALIAN TRANSPORT BY MODE, 1990-2020

(gigagrams emitted)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	22.60	0.15	2.09	0.28	25.13
1991	22.61	0.15	2.11	0.25	25.11
1992	22.90	0.14	2.14	0.24	25.42
1993	23.43	0.14	2.16	0.25	25.98
1994	23.78	0.15	2.18	0.25	26.37
1995	24.67	0.15	2.22	0.26	27.30
1996	25.16	0.14	2.25	0.26	27.82
1997	25.19	0.15	2.27	0.27	27.87
1998	25.41	0.15	2.29	0.27	28.12
1999	25.57	0.15	2.30	0.27	28.30
2000	25.48	0.16	2.33	0.27	28.25
2001	24.94	0.16	2.35	0.27	27.73
2002	25.30	0.16	2.38	0.25	28.10
2003	25.16	0.17	2.41	0.25	27.99
2004	25.86	0.17	2.44	0.26	28.73
2005	25.38	0.18	2.46	0.26	28.28
2006	24.97	0.18	2.49	0.27	27.90
2007	24.74	0.18	2.51	0.28	27.71
2008	24.60	0.19	2.54	0.29	27.61
2009	24.71	0.19	2.56	0.29	27.76
2010	24.55	0.19	2.59	0.30	27.62
2011	24.20	0.19	2.61	0.30	27.31
2012	23.89	0.20	2.63	0.31	27.03
2013	23.58	0.20	2.66	0.31	26.75
2014	23.30	0.20	2.68	0.32	26.50
2015	23.09	0.20	2.70	0.32	26.31
2016	23.08	0.21	2.72	0.32	26.33
2017	22.96	0.21	2.75	0.33	26.25
2018	23.06	0.21	2.77	0.33	26.37
2019	23.20	0.21	2.79	0.34	26.53
2020	23.38	0.21	2.81	0.34	26.74

Note: Emission estimates relate to energy end-use (i.e. do not include emissions from fuel supply and processing, or from power generation for electric railways).

‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries, and from all fuel consumption for the coastal shipping task. Emissions due to military transport are excluded.

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

TABLE 1.5 BASE CASE PROJECTIONS OF DIRECT NITROUS OXIDE EMISSIONS FOR AUSTRALIAN TRANSPORT BY MODE, 1990-2020

(gigagrams emitted)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	2.32	0.05	0.07	0.07	2.51
1991	2.79	0.05	0.07	0.09	2.99
1992	3.22	0.05	0.07	0.10	3.43
1993	3.71	0.05	0.07	0.10	3.93
1994	4.23	0.05	0.07	0.10	4.45
1995	4.86	0.05	0.08	0.12	5.11
1996	5.39	0.05	0.07	0.13	5.64
1997	5.71	0.05	0.07	0.14	5.97
1998	6.09	0.05	0.07	0.14	6.35
1999	6.55	0.05	0.06	0.14	6.80
2000	6.98	0.05	0.06	0.14	7.23
2001	7.24	0.05	0.06	0.15	7.50
2002	7.83	0.05	0.06	0.13	8.08
2003	8.17	0.06	0.06	0.14	8.43
2004	8.86	0.06	0.06	0.16	9.13
2005	9.04	0.06	0.06	0.17	9.33
2006	9.16	0.06	0.06	0.18	9.46
2007	9.37	0.06	0.06	0.18	9.67
2008	9.61	0.06	0.06	0.19	9.92
2009	9.87	0.06	0.06	0.20	10.19
2010	10.06	0.06	0.06	0.21	10.39
2011	10.22	0.06	0.06	0.21	10.55
2012	10.36	0.07	0.06	0.22	10.70
2013	10.48	0.07	0.06	0.22	10.82
2014	10.59	0.07	0.06	0.22	10.94
2015	10.70	0.07	0.06	0.23	11.06
2016	10.80	0.07	0.06	0.23	11.16
2017	10.90	0.07	0.06	0.24	11.26
2018	11.01	0.07	0.06	0.24	11.38
2019	11.11	0.07	0.06	0.25	11.49
2020	11.23	0.07	0.06	0.25	11.61

Note: Emission estimates relate to energy end-use (i.e. do not include emissions from fuel supply and processing, or from power generation for electric railways).

‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries, and from all fuel consumption for the coastal shipping task. Emissions due to military transport are excluded.

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

CHAPTER 2 MODAL PROJECTIONS

Road sector emission projections

Emissions from the Australian road transport sector in 2010 are projected (in the current BTRE *base case*), to be around 55.5 per cent above the level for 1990, reaching 82.6 million tonnes of CO_2 equivalent. By 2020, the projected base case emissions for road transport increase to 74.7 per cent above 1990 levels (at 92.8 million tonnes of CO_2 equivalent).

BTRE *base case* projections for the road sector have vehicle kilometres travelled (VKT) growing steadily over the projection period – with estimated total national VKT of 222 billion kilometres in 2004 projected to increase 30 per cent (close to 1.7 per cent per annum) by 2020, to around 289 billion kilometres. Underlying growth in total vehicle stock should exhibit a similar growth pattern – with the total number of Australian vehicles registered rising from around 13.6 million in 2004, to a projected 17.5 million vehicles in 2020 (see figure 2.1). Metropolitan VKT is projected to grow at a faster rate than non-urban travel (e.g. metropolitan car use is projected to increase by 25.4 per cent between 2004 and 2020, with non-metropolitan car VKT increasing by 19.2 per cent).

This projected increase of 30 per cent in national VKT by all vehicles (between 2004 and 2020) is comprised of an increase of about 23 per cent in travel by passenger cars (including 4-wheel drive passenger vehicles), 62 per cent by light commercial vehicles (LCVs), 19 per cent by rigid trucks, 58 per cent by articulated trucks, 26 per cent by buses and 56 per cent by motorcycles (see figure 2.2).

Projected total VKT growth would have been considerably stronger if all vehicle types had their activity levels as closely tied to economic growth as freight vehicles. Commercial vehicle utilisation is projected to grow at a substantially higher rate than that for private vehicle travel – with the freight task likely to continue exhibiting faster than GDP growth for the foreseeable future.

However, growth in personal vehicle travel (i.e. per capita kilometres travelled in passenger cars) has slowed markedly over time, especially after the early

1990s. It thus appears that Australians are already approaching a level of travel each day that uses up as much of their average daily time budget as they are willing to commit. Any further car travel, beyond such a (saturation) level in per capita kilometres, would not be an attractive option to most people, even if average incomes continued rising.

The BTRE (in the Fuel_Car submodule of the CARMOD fleet model) uses a structural approach whereby passenger vehicle travel per person has been modelled as a saturating curve, relative to real Australian GDP per person. A *logistic* curve (fit to 50 years data) gave the most adequate formulation (see figure 2.3).

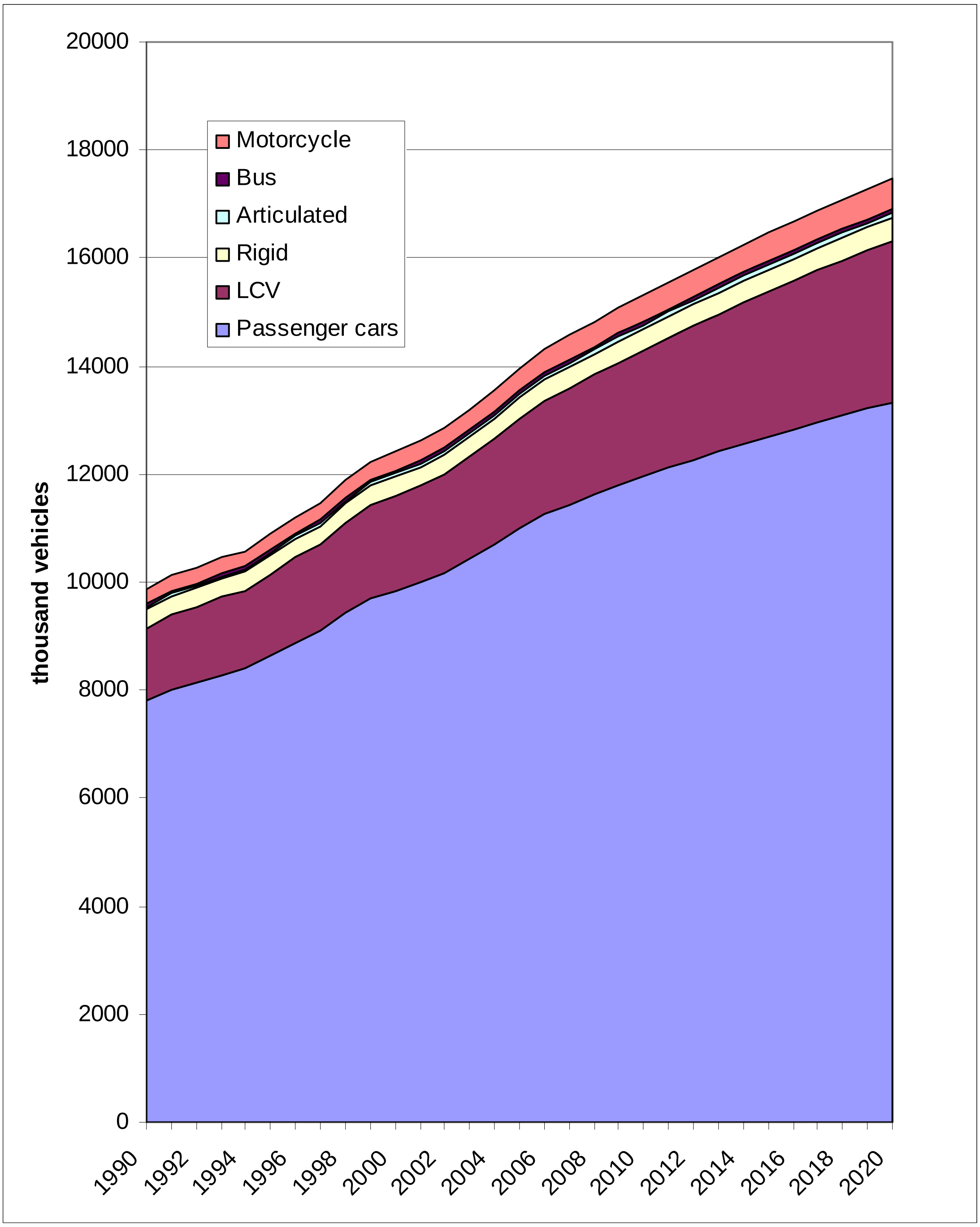
It could be argued that eventually a similar effect should become evident for freight vehicle use – and if the projections were over a longer time period, the models might have had to allow for eventual saturation effects in per capita goods movement as well as in per capita daily car travel. However, this should not be an issue for the current projections to 2020. Since there is not yet any evidence of a growth slowdown in road freight (as is already apparent for car VKT), and there appears to be significant scope for further growth (e.g. USA tonnes of non-urban freight per person are considerably higher than current Australian levels), the BTRE assessment is that growth in freight tonne-kilometres (tkm) should remain coupled to GDP growth over the projection period.

Due to the base case incorporating the effects of:

- future economic growth and increasing national population levels (and a consequent increase in demand for travel),
- an increasing proportion of the Australian population living in urban areas,
- increasing urban traffic congestion levels,
- deterioration in average vehicle performance as the vehicle ages, and
- an increasing proportion of total travel accounted for by the heavier commercial component of the vehicle fleet (since forecast rates of growth are stronger for truck VKT than for car VKT),

total fuel consumption by the road sector is projected to rise substantially over the projection period (at around 1.5 per cent per annum between 2004 and 2020), even despite the saturating trend in per capita car travel and an expected continuation of improvements in the (rated) fuel efficiency of new vehicles (see tables 2.1 and 2.2 for projected light vehicle fuel intensity trends and figure 2.4 for projected fuel consumption by the various vehicle types).

Figure 2.1 Base case projected growth in road vehicle stock for Australia, 1990 - 2020

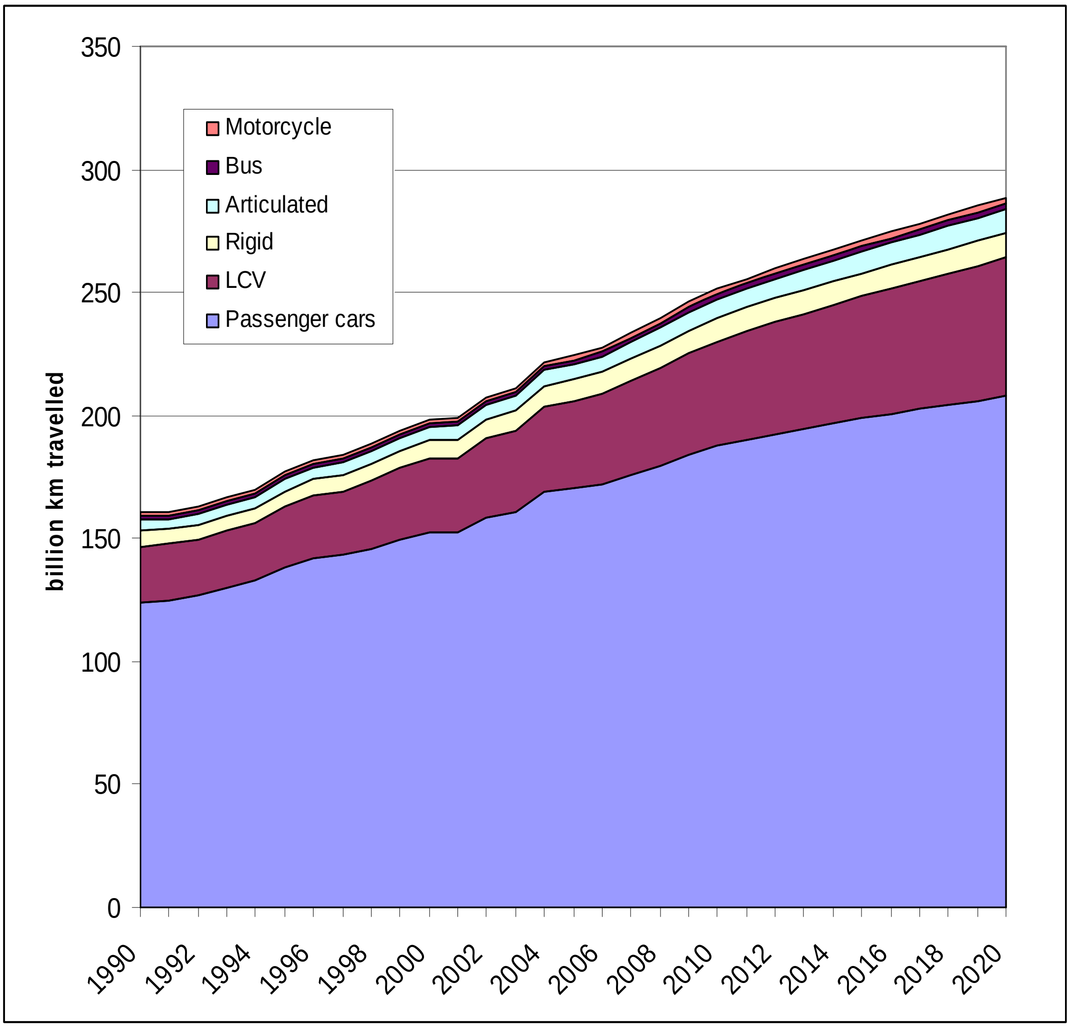


Notes: 'Cars' include 4-wheel drive passenger vehicles ('All Terrain Wagons' – ATWs).
'Bus' includes long-distance coaches. 'Articulated' means all articulated trucks.
'Rigid' includes all heavy vehicles that are not articulated trucks or buses.

LCVs - light commercial vehicles.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), Cosgrove (2003), BTE (1999), ABS (2004 and earlier).

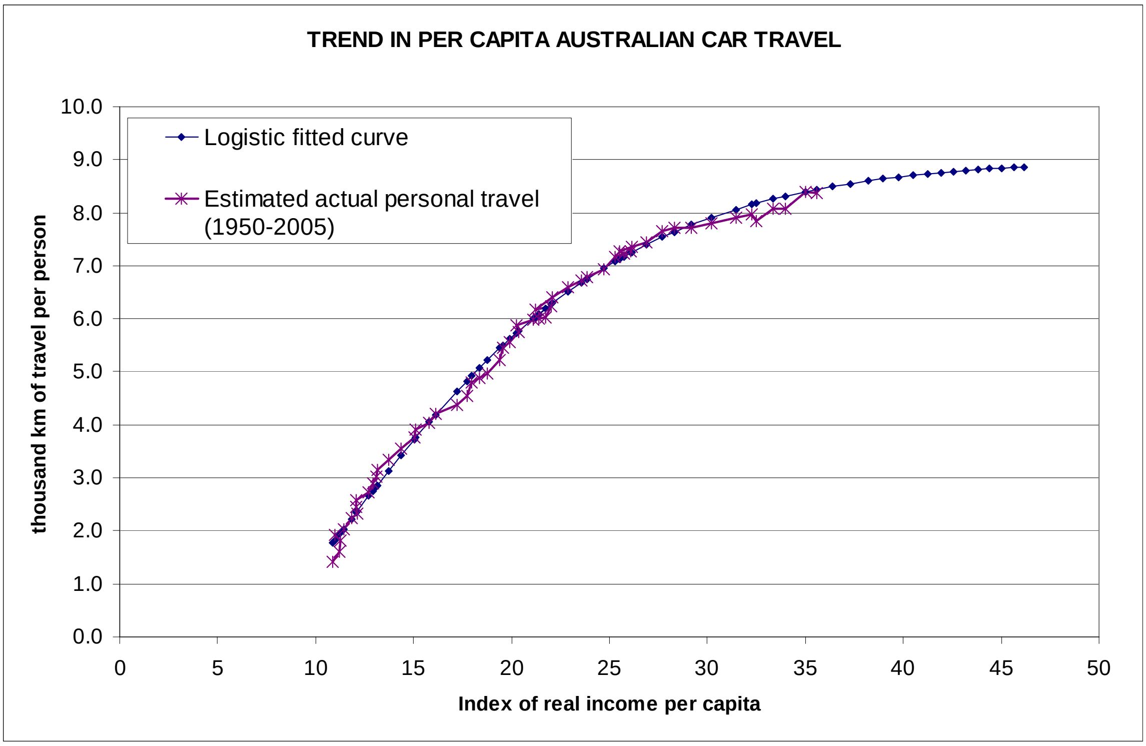
Figure 2.2 Base case projected growth in road vehicle travel for Australia, 1990 - 2020



Notes: 'Cars' include 4-wheel drive passenger vehicles ('All Terrain Wagons' – ATWs).
LCVs - light commercial vehicles. 'Rigid' includes activity by all non-articulated truck types.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), Cosgrove (2003), BTE (1999), ABS (2004 and earlier).

Figure 2.3 Fitted trend in passenger vehicle travel (per capita) relative to real GDP per person, used for BTRE forecasts of car VKT



Sources: BTRE estimates, BTRE (2002), ABS (2004 and earlier).

Tables 2.1 and 2.2 give the forecast values for fuel intensity (rated L/100km) of new light motor vehicles (i.e. all vehicles under 3.5 tonnes Gross Vehicle Mass) – where allowance has been made for the fuel efficiency targets currently agreed to, or proposed, by motor vehicle manufacturers, as part of the Environmental Strategy for the Motor Vehicle Industry (ESMVI).

For the BTRE base case, the National Average Fuel Consumption (NAFC) targets are predicted to *accelerate* trend improvement in the average fuel efficiency of new light vehicle sales, but not quite to the extent that the targets are met by the currently discussed timeframe (i.e. that all light vehicle sales categories show an 18 per cent improvement over 2002 average L/100km by 2010). In the BTRE 2005 base case, new passenger cars are projected to have, on average, a 12 per cent lower rated L/100km in 2010, relative to 2002 (getting to 21 per cent lower by 2020). New LCV sales are projected to have a 6 per cent lower rated L/100km in 2010 (with 13.4 per cent lower by 2020, compared with virtually no change over this period assumed for the BTRE 2003 base case).

TABLE 2.1 BASE CASE PROJECTIONS OF NEW PASSENGER CAR FUEL INTENSITY, 1990-2020

(L/100km gasoline equivalent)

Year	*Rated Fuel Consumption for 'standard' passenger cars (L/100km on NAFC test)*	*Rated Fuel Consumption for 4WD passenger vehicles (ATWs) (L/100km on NAFC test)*	*Percentage of new passenger vehicle sales accounted for by ATWs*	*Percentage of new passenger vehicle sales accounted for by hybrids*	*Weighted average new passenger car fuel intensity (L/100km on NAFC test)*
1990	8.65	12.98	8.1%	0.0%	9.00
1991	8.42	12.82	8.4%	0.0%	8.79
1992	8.41	12.89	8.9%	0.0%	8.81
1993	8.45	12.36	10.0%	0.0%	8.85
1994	8.51	12.12	11.1%	0.0%	8.90
1995	8.44	12.26	8.5%	0.0%	8.77
1996	8.33	12.35	8.5%	0.0%	8.67
1997	8.32	12.25	8.4%	0.0%	8.65
1998	8.14	11.69	13.3%	0.0%	8.61
1999	8.11	11.59	15.1%	0.0%	8.63
2000	8.11	11.24	16.1%	0.0%	8.62
2001	7.99	11.41	16.8%	0.0%	8.57
2002	7.93	11.30	18.0%	0.0%	8.53
2003	7.81	11.11	20.0%	0.1%	8.47
2004	7.70	10.91	21.0%	0.1%	8.37
2005	7.59	10.72	23.0%	0.1%	8.30
2006	7.47	10.53	23.0%	0.2%	8.17
2007	7.36	10.33	23.0%	0.2%	8.04
2008	7.25	10.14	23.5%	0.3%	7.92
2009	7.14	9.95	23.5%	0.5%	7.78
2010	6.98	9.67	24.0%	0.9%	7.60
2011	6.91	9.55	24.1%	1.5%	7.50
2012	6.85	9.42	24.2%	1.9%	7.41
2013	6.78	9.30	24.3%	2.2%	7.33
2014	6.72	9.18	24.4%	2.5%	7.25
2015	6.65	9.05	24.5%	2.7%	7.16
2016	6.59	8.93	24.6%	3.0%	7.08
2017	6.52	8.80	24.7%	3.2%	6.99
2018	6.46	8.68	24.8%	3.4%	6.91
2019	6.39	8.56	24.9%	3.6%	6.83
2020	6.33	8.43	25.0%	3.7%	6.75

Notes: NAFC - 'National Average Fuel Consumption', and refers to dynamometer cycle testing (as opposed to actual on-road fuel intensity).

ATWs – All Terrain Wagons. *Hybrids* refers to hybrid petrol-electric passenger vehicles.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), ABS (2005).

TABLE 2.2 BASE CASE PROJECTIONS OF NEW LIGHT COMMERCIAL VEHICLE (LCV) FUEL INTENSITY, 1990-2020

(L/100km gasoline equivalent)

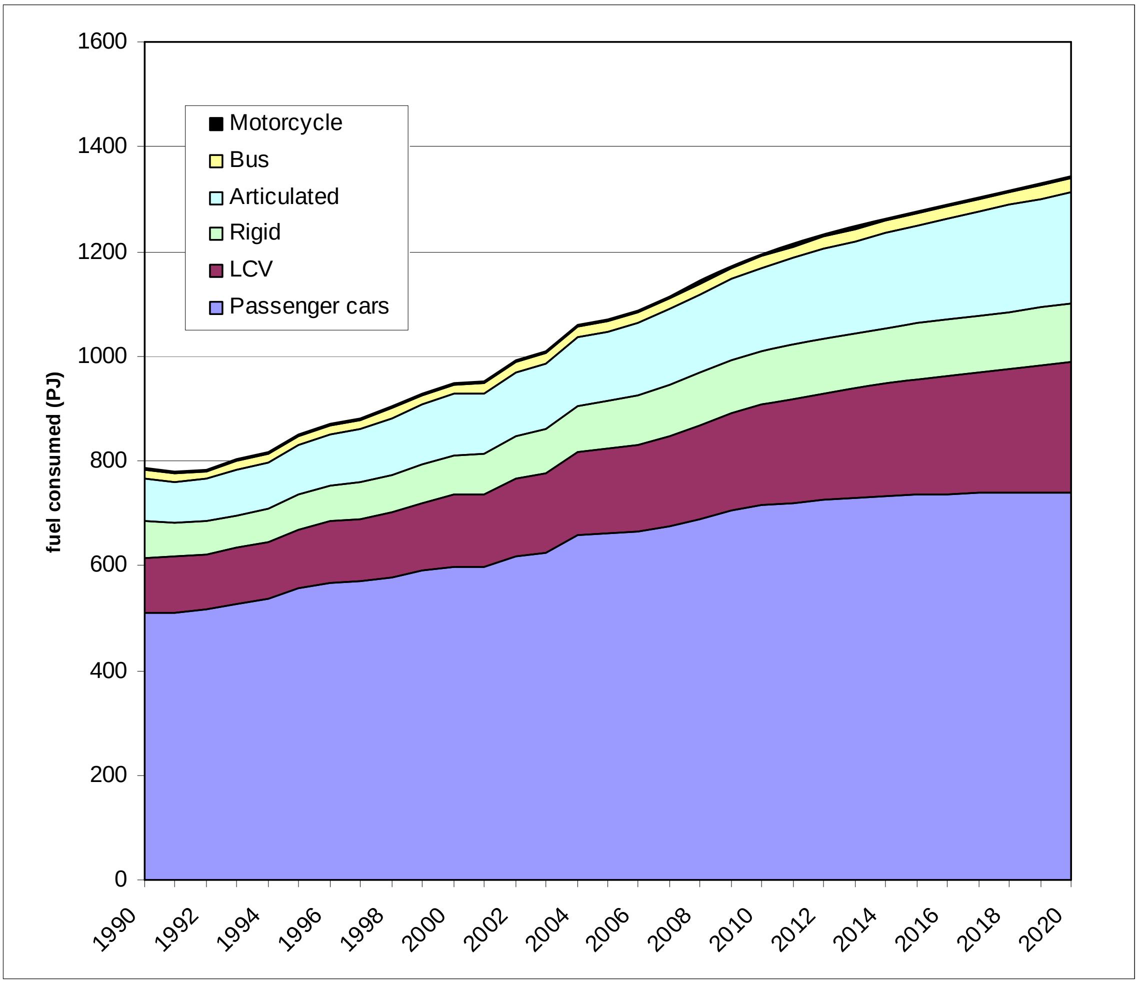
Year	*Rated Fuel Consumption for LCVs (L/100km on NAFC test)*	*Assumed percentage of new LCV sales accounted for by 4WD vehicles*
1990	10.08	27.0%
1991	10.08	27.0%
1992	10.25	31.2%
1993	10.58	39.5%
1994	10.40	35.0%
1995	10.35	33.8%
1996	10.34	33.6%
1997	10.41	35.2%
1998	10.48	37.0%
1999	10.52	38.0%
2000	10.44	36.0%
2001	10.40	35.0%
2002	10.40	37.0%
2003	10.24	35.0%
2004	10.20	36.0%
2005	10.15	37.0%
2006	10.08	37.2%
2007	10.01	37.4%
2008	9.93	37.6%
2009	9.86	37.7%
2010	9.78	37.9%
2011	9.70	38.1%
2012	9.63	38.3%
2013	9.55	38.5%
2014	9.47	38.7%
2015	9.39	38.9%
2016	9.32	39.1%
2017	9.24	39.3%
2018	9.16	39.5%
2019	9.08	39.7%
2020	9.01	39.9%

Notes: NAFC - 'National Average Fuel Consumption', and refers to dynamometer cycle testing (as opposed to actual on-road fuel intensity).
Includes all sales of Pickup and Cab Chassis 4X4s.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), ABS (2005).

Figure 2.4 Base case projected growth in energy consumption by road vehicles for Australia, 1990 – 2020

(petajoules)



Notes: 'Cars' include 4-wheel drive passenger vehicles ('All Terrain Wagons' – ATWs).
LCVs - light commercial vehicles. 'Rigid' includes activity by all non-articulated truck types.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTE (1999), BTRE Transport Statistics (2005), ABS (2004 and earlier).

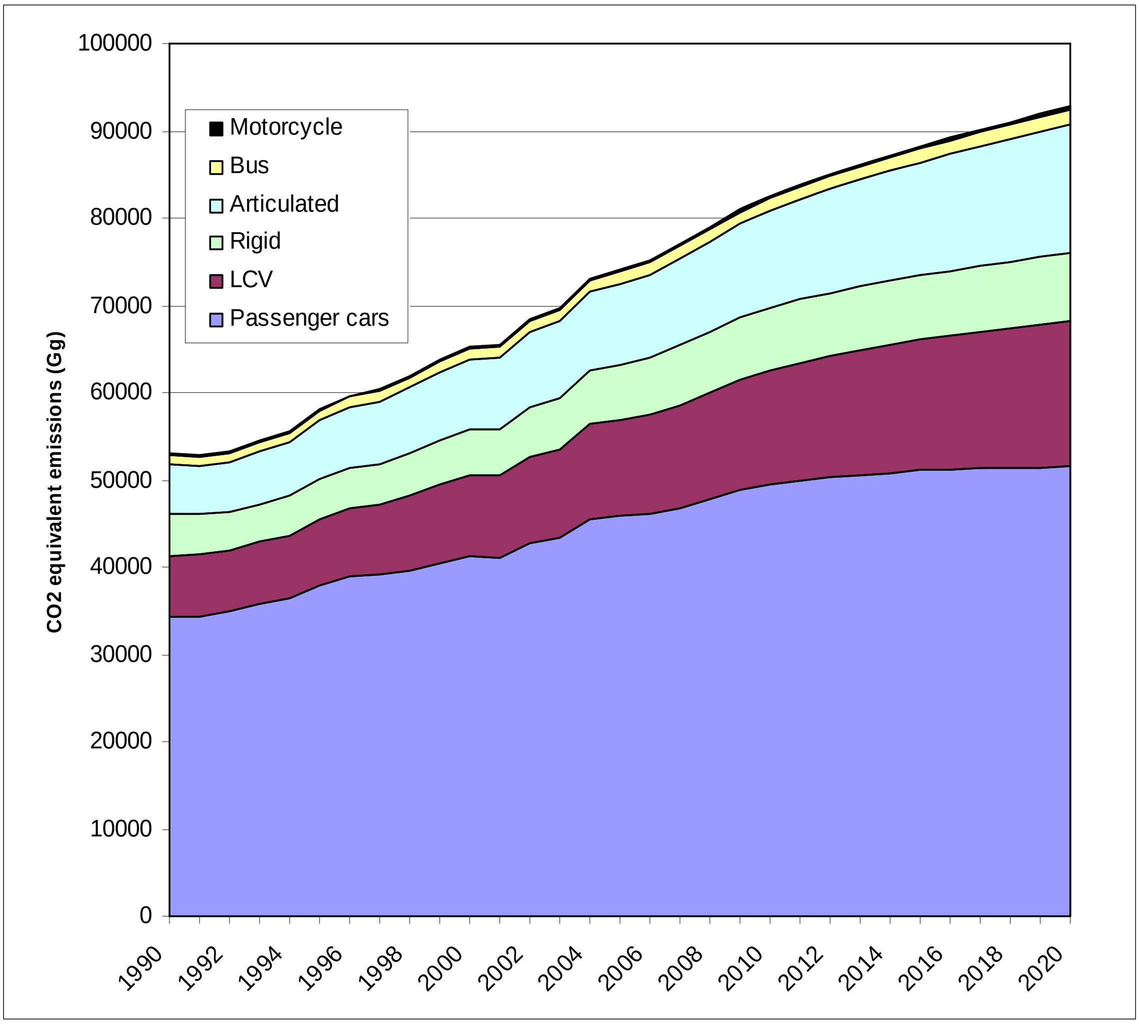
The projection of alternative road transport fuel use (i.e. probable market penetration of LPG, natural gas and biofuels) was based on previous Bureau studies (see BTE 1999, BTRE 2002 and DITR 2004).

The resulting emissions trend for road vehicles is plotted in figure 2.5 (where the year-by-year values have already been given in table 1.1).

Underlying fuel efficiency trends for the various fleets are given in the Appendix (with differences between the new vehicle fuel intensity assumptions in the current base case and the 2003 projections discussed in the next chapter).

Figure 2.5 Base case projected growth in greenhouse gas emissions by road vehicles for Australia, 1990 – 2020

(gigagrams)



Notes: 'Cars' include 4-wheel drive passenger vehicles ('All Terrain Wagons' – ATWs).
LCVs - light commercial vehicles. 'Rigid' includes activity by all non-articulated truck types.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTE (1999), ABS (2004 and earlier).

Rail sector emission projections

End-use emissions (i.e. excluding power generation for electric rail) from the Australian rail transport sector in 2010 are projected (in the current BTRE base case), to be around 29 per cent above the level for 1990, reaching 2.24 million tonnes of CO_2 equivalent. By 2020, the projected base case emissions (end-use) for rail transport increase to about 45 per cent above 1990 levels (at 2.52 million tonnes of CO_2 equivalent).

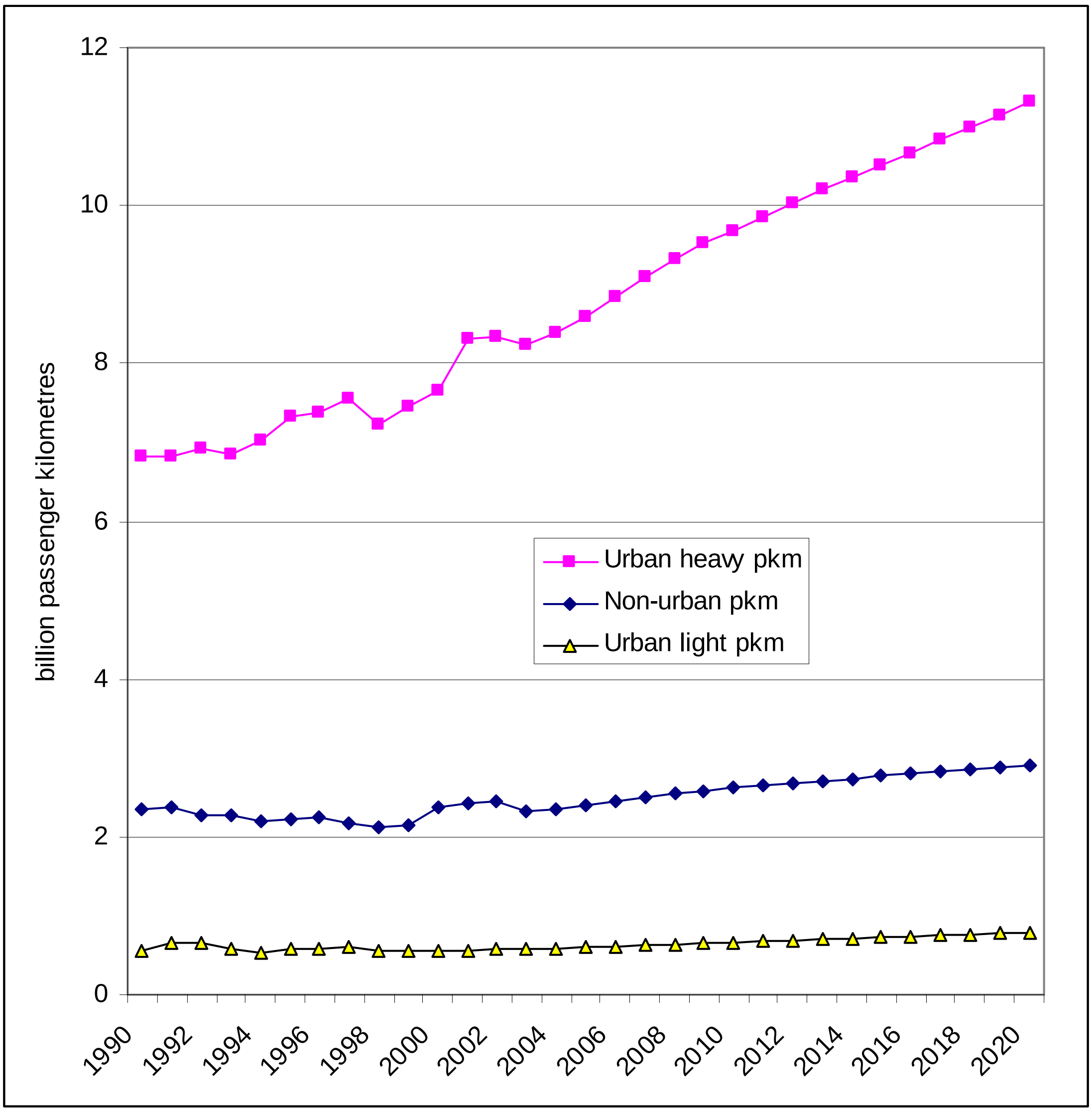
The BTRE methodology uses a combination of mathematical and econometric models to project rail task levels and the resulting energy consumption. Railways use both fossil fuels (primarily diesel) and electricity - so total energy consumption (expressed in petajoules of energy end-use, and modelled as the product of the railway tasks and of respective energy intensity levels) has to be disaggregated carefully when calculating emissions. The BTRE models forecast total rail emissions - both from non-electric rail (direct fuel combustion) and electric rail (emissions due to the required electric power generation). However, since AGO inventory processes only allocate *non-electric* rail emissions to the Transport sector (electricity used by railways being accounted for in the Stationary Energy sector), most tables in this report do not include electric rail emissions (though they are included in this section for the sake of completeness).

The full railway task is comprised of passenger and freight tasks, each of which has three distinct sub-sectors. The passenger task is comprised of 1) urban passengers on light rail, 2) urban passengers on heavy rail and 3) non-urban passengers (heavy rail). The freight task is comprised of 1) bulk freight and 2) non-bulk freight carried by Hire & Reward rail operators; and 3) bulk freight carried by Ancillary freight operators - generally on privately owned rail lines. The major commodity tonnage carried by such private railway systems is iron ore.

Passenger numbers and freight tonnages are modelled and then multiplied by average distances travelled to obtain task levels in passenger–kilometres (pkm) and tonne–kilometres (tkm).

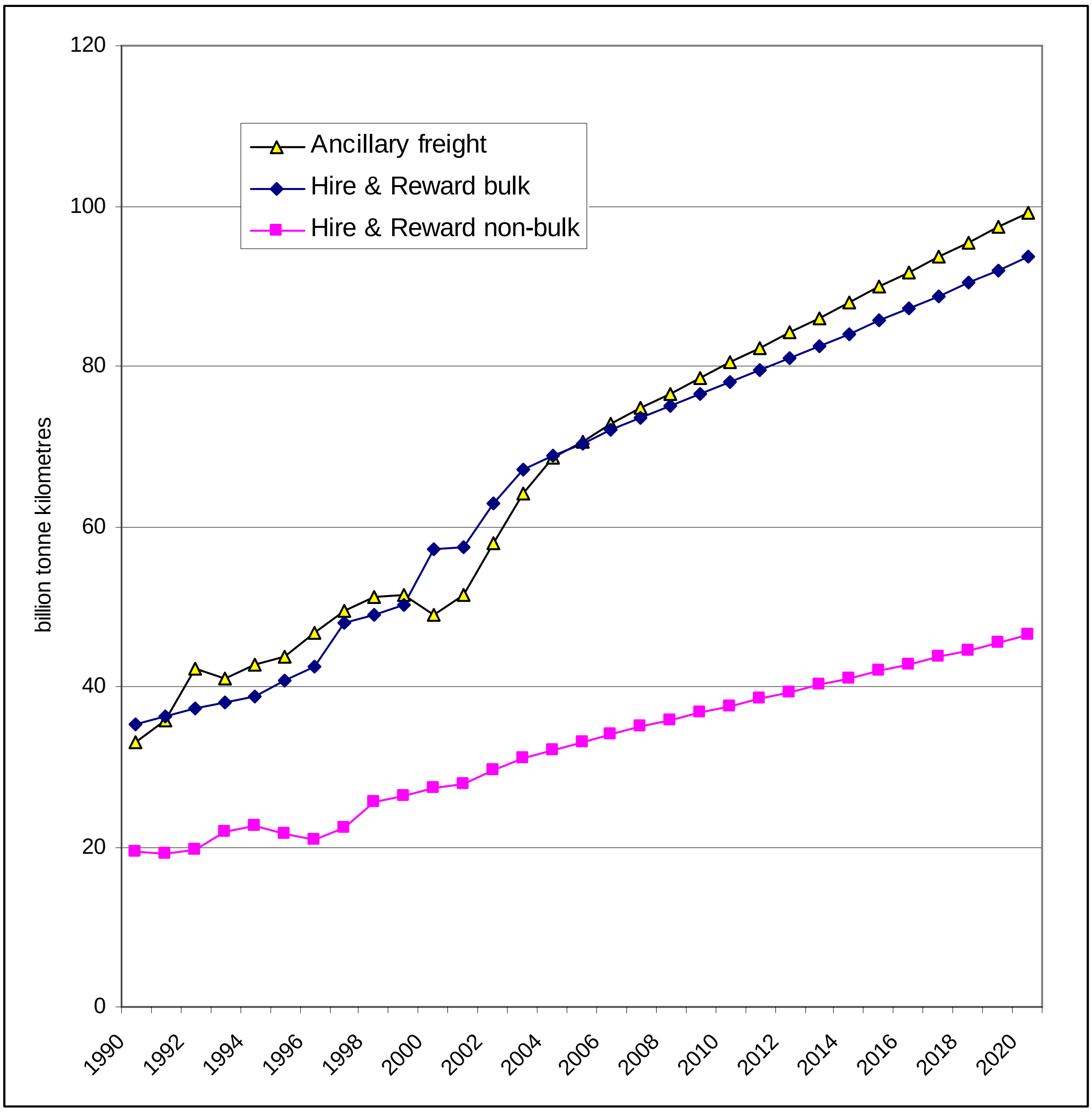
The projections of the rail passenger tasks are shown in figure 2.6, while the freight tasks are shown in figure 2.7 – followed by figure 2.8 showing total rail emission levels (with the split between electric and non-electric rail given in table 2.3). A range of time-series values dealing with these base case projections are provided in the Appendix.

Figure 2.6 Base case projections of rail passenger tasks for Australia, 1990 – 2020



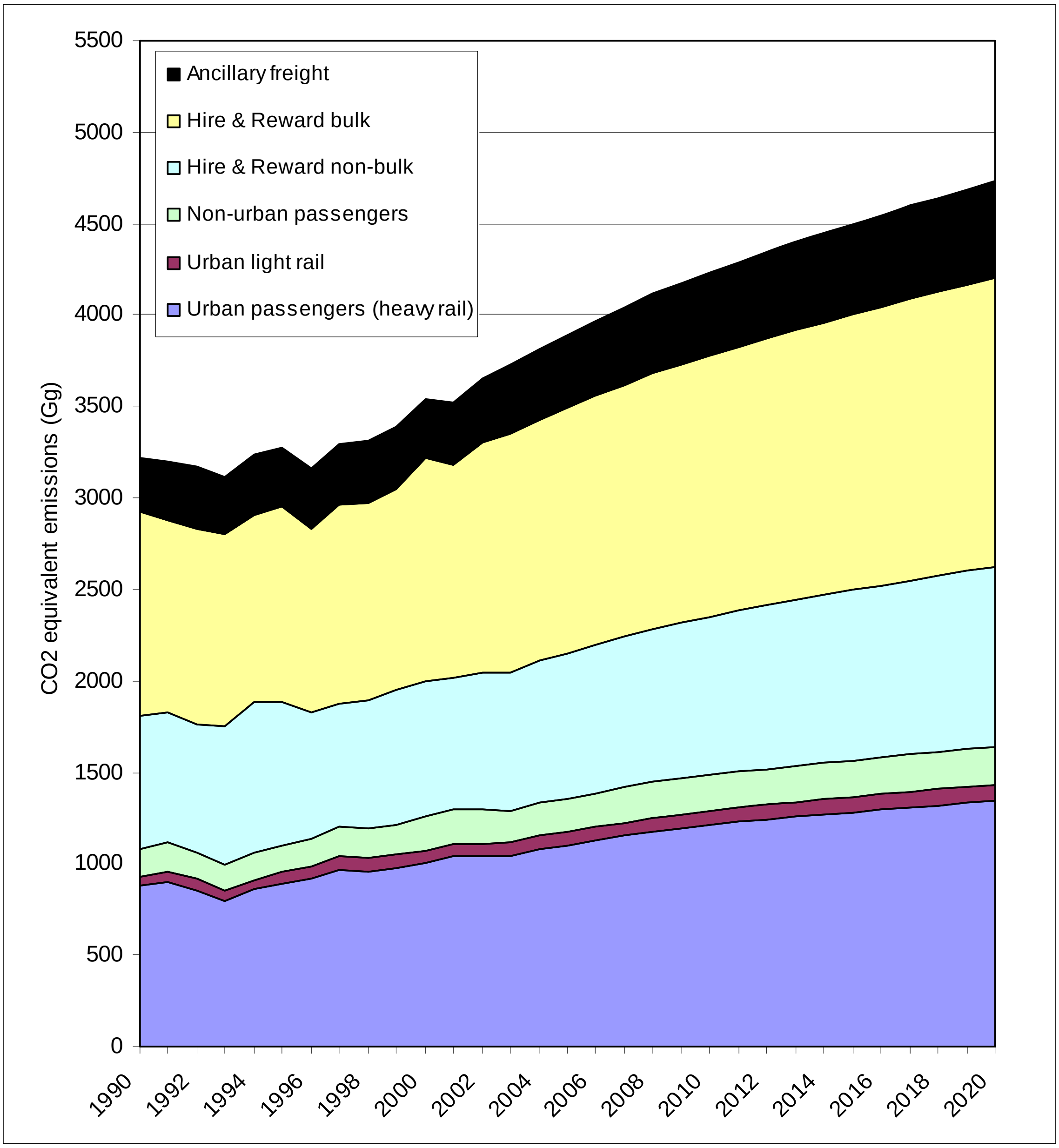
Sources: BTRE estimates, BTRE (2002, 2003b), BTCE (1996b), BTRE Transport Statistics (2005), ACG (2005).

Figure 2.7 Base case projections of rail freight tasks for Australian railways, 1990 – 2020



Sources: BTRE estimates, BTRE (2002, 2003b), BTCE (1996b), BTRE Transport Statistics (2005), ACG (2005).

Figure 2.8 Base case projections of total rail emissions (including both electric and non-electric railways) for Australia, 1990 – 2020



Note: Estimates here include emissions from power generation for electric railways.

Sources: BTRE estimates, BTRE (2002, 2003b), BTCE (1996b), ACG (2005).

TABLE 2.3 BASE CASE PROJECTIONS OF DIRECT GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN RAILWAYS (ELECTRIC AND NON-ELECTRIC), 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Passenger*		*Freight*		*Total*		
	non-elec	*elec*	*non-elec*	*elec*	*non-elec*	*elec*	*all*
1990	187.5	895.3	1553.2	581.7	1740.7	1477.0	3217.7
1991	186.5	930.4	1545.7	533.9	1732.3	1464.3	3196.6
1992	168.6	893.3	1515.9	595.1	1684.5	1488.5	3173.0
1993	159.2	839.2	1498.9	618.3	1658.1	1457.4	3115.5
1994	157.4	900.0	1634.5	541.0	1791.8	1441.0	3232.8
1995	151.0	945.7	1592.3	585.9	1743.2	1531.6	3274.8
1996	160.3	975.6	1535.6	489.8	1695.9	1465.4	3161.4
1997	163.7	1034.5	1565.5	534.5	1729.2	1569.1	3298.3
1998	167.7	1024.5	1589.6	528.2	1757.3	1552.8	3310.1
1999	170.5	1043.2	1637.3	540.6	1807.9	1583.9	3391.8
2000	186.3	1068.5	1687.8	598.6	1874.1	1667.1	3541.2
2001	188.3	1109.1	1652.0	572.2	1840.3	1681.3	3521.6
2002	188.6	1110.1	1737.9	614.6	1926.5	1724.8	3651.2
2003	177.6	1113.3	1798.9	637.1	1976.5	1750.4	3726.9
2004	178.2	1154.1	1837.8	646.5	2016.0	1800.5	3816.5
2005	181.9	1175.4	1877.7	656.0	2059.6	1831.3	3890.9
2006	184.3	1200.9	1918.5	665.7	2102.8	1866.6	3969.4
2007	186.9	1229.3	1954.6	674.4	2141.6	1903.7	4045.2
2008	189.3	1255.9	1987.0	682.2	2176.3	1938.1	4114.4
2009	190.8	1275.1	2019.6	690.1	2210.3	1965.2	4175.6
2010	192.0	1292.2	2052.0	698.0	2244.0	1990.2	4234.2
2011	193.1	1308.8	2084.3	705.9	2277.4	2014.7	4292.1
2012	194.2	1325.2	2116.0	713.6	2310.1	2038.7	4348.9
2013	195.2	1341.0	2144.2	721.3	2339.4	2062.2	4401.6
2014	196.2	1356.1	2170.9	728.8	2367.2	2085.0	4452.2
2015	197.0	1369.4	2197.3	736.4	2394.3	2105.8	4500.1
2016	197.9	1383.3	2223.0	743.8	2420.9	2127.1	4548.0
2017	198.8	1397.8	2248.2	751.2	2447.0	2149.0	4596.0
2018	199.6	1411.2	2272.9	758.5	2472.5	2169.8	4642.3
2019	200.5	1425.2	2297.3	765.8	2497.8	2191.0	4688.9
2020	201.4	1439.5	2321.7	773.2	2523.1	2212.6	4735.7

Note: Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (i.e. do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

Estimates here ('elec') include emissions from power generation for electric railways.

All results refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2003b, 2002), BTCE (1996b, 1995a), ACG (2005).

Marine sector emission projections

Emissions from the Australian maritime transport sector in 2010 are projected (in the current BTRE base case), to be around 10 per cent below the level for 1990, at 2.06 million tonnes of CO_2 equivalent. By 2020, the projected marine sector emissions increase slightly from the 2010 level, to be about 7.6 per cent below 1990 levels (at 2.12 million tonnes of CO_2 equivalent).

The dominant activity for shipping is the long-distance carriage of bulk goods – and estimating emissions for the marine sector essentially relies on projecting bulk commodity movements. The BTRE projections of shipping freight tasks are plotted in figure 2.9 for coastal shipping and figure 2.10 for international shipping (servicing Australian trade).

Since fuel is generally more expensive in Australia than in some other countries, only a small proportion of the fuel required for the international shipping task (to and from Australia) is uplifted in Australia (about 6 to 8 per cent). The approach adopted by the BTRE in modelling the uplift of bunker fuel in Australia for international shipping involves two parts. Firstly, a model of the *total* international shipping task servicing Australian trade (and consequent *total* fuel use) comprises the basic model. Secondly, once total fuel use has been modelled, the fraction of this total that is uplifted in Australia is estimated.

Table 2.4 gives the estimated fuel consumptions for the international shipping fleet – along with fuel use by the domestic (civil) sector. Australian maritime emissions (CO_2 equivalent) are given in table 2.5, where international shipping figures are on a *jurisdictional* basis (i.e. relate to the amount of fuel uplifted in Australia).

The calculation of maritime emissions is complicated by the wide variety of activities within the sector, and their varied sources of fuel use. For example, a mix of automotive distillate, industrial diesel fuel, heavy fuel oil, coal, natural gas and automotive gasoline is consumed within the sector – and used by domestic shipping, international shipping, coastal ferries, inland ferries, pleasure craft, cruise ships, fishing boats and military craft. The fuel is bought both locally (primarily from marine bunkers, but also from standard automotive sources for smaller craft) and overseas (especially, as noted above, for international shipping).

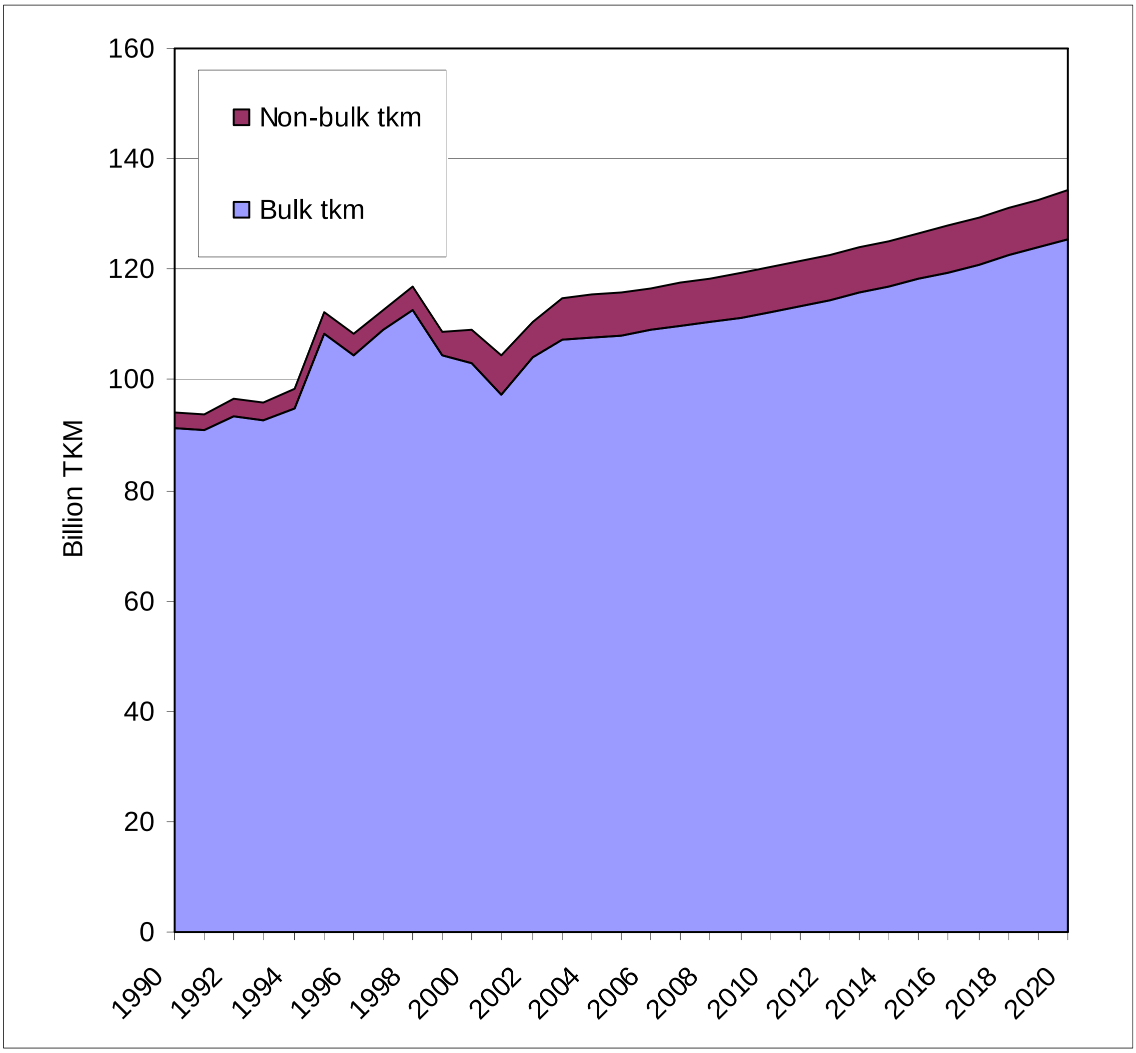
The BTRE emission estimates follow the NGGI guidelines and exclude fuel used by military vessels. However, due to fuel accounting problems brought on by the above-mentioned diverse operations within the sector, the current NGGI derives quite different estimates for domestic civil maritime emissions to ours. The BTRE estimates are properly based on the total fuel consumed in conducting Australia’s coastal shipping task. This task was once accomplished fully through the use of local bunker fuel – but in recent years a substantial component of the domestic task has been undertaken by internationally registered ships, using a mix of locally bought bunker fuel and overseas bought fuel. The current NGGI method is not capturing all of this fuel use and will tend to underestimate coastal shipping emissions.

It is not possible to give an exact quantification of how the BTRE projections would change if this overseas bought fuel was excluded from our calculations – since to do so would require the impractical task of forecasting the fuel purchasing decisions of the future coastal fleet. However, as an order of magnitude example (based on ACG 2005 data), if the 2003 BTRE estimates had excluded foreign-bought bunker fuel (used in the commission of Australian coastal shipping), then the figure for domestic civil maritime emissions would have been approximately 20 per cent lower.

Though this issue has a substantial effect of the maritime sector estimates – the small overall contribution of shipping to total Australian transport emissions means that aggregate emission values would only be altered by 0.5 per cent (or less) depending on whether this overseas fuel was excluded or included. (For some rough NGGI concordance estimates – based on this percentage difference – see the end of chapter 3.)

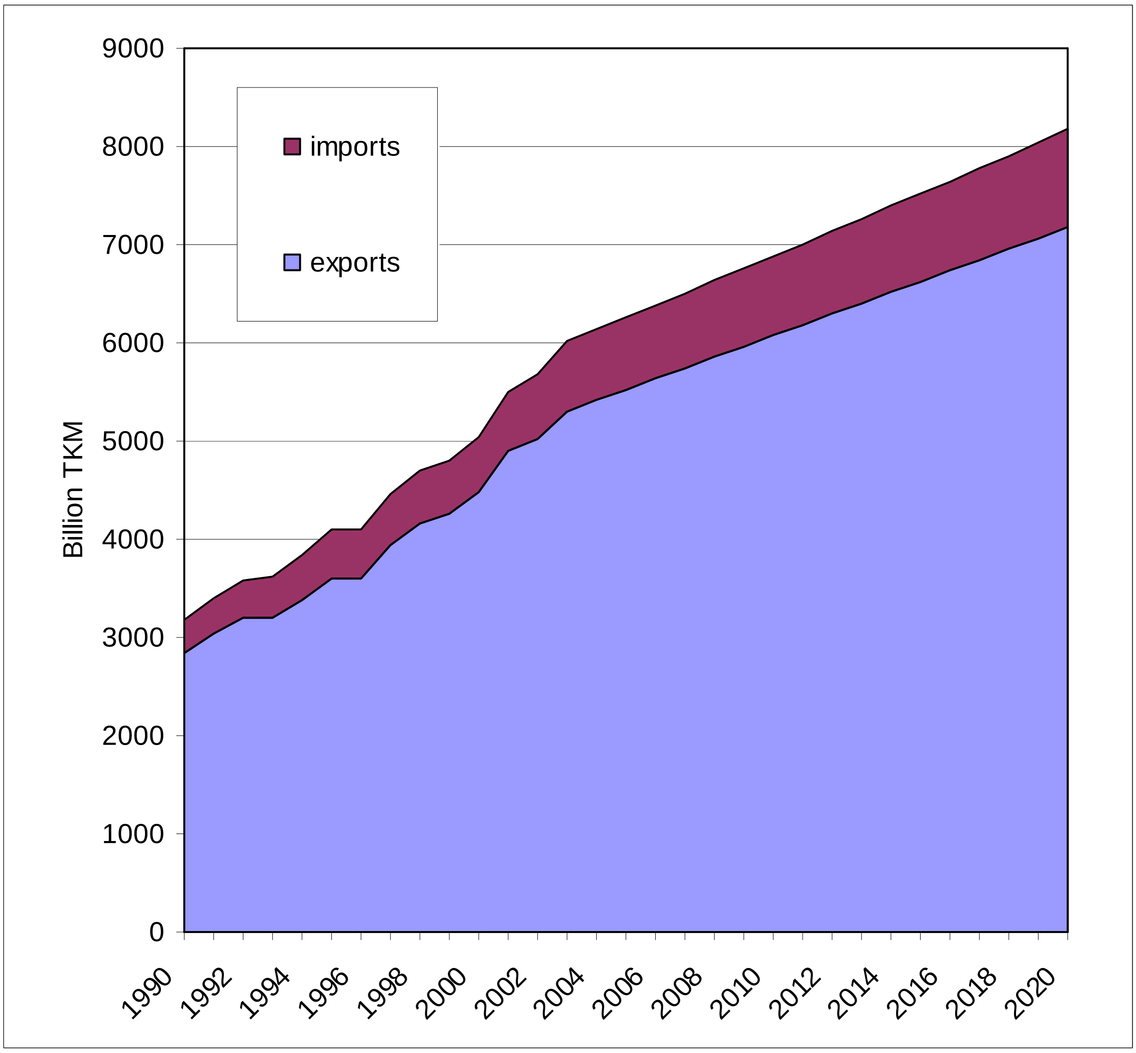
A range of time-series values (dealing with the base case projections) are provided in the Appendix.

Figure 2.9 Base case projections of freight tasks performed by Australian coastal shipping, 1990 – 2020



Sources: BTRE estimates, BTRE (2002, 2003b), BTRE Transport Statistics (2005), BTCE (1995a), ACG (2005).

Figure 2.10 Base case projections of freight tasks performed by international shipping into and out of Australia, 1990 – 2020



Sources: BTRE estimates, BTRE (2002), BTCE (1996b, 1995a), BTRE Transport Statistics (2005), ACG (2005).

TABLE 2.4 BASE CASE PROJECTIONS OF FUEL CONSUMPTION BY AUSTRALIAN CIVIL MARINE SECTOR, 1990-2020

(PJ energy end-use)

Fin. Year	*Domestic*			*International*	
	Coastal shipping	*Other marine*	*Total*	*Total for all shipping servicing Australian trade*	*Bunker fuel uplifted in Australia*
1990	24.49	5.74	30.23	331.3	24.5
1991	22.51	5.84	28.36	356.6	25.7
1992	23.14	5.93	29.06	375.3	27.8
1993	23.04	6.01	29.05	372.2	27.5
1994	23.59	6.08	29.67	385.6	29.7
1995	26.54	6.17	32.71	459.1	36.7
1996	23.80	6.30	30.10	451.5	33.9
1997	23.65	6.36	30.01	482.9	36.2
1998	23.61	6.41	30.02	414.9	31.1
1999	21.59	6.47	28.06	416.1	29.1
2000	21.23	6.54	27.77	428.9	30.0
2001	19.86	6.62	26.47	459.9	29.9
2002	20.42	6.70	27.12	466.2	31.7
2003	20.09	6.79	26.88	485.4	29.1
2004	19.93	6.87	26.80	486.6	31.6
2005	19.79	6.95	26.74	487.7	31.7
2006	19.73	7.02	26.75	488.6	31.8
2007	19.68	7.09	26.78	489.4	31.8
2008	19.64	7.17	26.80	490.1	31.9
2009	19.57	7.24	26.81	490.6	31.9
2010	19.55	7.31	26.86	491.1	31.9
2011	19.53	7.38	26.91	491.4	31.9
2012	19.53	7.45	26.97	491.6	32.0
2013	19.52	7.51	27.03	491.7	32.0
2014	19.53	7.57	27.10	491.7	32.0
2015	19.55	7.64	27.19	491.7	32.0
2016	19.57	7.70	27.27	491.5	31.9
2017	19.60	7.76	27.36	491.3	31.9
2018	19.63	7.82	27.45	490.9	31.9
2019	19.68	7.88	27.55	490.6	31.9
2020	19.72	7.94	27.66	490.1	31.9

Notes: *'Other marine'* is comprised of ferries and pleasure craft.

'*Coastal Shipping'* includes some fuel uplifted outside Australia but consumed by vessels undertaking a domestic shipping task.

Sources: BTRE estimates, BTRE (2003b, 2002), BTCE (1996b, 1995a), ACG (2005).

TABLE 2.5 BASE CASE PROJECTIONS OF DIRECT GREENHOUSE GAS EMISSIONS BY AUSTRALIAN CIVIL MARINE SECTOR, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Domestic*			*International*
	Coastal shipping	*Other marine*	*Total*	*For fuel uplifted in Australia*
1990	1868	426	2294	1797
1991	1719	433	2152	1882
1992	1762	439	2201	2036
1993	1751	445	2196	2019
1994	1789	451	2240	2177
1995	2014	457	2471	2693
1996	1806	467	2273	2483
1997	1794	471	2265	2655
1998	1794	475	2269	2281
1999	1651	479	2131	2136
2000	1631	485	2116	2201
2001	1531	490	2021	2191
2002	1583	496	2079	2324
2003	1553	503	2056	2135
2004	1545	509	2054	2319
2005	1536	515	2051	2324
2006	1532	520	2053	2328
2007	1529	525	2054	2332
2008	1525	531	2056	2335
2009	1521	536	2057	2338
2010	1519	542	2061	2340
2011	1518	547	2064	2342
2012	1517	552	2069	2343
2013	1517	556	2073	2343
2014	1517	561	2079	2343
2015	1519	566	2085	2343
2016	1520	570	2090	2342
2017	1522	575	2097	2341
2018	1525	579	2104	2340
2019	1528	584	2112	2338
2020	1531	588	2119	2336

Notes: '*Other marine*' is comprised of ferries and pleasure craft.

'*Coastal Shipping'* includes some emissions due to fuel uplifted outside Australia but consumed by vessels undertaking a domestic shipping task. This component of the coastal estimates makes a contribution of less than 0.5 per cent to total transport emissions.

Sources: BTRE estimates, BTRE (2003b, 2002), BTCE (1996b, 1995a), ACG (2005).

Aviation sector emission projections

Emissions from the Australian aviation sector in 2010 are projected (in the BTRE base case), to be around 180 per cent above the level for 1990, reaching about 7.2 million tonnes of CO_2 equivalent. By 2020, the projected base case emissions for air transport increase to 240 per cent above 1990 levels (at 8.7 million tonnes of CO_2 equivalent).

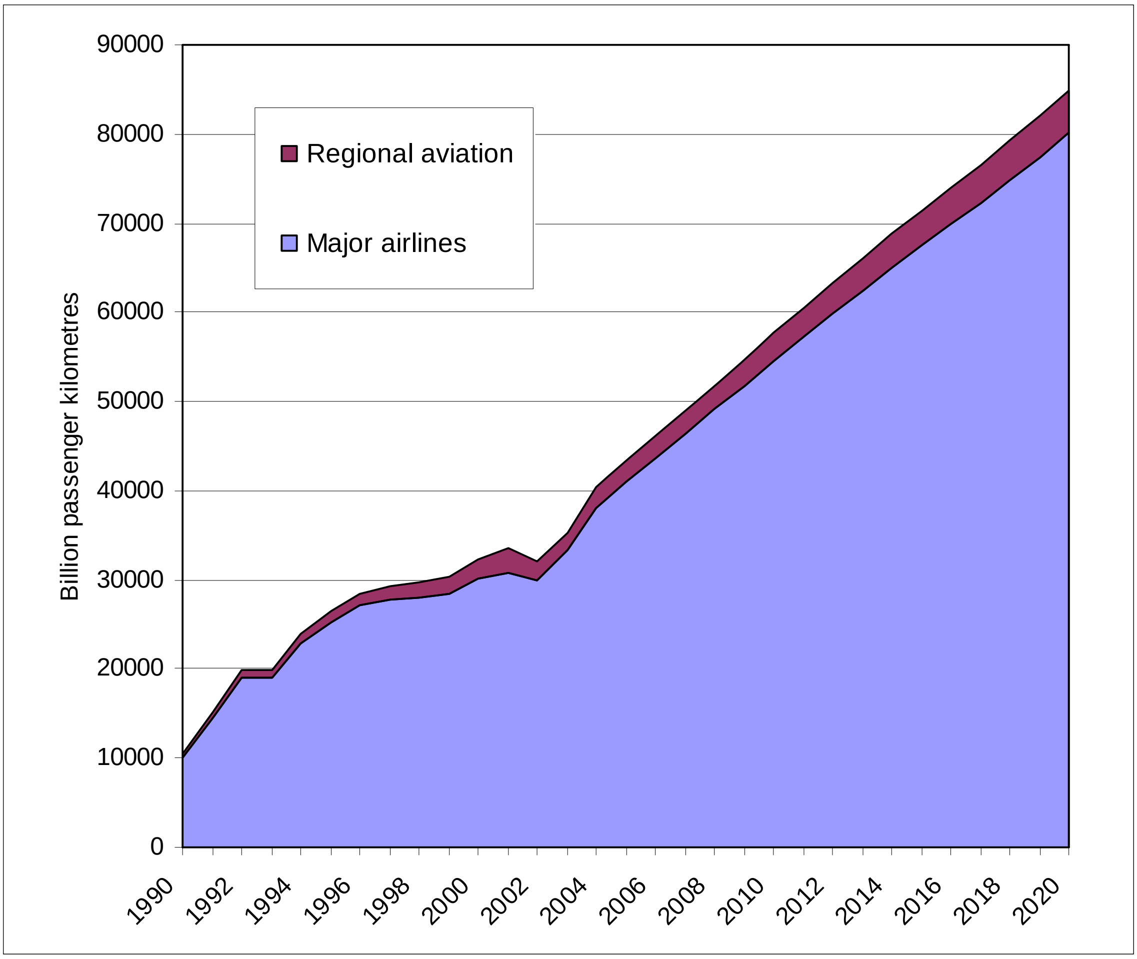
The BTRE has separate models for the various domestic and international air travel tasks. The domestic aviation industry is essentially split into two groups, depending on the type of fuel used. Aviation gasoline (avgas) is used primarily by the general aviation market and aviation turbine fuel (avtur) is used primarily by scheduled airline services. The general aviation market (including charter services, private and training flights, and aerial agricultural work) is relatively small compared to the domestic airline market, accounting for less than 5 per cent of domestic aviation fuel use. Also, avgas consumption has typically changed little over the past 25 years. International aviation uses only avtur. Approximately 40 per cent of total aviation turbine fuel consumed by international air travel to and from Australia is uplifted in Australia.

For domestic aviation, the BTRE modelling process projects total greenhouse gas emission levels from domestic civil aviation fuel consumption. This includes fuel used on trunk and regional routes. Military fuel use is not included (the BTRE estimates that approximately 10-20 per cent of domestic avtur sales are to the military). To estimate fuel consumption, models for the passenger task deal with two major segments separately: Australian resident passengers flying on the domestic network and foreign passengers flying on the domestic network (since variables affecting the number of Australian travellers will tend to differ from the those affecting numbers of foreign visitors).

The BTRE projections of the total domestic airline passenger task are plotted in figure 2.11 – showing the components due to major airline operations and to regional aviation – and given in table 2.6, divided here into the foreign visitor and Australian resident components. The international task indicators are also given in table 2.6.

Aviation fuel consumption projections are given in table 2.7, with aviation emissions (CO_2 equivalent) being given in table 2.8, where international figures are on a *jurisdictional* basis (i.e. relate to the amount of fuel uplifted in Australia).

Figure 2.11 Base case projections of passenger tasks performed by Australian domestic aviation, 1990 – 2020



Sources: BTRE estimates, BTRE (2002, 2003b), BTCE (1996b, 1995a), ACG (2005), BTRE Transport Statistics (2005, AVSTATS).

TABLE 2.6 BASE CASE PROJECTIONS OF AUSTRALIAN CIVIL AVIATION TASKS, AIRLINES, 1990-2020

Fin. Year	*Domestic Airlines (million pkm)*			*International Aviation (thousand passengers)*	
	Passenger task for foreign visitors on domestic network	*Australian passenger km on domestic network*	*Total domestic passenger km*	*Foreign visitor arrivals*	*Australian resident departures*
1990	1549	8976	10524	2149	2089
1991	1653	13507	15160	2240	2107
1992	1941	17887	19829	2508	2177
1993	2144	17704	19848	2796	2290
1994	2526	21336	23862	3159	2296
1995	2879	23552	26431	3554	2418
1996	3266	25148	28414	3961	2601
1997	3614	25730	29344	4257	2826
1998	3626	26094	29720	4240	3039
1999	3707	26684	30391	4300	3202
2000	4028	28186	32214	4627	3338
2001	4420	29105	33525	5002	3600
2002	4222	27797	32019	4745	3450
2003	4159	31073	35231	4641	3350
2004	4564	35849	40413	5042	3900
2005	5070	38236	43306	5547	4173
2006	5396	40695	46091	5845	4333
2007	5792	43151	48943	6211	4495
2008	6237	45593	51831	6623	4681
2009	6738	48010	54748	7084	4892
2010	7268	50386	57654	7565	5108
2011	7825	52710	60535	8064	5328
2012	8371	54967	63337	8541	5523
2013	8939	57142	66082	9031	5720
2014	9577	59222	68799	9579	5946
2015	10243	61190	71433	10144	6173
2016	10936	63032	73969	10724	6403
2017	11657	64929	76586	11317	6633
2018	12405	66884	79288	11924	6864
2019	13177	68895	82073	12541	7095
2020	13975	70966	84940	13168	7326

Sources: BTRE estimates, BTRE (2003b, 2002), BTRE Transport Statistics (2005, AVSTATS), ACG (2005).

TABLE 2.7 BASE CASE PROJECTIONS OF FUEL CONSUMPTION BY AUSTRALIAN CIVIL AVIATION, 1990-2020

(PJ energy end-use)

Fin. Year	*Domestic aviation*			*International*	
	Avtur	*Avgas*	*Total*	*Total for all flights into and out of Australia*	*Avtur uplifted in Australia*
1990	33.1	4.3	37.4	150	63.0
1991	42.3	3.5	45.8	156	65.5
1992	46.2	3.3	49.5	166	69.5
1993	48.3	3.5	51.8	179	75.1
1994	50.7	3.4	54.1	184	77.3
1995	58.9	3.5	62.4	202	84.7
1996	64.4	3.4	67.7	217	91.2
1997	67.2	3.4	70.6	224	94.2
1998	67.3	3.4	70.7	249	104.5
1999	66.3	3.5	69.8	237	99.6
2000	69.5	3.5	73.0	221	93.0
2001	71.6	3.4	75.0	249	104.5
2002	65.8	3.2	69.0	227	95.2
2003	70.5	3.1	73.6	230	94.3
2004	78.5	3.0	81.5	252	98.2
2005	83.8	3.0	86.8	266	103.7
2006	87.8	3.1	90.8	275	110.0
2007	90.5	3.1	93.6	286	117.1
2008	94.3	3.2	97.5	298	125.1
2009	98.0	3.2	101.2	311	130.7
2010	101.5	3.3	104.7	325	136.4
2011	103.5	3.3	106.8	338	142.2
2012	106.5	3.3	109.8	351	147.2
2013	109.3	3.4	112.7	363	152.3
2014	110.6	3.4	114.0	376	158.1
2015	112.9	3.4	116.4	390	163.8
2016	115.0	3.5	118.5	404	169.6
2017	117.2	3.5	120.7	417	175.3
2018	119.3	3.5	122.9	431	180.9
2019	121.5	3.6	125.1	444	186.5
2020	123.7	3.6	127.3	457	191.9

Sources: BTRE estimates, BTRE (2003b, 2002), BTRE Transport Statistics (2005), ACG (2005), BTCE (1996b).

TABLE 2.8 BASE CASE PROJECTIONS OF DIRECT GREENHOUSE GAS EMISSIONS BY AUSTRALIAN CIVIL AVIATION, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Domestic*			*International*
	Avtur	*Avgas*	*Total*	*For Avtur uplifted in Australia*
1990	2265	299	2564	4310
1991	2897	243	3140	4484
1992	3162	229	3392	4757
1993	3309	243	3552	5142
1994	3470	236	3706	5291
1995	4033	240	4273	5793
1996	4405	233	4638	6242
1997	4601	236	4837	6447
1998	4605	239	4845	7153
1999	4537	243	4780	6819
2000	4757	241	4998	6361
2001	4902	233	5135	7152
2002	4503	222	4725	6517
2003	4823	215	5039	6454
2004	5373	208	5581	6720
2005	5737	208	5946	7095
2006	6007	213	6219	7526
2007	6194	217	6411	8014
2008	6453	221	6674	8560
2009	6705	225	6929	8945
2010	6946	227	7173	9334
2011	7083	229	7312	9727
2012	7290	231	7522	10075
2013	7482	234	7716	10420
2014	7567	236	7803	10816
2015	7729	238	7967	11210
2016	7873	241	8114	11603
2017	8019	243	8262	11993
2018	8167	246	8412	12379
2019	8316	248	8564	12760
2020	8466	250	8716	13133

Sources: BTRE estimates, BTRE (2003b, 2002), BTCE (1996b, 1995a), ACG (2005).

CHAPTER 3 MODEL DIFFERENCES AND DETAILS

The 2005 projection results are quite similar in aggregate with both those published in BTRE Report 107 (BTRE 2002) and the unpublished BTRE 2003 updates for AGO (for comparison purposes, a summary of the 2003 results is provided in Appendix table A.10) - though the sectoral composition of the projections show some differences between the studies. For the major sectoral growths in domestic transport:

- the BTRE 2005 base case projection of growth in greenhouse emissions for the total transport sector (2000-2020) is 43.1 per cent, slightly above the BTRE Report 107 result of 39.7 per cent and the BTRE 2003 update projections result of 39.2 per cent;
- road transport emissions in the 2005 update now have slightly faster projected growth (with 1.78 per cent per annum, 2000-2020, in the new base case) compared to the 1.67 per cent per annum in the 2003 base case (and the Report 107 result of around 1.1 per cent per annum);
- the BTRE 2005 air transport emission estimates also have a similar projected growth rate, at 2.8 per cent per annum, as the 2003 estimates (at around 2.5 per cent per annum). As well as changes to the methodology since Report 107 was published, the Report 107 analyses were also done before the 2002 aviation slowdown and while fuel prices were significantly lower – so had derived a projected growth rate considerably higher (at around 4.4 per cent per annum).

The population and income (real GDP) projections used for this work are slightly higher than those used for the BTRE 2003 projections, serving (in the absence of any other effects) to slightly increase projected emission trends for most sub-sectors.

The fuel price projections used for the 2005 estimates are substantially higher than those used for Report 107, and are also higher than for the 2003 BTRE projections. (For the base case input assumptions regarding crude oil prices, see the fuel price section of the following chapter on Model Sensitivity Tests, and the Appendix).

Generally, oil price rises will cause declines in most transport indicators, but the effects will vary between modes. For example, in the road sector, increases in the price of petrol will tend (in the absence of any other effects) to decrease travel in private cars, while serving to increase the passenger market share of competing modes (such as bus travel). If price changes are sustained over the medium to long term, then consumer choices in vehicle purchases are also affected (higher fuel prices tending to encourage the purchase of more fuel efficient vehicle models). Fuel price increases will also have some impact on freight demand levels – through the subsequent rises in freight rates to meet the higher fuel input costs. Trends in future aviation demand will also be quite sensitive to movements in the price of jet fuel.

Road transport

As mentioned previously, passenger car travel per person has been modelled as a saturating curve of real Australian GDP per person (where a 'logistic' curve formulation was chosen for the BTRE modelling – see Report 107 for more details). Once the overall level of the likely saturation (in per capita travel) is set by the structural equation, adjustments are made using econometric models of new vehicle sales and average vehicle utilisation. Projections of average car utilisation (kilometres per car per annum) were estimated using the trend in annual GDP change, trends in household ownership of vehicles, and projected changes in the proportion of the population of working age—as a proxy for a variety of demographic factors that affect average VKT as the average age of the population changes or as the driving age population increases or decreases.

This initial estimated trend in VKT per car was then combined with the initial estimate of VKT per person (from the logistic formulation) to give a starting point trend for cars per person to 2020.

These initial trends estimates were then modified (where the Fuel_Car submodule of BTRE CARMOD uses an iterative procedure), adjusting for changes in vehicle prices over time and for projected fuel price changes, to derive adjusted (equilibrium) trend estimates for Australian car ownership, average VKT per car, and average per capita car travel.

Though the estimation process is dependent on the chosen elasticity values within the models, the final utilisation trends derived by this formulation are not highly sensitive to variations in those elasticity values, since car travel is relatively inelastic. Also, the logistic curve for per capita car travel exhibits slowing growth over the projection period and is quite flat after about 2010 to 2012 – meaning that projected values for car use beyond that point show little response to income increases, and growth in total car VKT becomes roughly equivalent to population growth rates.

Transport demand tends to be fairly inelastic with respect to fuel prices, since even though the cost of fuel is an important contribution to overall transport costs, it tends to be overshadowed by other effects. For example, if we consider the total *generalised cost* of motoring - i.e. a combination of the value of in-vehicle travel time and the fuel costs for each trip; and from other operating costs (such as depreciation and maintenance), parking fees and tolls; as well as contributions from original vehicle purchase costs and access charges (such as vehicle registration) – and make allowances for the premium travellers attach to car travel (with the convenience of choosing time of travel, route, exact destination etc), then fuel prices tend to comprise only a small proportion of the total effect on transport behaviour. Similarly, fuel costs tend to account for only around 20 per cent of total freight vehicle operating costs. The short-term price elasticity of fuel demand appears to be around -0.1 to -0.2 for passenger vehicles.

The road transport emission projections in both updates subsequent to Report 107 have higher rates of estimated growth - primarily due to extensions of the BTRE modelling of Australian motor vehicle fleets. The BTRE Motor Vehicle Emission suite (MVEm) estimates a wide range of pollutant emissions by vehicle type, not only nationally, but for all road vehicle fleets operating in Australian metropolitan areas. Using the Cong_Car submodule of BTRE CARMOD allows the emission models to estimate the likely effects of future urban traffic congestion levels (i.e. serving to raise both average fuel consumption and noxious emission rates) on a city by city basis. Congestion calculations were included in the Report 107 methodology, but only using aggregate parameters. The revised routines now model congestion effects in much more detail, with the result that the total estimated impact of future congestion levels are now appreciably higher than in the Report 107 projection work.

The dynamic fleet models (coupled to the Cong_Car model) use an iterative procedure for each projection year:

- allowing for new vehicles entering the fleet to gradually improve the average fuel efficiency of the respective vehicle stocks (where over the longer term, decreases in average fuel consumption serve to lower the cost of motoring and encourage higher average VKT, negating a portion of the fuel savings gained from the fuel efficiency improvement); and

- allowing for the projected growth in vehicle stocks and total VKT in each major metropolitan area to increase traffic volumes. When combined with an assumed rate of future road construction, this gives projections of average network volume/capacity (VC) ratios for each Australian capital city (where a feedback loop then calculates the effect on average network speeds, for the VC ratio increases, and the consequent increases in average fleet fuel intensity and any dampening of peak travel demand due to the increased travel times).

The congestion effects estimated within the 2005 Bureau projections are of a similar magnitude to those derived for the 2003 BTRE study – though slightly lower, since the latest base case has slightly higher assumed growth rates for future road capacity improvements within the major Australian cities than that assumed for the 2003 scenarios.

The equilibrium values for vehicle travel and average fuel consumption rates across the networks (derived from the feedback modules) are then passed onto the emission models (MVEm) which contain all the detailed emission factors (by vehicle type, age, condition, area of operation, technology type, fuel type etc) for converting activity data into emission projection estimates.

As mentioned in the previous chapter, projections of alternative fuel use (LPG, natural gas, and biofuels such as ethanol) have been based on previous Bureau analyses (see BTE 1999, BTRE 2002, BTRE 2003a, BTCE 1994 and DITR 2004).

Much of the emission factor details contained in the BTRE MVEm suite are redundant for this particular projection exercise – since their level of detail is primarily required for getting decent estimates of noxious pollutants for urban areas. The estimation of greenhouse gas totals for road transport, however, is primarily dependant on the carbon content of the various transport fuels (since full carbon combustion is the standard methodological assumption in studies such as this) - where these carbon content values are taken from the AGO National Greenhouse Gas Inventory (NGGI).

Note that BTRE bottom-up emission values will tend to differ to some extent from the emission estimates contained in the AGO National Greenhouse Gas Inventory (NGGI). The BTRE estimation methodologies and emission factors are substantially more detailed than the default methods of the NGGI *Workbook for Transport*—not only on the side of emission speciation and emission rate determination, but also dealing with activity level determination (especially concerning analyses of transport and fuel data inconsistencies, breaks in time-series, and standardisation of ABS *Survey of Motor Vehicle Use* values and vehicle stock statistics).

The most significant variation between BTRE and current NGGI estimates is probably due to differences in the N_2O emission factors assigned to passenger motor vehicles fitted with three-way catalytic converters. The N_2O emission factors for such vehicles reported in the NGGI transport workbook (NGGIC

2005) are much higher than BTRE values (based on data presented in BTCE 1995a and US Environmental Protection Agency 2001b) – in some cases by as much as threefold. Note that there is considerable uncertainty surrounding the actual level of N_2O emissions from motor vehicles, and there has been little vehicle testing done for N_2O. (Ongoing reviews of the NGGI transport methods may resolve this issue and, in the future, provide more robust estimates for N_2O emissions from transport.)

Emission rates within the MVEm models also incorporate deterioration factors (as the vehicle ages) for methane and nitrous oxide. These rates were held constant in the Report 107 modelling (with the current NGGI workbook also not including deterioration factors for N_2O emission rates). This difference in approach is again especially significant for catalytic converter-equipped vehicles. (For some rough NGGI concordance estimates – based on relative N_2O emission rates between the NGGI and the MVEm models – see the end of this chapter).

The BTRE base case scenario takes account of the recent fuel efficiency targets, for the National Average Fuel Consumption (NAFC) rating of new vehicle sales, that are part of the Government policy measures comprising the Environmental Strategy for the Motor Vehicle Industry (ESMVI). The exact target specifications, for each of the light vehicle categories, are still in the process of being finalised, in negotiation with the motor vehicle manufacturers. Roughly, the overall magnitude of the proposed targets is for an 18 per cent reduction (over current average L/100km levels) in the sales-weighted NAFC across the whole new light vehicle fleet by 2010.

Thus, fuel efficiency trends for new light vehicles - passenger cars (including All-Terrain Wagons) and LCVs (including the 4-wheel drive Pickup/Cab Chassis section of the light commercial vehicle fleet) - show more improvement over time in the 2005 projections than in the earlier base case scenarios (due to the assumed effects of the motor manufactures endeavouring to meet the voluntary intensity targets).

The 2005 projections also allow for hybrid petrol-electric vehicles to gain a growing market share of new car sales over the forecast period (where the fuel intensity of such hybrids is around half that of a standard medium-sized sedan). Recent surges in new vehicle sales (especially for cars and LCVs) also mean that the average penetration rate of the latest fuel efficiency technology has been accelerated lately (and that vehicle stock projections in the 2005 projections are higher than those for the 2003 base case). Note that, particularly for heavy vehicles, meeting future Australian Design Rules (ADRs) to limit noxious emissions could involve possible fuel efficiency over-heads.

Though the base case scenario has an acceleration in the 'business-as-usual' trend improvement[1] for new light vehicle fuel intensity, due to the impact of the ESMVI targets, it does not incorporate NAFC reductions at a fast enough rate to meet the currently proposed timing of those targets (i.e. by 2010). Given the rapid decrease (in the NAFC) over the next 5 years required to meet the proposed targets - restricted by the generally long lead-times required to introduce new model designs, and by existing consumer preferences to commonly sacrifice higher fuel efficiency for greater vehicle performance (see BTE 2002) - the Bureau assessment is that a more likely future trend would be roughly half way between a 'business-as-usual' (BAU) trend and one of full ESMVI compliance.

Table 3.1 is provided to aid comparisons between these various trends, where the base case results (for the road sector) are contrasted with estimates from a BAU scenario and a 'full ESMVI' scenario. Specifically:

- the BAU scenario extrapolates from historical trends (and from motor vehicle industry product plans that were released prior to the ESMVI process), to obtain a fuel efficiency trend expected in the absence of the ESMVI targets.
- the 'full ESMVI' scenario assumes that not only can the technical obstacles to meeting the targets be overcome in the proposed timeframe (i.e. by 2010), but that market preferences (typically for large, high performance vehicles) can be pointed enough towards lighter or high technology vehicles to allow the sales-weighted L/100km of the new vehicle fleet to decline by 18 per cent by 2010.

As can be seen from the table, if full compliance with the proposed targets were to be possible, this should have the capability of reducing BAU-expected emissions by around 1.4 million tonnes (direct CO_2 equivalent) in 2010; with the potential benefit of the ESMVI targets increasing to a 5 million tonne reduction by 2020.

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[1] Where 'business-as-usual' (BAU) means, in this context, an expected future trend based on continuation of the industry practices and trend improvements of the 1990s.

TABLE 3.1 ESMVI SCENARIO: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN ROAD TRANSPORT TO 2020

(gigagrams of CO_2 equivalent)

Fin. Year	*BTRE 2005 base case*	*Adjusted to 'Business-as-usual' scenario*	*Full ESMVI scenario*
2003	69676	69676	69676
2004	73123	73123	73123
2005	74069	74076	74058
2006	75166	75226	75006
2007	77009	77177	76715
2008	78985	79297	78476
2009	81005	81404	80290
2010	82600	83113	81675
2011	83886	84568	82730
2012	85106	85966	83693
2013	86204	87253	84539
2014	87251	88497	85342
2015	88253	89705	86177
2016	89172	90837	86948
2017	90114	92003	87794
2018	90999	93110	88594
2019	91915	94222	89431
2020	92816	95305	90284

Notes: The base case scenario assumes that new vehicle fuel efficiency targets (for NAFC) will affect trends for all light vehicles (including LCVs and 4-wheel drive passenger vehicles, as well as sedans) and accelerate trend improvements (i.e. from what would have occurred in the absence of the manufacturer targets).

The 'business-as-usual' (BAU) scenario uses a continuation of earlier vehicle industry product plans, to give a trend assumed likely to have occurred in the absence of the ESMVI targets (i.e. future trend improvements closer to historical trends).

The 'full ESMVI' scenario assumes full compliance with the proposed targets is possible (i.e. NAFC across all new light vehicle sales can be reduced by 18 per cent from current levels by 2010).

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (i.e. do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTE (1999).

Recent BTRE studies on Australian freight tasks, along with the availability of some updated activity data, have also allowed the revision of some underlying parameter items. The most significant changes involved revisions to trends in average loads carried by freight vehicles – where the revised time-series tended to have somewhat slower trend improvements than previously. This was most noticeable for medium sized freight vehicles, with result that the 2005 projections assume less growth in average loads for rigid trucks, with a 9.4 per cent increase 2003 to 2020 (compared with a 17 per cent increase assumed under the previous base case settings). Current negotiations with the road freight industry involving load and size limits on freight vehicles (including the impacts of future ADRs) could have an influence on the average load assumptions (especially for the multiple-trailer component, B-doubles and road trains, of the fleet) in future studies.

For tables giving the results of the BTRE modelling of fuel efficiency trends for road transport fleets, see the Appendix.

Aviation

The aviation sector exhibited significant slowdowns over the 2001 to 2003 period, aviation demand being strongly affected by both international events (such as the September 11 attacks, the SARS virus outbreaks and the Iraq war) and domestic ones (such as the collapse of Ansett airlines and higher than originally expected average fare levels). However, task levels for both domestic aviation and for international aviation (into and out of Australia) have tended to recover substantially over the last couple of years, and significant growth in demand is likely in the future - e.g. capacity planning by the Sydney Airport Corporation is currently based on the expectation that Sydney airport passenger numbers will triple over the next 20 years (Chan 2005).

Both the 2003 and 2005 aviation projections have slower trend growth in domestic air travel than the base case chosen for Report 107 (though similar to one of the sensitivity results canvassed in Report 107, which had used the method now adopted in the newer base cases). Specifically, this methodological change (adopted in the 2003 base case, and continued in the 2005 update) applies a *share constraint* to air travel (relative to other modes of non-urban passenger transport).

The Report 107 aviation base case results were done on the assumption that future growth in Australian air travel demand will not be constrained in any way. Since the underlying growth rates tend to be high for aviation, continuing such *unconstrained* growth for the entire projection period ends up with estimates implying air travel by 2020 will account for over half of all non-urban travel. Given that local rural trips (which are not contestable by air travel) form a large component of total non-urban travel, it was decided that a more realistic assumption for aviation projections would be to use a constrained growth approach, using mode share models (see BTE Working Paper 38 for details of such models).

Within the non-urban travel model, air travel was constrained in the future to never exceed a 40 per cent mode share of non-urban passenger-kilometres (assuming that by this level, aviation would have totally replaced the contestable portion of long-distance travel, leaving mostly local traffic as the residual).

BTRE projections of average airline fuel intensity allow for the gradual replacement of the fleet with new aircraft that are more fuel efficient than existing aircraft (and are generally larger than the planes they replace) – resulting in a base case decrease in fuel intensity (litres of avtur per seat-kilometre) of 22 per cent between 2005 and 2020 for domestic airlines and 18.5 per cent for international airlines. Though roughly consistent with the assumed trend to larger aircraft, these projections do not specifically allow for the introduction of the new Airbus A380s and A350s, and their exact impacts may need to be assessed in the future.

Modelling aviation emissions is further complicated by apparent data discontinuities (for various years) in aviation turbine fuel time-series reported by the Department of Industry, Tourism and Resources (*Australian Petroleum Statistics*).

Other transport

Demand growth for rail and shipping tasks are highly dependent on the production levels for various primary industries, and the subsequent need for (generally bulk) commodity movements. There has been recent strong growth in a variety of the major Australian commodity exports (with strong underlying growth in several resources sectors, such as iron ore production and coal production).

ABARE (2005) expects continued strong growth in Australian production of such commodities (e.g. ABARE's 2005 commodity projections forecast growth of 72 per cent in iron ore production between 2003 and 2010 – for details see www.abareconomics.com/australiancommodities/commods/ironore.htm).

This strong commodity growth leads to higher projections of rail freight and shipping in the 2005 base case projections than in the 2003 base case.

As mentioned in chapter 2 (and also briefly dealt with below), the estimation of fuel use in the maritime sector is complicated by the use of bunker fuel purchased outside Australia but consumed by vessels while undertaking domestic shipping tasks.

NGGI differences

The latest AGO National Greenhouse Gas Inventory (AGO 2005, NGGIC 2005) derives an estimate of 79.8 million tonnes (of CO_2 equivalent *direct* emissions from energy end-use) for the 2003 greenhouse contribution of the Australian civil transport sector. This compares quite closely with the BTRE estimate for 2003 emissions (see table 1.2) of 78.8 million tonnes (CO_2 equivalent).

This correspondence is to be expected – since the BTRE estimates provided here are done on a consistent sectoral definition to the NGGI, and the basic approach of the NGGI is also roughly equivalent (though on a much more aggregate level and using much lower detail) to the BTRE bottom-up methodology.

In fact, many of the sub-sectoral component estimates of the two analyses are even more comparable than this 1.3 per cent divergence (in the 2003 aggregate values) implies. As mentioned previously, the two main differences, in the current BTRE and NGGI results, concern:

1. the NGGI emission factors for N_2O from passenger motor vehicles fitted with three-way catalytic converters (which will probably result in total CO_2 equivalent emissions from the road sector being overestimated in the NGGI); and

2. the NGGI apportioning of bunker fuel data, which will tend to underestimate total CO_2 equivalent emissions for the NGGI domestic maritime sector.

For accounting purposes, table 3.1 gives a rough comparison (to the actual base case values) of what the projected trend would likely have been, had the modelling been done using the high NGGI N_2O emission factor (for motor vehicles fitted with three-way catalytic converters) and the low NGGI fuel use fraction for coastal shipping. As can be seen from this table, allowing for these two systematic differences closes the gap between the 2003 estimated values (i.e. current NGGI versus adjusted BTRE) to only about 0.5 per cent (though, over time, the increasing penetration of the fleet by three-way converters does lead to a reasonable endpoint divergence between the BTRE base case and that of the 'adjustment' scenario).

TABLE 3.2 INVENTORY LEVEL ADJUSTMENT SCENARIO: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN DOMESTIC CIVIL TRANSPORT

(gigagrams of CO_2 equivalent)

Fin. Year	*BTRE 2005 base case*	*Base case adjusted to NGGI 2003 processes*
2003	78813	80188
2004	82841	84493
2005	84193	86025
2006	85609	87628
2007	87684	89936
2008	89961	92444
2009	92272	94992
2010	94148	97064
2011	95611	98685
2012	97079	100291
2013	98405	101743
2014	99573	103036
2015	100773	104346
2016	101871	105527
2017	102995	106728
2018	104064	107856
2019	105164	109011
2020	106251	110164

Note: This table gives a comparison (relative to the BTRE base case values) of roughly how much the projected trend would have been altered if the modelling had been done using the high NGGI N_2O emission factor (for motor vehicles fitted with three-way catalytic converters) and the low NGGI fuel use fraction for coastal shipping.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (ie do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTE (1999), AGO (2005).

CHAPTER 4 SENSITIVITY ANALYSES

The projected trends are sensitive to a variety of input assumptions in the projection modelling – such as future income and population growth, and the penetration rates of more fuel-efficient vehicle technology.

As a part of the BTRE's current revision of the projections of transport sector emissions, the AGO requested that the Bureau undertake sensitivity testing of the results to changes in the underlying assumptions. This chapter gives the results of various sensitivity tests, following AGO specifications, that were conducted by the BTRE. The sensitivity analyses - to variations in the input assumptions for economic growth, population growth, fuel prices, the effects of future congestion levels and future fuel efficiency for new vehicles – are presented in different sections of the chapter, for each input variation.

As requested by the AGO, combination *high* and *low* scenarios (that alter all these input parameters simultaneously), along with a '*Concordance*' scenario - which aims to compare the results of the BTRE models when run using parameter inputs as close as possible to those used in the Apelbaum Consulting Group (ACG) modelling - are also presented.

Note that the different settings of the various underlying variables (such as economic growth) used in the sensitivity tests do not necessarily represent alternative 'probable' scenarios for future growth. They simply relate to value ranges, agreed with the AGO, to test the response of the base case results to variations in underlying assumptions.

Generation of demand by income and population levels

Table 4.1 shows the result for the sector of assuming that the economic growth rate is 0.5 per cent per year higher or lower than in the base case and the population growth rate is 0.1 per cent per year higher or lower than in the base case. The base case assumptions for population and economic growth are listed in Appendix tables A.1 to A.3 (with average compound GDP growth of around 2.8 per cent per annum over the period of 2000 to 2020).

Overall, since car use is displaying signs of tending to saturate with regard to income, and since some sub-sectors are relatively independent of Australian economic growth (e.g. some commodity flows depend more on the economic growth of our major export markets than on local income growth), the effect on total emissions is somewhat muted. The sub-sectors most responsive to economic growth are road freight and aviation.

The income (real GDP) and population sensitivity analyses change total 2020 emission levels by around 5 per cent (up and down) from the base case.

Specifically, the low demand scenario assumed that real Australian GDP growth is 0.5 per cent less each year (to 2020) than the per annum GDP growth assumed for the base case. Population growth is lowered by 0.1 percentage points per year over the projection period. Resulting aggregate emissions in 2010 are about 0.8 per cent below the base case.

The high demand scenario assumed GDP growth of 0.5 per cent more each year (to 2020) than the GDP growth assumed for the base case. Population growth is increased by 0.1 percentage points per year over the projection period. Resulting aggregate emissions in 2010 are about 0.8 per cent above the base case value.

TABLE 4.1 LOW GDP AND POPULATION SENSITIVITY: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75194	2101	2052	6215	85563
2007	76911	2136	2052	6395	87494
2008	78763	2167	2052	6645	89627
2009	80658	2197	2051	6888	91794
2010	82034	2223	2052	7110	93419
2011	83023	2247	2052	7221	94543
2012	83937	2270	2052	7400	95659
2013	84713	2289	2052	7563	96617
2014	85422	2305	2053	7617	97396
2015	86060	2321	2054	7745	98180
2016	86601	2335	2054	7854	98845
2017	87138	2348	2055	7963	99504
2018	87600	2360	2057	8071	100087
2019	88068	2371	2058	8179	100676
2020	88500	2381	2060	8286	101225

Note: The ‘low’ scenario assumes a decrease of 0.5 per cent per annum in the base case values for real Australian GDP growth over the projection period, and a 0.1 per cent decrease in per annum population growth.

‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (i.e. do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results for all tables refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b).

TABLE 4.2 HIGH GDP AND POPULATION SENSITIVITY: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75277	2104	2053	6224	85658
2007	77255	2147	2057	6428	87887
2008	79366	2186	2060	6705	90317
2009	81522	2225	2063	6973	92783
2010	83353	2266	2070	7239	94928
2011	84956	2310	2078	7410	96754
2012	86506	2353	2087	7652	98598
2013	87950	2394	2096	7880	100320
2014	89360	2433	2106	8003	101903
2015	90752	2473	2118	8205	103548
2016	92078	2513	2129	8392	105111
2017	93455	2553	2142	8582	106732
2018	94795	2593	2155	8777	108320
2019	96191	2634	2169	8976	109970
2020	97595	2676	2183	9178	111632

Note: The ‘high’ scenario assumes an increase of 0.5 per cent per annum in the base case values for real Australian GDP growth over the projection period, and a 0.1 per cent decrease in per annum population growth.

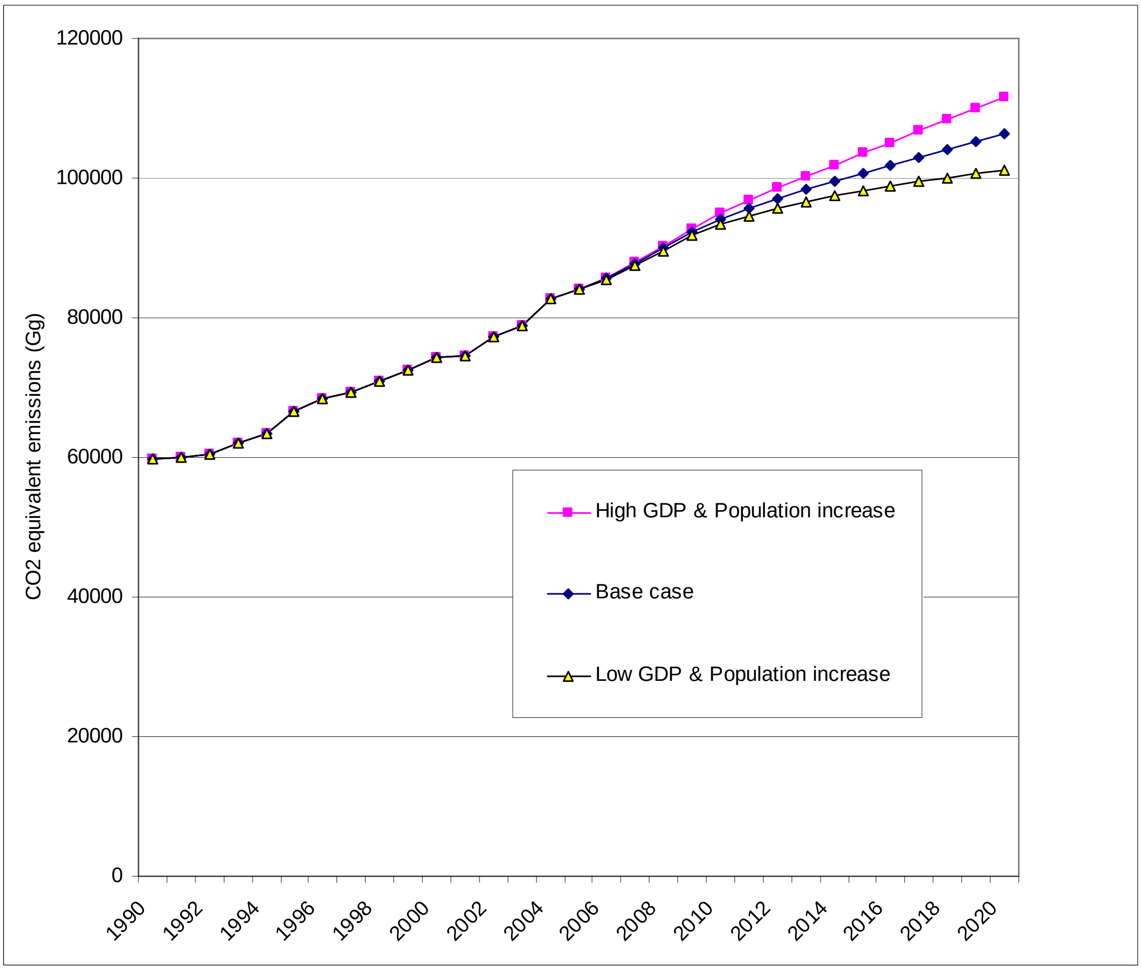
‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (i.e. do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b).

Figure 4.1 Sensitivity of total transport emission projections to GDP and population assumptions



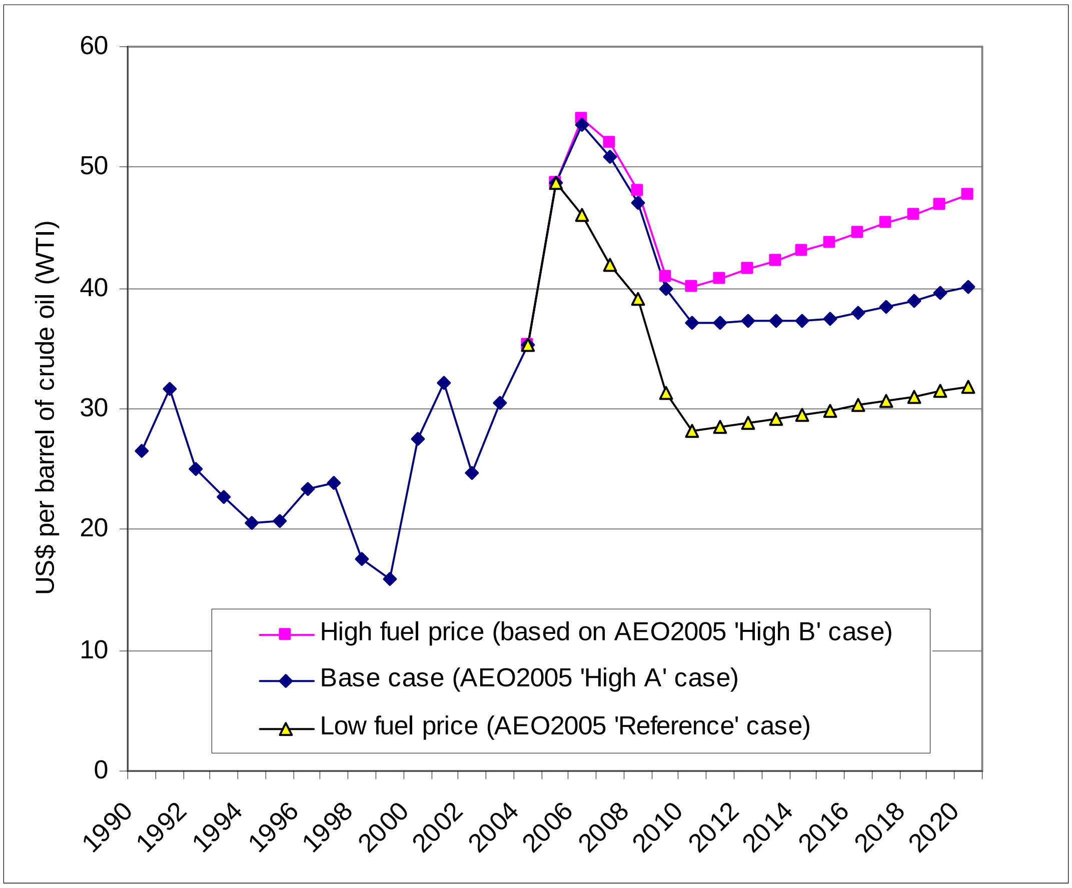
Sources: BTRE estimates, BTRE (2002, 2003b).

Fuel prices

The sensitivity analyses on fuel prices change total 2020 emission levels by around 3 per cent from the base case.

Base case trends in fuel prices (as well as the *high* and *low* trends for this sensitivity result) are based on long-term projections of crude oil prices by the US Energy Information Administration (EIA 2005a) – *Annual Energy Outlook 2005* (*AEO2005*) - supplemented with values from their short-term forecasting results (EIA 2005b). The 2005 BTRE base case uses estimates of West Texas Intermediate (WTI) prices calculated from the EIA 'High A' scenario. The BTRE high fuel price sensitivity uses the EIA 'High B' scenario and the BTRE low fuel price sensitivity uses the EIA 'Reference' scenario (EIA 2005a). These three derived trends are shown in figure 4.2 (and Appendix table A.11).

Figure 4.2 Projections of crude oil prices (in real terms, 2004 dollars)



Sources: EIA (adjusting US Refiner's Acquisition Cost values in the *AEO2005* report to WTI values), BTRE estimates.

TABLE 4.3 LOW FUEL PRICE SENSITIVITY: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75263	2103	2053	6221	85639
2007	77196	2141	2054	6418	87808
2008	79263	2175	2056	6685	90179
2009	81374	2209	2056	6946	92585
2010	83127	2242	2060	7198	94626
2011	84626	2274	2063	7349	96311
2012	86067	2305	2066	7571	98009
2013	87397	2333	2070	7778	99578
2014	88687	2360	2075	7878	101000
2015	89950	2386	2080	8057	102473
2016	91142	2411	2085	8218	103856
2017	92375	2435	2091	8382	105284
2018	93565	2459	2097	8549	106671
2019	94803	2483	2104	8718	108108
2020	96040	2506	2111	8890	109547

Note: In the ‘low’ scenario, crude oil price in 2020 is assumed to be around US$ 32 per barrel (WTI) compared with around US$ 40 in the base case.

‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (ie do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

TABLE 4.4 HIGH FUEL PRICE SENSITIVITY: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75208	2103	2053	6218	85582
2007	76969	2143	2055	6405	87572
2008	78864	2179	2057	6663	89764
2009	80802	2215	2058	6914	91990
2010	82254	2251	2063	7149	93717
2011	83346	2287	2068	7278	94979
2012	84366	2323	2073	7477	96239
2013	85254	2356	2079	7659	97348
2014	86079	2387	2085	7734	98286
2015	86844	2418	2093	7885	99240
2016	87516	2449	2100	8018	100082
2017	88193	2479	2108	8151	100931
2018	88801	2509	2116	8286	101713
2019	89425	2539	2125	8421	102510
2020	90018	2569	2135	8557	103280

Note: In the ‘high’ scenario, crude oil price in 2020 is assumed to be around US$ 48 per barrel (WTI) compared with around US$ 40 in the base case.

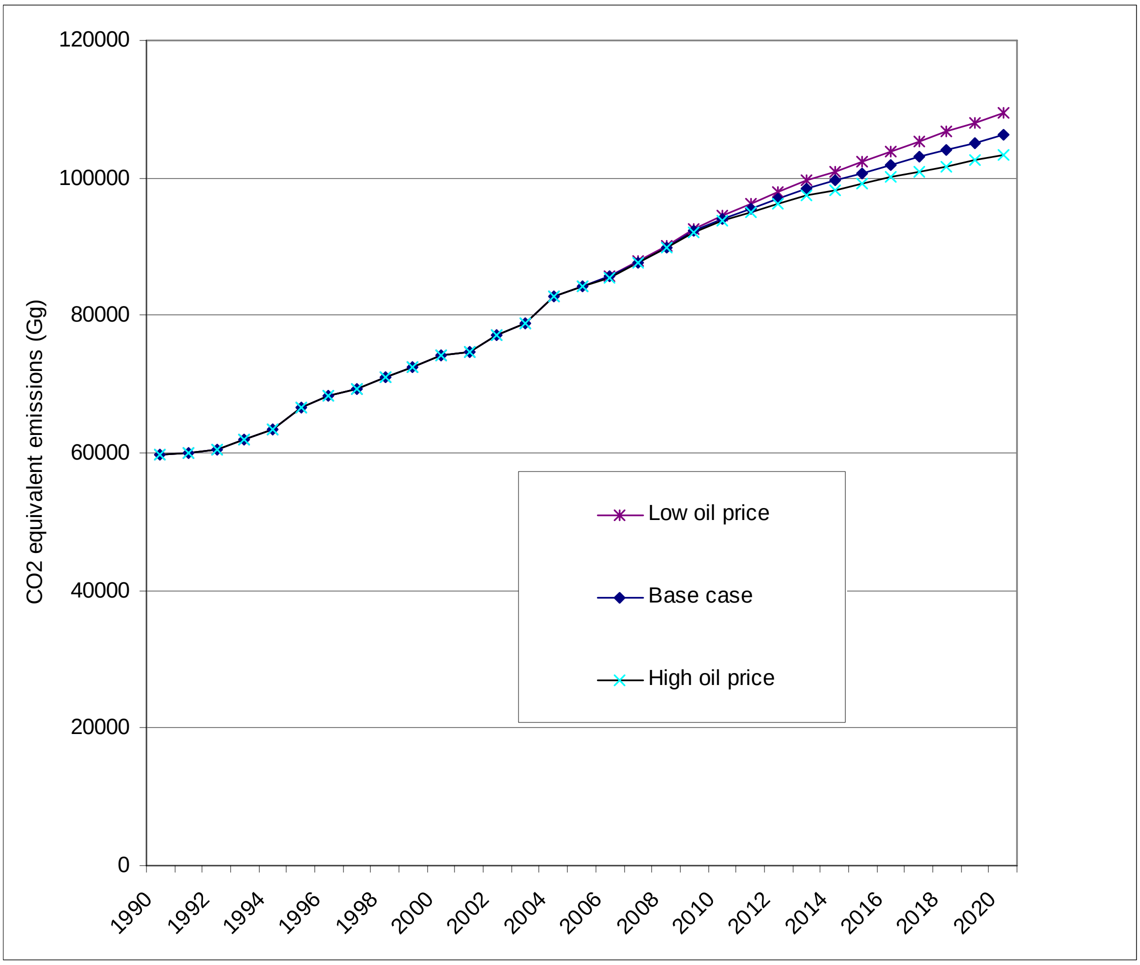
‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (ie do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

Figure 4.3 Sensitivity of total transport emission projections to fuel price assumptions



Sources: BTRE estimates, BTRE (2002), EIA (2005a, 2005b).

Since the chosen sensitivity range for future oil prices is relatively conservative here (with large scale fluctuations being inflationary and thus beyond the typical scope of bottom-up modelling analyses), and most transport activities are relatively inelastic with respect to fuel prices, the high and low scenario values for 2010 only vary from the base case values by 0.5 per cent (with 2020 values, respectively, of about 2.8 per cent below the base case and 3.1 per cent above the base case).

Congestion effects

Using methods developed for Bureau's Report 92 (*Traffic Congestion and Road User Charges in Australian Capital Cities*, BTCE 1996a) and more recent work on metropolitan transport pollution (*Urban Pollutant Emissions From Motor Vehicles: Australian Trends To 2020*, BTRE 2003a), the base case incorporates allowances for urban traffic congestion effects on vehicle fuel consumption. In summary, the base case estimate is that the increases in urban traffic volumes (between 1990 and 2020) will increase average urban fuel intensity by around 18 per cent above the level it would otherwise have reached. This projected fuel efficiency penalty - from traffic delays and interruptions to traffic flow increasing average fuel consumption - varies considerably from city to city, depending on the particular network characteristics and the expected rate of population growth.

The 'high congestion' scenario assumed that the response of vehicle fuel intensity to increases in urban traffic congestion was 50 per cent stronger than in the base case model settings.

The 'low congestion' scenario assumed induced rises in average vehicle fuel intensity due to increases in urban traffic congestion were 50 per cent weaker than in the base case parameter settings.

Altering the congestion feedback parameters in the BTRE vehicle fleet models (by this variation of 50 per cent up and down) resulted in a variation of the 2010 base case values (for total transport emissions) of close to 0.7 per cent. The changes to total 2020 emission levels were around 4 per cent from the base case level.

TABLE 4.5 LOW CONGESTION SENSITIVITY: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75196	2103	2053	6219	85571
2007	76921	2142	2054	6411	87527
2008	78779	2176	2056	6674	89686
2009	80682	2210	2057	6929	91878
2010	82070	2244	2061	7173	93547
2011	83076	2277	2064	7312	94730
2012	84008	2310	2069	7522	95908
2013	84802	2339	2073	7716	96931
2014	85529	2367	2079	7803	97778
2015	86189	2394	2085	7967	98635
2016	86751	2421	2090	8114	99376
2017	87311	2447	2097	8262	100117
2018	87796	2473	2104	8412	100785
2019	88290	2498	2112	8564	101464
2020	88748	2523	2119	8716	102107

Note: The ‘low’ scenario assumes a 50 per cent weaker traffic congestion response than the base case.

‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (ie do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

TABLE 4.6 HIGH CONGESTION SENSITIVITY: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75274	2103	2053	6219	85649
2007	77242	2142	2054	6411	87848
2008	79343	2176	2056	6674	90250
2009	81489	2210	2057	6929	92686
2010	83303	2244	2061	7173	94781
2011	84884	2277	2064	7312	96538
2012	86410	2310	2069	7522	98310
2013	87829	2339	2073	7716	99957
2014	89213	2367	2079	7803	101462
2015	90576	2394	2085	7967	103023
2016	91873	2421	2090	8114	104498
2017	93218	2447	2097	8262	106024
2018	94526	2473	2104	8412	107514
2019	95887	2498	2112	8564	109060
2020	97254	2523	2119	8716	110613

Note: The ‘high’ scenario assumes a 50 per cent stronger congestion response than the base case.

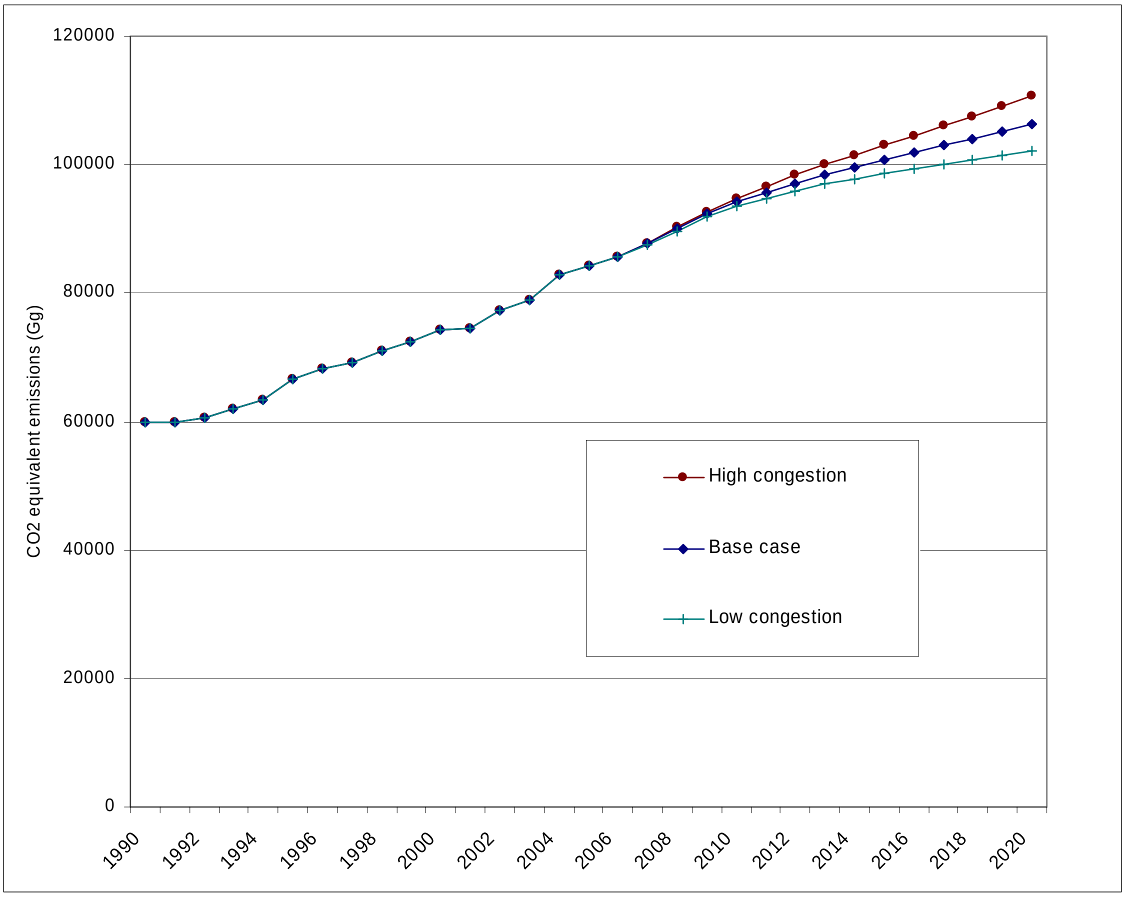
‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (ie do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a)).

Figure 4.4 Sensitivity of total transport emission projections to traffic congestion response parameters



Source: BTRE estimates, BTRE (2003a, 2002), Cosgrove (2003).

Fuel intensity

Altering assumed penetration rates for fuel-efficient technology changes total 2020 emission levels by 6 to 7 per cent.

The 'low fuel intensity' scenario assumes that, by the end of the projection period:

- new passenger cars are 15 per cent more fuel efficient than for the base case trend improvement;
- new LCVs are 10 per cent more fuel efficient than for the base case trend improvement;
- the fuel consumption rate and average load parameters for rigid trucks change over time such that the average freight task efficiency of the fleet improves by 0.2 per cent per annum faster than the base case trend improvement (in MJ/tkm terms);
- the fuel consumption rate and average load parameters for articulated trucks change over time such that the average freight task efficiency of the fleet improves by 0.5 per cent per annum faster than the base case trend improvement (in MJ/tkm terms); and
- the average fuel intensity for all other transport fleets is 10 per cent below the base case trend.

The 'high fuel intensity' scenario assumes that, by the end of the projection period:

- new passenger cars are 15 per cent less fuel efficient than for the base case trend improvement;
- new LCVs are 10 per cent less fuel efficient than for the base case trend improvement;
- the fuel consumption rate and average load parameters for rigid trucks change over time such that the average freight task efficiency of the fleet improves by 0.2 per cent per annum slower than the base case trend improvement (in MJ/tkm terms);
- the fuel consumption rate and average load parameters for articulated trucks change over time such that the average freight task efficiency of the fleet improves by 0.5 per cent per annum slower than the base case trend improvement (in MJ/tkm terms); and

- the average fuel intensity for all other transport fleets is 10 per cent above the base case trend.

Assumed variations in the rates of fleet efficiency improvements for these scenarios is partly based on technology penetration models developed for BTCE Report 94 and BTRE Report 107 (in particular, components of the Bureau's car fleet model - CARMOD, the road freight model – TRUCKMOD, and an aircraft fleet model – AVMOD).

Altering the fuel intensity assumptions (by these ranges) resulted in a variation of the 2010 base case values (for total transport emissions) of 1.1 per cent below and 1.4 per cent above, for the low and high scenarios respectively. The respective changes to total 2020 emission levels were 5.9 per cent below and 6.6 per cent above the base case level.

TABLE 4.7 LOW FUEL INTENSITY SENSITIVITY: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75150	2100	2051	6211	85512
2007	76849	2132	2046	6378	87406
2008	78650	2160	2042	6616	89468
2009	80474	2186	2037	6847	91544
2010	81842	2207	2030	7046	93125
2011	82865	2224	2019	7127	94235
2012	83787	2239	2009	7276	95311
2013	84552	2250	1998	7406	96205
2014	85230	2258	1987	7426	96901
2015	85829	2264	1975	7518	97587
2016	86315	2269	1963	7589	98136
2017	86788	2272	1950	7657	98666
2018	87172	2273	1936	7722	99104
2019	87553	2272	1922	7785	99533
2020	87886	2271	1907	7845	99909

Note: The ‘low’ scenario assumes approx. 10-15 per cent faster improvements (by 2020) in fleet fuel efficiency trends than the base case.

‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (ie do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

TABLE 4.8 HIGH FUEL INTENSITY SENSITIVITY: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73187	2016	2054	5581	82839
2005	74136	2060	2051	5946	84193
2006	75324	2105	2055	6227	85711
2007	77329	2151	2062	6444	87986
2008	79525	2193	2070	6732	90520
2009	81825	2234	2077	7012	93149
2010	83773	2281	2091	7299	95444
2011	85461	2331	2109	7497	97399
2012	87101	2381	2129	7768	99379
2013	88630	2429	2149	8026	101235
2014	90121	2476	2170	8181	102948
2015	91578	2524	2194	8417	104714
2016	92961	2573	2218	8639	106391
2017	94379	2622	2244	8867	108113
2018	95750	2672	2272	9102	109796
2019	97164	2723	2301	9342	111530
2020	98572	2775	2331	9588	113266

Note: The 'high' scenario assumes approx. 10-15 per cent slower improvements (by 2020) in fleet fuel efficiency trends than the base case.

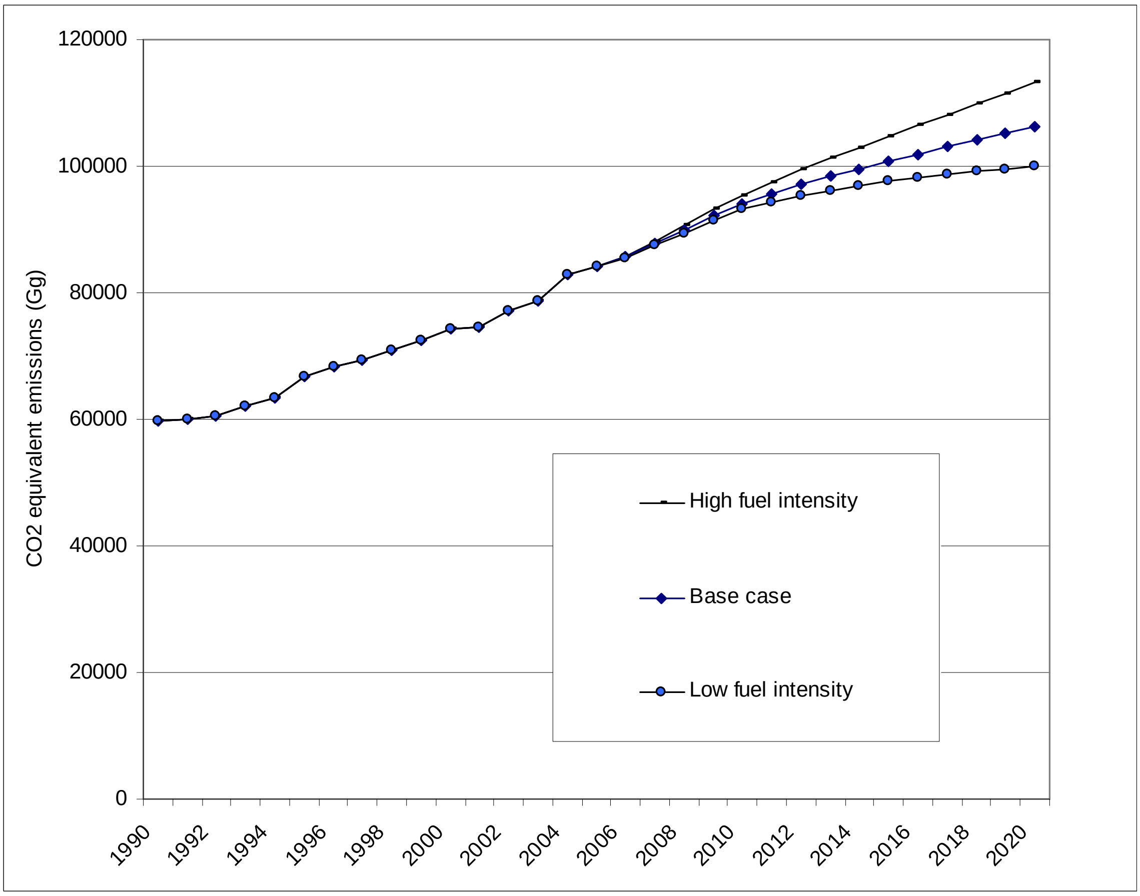
'Motor Vehicles' includes all road vehicles plus off-road recreational vehicles. 'Aviation' includes emissions from general aviation. 'Maritime' includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (ie do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

Figure 4.5 Sensitivity of total transport emission projections to fleet fuel intensity assumptions



Sources: BTRE estimates, BTRE (2003a, 2003b, 2002).

High and Low Combination scenarios

This section provides, at AGO's request, high and low *combination* scenarios - to demonstrate how much the projections are altered if the major input assumptions are all varied together, yielding the highest and lowest potential estimates (given the current base case model formulation).

The *Low Emissions* scenario is the result of running the BTRE emission models using the combination of deviations from each of the above sensitivity scenarios that yields the lowest level of aggregate transport emissions likely (including the effects of low economic growth, low population growth, a higher rate of fuel intensity improvements than the base case, high oil prices and low urban congestion response). The low combination settings gave total 2010 emission levels of around 2.6 per cent below the base case, with total 2020 emission levels around 16 per cent lower than the base case.

Similarly, the *High Emissions* scenario uses the combination of sensitivity deviations that yields the highest likely level of aggregate emissions (based on high economic growth, high population growth, , a lower rate of fuel intensity improvements than the base case, low future oil prices and high level of response to urban traffic congestion). The high combination settings resulted in total 2010 emission levels of around 2.9 per cent above the base case, with total 2020 emission levels around 17.7 per cent higher than the base case.

TABLE 4.9 LOW SCENARIO – COMBINED EFFECTS OF SENSITIVITY SETTINGS: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75097	2099	2050	6207	85453
2007	76512	2128	2044	6359	87042
2008	78061	2152	2039	6582	88834
2009	79653	2175	2032	6798	90658
2010	80498	2190	2022	6972	91683
2011	80774	2198	2008	7019	91999
2012	80947	2205	1994	7131	92278
2013	80946	2207	1979	7224	92356
2014	80837	2206	1964	7205	92212
2015	80598	2203	1948	7254	92003
2016	80226	2197	1931	7281	91636
2017	79785	2189	1914	7302	91190
2018	79223	2178	1895	7319	90615
2019	78613	2166	1876	7329	89984
2020	77912	2151	1855	7334	89253

Note: The 'low' scenario assumes the combination of all the sensitivity deviations that yields the lowest level of aggregate emissions.

'Motor Vehicles' includes all road vehicles plus off-road recreational vehicles. 'Aviation' includes emissions from general aviation. 'Maritime' includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (ie do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

TABLE 4.10 HIGH SCENARIO – COMBINED EFFECTS OF SENSITIVITY SETTINGS: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75387	2106	2055	6232	85781
2007	77706	2157	2064	6465	88392
2008	80159	2203	2074	6768	91204
2009	82658	2248	2083	7064	94053
2010	85088	2302	2100	7378	96868
2011	87498	2362	2122	7614	99596
2012	89885	2422	2146	7923	102375
2013	92207	2481	2170	8221	105079
2014	94541	2539	2196	8418	107694
2015	96924	2599	2225	8700	110448
2016	99282	2660	2254	8969	113165
2017	101764	2722	2286	9248	116020
2018	104261	2786	2319	9535	118901
2019	106876	2852	2354	9831	121913
2020	109559	2920	2391	10136	125005

Note: The ‘high’ scenario assumes the combination of all the sensitivity deviations that yields the highest level of aggregate emissions.

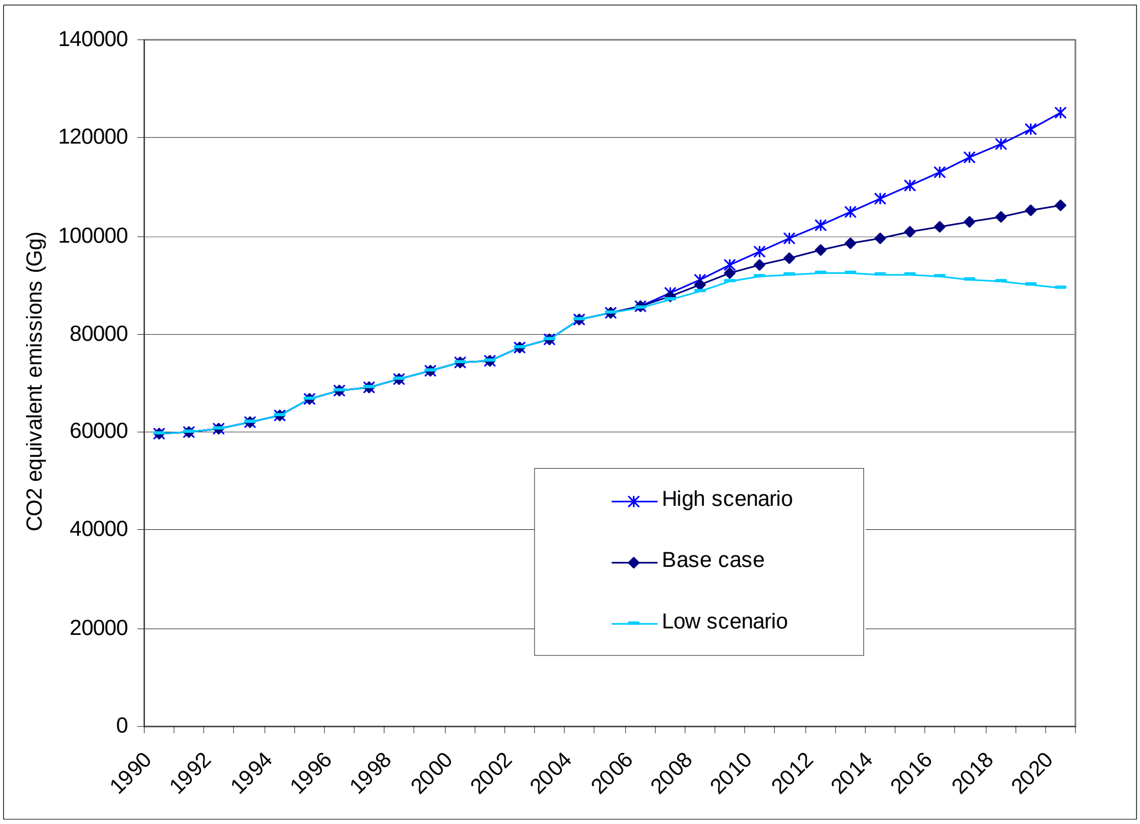
‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles. ‘Aviation’ includes emissions from general aviation. ‘Maritime’ includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (i.e. do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), BTCE (1996b, 1995a).

Figure 4.6 High and Low Combination scenarios for total domestic transport emissions



Sources: BTRE estimates, BTRE (2003a, 2003b, 2002).

Concordance scenario

This section gives the results of a 'Concordance' scenario or 'Comparison case' - which aims to compare the results of the BTRE models when run using input assumptions as close as possible to those used by Apelbaum Consulting Group Pty Ltd (ACG) in concurrent projections work.

Specifically,

- for this run of CARMOD, the segment of the Fuel_Car module that handles the saturation constraints (in personal vehicle travel) are disabled – leading to much higher projections of VKT demand.
- the congestion feedback loops in Cong_Car are also disabled, serving to change average projected network speeds and have lower average fuel intensity values for the vehicle fleets being passed through to the MVEm model routines.
- ascertaining that the aggregate demographic and economic input assumptions are compatible between the BTRE and ACG models - which involved replacing the BTRE base case trend for real GDP with the slightly higher ACG values (sourced to Access Economics).

The comparison case assumptions resulted in aggregate 2020 transport emissions being about 6.1 per cent higher than for the BTRE 2005 base case (with a 6.6 per cent increase in 2020 road transport emissions). This particular scenario run is not a particularly realistic use of our models, since disabling the saturation and congestion feedback loops partially invalidates the demand response formulation of the BTRE modelling process (e.g. part of the demand projections rely on estimating balances between the various input costs that influence travel behaviour, and turning off these model components means calculations of total generalised motoring cost do not receive valid estimates of the value of in-vehicle travel time or of urban vehicle operating costs). However, the scenario is included here – at AGO request - as an aid to understanding any divergences between the projection outputs for the BTRE and ACG models.

TABLE 4.11 COMPARISON CASE – ACG PARAMETER SETTINGS: GREENHOUSE GAS EMISSIONS FOR AUSTRALIAN TRANSPORT, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53184	1741	2294	2564	59783
1991	52905	1732	2152	3140	59929
1992	53280	1685	2201	3392	60557
1993	54578	1658	2196	3552	61984
1994	55713	1792	2240	3706	63450
1995	58156	1743	2471	4273	66643
1996	59744	1696	2273	4638	68351
1997	60424	1729	2265	4837	69255
1998	62045	1757	2269	4845	70917
1999	63812	1808	2131	4780	72531
2000	65286	1874	2116	4998	74274
2001	65591	1840	2021	5135	74587
2002	68484	1926	2079	4725	77215
2003	69742	1977	2056	5039	78813
2004	73189	2016	2054	5581	82841
2005	74136	2060	2051	5946	84193
2006	75298	2104	2053	6222	85676
2007	77195	2145	2055	6420	87815
2008	79233	2182	2058	6690	90163
2009	81341	2218	2060	6952	92571
2010	83017	2256	2066	7208	94546
2011	84533	2294	2072	7364	96263
2012	86067	2333	2078	7590	98068
2013	87578	2368	2085	7802	99834
2014	89134	2402	2093	7909	101537
2015	90750	2436	2102	8093	103380
2016	92401	2469	2111	8260	105241
2017	93986	2503	2121	8431	107040
2018	95580	2536	2131	8604	108851
2019	97275	2570	2142	8781	110767
2020	99024	2603	2153	8959	112740

Note: This scenario disables per capita VKT saturation and congestion response functions – along with alterations to GDP input projections.

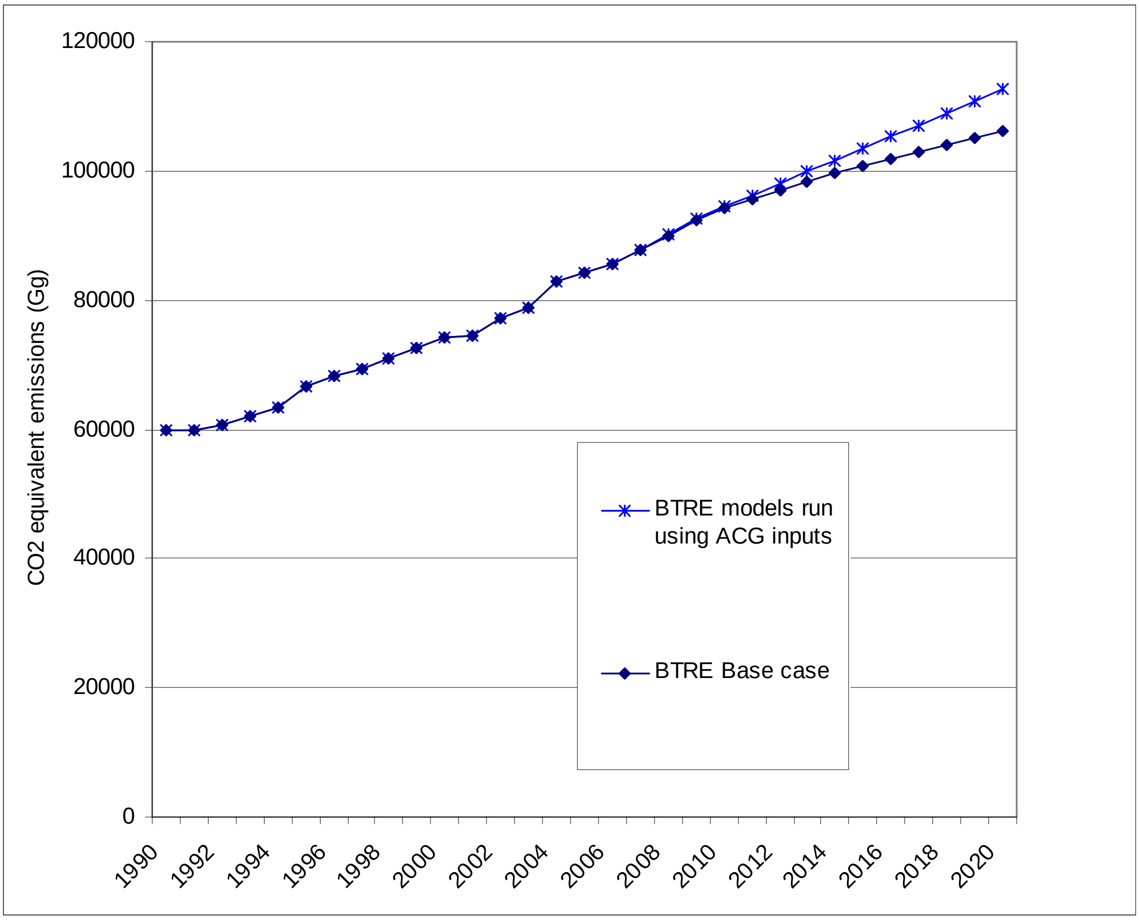
'Motor Vehicles' includes all road vehicles plus off-road recreational vehicles. 'Aviation' includes emissions from general aviation. 'Maritime' includes emissions from small pleasure craft and ferries.

Emissions are direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (i.e. do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

All results to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2003a, 2003b, 2002), ACG (pers. comm.).

Figure 4.7 Comparison case – BTRE versus ACG parameter settings



Sources: BTRE estimates, ACG (pers. comm.).

Projection Uncertainty

The above sensitivity tests give some idea of the uncertainty levels associated with the projections - where even if the models are well formulated, the difficulties inherent in accurately forecasting all the model input data and parameters mean that there will always be a certain range of fundamental variability in the results. The sensitivity tests appear to reveal this underlying variability for the projection procedures to be of the order of a 5 per cent variation (in the projection period endpoint) for the chosen likely range in any one particular major parameter. Implied furthermore (assuming the model structure is an accurate reflection of the transport sector's dynamics and that current travel behaviour trends continue), is that 2020 aggregate emissions are unlikely to lie more than 15-20 per cent from the base case values – unless there is major structural change to the sector (or there are other major unforeseen events impacting on transport activity), over the next 15 years.

Regarding structural change, there will be some projection uncertainty associated with saturation effects. The BTRE models have saturation constraints imposed in future average car travel and future air travel levels. Theoretically, there may be enough demand growth opportunity, given the right conditions, for these saturation levels to be exceeded by 2020 – however there is quite strong evidence that they are legitimate parts of the transport model configuration.

On the other hand, the current BTRE freight models (including BTRE TRUCKMOD) do not include any saturation constraints. It could be argued freight vehicles may also face saturation effects by 2020. However, as mentioned earlier, there is currently no evidence that Australian freight movement is levelling off in any way – so the base case assumes no saturation effects on freight before 2020.

Regarding sudden events or other major contingencies affecting transport behaviour, the greatest uncertainty concerning the currently projected levels would probably be the risk of significant disruptions to oil supply occurring during the forecast period. Any extreme rises in fuel prices will likely have severe impacts on transport activity levels, particularly for road and air travel. The model sensitivities above only addressed a moderate range of fuel price variations – partly because very large increases in the price of crude oil will tend to be inflationary, and require modelling at a whole economy level, rather than just at the transport sector level (as for the BTRE fleet modelling).

Additionally, even though treated here as a *high* scenario, the EIA 'High B' oil price trend – which averages about US$ 45 per barrel of crude (in real terms) - is still considerably lower than the 50 to 60 dollars per barrel that a variety of energy forecasters judge as possible over the medium to long term; and is much lower than some of the outlooks presented. For example, there are market forecasters that consider US$ 100 per barrel to be possible by 2010 – see Rubin (2005).

More of an issue (than the price spikes of short-term disruptions) with forecasting of a long-term price trend with oil, is the timing of the possible *roll-over* in the global oil market (i.e. the point where the world demand for oil outstrips the capacity to produce that much). Though there are still large global oil reserves (especially if non-conventional sources such as tar-sands are included), considerable evidence suggests that the steep growth in world energy demand will eventually overtake the level that is economically viable (at current price levels) to produce extra petroleum fuel. So even before there is major reserve depletion, oil prices will probably have to rise significantly, to match demand growth to possible supply growth (and if global depletion in conventional oil reserves then follows, fuel prices could be expected to rise dramatically). Energy forecasters tend to disagree strongly about the timing of such a *roll-over* or *production peak*; some predicting the short-term, others predicting it is well in the future. This debate is thoroughly discussed in a recent Bureau publication - Working Paper 61 (BTRE 2005c).

One of the most quoted studies in this area has been done by the US Energy Information Administration (EIA), based on resource data complied by the United States Geological Survey (USGS 2000). The results of EIA's analyses (EIA 2000, 2004) conclude that the most likely timing of the oil production peak (given current demand and recovery growth) will be between 2030 and 2040, and regarding the possible range they state:

> "depending on what actually happens to demand, as well as on how fortunate the world eventually proves to be *vis a vis* the volume of its conventional crude oil resource endowment, peak world conventional crude oil production could plausibly occur anywhere between 2021 at a volume of 48.5 billion barrels per year and 2112 at a volume of 24.6 billion barrels per year, though neither of these extremes has a substantial probability of occurrence… [and] if the USGS mean resource estimate proves to be correct… world conventional crude oil production would be expected to peak in 2037 at a volume of 53.2 billion barrels per year."

Even though the oil roll-over is a possibility before 2020, the balance of current evidence suggests that it is more likely to occur over a longer timeframe – and that the current projection scenarios should be valid. However, any subsequent projection studies, attempting to forecast transport emissions over the longer term (further than about 2020), will probably have to examine this issue further. Until future oil supply is more precisely known, fuel use projections longer than a 2030 timeframe must be considered as very uncertain.

Another possible source of uncertainty in the projections relates to the use of alternative fuels, with the possibility either of existing alternative transport fuels gaining significant market share or of new alternatives being introduced. If use of these alternative fuels involves a different carbon-intensity to petroleum then greenhouse gas projections can be altered. The BTRE projections contain a fairly strong growth rate for alternative fuel use in the road transport sector – but given the low base use (i.e. all present-day alternatives accounting for only 6 per cent of road fuel consumption), market shares remain relatively small throughout the forecast period (for an example, see Appendix table A.12).

BTRE medium-term projections of the likely penetration of alternative fuel use in the transport sector have been based on previous Bureau studies: including market share analysis in BTE 1999 and BTCE 1994 ; analysis of potential LPG and CNG fleets in BTRE 2002 ; and a joint CSIRO, ABARE and BTRE project on the use of biofuels in transport (*Appropriateness of a 350 ML Biofuels Target*, DITR 2004).

The latter study estimated that, under existing policy settings, a reasonable *reference* scenario would be for biofuel use in transport to increase from the current consumption of around 50 million litres (ML) per annum, to around 115 ML by 2010. The reference case scenario then held transport biofuel consumption at around this 115 ML per annum level from 2010 to 2020; comprising approximately 80 ML of ethanol from waste starch, 5 ML of ethanol from molasses, and 30 ML of biodiesel from waste oil.

This study also analysed the likelihood of the biofuels industry being able to attain a transport consumption level of 350 million litres per annum, given current market conditions. The biofuels study (DITR 2004, pg. 15) finds that:

"…in order to reach a target of 350 ML in 2010, the biofuels industry would require *substantial and ongoing assistance*. In the absence of government assistance, all other options for producing biofuels in Australia examined in this review are considered unlikely to be cost competitive with traditional fuels over the medium to longer term. Under a scenario where the 350 ML biofuels target is assumed to be met, the additional 235 ML of biofuels is assumed to comprise 205 ML of ethanol and 30 ML of biodiesel. The ethanol is assumed to be produced using C molasses (60 ML) and whole cereal grains (145 ML). The biodiesel is assumed to be produced from waste cooking oil (another 30 ML). "

As an indication how the aggregate projection levels are relatively insensitive to the assumptions concerning penetration of alternative fuels, consider the difference to the results if it were assumed that the infrastructure and marketing obstacles facing greater use of biofuels can be overcome, and the 350ML biofuels target can be reached. Even though this seven-fold increase in biofuel use could only be achieved at high relative cost, total (full fuel cycle) transport emissions would only be reduced by less than 0.3 per cent.

There are a wide variety of energy sources that will probably eventually make significant contributions to the transport fuel mix – from increased use of natural gas, or the use of non-conventional petroleum (e.g. sourced from shale oils or gas-to-liquid production), to the use of new technologies such as hydrogen-fed fuel cells. However, given the generally long lead-times required for substantial mass-market penetration of new energy technologies (and that the price comparisons for most alternatives will probably not become attractive until after the conventional oil production peak), then it is not very likely that more than a minor share of transport petroleum use will be substituted by the projection timeframe of 2020.

In closing this section, a couple of final items to note:

1) What exactly are 'Greenhouse Gas Emissions from Transport'?

The emission projection values in this study, in accordance with AGO specifications, all refer to *direct* CO_2 equivalent emissions—i.e. they include solely the effects of the directly radiative gases emitted from transport fuel use: carbon dioxide, methane (CH_4) and nitrous oxide (N_2O). The specified Global Warming Potentials (GWPs) for calculating the CO_2 equivalent mass estimates for emissions of methane and nitrous oxide (21 times for CH_4 and 310 times for N_2O, using a reference period for warming effects of 100 years) are from previous Intergovernmental Panel on Climate Change (IPCC) guidelines on national greenhouse gas inventories (IPCC 1996, 1997).

Due to the difficulty in accurately quantifying global averages for warming due to 'indirect' greenhouse effects (i.e. the effects of gases such as carbon monoxide, which are not radiatively active themselves, but which can influence the concentrations of the direct gases), the IPCC reports referenced (1996, 1997) did not give GWP values for indirect greenhouse gases[2]. The greenhouse gas

[2] Note that an earlier IPCC report (1990) attempted to roughly quantify the indirect effects using a GWP approach, and more recent IPCC research reports (e.g. see IPCC 2001, http://www.grida.no/climate/ipcc_tar/wg1/249.htm) have also discussed ways to incorporate the indirect gases into a basic GWP reporting formulism. IPCC 2001 presents a possible carbon monoxide GWP of between 1 and 3.

emission estimates would be significantly higher if the indirect effects of other gases emitted from transport—particularly the ozone precursors such as carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOCs)—were also taken into account.

This fact should be borne in mind when policy assessments are being made with regards to emission abatement measures – i.e. not only will calculated greenhouse gas emission levels be higher if future target negotiations manage to incorporate the indirect gases, but the scope for future abatement of those levels will also be widened (since control-technology or other measures that promote the reduction of noxious engine emissions could also then be counted as greenhouse abatement measures).

Previous Bureau studies (e.g. BTCE Reports 88 and 94) imply that total CO_2 equivalent emissions for transport, calculated using the major six gas species (CO_2, CH_4, N_2O, CO, NO_x and NMVOCs) will tend to be 10 to 20 per cent higher than those calculated using just the three direct gases (CO_2, CH_4, N_2O—as in this report and the current AGO NGGI).

The total for transport would also be higher if it included:

- emissions from additional sources, such as military transport or energy use for commodity movements by pipelines (these two areas probably accounting for a further 3-5 per cent of transport emissions).
- the *full fuel cycle* (FFC) for transport vehicle energy use – i.e. as well as direct fuel combustion, the estimates also included energy used for fuel supply and processing. The inclusion of emissions due to fuel extraction, due to power generation (e.g. for electric railways) and due to fuel refining or conversion would add around 15 to 20 per cent to energy end-use emission totals for transport (BTRE 2002, BTCE 1995a).
- a wide range of emissions from sources associated with transport vehicle use and transport infrastructure provision (e.g. emissions from energy used in vehicle construction, repairs and disposal; evaporative losses from service stations; energy use in road and rail track construction and maintenance). Bureau estimates of the emission add-on for such *full system cycle* effects are in the order of a further 15 per cent (BTCE 1995a).

The energy end-use estimate for total civil domestic transport sector emissions is given as 82.8 million tonnes of direct CO_2 equivalent for 2004 (table 1.2). Inclusion of fuel used by international transport to and from Australia (and bought in Australia) raises this 2004 total to around 91.9 million tonnes of direct CO_2 equivalent. Further including emissions due to military vehicles and to pipelines would bring the total to about 96.5 million tonnes.

Now if full fuel cycle emissions and indirect non-CO_2 emissions (using BTCE Report 94 GWP values) are also added on, then the resulting estimate for total CO_2 equivalent emissions from the Australian transport sector in 2004 is around 122 million tonnes. Additionally including the extra system cycle emissions, gives roughly 140 million tonnes (CO_2 equivalent) as the total 2004 emissions due to Australian transport activity.

When considering the impact of emission abatement policy measures, quite different conclusions could be reached if the effects over the full transport system are allowed for, as opposed to just looking at changes in direct end-use emission levels.

1) *If all sectors of the economy had to reduce emissions, can transport output be reduced as much as other sectors, given its strong growth?*

The emission projections (e.g. figure 1.1) show significant growth expected over the next 15 years, with strong underlying growth in transport demand – a demand that also happens to be relatively inelastic to price variations.

Such expected trends have caused some commentators to express how difficult it would be to reduce transport sector emissions by enough if a national emissions target had ever to be met - with the presumption, it appears, that each sector of the economy must reduce its emissions by an equal percentage.

Such an approach could however be very inefficient – since meeting any required emission target at the lowest overall cost to the Australian community is typically best done on the basis of economy-wide marginal costs. That is, if costs to Australia are to be minimised, then the choice of abatement measures should be based on comparisons of the social costs of options in all sectors of the economy, not just those in the transport sector. Reductions in each sector should be pursued until the marginal cost of further abatement in that sector equals the marginal cost of reducing emissions across the other sectors.

Since transport has such strong intrinsic growth, and some areas of the sector are already highly energy-efficient (such as the movement of bulk freight), it could be more cost-effective to target other sectors with greater initial scope for emission reductions, until the marginal social costs in those sectors become equivalent to transport emission reduction costs.

APPENDIX AGGREGATE MODEL INPUTS AND DETAILED DATA SERIES

TABLE A.1 STATE AND TERRITORY POPULATION PROJECTIONS

(thousand persons)

Year	*NSW*	*Vic*	*Qld*	*SA*	*WA*	*Tas*	*NT*	*ACT*	*Total*
1990	5832	4378	2905	1431	1615	462	164	283	17070
1991	5896	4415	2967	1444	1637	466	166	289	17280
1992	5955	4445	3039	1452	1658	469	168	295	17480
1993	6005	4464	3123	1459	1679	471	171	299	17670
1994	6056	4478	3194	1461	1705	472	173	301	17841
1995	6120	4507	3270	1464	1735	472	178	304	18050
1996	6242	4585	3365	1479	1779	476	184	309	18420
1997	6280	4612	3409	1479	1803	472	188	307	18550
1998	6328	4650	3453	1482	1831	470	190	307	18711
1999	6399	4703	3505	1490	1857	469	193	310	18926
2000	6472	4763	3560	1496	1887	468	195	312	19153
2001	6555	4827	3624	1506	1919	468	199	315	19413
2002	6626	4878	3686	1513	1949	468	202	318	19641
2003	6687	4917	3797	1527	1952	477	198	323	19879
2004	6731	4973	3882	1534	1982	482	200	324	20109
2005	6845	5019	3892	1538	2047	469	213	328	20350
2006	6909	5057	3957	1543	2077	469	217	331	20560
2007	6973	5095	4022	1549	2108	468	220	333	20768
2008	7039	5135	4090	1555	2140	468	224	336	20986
2009	7103	5173	4156	1560	2171	468	228	339	21196
2010	7167	5211	4223	1566	2202	467	231	341	21408
2011	7229	5246	4288	1570	2233	467	235	344	21612
2012	7287	5280	4353	1574	2263	466	238	346	21806
2013	7343	5310	4415	1577	2292	464	242	348	21991
2014	7398	5341	4478	1580	2321	463	245	350	22178
2015	7455	5372	4542	1584	2351	462	249	353	22367
2016	7508	5401	4604	1586	2379	460	253	355	22546
2017	7561	5430	4667	1589	2408	459	256	357	22726
2018	7611	5456	4727	1591	2436	457	260	358	22897
2019	7661	5482	4788	1593	2464	455	263	360	23068
2020	7712	5509	4850	1595	2493	453	267	362	23241

Sources: BTRE estimates based on ABS (mid-range series B) long-term projections.

TABLE A.2 CAPITAL CITY POPULATION PROJECTIONS

(thousand persons)

Year	*Syd*	*Mel*	*Bne*	*Adl*	*Per*	*Hob*	*Dar*	*Cbr*	*Total*
1990	3632	3127	1331	1047	1174	189	75	283	10857
1991	3672	3153	1359	1056	1189	190	76	289	10986
1992	3712	3180	1390	1063	1207	192	77	295	11115
1993	3746	3199	1426	1068	1225	193	78	299	11233
1994	3782	3214	1456	1070	1246	194	78	301	11341
1995	3825	3241	1489	1072	1270	194	80	304	11475
1996	3904	3302	1530	1084	1305	196	82	309	11714
1997	3940	3327	1550	1083	1324	195	84	307	11811
1998	3978	3364	1573	1086	1342	194	86	307	11929
1999	4033	3410	1598	1091	1361	194	88	310	12085
2000	4093	3462	1624	1097	1385	193	90	312	12256
2001	4157	3516	1654	1106	1410	193	91	315	12444
2002	4212	3561	1684	1113	1433	193	93	318	12607
2003	4270	3604	1715	1121	1457	193	95	323	12778
2004	4325	3643	1747	1128	1481	194	97	324	12938
2005	4382	3682	1780	1135	1505	194	99	328	13106
2006	4433	3717	1811	1140	1528	194	101	331	13254
2007	4483	3751	1842	1145	1551	194	103	333	13403
2008	4536	3787	1873	1151	1574	194	105	336	13557
2009	4587	3821	1904	1156	1597	194	107	339	13706
2010	4639	3855	1936	1161	1620	194	109	341	13857
2011	4689	3888	1967	1165	1643	194	111	344	14002
2012	4738	3919	1997	1169	1665	194	114	346	14142
2013	4784	3949	2027	1173	1687	194	116	348	14277
2014	4831	3978	2057	1177	1709	194	118	350	14412
2015	4878	4008	2087	1180	1730	194	120	353	14549
2016	4924	4035	2116	1183	1752	193	122	355	14680
2017	4970	4064	2146	1187	1773	193	124	357	14812
2018	5014	4090	2175	1189	1794	192	126	358	14938
2019	5058	4116	2204	1192	1814	192	128	360	15065
2020	5103	4143	2233	1195	1835	192	130	362	15193

Sources: BTRE estimates based on ABS (mid-range series B) long-term projections.

TABLE A.3 BASE CASE GDP GROWTH ASSUMPTIONS

(per cent change per annum)

Financial year	*Australian real GDP growth*
2003	3.21
2004	4.09
2005	3.00
2006	3.25
2007	3.50
2008	3.50
2009	3.10
2010	3.00
2011	2.85
2012	2.70
2013	2.55
2014	2.40
2015	2.30
2016	2.25
2017	2.20
2018	2.15
2019	2.10
2020	2.00

Source: AGO (pers. comm., based on Treasury estimates).

Road transport time-series estimates were based on data collected by the ABS *Survey of Motor Vehicle Use* – which have been appropriately scaled and standardised, according to the methods described in Cosgrove & Mitchell (2001), to allow for methodological variations between the various survey years.

TABLE A.4 BASE CASE PROJECTIONS OF NATIONAL ROAD FREIGHT TASK BY TYPE OF VEHICLE

(billion tonne-kilometres)

Fin. Year	*Light Commercial Vehicles*	*Rigid and other trucks*	*Articulated trucks*	*Total*
2002	6.5	28.5	114.9	149.9
2003	6.7	29.2	118.2	154.1
2004	7.0	30.7	124.6	162.3
2005	7.3	31.8	129.6	168.6
2006	7.5	32.9	135.5	175.9
2007	7.8	33.9	142.6	184.4
2008	8.1	34.9	150.2	193.2
2009	8.4	35.6	157.5	201.5
2010	8.8	36.1	165.1	210.0
2011	9.1	36.4	172.8	218.3
2012	9.4	36.7	180.5	226.6
2013	9.7	36.9	188.2	234.8
2014	10.0	37.2	195.6	242.9
2015	10.3	37.5	203.1	250.9
2016	10.7	37.9	210.5	259.0
2017	11.0	38.3	218.0	267.3
2018	11.3	38.7	225.6	275.6
2019	11.7	39.3	233.0	284.0
2020	12.0	39.9	240.4	292.3

Note: All results for all tables refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b, 2005d), BTE (1999), ABS (2004 and earlier).

TABLE A.5 BASE CASE PROJECTIONS OF NATIONAL VEHICLE KILOMETRES TRAVELLED BY TYPE OF VEHICLE, 1990-2020

(billion kilometres)

Fin. Year	*Cars*	*Light Commercial Vehicles*	*Rigid and other trucks*	*Articulated trucks*	*Buses*	*Motor cycles*	*Total*
1990	124.16	22.57	6.77	4.11	1.41	1.74	160.76
1991	124.88	22.85	6.26	4.05	1.36	1.62	161.02
1992	126.95	22.80	6.07	4.10	1.34	1.63	162.88
1993	130.08	23.11	5.97	4.39	1.35	1.66	166.56
1994	132.62	23.41	6.16	4.49	1.41	1.63	169.73
1995	138.22	24.79	6.29	4.80	1.45	1.62	177.17
1996	142.03	25.59	6.42	4.91	1.50	1.52	181.98
1997	143.33	25.98	6.55	5.06	1.55	1.52	183.99
1998	145.99	27.34	6.67	5.37	1.60	1.46	188.44
1999	149.75	28.68	6.90	5.55	1.65	1.40	193.94
2000	152.76	29.84	7.18	5.66	1.68	1.42	198.53
2001	152.31	30.34	7.33	5.70	1.75	1.46	198.89
2002	158.45	31.98	7.80	5.91	1.76	1.48	207.37
2003	160.63	33.12	7.99	5.99	1.80	1.52	211.07
2004	168.99	34.80	8.36	6.21	1.83	1.64	221.83
2005	170.45	35.38	8.61	6.35	1.87	1.77	224.44
2006	172.08	36.65	8.87	6.51	1.90	1.90	227.93
2007	175.69	38.11	9.12	6.75	1.93	2.01	233.61
2008	179.76	39.58	9.32	7.01	1.96	2.09	239.72
2009	184.32	40.89	9.48	7.24	1.99	2.13	246.04
2010	187.69	42.39	9.55	7.47	2.01	2.17	251.28
2011	190.30	43.84	9.60	7.71	2.04	2.21	255.70
2012	192.64	45.26	9.62	7.97	2.07	2.25	259.81
2013	194.81	46.65	9.62	8.23	2.10	2.28	263.69
2014	196.91	47.99	9.66	8.47	2.13	2.32	267.47
2015	198.97	49.30	9.68	8.70	2.15	2.36	271.16
2016	200.76	50.63	9.74	8.93	2.18	2.40	274.64
2017	202.53	52.08	9.79	9.16	2.21	2.44	278.19
2018	204.21	53.54	9.82	9.38	2.23	2.47	281.66
2019	205.87	55.01	9.91	9.60	2.26	2.51	285.16
2020	207.70	56.45	9.97	9.80	2.30	2.55	288.78

Note: 'Passenger car' results in all tables include 4-wheel drive passenger vehicles ('All Terrain Wagons' – ATWs), unless explicitly noted otherwise.

LCV (light commercial vehicle) fleet results include the (generally) heavier 4-wheel drive vehicles primarily purchased for business uses.

In projection tables, year values refer to financial year (i.e. 'year ending 30 June').

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTE (1999), ABS (2004 and earlier).

TABLE A.6 BASE CASE PROJECTIONS OF METROPOLITAN AND NON-METROPOLITAN VEHICLE KILOMETRES TRAVELLED FOR PASSENGER VEHICLES, 1990-2020

(million kilometres)

Fin. Year	*Metropolitan Cars*	*Non-Metropolitan Cars*	*Total*
1990	73428	50736	124164
1991	73838	51041	124879
1992	75068	51881	126949
1993	76982	53100	130082
1994	78556	54062	132618
1995	81957	56262	138219
1996	84300	57726	142025
1997	85213	58122	143335
1998	86924	59067	145991
1999	89212	60537	149749
2000	91238	61523	152761
2001	91135	61176	152311
2002	94937	63513	158450
2003	96366	64268	160634
2004	101514	67473	168987
2005	102529	67925	170454
2006	103640	68440	172080
2007	105951	69741	175692
2008	108542	71222	179764
2009	111432	72884	184316
2010	113611	74075	187686
2011	115339	74960	190299
2012	116901	75738	192639
2013	118363	76443	194806
2014	119790	77119	196908
2015	121193	77774	198967
2016	122438	78324	200762
2017	123670	78860	202529
2018	124853	79361	204214
2019	126022	79850	205872
2020	127299	80400	207699

Note: ‘Metropolitan’ results refer to all activity within the greater metropolitan areas of the 8 State and Territory capital cities.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTE (1999), ABS (2004 and earlier).

TABLE A.7 BASE CASE PROJECTIONS OF CARBON DIOXIDE (CO_2) EMISSIONS FOR AUSTRALIAN ROAD TRANSPORT BY TYPE OF VEHICLE, 1990-2020

(gigagrams)

Fin. Year	*Cars*	*Light Commercial Vehicles*	*Rigid and other trucks*	*Articulated trucks*	*Buses*	*Motor cycles*	*Total*
1990	33264	6899	4842	5533	1168	229	51936
1991	33315	6941	4480	5458	1106	210	51511
1992	33705	6882	4339	5534	1073	211	51744
1993	34424	6955	4274	5948	1061	215	52877
1994	34967	7024	4420	6126	1096	212	53845
1995	36204	7424	4522	6594	1118	210	56072
1996	37045	7666	4629	6799	1147	198	57484
1997	37154	7767	4731	7038	1177	197	58064
1998	37639	8179	4824	7522	1208	189	59562
1999	38365	8579	4998	7821	1237	182	61182
2000	38971	8907	5199	8014	1253	183	62527
2001	38773	9076	5331	8112	1280	186	62758
2002	40271	9579	5682	8457	1284	190	65463
2003	40722	9930	5833	8626	1305	199	66616
2004	42795	10424	6103	8983	1316	214	69836
2005	43033	10604	6302	9224	1342	229	70734
2006	43216	10977	6508	9492	1362	247	71802
2007	43971	11402	6704	9867	1382	258	73585
2008	44859	11831	6867	10267	1398	269	75490
2009	45899	12205	6999	10629	1423	271	77427
2010	46539	12633	7075	11003	1440	276	78967
2011	46938	13036	7131	11365	1461	281	80211
2012	47261	13423	7169	11776	1482	284	81394
2013	47511	13792	7190	12179	1502	288	82462
2014	47731	14142	7239	12554	1522	290	83479
2015	47930	14481	7284	12924	1538	295	84452
2016	48033	14816	7355	13279	1561	297	85341
2017	48119	15191	7420	13638	1587	299	86255
2018	48165	15558	7477	13998	1604	301	87104
2019	48209	15923	7577	14341	1628	306	87984
2020	48267	16272	7661	14677	1660	308	88844

Note: Emission values based on the assumption of *full carbon combustion* for transport fuels. All results refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTE (1999).

TABLE A.8 BASE CASE PROJECTIONS OF METHANE (CH_4) EMISSIONS FOR AUSTRALIAN ROAD TRANSPORT BY TYPE OF VEHICLE, 1990-2020

(gigagrams)

Fin. Year	*Cars*	*Light Commercial Vehicles*	*Rigid and other trucks*	*Articulated trucks*	*Buses*	*Motor cycles*	*Total*
1990	18.44	2.81	0.65	0.19	0.14	0.35	22.58
1991	18.49	2.82	0.62	0.19	0.14	0.32	22.58
1992	18.79	2.83	0.59	0.19	0.15	0.33	22.88
1993	19.21	2.93	0.56	0.20	0.16	0.33	23.40
1994	19.52	2.98	0.56	0.21	0.17	0.33	23.76
1995	20.23	3.15	0.55	0.21	0.18	0.32	24.64
1996	20.58	3.32	0.53	0.21	0.18	0.30	25.13
1997	20.55	3.39	0.51	0.20	0.19	0.30	25.16
1998	20.65	3.56	0.48	0.20	0.20	0.29	25.38
1999	20.70	3.70	0.46	0.20	0.20	0.28	25.54
2000	20.59	3.74	0.44	0.19	0.21	0.28	25.45
2001	19.89	3.89	0.41	0.18	0.24	0.29	24.92
2002	20.15	3.96	0.41	0.18	0.27	0.30	25.27
2003	19.91	4.05	0.38	0.18	0.30	0.30	25.13
2004	20.45	4.18	0.37	0.18	0.32	0.33	25.83
2005	19.97	4.17	0.36	0.18	0.32	0.35	25.35
2006	19.52	4.21	0.34	0.18	0.32	0.38	24.94
2007	19.26	4.23	0.33	0.18	0.31	0.40	24.71
2008	19.12	4.23	0.31	0.18	0.31	0.42	24.57
2009	19.24	4.23	0.30	0.18	0.30	0.43	24.68
2010	19.07	4.24	0.29	0.18	0.30	0.43	24.51
2011	18.75	4.21	0.28	0.18	0.30	0.44	24.17
2012	18.46	4.19	0.27	0.19	0.29	0.45	23.86
2013	18.16	4.18	0.27	0.19	0.29	0.46	23.55
2014	17.90	4.16	0.26	0.19	0.29	0.46	23.27
2015	17.69	4.15	0.26	0.20	0.29	0.47	23.05
2016	17.63	4.20	0.26	0.20	0.29	0.48	23.05
2017	17.47	4.23	0.25	0.20	0.29	0.49	22.93
2018	17.49	4.30	0.25	0.20	0.29	0.49	23.03
2019	17.52	4.38	0.25	0.21	0.29	0.50	23.16
2020	17.59	4.48	0.26	0.21	0.30	0.51	23.34

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTE (1999).

TABLE A.9 BASE CASE PROJECTIONS OF NITROUS OXIDE (N_2O) EMISSIONS FOR AUSTRALIAN ROAD TRANSPORT BY TYPE OF VEHICLE, 1990-2020

(gigagrams)

Year	*Cars*	*Light Commercial Vehicles*	*Articulated trucks*	*Rigid and other trucks*	*Buses*	*Motor cycles*	*Total*
1990	1.81	0.19	0.17	0.10	0.04	0.01	2.31
1991	2.24	0.24	0.15	0.10	0.03	0.01	2.78
1992	2.64	0.29	0.15	0.10	0.03	0.01	3.22
1993	3.08	0.33	0.15	0.11	0.03	0.01	3.71
1994	3.54	0.37	0.15	0.11	0.04	0.01	4.23
1995	4.11	0.43	0.16	0.12	0.04	0.01	4.86
1996	4.58	0.48	0.16	0.12	0.04	0.01	5.39
1997	4.85	0.52	0.17	0.13	0.04	0.01	5.71
1998	5.17	0.57	0.17	0.13	0.04	0.01	6.09
1999	5.56	0.63	0.18	0.14	0.04	0.01	6.55
2000	5.92	0.68	0.18	0.14	0.04	0.01	6.97
2001	6.12	0.74	0.19	0.14	0.04	0.01	7.24
2002	6.64	0.79	0.20	0.15	0.04	0.01	7.83
2003	6.92	0.84	0.21	0.15	0.05	0.01	8.17
2004	7.52	0.91	0.22	0.16	0.05	0.01	8.85
2005	7.66	0.94	0.22	0.16	0.05	0.01	9.04
2006	7.73	0.98	0.23	0.16	0.05	0.01	9.16
2007	7.88	1.02	0.24	0.17	0.05	0.01	9.37
2008	8.07	1.06	0.24	0.18	0.05	0.01	9.61
2009	8.29	1.10	0.24	0.18	0.05	0.01	9.87
2010	8.43	1.13	0.25	0.19	0.05	0.01	10.06
2011	8.54	1.17	0.25	0.20	0.05	0.01	10.22
2012	8.64	1.20	0.25	0.20	0.05	0.01	10.36
2013	8.72	1.23	0.25	0.21	0.05	0.01	10.48
2014	8.80	1.25	0.26	0.22	0.05	0.01	10.59
2015	8.88	1.27	0.26	0.22	0.06	0.01	10.70
2016	8.94	1.29	0.26	0.23	0.06	0.01	10.80
2017	9.01	1.32	0.26	0.24	0.06	0.01	10.90
2018	9.09	1.34	0.27	0.24	0.06	0.01	11.00
2019	9.17	1.35	0.27	0.25	0.06	0.01	11.11
2020	9.27	1.36	0.27	0.25	0.06	0.01	11.23

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b), BTE (1999).

TABLE A.10 BTRE 2003 BASE CASE PROJECTIONS: COMPARISON TABLE FOR EMISSIONS FOR AUSTRALIAN TRANSPORT BY MODE, 1990-2020

(gigagrams of CO_2 equivalent)

Fin. Year	*Road*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	53198	1741	2369	2565	59872
1991	52831	1727	2246	3141	59944
1992	53406	1673	2183	3393	60655
1993	54894	1641	2130	3553	62218
1994	56014	1769	2115	3707	63605
1995	58400	1708	2322	4274	66704
1996	59757	1672	2232	4640	68300
1997	60394	1806	2278	4838	69316
1998	62249	1743	2086	4846	70924
1999	63777	1717	1948	4782	72223
2000	64886	1782	1982	4996	73645
2001	64813	1755	1924	5277	73768
2002	66831	1748	1915	4764	75258
2003	68907	1783	1907	4937	77534
2004	71136	1812	1900	5155	80003
2005	73052	1843	1895	5388	82178
2006	74320	1874	1890	5643	83727
2007	75696	1900	1886	5891	85373
2008	76928	1921	1884	6131	86864
2009	78126	1942	1881	6363	88312
2010	79513	1963	1873	6584	89933
2011	80687	1983	1864	6794	91328
2012	81837	2002	1855	6991	92684
2013	82943	2021	1846	7175	93985
2014	84048	2038	1838	7344	95268
2015	85129	2055	1830	7498	96512
2016	86174	2071	1823	7635	97703
2017	87410	2087	1818	7774	99088
2018	88432	2102	1814	7915	100262
2019	89410	2116	1813	8057	101395
2020	90369	2130	1815	8200	102514

Note: Emission estimates are for direct greenhouse gas emissions only – carbon dioxide, methane and nitrous oxide (ie do not include indirect effects of gases such as the ozone precursors carbon monoxide and nitrogen dioxide); converted into CO_2 equivalent figures using AGO-preferred values for the *Global Warming Potentials* (of 21 for methane and 310 for nitrous oxide).

Emission estimates relate to energy end-use (i.e. do not include emissions from fuel supply and processing, or from power generation for electric railways).

'Aviation' includes emissions from general aviation.

'Maritime' includes emissions from small pleasure craft and ferries, and from overseas-bought fuel that is used in coastal shipping.

All results refer to 'year ending 30 June'.

Sources: BTRE unpublished estimates for AGO (BTRE 2003b) – based on BTRE (2003a, 2002) & BTE (1999).

TABLE A.11 BASE CASE PROJECTIONS OF CRUDE OIL PRICES

Real 2004 US$ per barrel of crude (WTI)

Fin. Year	*Base Case*	*High scenario*	*Low scenario*
1990	26.53	26.53	26.53
1991	31.66	31.66	31.66
1992	25.03	25.03	25.03
1993	22.76	22.76	22.76
1994	20.50	20.50	20.50
1995	20.69	20.69	20.69
1996	23.45	23.45	23.45
1997	23.89	23.89	23.89
1998	17.56	17.56	17.56
1999	15.94	15.94	15.94
2000	27.45	27.45	27.45
2001	32.09	32.09	32.09
2002	24.78	24.78	24.78
2003	30.53	30.53	30.53
2004	35.28	35.28	35.28
2005	48.71	48.71	48.71
2006	53.49	54.00	46.00
2007	50.92	52.00	42.00
2008	47.00	48.00	39.16
2009	40.00	41.00	31.30
2010	37.11	40.11	28.11
2011	37.16	40.84	28.46
2012	37.22	41.58	28.82
2013	37.27	42.32	29.17
2014	37.33	43.06	29.53
2015	37.38	43.80	29.88
2016	37.93	44.58	30.28
2017	38.47	45.35	30.67
2018	39.02	46.13	31.07
2019	39.56	46.91	31.46
2020	40.11	47.69	31.86

Note: US Refiner's Acquisition Cost values in the *AEO2005* report have been adjusted to WTI values.

Sources: EIA (2005a, 2005b), BTRE estimates.

TABLE A.12 BASE CASE PROJECTIONS OF TOTAL PASSENGER CAR ENERGY CONSUMPTION, 1990-2020

(petajoules)

Year	*LP/LRP*	*ULP/PULP*	*Total petrol*	*ADO*	*LPG*	*NG*	*Ethanol*	*Total*
1990	347.8	129.7	477.5	13.5	19.2	0.0	0.0	510.3
1991	319.3	157.9	477.2	16.2	17.2	0.0	0.0	510.7
1992	298.5	179.9	478.4	17.0	21.5	0.1	0.0	517.1
1993	279.2	207.9	487.1	17.4	23.6	0.1	0.1	528.3
1994	256.0	238.2	494.3	17.8	24.4	0.1	0.1	536.6
1995	237.4	273.8	511.3	18.9	25.2	0.1	0.1	555.6
1996	211.8	309.1	520.9	19.3	28.3	0.1	0.2	568.8
1997	180.8	336.7	517.4	19.7	33.4	0.2	0.2	570.9
1998	156.1	365.1	521.1	20.8	36.0	0.2	0.5	578.6
1999	127.7	402.4	530.1	22.0	36.7	0.2	0.7	589.8
2000	102.9	433.7	536.6	23.9	37.4	0.3	0.8	599.1
2001	82.2	450.2	532.4	25.1	37.3	0.3	0.9	596.0
2002	68.3	486.1	554.4	25.9	37.3	0.3	1.1	618.9
2003	56.6	504.2	560.8	26.2	37.3	0.4	1.1	625.8
2004	47.7	542.6	590.3	28.2	37.4	0.5	1.1	657.4
2005	39.3	552.4	591.7	30.1	37.5	0.5	1.2	661.0
2006	28.4	564.5	592.9	31.5	37.5	0.6	1.2	663.8
2007	23.3	579.4	602.7	32.9	37.6	0.7	1.3	675.3
2008	16.9	597.5	614.5	34.5	37.7	0.8	1.3	688.8
2009	14.0	614.5	628.5	36.0	37.8	1.0	1.4	704.7
2010	11.6	624.7	636.3	37.7	37.9	1.1	1.4	714.5
2011	8.4	631.9	640.3	39.4	38.0	1.3	1.5	720.5
2012	5.9	637.1	643.0	41.2	38.1	1.5	1.5	725.4
2013	4.9	639.7	644.5	43.1	38.2	1.8	1.6	729.2
2014	3.3	642.1	645.4	45.1	38.3	2.1	1.6	732.6
2015	2.7	643.2	645.9	47.2	38.4	2.4	1.7	735.6
2016	2.2	642.5	644.7	49.4	38.5	2.8	1.8	737.2
2017	1.8	641.3	643.1	51.6	38.6	3.3	1.8	738.5
2018	1.5	639.3	640.8	54.0	38.7	3.8	1.9	739.2
2019	1.2	637.0	638.2	56.5	38.8	4.5	2.0	739.9
2020	1.0	635.6	636.6	58.1	39.0	5.2	2.0	740.9

Notes: LP/LRP = leaded petrol (discontinued 2001), lead replacement petrol, and all petrol use with additives for anti-valve seat recession (esp. after eventual phase out of LRP).
ULP/PULP = unleaded petrol / premium unleaded petrol.

Total petrol = all automotive gasoline use
ADO = automotive diesel oil.
LPG = liquefied petroleum gas.
NG = natural gas.

Motor vehicle sales of ethanol are commonly as a 10 per cent ethanol-petrol blend (E10).

Sources: BTRE estimates, BTRE (2002, 2003a).

TABLE A.13 BASE CASE PROJECTIONS OF NATIONAL MOTOR VEHICLE ENERGY CONSUMPTION BY TYPE OF VEHICLE, 1990-2020

(petajoules)

Year	*Cars*	*Light Commercial Vehicles*	*Rigid and other trucks*	*Articulated trucks*	*Buses*	*Motor cycles*	*Total*
1990	510.3	104.8	70.8	80.2	17.0	3.5	786.6
1991	510.7	105.5	65.6	79.1	16.1	3.2	780.2
1992	517.1	104.7	63.5	80.2	15.6	3.2	784.4
1993	528.3	106.0	62.6	86.2	15.5	3.3	801.7
1994	536.6	107.1	64.6	88.8	16.0	3.2	816.4
1995	555.6	113.4	66.1	95.6	16.3	3.2	850.2
1996	568.8	117.0	67.6	98.5	16.8	3.0	871.7
1997	570.9	118.5	69.1	102.0	17.2	3.0	880.7
1998	578.6	124.7	70.4	109.0	17.7	2.9	903.3
1999	589.8	130.7	72.9	113.3	18.1	2.8	927.6
2000	599.1	135.7	75.7	116.1	18.4	2.8	947.8
2001	596.0	138.3	77.7	117.6	19.0	2.9	951.3
2002	618.9	145.9	82.8	122.6	19.1	2.9	992.1
2003	625.8	151.2	85.0	125.0	19.5	3.0	1009.5
2004	657.4	158.7	88.9	130.2	19.7	3.3	1058.2
2005	661.0	161.4	91.8	133.7	20.2	3.5	1071.5
2006	663.8	167.0	94.8	137.6	20.5	3.8	1087.4
2007	675.3	173.5	97.6	143.0	20.8	3.9	1114.1
2008	688.8	179.9	100.0	148.8	21.1	4.1	1142.7
2009	704.7	185.6	101.9	154.1	21.5	4.2	1171.9
2010	714.5	192.1	103.0	159.5	21.8	4.2	1195.0
2011	720.5	198.2	103.8	164.7	22.1	4.3	1213.7
2012	725.4	204.1	104.4	170.7	22.4	4.3	1231.4
2013	729.2	209.7	104.7	176.5	22.8	4.4	1247.3
2014	732.6	215.1	105.4	182.0	23.1	4.4	1262.6
2015	735.6	220.3	106.1	187.3	23.4	4.5	1277.2
2016	737.2	225.5	107.1	192.5	23.8	4.6	1290.5
2017	738.5	231.3	108.1	197.7	24.2	4.6	1304.3
2018	739.2	237.0	108.9	202.9	24.6	4.6	1317.2
2019	739.9	242.8	110.4	207.9	25.0	4.7	1330.5
2020	740.9	248.4	111.7	212.7	25.5	4.7	1343.9

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b).

TABLE A.14 BASE CASE PROJECTIONS OF AVERAGE FUEL INTENSITY FOR ALL AUSTRALIAN ROAD TRAVEL BY TYPE OF VEHICLE, 1990-2020

(L/100km)

Year	*Cars*	*Light Commercial Vehicles*	*Rigid and other trucks*	*Articulated trucks*	*Buses*	*Motor cycles*
1990	12.02	13.58	27.12	50.54	31.10	5.90
1991	11.96	13.50	27.14	50.56	30.68	5.80
1992	11.91	13.43	27.13	50.63	30.19	5.80
1993	11.87	13.41	27.15	50.85	29.75	5.80
1994	11.83	13.38	27.17	51.17	29.46	5.80
1995	11.75	13.37	27.22	51.59	29.19	5.80
1996	11.71	13.37	27.29	51.94	28.99	5.80
1997	11.65	13.33	27.33	52.19	28.79	5.80
1998	11.59	13.33	27.35	52.55	28.65	5.80
1999	11.52	13.32	27.34	52.88	28.50	5.80
2000	11.47	13.30	27.34	53.20	28.32	5.75
2001	11.44	13.32	27.43	53.48	28.11	5.70
2002	11.42	13.34	27.48	53.77	28.04	5.75
2003	11.39	13.35	27.53	54.05	27.98	5.85
2004	11.38	13.33	27.54	54.31	27.94	5.85
2005	11.34	13.34	27.61	54.54	27.91	5.80
2006	11.28	13.32	27.66	54.74	27.87	5.80
2007	11.24	13.31	27.72	54.90	27.88	5.75
2008	11.20	13.29	27.78	55.03	27.89	5.75
2009	11.18	13.27	27.85	55.16	27.91	5.70
2010	11.13	13.25	27.94	55.28	27.99	5.70
2011	11.07	13.22	28.01	55.37	28.03	5.70
2012	11.01	13.18	28.09	55.48	28.09	5.65
2013	10.95	13.15	28.18	55.58	28.15	5.65
2014	10.88	13.11	28.27	55.67	28.21	5.60
2015	10.81	13.06	28.37	55.75	28.27	5.60
2016	10.74	13.02	28.48	55.83	28.33	5.55
2017	10.66	12.99	28.60	55.93	28.46	5.50
2018	10.58	12.94	28.72	56.02	28.54	5.45
2019	10.51	12.91	28.86	56.11	28.62	5.45
2020	10.43	12.87	29.01	56.22	28.71	5.40

Note: Gasoline equivalent L/100km for light vehicles and diesel equivalent L/100km for heavy vehicles.

Sources: BTRE estimates, BTRE (2002, 2003a), ABS (2004 and earlier).

TABLE A.15 BASE CASE PROJECTIONS OF AVERAGE ENERGY INTENSITY FOR NATIONAL ROAD FREIGHT TASKS, BY TYPE OF VEHICLE

(MJ per tonne-kilometre)

Fin. Year	*Light Commercial Vehicles*	*Rigid and other trucks*	*Articulated trucks*
2002	22.36	2.91	1.07
2003	22.60	2.91	1.06
2004	22.57	2.89	1.05
2005	22.25	2.89	1.03
2006	22.23	2.88	1.02
2007	22.18	2.88	1.00
2008	22.11	2.87	0.99
2009	22.02	2.86	0.98
2010	21.93	2.86	0.97
2011	21.81	2.85	0.95
2012	21.69	2.84	0.95
2013	21.56	2.84	0.94
2014	21.43	2.83	0.93
2015	21.30	2.83	0.92
2016	21.17	2.82	0.91
2017	21.04	2.82	0.91
2018	20.92	2.82	0.90
2019	20.79	2.81	0.89
2020	20.67	2.80	0.88

Notes: Values are calculated using total fuel use and total tkm estimates – so are averages across total vehicle activity (even trips while unladen).

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b, 2005d), BTE (1999), ABS (2004 and earlier).

TABLE A.16 BASE CASE PROJECTIONS OF AVERAGE LOAD FOR NATIONAL ROAD FREIGHT TASKS, BY TYPE OF VEHICLE

(tonnes)

Fin. Year	*Light Commercial Vehicles*	*Rigid and other trucks*	*Articulated trucks*
2002	0.204	3.65	19.46
2003	0.202	3.65	19.73
2004	0.202	3.67	20.06
2005	0.205	3.69	20.41
2006	0.205	3.70	20.82
2007	0.205	3.72	21.13
2008	0.206	3.74	21.45
2009	0.206	3.76	21.77
2010	0.207	3.78	22.09
2011	0.207	3.80	22.42
2012	0.208	3.81	22.65
2013	0.209	3.83	22.88
2014	0.209	3.85	23.10
2015	0.210	3.87	23.34
2016	0.210	3.89	23.57
2017	0.211	3.91	23.80
2018	0.212	3.94	24.04
2019	0.212	3.97	24.28
2020	0.213	4.00	24.53

Notes: Values are calculated using total VKT and total tkm estimates – so are averages across total vehicle activity (even trips while unladen).

All results refer to 'year ending 30 June'.

Sources: BTRE estimates, BTRE (2002, 2003a, 2003b, 2005d), BTE (1999), ABS (2004 and earlier).

TABLE A.17 BASE CASE PROJECTIONS OF RAIL TASKS, 1990-2020

(billion)

Fin. Year	*Non-urban passenger*	*Urban (heavy pass. rail)*	*Urban (light pass. rail)*	*Hire & Reward non-bulk freight*	*Hire & Reward bulk*	*Hire & Reward total*	*Ancillary freight*
	pkm	*pkm*	*pkm*	*tkm*	*tkm*	*tkm*	*tkm*
1990	2.35	6.83	0.56	19.49	35.36	54.86	33.06
1991	2.36	6.83	0.65	19.17	36.20	55.36	35.76
1992	2.26	6.93	0.66	19.72	37.35	57.07	42.25
1993	2.26	6.85	0.57	21.78	37.92	59.69	41.09
1994	2.21	7.03	0.53	22.65	38.81	61.46	42.76
1995	2.22	7.33	0.57	21.69	40.71	62.40	43.79
1996	2.25	7.37	0.58	20.90	42.58	63.48	46.77
1997	2.18	7.55	0.61	22.25	47.97	70.22	49.40
1998	2.12	7.22	0.55	25.51	48.93	74.44	51.15
1999	2.15	7.46	0.55	26.33	50.08	76.41	51.55
2000	2.38	7.66	0.57	27.39	57.17	84.57	49.00
2001	2.43	8.32	0.56	27.95	57.46	85.41	51.50
2002	2.44	8.34	0.57	29.60	62.90	92.50	57.96
2003	2.33	8.23	0.58	30.99	67.19	98.18	64.00
2004	2.36	8.40	0.59	31.96	68.74	100.70	68.48
2005	2.40	8.60	0.60	32.96	70.32	103.28	70.53
2006	2.45	8.83	0.61	33.99	71.94	105.93	72.74
2007	2.50	9.08	0.63	34.93	73.47	108.40	74.75
2008	2.55	9.33	0.64	35.80	74.94	110.73	76.61
2009	2.58	9.51	0.65	36.67	76.42	113.10	78.48
2010	2.62	9.69	0.66	37.56	77.93	115.49	80.38
2011	2.65	9.86	0.67	38.45	79.45	117.89	82.28
2012	2.68	10.03	0.69	39.33	80.97	120.30	84.16
2013	2.71	10.20	0.70	40.21	82.51	122.73	86.06
2014	2.74	10.36	0.71	41.09	84.06	125.15	87.94
2015	2.77	10.51	0.72	41.97	85.62	127.59	89.82
2016	2.80	10.67	0.74	42.85	87.19	130.03	91.69
2017	2.83	10.83	0.75	43.72	88.77	132.49	93.56
2018	2.85	10.98	0.77	44.59	90.37	134.96	95.42
2019	2.88	11.14	0.78	45.46	91.98	137.45	97.29
2020	2.91	11.31	0.79	46.34	93.62	139.97	99.17

Note: Values refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2002, 2003b, 2005), ACG 2005.

TABLE A.18 BASE CASE PROJECTIONS OF TOTAL ENERGY CONSUMPTION (END-USE) BY AUSTRALIAN CIVIL TRANSPORT BY MODE, 1990-2020

(petajoules)

Fin. Year	*Motor Vehicles*	*Rail (non-electric)*	*Maritime*	*Aviation*	*Total*
1990	787.4	24.7	30.2	37.4	879.8
1991	781.1	24.6	28.4	45.8	879.8
1992	785.2	23.9	29.1	49.5	887.7
1993	802.6	23.5	29.0	51.8	907.0
1994	817.3	25.4	29.7	54.1	926.5
1995	851.1	24.7	32.7	62.4	970.9
1996	872.6	24.1	30.1	67.7	994.5
1997	881.7	24.5	30.0	70.6	1006.8
1998	904.2	24.9	30.0	70.7	1029.9
1999	928.6	25.7	28.1	69.8	1052.1
2000	948.8	26.6	27.8	73.0	1076.1
2001	952.3	26.1	26.5	75.0	1079.8
2002	993.0	27.3	27.1	69.0	1116.5
2003	1010.5	28.1	26.9	73.6	1139.0
2004	1059.2	28.6	26.8	81.5	1196.1
2005	1072.5	29.2	26.7	86.8	1215.3
2006	1088.4	29.8	26.8	90.8	1235.8
2007	1115.1	30.4	26.8	93.6	1265.9
2008	1143.7	30.9	26.8	97.5	1298.9
2009	1172.9	31.4	26.8	101.2	1332.3
2010	1196.1	31.9	26.9	104.7	1359.5
2011	1214.7	32.3	26.9	106.8	1380.7
2012	1232.4	32.8	27.0	109.8	1402.0
2013	1248.4	33.2	27.0	112.7	1421.4
2014	1263.7	33.6	27.1	114.0	1438.3
2015	1278.3	34.0	27.2	116.4	1455.8
2016	1291.6	34.4	27.3	118.5	1471.8
2017	1305.4	34.7	27.4	120.7	1488.2
2018	1318.3	35.1	27.5	122.9	1503.7
2019	1331.7	35.5	27.6	125.1	1519.8
2020	1345.0	35.8	27.7	127.3	1535.8

Notes: Estimates relate to energy end-use (i.e. do not include emissions from fuel supply and processing, or from power generation for electric railways).

‘Aviation’ includes emissions from general aviation.

‘Maritime’ includes emissions from small pleasure craft and ferries, and from overseas-bought fuel that is used in coastal shipping.

‘Motor Vehicles’ includes all road vehicles plus off-road recreational vehicles.

Energy use due to military transport is excluded.

All results refer to ‘year ending 30 June’.

Sources: BTRE estimates, BTRE (2003a, 2002, 2003b, 2005), ACG 2005 .

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ABS	Australian Bureau of Statistics
AGO	Australian Greenhouse Office
AGPS	Australian Government Publishing Service
ACG	Apelbaum Consulting Group
AIP	Australian Institute of Petroleum
BTCE	Bureau of Transport and Communications Economics
BTE	Bureau of Transport Economics
BTR	Bureau of Tourism Research
BTRE	Bureau of Transport and Regional Economics
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DISR	Department of Industry, Science and Resources
DITR	Department of Industry, Tourism and Resources
DOTARS	Department of Transport and Regional Services
DPIE	Department of Primary Industries and Energy
EIA	US Energy Information Administration
FORS	Federal Office of Road Safety
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
NGGIC	National Greenhouse Gas Inventory Committee
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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